Air Quality Impact Assessment for the Kangala Colliery Co-Disposal Coal Discard Facility in Mpumalanga

Project done for **Environmental Impact Management Services (EIMS)**

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Report Details

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Reviewed by	Hanlie Liebenberg-Enslin, PhD (University of Johannesburg)
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Revision Record

Version	Date	Comments
Final	25 May 2021	For client review

Competency Profiles

Report author: R Bornman (MPhil GIS and Remote Sensing, University of Cambridge)

Rochelle Bornman has been working in the field of air pollution impact assessment and air quality management from 2008. Prior to becoming involved in air quality consultation, she worked as a GIS analyst at the Malaria Research Lead Programme in Durban. Since joining Airshed Planning Professionals she has been involved in air pollution impact studies. She presented at the NACA 2010 Annual Conference on using a spatial approach to regional air quality model verification and delivered a poster at the NACA 2011 Annual Conference on developing a spatial meteorological data repository for internal organizational use. Rochelle recently completed a Laboratory Systems Course (ISO 17025:2017) as part of the requirements towards Airshed Laboratory accreditation.

Whilst most of her working experience has been in South Africa, a number of investigations were completed in countries elsewhere, including Mali, Mozambique, Namibia, and Saudi Arabia.

The CV of Rochelle Bornman is provided in Appendix A.

Specialist Declaration

I, Rochelle Bornman, as the independent air quality specialist for the Kangala Co-Disposal Facility Project, hereby declare that I:

- acted as the independent specialist in this baseline assessment;
- performed the work relating to the study in an objective manner;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct,
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment;
- declare that there are no circumstances that may compromise my objectivity in performing such work;
- have expertise in conducting the specialist report relevant to this application;
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- have no vested interest in the proposed activity proceeding;
- undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing the decision of the competent authority; and
- all the particulars furnished by us in this specialist input/study are true and correct.

Signature of the specialist:
Name of Specialists: Rochelle Bornman
Date: 25 May 2021

NEMA Regulation (2014), Appendix 6

NEMA Regulations (2014) - Appendix 6	**Relevant section in report**
Details of the specialist who prepared the report.	Report details (page ii)
The expertise of that person to compile a specialist report including curriculum vitae.	Report details (page ii) Appendix A
A declaration that the person is independent in a form as may be specified by the competent authority.	Report details (page i)
An indication of the scope of, and the purpose for which, the report was prepared.	Introduction and background (Executive Summary) Section 1.1: Study Objective Section 1.2: Scope of Work
The date and season of the site investigation and the relevance of the season to the outcome of the assessment.	Not applicable
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Introduction and background (Executive Summary) Section 1.1: Study Objective Section 1.2: Scope of Work Section 4.2: Atmospheric Dispersion Modelling Section 12: Significance rating methodology
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 3.3: Receiving Environment Section 3.4: Existing Sources of Emissions in the Region
An identification of any areas to be avoided, including buffers.	Not applicable
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.	Not applicable
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 1.5: Limitations and Assumptions
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment.	Executive Summary Section 4.3: Impact assessment – Dispersion modelling results Section 4.4: Impact on animals and vegetation Section 5: Impact significance rating Section 7: Conclusions
Any mitigation measures for inclusion in the environmental management programme report	Section 6: Recommended air quality management measures
Any conditions for inclusion in the environmental authorisation	Section 7.2: Recommendations Section 7.3: Conclusions
Any monitoring requirements for inclusion in the environmental management programme report or environmental authorisation.	Section 6.2: Ambient monitoring Section 7.3: Conclusions
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised.	Section 7.3: Conclusions
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 environmental management programme report, and where applicable, the closure plan.	Section 6: Recommended air quality management measures
A description of any consultation process that was undertaken during the course of carrying out the study.	Not applicable
A summary and copies if any comments that were received during any consultation process.	Not applicable.

Details of the specialist who prepared the report.	Report details (page ii)

Abbreviations

AEL	Atmospheric Emissions License
Airshed	Airshed Planning Professionals (Pty) Ltd
APPA	Air Pollution Prevention Act
AQIA	Air quality Impact Assessment
AQSR	Air Quality Sensitive Receptors
ASTM	American Standard Testing Method
CE	Control efficiency
CHPP	Coal Handling and Preparation Plant
DEA	Department of Environmental Affairs (now DEFF)
DEFF	Department of Environment, Forestry and Fisheries (previously DEA)
EHS	Environmental, Health, and Safety (IFC)
EIA	Environmental Impact Assessment
EIMS	Environmental Impact Management Services
GG	Government Gazette
GHG	Greenhouse gas
GLC	Ground Level Concentration
HFO	Heavy Fuel Oil
I&APs	Interested and Affected Parties
IFC	International Finance Corporation
Kangala	Kangala Colliery
LOM	Life of Mine
Ltd	Limited
NAAQSs	National Ambient Air Quality Standards
NDCR	National Dust Control Regulations
NEMAQA	National Environment Management Air Quality Act
NPI	National Pollutant Inventory (Australia)
ROM	Run-of-mine
SAAQIS	South Africa Air Quality Information System
SABS	South African Bureau of Standards
SANS	South African National Standards
SoW	Scope of Work
US EPA	United States Environmental Protection Agency
WBG	World Bank Group
WHO	World Health Organisation

Symbols and Units

°C	Degrees Celsius
µg	Microgram(s)
µg/m^3	Micrograms per cubic meter
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
HFCs	Hydrofluorocarbons
L_{MO}	Monin-Obukhov Length
m/s	Metres per second
m^2	Metres squared
masl	Metres above sea level
mg	Milligram(s)
mg/m^2/day	Milligram per metre squared per day
mm	Millimetres
mtpa	million tons per annum
N_2O	Nitrous oxide
NOx	Oxides of nitrogen
NO_2	Nitrogen dioxide
PFCs	Perfluorocarbons
PM	Particulate Matter
PM_{10}	Thoracic particulate matter
$PM_{2.5}$	Respirable particulate matter
SF_6	Sulfur hexafluoride
SO_2	Sulfur dioxide
TSP	Total Suspended Particulate
%	Percentage

Glossary

Air pollution	This means any change in the composition of the air caused by smoke, soot, dust (including fly ash), cinders, solid particles of any kind, gases, fumes, aerosols and odorous substances
Ambient Air	This is defined as any area not regulated by Occupational Health and Safety regulations
Atmospheric emission or emission	Any emission or entrainment process emanating from a point, non-point or mobile source that results in air pollution
Averaging period	This implies a period of time over which an average value is determined
Dispersion	The spreading of atmospheric constituents, such as air pollutants
Dust	Solid materials suspended in the atmosphere in the form of small irregular particles, many of which are microscopic in size
Frequency of Exceedance	A frequency (number/time) related to a limit value representing the tolerated exceedance of that limit value, i.e. if exceedances of limit value are within the tolerances, then there is still compliance with the standard
Mechanical mixing	Any mixing process that utilizes the kinetic energy of relative fluid motion
Particulate Matter (PM)	These comprise a mixture of organic and inorganic substances, ranging in size and shape. These can be divided into coarse and fine particulate matter. The former is called Total Suspended Particulates (TSP), whilst PM_{10} and $PM_{2.5}$ fall in the finer fraction.
PM_{10}	Particulate Matter with an aerodynamic diameter less than or equal to 10 µm. it is also referred to as thoracic particulates and is associated with health impacts due to its tendency to be deposited in, and damaging to, the lower airways and gas-exchanging portions of the lung
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter less than or equal to 2.5 µm. it is also referred to as respirable particulates. It is associated with health impacts due to its high tendency to be deposited in, and damaging to, the lower airways and gas-exchanging portions of the lung
Vehicle Entrainment	This is the lifting and dropping of particles by the rolling wheels leaving the road surface exposed to strong air current in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed

Executive Summary

Universal Coal Development 1 (UCD1) wishes to apply for an environmental authorisation in support of the establishment of a new co-disposal coal discard facility[1] at Kangala Colliery (Kangala), which has been an operating mine since April 2014.

An environmental air quality specialist study was conducted in 2018 for the proposed opencast Eloff Phase 3 Project, which is the life extension of Kangala from 2020 onwards when the coal reserves at Kangala are depleted. UCD1 has recently received an Environmental Authorisation for the adjacent Eloff Colliery Extension Project in which the coal from this mining operation will be processed at the existing Kangala Colliery plant. It was assumed that the study conducted in 2018 reflects the baseline mining operations.

