Air Quality Impact Assessment for the Proposed Expansion of the Ash Disposal Facility at the Kriel Power Station

Project done on behalf of **Aurecon South Africa (Pty) Ltd**

Project Compiled by:

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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.
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Revision Record

Revision Number	Date	Reason for Revision
Draft	November 2016	For client review
Rev 0.1	June 2017	To incorporate minor grammatical changes
Rev 0.2	June 2017	To incorporate minor grammatical changes and include project description

EXECUTIVE SUMMARY

Introduction

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Aurecon South Africa (Pty) Ltd. to undertake an air quality impact assessment for the proposed Kriel Power Station ash disposal facility expansion and associated infrastructure (hereafter referred to as the proposed project).

The aim of the investigation is to quantify the possible impacts resulting from the proposed project activities on the surrounding environment and human health. To achieve this, a good understanding of the local dispersion potential of the site is necessary and subsequently an understanding of existing sources of air pollution in the region and the resulting air quality.

Study Approach and Methodology

The investigation followed the methodology required for a specialist report as prescribed in the Environmental Impact Assessment EIA Regulations (Government Notice R.543 in Government Gazette 33306 of 18 June 2010 and amendments provided in Government Notice R.326 in Government Gazette 40772 of 7 April 2017).

Baseline Assessment

The baseline study encompassed the analysis of meteorological data. Local meteorological data (including wind speed, wind direction and temperature) was obtained from the Eskom operated monitoring station at Kriel for the period 2013 to 2015.

Impact Assessment Criteria

Particulates represent the main pollutants of concern in the assessment of operations from the proposed project. Particulate matter is classified as a criteria pollutant, with ambient air quality guidelines and standards having been established by various countries to regulate ambient concentrations of these pollutants. For the current study, the impacts were assessed against published National Ambient Air Quality Standards (NAAQS) and Dust Control Regulations (NDCR).

Emissions Inventory

Emissions inventories provide the source input required for the simulation of ambient air concentrations. Fugitive source emissions from materials handling and wind erosion from tailings facilities were quantified.

Impact Prediction Study

Particulate concentrations and dustfall rates due to the proposed operations were simulated using the United States Environmental Protection Agency (US-EPA) approved AERMET/AERMOD dispersion modelling suite. Ambient concentrations were simulated to ascertain highest hourly, daily and annual averaging levels occurring as a result of the proposed project operations.

Assumptions, Exclusions and Limitations

The main assumptions, exclusions and limitations consisted of the following:

- The quantification of sources of emission was restricted to the proposed project activities only.
- The construction and closure phases were assessed qualitatively due to the temporary nature of these operations, whilst the operational phase was assessed quantitatively.
- The impact assessment was limited to airborne particulates (including total suspended particulates (TSP), particulate matter of less than 10 µm in diameter (PM_{10}) and particulate matter of less than 2.5 µm in diameter ($PM_{2.5}$)).

Findings

The main findings from the baseline assessment were as follows:

- The main sources likely to contribute to cumulative particulate ground-level concentrations near 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 to the proposed ash facility extension is Kriel (~4 km east).

- 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 proposed project operations were as follows:

- The highest $PM_{2.5}$ and PM_{10} concentrations due to proposed project operations were in compliance with NAAQS at the closest sensitive receptors. The highest daily dust depositions due to proposed operations were below the NDCR of 600 mg/m²/day for residential areas at all sensitive receptors within the study area.

Recommendations

The following recommendations are made:

- It is recommended that a dust fallout monitoring network be implemented at the proposed project site as recommended in Section 5 to monitor the impacts from the proposed project activities.

- Due to the elevated baseline, ambient air quality levels for particulate matter, it is recommended that mitigation measures on the main sources of fugitive dust (as recommended in Section 4.2.2) be implemented to minimise impacts as far as possible.

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LIST OF ACRONYMS AND SYMBOLS

APCS	Air pollution control systems
AQA	Air Quality Act
°C	Degrees Celsius
CO	Carbon monoxide
CO_2	Carbon dioxide
CEPA	Canadian Environmental Protection Agency
DEA	Department of Environmental Affairs
EIA	Environmental Impact Assessment
km	Kilometre
LMo	Monin-Obukhov length
m^3	Cubic metre
m^2	Square metre
NAAQS	National Ambient Air Quality Standards
NDCR	National Dust Control Regulations
NO_2	Nitrogen dioxide
O_3	Ozone
Pb	Lead
PM	Particulate matter
PM_{10}	Particulate Matter with an aerodynamic diameter of less than 10μm
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter of less than 2.5μm
SAAQIS	South African Air Quality Information System
SABS	South African Bureau of Standards
SANS	South African National Standards
SO_2	Sulfur Dioxide
TSP	Total Suspended Particles
US-EPA	United States Environmental Protection Agency

Content of Specialist Report as per Appendix six of the NEMA EIA Regulations of 2014

(1) A specialist report prepared in terms of these Regulations must contain	Section
(a) details of- (i) the specialist who prepared the report; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	1.4 and Appendix A
(b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	1.4
(c) an indication of the scope of, and the purpose for which, the report was prepared;	1.2 and 1.3
(d) the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	NA
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process;	1.5
(f) the specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;	3.2
(g) an identification of any areas to be avoided, including buffers;	NA
(h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	3.2
(i) a description of any assumptions made and any uncertainties or gaps in knowledge;	1.6
(j) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment;	4
(k) any mitigation measures for inclusion in the EMPr;	4.3.2
(l) any conditions for inclusion in the environmental authorisation;	7.2
(m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	6
(n) a reasoned opinion- (i) as to whether the proposed activity or portions thereof should be authorised; and (ii) if the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	7.2
(o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	NA
(p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	NA
(q) any other information requested by the competent authority.	NA

Air Quality Impact Assessment for the Proposed Expansion of the Ash Disposal Facility at the Kriel Power Station

1 INTRODUCTION

1.1 Project Description

The construction of Kriel Power Station (owned by Eskom Holdings SOC Limited, Eskom) was completed in 1979 and was considered to be the largest coal-fired power station in the southern hemisphere at the time (**Figure 1-1**). The 38 year old power station, with an installed capacity of 3 000 MW, is located approximately 7 km west of the small town of Kriel (also known as Ga-nala) in the Mpumalanga Province. Through the process of electricity generation, coarse and fine ash is produced by burning coal. At full capacity, each of the six boilers can produce up to 740 000 tonnes/year of coarse ash/ boiler bottom ash (approximately 20% of total ash produced) and 2 960 000 tonnes/year of fly ash/ precipitator fly ash (approximately 80% of total ash produced).

Figure 1-1: Location of the Kriel Power Station and current ash dam complex

Kriel Power Station makes use of a wet ashing process to dispose of its ash. Coarse ash is transferred with a small volume of fine ash (fly ash, to limit pipeline wear) from the Power Station to sumps, from where it is pumped as a slurry mixture to the Wet Ash Disposal Facilities (WADF) (ash dams). The fine ash is transported separately to the existing ash dam complex, via two conveyors that are located south-east of Kriel Power Station. As mentioned above, Kriel uses wet ashing system, which involves conditioning fly ash and coarse ash with water for pneumatic transportation to the ash dams through conveyor belts and ash lines, respectively.

Upon reaching the ash dams, conditioning water, from ash, sluices into the designed lowest point of ash dam wherein it gets drained through penstocks. All the water collected from Kriel ash dams through the penstocks is stored in Ash Water Return (AWR) dams. From the AWR dams the ash water gravitates to a manifold and is then pumped back to a High Level AWR dam. From the High Level AWR dam the water gravitates to the pollution control dams known as the Borrow Pits and Swartpan. The Borrow Pits contain mainly excess ash water from High Level AWR dam while Swartpan contains mainly excess overflow ash water from the Borrow Pits. Both Swartpan and the Borrow Pits dams are part of ash water cycle and are used as emergency containment dams. This water is then pumped from Swartpan for re-use by the Power Station for ashing purposes.

The three existing ash dams will reach their capacity by end July 2021. Eskom is, thus, proposing to expand its existing ash disposal facility by constructing and commission an additional ash disposal facility footprint before the existing ash dams reach their capacity in 2021.

The complete proposed expansion with new ash dams (AD4.1, AD4.2 and AD4.3) (**Figure 1-2**) would fulfil the ash disposal requirements for the Power Station's extended -operational life, whereby decommissioning of the six generating units is planned to commence in 2039. AD4.3 is however located on a previously mined and backfilled area, which needs to be tested first for stability. The expansion project is, therefore, divided into two phases, namely Phase 1, which covers construction of AD4.1 and AD4.2 (the subject of this application) (**Figure 1-3**) and Phase 2 which covers AD4.3. A Monitored Test Embarkment is underway for AD4.3 and therefore this EIA only deals with Phase 1. Once the stability of AD4.3 has been confirmed, depending on the results, an additional EIA may be undertaken for AD4.3. To smoothen the decommissioning process, a five year contingency has been allowed for, thus it is assumed that the Power Station will be operated for an additional five years, thereby allowing for the power station decommissioning from 2041 to 2045.

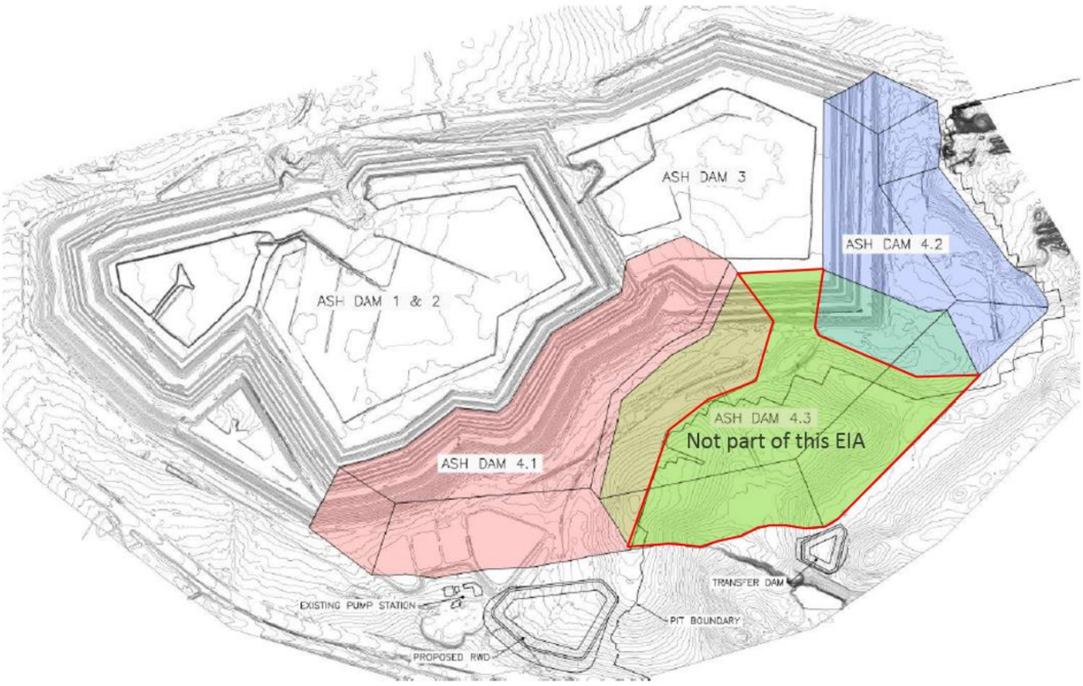

Figure 1-2: Ash Dam 4 Concept (Source: JW044/16/E821)

Figure 1-3: Phase 1, construction of AD4.1 and AD4.2 (the subject of this application)

The development of ash dam 4 will be sequenced to distribute large immediate capital expenditure cost. Dam 4.2 will be developed first in 2021 and will utilize a ring main system to distribute ash within the ash dam basin. Water generated on the dam will be decanted into solution trenches, running along the toe of the new dams, utilizing penstocks and subsoil drains. Ash water from Dam 4.2 will be gravitated to a transfer dam from where it will be pumped to the AWR dam.

Deposition was split between the existing and new dams in order to reduce the height of the preliminary starter walls, as well as the final height of the new dams. It was assumed that deposition on the existing dams will continue for 4 years after the commissioning of the first phase of AD4 (i.e. until the final phase of AD4 is commissioned). Once AD4.1, AD4.2 and AD4.3 are operational, the existing dams will be decommissioned, and rehabilitated. A period of two (2) years was allowed for between the construction phases of AD4 in order to defer large immediate capital costs. Thus, after AD4.2 is commissioned in July 2021, AD4.1 will be commissioned in July 2023, and subsequently AD4.3 in July 2025.

From the AWR dam, ash water will be pumped back to the power station and ash dam pump-house to be reused in the placement of ash from the power station.

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Aurecon South Africa (Pty) Ltd to undertake an air quality impact assessment for the proposed Kriel Power Station ash disposal facility expansion and associated infrastructure (hereafter referred to as the proposed project).

Typical of specialist investigations conducted, the air quality investigation comprises both a baseline study and an impact assessment. The baseline study includes the review of site-specific atmospheric dispersion potentials, and existing ambient air quality in the region, in addition to the identification of potentially sensitive receptors.

Particulates represent the main pollutant of concern in the assessment of activities from the proposed project. Particulate matter is classified as criteria pollutant, with ambient air quality guidelines and standards having been established by various countries to regulate ambient concentrations of this pollutant. Particulates in the atmosphere may contribute to visibility reduction, pose a threat to human health, or simply be a nuisance due to their soiling potential.

1.2 Terms of Reference/Scope of Work

The terms of reference for the assessment are as follows:

1. Baseline
    - Identification of existing air pollution sources;
    - Identification of air quality-sensitive receptors, including any nearby residential dwellings in the vicinity of the Project;
    - Collection of local weather conditions either from local weather station sources or by modelled data;
    - Preparation of three years of raw meteorological data. The required meteorological data includes hourly average wind speed, wind direction and temperature data.
    - Simulation of wind field, mixing depth and atmospheric stability.
    - The legislative and regulatory context, including ambient air quality standards.
    - Assessment of baseline air pollutant measurements (from available information).

2. Impact Assessment

- Quantification of all sources of atmospheric emissions associated with the project.
- Formatting of meteorological data for input to the dispersion.
- Obtain and process topographical data for input into the dispersion model (if required).
- Dispersion simulations of ground level pollutants, due to routine emissions from the project, reflecting highest daily and annual average concentrations. The United States Environmental Protection Agency (US EPA) approved AERMOD model to be used.
- Analysis of dispersion modelling results.
- Evaluation of potential for human health and environmental impacts.

1.3 Deliverables

At the core of the study is the provision of a mathematical tool (i.e. the dispersion model) that credibly describes the fluxes and dispersion of air emissions from the project through the incorporation of meteorological and emission configuration complexities.

The final deliverables are particulate air concentration and total dust deposition predictions provided as isopleths superimposed on base maps of the study area.

1.4 Specialist Details

1.4.1 Statement of Independence

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.

