Air Quality Impact Assessment for the Proposed Kriel Power Station FFP Retrofit

Project done on behalf of **Wandima Environmental Services**

Report Compiled by:
T Bird

Project Manager:
R von Gruenewaldt

Report No: 15WES01 | **Date:** April 2016

Address: 480 Smuts Drive, Halfway Gardens | **Postal:** P O Box 5260, Halfway House, 1685
Tel: +27 (0)11 805 1940 | **Fax:** +27 (0)11 805 7010
www.airshed.co.za

Report Details

Reviewed by	15WES01
Status	Draft
Report Title	Air Quality Impact Assessment for the Proposed Kriel Power Station FFP Retrofit
Date	April 2016
Client	Wandima Environmental Services
Prepared by	Terri Bird, PhD (Wits)
Reviewed by	Renee von Gruenewaldt, (Pr. Sci. Nat.), MSc (University of Pretoria)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.
Copyright Warning	Unless otherwise noted, the copyright in all text and other matter (including the manner of presentation) is the exclusive property of Airshed Planning Professionals (Pty) Ltd. It is a criminal offence to reproduce and/or use, without written consent, any matter, technical procedure and/or technique contained in this document.

Revision Record

Revision Number	Date	Reason for Revision
Draft	April 2016	For Client Review

Abbreviations

Airshed	Airshed Planning Professionals (Pty) Ltd
ADF	Ash disposal facility
AEL	Atmospheric Emissions Licence
AIR	Atmospheric Impact Report
AMS	American Meteorological Society
AQA	Air Quality Act
AQM	Air quality management
AQG(s)	Air Quality Guideline(s)
AQSRs	Air Quality Sensitive Receptor(s)
AST	Anemometer starting threshold
ASTM	American Society for Testing and Materials
BAT	Best available technology
CSP	Coal stock-pile
DEA	Department of Environmental Affairs
ESP	Electrostatic precipitator
FFP	Fabric Filter Plant
GLCs	Ground-level concentration(s)
HPA	Highveld Priority Area
I&APs	Interested and Affected Parties
IFC	International Finance Corporation
IPPC	Integrated Pollution Prevention and Control
ISC	Industrial Source Complex Short Term
IT	Interim Target
mamsl	Meters above mean sea level
MES	Minimum Emission Standards
NAAQ Limit	National Ambient Air Quality Limit concentration
NAAQS	National Ambient Air Quality Standards (as a combination of the NAAQ Limit and the allowable frequency of exceedance)
NEM(A)	National Environmental Management (Act)
SABS	South African Bureau of Standards
SANAS	South African National Accreditation System
US-EPA	United States Environmental Protection Agency

GLOSSARY

Air pollution[(a)]	The presence of substances in the atmosphere, particularly those that do not occur naturally
Dispersion[(a)]	The spreading of atmospheric constituents, such as air pollutants
Dust[(a)]	Solid materials suspended in the atmosphere in the form of small irregular particles, many of which are microscopic in size
Instability[(a)]	A property of the steady state of a system such that certain disturbances or perturbations introduced into the steady state will increase in magnitude, the maximum perturbation amplitude always remaining larger than the initial amplitude
Mechanical mixing[(a)]	Any mixing process that utilizes the kinetic energy of relative fluid motion
Oxides of nitrogen (NO_x)	The sum of nitrogen oxide (NO) and nitrogen dioxide (NO_2) expressed as nitrogen dioxide (NO_2)
Particulate matter (PM)	Total particulate matter, that is solid matter contained in the gas stream in the solid state as well as insoluble and soluble solid matter contained in entrained droplets in the gas stream
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter of less than 2.5 µm
PM_{10}	Particulate Matter with an aerodynamic diameter of less than 10 µm
Stability[(a)]	The characteristic of a system if sufficiently small disturbances have only small effects, either decreasing in amplitude or oscillating periodically; it is asymptotically stable if the effect of small disturbances vanishes for long time periods

Notes:

(a) Definition from American Meteorological Society's glossary of meteorology (AMS, 2014)

SYMBOLS AND UNITS

°C	Degree Celsius
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
g	Gram(s)
g/s	Gram(s) per second
K	Kelvin (temperature)
kg	Kilograms
1 kilogram	1 000 grams
km^2	Square kilometre
kpa	kilo Pascal
m	Meters
m/s	Meters per second
MW	Megawatt
MWth	Megawatt (thermal output)
µg	Microgram(s)
$µg/m^3$	Micrograms per cubic meter
µm	Micrometre
mg	Milligram(s)
mg/Nm^3	Milligrams per normal cubic meter
m^2	Square meter
mm	Millimetres
NO	Nitrogen oxide
N_2O	Nitrous oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
$PM_{2.5}$	Inhalable particulate matter (aerodynamic diameter less than 2.5 µm)
PM_{10}	Thoracic particulate matter (aerodynamic diameter less than 10 µm)
SO_2	Sulfur dioxide
tpa	Tonnes per annum
TSP	Total Suspended Particulates
1 ton	1 000 000 grams

EXECUTIVE SUMMARY

Kriel Power Station intends to replace the current electrostatic precipitators (ESP) with retrofitted fabric filter plants (FFP). The retrofit of the FFP technology at Kriel Power Station is to ensure compliance with the Minimum Emission Standards for particulate emissions from Solid Fuel Combustion Installations (Government Notice 893, November 2013 – Government Gazette No. 37054).

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Wandima Environmental Services to conduct an air quality impact assessment for this project. The main objective of the air quality study is to determine air quality related impacts as a result of the Kriel Power Station before and after the retrofit of the FFP technology. Fine particulates with aerodynamic diameters than 10 µm and 2.5 µm (PM_{10} and $PM_{2.5}$, respectively) were the pollutants of concern for the Kriel Power Station retrofit.

The nearest residential areas to the Kriel Power Station are the staff villages of Kriel and Matla Power Stations, and the Matla mine (within 5 km of the power station); and the town of Kriel (7.5 km east). Current land use near the Project area, excluding the power stations and coal mine, is predominantly agricultural.

Near-site surface meteorological data, recorded at the Eskom-operated Kriel Village ambient air quality monitoring station, was used to generate AERMOD-ready meteorological files. The period of the meteorological data was 8th January 2013 to 30 November 2015. The wind field was dominated by winds from the north-west; north-east; and, less frequently the south-west. Calm conditions, after correction, occurred less than 1% of the time.

Measured ambient PM_{10} concentrations at the Kriel Village monitoring station were non-compliant with the National Ambient Air Quality Standards (NAAQS) (for daily and annual averaging periods) for the three-years assessed (2013 to 2015).

The quantification of sources of emission was restricted to current (ESP) and future (FFP) operations at the Kriel Power Station. The wind-blown dust from the coal stockpile and ash disposal facility located near the Power Station was also quantified as part of the assessment. Although other background sources were identified, such sources were not quantified.

The main findings from the impact assessment due to current operations and proposed FFP retrofit at all six units were as follows:

- The simulated daily and annual PM_{10} and $PM_{2.5}$ concentrations within the domain (due to current and future power station stack releases, existing ash dam operations and coal stockpile operations only) were within the NAAQS.
- The simulated FFP retrofit to the Kriel Power Station units would reduce the impact of PM_{10} from the stacks (only) by ~96%. Before and after the retrofit the simulated annual PM_{10} concentrations (due to stack emissions only) were predicted to be a maximum of 0.90 µg/m³ and 0.52 µg/m³ respectively.

The low simulated annual concentrations for the Power Station stack emissions only highlight the contribution of the fugitive sources at the Power Station and sources off-site to be background measured values where non-compliance with the ambient standards were recorded for the period assessed. It is recommended that the FFP retrofit be implemented as an air quality management measure to meet Minimum Emission Standards and to ensure the lowest possible impacts on the surrounding environment.

TABLE OF CONTENTS

LIST OF TABLES

List of Figures

Air Quality Impact Assessment for the Proposed Kriel Power Station FFP Retrofit

1 Introduction

Kriel Power Station complex is located approximately 7.5 km west of the town of Kriel, in central Mpumalanga Province (Figure 1-1). Kriel Power Station comprises of six operational units with a combined base-load capacity of 3 000 MW. The power station is adjacent to the Matla Power Station and the Matla Mine (Exxaro). The land use surrounding the two power stations and mine is primarily agricultural, comprising low density farmsteads and infrastructure, crops on the arable soils, and livestock grazing.

Kriel Power Station intends to replace the current electrostatic precipitators (ESP) with retrofitted fabric filter plants (FFP). These alternatives are control technologies to limit the particulate emissions from the power station chimney stacks. The retrofit of the FFP technology at Kriel Power Station is to ensure compliance with the Minimum Emission Standards for particulate emissions from (Subcategory 1.1) Solid Fuel Combustion Installations (as contemplated by Section 21 of the National Environmental Management (NEM): Air Quality Act (AQA), No.39 of 2004 and defined in the Government Notice 893, November 2013 – Government Gazette No. 37054).

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Wandima Environmental Services to conduct an air quality impact assessment for this project. The main objective of the air quality study is to determine air quality related impacts as a result of the Kriel Power Station before and after the retrofit of the FFP technology.

1.1 Scope of Work

As is typical of an air quality impact assessment, the study encompassed the following tasks:

A. The baseline air quality characterisation including the assessment of:
   - the regional climate and site-specific atmospheric dispersion potential;
   - preparation of hourly average meteorological data for the wind field model;
   - the legislative and regulatory context, including national minimum emission limits and national ambient air quality standards and dustfall classifications.

B. The impact prediction study included the following:
   - dispersion simulations of particulate concentrations from the operational activities using stack emissions and parameters as supplied by the proponent and calculated windblown dust from the ash dump and coal stockpile;
   - analysis of dispersion modelling results from operations, incorporating:
     (a) assessment of the predicted cumulative ground-level concentrations (stack emissions and windblown particulates from the coal and ash dump facilities on-site only);
     (b) assessment of the predicted incremental ground-level concentrations (stack emissions only);
   - evaluation of potential for human health and environmental impacts;
   - evaluation of potential for human health and environmental impacts; and,
   - provision of recommendations from an air quality perspective.

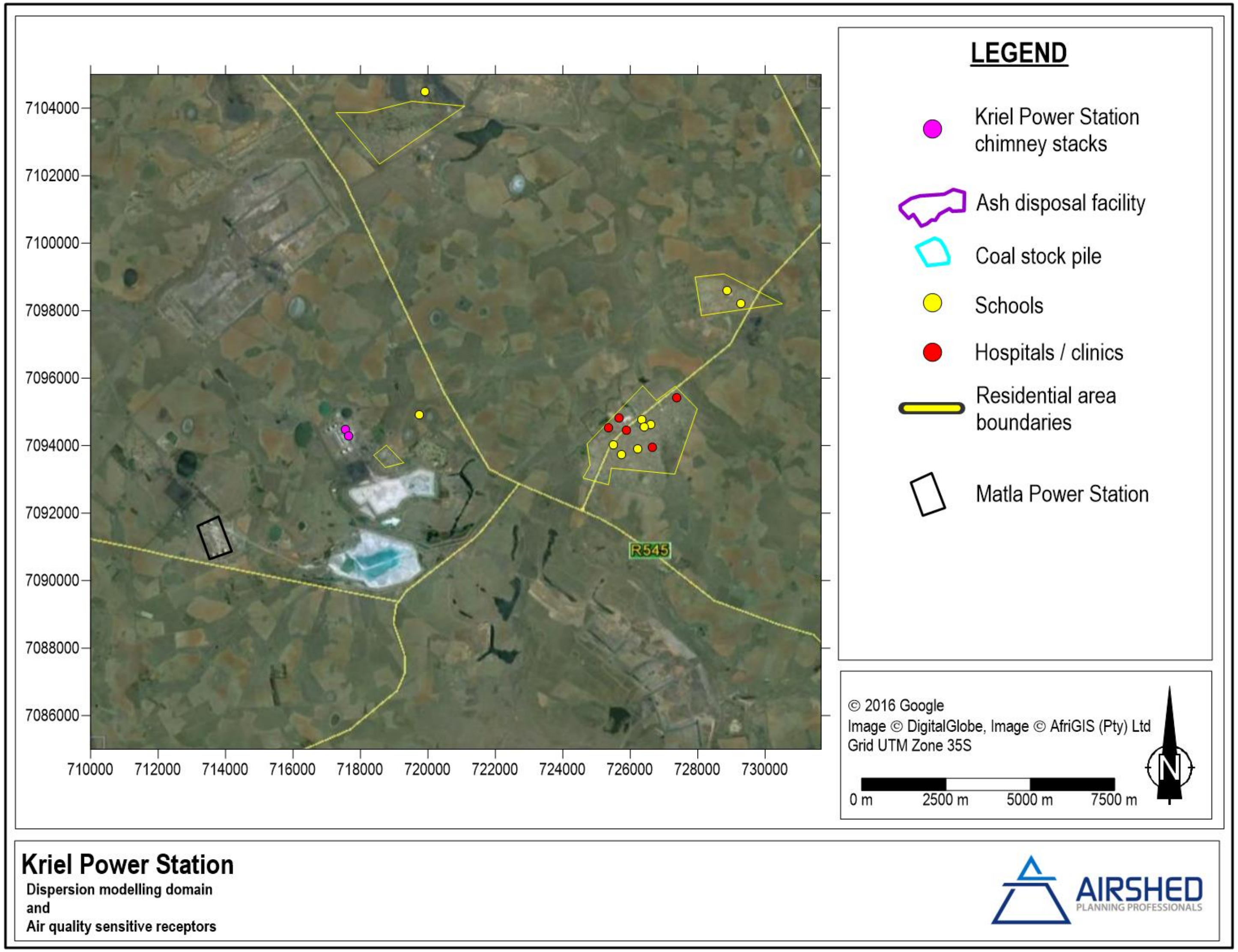

Figure 1-1: Location map of the Kriel Power Station

1.2 Description of Project Activities from an Air Quality Perspective

The Kriel Power Station's six boiler units vent gaseous and particulate emissions to the atmosphere via two chimney stacks. Although not the only pollutants emitted to the atmosphere during normal operations at the Kriel Power station (Table 1-1), the pollutants of concern associated with the project were particulates. The current (ESP) and planned (FFP) abatement technologies are implemented to control particulate emissions, thus the focus of the study.