Airshed Planning Professionals (Pty) Ltd was appointed by Environmental Impact Management Services (EIMS), to assess the potential for air quality related impacts from the planned co-disposal facility on the surrounding environment and human health. The current document constitutes the impact assessment of the proposed study.

The main objective of the investigation is to quantify the potential impacts resulting from the proposed co-disposal facility on the surrounding environment and human health. As part of the air quality assessment, a good understanding of the regional climate and local dispersion potential of the site is necessary as well as an understanding of existing and proposed sources of air pollution in the region and the current and potential future air quality. The findings are based on the quantitative assessment of the potential impacts.

The findings from the baseline assessment can be summarised as follows:

- Particulates represent the main criteria pollutant of concern in the assessment of operations from the Project.

- The wind field is dominated by winds from the north and north-northeast with an average wind speed of 3.22 m/s. Wind speeds exceeding 5 m/s occurred for 14.4% of the time. During the day, northerly wind flow is more frequent whereas at night, north-northeasterly wind flow becomes more frequent.

- The topography of the study area is fairly flat, comprising of undulating terrain slightly increasing in height above mean sea level to the northeast of the area. An analysis of topographical data indicated a slope of less than 1:10 over most of the project area. Average total annual rainfall for the study region is in the range of 681 mm. The climate is classified as warm and temperate. The region is the coldest during August with a minimum temperature of -1.2°C during the night and warmest during January when temperatures reach 31°C during the day.

- Based on the nature of the project and expected air quality impacts, a study area of 15 km east-west by 15 km north-south, with the Project site located centrally, was selected. Air quality sensitive receptors

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[1] The new co-disposal facility was planned to accommodate coal from the neighbouring Middelbult mine as well as from Eloff Colliery but based on recent developments and planning no additional coal from Middelbult will be transported to and processed at Kangala Colliery.

(AQSR) within the study area include farmsteads, residential areas, schools, a hospital, agricultural holdings and Afgri silos.

- Existing sources of air emissions include power generation, agricultural activities, metallurgical manufacturing processes, opencast coal mining and residential fuel burning.

- The measured PM_{10} daily ground level concentrations from the Kangala PM_{10} monitoring station for the period May 2016 to July 2018 regularly exceeded the daily NAAQS. The PM_{10} annual concentrations (calculated from the daily concentrations for the monitoring period) were 46 µg/m³ (2015/2016); 23 µg/m³ (2016/2017); and 26 µg/m³ (2017/2018).

- Monitored dustfall levels at the UD-003 monitoring station exceeded the residential limit of 600 mg/m²/day more than twice per year, and for sequential months, during the 2015/2016, 2016/2017, and 2017/2018 sampling periods. This may be due to its close proximity to the R42 road.

- The Project is located within the Highveld Priority Area, in close proximity to Leeuwpan and Stuart (opencast) collieries.

To determine the significance of air pollution impacts from the proposed Project, two scenarios were taken into account:

- **Baseline scenario (Scenario 1)** – representative of maximum throughput from opencast mining activities at the Eloff Project area (in the year 2026), with discard throughput and site design as used in the 2018 study; and
- **Project scenario (Scenario 2)** – representative of maximum throughput from opencast mining activities at the Eloff Project area (in the year 2026), with additional activities in the form of windblown dust from the new co-disposal facility, truck activity on onsite unpaved roads (transporting coarse discard and slurry to the co-disposal facility); and materials handling at the CHPP and new co-disposal facility. Waste and ROM throughputs were assumed to be the same as that used in the baseline scenario, but a higher volume of discard was used according to the latest information that was provided. Additional roads and waste stockpiles were identified from the latest site design that was provided and included in the model.

The baseline scenario emissions and impacts were used from the 2018 study and no remodelling was done. Emission equations were used to quantify emissions from the proposed activities (Scenario 2) and both unmitigated and mitigated activities were assessed. Each of the baseline and project scenarios had 3 sub-scenarios, namely (a) unmitigated operations, (b) design mitigated operations and (c) additionally mitigated operations.

Estimated emissions were higher for the Project scenario than for the Baseline scenario due to the updating of the model to include the latest information (discard throughput and additional sources identified from the latest site layout). Emissions due to materials handling were also slightly higher because of higher wind speeds in the meteorological dataset that was used. (Meteorological data for 2015 to 2017 were used in the model to comply with Regulations for Dispersion Modelling, whereas the previous dataset spanned the period 2014 to 2016).

The main findings for the Project Scenario (proposed co-disposal facility) were as follows:

- The daily **PM_{10}** SA NAAQS was exceeded at all AQSRs (27) for unmitigated activities. For the design mitigated scenario, simulated PM_{10} concentrations exceeded the daily SA NAAQS at 6 AQSRs. With additional mitigation, non-compliances were still simulated at 3 AQSRs. Over an annual average unmitigated PM_{10} impacts exceeded the annual NAAQS at 2 AQSRs. These impacts were reduced when design mitigation is applied, with exceedances simulated at only one AQSR and no exceedances for additionally mitigated activities.
- **$PM_{2.5}$** daily GLCs, with no mitigation in place, were in non-compliance with the 2030 NAAQSs at 4 AQSRs. Simulated impacts were reduced when design mitigation is applied with exceedance of the 2030 NAAQS simulated at two AQSRs. With additional mitigation, simulated $PM_{2.5}$ daily GLCs were within compliance at all AQSRs. Over an annual average design mitigated simulated GLCs and additionally mitigated GLCs, were within compliance currently and after 2030.
- The simulated maximum daily **dustfall** rates due to the unmitigated scenario exceeded the NDCR for residential areas at only one AQSR. Simulated dustfall rates at all AQSRs were well within the residential limit for the design mitigated and additionally mitigated scenarios.
- Both Baseline and Project operations resulted in **High** significance for design mitigated operations and **Medium** significance for additionally mitigated operations. The highest PM_{10} and $PM_{2.5}$ impacts were mainly due to vehicle entrained dust from unpaved roads, whereas the highest dustfall impacts were due to windblown dust.

Simulated results from the impact assessment due to the Baseline and Project did not show any significant differences with respect to compliance of PM_{10} and $PM_{2.5}$ ground level concentrations with the SA NAAQS and compliance of simulated dustfall levels with the NDCR for residential areas. Simulated footprint areas of exceedance for PM_{10} and $PM_{2.5}$ impacts due to Project operations were slightly bigger than those due to Baseline operations. Two additional AQSRs were included in the model to assess impacts at Eloff Landgoed and Eloff Silo.

As there aren't any air quality limits for chickens or crops, impacts at the Eloff Landgoed and AFGRI sites had to be screened against the NAAQSs. Simulated dustfall rates at the closest AFGRI site were very low, which suggests that the grain from the AFGRI silos and the crops at the nearby Eloff Landgoed will not be adversely affected by the proposed development.

Recommendations

The proposed Eloff Project is located within the Highveld Priority Area and close to various mining and power generation sources. The management plan objectives for this priority area are to minimise impacts on the surrounding environment. It is therefore recommended that air quality management measures be implemented to ensure the lowest possible impacts on the surrounding environment from the mining operations. These measures should include:

- Implementation and monitoring of design mitigation measures. Additional mitigation measures are recommended to ensure mining related impacts remain within the Mine License Area. Based on the ranking of the main sources, these include:
    - Frequent water sprays (> 2 litres/m²/hr) on the in-pit roads to ensure a control efficiency of at least 75% and chemical suppressants on the unpaved haul roads to ensure a control efficiency of more than 90%;
    - Temporary wind breaks to be installed onto the topsoil stockpile (30% control efficiency) and vegetation cover to be established on the dormant areas and side slopes (40% control efficiency) (NPI, 2011).
- To ensure the impacts on the surrounding environment and human health remain acceptable throughout the Life of Mine (LoM), 3 dustfall units are recommended to be added to the existing dustfall monitoring network. Should dustfall at the Delmas residential receptor (EL-003) exceed the NDCR, it is recommended that a 3-month PM_{10} sampling campaign be undertaken to assess whether a permanent PM_{10} sampler should be installed.