1.4.2 Competency Profiles

1.4.2.1 RG von Gruenewaldt (MSc (Meteorology), BSc, Pr. Sci Nat.)

Reneé von Gruenewaldt is a Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP) and a member of the National Association for Clean Air (NACA).

Following the completion of her bachelor's degree in atmospheric sciences in 2000 and honours degree (with distinction) with specialisation in Environmental Analysis and Management in 2001 at the University of Pretoria, her experience in air pollution started when she joined Environmental Management Services (now Airshed Planning Professionals) in 2002. Reneé von Gruenewaldt later completed her Master's Degree (with distinction) in Meteorology at the University of Pretoria in 2009.

Reneé von Gruenewaldt became partner of Airshed Planning Professionals in September 2006. Airshed Planning Professionals is a technical and scientific consultancy providing scientific, engineering and strategic air pollution impact assessment and management services and policy support to assist clients in addressing a wide variety of air pollution related risks and air quality management challenges.

She has extensive experience on the various components of air quality management including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. Reneé has been the principal air quality specialist and manager on several Air Quality Impact Assessment projects between 2006 to present and her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality.

A comprehensive curriculum vitae of Reneé von Gruenewaldt is provided in Appendix A.

The declaration of independence for Reneé von Gruenewaldt is provided in Appendix B.

1.5 Approach and Methodology

The methodology followed in the assessment to quantify the air quality impacts associated with the proposed project is discussed below. The general tasks included:

- The establishment of the baseline air quality (based on available information);
- Quantification of air emissions from the proposed project;
- Discussion of meteorological parameters required to establish the atmospheric dispersion potential;
- Calculation of the air concentrations and dust fallout using a suitable atmospheric dispersion model;

- Assessment of the significance of the impact through the comparison of simulated air concentrations (and fallout rates) with local standards (for compliance);
- Recommendations for mitigation and monitoring.

1.5.1 Potential Air Emissions from the Proposed Project

The air pollution associated with the proposed project activities includes the air emissions emitted during construction, operation and closure. During operational phase air emissions include wind erosion from the ash facility.

1.5.2 Regulatory Requirements and Assessment Criteria

In the evaluation of air emissions and ambient air quality impacts reference is made to National Ambient Air Quality Standards (NAAQS). These standards generally apply only to a number of common air pollutants, collectively known as criteria pollutants. Criteria pollutants typically include sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), inhalable particulate matter (including thoracic particulate matter with an aerodynamic diameter of equal to or less than 10 µm or PM_{10} and Inhalable particulate matter with an aerodynamic diameter equal to or less than 2.5 µm or $PM_{2.5}$), benzene, ozone and lead.

Particulates represent the main pollutants of concern in the assessment of operations from the proposed project. For the current assessment, the impacts were assessed against published National Ambient Air Quality Standards (NAAQS) and National Dust Control Regulations (NDCR).

1.5.3 Description of the Baseline Environment

An understanding of the atmospheric dispersion potential of the area is essential to an air quality impact assessment. For this assessment use was made of near-site surface meteorological data (including wind speed, wind direction and temperature) recorded at the Eskom-operated Kriel Village ambient air quality monitoring station which was used to generate AERMOD-ready meteorological files. The period of the meteorological data was January 2013 to November 2015.

1.5.4 Atmospheric Dispersion Modelling

In the calculation of ambient air pollutant concentrations and dustfall rates use was made of the US EPA AERMOD atmospheric dispersion modelling suite. AERMOD is a Gaussian plume model best used for near-field applications where the steady-state meteorology assumption is most likely to apply. AERMOD is a model developed with the support of the AMS/EPA Regulatory Model Improvement Committee (AERMIC), whose objective has been to include state-of the-art science in regulatory models (Hanna, Egan, Purdum, & Wagler, 1999). 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).

The dispersion of pollutants was modelled with a coarse grid for an area covering 30 km (north-south) by 30 km (east-west). These areas were divided into a grid with a resolution of 250 m (north-south) by 250 m (east-west). A finer grid of 99m resolution covering the operations was also run for an area covering 14.85 km (north-south) by 10.89 km (east-west). AERMOD simulates ground-level concentrations for each of the receptor grid points.

1.5.5 Management and Mitigation

The findings of the above components informed recommendations of air quality management measures, including mitigation and monitoring.

1.6 Limitations, Exclusions and Assumptions

The main assumptions, exclusions and limitations are summarised below:

- **Meteorological data:** a minimum of 1 year, and typically 3 to 5 years of meteorological data are generally recommended for use in atmospheric dispersion modelling for air quality impact assessment purposes. 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% (sufficient for dispersion modelling purposes).
- **Emissions:**
  - The quantification of sources of emission was restricted to the proposed Kriel Power Station ash facility extension only (with the inclusion of existing Kriel ash facilitys and the Kriel Power Station). Although other background sources were identified, such sources were not quantified.
  - Information required for the calculation of emissions from fugitive dust sources for the proposed project operations were provided. The assumption was made that this information was accurate and correct.
- **Impact assessment:**
  - The construction and closure phases were assessed qualitatively due to the temporary nature of these operations, whilst the operational phase was assessed quantitatively.
  - The impact assessment was limited to airborne particulates (including total suspended particulates (TSP), particulate matter of less than 10 µm in diameter (PM_{10}) and particulate matter of less than 2.5 µm in diameter ($PM_{2.5}$)). Although ash facilitys also contain trace elements, the quantities of these elements are expected to be low and were not included in the assessment.
  - Proposed operations were assumed to be twenty-four hours over a 365 day year as a conservative approach.

1.7 Outline of Report

Assessment criteria applicable to the proposed project are presented in Section 2. The study area, atmospheric dispersion potential and the existing air quality for the area are discussed in Section 3. Dispersion model results are presented and the main findings of the air quality impact assessments documented in Section 4. The significance rating for the proposed impacts is provided in Section 5. A dust management plan is provided in Section 6 and finding and recommendations provided in Section 7.

2 REGULATORY REQUIREMENTS AND ASSESSMENT CRITERIA

The environmental regulations and guidelines governing the emissions and impact of the mining operations need to be considered prior to potential impacts and sensitive receptors are identified.

Air quality guidelines and standards are funfacilityental 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 Regulations

2.1.1 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}, sulfur dioxide (SO_2), nitrogen dioxide (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**). The pollutants of concern for the proposed project are provided in bold.

Table 2-1: South African National Ambient Air Quality Standards (DEA, 2009) (DEA, 2012)

Substance	Molecular formula / notation	Averaging period	Concentration limit (µg/m³)	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**	**4**	**Immediate**
			25	**4**	**1 Jan 2030**
		1 year	**20**	**-**	**Immediate**
			15	**-**	**1 Jan 2030**
Ozone	O_3	8 hours (running)	120	11	Immediate
Benzene	C_6H_6	1 year	5	-	Immediate
Lead	Pb	1 year	0.5	-	Immediate
	CO	1 hour	30 000	88	Immediate

Substance	Molecular formula / notation	Averaging period	Concentration limit (µg/m³)	Frequency of exceedance[1]	Compliance date[2]
Carbon monoxide		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.					

2.1.2 National Regulations for Dust Deposition

South Africa's Draft National Dust Control Regulations were published on the 27 May 2011 with the dust fallout standards passed and subsequently published on the 1st of 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. SA NDCRs were published on the 1st of November 2013. Acceptable dustfall rates per the regulation are summarised in **Table 2-2**.

Table 2-2: Acceptable dustfall rates (DEA, 2011)

Restriction Area	Dustfall rate (D) (mg m^{-2} day^{-1}, 30-day average)	Permitted frequency of exceeding dust fall rate
Residential	D < 600	Two within a year, not sequential months.
Non-residential	600 < D < 1 200	Two within a year, not sequential months

The regulation also specifies 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.

2.2 Effect of Dust on Vegetation, Animals and Susceptible Human Receptors

2.2.1 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 facilityage and death of some species as a result of both the phytotoxicity and the abrasive action during turbulent deposition (Harmens, Mills, Hayes, Williams, & De Temmerman, 2005). Heavy particle loads can also result in reduced light transmission to the chloroplasts and the occlusion of stomata (Ricks & Williams, 1974) (Hirano, Kiyota, & Aiga, 1995) (Naidoo & Chirkoot, 2004) (Harmens, Mills, Hayes, Williams, & De Temmerman, 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 & 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, Garner, & Johnson, 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, 2009). 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 facilityage. 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/FPAC Working Group, 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.

2.2.2 Effects of Particulate Matter on Animals

As presented by the Canadian Environmental Protection Agency (CEPA/FPAC Working Group, 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).

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, Phalen, & Solomon, 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 and SANS limit values.

2.2.3 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/FPAC Working Group, 1998) (Dockery & 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 facilityaging 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, Ostro, & F, 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, Fabianova, Koppova, & Vandenberg, 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 2-3**.

Table 2-3: 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.
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)

2.3 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 Air Quality Act (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 operation 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 operation 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 funfacilityental 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 adequately covered. No receptors however should be located within the property line as health and safety legislation (rather than ambient air quality standards) are applicable within the site.

Chapter 5 provides general guidance on geophysical data, model domain and coordinates system 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 oxides of nitrogen (NO_x) emissions, chemical transformation of sulfur dioxide into sulfates and deposition processes.

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

2.4 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.

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 RECEIVING ENVIRONMENT

3.1 Site Description

One potential site for the Kriel ash facility expansion has been identified. The terrain around the proposed sites is undulating with small hills and valleys, typical of the Mpumalanga Highveld region. A representation of the topography for the region is presented in **Figure 3-1**.

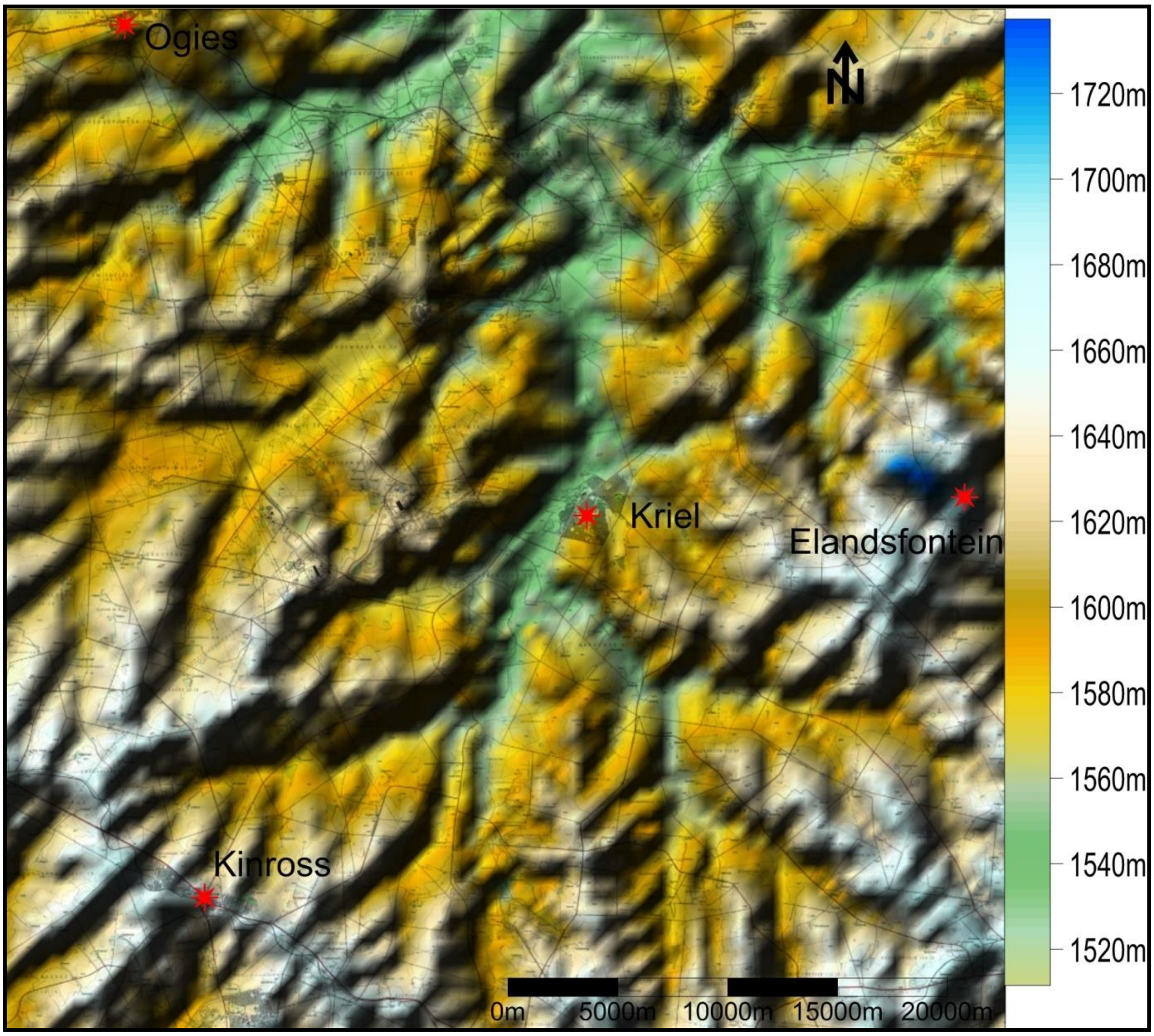

Figure 3-1: Topographical map of the area surrounding the Kriel Power Station and the Kriel ash disposal facilities

3.2 Sensitive Receptors

In the area surrounding the proposed project there are several towns and human settlements, the closest of which is Kriel ~4 km east (**Figure 3-2**).