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 focus of the study was refined to only include the finer particulate fractions (PM_{10} and $PM_{2.5}$) because the retrofitting process will affect only the emissions from the chimney stacks, from which coarser fractions are rarely emitted.

Table 1-1: Air emissions and pollutants associated with coal-fired power plants

Details	Activities	Pollutants
Gaseous flue-emissions from boiler units	Coal combustion	SO_2, NO_x, and particulates (PM_{10} and $PM_{2.5}$), and potentially trace quantities of metal compounds
Coal and ash transfer points and at stockpiles	Off-loading/transfer and other tipping operations	TSP, PM_{10} and $PM_{2.5}$
Coal and ash storage	Wind erosion	TSP, PM_{10} and $PM_{2.5}$
Crushers and screens	Crushing and screening	TSP, PM_{10} and $PM_{2.5}$
Transport of staff and materials on on-site roads	Wheel entrainment and exhaust gas	Mainly TSP, PM_{10} and $PM_{2.5}$, but vehicle tailpipe emissions including NO_x, CO_2, CO, SO_2, CH_4, nitrous oxide (N_2O) and particulates

1.3 Approach and Methodology

1.3.1 Atmospheric Dispersion Model Selection

Dispersion models compute ambient pollutant concentrations as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations arising from the emissions from various sources. Increasing reliance has been placed on concentration estimates from models as the primary basis for environmental and health impact assessments, risk assessments and emission control requirements.

The US Environmental Protection Agency's (US-EPA) approved regulatory model – AERMOD - was selected for this study. It is one of the models recommended for Level 2 assessments, for near-source (less than 50 km from source) applications in all terrain types, in the South African Regulations Regarding Air Dispersion Modelling (Government Gazette No. 37804;11 July 2014).

The AERMOD suite of models was developed under the support of the American Meteorological Society/US-EPA Regulatory Model Improvement Committee (AERMIC), whose objective has been to include state-of the-art science in regulatory models (Hanna *et al.*, 1999). The AERMOD is a dispersion modelling system with three components, namely:

AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

AERMOD is an advanced new-generation model. It is designed to predict pollution concentrations from continuous point, flare, area, line, and volume sources. AERMOD offers new and potentially improved algorithms for plume rise and buoyancy, and the computation of vertical profiles of wind, turbulence and temperature however retains the single straight line trajectory limitation of ISCST3 (Hanna *et al.*, 1999).

AERMET is a meteorological pre-processor for the AERMOD model. Input data can come from hourly cloud cover observations, surface meteorological observations and twice-a-day upper air soundings. Output includes surface meteorological observations and parameters and vertical profiles of several atmospheric parameters.

AERMAP is a terrain pre-processor designed to simplify and standardize the input of terrain data for the AERMOD model. Input data includes receptor terrain elevation data. The terrain data may be in the form of digital terrain data. For each receptor, output includes location and height scale, which are elevations used for the computation of air flow around hills.

There will always be some error in any geophysical model, but it is desirable to structure the model in such a way to minimise the total error. A model represents the most likely outcome of an ensemble of experimental results. The total uncertainty can be thought of as the sum of three components: the uncertainty due to errors in the model physics; the uncertainty due to data errors; and the uncertainty due to stochastic processes (turbulence) in the atmosphere.

The stochastic uncertainty includes all errors or uncertainties in data such as source variability, observed concentrations, and meteorological data. Even if the field instrument accuracy is excellent, there can still be large uncertainties due to unrepresentative placement of the instrument (or taking of a sample for analysis). Model evaluation studies suggest that the data input error term is often a major contributor to total uncertainty. Even in the best tracer studies, the source emissions are known only with an accuracy of ±5%, which translates directly into a minimum error of that magnitude in the model predictions. It is also well known that wind direction errors are the major cause of poor agreement, especially for relatively short-term predictions (minutes to hourly) and long downwind distances. All of the above factors contribute to the inaccuracies not even associated with the mathematical models themselves.

Dispersion models do not contain all the features of a real environmental system but contain the feature of interest for the management issue or scientific problem to be solved (MFE, 2001). Gaussian plume models are generally regarded to have an uncertainty range between -50% to 200%. It has generally been found that the accuracy of off-the-shelf dispersion models improve with increased averaging periods. The accurate prediction of instantaneous peaks are the most difficult and are normally performed with more complicated dispersion models specifically fine-tuned and validated for the location.

Input data types required for the AERMOD model include: meteorological data, source data, and information on the nature of the receptor grid. Each of these data types will be described below.

1.3.2 Meteorological Data Requirements

AERMOD requires two specific input files generated by the AERMET pre-processor. AERMET is designed to be run as a three-stage processor and operates on three types of data (upper air data, on-site measurements, and the national meteorological database). Near-site surface meteorological data (including wind speed, wind direction and temperature) recorded at the Eskom-operated Kriel Village ambient air quality monitoring station was used to generate AERMOD-ready meteorological files. The period of the meteorological data was January 2013 to November 2015.

1.3.3 Source Data Requirements

The AERMOD model is able to model point, area, volume and line sources. The atmospheric emissions of the particulate fractions of concern, as a result of operations from the proposed project, were modelled as point sources (chimney stacks), and area sources (ash disposal facility and coal stock pile).

1.3.4 Modelling Domain

The dispersion of pollutants was modelled for an area covering 28 km (north-south) by 28 km (east-west) centred over the power station. The modelling domain was selected on the basis of the sources of emissions and potential impact areas. This area was divided into a grid with a resolution of 250 m (north-south) by 250 m (east-west). A finer grid (100 m resolution) was used within 5 km of the power station. AERMOD simulates ground-level concentrations for each of the receptor grid points.

1.4 Assumptions, Exclusions and Limitations

A number of assumptions had to be made resulting in certain limitations associated with the results. The most important assumptions and limitations of the air quality impact assessment are:

- The quantification of sources of emission was restricted to current (ESP) and future (FFP) operations at the Kriel Power Station. The wind-blown dust from the coal stockpile and ash disposal facility located near the Power Station was also quantified as part of the assessment. Although other background sources were identified, such sources were not quantified.
- PM_{10} and $PM_{2.5}$ were the pollutants of concern for the Kriel Power Station retrofit.
    - All particulate emissions assumed to be PM_{10} or smaller. $PM_{2.5}$ assumed to be 90% of total particulate emissions from the stacks
- Annual emissions from the power plant were provided and modelled based on normal operating conditions. Atmospheric releases occurring as a result of accidents, maintenance or start-up conditions were not accounted for.
- Stack parameters were used as reported in the recent Kriel Power Station AIR (uMoya-NILU, 2014).
    - It was indicated that stack parameters – especially those affecting pollutant dispersion – would not be materially affected by the FFP retrofit. This was assumed to be accurate. The limitation of this assumption is that changes in some exit parameters, such as temperature and velocity, may affect the dispersion and ground-level impact of the particulate matter and other pollutants.
- Three years of meteorological data (from the Kriel Village ambient air quality monitoring station) were used in the atmospheric dispersion modelling with a data availability of over 78%.
- The construction was assessed qualitatively due to the temporary nature of these operations.
- As a conservative approach, proposed operations were assumed operate over twenty-four hours a day; 365-days per year.

2 REGULATORY REQUIREMENTS AND ASSESSMENT CRITERIA

The air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality guideline values indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. The air quality guidelines and standards are normally given for specific averaging periods.

Ambient air quality standard, for pollutants applicable to this assessment are discussed in Section 2.2 and the legislative context of minimum emissions standards for power stations are discussed in Section 2.3.

2.1 National Ambient Air Quality Standards (NAAQS)

The South African Bureau of Standards (SABS) was engaged to assist Department of Environmental Affairs (DEA) in the facilitation of the development of ambient air quality standards. This included the establishment of a technical committee to oversee the development of standards. National Ambient Air Quality Standards (NAAQS) were determined based on international best practice for $PM_{2.5}$, PM_{10}, SO_2, NO_2, CO, ozone, lead and benzene. The NAAQS for the pollutants of concern for the current assessment is provided in Table 2-1.

Table 2-1: NAAQS for pollutants of concern for the current assessment

<table>
<tr><th>Substance</th><th>Molecular Formula / Notation</th><th>Averaging Period</th><th>Concentration (µg/m³)</th><th>Frequency of Exceedance</th><th>Compliance Date</th><th>Reference</th></tr>
<tr><td rowspan="6">Particulate Matter</td><td rowspan="4">$PM_{2.5}$</td><td rowspan="2">24 hour</td><td>40</td><td>4</td><td>1 Jan 2016 – 31 Dec 2029</td><td rowspan="4">(Department of Environmental Affairs, 2011)</td></tr>
<tr><td>25</td><td>4</td><td>01-Jan-30</td></tr>
<tr><td rowspan="2">1 year</td><td>20</td><td>-</td><td>1 Jan 2016 – 31 Dec 2029</td></tr>
<tr><td>15</td><td>-</td><td>01-Jan-30</td></tr>
<tr><td rowspan="2">PM_{10}</td><td>24 hour</td><td>75</td><td>4</td><td>01-Jan-15</td><td rowspan="2">(Department of Environmental Affairs, 2009)</td></tr>
<tr><td>1 year</td><td>40</td><td>-</td><td>01-Jan-15</td></tr>
</table>

2.2 Listed Activities and Minimum Emissions Standards

Power Generation was a Scheduled Process under the Atmospheric Pollution Prevention Act of 1965 (Process 29) and a Listed Activity under the NEM Air Quality Act of 2004 (AQA). Thus minimum national emission limits have been developed for Combustion Installations with a design capacity of more than or equal to 50 MW heat input. All existing and new applications are subject to a new Atmospheric Emissions License (AEL). This license requires provision of all sources of pollution from a Listed Activity facility, including point and non-point emissions. The Listed Activities and Associated Minimum Emission Standards were published in terms of Section 21 of the NEM: Air Quality Act on the 22 November 2013 (Government Gazette No. 57054).

Table 2-2 provides the requirements as set out in the published Listed Activities and Associated Minimum Emission Standards for Combustion Installations requires that all existing power stations conform to the new plant standard of 50 mg/Nm[3] for particulate emissions, by 1 April 2020. All six units at the Kriel Power Station were originally commissioned with Electrostatic Precipitator (ESP) technology for particulate abatement. The functioning of the ESPs does not allow the station to meet the new emission standards promulgated by the Department of Environmental Affairs (DEA), and as such it is proposed that all ESPs be retrofitted to fabric filter plants (FFPs).

Additional requirements, as set out in the published Section 21 include specific requirements for continuous monitoring, including:

- the averaging period for the purposes of compliance monitoring is one calendar month;
- the emissions monitoring system must be maintained to yield a minimum of 80% valid hourly average values during the reporting period;
- no more than five half-hourly average values in any day, and ten daily average values per year, may be disregarded due to malfunction or maintenance; and,
- continuous monitoring systems must be audited by a SANAS accredited laboratory at least once every two years.

Table 2-2: Section 1 on Combustion Installations, Subcategory 1.1. Solid Fuel Combustion Installations

<table>
<tr><th>Description:</th><td colspan="3">Solid fuels (excluding biomass) 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/Nm³ under normal conditions of 10% O₂, 273 K and 101.3 kPa</th></tr>
<tr><th>Common name</th><th>Chemical symbol</th></tr>
<tr><td rowspan="2">Particulate matter</td><td rowspan="2">N/A</td><td>New</td><td>50</td></tr>
<tr><td>Existing</td><td>100</td></tr>
<tr><td rowspan="2">Sulfur dioxide</td><td rowspan="2">SO_2</td><td>New</td><td>500</td></tr>
<tr><td>Existing</td><td>3500</td></tr>
<tr><td rowspan="2">Oxides of nitrogen</td><td rowspan="2">NO_x expressed as NO_2</td><td>New</td><td>750</td></tr>
<tr><td>Existing</td><td>1100</td></tr>
<tr><td colspan="4">a) The following special agreement shall apply:
• Continuous monitoring of PM, SO_2 and NO_x is required</td></tr>
</table>

2.3 Highveld Priority Area

The Highveld Airshed Priority Area (HPA) was declared by the Minister of Environmental Affairs at the end of 2007, requiring the development of an Air Quality Management Plan for the area. The plan (HPA, 2011) includes the establishment of emissions reduction strategies and intervention programmes based on the findings of a baseline characterisation of the area. The implication of this is that all contributing sources in the area will be assessed to determine the emission reduction targets to be achieved over the following few years.

The Kriel Power Station is within the footprint of the Highveld Priority Area. Emission reduction strategies are included for the numerous operations in the area with specific associated targets. Included in this management plan are seven goals, each of which has a further list of objectives that has to be met. The seven goals for the Highveld Priority Area are as follows:

- **Goal 1**: By 2015, organisational capacity in government is optimised to efficiently and effectively maintain, monitor and enforce compliance with ambient air quality standards
- **Goal 2**: By 2020, industrial emissions are equitably reduced to achieve compliance with ambient air quality standards and dust fallout limit values
- **Goal 3**: By 2020, air quality in all low-income settlements is in full compliance with ambient air quality standards
- **Goal 4**: By 2020, all vehicles comply with the requirements of the National Vehicle Emission Strategy
- **Goal 5**: By 2020, a measurable increase in awareness and knowledge of air quality exists
- **Goal 6**: By 2020, biomass burning and agricultural emissions will be 30% less than current
- **Goal 7**: By 2020, emissions from waste management are 40% less than current.