Conclusions

The planned operations would likely not have a significant *incremental* impact (over and above the baseline) on the surrounding environment and human health during the operational phase, provided additional mitigation measures are applied. The application of additional mitigation on haul roads is recommended to ensure that people (and livestock) not be exposed to ambient air quality that may be harmful to human health. The low dustfall rates that were simulated at the closest AFGRI site suggests that the grain from the AFGRI silos and the crops at the nearby farms will not be affected adversely by the proposed development.

Table of Contents

List of Tables

List of Figures

1 Introduction

Universal Coal Development 1 (UCD1) wishes to apply for an environmental authorisation in support of the establishment of a new co-disposal coal discard facility at Kangala Colliery (Kangala). Kangala has been an operating mine since April 2014. Kangala Colliery is located 65 km due east of Johannesburg and 8.0 km south-west of the town of Delmas, in the Victor Khanye Local Municipality and the Nkangala District Municipality, Mpumalanga Province (Figure 1).

An environmental air quality specialist study was conducted in 2018 for the opencast Eloff Phase 3 Project, which is the life extension of Kangala from 2020 onwards when the coal reserves at Kangala have been depleted. The Eloff Project mining area is contiguous to the Kangala area and is situated close to the R42 provincial road and to the south of the R555 road. The mine uses a standard truck and shovel mining method based on strip mining design and layout.

UCD1 has recently received an Environmental Authorisation for the adjacent Eloff Colliery Extension Project (MP 30/5/1/2/3/2/1 (10169) EM) in which the coal from this mining operation will be processed at the existing Kangala Colliery plant. As a result of the additional volume of coal from Eloff Colliery to be processed on Kangala, the existing coal co-disposal facility will reach capacity in approximately 12-13 months. As such, a new coal co-disposal discard facility is required that will accommodate the expansion of the mining into the neighbouring Eloff block mine. UCD1 now proposes the establishment of a new co-disposal coal discard facility to the north of the CHPP.

The proposed activities will result in air quality impacts in the study area. Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Environmental Impact Management Services (EIMS) to undertake an environmental air quality specialist study for the project as part of the Environmental Impact Assessment (EIA) process. The air quality investigation comprises both a baseline study and an impact assessment.

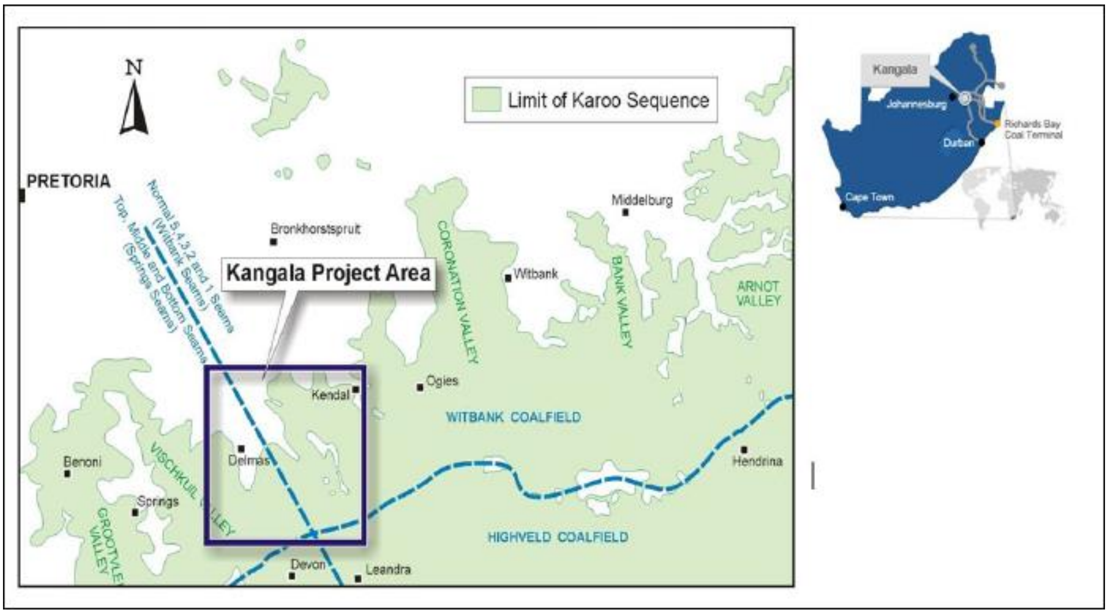

Figure 1: Study area

1.1 Study Objective

The main objective of the investigation is to quantify the potential impacts resulting from the proposed activities on the surrounding environment and human health. As part of the air quality assessment, a good understanding of the regional climate and local dispersion potential of the site is necessary as well as an understanding of existing sources of air pollution in the region and the current and potential future air quality and subsequently an understanding of existing and proposed sources of air pollution in the region and the resulting air quality.

The location of the proposed co-disposal facility (relative to the CHPP and existing co-disposal facility) is provided in Figure 2.

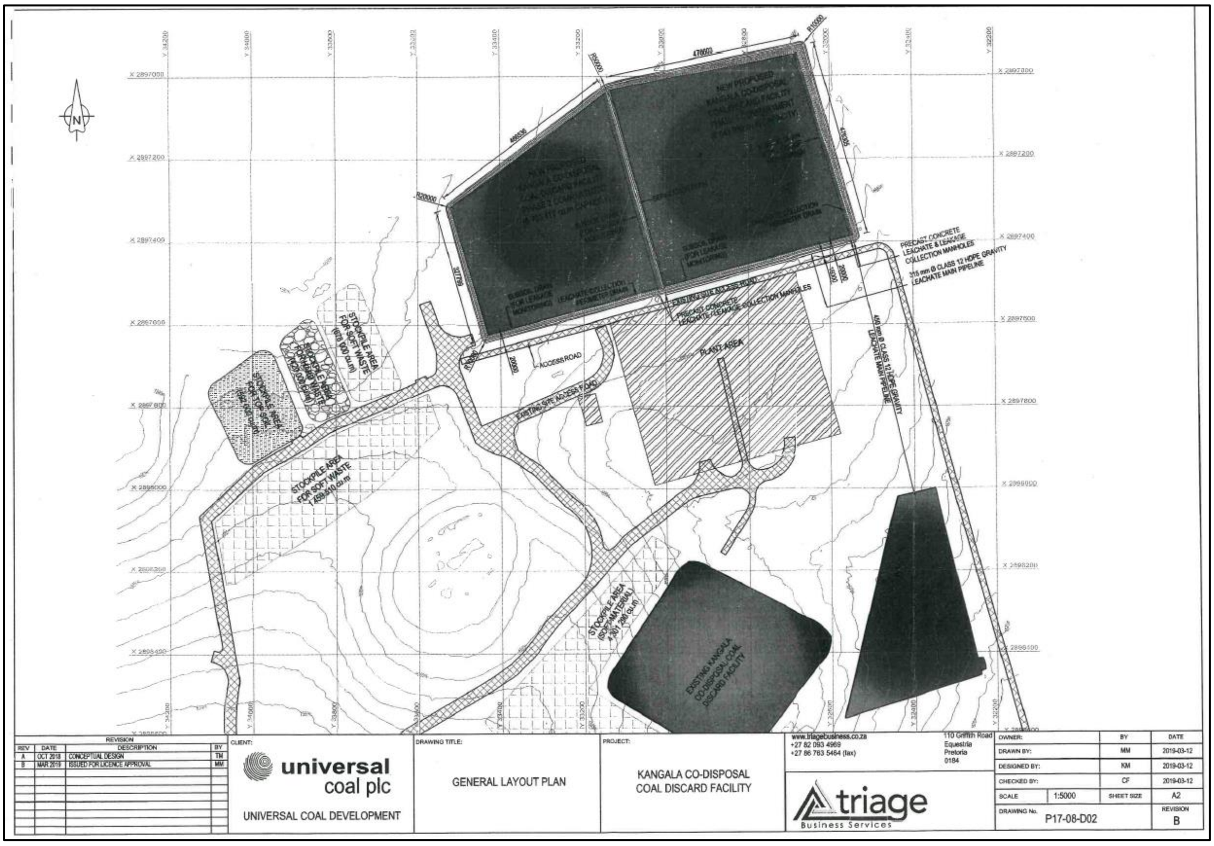

Figure 2: Location of the proposed co-disposal facility

1.2 Scope of Work

Based on the required scope, the following tasks have been identified to be covered as part of the impact assessment:

- A study of the receiving environment by referring to:
  - Desktop review of all available project and associated data, including meteorological data, previous air quality assessments, EIAs and technical air quality data and modelling.