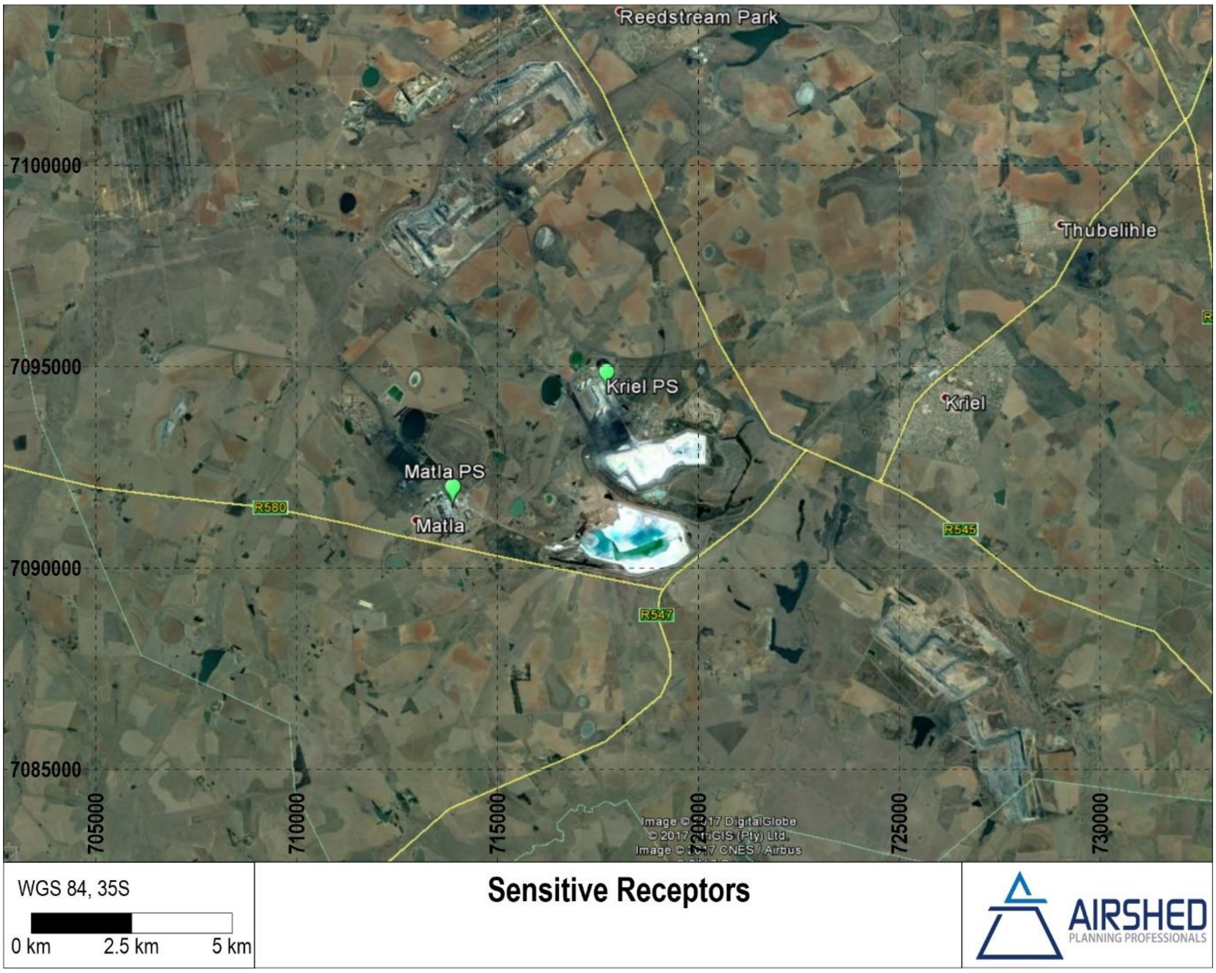

Figure 3-2: Location of the sensitive receptors to the proposed operations

3.3 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 the wind speed, in combination with the surface roughness. The wind direction, and the 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 & 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 & 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.

Meteorological information was obtained from the Kriel village ambient air quality monitoring station for the period 8th January 2013 to 30 November 2015. The data availability of the meteorological data is provided in **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%**

3.3.1 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 3-3**. Seasonal wind roses for the period 8th January 2013 to 30th November 2015 are shown in **Figure 3-4**.

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.

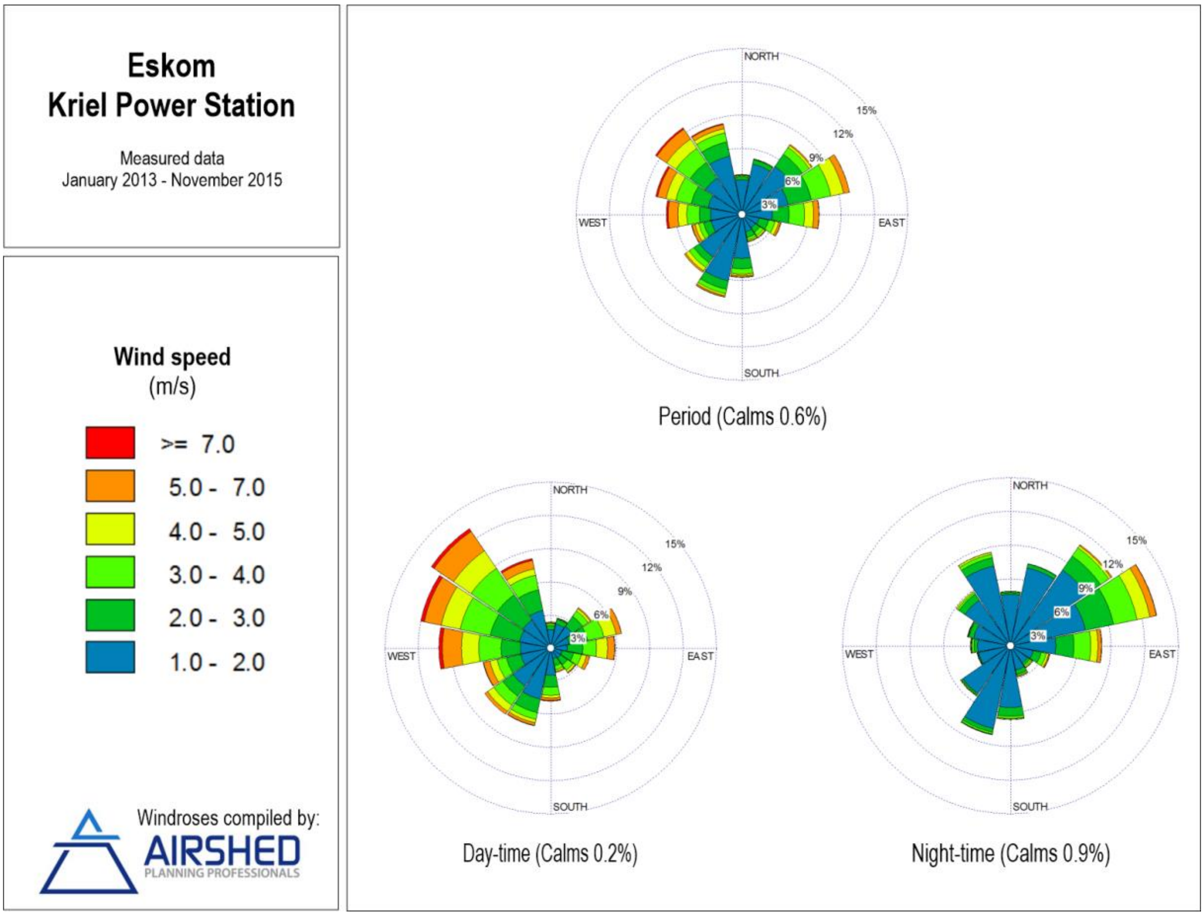

Figure 3-3: Period average, day-time and night-time wind roses (measured data; 2013 to 2015)

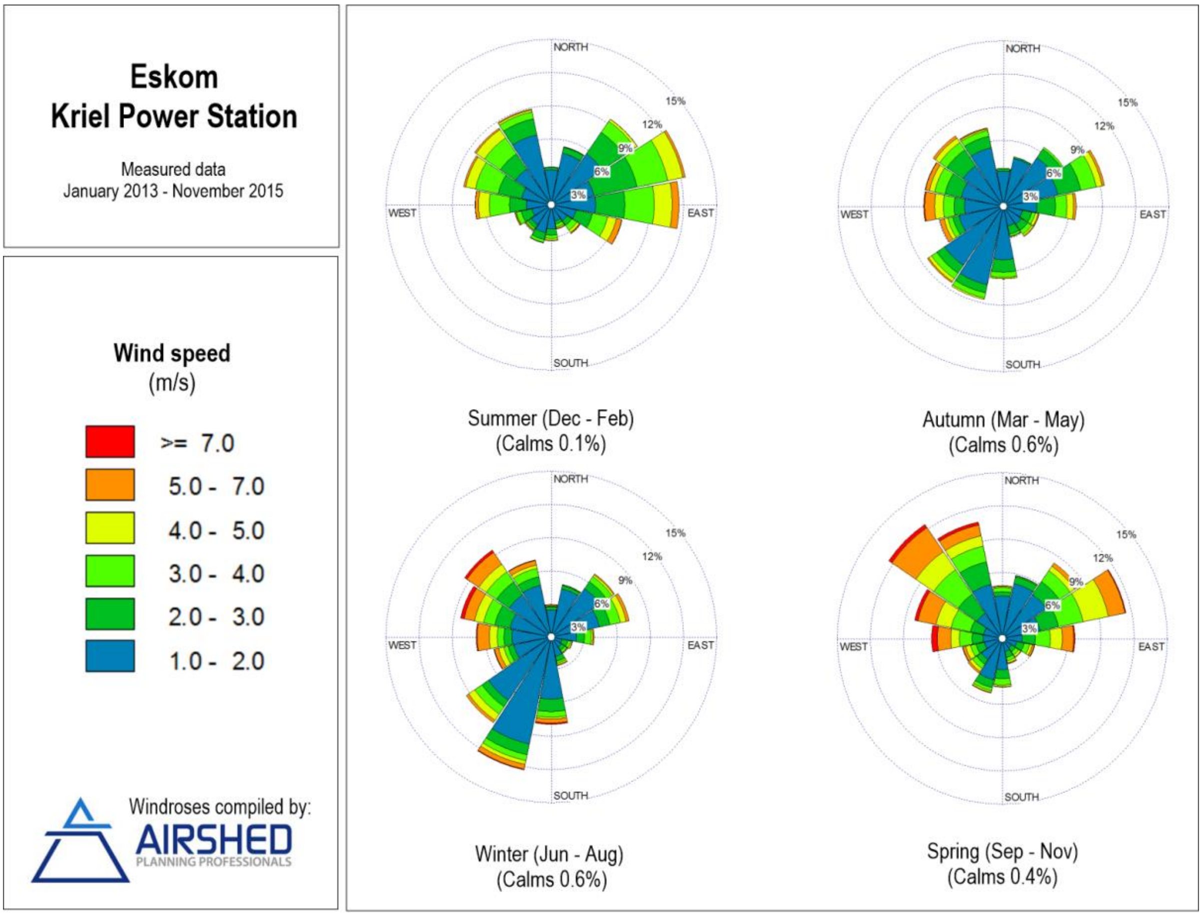

Figure 3-4: Seasonal wind roses (measured data; 2013 to 2015)

3.3.2 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 3-5. 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.

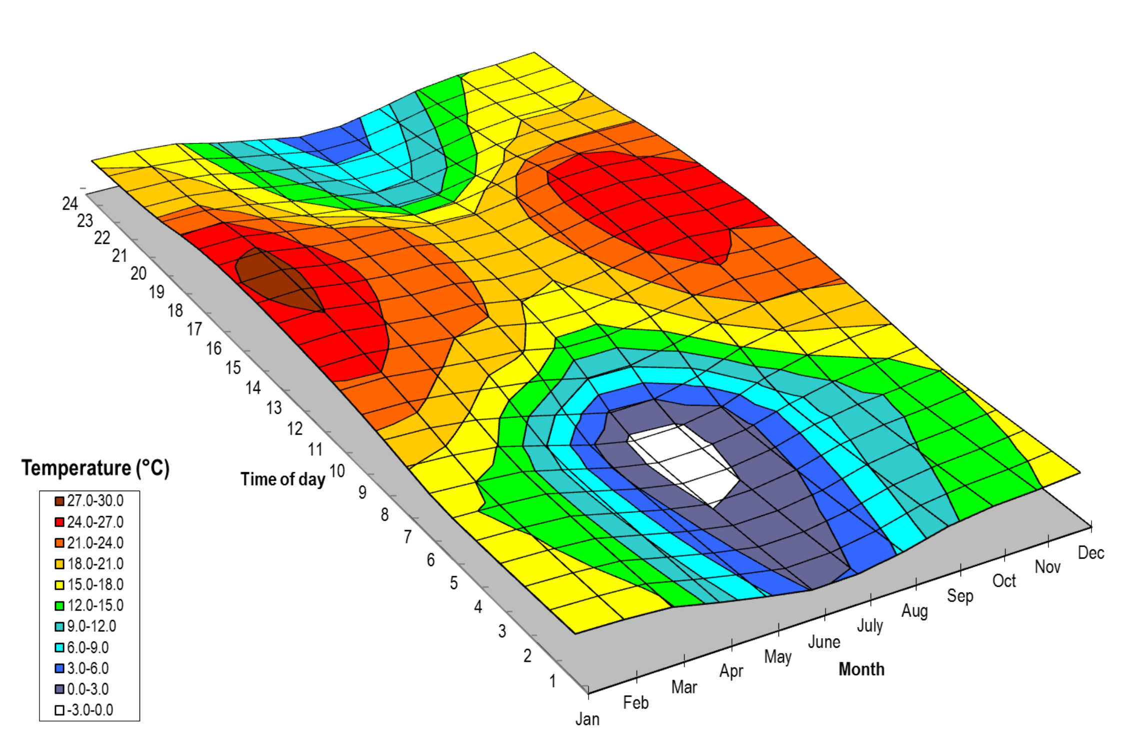

Figure 3-5: Monthly temperature profile (measured data; 2013 to 2015)

3.4 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.).
- Stack, vent and fugitive emissions from industrial operations (located in Witbank and Secunda),

3.5 Status Quo Ambient Air Quality

It is anticipated that airborne particulates would be the most significant pollutant originating at the proposed Kriel Ash facility expansion.

Together with the meteorological data made available by Eskom for this assessment, ambient concentrations of PM_{10} measured at the Kriel Village ambient monitoring station (the closest monitoring station to the proposed project) were also provided for analysis (**Table 3-2**). It should be noted that the ambient PM_{10} concentrations measured at the Kriel Village may be due to local activities and may not be representative of the ambient air quality at the projectsite. The following sections summarise the data collected in the period 8th January 2013 to 30 November 2015.

No dustfall measurement could be found in the vicinity of the existing or proposed ash facilities.

Table 3-2: Availability of valid ambient pollutant concentrations from the Kriel Village air quality monitoring station

Year	PM_{10}
2013	83.9%
2014	57.4%
2015	70.0%
Total	70.5%

During the period of assessment (2013 to 2015) 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 3-3**; and **Figure 3-6**). Annual average concentrations were also in non-compliance with the NAAQS (**Table 3-3**).