Goal 2 applies directly to the Kriel Power Station, the objectives associated with this goal include:

- Emissions are quantified from all sources.
- Gaseous and particulate emissions are reduced.
- Fugitive emissions are minimised.
- Emissions from dust generating activities are reduced.
- Incidences of spontaneous combustion are reduced.
- Abatement technology is appropriate and operational.
- Industrial Air Quality Management (AQM) decision making is robust and well-informed, with necessary information available.
- Clean technologies and processes are implemented.
- Adequate resources are available for AQM in industry.
- Ambient air quality standard and dust fallout limit value exceedances as a result of industrial emissions are assessed.
- A line of communication exists between industry and communities.

Each of these objectives is further divided into activities, each of which has a timeframe, responsibility and indicator. Refer to the Highveld Priority Management Plan for further details (HPA, 2011).

3 Description of the Receiving Environment

3.1 Air Quality Sensitive Receptors (AQSRs)

The nearest residential areas to the Kriel Power Station are the staff villages of Kriel and Matla Power Stations, and the Matla mine (within 5 km of the power station); and the town of Kriel (7.5 km east). Current land use near the Project area, excluding the power stations and coal mine, is predominantly agricultural (Figure 1-1). These residential areas, as well as schools and hospitals within the modelling domain, were included in the model simulations as additional receptors.

3.2 Atmospheric Dispersion Potential

Physical and meteorological mechanisms govern the dispersion, transformation, and eventual removal of pollutants from the atmosphere. The analysis of hourly average meteorological data is necessary to facilitate a comprehensive understanding of the dispersion potential of the site. Parameters useful in describing the dispersion and dilution potential of the site i.e. wind speed, wind direction, temperature and atmospheric stability, are subsequently discussed. The availability of the meteorological parameters from the Kriel village ambient air quality monitoring station for the period 8th January 2013 to 30 November 2015 was 78% or better (Table 3-1).

Table 3-1: Availability of meteorological data from the Kriel Village air quality monitoring station

Year	Wind speed	Wind direction	Temperature	Relative humidity	Pressure	Solar radiation	Rainfall
2013	87%	87%	87%	87%	87%	87%	87%
2014	87%	87%	87%	87%	87%	69%	87%
2015	86%	86%	86%	86%	90%	78%	90%
Total	**87%**	**87%**	**87%**	**87%**	**88%**	**78%**	**88%**

3.2.1 Surface Wind Field

The wind field determines both the distance of downward transport and the rate of dilution of pollutants. The generation of mechanical turbulence is a function of the wind speed, in combination with the surface roughness. The wind field for the study area is described with the use of wind roses. 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 in between 4 and 5 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories.

Calm conditions are periods when the wind speed was below 1 m/s. These low values can be due to “meteorological” calm conditions when there is no air movement; or, when there may be wind but it is below the anemometer starting threshold (AST). AERMET, the meteorological pre-processor to AERMOD, treats calm conditions (wind speeds <1 m/s) as missing data, which can result in overly conservative concentration estimates simulated in AERMOD. The Regulations regarding Air Dispersion Modelling (Gazette No 37804 vol 589; published 11 July 2014) suggest that all wind speeds greater than or equal to the anemometer starting threshold (AST) and less than 1 m/s be replaced with the value of 1 m/s. This approach was used with the Kriel Village data and 7 535 hours of the data set were corrected with of 1 m/s.

The period, day-time and night-time wind roses for the period 8th January 2013 to 30th November 2015 is shown in Figure 3-1. Seasonal wind roses for the period 8th January 2013 to 30th November 2015 are shown in Figure 3-2.

The wind field was dominated by winds from the north-west; north-east; and, less frequently the south-west. Calm conditions, after correction, occurred less than 1% of the time. During the day, winds at higher wind speeds occurred more frequently from the easterly sector, with 0.2% calm conditions. Night-time airflow had winds also most frequently from the easterly sector but at lower wind speeds. The frequency of night-time calm conditions increased to 0.9%, relative to day-time. Summer and spring show similar wind direction profiles to the period average, while autumn and winter show the more frequent winds from the south-west. There is an increased frequency of wind speeds of 3 m/s or more in spring.

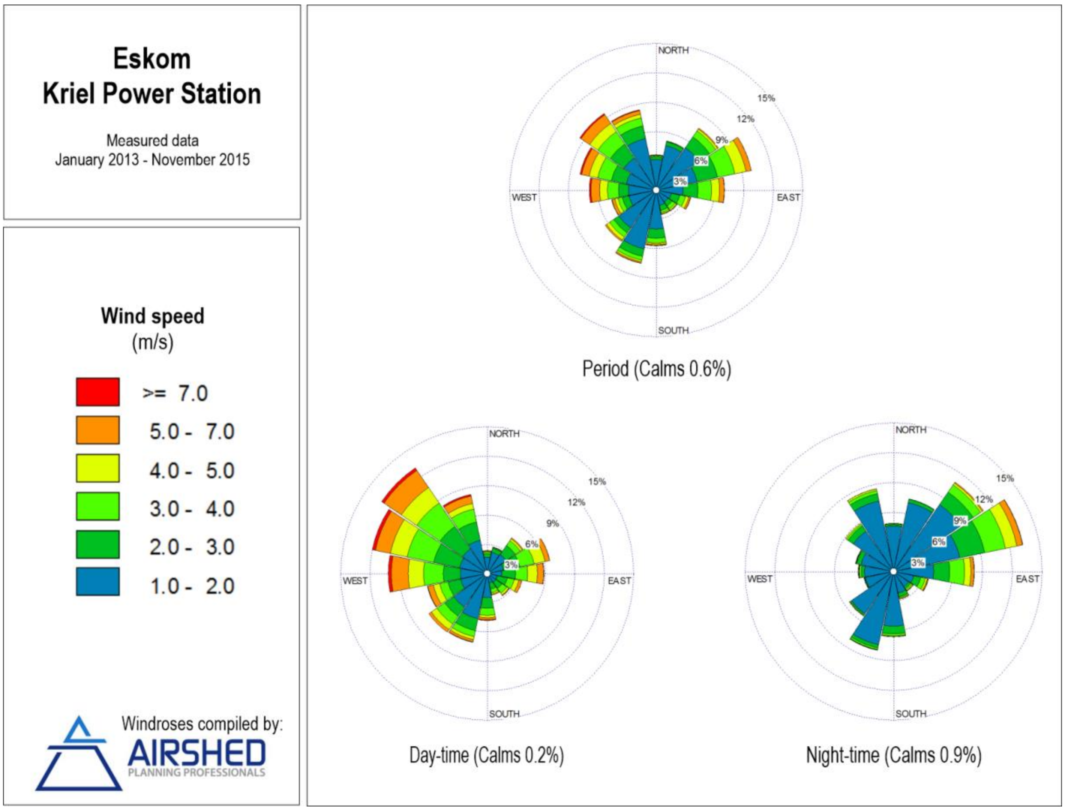

Figure 3-1: Period average, day-time and night-time wind roses (measured data; 2013 to 2015)

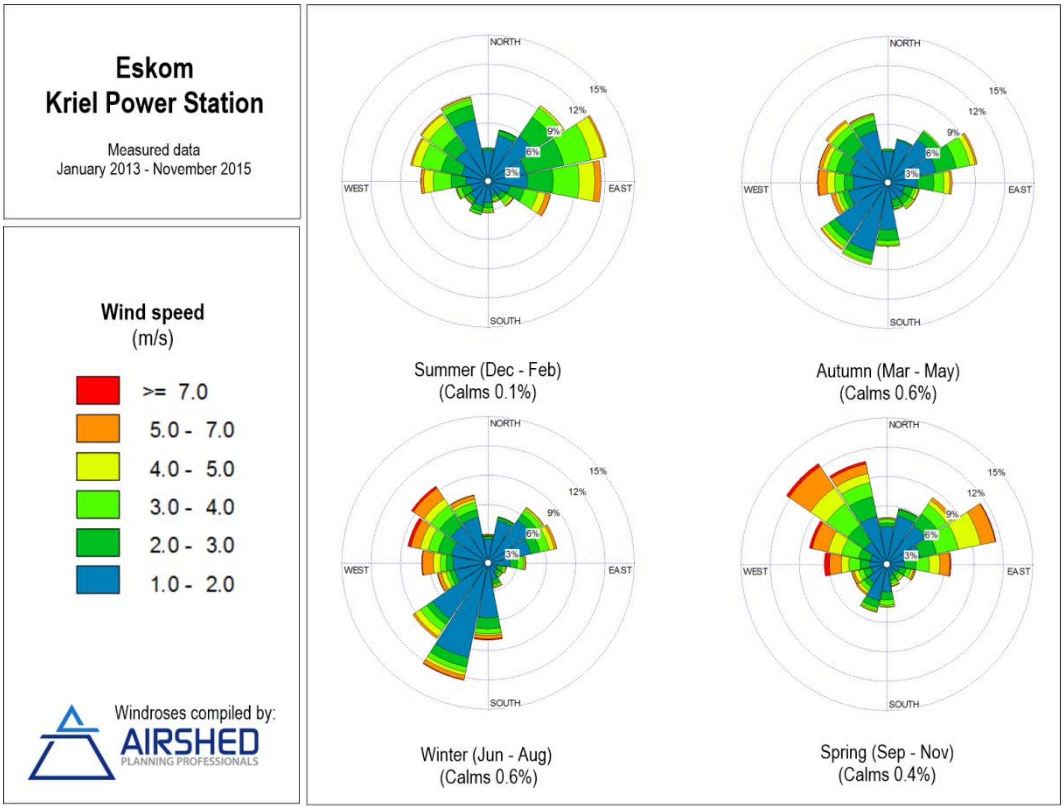

Figure 3-2: Seasonal wind roses (measured data; 2013 to 2015)

3.2.2 Temperature

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher a pollution plume is able to rise), and determining the development of the mixing and inversion layers. The monthly temperature pattern is shown in Figure 3-3. The area experienced warm temperatures above 24°C during summer. Winter temperatures were relatively low especially in the months of June and July. Average daily maximum temperatures range from 27.9°C in February to 18.9°C in July, with daily minima is between -1.0°C in July and 11.0°C in October.

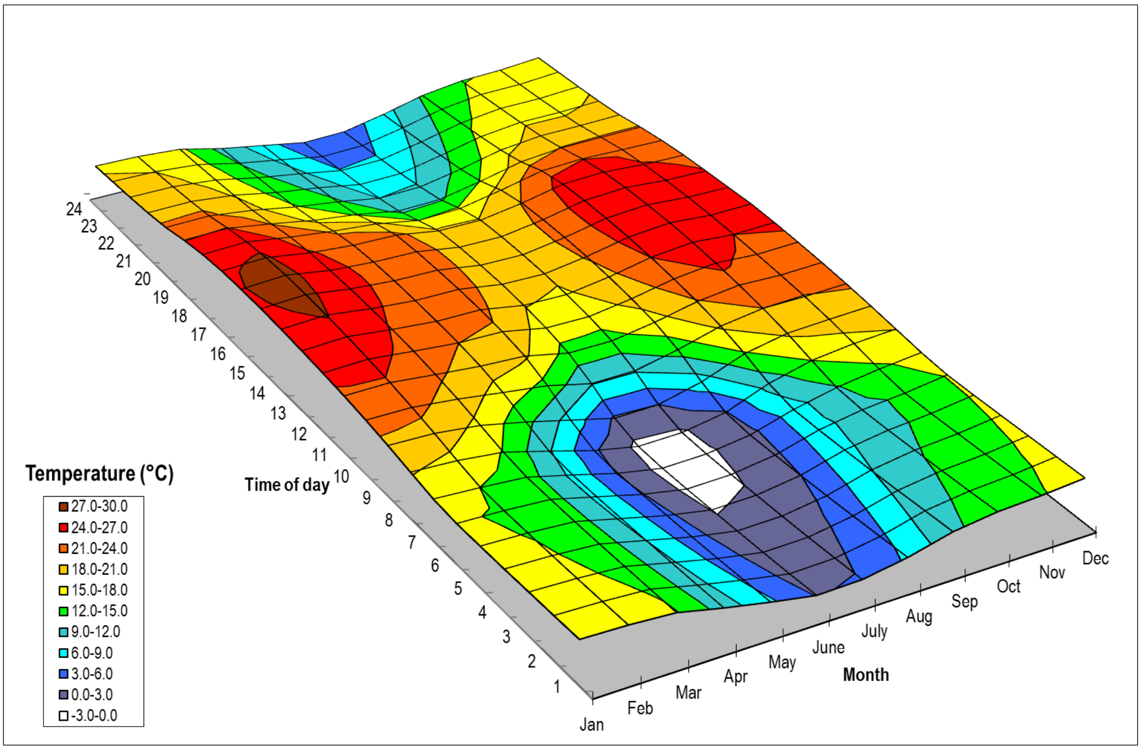

Figure 3-3: Monthly temperature profile (measured data; 2013 to 2015)

3.3 Existing Sources of Emissions near the Kriel Power Station

A comprehensive emissions inventory for the study area was not available for the current assessment and the establishment of such an inventory was not within the scope of the current study. Instead source types present in the area and the pollutants associated with such source types are noted with the aim of identifying pollutants which may be of importance in terms of cumulative impact potentials. The main types of sources include:

- mining activities;
- vehicle tailpipe emissions (from the R545 and R580);
- household fuel combustion (particularly coal and wood used by lower income communities);
- biomass burning (veld fires in agricultural areas within the region); and,
- various miscellaneous fugitive dust sources (i.e. agricultural activities, wind erosion from unvegetated areas, vehicle-entrainment of dust along paved and unpaved roads, etc.).