  - Details on the physical environment i.e. meteorology (atmospheric dispersion potential), land use and topography The meteorological dataset used in the 2018 assessment – MM5 modelled data for the study site, 2014 to 2016, was updated to include an extra year (2017).
  - Identification of existing air pollution sources (other mines; power stations; industries; etc.).
  - Identification of air quality-sensitive receptors, including any nearby residential dwellings and proposed receptors (temporary or permanent workers accommodation site(s)) in the vicinity of the mine.
  - Any and all freely available ambient air quality data for PM (PM_{10}, $PM_{2.5}$ and TSP).

The following tasks were included in the analysis and impact assessment:

- Development of comprehensive atmospheric source and emissions inventory, including:
  - Source descriptions;
  - Source locations;
  - Emission rates and the methodology/emission factors used (pollutants to include PM_{10}, $PM_{2.5}$, and TSP).
- Atmospheric dispersion simulations using the United States Environmental Protection Agency's regulatory AERMOD modelling suite.
- Human health, nuisance, and environmental impact screening.
- A qualitative cumulative air quality assessment.
- Development of an air quality management, mitigation, and monitoring plan.
- A specialist air quality impact report.

1.3 Process Description

The proposed co-disposal facility will form part of the current mining activities at Kangala Colliery, which includes opencast mining and coal processing to deliver coal destined for the export and domestic markets. A detailed description of mining and processing activities at Kangala Colliery is given in Appendix B. A brief process description is provided below.

- The ROM coal from the Eloff opencast area is hauled to the existing ROM tip and the stockpile at the CHPP via the haul road that joins the Eloff opencast pit with the existing Kangala haul road to the west of the CHPP (see Figure 3).
- The Kangala CHPP consists of two processes:
  - Crush and Screen: High-quality raw coal is directly crushed and screened to the final Eskom product.
  - Dense medium separation (DMS) plant: Lower raw quality coal is crushed, screened, and then washed to produce a higher-grade coal that can be blended with the raw product to produce the final Eskom product.
- There is an existing discard dump to the east of the CHPP to store the discard coal separated during the washing plant process. The discard is hauled by road to this discard dump for placement and compaction (Figure 3).

1.4 Description of Activities from an Air Quality Perspective

Particulates represent the main criteria pollutant of concern in the assessment of operations from the Project. Airborne particulate matter comprises a mixture of organic and inorganic substances, varying in size, shape and density. These can be divided into Total Suspended Particulates (TSP), thoracic particles or PM_{10} (particulate matter with an aerodynamic diameter of less than 10 µm) and respirable particles or $PM_{2.5}$ (particulate matter with an aerodynamic diameter of less than 2.5 µm). PM_{10} and $PM_{2.5}$ are associated with health impacts; TSP is associated with nuisance caused by dust fallout (Colls, 2002). For the current assessment, the impacts were assessed against published PM_{10} and $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS) and Dust Control Regulations (NDCR).

Gaseous and particulate emissions are expected to arise from construction activities. Typical sources of the fugitive emissions likely to occur during the construction of the co-disposal facility are listed in Table 1.

Table 1: Typical sources of fugitive emissions associated with construction

Impact	Source	Activity
Gases	Vehicle tailpipe	Transport and general construction activities
Dustfall, PM_{10} and $PM_{2.5}$	Establishment of co-disposal facility	Construction of overburden and topsoil stockpiles and co-disposal facility, vehicle activity, wind erosion from open areas

Each of the operations in Table 1 has their own duration and potential for dust generation. The impacts are likely to be localised and will depend on the dispersion potential of the site.

The following operations at the open pit and CHPP (**baseline scenario**) are likely to result in atmospheric emissions:

- Drilling of waste rock and ROM;
- Blasting of waste rock and ROM;
- Truck and shovel operations in-pit;
- Hauling of ROM coal on unpaved roads;
- Primary and secondary crushing at the crushing and screening plant;
- Primary and secondary crushing at the DMS plant;
- Material transfer via conveyors to Eskom product stockpile from the crushing and screening plant;
- Material transfer via conveyors to Eskom product stockpile and export product stockpile from the DMS plant (wet process);
- Reclamation of coal from product stockpiles via frontend loader and loading to haul trucks; and
- Off-site hauling of product via the access road to the R42.

The co-disposal facility (**project scenario**) would likely result in the following additional activities:

- Windblown dust from the new co-disposal facility;
- Truck activity on onsite unpaved roads (transporting coarse discard and slurry to the co-disposal facility); and
- Materials handling at the CHPP and new co-disposal facility.

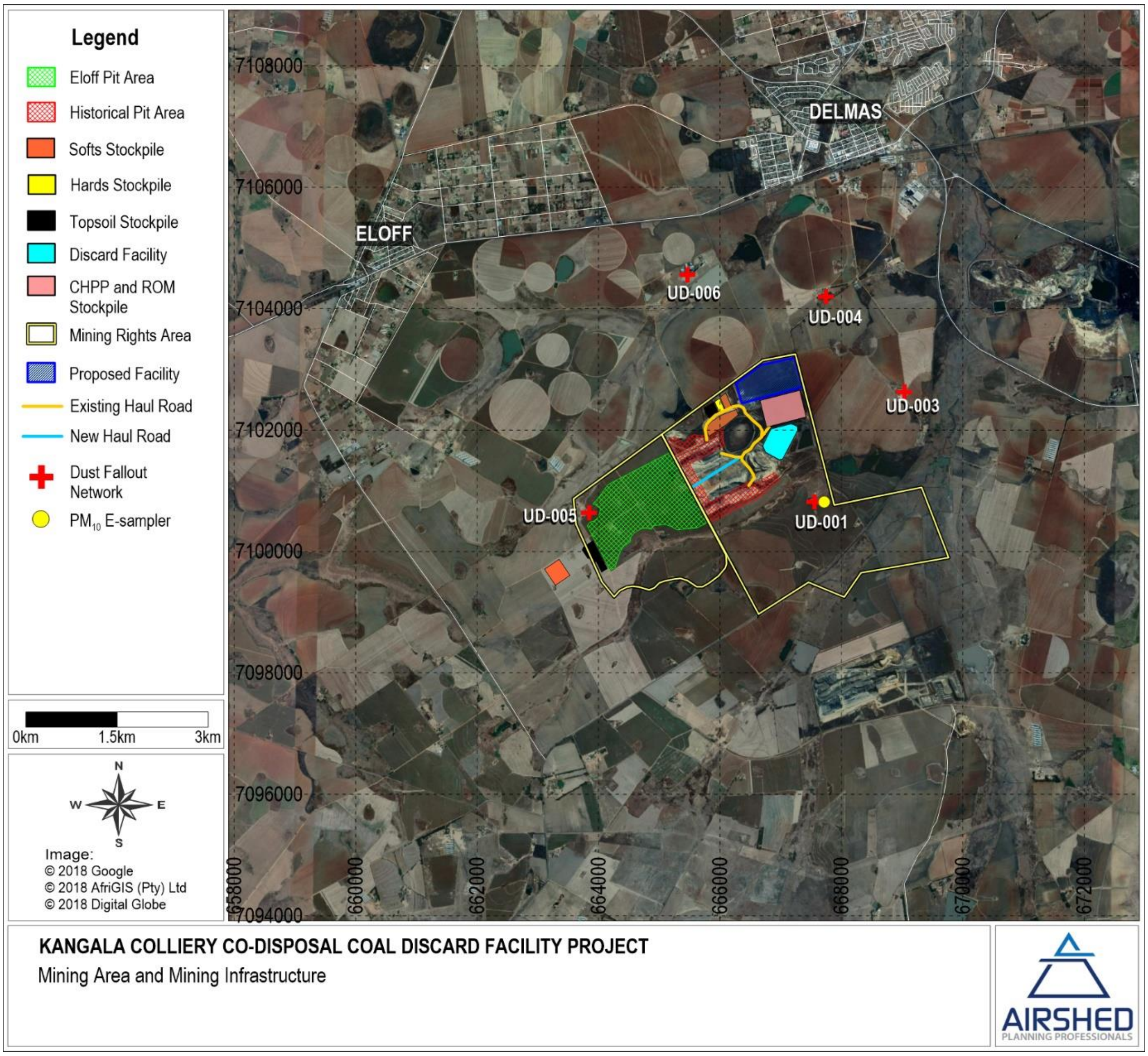

Figure 3: Site layout

1.5 Limitations and Assumptions

1. It is assumed that the ROM and waste material throughput as used in the 2018 Eloff investigation are the same, and that the 2018 study may be used as the baseline scenario.
2. For the Project scenario, the most recently provided discard throughput and site design (including topsoil, soft waste and hard waste stockpiles, roads, and the new co-disposal facility) were used to quantify emissions and assess the addition to the cumulative impacts.
3. Meteorology:

   a. In the absence of on-site meteorological data (that is required for atmospheric dispersion modelling), use was made of MM5 modelled meteorological data for the study site for the period 2015-2017.
   b. The National Code of Practice for Air Dispersion Modelling prescribes the use of a minimum of one-year on-site data or at least three years of appropriate off-site data for use in Level 2 assessments. It also states that the meteorological data must be for a period no older than five years to the year of assessment. The data set applied in this study complies with the requirements of the code of practice.
4. Baseline air quality: A discussion of baseline air quality included analyses of on-site monitoring data for the period April 2015 to July 2018 (PM_{10}) and January 2015 to June 2018 (dustfall).
5. There will always be some error in any geophysical model; however, modelling is recognised as a credible method for evaluating impacts, but it is desirable to structure the model in such a way to minimise the total error. A model represents the most likely outcome of an ensemble of experimental results. The total uncertainty can be thought of as the sum of three components: the uncertainty due to errors in the model physics; the uncertainty due to data errors; and the uncertainty due to stochastic processes (turbulence) in the atmosphere.

2 Regulatory Requirements and Impact Assessment Criteria

Prior to assessing the impact of proposed activities on human health and the environment, reference needs to be made to the environmental regulations governing the impact of such operations; i.e. air emission standards, ambient air quality standards, and dust control regulations.

Air quality legislation that is relevant to the project is provided in Table 2.

Table 2: Legislation applicable to the project

Air Quality Legislation	Implementation/ revision dates	Reference	Affected Project Activity
National Framework	Second Generation 2013 Third Generation 2018	Government Gazette (GG) 37078, 29 Nov 2013 GG 41996 of 26 Oct 2018	Industry legal responsibilities
Section 21 – Listed Activities	Implemented: 1 April 2010 Revised: 2013 Amendments: 2015 and 2018	GG 37054, 22 Nov 2013 GG 38863, 12 Jun 2015	N.A. – no Listed Activity planned
National Ambient Air Quality Standards (NAAQS)	24 December 2009 29 July 2012	GG 32816, 24 Dec 2009 GG 35463, 29 Jun 2012	SO_2, NO_2, CO, PM_{10} and $PM_{2.5}$ ground level concentrations as a result from the mining activities
National Dust Control Regulations (NDCR)	1 November 2013	GG 37054, 22 Nov 2013	Dust fallout rates as a result from the mining activities
National Atmospheric Emission Reporting Regulations (NAERR)	2 April 2015	GG 3863, 2 Apr 2015	Emissions reporting on mining operations
Regulation on Administrative Fines and Air quality offsets guideline	18 March 2016	GG 39833, 18 Mar 2016	N.A. – no Listed Activity planned
Declaration of Greenhouse Gases (GHG) as Priority Air Pollutants	Draft in 2016	GG 40996, 21 Jul 2017	N.A.(a)
National Pollution Prevention Plans (PPP) Regulations	Draft in 2016 Final 2017	GG 40996, 21 Jul 2017	N.A.(a)
National Greenhouse Gas (GHG) Emission Reporting Regulations	3 April 2017	GG 40762, 3 Apr 2017	Mining and quarrying to report on all stationary combustion emissions above 10 MW(th)

Notes: (a) only apply to direct emission of GHG in excess of 0.1 Megatonnes (Mt) annually measured as carbon dioxide equivalents (CO_2-eq)

2.1 National Framework

The National Framework (first published in Government Gazette Notice No. 30284 of 11 September 2007) was updated in 2013) and provides national norms and standards for air quality management to ensure compliance. The National Framework states that aside from the various spheres of government's responsibility towards good air quality, industry too has a responsibility not to impinge on everyone's right to air that is not harmful to health and well-being. Industries therefore should take reasonable measures to prevent such pollution order degradation from occurring, continuing or recurring.

In terms of AQA, certain industries have further responsibilities, including:

- Compliance with any relevant national standards for emissions from point, non-point or mobile sources in respect of substances or mixtures of substances identified by the Minister, MEC or municipality.
- Compliance with the measurement requirements of identified emissions from point, non-point or mobile sources and the form in which such measurements must be reported and the organs of state to whom such measurements must be reported.
- Compliance with relevant emission standards in respect of controlled emitters if an activity undertaken by the industry and/or an appliance used by the industry is identified as a controlled emitter.
- Compliance with any usage, manufacture or sale and/or emissions standards or prohibitions in respect of controlled fuels if such fuels are manufactured, sold or used by the industry.
- Comply with the Minister's requirement for the implementation of a pollution prevention plan in respect of a substance declared as a priority air pollutant.
- Comply with an Air Quality Officer's legal request to submit an atmospheric impact report in a prescribed form.
- Taking reasonable steps to prevent the emission of any offensive odour caused by any activity on their premises.
- Furthermore, industries identified as Listed Activities have further responsibilities, including:
  - Making application for an Atmospheric Emissions License (AEL) and complying with its provisions.
  - Compliance with any minimum emission standards in respect of a substance or mixture of substances identified as resulting from a listed activity.
  - Designate an Emission Control Officer **if** required to do so.
  - Section 51 of the Air Quality Act lists possible offences according to the requirements of the Act with Section 52 providing for penalties in the case of offences.

2.2 National Standards

2.2.1 Emission Standards

The NEMAQA (Act No. 39 of 2004 as amended) (DEA, 2005) mandates the Minister of Environment to publish a list of activities which result in atmospheric emissions and consequently cause significant detrimental effects on the environment, human health and social welfare. All scheduled processes as previously stipulated under the Air Pollution Prevention Act (APPA) (Dept of Labour, 1993) are included as listed activities with additional activities added to the list. The updated Listed Activities and Minimum National Emission Standards (MES) were published on the 22nd November 2013 (Government Gazette No. 37054). An amendment to this Act was published in June 2015, and further amendments in October 2018.

According to the Project description, none of the Project activities trigger the MES's nor the need for an AEL application.

2.2.2 Ambient Air Quality Standards for Criteria Pollutants

Criteria pollutants are considered those pollutants most commonly found in the atmosphere, that have proven detrimental health effects when inhaled and are regulated by ambient air quality criteria. These include CO, NO_2, SO_2, $PM_{2.5}$ and PM_{10}. The pollutant of concern in this study is particulate matter.

The South African Bureau of Standards (SABS) assisted the DEA (now DEFF) in the development of ambient air quality standards. NAAQS were determined based on international best practice for PM_{10}, $PM_{2.5}$, dustfall, SO_2, NO_2, O_3, CO, lead and benzene.

The final revised NAAQSs were published in the Government Gazette on 24 of December 2009 (DEA, 2009) and in some instances included a margin of tolerance and linked implementation timelines. NAAQSs for $PM_{2.5}$ were published on 29 June 2012 (DEA, 2012). NAAQSs for the criteria pollutants assessed in this study are listed in Table 3. Currently, only $PM_{2.5}$ has a margin of tolerance, which is applicable until 31 December 2029. Short-term standards (daily) are represented by a limit value based on the 99th percentile of the observation (or simulated concentration) for that averaging period.

With the main pollutants of concern being particulates, the NAAQSs applicable to PM_{10} and $PM_{2.5}$ are provided in Table 3.

Table 3: Air quality standards for specific criteria pollutants (NAAQS)

Pollutant	Averaging Period	Limit Value (µg/m³)	Frequency of Exceedance	Compliance Date
PM_{10}	24-hour	75	4	1 Jan 2015
	1 year	40	0	1 Jan 2015
$PM_{2.5}$	24-hour	40	4	1 Jan 2016 – 31 Dec 2029
		25	4	1 Jan 2030
	1 year	20	0	1 Jan 2016 – 31 Dec 2029
		15	0	1 Jan 2030

2.2.3 National Dust Control Regulations

The NDCR were published on the 1st of November 2013 (DEA, 2013). The purpose of the regulations is to prescribe general measures for the control of dust from areas operations identified by a local Air Quality Officer as potentially causing a nuisance. Acceptable dustfall rates for residential and non-residential areas according to the regulation is summarised in Table 4.