Table 3-3: 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

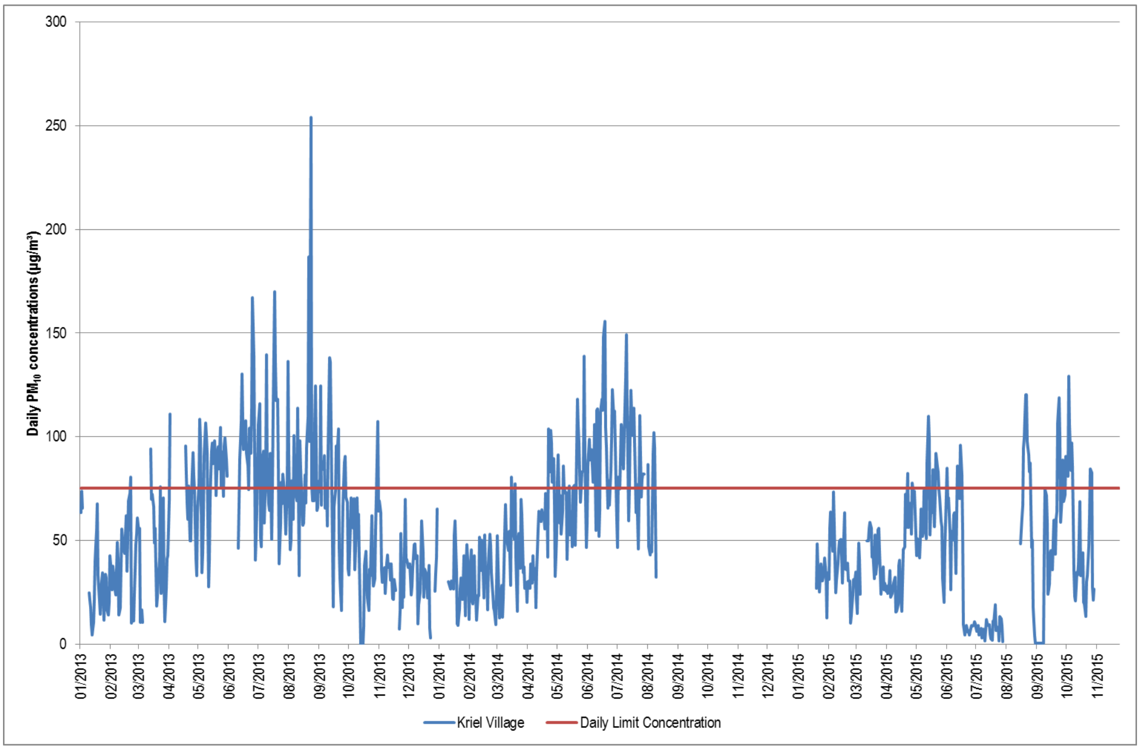

Figure 3-6: Daily average PM_{10} concentrations measured at Kriel Village for the period January 2013 to November 2015

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 3-7**), 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.

Elevated PM_{10} concentrations (80 µg/m³ or above) originate to the north-westerly sector at wind speeds greater than 4 m/s (likely due the mining activities 10 km north-west of the monitoring station). 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 3-7**).

A time variation plot (**Figure 3-8**) 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 (Figure 3-8). 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.

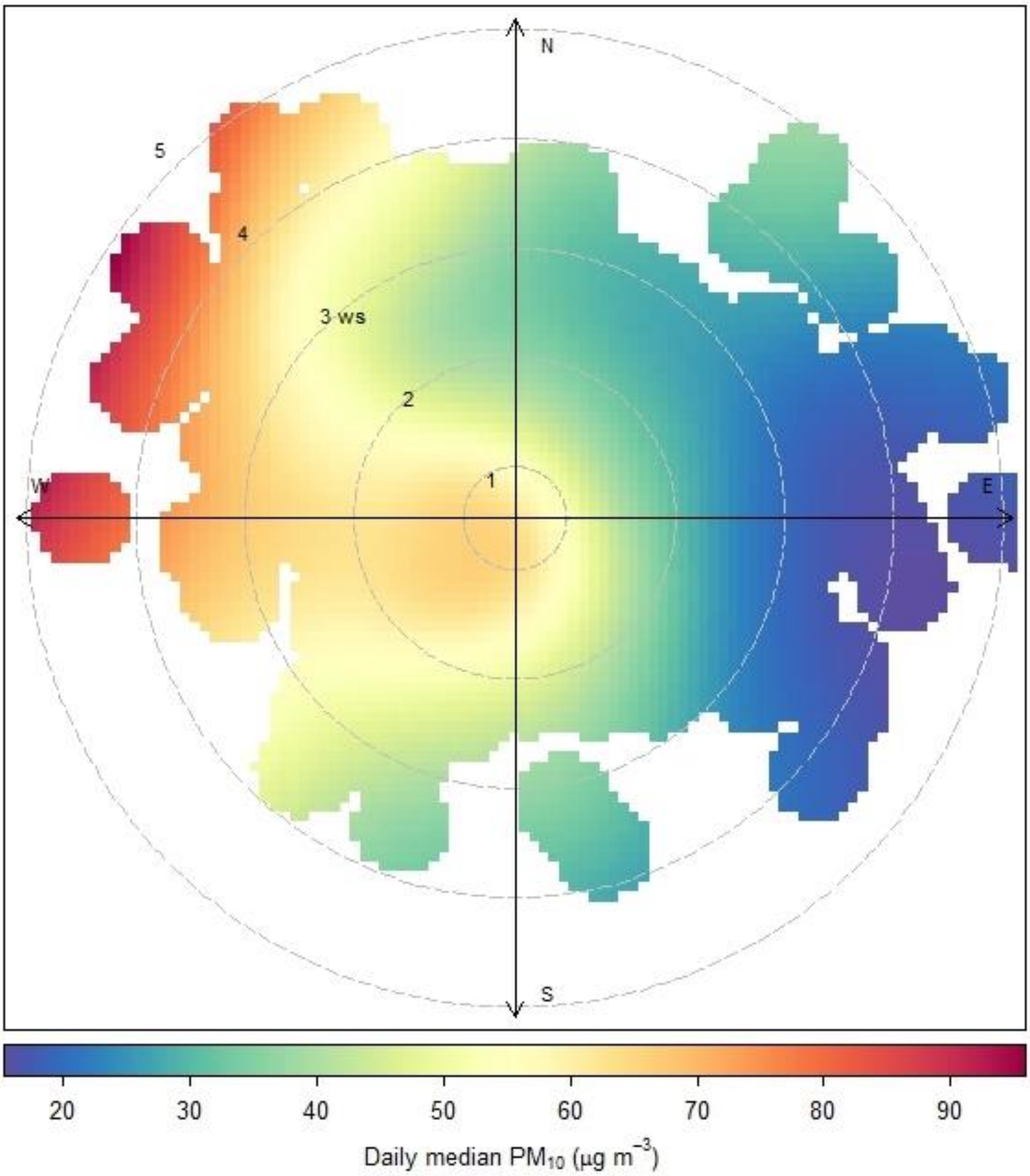

Figure 3-7: Median polar plots for Kriel Village monitoring station (2013 to 2015) daily PM_{10}

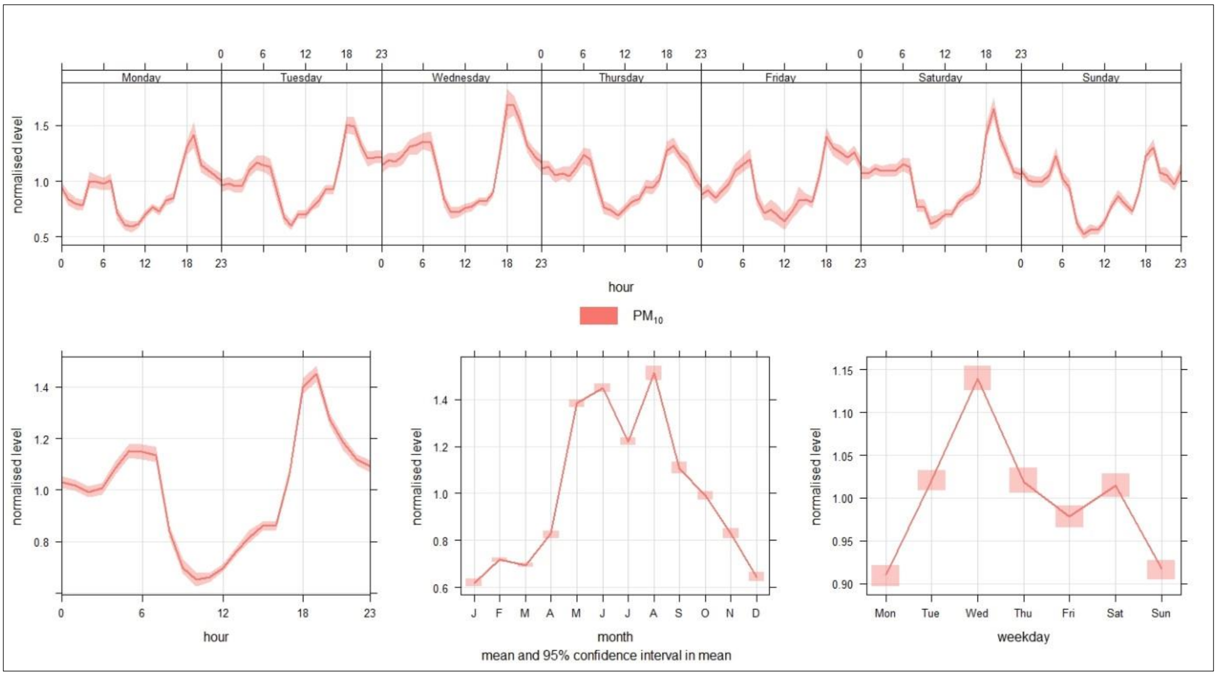

Figure 3-8: Time variation of normalised PM_{10} concentrations at the Kriel Village monitoring station

3.6 Dispersion Modelling Assessment of Baseline Air Quality

3.6.1 Emissions Inventory

The establishment of an emission inventory formed the basis for the assessment of the air quality impacts from the current Kriel Power Station operations. Emission sources 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).

3.6.1.1 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 3-4** and **Table 3-5**). Simulations were run for the year 2013 as this provided the highest emission over the three-year period.

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 3-4: 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

Table 3-5: 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

3.6.1.2 Wind Erosion

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; Burger et al., 1995).

The potential emission due to windblown dust from the existing Kriel and Matla ash disposal facilities assessed (**Figure 3-9**). The properties of the ash facility material and particle size distribution is given in **Table 3-6** and **Table 3-7** respectively.

Figure 3-9: Existing ash disposal facilities near the Kriel Power Station

Table 3-6: Ash facility sample properties

Sample ID	Moisture (%)	Bulk Density (t/m³)	Fraction >2mm (g)	Fraction <2mm >1mm (g)	Fraction <1mm (g)
Ash Facility 2	17.65	0.66	1213	42	857
Ash Facility 3	30.94	1.14	546	78	826

Table 3-7: Particle size distribution (given as a percentage) of the ash facility samples

Size µm	Ash Dump 2	Ash Dump 3
351.45	0	0.0001
190.8	0.0044	0.0198
103.58	0.0996	0.0612
76.32	0.1068	0.071
48.27	0.1958	0.16
30.53	0.1763	0.0576

Size µm	Ash Dump 2	Ash Dump 3
19.31	0.1658	0.2577
14.22	0.0392	0.0822
10.45	0.0563	0.0706
4.88	0.0886	0.1239
3.09	0.0268	0.0392
1.95	0.0153	0.0203
1.06	0.0251	0.0364

3.6.2 Dispersion Simulation Results

The plots provided for the relevant pollutants of concern are given in **Table 3-8**. Only plots were exceedances of NAAQS were included. Deposition impacts were also included in the current section. The predicted impacts are due to operations at the Kriel Power Station and existing Kriel ash facilitys only.

It should be noted that the predicted $PM_{2.5}$, PM_{10} and dust deposition are expected to be higher than the modelled impacts for this study area due to the extensive mining activities surrounding the Kriel ash facility expansion that could not be accounted for in the current assessment.

Table 3-8: Isopleth plots presented in the current section

Pollutant	Figure
$PM_{2.5}$	3-10
PM_{10}	3-11
Dustfall	3-12

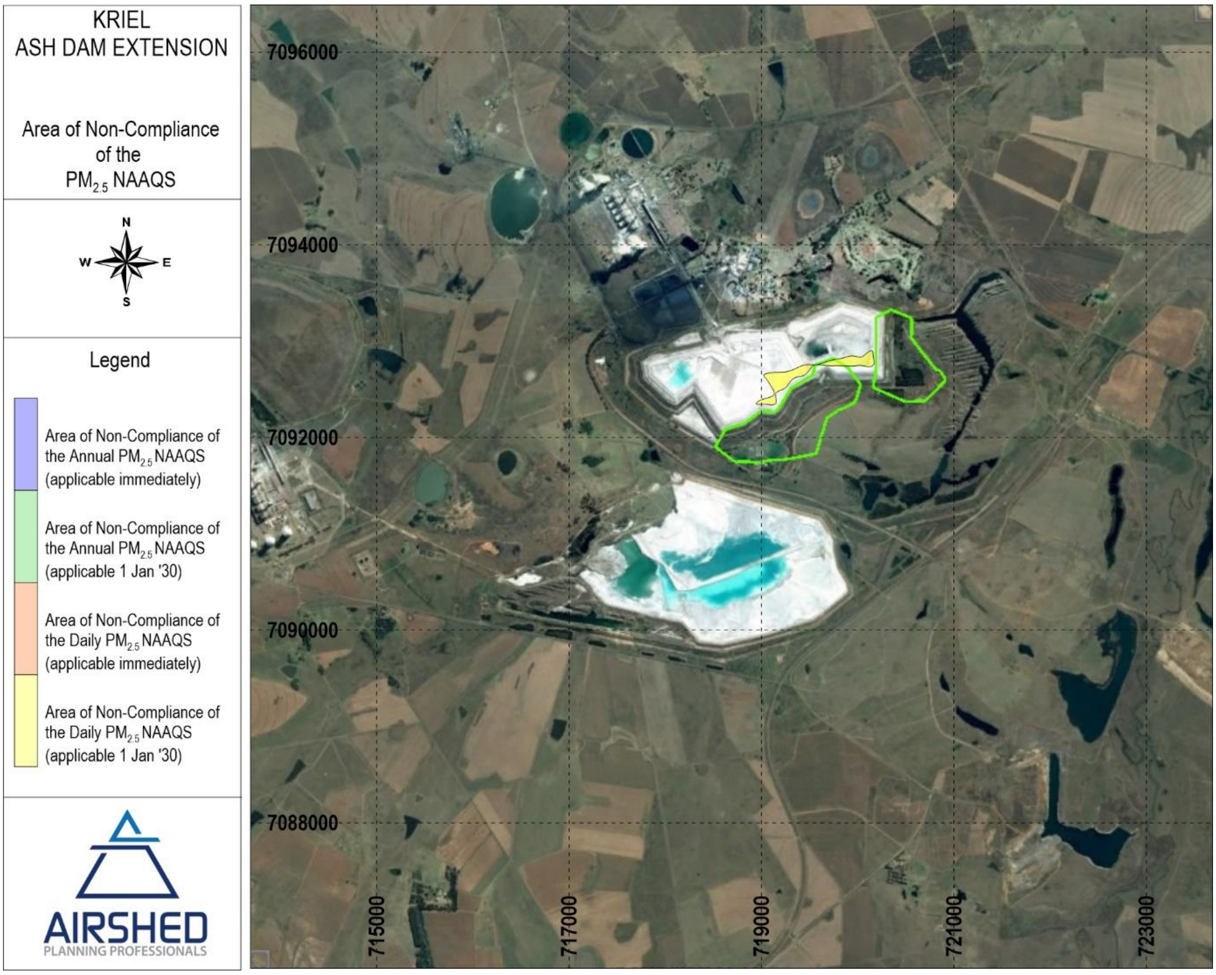

Figure 3-10: Area of non-compliance of the $PM_{2.5}$ NAAQS due to current baseline operations (including stack releases and current ash facility operations only)