3.4 Status Quo Ambient Air Quality

Together with the meteorological data made available by Eskom for this assessment, PM_{10} concentrations measured at the Kriel Village ambient monitoring station were also provided for analysis. The period assessed was (as for the meteorological data) from the 8th January 2013 to 30 November 2015. During this period the ambient PM_{10} concentrations recorded at the Kriel Village station were in non-compliance with the NAAQS (maximum allowable number of days exceeding the limit concentration (75 µg/m³) is 4 days per year) (Table 3-2; and Figure 3-4). Annual average concentrations were also in non-compliance with the NAAQS (Table 3-2).

Table 3-2: Summary of PM_{10} concentrations measured at the Kriel Village station (January 2013 to November 2015)

Year	Number of days in dataset	Days exceeding NAAQ limit concentration	Annual average concentration (µg/m³)
2013	358	96	60.4
2014	365	71	60.9
2015	334	37	42.9

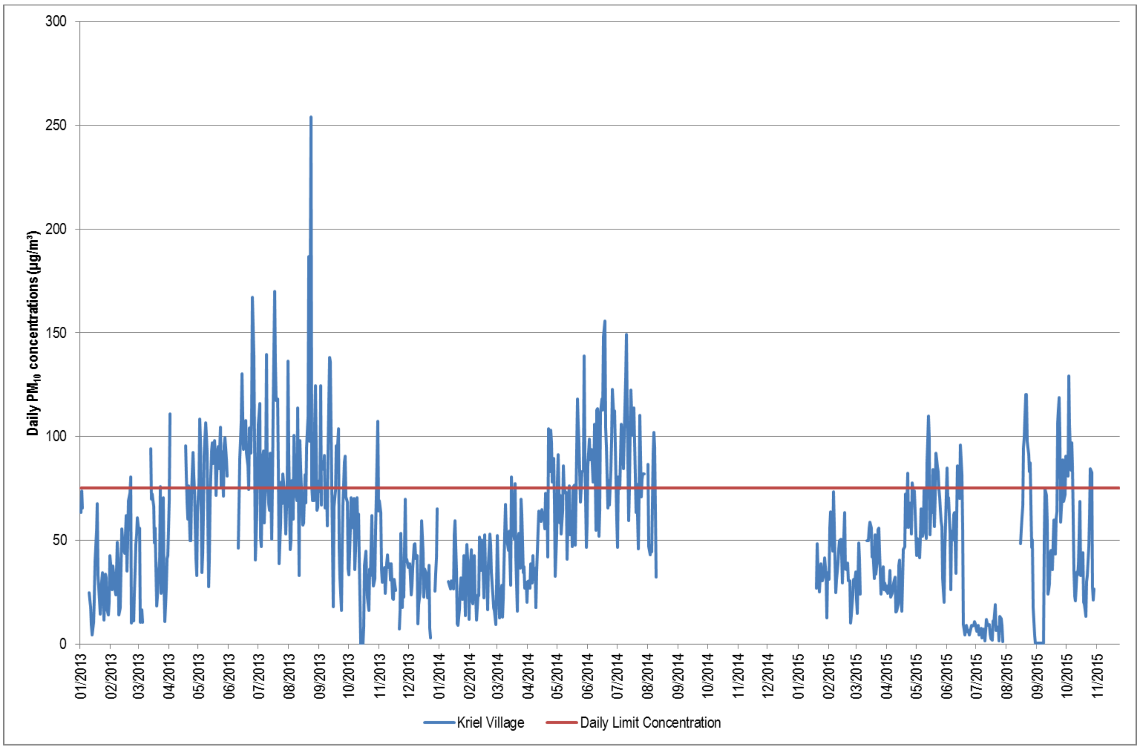

Figure 3-4: Daily average PM_{10} concentrations measured at Kriel Village for the period January 2013 to November 2015

The 'openair' statistical package (Carslaw & Ropkins, 2012; Carslaw, 2014) was used to plot the ambient pollutant concentrations measured at the Kriel Village monitoring station. An analysis of the observed PM_{10} concentrations at the Kriel Village monitoring station involved categorising the concentration values into wind speed and direction bins for different concentrations. Polar plots can provide an indication of the directional contribution as well as the dependence of concentrations on wind speed, by providing a graphical impression of the potential sources of a pollutant at a specific location. The directional display is fairly obvious, i.e. when higher concentrations are shown to occur in a certain sector, e.g. westerly for PM_{10} at Kriel Village (Figure 3-5), it is understood that most of the high concentrations occur when winds blow from that sector. The dotted circular lines indicate the wind-speed with which the concentrations are associated. Therefore, high concentrations (80 µg/m³ or above) originate to the north-westerly sector at wind speeds greater than 4 m/s. Similarly, low wind speeds (<1 m/s) result in an almost equal contribution to PM_{10} concentrations from all wind sectors, with daily average concentrations of approximately 60 µg/m³ (Figure 3-5).

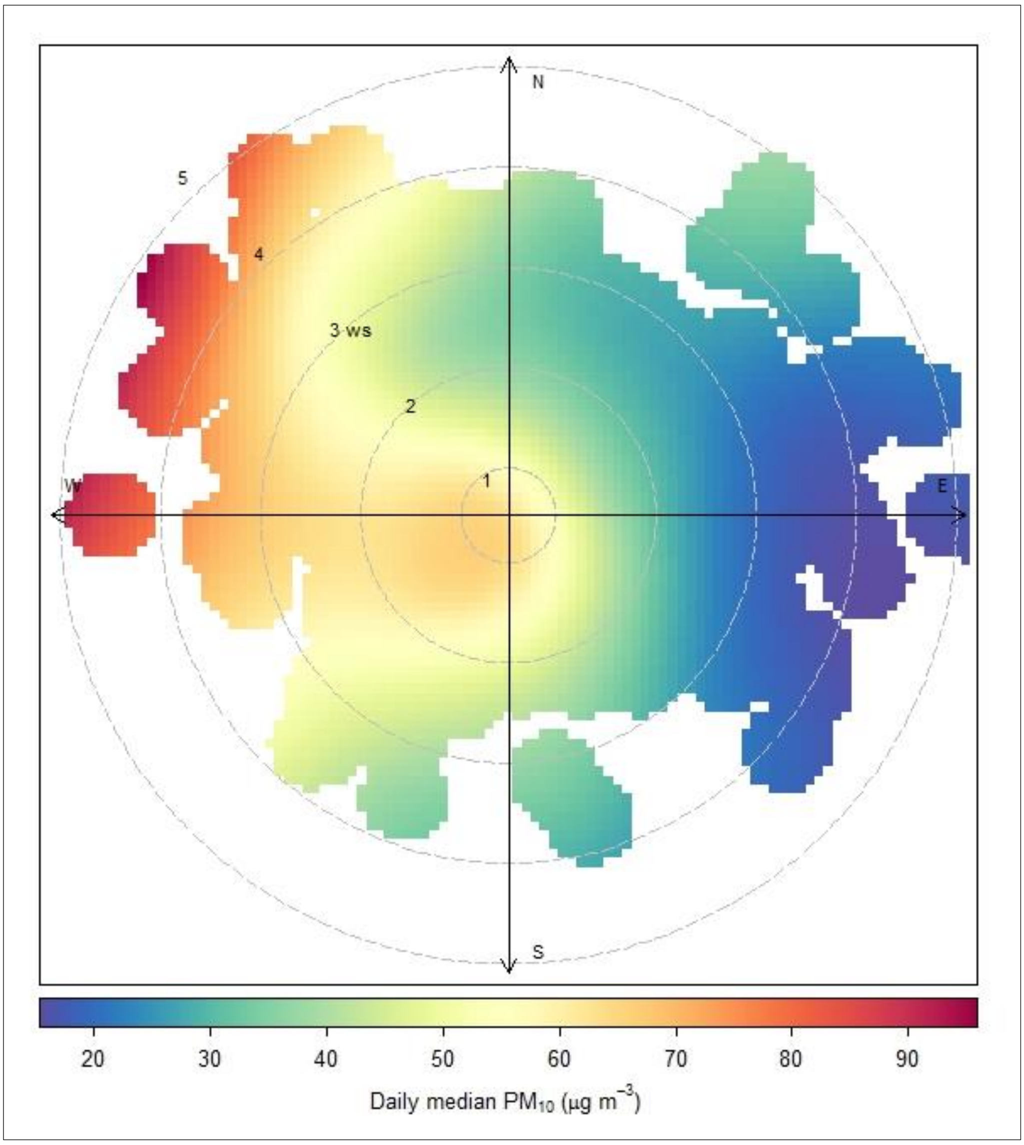

Figure 3-5: Daily median PM_{10} polar plot

A time variation plot (Figure 3-6) provides information regarding any time-based variations in pollutant concentrations. The figures indicate the mean ± the 95% confidence interval. PM_{10} concentrations show a diurnal fluctuation with peaks in the evening, probably associated with domestic fuel combustion for cooking requirements. The increase in PM_{10} concentrations during winter (May to August) is likely to be associated with the use of coal, wood and gas for heating requirements, especially in informal settlements or areas where electrification is less common.

Other potential sources in the vicinity contributing to elevated PM_{10} concentrations include: the Kriel Power Station and ash disposal facility; the Matla Power Station and ash disposal facility; agricultural activities; and mining activities.

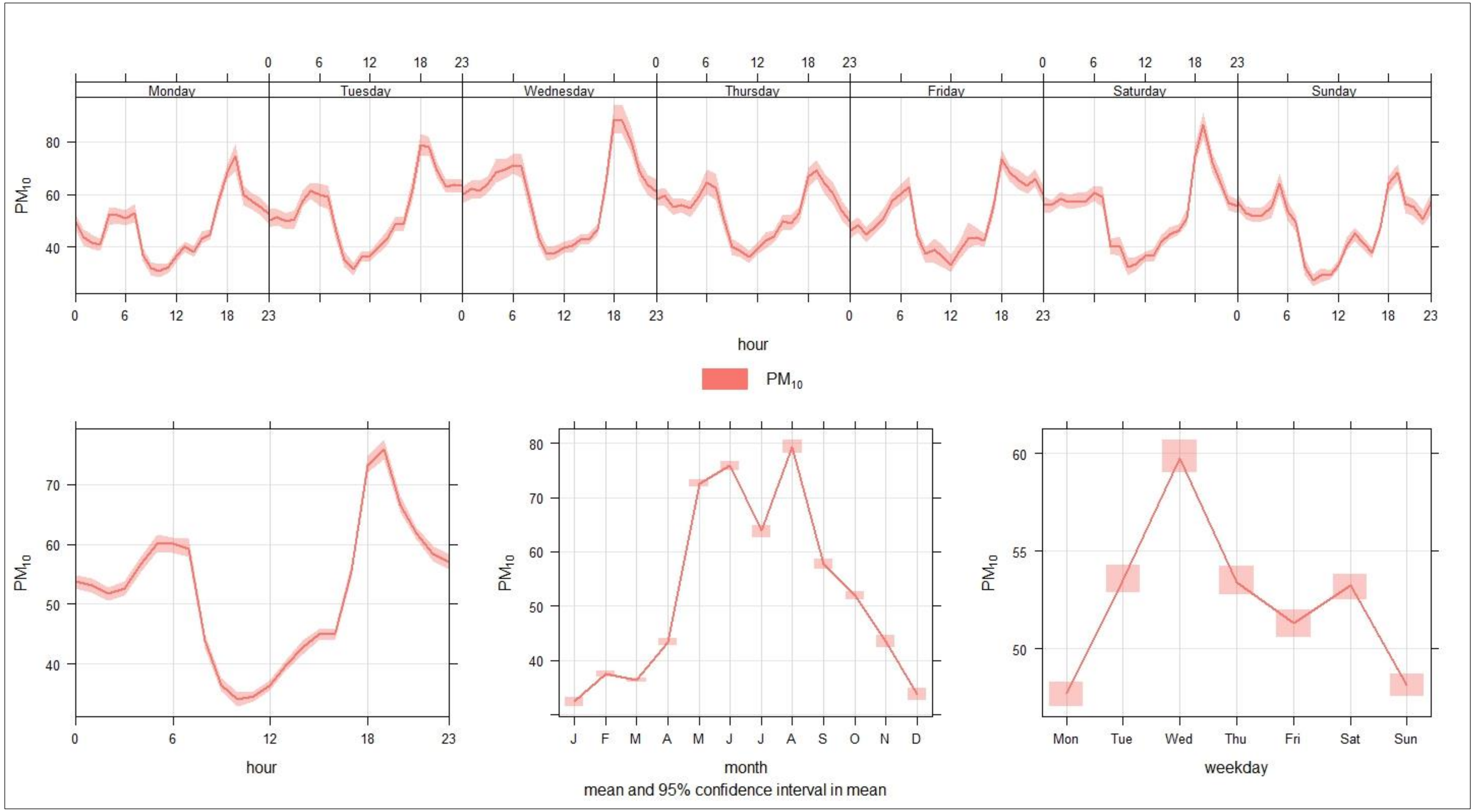

Figure 3-6: Time variation of PM_{10} concentrations at the Kriel Village monitoring station

4 DISPERSION MODELLING ASSESSMENT OF BASELINE AIR QUALITY

4.1.1 Emissions Inventory

The establishment of an emission inventory formed the basis for the assessment of the air quality impacts from Baseline and Future (FFP) operations. Emission sources for both current and future operations included: the boiler unit chimney stacks; and fugitive emissions from the ash disposal facility, and the coal stock pile. Fugitive emissions refer to emissions that are spatially distributed over a wide area and not confined to a specific discharge point as would be the case for process related emissions (IFC, 2007).