Table 4: Acceptable dustfall rates

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

Limited information is available on the impact of dust on vegetation and grazing quality. While there is little direct evidence of the impact of dustfall on vegetation in the 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 dustfall rates greater than 400 mg/m^2/day (Farmer, 1993). In addition, there is anecdotal evidence to indicate that over extended periods, high dustfall levels in grazing lands can soil vegetation and this can impact the teeth of livestock (Farmer, 1993).

The regulation also specifies that the method to be used for measuring dustfall and the guideline for locating sampling points shall be American Standard Testing Method (ASTM, 1970)[2], or equivalent method approved by any internationally recognized body. It is important to note that dustfall is assessed for nuisance impact and not inhalation health impact.

2.3 National Atmospheric Emission Reporting Regulations (NAERR)

The National Atmospheric Emission Reporting Regulations (NAERR) was published on the 2nd of April 2015 by the Minister of Environmental Affairs. The regulation aims to standardize the reporting of data and information from an identified point, non-point and mobile sources of atmospheric emissions to an internet-based National Atmospheric Emissions Inventory System (NAEIS), towards the compilation of atmospheric emission inventories (DEA , 2015).

Annexure 1 of the NAERR classifies **mines** (holders of a mining right or permit in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002)) as a data provider under **Group C**. **Listed Activities** as published in terms of Section 21(1) of the AQA falls under **Group A**.

Sections of the regulation that applies to data providers are summarized below.

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[2] ASTM 1739:70 is a previous version of ASTM 1739 which did not prescribe a wind shield around the opening of the bucket; the addition of a wind shield is intended to deflect wind away from the lip of the container, allowing for a more laminar flow across the top of the collecting container (Kornelius *et al.*, 2015). SANS 1929-2004 does, however, refer to ASTM 1739-98 (ASTM, 1998), which has a wind shield. The latest draft of the NDCR stipulates the latest version of D1738. It has not been propagated but is expected early 2020.

With regards to registration, the regulation stipulates that:

(a) A person classified as a data provider must register on the NAEIS within 30 days from the date upon which these Regulations came into effect;

(b) A person classified as a data provider and who commences with an activity or activities classified as emission source in terms of the regulation 4(1) after the commencement of these Regulations, must register on the NAEIS within 30 days after commencing with such an activity or activities.

With regards to reporting and record keeping, the regulation stipulates that:

(a) A data provider must submit the required information for the preceding calendar year, as specified in Annexure 1 to the Regulations, to the NAEIS by 31 March of each calendar year.

(b) A data provider must keep a record of the information submitted to the NAEIS for five years and such record must, on request, be made available for inspection by the relevant authority.

With regards to verification of information, the regulation requires data providers to verify requested information within 60 days after receiving the written request from the relevant authority.

2.4 Regulations Regarding Air Dispersion Modelling

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to assess 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 NEMAQA;

b) in the development of a priority area air quality management plan, as contemplated in section 19 of the NEMAQA;

c) in the development of an atmospheric impact report, as contemplated in section 30 of the NEMAQA; and,

d) in the development of a specialist air quality impact assessment study, as contemplated in Chapter 5 of the NEMAQA.

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 clear 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 project falls under a Level 2 assessment – which is described as follows:

- The distribution of pollutant concentrations and deposition 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 kilometers (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 Regulation prescribe the source data input to be used in the model. 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.

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

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.

The modelling domain would normally be decided on the expected zone of influence; the extent being defined by simulated 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 should however be located within the property line as health and safety legislation (rather than ambient air quality standards) is applicable within the site.

Chapter 5 provides general guidance on geophysical data, model domain and coordinates system requirements, whereas Chapter 6 elaborates more on these parameters as well as the inclusion of background air pollutant concentration data. Chapter 6 also provides guidance on the treatment of NO_2 formation from NOx emissions, chemical transformation of SO_2 into sulphates and deposition processes.

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

2.5 Highveld Priority Area

The Highveld Airshed was declared the second priority area by the minister at the end of 2007. This required that an Air Quality Management Plan for the area be developed. The plan includes the establishment of an emissions reduction strategies and intervention programmes based on the findings of a baseline characterisation of the area.

The implication of this is that all contributing sources in the area will be assessed to determine the emission reduction targets to be achieved over the following few years.

The project area is located within the footprint demarcated as the Highveld Priority Area. Emission reduction strategies will be included for the numerous coal mines in the area with specific targets. The DEA published the management plan for the Highveld Priority Area in September 2011. Included in this management plan are seven goals, each of which has a further list of objectives that must be met. The 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 NAAQSs and NDCR 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 Project. 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 dustfall limit value exceedances as a result of industrial emissions are assessed; and,
- A line of communication exists between industry and communities.

Each of these objectives is further divided into activities, each of which have a timeframe, responsibility and indicator. Refer to the DEA (2011) Highveld Priority Management Plan for further details[3].

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[3] This document can be downloaded from the SAAQIS website: www.saaqis.org.za

3 Description of the Receiving Environment

This chapter provides details of the receiving environment which is described in terms of:

- A study of the atmospheric dispersion potential of the area;
- The identification of Air Quality Sensitive Receptors (AQSRs) from available maps;
- The identification of existing sources of emissions in the study area; and
- The analysis of all available ambient air quality information/data.

3.1 Atmospheric Dispersion Potential

Physical and meteorological mechanisms govern the dispersion, transformation, and eventual removal of pollutants from the atmosphere. The analysis of hourly average meteorological data is necessary to facilitate a comprehensive understanding of the dispersion potential of the site. Parameters useful in describing the dispersion and dilution potential of the site i.e. wind speed, wind direction, temperature and atmospheric stability, are subsequently discussed.

In the absence of on-site meteorological data (that is required for atmospheric dispersion modelling), use was made of MM5[4] modelled meteorological data for the study site for the period 2015-2017.

Ambient monitoring data (PM_{10} concentrations and dust fallout levels) in the Project area is available for the period 2015-2018. Potential air quality sensitive receptors (AQSRs) were identified from Google Earth imagery. Additional receptors were included to assess impacts at Afgri Silos and at the adjacent landowner's property (Eloff Agricultural Holdings).

3.1.1 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. 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 (DEA, 2014) suggest that all wind speeds greater

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[4] MM5 is a widely-used three-dimensional numerical meteorological model which contains non-hydrostatic dynamics, a variety of physics options for parameterizing cumulus clouds, microphysics, the planetary boundary layer and atmospheric radiation. MM5 has the capability to perform Four Dimensional Data Assimilation (FDDA), and are able to simulate a variety of meteorological phenomena such as tropical cyclones, severe convective storms, sea-land breezes, and terrain forced flows such as mountain valley wind systems.

than or equal to the anemometer starting threshold and less than 1 m/s be replaced with the value of 1 m/s. This approach has been adopted.

The period wind field and diurnal variability in the wind field from the modelled MM5 data are shown in Figure 4 and Figure 5, while the seasonal variations in the wind field are provided in Figure 6. During the 2015 to 2017 period, the wind field was dominated by strong winds from the north, and north-northeast. The strongest winds (more than 6 m/s) were recorded from the north-northwest, north and north-northeast, occurring mostly during the day (06:00 to 18:00). An increase in dominant winds from the north-northeast occurred at night (18:00 to 06:00).

Seasonal wind fields vary - during spring and summer the dominant winds are from the north and north-northeast, with very little wind from the south, whereas the autumn and winter seasons are dominated by northerly winds with an increase in winds from the south and the east.