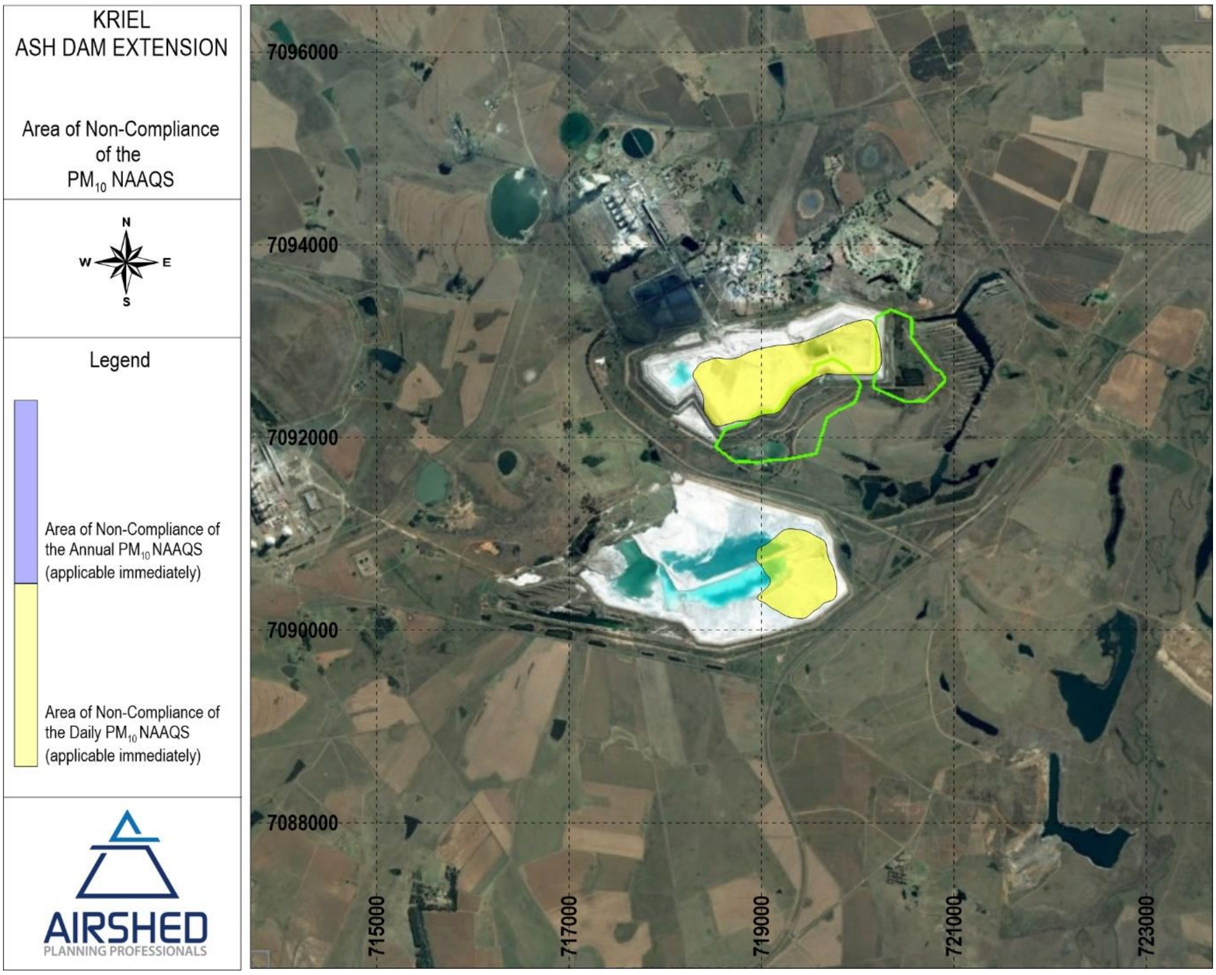

Figure 3-11: Area of non-compliance of the PM_{10} NAAQS due to current baseline operations (including stack releases and current ash facility operations only)

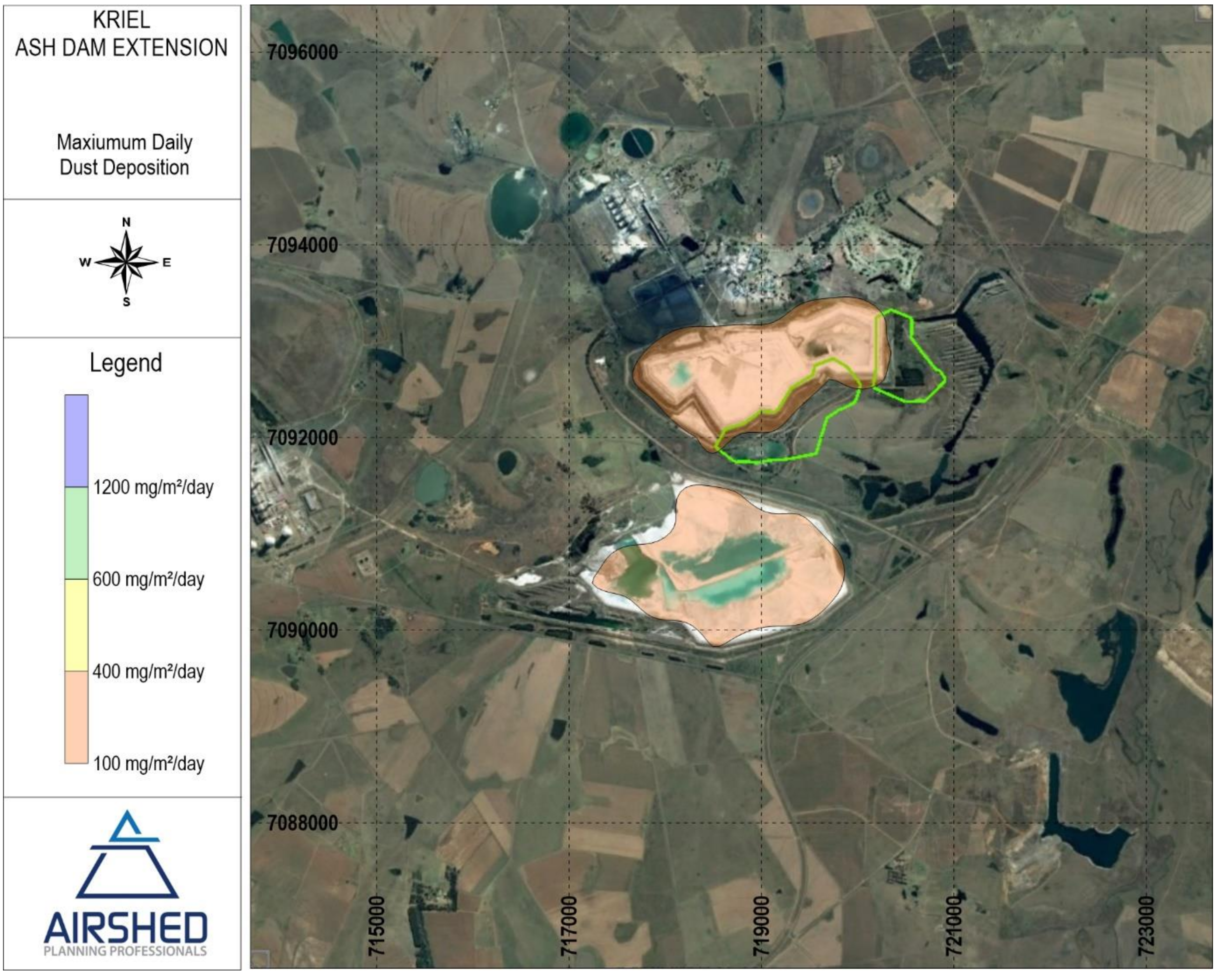

Figure 3-12: Maximum daily dust deposition due to current baseline operations (including stack releases and current ash facility operations only)

3.6.3 Compliance Assessment of Predicted Impacts

3.6.3.1 Inhalable Particulate Matter of less than 2.5 µm ($PM_{2.5}$)

Predicted $PM_{2.5}$ ground level concentrations at sensitive receptors included in the study area are illustrated in **Figure 3-10**. The predicted $PM_{2.5}$ impacts at the sensitive receptors (due to current power station stack releases and existing ash facility operations only) are within the proposed NAAQS.

3.6.3.2 Inhalable Particulate Matter of less than 10 µm (PM_{10})

Predicted PM_{10} ground level concentrations at sensitive receptors included in the study area are illustrated in **Figure 3-11**. The predicted PM_{10} impacts at the sensitive receptors (due to current power station stack releases and existing ash facility operations only) are within the NAAQS.

3.6.3.3 Predicted Dustfall Rates

Predicted dustfall rates due to current power station stack releases and existing ash facility operations only are provided in **Figure 3-12**. Predicted dustfall at all sensitive receptors were within the NDCR of 600 mg/m²/day considered acceptable for residential areas.

It should be noted that the $PM_{2.5}$, PM_{10} and dust deposition are expected to be higher than the modelled impacts for this study area due to the extensive mining activities surrounding the Kriel ash facility expansion that could not be accounted for in the current assessment. This is verified by the baseline measured PM_{10} concentrations at Kriel monitoring station which are in non-compliance with NAAQS.

4 IMPACTS FROM THE PROPOSED PROJECT ON THE RECEIVING ENVIRONMENT

4.1 Construction Phase

4.1.1 Identification of Environmental Aspects

The construction phase will comprise a series of different operations including land clearing, topsoil removal, material loading and hauling, stockpiling, grading, bulldozing, compaction, (etc.). Each of these operations has its own duration and potential for dust generation. It is anticipated therefore that the extent of dust emissions would vary substantially from day to day depending on the level of activity, the specific operations, and the prevailing meteorological conditions. This is in contrast to most other fugitive dust sources where emissions are either relatively steady or follow a discernible annual cycle.

A list of all the potential dust generation activities expected during the construction phase is provided in **Table 4-1**. Unmitigated construction activities provide the potential for impacts on local communities, primarily due to nuisance and aesthetic impacts associated with fugitive dust emissions. On-site dustfall may also represent a nuisance to employees.

Impact due to the construction phase was not assessed as these sources would be of a relatively short-term duration and the impact would be near to site.

Table 4-1: Typical sources of fugitive particulate emission associated with construction

Pollutant(s)	Aspect	Activity
Particulates	Construction of proposed ash facility site	Clearing of groundcover
		Levelling of area
		Wind erosion from topsoil storage piles
		Tipping of topsoil to storage pile
	Vehicle activity on-site	Vehicle and construction equipment activity during construction operations
Gases and particles	Vehicle and construction equipment activity	Tailpipe emissions from vehicles and construction equipment such as graders, scrapers and dozers

4.1.2 Mitigation Measures Recommended

Incremental PM_{10} and $PM_{2.5}$ concentrations and deposition rates due to the Construction Phase of the proposed project will be of relatively short-term and of local impact. The implementation of effective controls, however, during this phase would also serve to set the president for mitigation during the operational phase.

Dust control measures which may be implemented during the construction phase are outlined in **Table 4-2**. Control techniques for fugitive dust sources generally involve watering and/or, chemical stabilization, and/or the reduction of surface wind speed though the use of windbreaks and source enclosures.

Table 4-2: Dust control measures that may be implemented during construction activities

Construction Activity	Recommended Control Measure(s)
Materials storage, handling and transfer operations	Wet suppression where feasible on stockpiles and materials handling activities
Open areas (windblown emissions)	Minimise extent of disturbed areas. Reduction of frequency of disturbance. Early re-vegetation Stabilisation (chemical, rock cladding or vegetative) of disturbed soil

4.2 Operation Phase

4.2.1 Quantification of Environmental Aspects and Impact Classification

4.2.1.1 Emissions Inventory

The operation phase is assessed quantitatively with the emissions provided in the current section. The emission factors and calculated emission rates are provided in **Table 4-3**.

Table 4-3: Emission factors used to qualify the routine emissions from the operational phase for the proposed project

Activity	Emission Equation	Source	Information assumed/provided
Wind Erosion	$E(i) = G(i)10^{(0.134(\%clay)-6)}$ For $G(i) = 0.261\left[\frac{P_a}{g}\right]u^{*3}(1+R)(1-R^2)$ And $R = \frac{u_*^{\,t}}{u^*}$ where, $E_{(i)}$ = emission rate (g/m²/s) for particle size class i P_a = air density (g/cm³) G = gravitational acceleration (cm/s³) u_*^t = threshold friction velocity (m/s) for particle size i u^* = friction velocity (m/s)	Marticorena & Bergametti, 1995	One potential site for the proposed ash facility was assessed, i.e. Site 10. Site 10 is made up of two sections and is located south of the existing Kriel ash facility. Particle size distribution from the existing ash facility was assumed for the proposed ash facilitys. As wet deposition (as proposed for the ash facility extension operations) would lead to a wetter surface, the wet area of the ash facility was assumed to be similar to the current ash facility (40%).

4.2.1.2 Dispersion Simulation Results and Compliance Assessment

Simulations were undertaken to determine the particulate matter concentrations as well as total daily dust deposition from operations due to the Kriel ash facility extension. The proposed impacts were assessed with the current operations of the Kriel Power Station boilers as well as the existing ash facility facilities.

Isopleth plots reflecting hourly/daily averaging periods contain only the highest predicted ground level concentrations for that averaging period, over the entire period for which simulations were undertaken. It is therefore possible that even though a high hourly/daily concentration is predicted to occur at certain locations, that this may only be true for one hour/day during the entire period.

The plots provided for the relevant pollutants of concern are given in **Table 4-4**. Only plots were exceedances of the NAAQS were included. Deposition impacts were also included in the current section.

One scenario was assessed for proposed Kriel ash facility extension operations: ash facility extension operations considering wet deposition at proposed ash facility Site 10.

Table 4-4: Isopleth plots presented in the current section

Pollutant	Figure
$PM_{2.5}$	4-1
PM_{10}	4-2
Dustfall	4-3

The highest $PM_{2.5}$ and PM_{10} concentrations due to proposed project operations are in compliance with NAAQS at the closest sensitive receptors (**Figure 4-1** and **Figure 4-2** respectively). The highest daily dust depositions due to proposed operations are below the NDCR of 600 mg/m²/day for residential areas at all sensitive receptors within the study area (**Figure 4-3**).