4.1.1.1 Boiler Unit Chimney Stacks

Annual particulate emission rates were provided by the client for the year's corresponding to the meteorological data provided; 2013, 2014, and 2015 (Dr K. Langerman, via email, 29th February 2016) (Table 4-1 and Table 4-2). Due to the variability between the three years, simulations were run for each year and the maximum impact at each grid point was plotted. This allows for the conservative assessment of the combination of meteorological conditions and maximum emissions.

Table 4-1: Kriel Power Station chimney stack particulate emissions: baseline operations

Year of operation	Annual PM emissions for both stacks (tpa)	Annual PM emissions per stack (tpa)	Emission rate per stack for dispersion modelling (g/s)[(a)]	
			PM_{10}	$PM_{2.5}$
2013	12 551	6 276	199.0	179.1
2014	8 174	4 087	129.6	116.6
2015	12 155	6 078	192.7	173.4

Note:
(a) All particulate emissions assumed to be PM_{10} or smaller. $PM_{2.5}$ assumed to be 90% of total particulate emissions from the stacks

The parameters required in the dispersion model for the emissions from the Kriel Power Stack chimney stacks were used as presented in the recent Atmospheric Impact Report (AIR) for the Kriel Power Station (uMoya-NILU, 2014).

Table 4-2: Stack parameters of the Kriel Power Station

Parameter	Stack 1	Stack 2	Units
Stack height	213	213	m
Stack diameter	14.3	14.3	m
Exit velocity	17	17	m/s
Exit temperature	130	130	°C

4.1.1.2 Fugitive Particulate Emissions

Emissions may arise due to the mechanical disturbance of granular material from open stockpiles. Parameters which have the potential to impact on the rate of emission of fugitive dust include the moisture content of the material transported, particle size distribution, wind speed and precipitation. Any factor that binds the erodible material, or otherwise reduces the availability of erodible material on the surface, decreases the erosion potential of the fugitive source. High moisture contents, whether due to precipitation or deliberate wetting, promote the aggregation and cementation of fines to the surfaces of larger particles, thus decreasing the potential for dust emissions. The particle size distribution of the material is important since it determines the rate of entrainment of material from the surface, the nature of dispersion of the dust plume, and the rate of deposition, which may be anticipated (Burger, 1994).

The potential emissions due to wind-blown dust from the existing Kriel ash disposal facility and coal stockpile were assessed Figure 1-1. The properties of the ash disposal facility and coal stockpile material and particle size distribution (as obtained from similar processes) is given in Table 4-3 and Table 4-4 respectively. It should be noted that the current ash disposal facility was conservatively considered to have no coverage by re-vegetation or additional dust suppression through watering for dispersion modelling purposes. A detailed description of the emission factors used in the calculation of the wind-blown dust from the ash disposal facility and coal stockpile is provided in Appendix A.

Table 4-3: Ash disposal facility and coal stockpile properties

Sample ID	Bulk Density (t/m³)	Component >2mm (%)	Component <2mm >1mm (%)	Component <1mm (%)
Ash disposal facility	1.01	5	4	90
Coal Stockpile	0.98	32	15	52

Table 4-4: Particle size distribution (given as a percentage) of the ash disposal facility and the coal stockpile

Ash Disposal Facility		Coal Stockpile	
Size (µm)	Percentage (%)	Size (µm)	Percentage (%)
1000	4	1000	15
301	1	879	10
140	18	409	13
103	9	222	12
76	8	104	4
56	7	66	5
48	3	23	3
30	9	11	2
16	12	6	3
10	8	1	1
6	6		
3	6		
2	2		
1	3		

4.1.2 Screening of Simulated Human Health Impacts

The results from the dispersion modelling assessment are included below the criteria pollutants considered in the Baseline scenario in the form of isopleth plots indicating simulated ground-level concentrations compared with the adopted evaluation criteria, for the applicable averaging periods (Table 2-1).

4.1.2.1 Impact on PM_{10}

Exceedances of the PM_{10} NAAQ limit concentration were simulated to comply with the four daily exceedances allowed by the NAAQS (Figure 4-1). The maximum simulated daily PM_{10} concentration across the domain is 242 µg/m³ (NAAQ limit concentration is 75 µg/m³) and the maximum number of days where the 75 µg/m³ limit is exceeded is 3-days per year.

Annual PM_{10} concentrations as a result of baseline operations at the Kriel Power Station were simulated to represent less than 10% of the annual NAAQS (Figure 4-2).

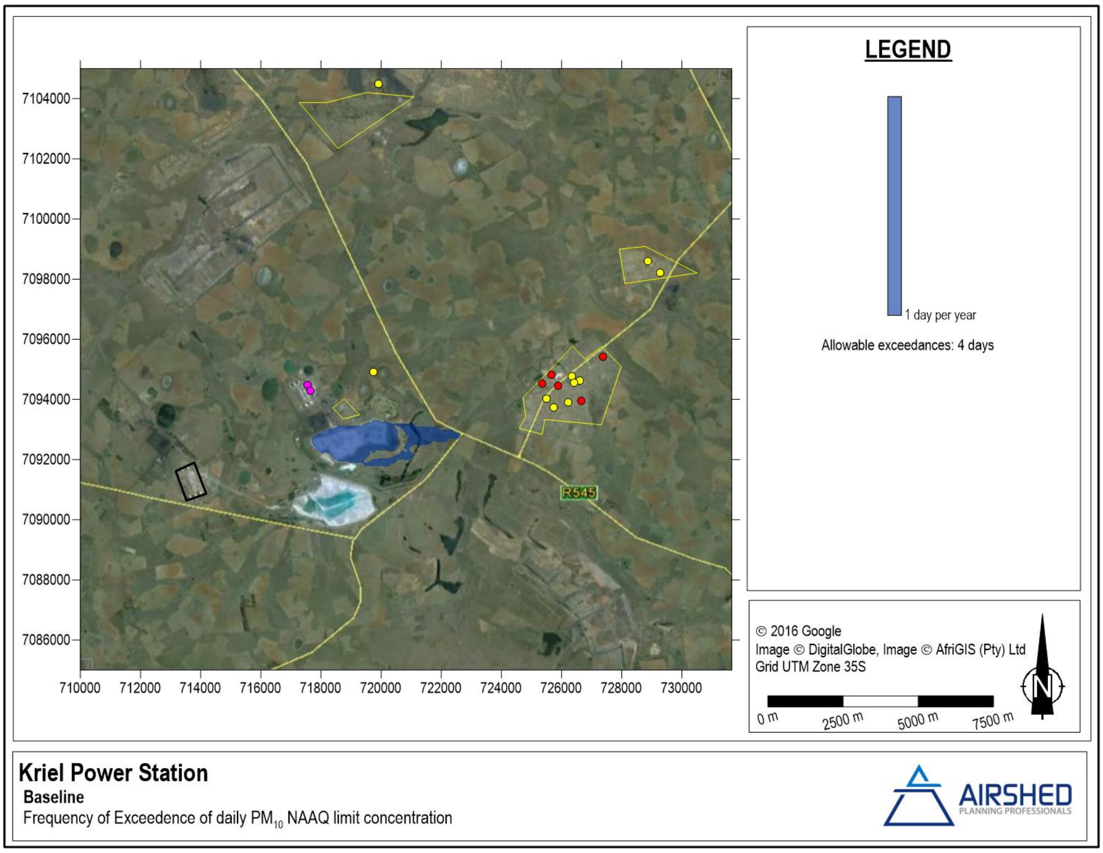

Figure 4-1: Simulated daily PM_{10} concentrations (Baseline)

4.1.2.2 Impact on $PM_{2.5}$

The simulated $PM_{2.5}$ concentrations were compared against the most stringent ambient standards that will be applicable from 1 January 2030 (Table 2-1).

Compliance with the four daily exceedances allowed by the daily $PM_{2.5}$ NAAQS was simulated for baseline operations at the Kriel Power Station (Figure 4-3). The maximum simulated daily $PM_{2.5}$ concentration across the domain is 73 µg/m³ (NAAQ limit concentration is 25 µg/m³) and the maximum number of days where the 25 µg/m³ limit is exceeded is 3-days per year.

Annual $PM_{2.5}$ concentrations as a result of baseline operations at the Kriel Power Station were simulated to represent less than 10% of the annual NAAQS (Figure 4-4).

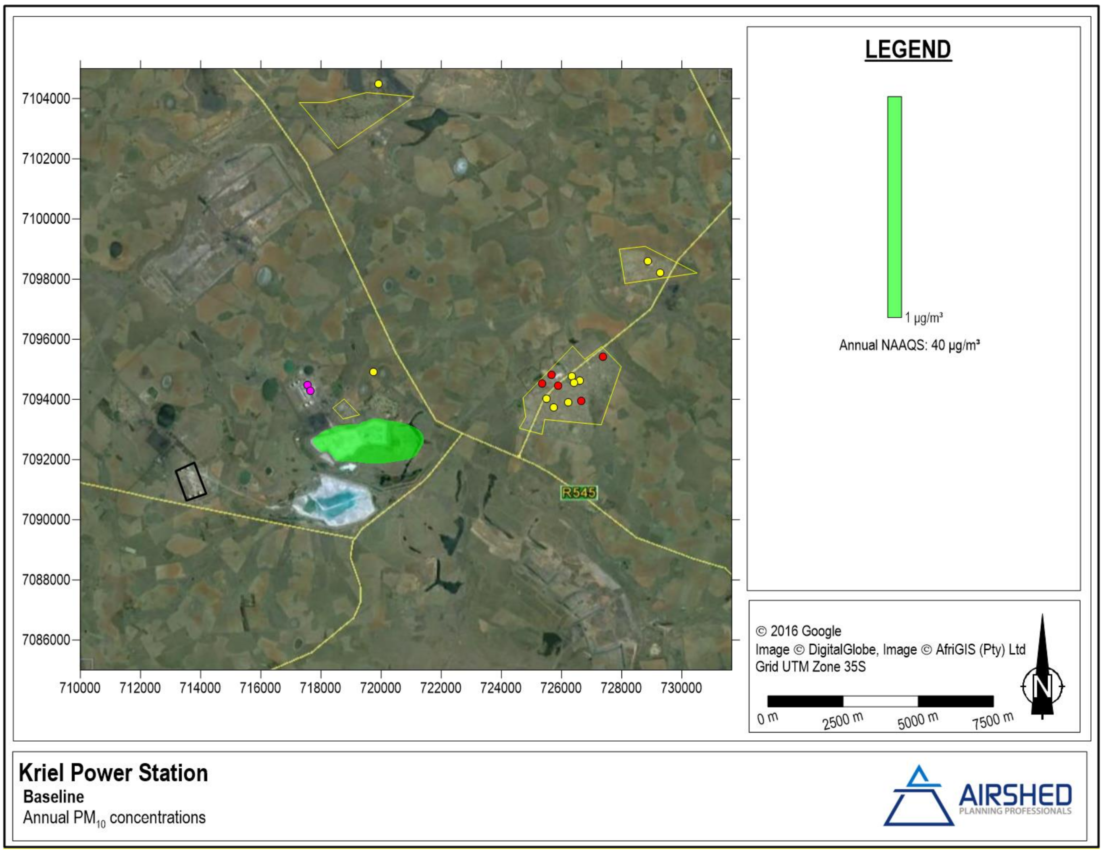

Figure 4-2: Simulated annual PM_{10} concentrations (Baseline) (maximum simulated concentration 2.9 µg/m³)

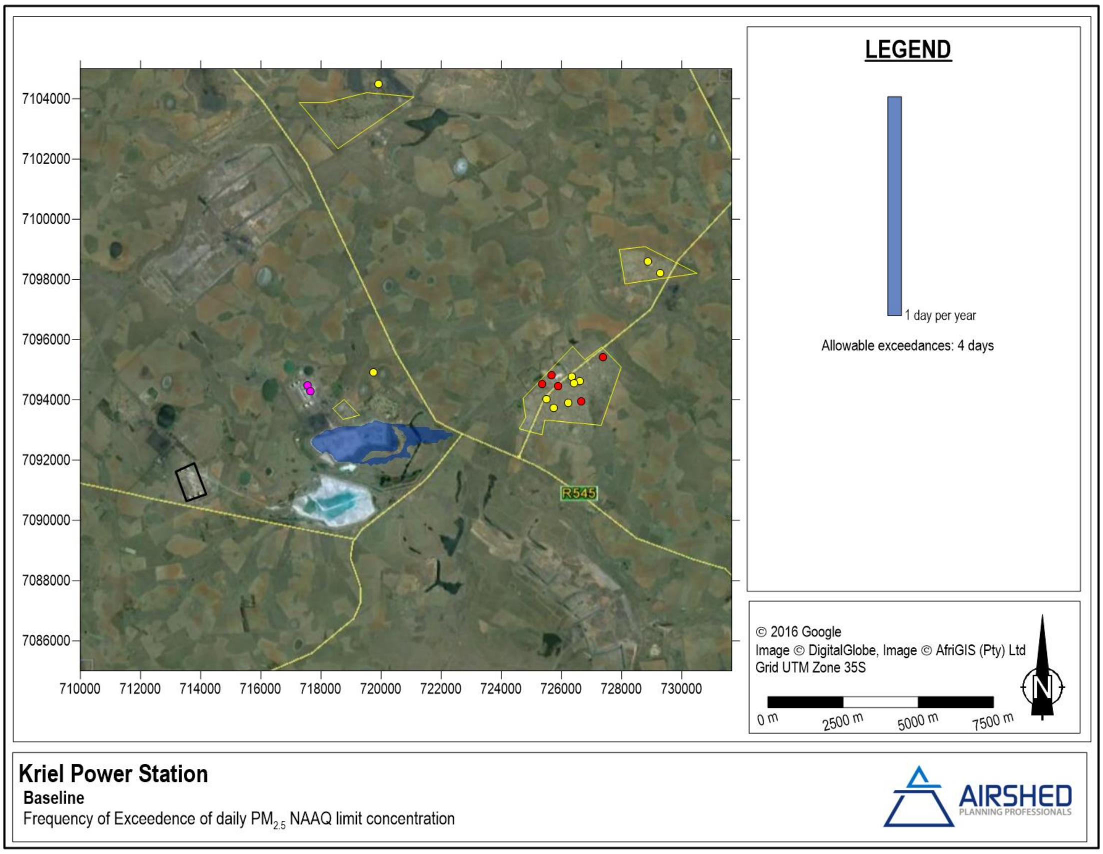

Figure 4-3: Simulated daily $PM_{2.5}$ concentrations (Baseline)