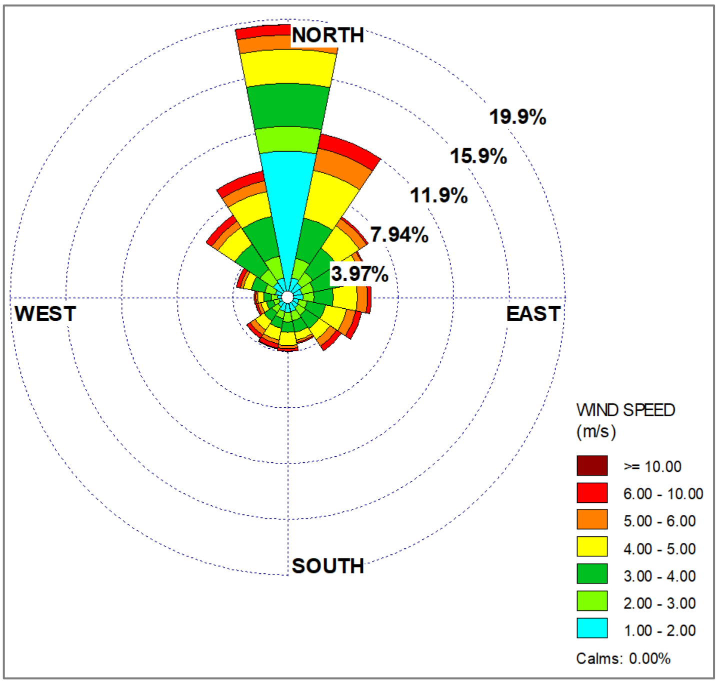
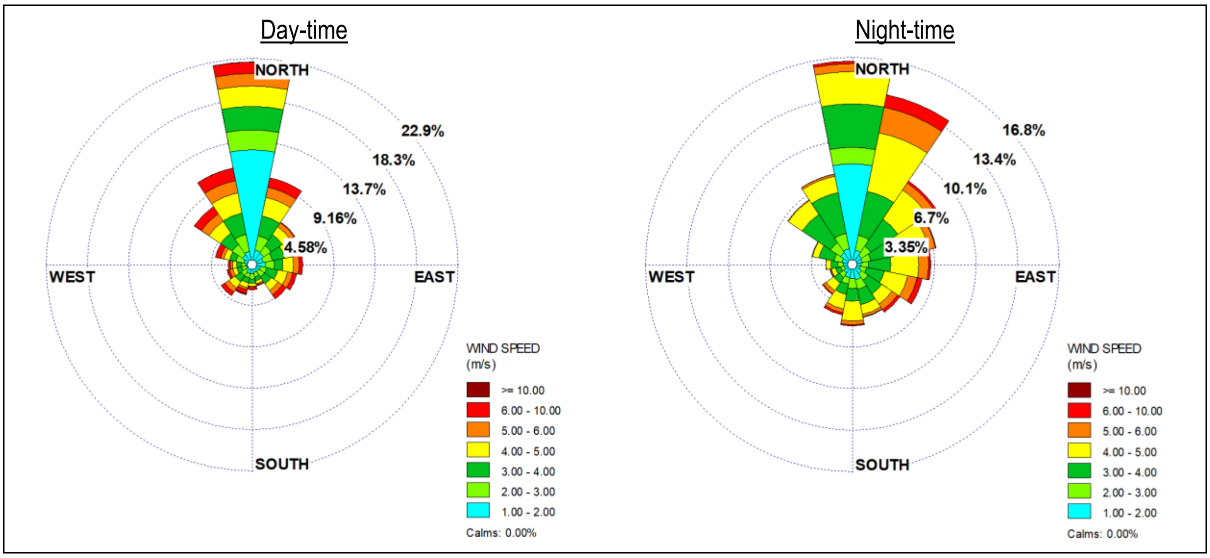


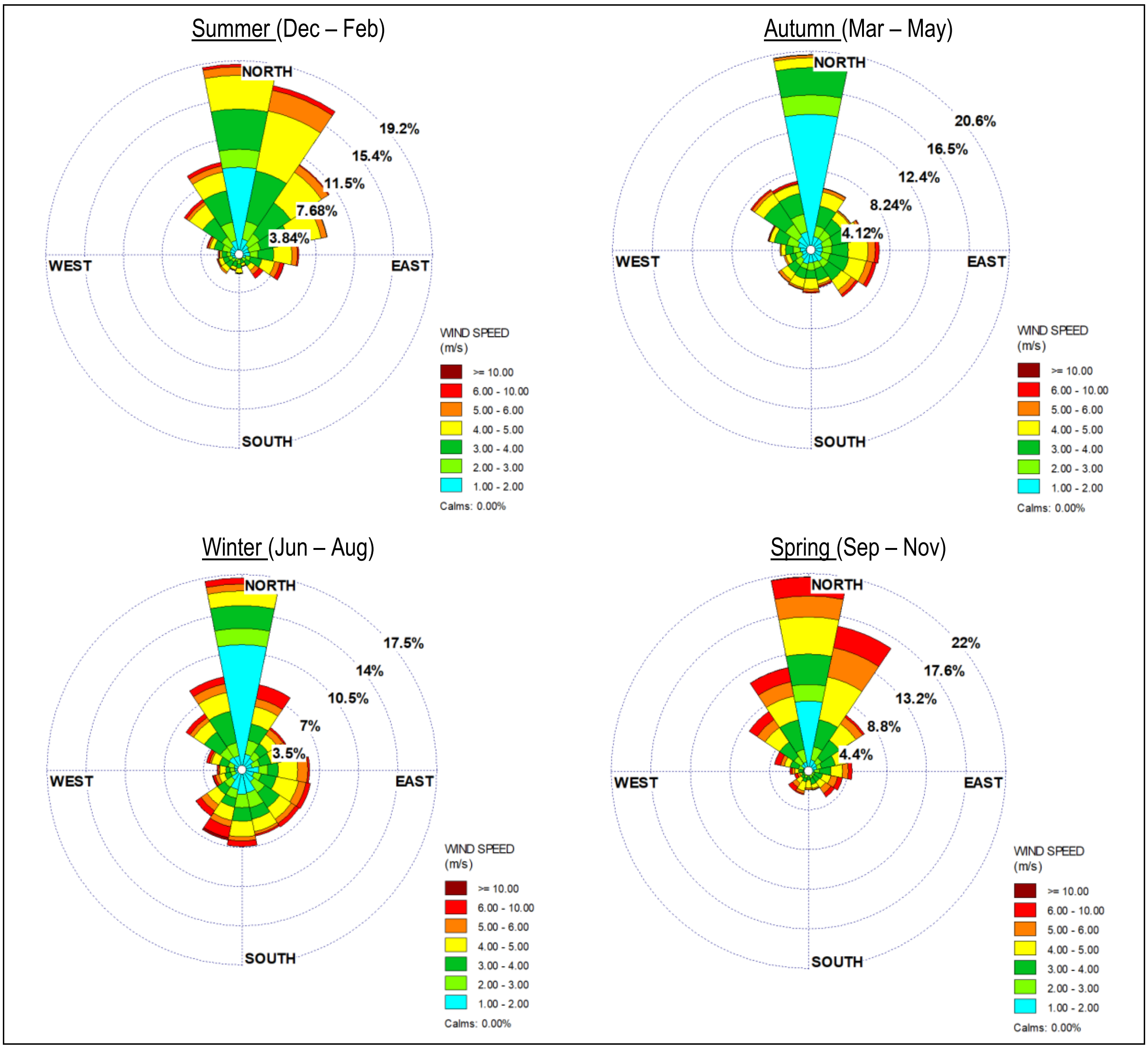
Figure 4: Period average wind rose (MM5 modelled data for the study site, 2015 to 2017)



Day-time

Night-time

Figure 5: Day-time and night-time wind roses (MM5 modelled data for the study site, 2015 to 2017)



Summer (Dec – Feb)

Autumn (Mar – May)

Winter (Jun – Aug)

Spring (Sep – Nov)

Figure 6: Seasonal wind roses (MM5 modelled data for the study site, 2015 to 2017)

3.2 Topography

Changes in terrain around an air pollution source can significantly influence the way the plume is dispersed. Hills or rough terrain influence the wind speed, wind direction and turbulence characteristics. Significant valleys can cause persistent drainage flows and restrict horizontal movement whereas sloping terrain may help provide katabatic or anabatic flows. The topography of the study area is fairly flat, comprising of undulating terrain slightly increasing in height above mean sea level to the northeast of the area. An analysis of topographical data indicated a slope of less than 1:10 from over most of the project area. Dispersion modelling guidance recommends the inclusion of topographical data in dispersion simulations only in areas where the slope exceeds 1:10 (US EPA, 2004).