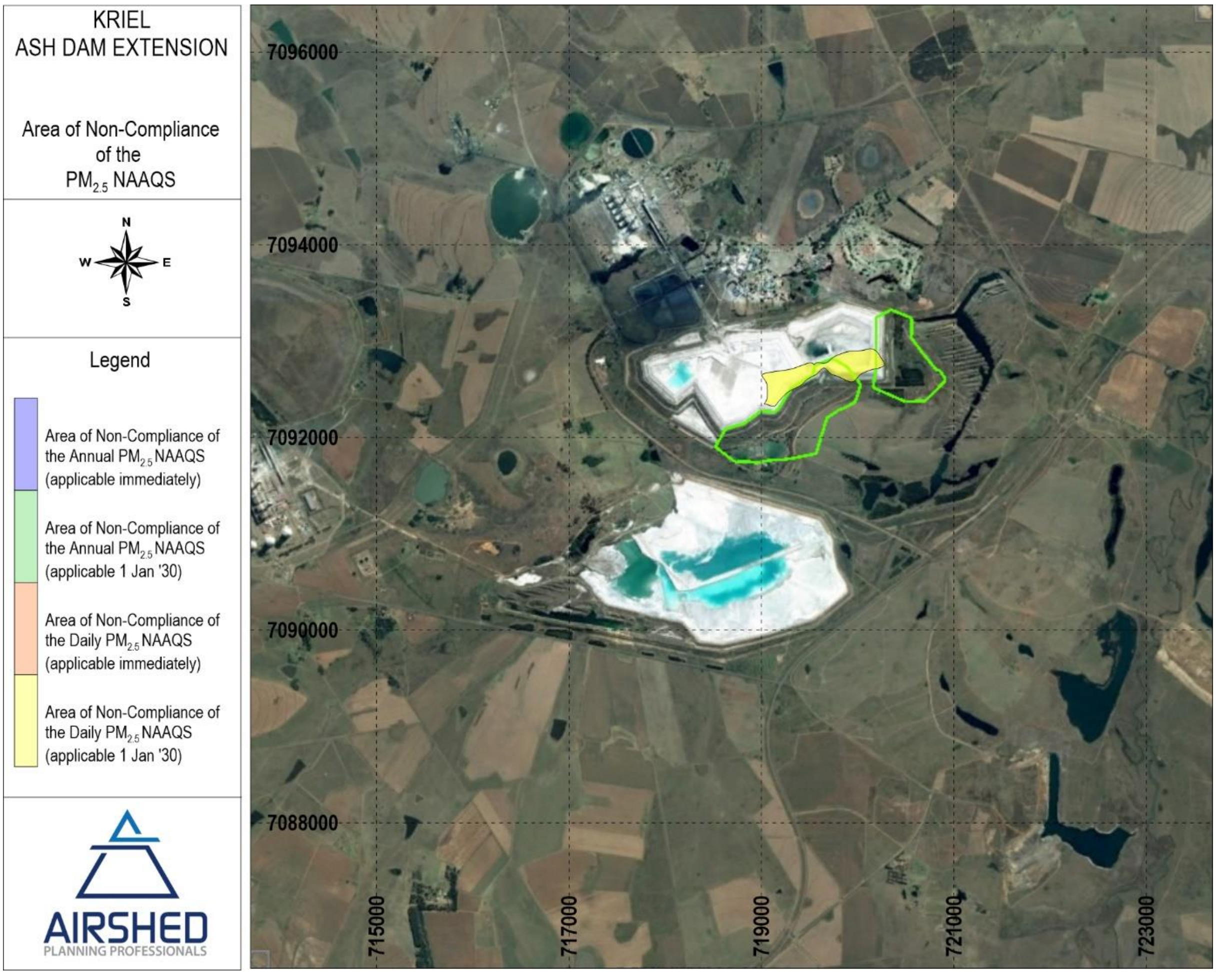

Figure 4-1: Area of non-compliance of $PM_{2.5}$ NAAQS due to proposed operations

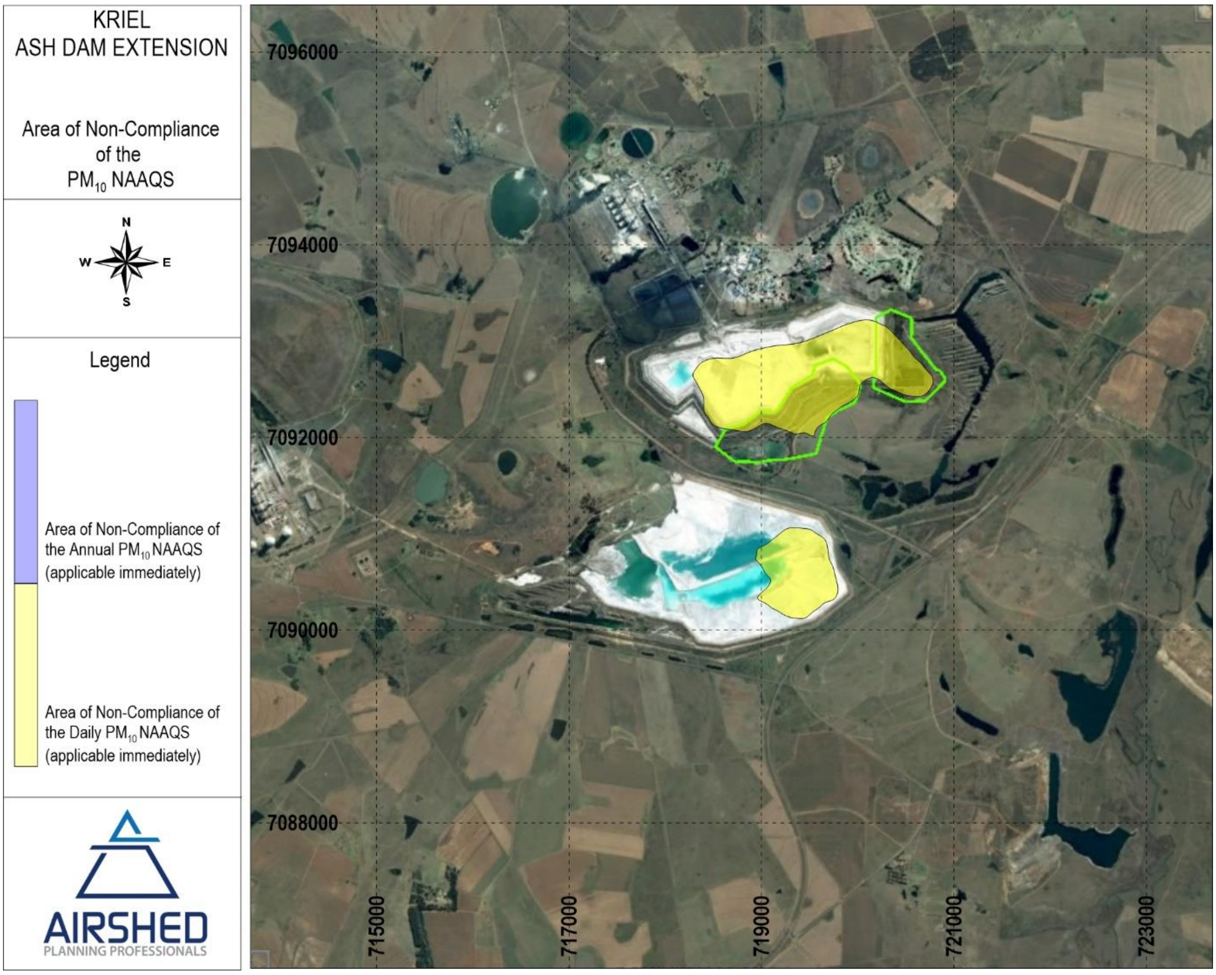

Figure 4-2: Area of non-compliance of PM_{10} NAAQS due to proposed operations

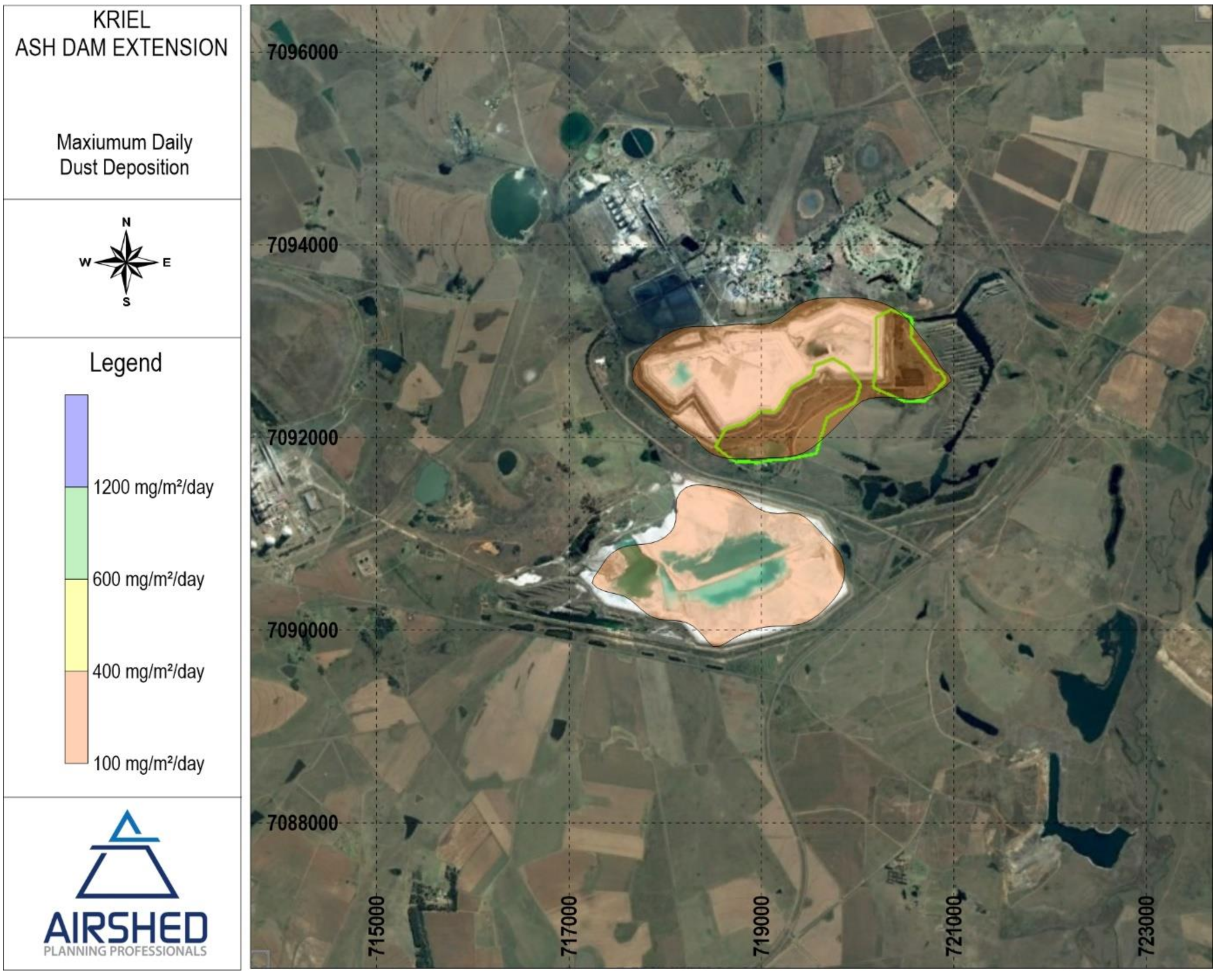

Figure 4-3: Maximum daily dust deposition due to proposed operations

4.2.1.3 Cumulative Impacts

Literature states that by adding the peak model concentrations to the background concentrations, this can result in sever overestimation of the source contribution and that a more realistic method is to add twice the annual mean background concentrations to the peak (or 99.9th percentile) (Ministry for the Environment, 2004). If the background PM_{10} concentrations as measured at the Kriel Village (54.7 µg/m³ annual average for the period 2013 to 2015) are assumed to be representative of the study area, the annual and daily cumulative ground level concentrations may increase with a further 55 µg/m³ and 110 µg/m³ respectively.

4.2.1.4 Predicted Impacts on Vegetation and Animals

No national ambient air quality standards or guidelines are available for the protection of animals and vegetation. In the absence of national ambient standards for animals, the standards used for the protection of human beings may be used to assess the impacts on animals. Areas of non-compliance of PM_{10} and $PM_{2.5}$ NAAQS due to the proposed project operations are provided in Section 4.2.1.2.

While there is little direct evidence of what the impact of dustfall on vegetation is under a South African context, 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/m²/day (Farmer, 1991). The simulated dustfall rates due to the proposed project operations are provided in **Figure 4-3**.

If more detailed information is required on the impact of particulate matter on vegetation and animals, it is recommended that the predicted PM concentrations and dust depositions be used in a more detailed biodiversity and/or health risk assessment study.

4.2.2 Mitigation Measures Recommended

Air quality management measures should be implemented to ensure the lowest possible impacts on the surrounding environment from proposed operations. This can be achieved through a combination of mitigation measures and ambient monitoring.

A potentially significant impacting source may be wind erosion from the ash facilitys during periods of high winds (>9m/s). It is recommended that the sidewalls of the ash facilitys be vegetated. The vegetation cover should be such to ensure at least 80% control efficiency. The top surface area should have 40% wet beach area (if feasible and if wet deposition option is considered) and a water spraying system should be implemented on the surface of the ash facility covering the outer perimeter of the facility, spraying water when winds exceed 4 m/s.

4.3 Closure Phase

4.3.1 Identification of Environmental Aspects

It is assumed that all the operations will have ceased by the closure phase of the project. The potential for impacts during this phase will depend on the extent of demolition and rehabilitation efforts during closure. Aspects and activities associated with the demolition and closure phase of the proposed operations are listed in **Table 4-5**. Simulations of the closure phase were not included in the current study due to its temporary impacting nature.

Table 4-5: Activities and aspects identified for the closure phase

Impact	Source	Activity
Generation of TSP, $PM_{2.5}$ and PM_{10}	Ash facilitys	Topsoil recovered from stockpiles for rehabilitation and re-vegetation of ash facilitys

4.3.2 Mitigation Measures Recommended

Dust control measures for open areas can consist of wet suppression, chemical suppressants, vegetation, wind breaks, etc., as applicable. Wet suppressants and chemical suppressants are generally applied for short storage pile durations. For long-term control measures vegetation frequently represents the most cost-effective and efficient control.

Vegetation cover retards erosion by binding the soil with a root network, by sheltering the soil surface and by trapping material already eroded. Sheltering occurs by reducing the wind velocity close to the surface, thus reducing the erosion potential and volume of material removed. The trapping of the material already removed by wind and in suspension in the air is an important secondary effect. Vegetation is also considered the most effective control measure in terms of its ability to also control water erosion. In investigating the feasibility of vegetation types, the following properties are normally taken into account: indigenous plants; ability to establish and regenerate quickly; proven effective for reclamation elsewhere; tolerant to the climatic conditions of the area; high rate of root production; easily propagated by seed or cuttings; and nitrogen-fixing ability. The long-term effectiveness of suitable vegetation selected for the site will be dependent on the nature of the cover.

5 SIGNIFICANCE RATING

The significance of the impact was assessed with the assessment criteria as provided by Aurecon South Africa (Pty) Ltd (**Table 5-1**). The significance of the impact is "Medium" for unmitigated operations and "Low" to "Very Low" for mitigated operations.