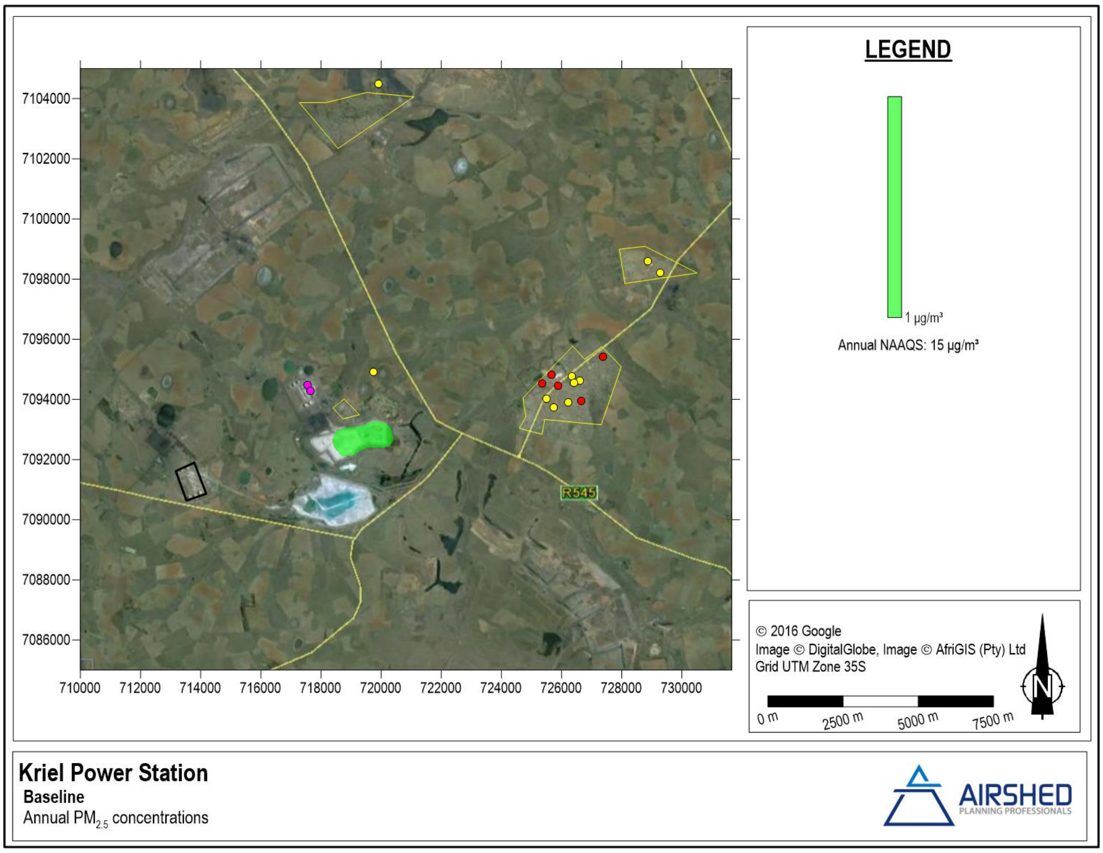

Figure 4-4: Simulated annual $PM_{2.5}$ concentrations (Baseline) (maximum simulated concentration 1.4 µg/m³)

5 IMPACT OF THE FUTURE OPERATIONS ON THE AMBIENT AIR QUALITY

The assessment of future operations at the Kriel Power Station considered the operation of the Power Station with the retrofitted FFP. Emissions were assumed to meet the "new plant" minimum emissions standards (Table 2-2). As for the baseline scenario, the assessment of the impact of the future operations included the wind-blown dust from the coal stockpile and ash disposal facility. The construction phase for the FFPs is considered from a qualitative perspective.

5.1 Construction Phase

The construction of the infrastructure associated with the FFPs is likely to impact the air quality. Construction activities would normally comprise a series of different operations including land clearing, topsoil removal, road grading, material loading and hauling, stockpiling, compaction, etc. Each of these operations will have a distinct duration and potential for particulate generation. It is anticipated that the extent of particulate emissions would vary substantially from day to day depending on the level of activity, the specific operations, and the prevailing meteorological conditions.

It is not anticipated that the various construction activities will result in higher off-site impacts than the operational activities. The temporary nature of the construction activities, and the likelihood that these activities will be localised and for small areas at a time, will reduce the potential for significant off-site impacts. The Environment Protection Authority South Australia recommends a management zone of 300 m from the nearest sensitive receptor when materials handling activities occur (AEPA, 2007).

5.2 Operational Phase

5.2.1 Dispersion Modelling Parameters and Emissions Quantification

5.2.1.1 Boiler Unit Chimney Stacks

Emission rates were calculated assuming that emissions were compliant with the MES applicable after 1 April 2020 (50 mg/Nm³) (Table 5-1). Actual operational emissions are likely to be lower than this maximum release rate, but a conservative approach was adopted for the dispersion modelling exercise. It was indicated that stack parameters – especially those affecting pollutant dispersion – would not be materially affected by the FFP retrofit. This was assumed to be accurate. The limitation of this assumption is that changes in some exit parameters, such as temperature and velocity, may affect the dispersion, and ground-level impact, of the particulate matter and other pollutants.

Table 5-1: Stack parameters and particulate emissions of the Kriel Power Station: future operations

Parameter	Stack 1	Stack 2	Units
Stack height	213	213	m
Stack diameter	14.3	14.3	m
Exit velocity	17	17	m/s
Exit temperature	130	130	°C
PM_{10} emission rate	101.6	101.6	g/s
$PM_{2.5}$ emission rate [(a)]	91.4	91.4	g/s
PM emission concentration (MES)	50	50	mg/Nm³

Note:
(a) $PM_{2.5}$ assumed to be 90% of total particulate emissions from the stacks

5.2.1.2 *Fugitive Particulate Emissions*

Fugitive emissions for the future operations were modelled as for the baseline scenario (Section 4.1.1.2).

5.2.2 Screening of Simulated Human Health Impacts

5.2.2.1 *Impact on PM_{10}*

Exceedances of the PM_{10} NAAQ limit concentration were simulated to comply with the four daily exceedances allowed by the NAAQS (Figure 4-1). The maximum simulated daily PM_{10} concentration across the domain is 242 µg/m³ (NAAQ limit concentration: 75 µg/m³) and the maximum number of days where the 75 µg/m³ limit is exceeded is 3-days per year. Annual PM_{10} concentrations as a result of baseline operations at the Kriel Power Station were simulated to represent less than 5% of the annual NAAQS (Figure 4-2).

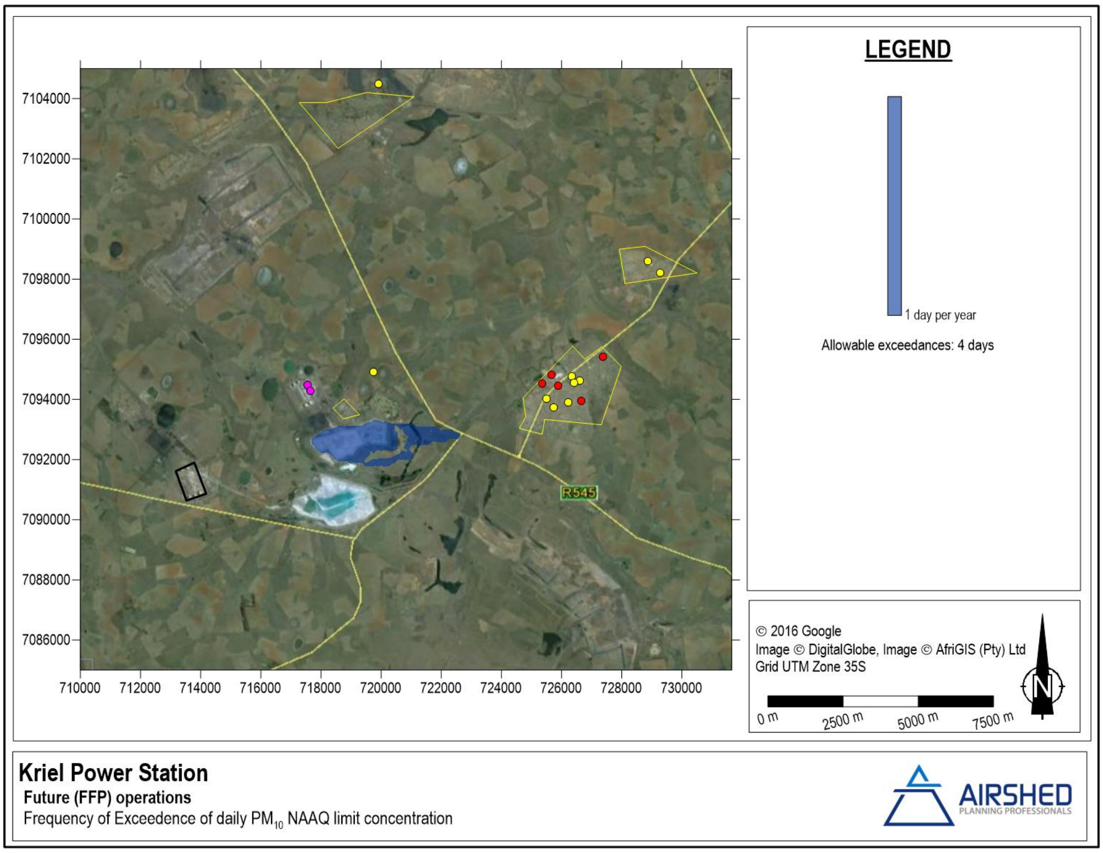

Figure 5-1: Simulated daily PM_{10} concentrations (Baseline)

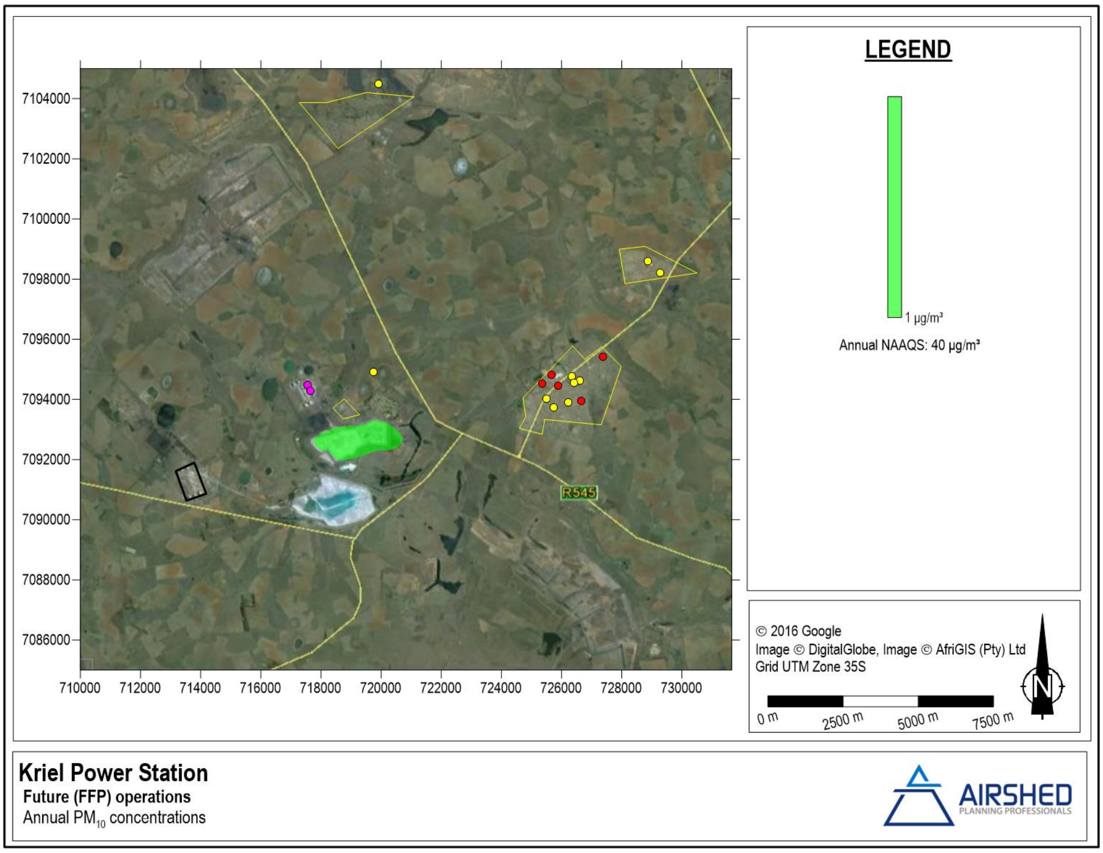

Figure 5-2: Simulated annual PM_{10} concentrations (Baseline) (maximum simulated concentration 2.6 µg/m³)

The comparative impact of the current particulate controls (ESP) and the proposed retrofitted FFP are not easy to discern from the plots for the combined sources included in the dispersion modelling (stack emissions and fugitive particulate sources). In order to compare the impact of the two particulate control technologies, the simulated annual average concentrations for stack emissions only, were plotted on the same figure at a comparative level (0.5 µg/m³) (Figure 5-3). The area impacted at this level shows a distinct advantage of the FFP technology that will reduce the area impacted on an annual basis at the 0.5 µg/m³ by 96% (Table 5-2).