Table 5-1: Significance rating for the proposed project operations

ID	Aspect	Phase	Impact description	Type	Extent	Magnitude	Duration	Probability	Confidence	Reversibility	Significance
1	Air Quality	Construction - unmitigated	Degraded ambient air quality	Negative	Local	Medium	Short term	Probable	Sure	Reversible	Medium (-)
2	Air Quality	Construction - mitigated	Degraded ambient air quality	Negative	Site specific	Low	Short term	Probable	Sure	Reversible	Very low (-)
3	Air Quality	Operation - unmitigated	Degraded ambient air quality	Negative	Site specific	Medium	Long term	Probable	Sure	Reversible	Medium (-)
4	Air Quality	Operation - mitigated	Degraded ambient air quality	Negative	Site specific	Low	Long term	Probable	Sure	Reversible	Low (-)
5	Air Quality	Decommissioning - unmitigated	Degraded ambient air quality	Negative	Site specific	Medium	Long term	Probable	Sure	Reversible	Medium (-)
6	Air Quality	Decommissioning - mitigated	Degraded ambient air quality	Negative	Site specific	Low	Medium term	Probable	Sure	Reversible	Low (-)

6 DUST MANAGEMENT PLAN

An air quality impact assessment was conducted for the proposed project operations. The main objective of this study was to determine the significance of the predicted impacts from the proposed operations on the surrounding environment and on human health.

6.1 Site Specific Management Objectives

The main objective of Air Quality Management measures for the proposed project is to ensure that all operations are within ambient air quality criteria. In order to define site specific management objectives, the main sources of pollution needed to be identified. Sources can be ranked based on source strengths (emissions) and impacts. Once the main sources have been identified, target control efficiencies for each source can be defined to ensure acceptable cumulative ground level concentrations.

Particulates were identified as the main pollutant of concern from the proposed project operations.

The ranking of sources serves to confirm or, where necessary revise, the current understanding of the significance of specific sources, and to evaluate the emission reduction potentials required for each. Sources of emissions for the proposed project may be ranked based on:

- emissions - based on the comprehensive emissions inventory established for the operations, and,
- impacts - based on the predicted dustfall levels and ambient inhalable and respirable particulate concentrations.

The ranking of sources serves to confirm or, where necessary revise, the current understanding of the significance of specific sources. The main source of emission and impact due to the Kriel ash facility extension is due to windblown dust from the ash facilitys.

6.2 Project-specific Management Measures

The proposed operations have been assessed during this study with all emissions quantified and dispersion simulations executed. As a result of the air quality assessment, it is found that the acceptability of proposed operations in terms of NAAQS with the potential of elevated background ambient concentrations (due to the nature of mining activities surrounding the site) may necessitate the implementation of an effective local dust management plan.

Given the potential for cumulative impacts, it is recommended that control measures be implemented throughout the life of the operations at the proposed ash facility and it is recommended that the project proponent commit itself to dust management planning.

The main contributing sources of particulate emissions have been identified and quantified.

6.3 Estimation of Dust Control Efficiencies

6.3.1 Identification of Suitable Pollution Abatement Measures

Suitable abatement measures have been discussed in detail in Section 4.2.2.

6.3.2 Performance Indicators

Key performance indicators against which progress may be assessed form the basis for all effective environmental management practices. In the definition of key performance indicators careful attention is usually paid to ensure that progress towards their achievement is measurable, and that the targets set are achievable given available technology and experience.

Performance indicators are usually selected to reflect both the source of the emission directly and the impact on the receiving environment. Ensuring that no visible evidence of wind erosion exists represents an example of a source-based indicator, whereas maintaining off-site dustfall levels to below 600 mg/m²/day represents an impact- or receptor-based performance indicator.

6.3.2.1 Specification of Source Based Performance Indicators

Source based performance indicators for proposed routine operations would include the following:

- Dustfall immediately downwind of the proposed ash facility to be <1200 mg/m²/day and dustfall at sensitive receptors to be <600 mg/m²/day.
- The absence of visible dust plume at the proposed ash facility.

6.3.2.2 Receptor based Performance Indicators

A dust fallout network provides management with an indication of what the increase in fugitive dust levels are. In addition, a dust fallout network can serve to meet various objectives, such as:

- Compliance monitoring;
- Validate 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.

Dust fallout monitoring network recommended for the operation of ash facility Site 10 is given in **Figure 6-1**. If this dust fallout network is established prior to operations, the measured data would be useful in assessing the baseline dust fallout levels. Once operations commence the dust fallout levels at these locations will provide an indication of the activities contribution to the overall measured dust fallout levels.

Recommended dust bucket placements are as follows (**Figure 6-1**):

- For the operation of the proposed ash facility at Site 10:
    - Bucket 1 – placed south of the ash facility operations and will be useful in measuring the impact from this windblown dust sources;
    - Bucket 2 – placed upwind of the ash facility operations;
    - Bucket 3 – placed at the hostels just north of the ash facility operations;
    - Bucket 4 – placed at the closest sensitive receptor of Kriel.

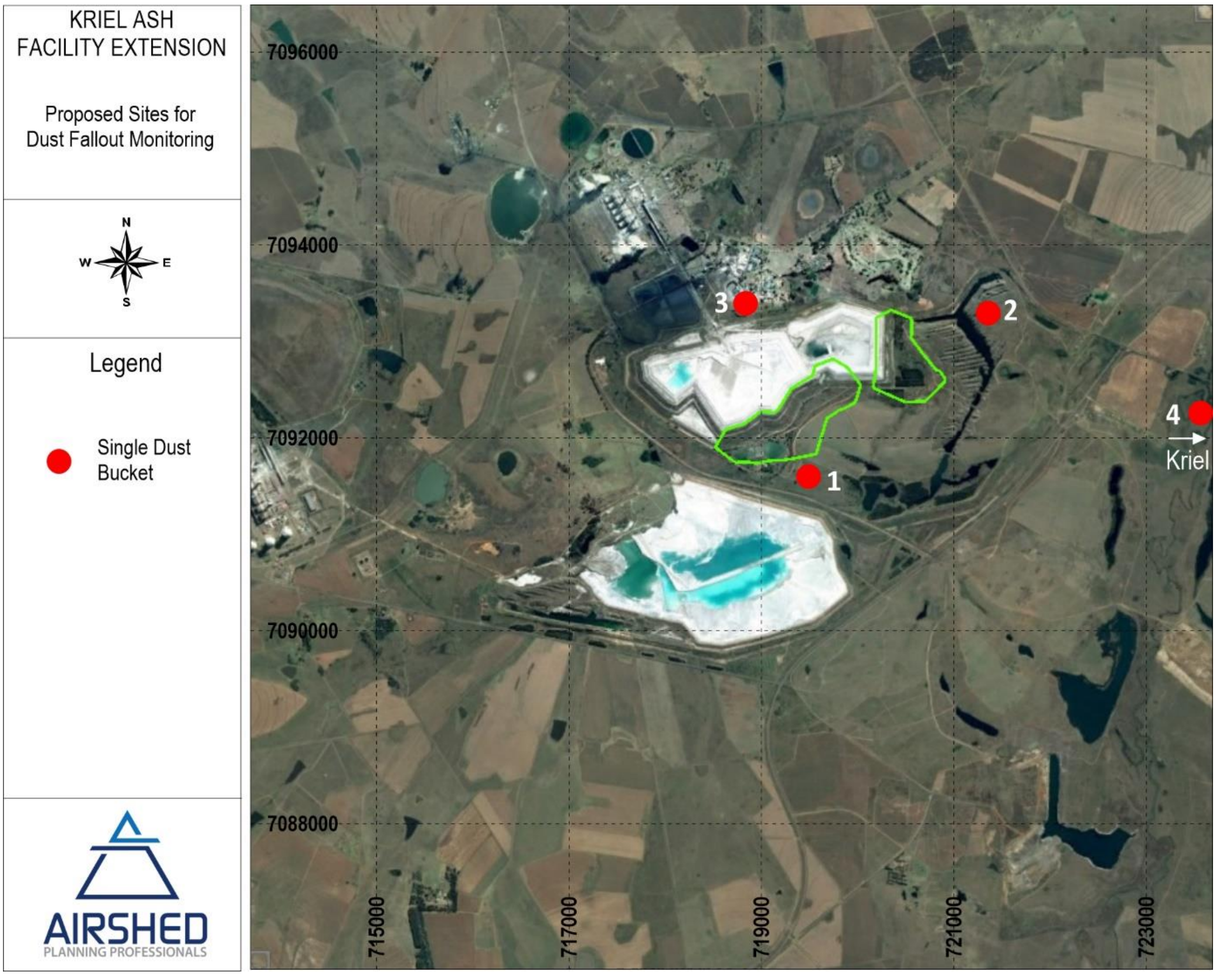

Figure 6-1: Proposed locations for the dust fallout network

The recommended performance assessment and reporting programme for dustfall monitoring is given in **Table 6-1**.

Table 6-1: Ambient air monitoring, performance assessment and reporting programme

Monitoring Strategy Criteria	Dustfall Monitoring
Monitoring objectives	- Assessment of compliance with dustfall limits within the main impact zone of the operation. - Facilitate the measurement of progress against environmental targets within the main impact zone of the operation. - Temporal trend analysis to determine the potential for nuisance impacts within the main impact zone of the operation. - Tracking of progress due to pollution control measure implementation within the main impact zone of the operation. - Informing the public of the extent of localised dust nuisance impacts occurring in the vicinity of the mine operations.
Monitoring location(s)	**Figure 6-1**
Sampling techniques	*Single Bucket Dust Fallout Monitors* Dust fallout sampling measures the fallout of windblown settle able dust. Single bucket fallout monitors to be deployed following the American Society for Testing and Materials standard method for collection and analysis of dustfall (ASTM D1739). This method employs a simple device consisting of a cylindrical container exposed for one calendar month (30 days, ±2 days).
Accuracy of sampling technique	Margin of accuracy given as $\pm$200 mg/m^2/day.
Sampling frequency and duration	On-going, continuous monitoring to be implemented facilitating data collection over 1-month averaging period.
Commitment to QA/QC protocol	Comprehensive QA/QC protocol implemented.
Interim environmental targets (i.e. receptor-based performance indicator)	Maximum total daily dustfall (calculated from total monthly dustfall) of not greater than 600 mg/m^2/day for residential areas. Maximum total daily dustfall to be less than 1 200 mg/m^2/day on-site (non-residential areas).
Frequency of reviewing environmental targets	Annually (or may be triggered by changes in air quality regulations).
Action to be taken if targets are not met	(i) Source contribution quantification. (ii) Review of current control measures for significant sources (implementation of contingency measures where applicable).
Procedure to be followed in reviewing environmental targets and other elements of the monitoring strategy (e.g. sampling technique, duration, procedure)	Procedure to be drafted in liaison with I&APs through the proposed community liaison forum. Points to be taken into account will include, for example: (i) trends in local and international ambient particulate guidelines and standards and/or compliance monitoring requirements, (ii) best practice with regard to monitoring methods, (iii) current trends in local air quality, i.e. is there an improvement or deterioration, (iv) future development plans within the airshed (etc.)
Progress reporting	At least annually to the necessary authorities and community forum.

6.3.3 Record-keeping, Environmental Reporting and Community Liaison

6.3.3.1 Periodic Inspections and Audits

Periodic inspections and external audits are essential for progress measurement, evaluation and reporting purposes. It is recommended that site inspections and progress reporting be undertaken at regular intervals (at least quarterly) during rehabilitation, with annual environmental audits being conducted. Annual environmental audits should be continued at least until closure. Results from site inspections and monitoring efforts should be combined to determine progress against source- and receptor-based performance indicators. Progress should be reported to all interested and affected parties, including authorities and persons affected by pollution.

The criteria to be taken into account in the inspections and audits must be made transparent by way of minimum requirement checklists included in the Environmental Management Plan.

Corrective action or the implementation of contingency measures must be proposed to the stakeholder forum in the event that progress towards targets is indicated by the quarterly/annual reviews to be unsatisfactory.

6.3.3.2 Liaison Strategy for Communication with Interested and Affected Parties (I&APs)

Stakeholder forums provide possibly the most effective mechanisms for information dissemination and consultation. EMPr should stipulate specific intervals at which forums will be held, and provide information on how people will be notified of such meetings. For operations for which un-rehabilitated or party rehabilitated impoundments are located in close proximity (within 3 km) from residential areas, it is recommended that such meetings be scheduled and held at least on a bi-annual basis.

6.3.3.3 Financial Provision (Budget)

The budget should provide a clear indication of the capital and annual maintenance costs associated with dust control measures and dust monitoring plans. It may be necessary to make assumptions about the duration of aftercare prior to obtaining closure. This assumption must be made explicit so that the financial plan can be assessed within this framework. Costs related to inspections, audits, environmental reporting and I&AP liaison should also be indicated where applicable. Provision should also be made for capital and running costs associated with dust control contingency measures and for security measures.

The financial plan should be audited by an independent consultant, with reviews conducted on an annual basis.

7 FINDINGS AND RECOMMENDATIONS

7.1 Findings

An air quality impact assessment was conducted for the proposed Kriel Power Station ash facility extension operations. The main objective of this study was to determine the significance of the predicted impacts from the proposed project operations on the surrounding environment and on human health. Emission rates were quantified for the proposed activities and dispersion modelling executed.

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 to the proposed ash facility extension is Kriel (~4 km east).

- 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 proposed project operations were as follows:

- The highest $PM_{2.5}$ and PM_{10} concentrations due to proposed project operations were in compliance with NAAQS at the closest sensitive receptors. The highest daily dust depositions due to proposed operations were below the NDCR of 600 mg/m²/day for residential areas at all sensitive receptors within the study area.

7.2 Recommendations

The following recommendations are made:

- It is recommended that a dust fallout monitoring network be implemented at the proposed project site as recommended in Section 5 in order to monitor the impacts from the proposed project activities.

- Due to the elevated baseline ambient air quality levels for particulate matter, it is recommended that mitigation measures on the main sources of fugitive dust (as recommended in Section 4.2.2) be implemented to minimise impacts as far as possible.

8 REFERENCES

Abbey, D., Ostro, B., & F, P. (1995). Chronic respiratory symptoms associated with estimated long-term ambient concentrations of fine particulates less than 2.5 microns in aerodynamic diameter (PM2.5) and other air pollutants. *J Expo Anal Environ Epidemiol 5*, 137–159.

Alade, O. L. (2009). *Characteristics of particulate matter over the South African industrialised Highveld. MSc dissertation.* Faculty of Science, University of the Witwatersrand.

Carslaw, D. (2014). *The openair manual - open-source tools for analysing air pollution data.* 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.

CEPA/FPAC Working Group. (1998). *National Ambient Air Quality Objectives for Particulate Matter. Part 1: Science Assessment Document.* A Report by the Canadian Environmental Protection Agency (CEPA) Federal-Provincial Advisory Committee (FPAC)on Air Quality Objectives and Guidelines.