Table 5-2: Comparative impact of the stack emissions only for the baseline and future scenarios

Scenario	Maximum annual concentration simulated in the domain	Area impacted by annual concentrations of 0.5 µg/m³ or higher
Baseline (ESP) scenario	0.90 µg/m³	3 226 ha
Future (FFP) scenario	0.52 µg/m³	127 ha

The low simulated annual concentrations for the Power Station stack emissions only highlight the contribution of the fugitive sources at the Power Station and sources off-site to be background measured values where non-compliance with the ambient standards were recorded for the period assessed.

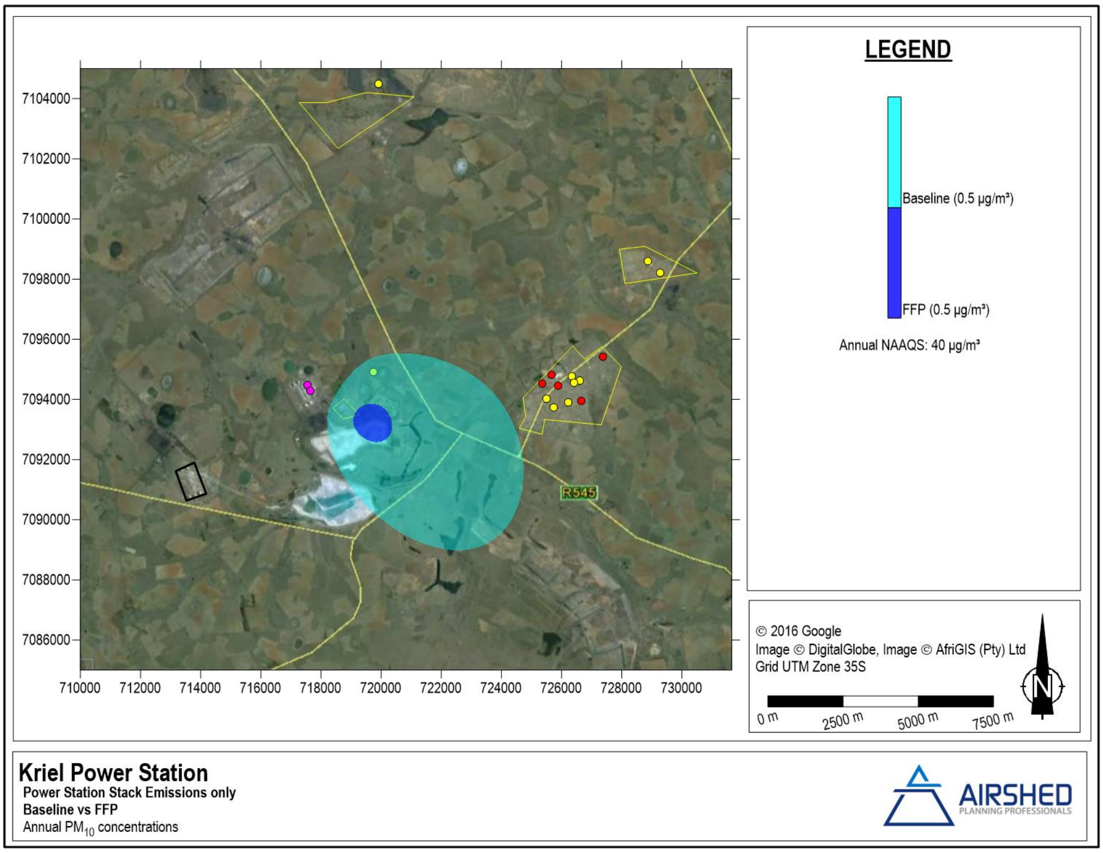

Figure 5-3: Comparison of baseline and future annual PM_{10} concentrations – Stack emissions only (level plotted 0.5 µg/m³)

5.2.2.2 *Impact on $PM_{2.5}$*

The simulated $PM_{2.5}$ concentrations were compared against the most stringent ambient standards that will be applicable from 1 January 2030 (Table 2-1).

Compliance with the four daily exceedances allowed by the daily $PM_{2.5}$ NAAQS was simulated for baseline operations at the Kriel Power Station (Figure 5-4). The maximum simulated daily $PM_{2.5}$ concentration across the domain is 73 µg/m³ (NAAQ limit concentration is 25 µg/m³) and the maximum number of days where the 25 µg/m³ limit is exceeded is 3-days per year.

Annual $PM_{2.5}$ concentrations as a result of baseline operations at the Kriel Power Station were simulated to represent less than 10% of the annual NAAQS (Figure 5-5).

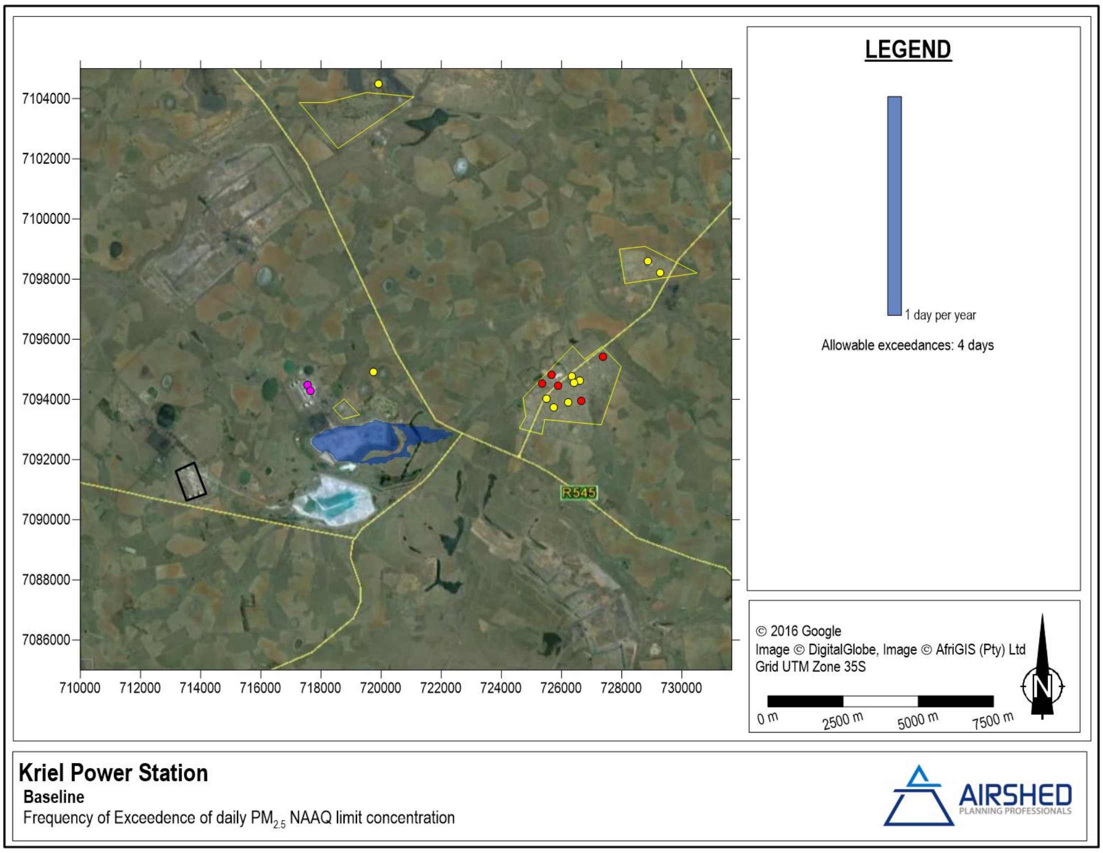

Figure 5-4: Simulated daily $PM_{2.5}$ concentrations (Baseline)

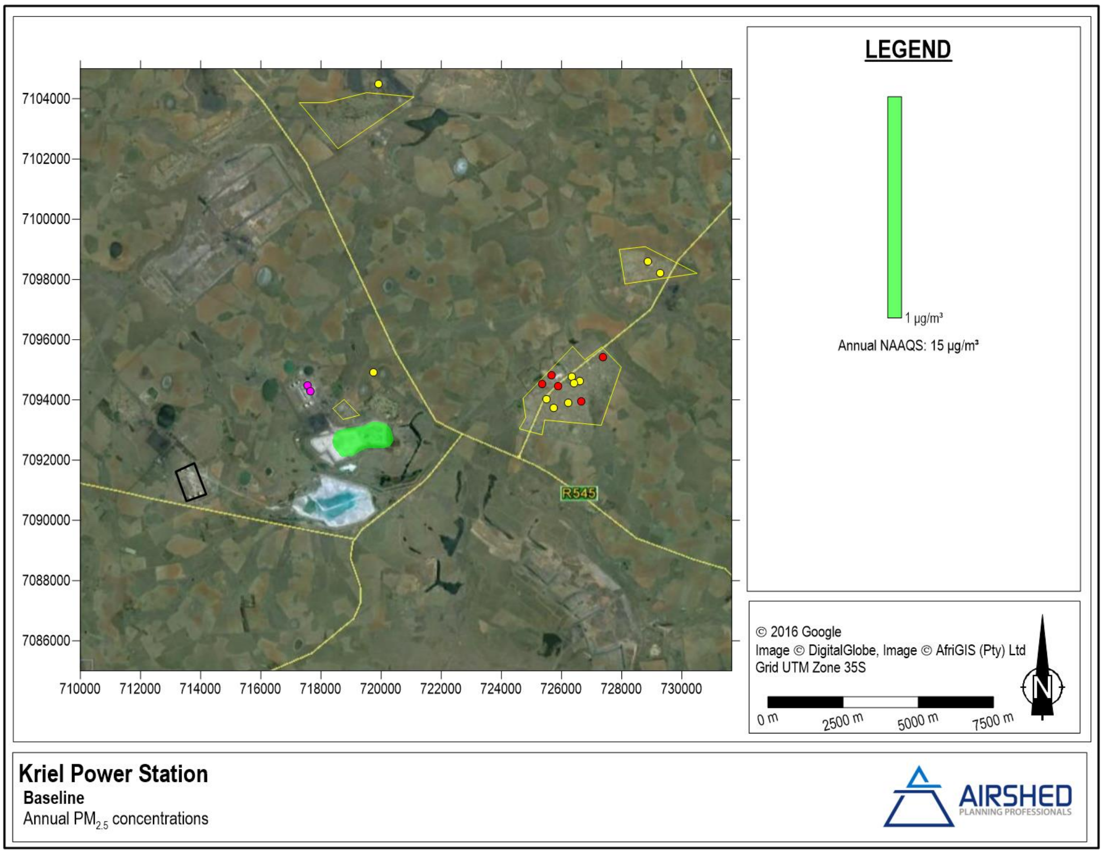

Figure 5-5: Simulated annual $PM_{2.5}$ concentrations (Baseline) (maximum simulated concentration 1.4 µg/m³)

5.3 Decommissioning Phase

During the decommissioning phase of the project all power station operations will have ceased. Emissions are likely to originate from the demolition of structures, wind-blown dust from exposed stockpiles (topsoil, overburden, coal and the ash) and unpaved roads. Generally emissions from this phase are minor, infrequent, and are expected to have minimal impacts on the environment provided proper rehabilitation efforts are put in place early-on during the operational phase.

6 RECOMMENDED AIR QUALITY MANAGEMENT MEASURES

6.1 Proposed FFP Technology

Primary kinds of particulate control used for coal combustion, according to the Air Pollution Engineering Manual (AWMA, 2000), include multiple cyclones, ESPs, fabric filters and venture scrubbers. The type of technology is guided by the type of furnace, coal properties and operating conditions. In the USA, ESPs were the preferred technology for emissions control in the 1970's. Due to significant progress in the recent years in the design and operation of fabric filter collectors, specifically for the collection of coal fly ash, these have become more popular for use in coal-fired power stations (AWMA, 2000).

Whereas ESPs remove particles from the gas stream through electrical forces, fabric filters remove dust by passing the gas stream through porous fabric. The efficacy of dust removal by bag filters is dependent on the design parameters; however, in general bag filters have higher removal efficiency for fine, sub-micrometre particles than ESPs. Bag filter designs are usually either reverse-air or pulse-jet types. The latter removes the particles by sending a pulsed jet of compressed air into the bag, resulting in an effective way of cleaning (AWMA, 2000).

6.1.1 Relation of FFP to World-Wide Best Practice

Best Available Techniques (BAT) according to the Integrated Pollution Prevention and Control (IPPC, 2004) on Large Combustion Plants includes either ESPs or FFPs. It states that particulate emission control of less than 20 mg/Nm³ can be achieved for coal and lignite plants of more than 300 MWth through ESPs and/ or FFPs. The IPPC confirms that FFPs achieve higher control efficiencies on the removal of small particles (i.e. 99.6% on particles <1 µm) than ESPs (i.e. 96.5% on particles <1 µm). Both technology options can achieve 99.95% removal of particles larger than 10 µm (IPPC, 2004).

The World Bank emission limits for Boilers (Solid Fuels Plant >=600 MWth) in degraded areas is 30 mg/Nm³ (IFC, 2008). The South African Minimum Emission Limits are however based on international best practice and applied. The FFP should therefore achieve, as a minimum, 50 mg/Nm³.

6.1.2 Monitoring

The Minimum Emission Standards require continuous stack emissions for Combustion Installations with design capacity of equal to or greater than 50 MW heat input per unit. This is in place at Kriel Power Station and is expected to continue after the in retrofit of the FFPs.

Stack emission parameters, including temperature, flow rate, and exit velocity, will be monitored in order to assess pollutant emission compliance. Variations in these parameters may affect the dispersion and ground-level impact of the particulate matter and other pollutants. It is recommended that these parameters be monitored for deviation from those used in this impact assessment, with the possible need to assess the impact of other pollutants on human health and the environment.

Table 6-1: Recommended source based performance indicators

Source	Emission Monitoring	Quality Assurance
Boilers	_Continuously_ monitor PM_{10}, SO_2 and NO_x emissions by means of online stack monitoring. These continuous measurements will provide a solid foundation for minimum emission standards compliance assessment. A contractor can be used for this purpose.	The emissions monitoring system must be maintained to yield a minimum of 80% valid hourly average values during the reporting period. No more than five half-hourly average values in any day, and ten daily average values per year, may be disregarded due to malfunction or maintenance. Continuous monitoring systems must be audited by a SANAS accredited laboratory at least once every two years.

6.1.2.1 Receptor-based Performance Indicators

An ambient monitoring network can serve to meet various objectives, such as:

- ambient compliance monitoring;
- validation of dispersion model results;
- use as input for health risk assessment;
- assist in source apportionment;
- temporal trend analysis;
- spatial trend analysis;
- source quantification; and,
- tracking progress made by control measures.

PM_{10} ambient monitoring is undertaken by Eskom at the Kriel Village ambient monitoring station, approximately 9 km east of the Kriel Power Station. Although background levels are high at this station, the measured PM_{10} data from this monitoring site is likely to reflect changes in the ambient PM_{10} concentrations before and after the FFP retrofit on all units. It is expected, and recommended, that this monitoring station be maintained after the FFP retrofit.

6.2 Record-keeping, Environmental Reporting and Community Liaison

6.2.1 Compliance Monitoring

Paragraph 15 of Section 21 of the NEM:AQA, No.39 of 2004 (Government Gazette No. 37054) describes the compliance monitoring requirements for listed activities where continuous emissions monitoring is required, such as the Kriel Power Station. The following stipulations are made:

a) the averaging period for the purposes of compliance monitoring shall be expressed on a daily average basis or as prescribed in the AEL;

b) the emission monitoring system must be maintained to yield a minimum of 80% valid hourly average values during the reporting period;

c) the emission monitoring system must be maintained and calibrated as per the original equipment manufacturers' specifications; and,

d) continuous emission monitoring systems must be audited by a SANAS accredited laboratory at least once every two (2) years.

It is understood that continuous emissions monitoring occurs at Kriel Power Station and that, for compliance purposes, it will continue during and after the FFP retrofit.

6.2.2 Reporting Requirements

Reporting requirements for listed activities are described in Paragraph 17 and 18 of Section 21 of the NEM:AQA (Government Gazette No. 37054) where the holder of an AEL should submit annual reports to the Licensing Authority (unless otherwise specified in the AEL). The annual reports for facilities requiring continuous emissions monitoring should include:

(i) Results of the spot measurements or correlation test carried out to verify the accuracy of the continuous emissions measurements;
(ii) The most recent correlation tests; and,
(iii) The availability of the system in terms of the number of full hours per annum that valid results were obtained.

Where exceedances of the MES were recorded by the continuous emissions monitoring systems occurred in the reporting period, an explanation of the circumstances, and the remedial actions and plans aimed to ensure that similar events do not re-occur.

It is understood that the Kriel Power Station complies with the reporting requirements and will continue to do so after the FFP retrofit.

6.2.3 Liaison Strategy for Communication with I&APs

It is recommended that a complaints register be initiated, if not already in use, to record complaints lodged by I&APs. It is also suggested that a collaborative Environmental Management forum be established, including representatives from the mining operations as well as the power stations. This forum would be an appropriate mechanism for communication with I&APs potentially affected by the Power Stations and near-by mining.

7 CONCLUSIONS AND RECOMMENDATIONS

The main findings from the baseline assessment were as follows:

- The main sources likely to contribute to cumulative particulate ground-level concentrations in the vicinity of Kriel Power Station are: Matla Power Station; Matla coal mine; surrounding agricultural activities; biomass burning, domestic fuel burning; other mining activities, especially open cast mining; vehicle entrainment on unpaved road surfaces; and, persistent pollutants from more distant industrial sources.
- The nearest sensitive receptors the Kriel Power Station are the town of Kriel; staff villages at the Kriel and Matla Power Stations; and the surrounding settlements (including farm houses).
- Measured ambient PM_{10} concentrations at the Kriel Village monitoring station were non-compliant with the NAAQS (for daily and annual averaging periods) for the three-years assessed (2013 to 2015).

The main findings from the impact assessment due to current operations and proposed FFP retrofit at all six units were as follows:

- The simulated daily and annual PM_{10} and $PM_{2.5}$ concentrations within the domain (due to current and future power station stack releases, existing ash dam operations and coal stockpile operations only) were within the NAAQS.
- The simulated FFP retrofit to the Kriel Power Station units would reduce the impact of PM_{10} from the stacks (only) by ~96%. Before and after the retrofit the simulated annual PM_{10} concentrations (due to stack emissions only) were predicted to be a maximum of 0.90 µg/m³ and 0.52 µg/m³ respectively.
- The low simulated annual concentrations for the Power Station stack emissions only highlight the contribution of the fugitive sources at the Power Station and sources off-site to be background measured values where non-compliance with the ambient standards were recorded for the period assessed.

7.1 Recommendations

In light of the findings, it is recommended that the FFP retrofit be implemented as an air quality management measure to meet Minimum Emission Standards and to ensure the lowest possible impacts on the surrounding environment.

8 REFERENCES

AEPA. (2007). *Guidelines for Separation Distances.* Environment Protection Authority South Australia.

Burger, L. W. (1994). *Ash Dump Dispersion Modelling, in Held G: Modelling of Blow-Off Dust From Ash Dumps.* Eskom Report TRR/S94/185, Cleveland, 40 pp.

Burger, L., Held, G., & Snow, N. (1995). *Ash Dump Dispersion Modeling Sensitivity Analysis of Meteorological and Ash Dump Parameters.* Cleveland: Eskom Report TRR/S95/077.

Carslaw, D. (2014). *The openair manual - open-source tools for analysing air pollution data. Manual for version 1.0.* King's College London.

Carslaw, D., & Ropkins, K. (2012). openair - an R package for air quality data analysis. *Environmental Modelling and Software, 27-28*, 52 - 61.

Department of Environmental Affairs. (2009, December 24). *Gazette No: 32816*.

Department of Environmental Affairs. (2011, August 5). *Gazette No. 34493*.

Hanna, S. R., Egan, B. A., Purdum, J., & Wagler, J. (1999). *Evaluation of ISC3, AERMOD, and ADMS Dispersion Models with Observations from Five Field Sites.*

HPA. (2011). *The Highveld Priority Area Air Quality Management Plan.* Durban: Report issued by uMoya-NILU Consulting (Pty) Ltd, Report number uMN003-10, on behalf of the Department of Environmental Affairs .

IFC. (2007). *General Environmental, Health and Safety Guidelines.* World Bank Group.

Marticorena, B., & Bergametti, G. (1995). Modelling the Atmospheric Dust Cycle 1 Design of a Soil-Derived Dust Emission Scheme. *Journal of Geophysical Research, 100*, 16415-16430.

Pasquill, F. (1974). *Atmospheric Diffusion: The Dispersion of Windborne Material from Industrial and other Sources.* London: Van Norstand Company Ltd.

Scire, J. S., Strimaitis, D. G., & Yamartino, R. J. (2000). *A User's Guide for the CALPUFF Dispersion Model (Version 5).* Concord, MA: Earth Tech Inc.

uMoya-NILU. (2014). *Atmospheric Impact Report in support of Eskom's application for postponement of the Minimum Emission Standards compliance timeframes for the Kriel Power Station.* Durban: uMoya-NILU (Pty) Ltd., Report No. uMN0046-2014, February 2014.

US-EPA. (1987). *Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD).* Research Triangle Park NC: US-EPA.

US-EPA. (1998). *Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long-Range Transport Impacts.* Research Triangle Park, NC: EPA-454/R-98-019; U.S. Environmental Protection Agency.

9 APPENDIX A – WIND EROSION EMISSION QUANTIFICATION

Wind-blown dust as a source of particulate matter was included due to large exposed areas and generally dry environment, resulting in potential particulate emissions from the exposed areas, including slimes dams, tailings facilities and stockpiles. Significant emissions arise due to the mechanical disturbance of granular material from open areas and storage piles. Parameters which have the potential to impact on the rate of emission of fugitive dust include the extent of surface compaction, moisture content, groundcover, the shape of the area, particle size distribution, wind speed and precipitation. Any factor that binds the erodible material, or otherwise reduces the availability of erodible material on the surface, decreases the erosion potential of the fugitive source. High moisture contents, whether due to precipitation or deliberate wetting, promote the aggregation and cementation of fines to the surfaces of larger particles, thus decreasing the potential for dust emissions. Surface compaction and ground cover similarly reduces the potential for dust generation. The shape of a storage pile or disposal dump influences the potential for dust emissions through the alteration of the airflow field. The particle size distribution of the material on the disposal site is important since it determines the rate of entrainment of material from the surface, the nature of dispersion of the dust plume, and the rate of deposition, which may be anticipated (Burger, Held, & Snow, 1997).

The calculation of emission rates for various wind speeds and stability classes representative of the simulation period was carried out using the ADDAS model. This model is based on the dust emission model by Marticorena and Bergametti (1995). The model attempts to account for the variability in source erodibility through the parameterisation of the erosion threshold (based on the particle size distribution of the source) and the roughness length of the surface. Shao (2008) proposed a three dust-emission mechanism to describe the vertical mass flux (Figure 9-1). With aerodynamic lift, dust particles can be lifted from the surface directly by aerodynamic forces, however as the importance of gravity and aerodynamic forces diminishes for smaller particles and inter-cohesion becomes more important, dust emission arising from this mechanism is small in general. With saltation bombardment, particles strike the surface and cause localised impacts which are strong enough to overcome the binding forces acting upon dust particles leading to dust emissions. This mechanism can be an order of magnitude larger than the aerodynamic entrainment. Disaggregation occurs when particles are released from aggregates in soil typically with high clay content. During a weak wind erosion event, sand particles coated with dusts behave as individuals and dust particles may not be released. During strong wind-erosion events, dustcoats and aggregates may disintegrate resulting in increased dust emissions.

Emission rates for the construction phases were calculated using both the Marticorena and Bergametti and Shao models. In this case the Marticorena and Bergametti model was the most conservative.

Emission rates were calculated based on the Kriel Village meteorological data (between 2013 and 2015) and appropriate particle size distributions (PSD). A conservative moisture content of all materials was used in the calculation to illustrate the worst-case scenario with respect to wind-blown dust. The parameters used to calculate emissions from wind-blown dust are presented in Table 4-3 and Table 4-4.

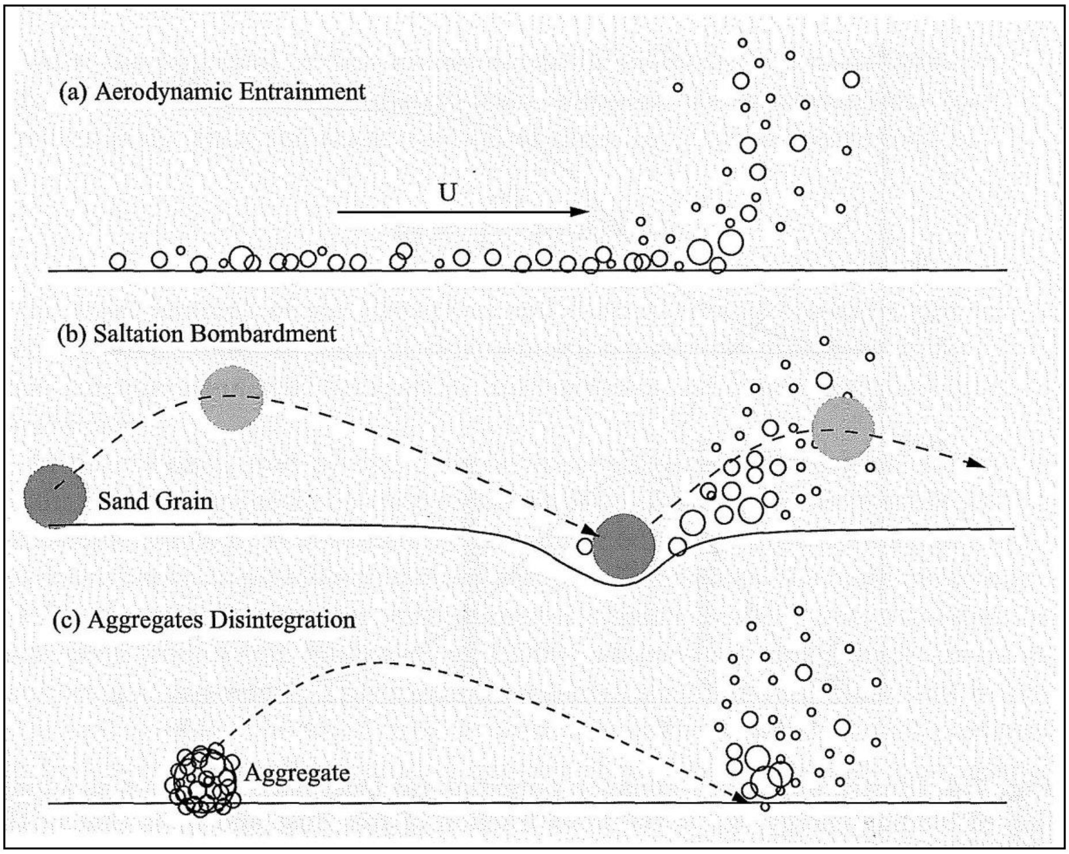

Figure 9-1: Mechanism for dust emission by: (a) aerodynamic lift, (b) saltation bombardment, (c) disaggregation (reproduced from Shao, 2008)