Davidson, C. I., Phalen, R. F., & Solomon, P. A. (2005). Airborne Particulate Matter and Human Health: A Review. *Aerosol Science and Technology , Volume 39, Issue 8*.

DEA. (2009, Dec 24). *National Ambient Air Quality Standards.* Department of Environmental Affairs, Government Gazette No. 32816, 24 December 2009.

DEA. (2011, August 5). National dust control regulations. *Gazette No. 34493*.

DEA. (2012, June 29). *National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter less than 2.5 micron metres (PM2.5).* Department of Environmental Affairs, Government Gazette No. 35463, 29 June 2012.

DEA. (2014). *Regulations regarding Air Dispersion Modelling.* Department of Environmental Affairs, Government Gazette No. 37804, 11 July 2014.

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

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

Dockery, D., & Pope, C. (1994). Acute Respiratory Effects of Particulate Air Pollution. *15*.

EPA. (1996). *Compilation of Air Pollution Emission Factors (AP-42).* US Environmental Protection Agency.

Farmer, A. M. (1991). The Effects of dust on vegetation-A review. *Enviromental Pollution*, 79: 63-75.

Goldreich, Y., & Tyson, P. (1988). Diurnal and Inter-Diurnal Variations in Large-Scale Atmospheric Turbulence over Southern Africa. *South African Geographical Journal*, 48-56.

Grantz, D. A., Garner, J. H., & Johnson, D. W. (2003). Ecological effects of particulate matter. *Env. Int*, 29 pp 213-239.

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.*

Harmens, H., Mills, G., Hayes, F., Williams, P., & De Temmerman, L. (2005). *Air Pollution and Vegetation.* The International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops Annual Report 2004/2005.

Hirano, T., Kiyota, M., & Aiga, I. (1995). Physical effects of dust on leaf physiology of cucumber and kidney bean plants. *Environmental Pollution*, 255–261.

HPA. (2011). *Highveld Priority Area Air Quality Management Plan.* Pretoria: SA Department of Environmental Affairs, Chief Directorate: Air Quality Management.

Hruba, F., Fabianova, E., Koppova, K., & Vandenberg, J. (2001). Childhood respiratory symptoms,hospital admissions,and long-term exposure to airborne particulate matter. *Journal of Exposure Analysis and Environmental Epidemiology 11*, 33–40.

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

Naidoo, G., & Chirkoot, D. (2004). The effects of coal dust on photosynthetic performance of the mangrove, Avicennia marina in Richards Bay, South Africa. *Environmental Pollution*, 359–366.

Pope, C. (2000). Epidemiology of fine particulate air pollution and human health: biologic mechanisms and who's at risk? *Environmental Health Perspectives*, 713-723.

Pope, C., Burnett, R., Thun, M., Calle, E., Krewski, D., Ito, K., et al. (2002). Lung cancer, cardiopulmonary mortality, and long term exposure to fine particulate air pollution. . *Journal of the American Medical Association*, 1132-1141.

Ricks, G., & Williams, R. (1974). Effects of atmospheric pollution on deciduous woodland part 2: effects of particulate matter upon stomatal diffusion resistance in leaves of Quercus petraes (Mattuschka) Leibl. *Environmental Pollution*, 87–109.

Sneeringer, S. (2009). Does Animal Feeding Operation Pollution Hurt Public Health? A National Longitudinal Study of Health Externalities Identified by Geographic Shifts in Livestock Production. *American Journal of Agricultural Economics, Vol. 91, No. 1*, pp. 124-137.

Spencer, S. (2001). Effects of coal dust on species composition of mosses and lichens in an arid environment. *Arid Environments 49*, 843-853.

Tiwary, A., & Colls, J. (2010). *Air Pollution: Measurement, Modelling and Mitigation.*

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.* Report No. uMN0046-2014.

APPENDIX A - COMPREHENSIVE CURRICULUM VITAE OF THE AUTHOUR OF THE CURRENT ASSESSMENT

CURRICULUM VITAE	RENÉ VON GRUENEWALDT

FULL CURRICULUM VITAE

Name of Firm	Airshed Planning Professionals (Pty) Ltd
Name of Staff	René von Gruenewaldt (*nee* Thomas)
Profession	Air Quality Scientist
Date of Birth	13 May 1978
Years with Firm	More than 15 years
Nationalities	South African

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP)
- Member of the National Association for Clean Air (NACA)

KEY QUALIFICATIONS

René von Gruenewaldt (Air Quality Scientist): René joined Airshed Planning Professionals (Pty) Ltd (previously known as Environmental Management Services cc) in 2002. She has, as a Specialist, attained over fifteen (15) years of experience in the Earth and Natural Sciences sector in the field of Air Quality and three (3) years of experience in the field of noise assessments. As an environmental practitioner, she has provided solutions to both large-scale and smaller projects within the mining, minerals, and process industries.

She has developed technical and specialist skills in various modelling packages including the AMS/EPA Regulatory Models (AERMOD and AERMET), UK Gaussian plume model (ADMS), EPA Regulatory puff based model (CALPUFF and CALMET), puff based HAWK model and line based models. Her experience with emission models includes Tanks 4.0 (for the quantification of tank emissions), WATER9 (for the quantification of waste water treatment works) and GasSim (for the quantification of landfill emissions). Noise propagation modelling proficiency includes CONCAWE, South African National Standards (SANS 10210) for calculating and predicting road traffic noise.

Having worked on projects throughout Africa (i.e. South Africa, Mozambique, Malawi, Kenya, Angola, Democratic Republic of Congo, Namibia, Madagascar and Egypt) René has developed a broad experience base. She has a good understanding of the laws and regulations associated with ambient air quality and emission limits in South Africa and various other African countries, as well as the World Bank Guidelines, European Community Limits and World Health Organisation.

RELEVANT EXPERIENCE

Mining and Ore Handling

René has undertaken numerous air quality impact assessments and management plans for coal, platinum, uranium, copper, cobalt, chromium, fluorspar, bauxite, manganese and mineral sands mines. These include: compilation of emissions databases for Landau and New Vaal coal collieries (SA), impact assessments and management plans for numerous mines over Mpumalanga (viz. Schoonoord, Belfast, Goedgevonden, Mbila, Evander South, Driefontein, Hartogshoop, Belfast, New Largo, Geluk, etc.), Mmamabula Coal Colliery (Botswana), Moatize Coal Colliery (Mozambique), Revuboe Coal Colliery (Mozambique), Toliera Sands Heavy Minerals Mine and Processing (Madagascar), Corridor Sands Heavy Minerals Mine monitoring assessment, El Burullus Heavy Minerals Mine and processing (Egypt), Namakwa Sands Heavy Minerals Mine (SA), Tenke Copper Mine and Processing Plant (DRC), Rössing Uranium (Namibia), Lonmin platinum mines including operations at Marikana, Baobab, Dwaalkop and Doornvlei (SA), Impala Platinum (SA), Pilannesburg Platinum (SA), Aquarius Platinum, Hoogland Platinum Mine (SA), Tamboti PGM Mine (SA), Sari Gunay Gold Mine (Iran), chrome mines in the Steelpoort Valley (SA), Mecklenburg Chrome Mine (SA), Naboom Chrome Mine (SA), Kinsenda Copper Mine (DRC), Kassinga Mine (Angola) and Nokeng Flourspar Mine (SA), etc.

Mining monitoring reviews have also been undertaken for Optimum Colliery's operations near Hendrina Power Station and Impunzi Coal Colliery with a detailed management plan undertaken for Morupule (Botswana) and Glencor (previously known as Xstrata Coal South Africa).

Air quality assessments have also been undertaken for mechanical appliances including the Durban Coal Terminal and Nacala Port (Mozambique) as well as rail transport assessments including BHP-Billiton Bauxite transport (Suriname), Nacala Rail Corridor (Mozambique and Malawi), Kusile Rail (SA) and WCL Rail (Liberia).

Metal Recovery

Air quality impact assessments have been carried out for Highveld Steel, Scaw Metals, Lonmin's Marikana Smelter operations, Saldanha Steel, Tata Steel, Afro Asia Steel and Exxaro's Manganese Pilot Plant Smelter (Pretoria).

Chemical Industry

Comprehensive air quality impact assessments have been completed for NCP (including Chloorkop Expansion Project, Contaminated soils recovery, C3 Project and the 200T Receiver Project), Revertex Chemicals (Durban), Stoppani Chromium Chemicals, Foskor (Richards Bay), Straits Chemicals (Coega), Tenke Acid Plant (DRC), and Omnia (Sasolburg).

Petrochemical Industry

Numerous air quality impact assessments have been completed for Sasol (including the postponement/exemption application for Synfuels, Infrachem, Natref, MIBK2 Project, Wax Project, GTL Project, re-commissioning of boilers at Sasol Sasolburg and

Ekandustria), Engen Emission Inventory Functional Specification (Durban), Sapref refinery (Durban), Sasol (at Elrode) and Island View (in Durban) tanks quantification, Petro SA and Chevron (including the postponement/exemption application).

Pulp and Paper Industry

Air quality studies have been undertaken or the expansion of Mondi Richards Bay, Multi-Boiler Project for Mondi Merebank (Durban), impact assessments for Sappi Stanger, Sappi Enstra (Springs), Sappi Ngodwana (Nelspruit) and Pulp United (Richards Bay).

Power Generation

Air quality impact assessments have been completed for numerous Eskom coal fired power station studies including the ash expansion projects at Kusile, Kendal, Hendrina, Kriel and Arnot; Fabric Filter Plants at Komati, Grootvlei, Tutuka, Lethabo and Kriel Power Stations; the proposed Kusile, Medupi (including the impact assessment for the Flue Gas Desulphurization) and Vaal South Power Stations. René was also involved and the cumulative assessment of the existing and return to service Eskom power stations assessment and the optimization of Eskom's ambient air quality monitoring network over the Highveld.

In addition to Eskom's coal fired power stations, various Eskom nuclear power supply projects have been completed including the air quality assessment of Pebble Bed Modular Reactor and nuclear plants at Duynefontein, Bantamsklip and Thyspunt.

Apart from Eskom projects, power station assessments have also been completed in Kenya (Rabai Power Station) and Namibia (Paratus Power Plant).

Waste Disposal

Air quality impact assessments, including odour and carcinogenic and non-carcinogenic pollutants were undertaken for the Waste Water Treatment Works in Magaliesburg, proposed Waterval Landfill (near Rustenburg), Tutuka Landfill, Mogale General Waste Landfill (adjacent to the Leipardsvlei Landfill), Cape Winelands District Municipality Landfill and the Tsoeneng Landfill (Lesotho). Air quality impact assessments have also been completed for the BCL incinerator (Cape Town), the Ergo Rubber Incinerator and the Ecorevert Pyrolysis Plant.

Cement Manufacturing

Impact assessments for ambient air quality have been completed for the Holcim Alternative Fuels Project (which included the assessment of the cement manufacturing plants at Ulco and Dudfield as well as a proposed blending platform in Roodepoort).

Management Plans

René undertook the quantification of the baseline air quality for the first declared Vaal Triangle Airshed Priority Area. This included the establishment of a comprehensive air pollution emissions inventory, atmospheric dispersion modelling, focusing on impact area "hotspots" and quantifying emission reduction strategies. The management plan was published in 2009 (Government Gazette 32263).

René has also been involved in the Provincial Air Quality Management Plan for the Limpopo Province.

Other Experience (2001)

Research for B.Sc Honours degree was part of the "Highveld Boundary Layer Wind" research group and was based on the identification of faulty data from the Majuba Sodar. The project was THRIP funded and was a joint venture with the University of Pretoria, Eskom and Sasol (2001).

EDUCATION

M.Sc Earth Sciences	University of Pretoria, RSA, Cum Laude (2009) Title: *An Air Quality Baseline Assessment for the Vaal Airshed in South Africa*
B.Sc Hons. Earth Sciences	University of Pretoria, RSA, Cum Laude (2001) Environmental Management and Impact Assessments
B.Sc Earth Sciences	University of Pretoria, RSA, (2000) Atmospheric Sciences: Meteorology

ADDITIONAL COURSES

CALMET/CALPUFF	Presented by the University of Johannesburg, RSA (March 2008)
Air Quality Management	Presented by the University of Johannesburg, RSA (March 2006)
ARCINFO	GIMS, Course: Introduction to ARCINFO 7 (2001)

COUNTRIES OF WORK EXPERIENCE

South Africa, Mozambique, Malawi, Liberia, Kenya, Angola, Democratic Republic of Congo, Namibia, Madagascar, Egypt, Suriname and Iran.

EMPLOYMENT RECORD

January 2002 - Present

Airshed Planning Professionals (Pty) Ltd, (previously known as Environmental Management Services cc until March 2003), Principal Air Quality Scientist, Midrand, South Africa.

2001

University of Pretoria, Demi for the Geography and Geoinformatics department and a research assistant for the Atmospheric Science department, Pretoria, South Africa.

Department of Environmental Affairs and Tourism, assisted in the editing of the Agenda 21 document for the world summit (July 2001), Pretoria, South Africa.

1999 - 2000

The South African Weather Services, vacation work in the research department, Pretoria, South Africa.

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

- Topographical Effects on Predicted Ground Level Concentrations using AERMOD, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2011.
- Emission Factor Performance Assessment for Blasting Operations, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2009.
- Vaal Triangle Priority Area Air Quality Management Plan – Baseline Characterisation, R.G. Thomas, H Liebenberg-Enslin, N Walton and M van Nierop. National Association for Clean Air (NACA) conference, October 2007.
- A High Resolution Diagnostic Wind Field Model for Mesoscale Air Pollution Forecasting, R.G. Thomas, L.W. Burger, and H Rautenbach. National Association for Clean Air (NACA) conference, September 2005.
- Emissions Based Management Tool for Mining Operations, R.G. Thomas and L.W. Burger. National Association for Clean Air (NACA) conference, October 2004.
- An Investigation into the Accuracy of the Majuba Sodar Mixing Layer Heights, R.G. Thomas. Highveld Boundary Layer Wind Conference, November 2002.

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent
Afrikaans	Fair	Good	Good

CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications, and my experience.

10/05/2017

Signature of staff member

Date (Day / Month / Year)

Full name of staff member: René Georgeinna von Gruenewaldt

APPENDIX B - DECLARATION OF INDEPENDENCE

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: René von Gruenewaldt

Name of Registration Body: South African Council for Natural Scientific Professions

Professional Registration No.: 400304/07

Declaration of independence and accuracy of information provided:

Atmospheric Impact Report in terms of section 30 of the Act.

I, René von Gruenewaldt, declare that I am independent of the applicant. I have the necessary expertise to conduct the assessments required for the report and will perform the work relating the application in an objective manner, even if this results in views and findings that are not favourable to the applicant. I will disclose to the applicant and the air quality officer all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the air quality officer. The additional information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of this Act.

Signed at Midrand on this 28th day of June 2017

R von Gruenewaldt

SIGNATURE

Principal Air Quality Scientist

CAPACITY OF SIGNATORY