3.2.1 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 diurnal temperature profile for the site is given in Figure 7 and the monthly mean and hourly maximum and minimum temperatures are given in Table 5. Average, maximum and minimum temperatures were 15.8°C, 31.0°C and -1.2°C, respectively. The month of August experienced the lowest temperature of -1.2°C whereas the maximum temperature of 31.0°C occurred in January. During the day, temperatures increase to reach maximum at around 14:00 in the afternoon. Ambient air temperature decreases to reach a minimum at around 05:00 i.e. just before sunrise.

Table 5: Minimum, maximum and average temperatures (MM5 modelled data for the study site, 2015 to 2017)

Hourly Minimum, Hourly Maximum and Monthly Average Temperatures (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean temperature (°C)	20.4	20.6	19.1	15.8	11.9	9.0	8.8	11.7	15.3	17.6	18.9	20.8
Maximum (°C)	31.0	29.4	27.8	26.8	20.9	18.4	18.4	23.8	25.1	29.0	29.4	30.4
Minimum (°C)	7.0	11.0	7.1	5.5	1.1	0.1	-0.2	-1.2	4.1	2.8	4.7	9.1

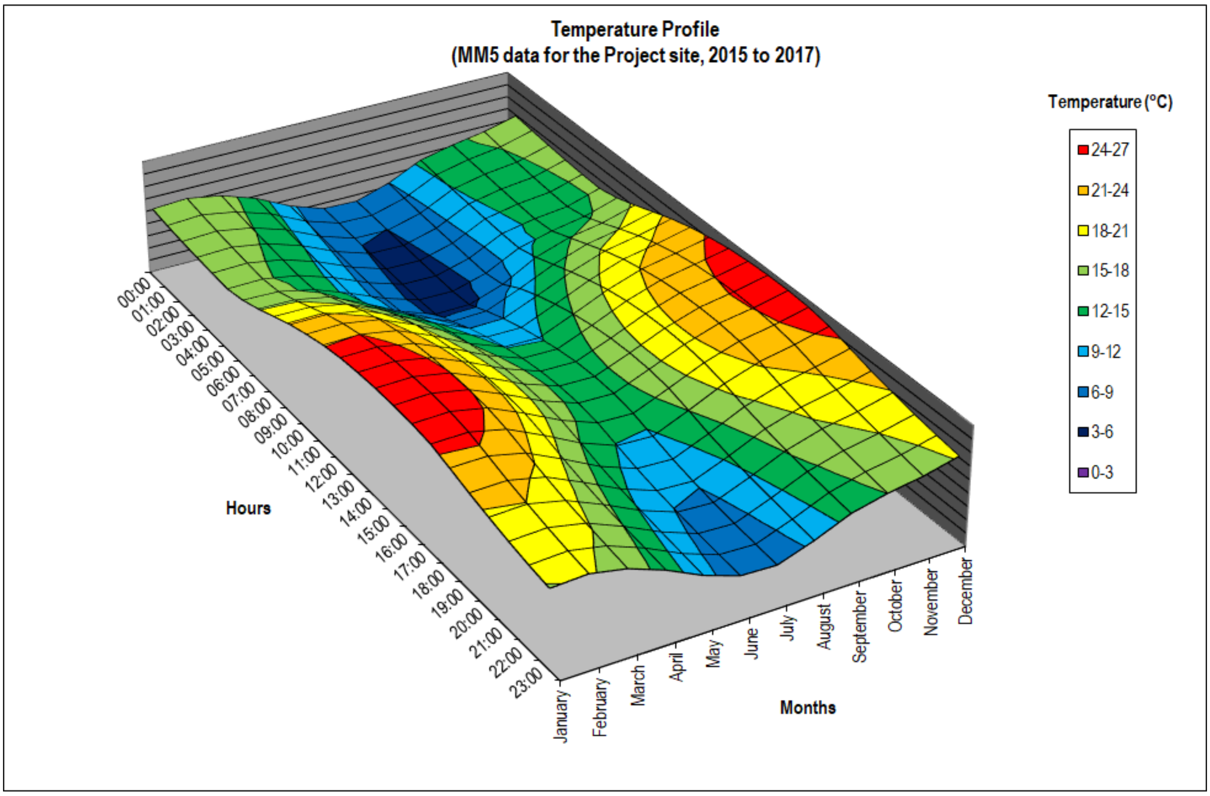


Figure 7: Diurnal monthly average temperature profile (MM5 modelled data for the study site, 2015 to 2017)

3.2.2 Precipitation

Precipitation is important to air pollution studies since it represents an effective removal mechanism for atmospheric pollutants and inhibits dust generation potentials. According to the rainfall data from the Delmas Vlakplaas Weather Station between 1979 and 2009, the mean annual precipitation is 681 mm (Maartens, 2011). Precipitation occurs as showers and thunderstorms and falls mainly from October to March (about 58 days of measurable rain per year) with the maximum falls occurring in November, December and January. Rainstorms are often violent (up to 120 mm can occur in one day) with severe lightning and strong winds, sometimes accompanied by hail. The winter months are dry with the combined rainfall in June, July and August making up only 3.1 % of the annual total according to the data obtained from the Delmas Vlakplaas Weather Station. The annual rainfall by month from 1979 to 2009 is given in Figure 8.

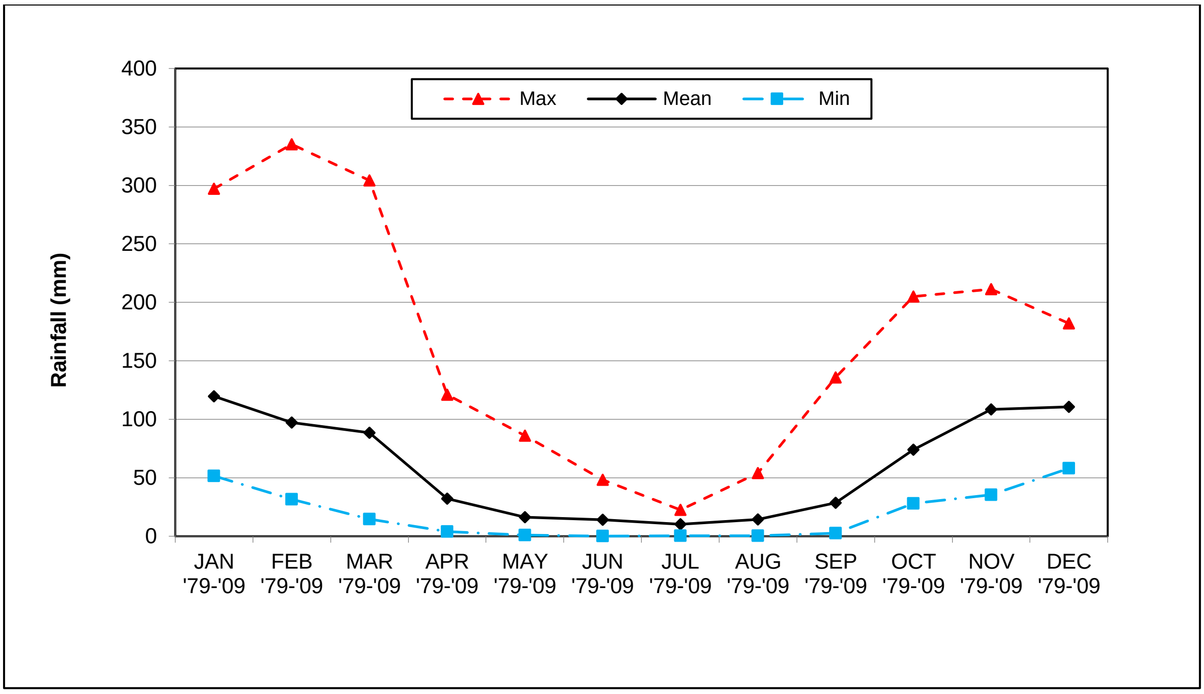


Figure 8: Average monthly precipitation at Delmas, Mpumalanga (Maartens, 2011)

3.2.3 Atmospheric Stability

The new generation air dispersion models differ from the models traditionally used in a number of aspects, the most important of which are the description of atmospheric stability as a continuum rather than discrete classes. The atmospheric boundary layer properties are therefore described by two parameters; the boundary layer depth and the Monin-Obukhov length, rather than in terms of the single parameter Pasquill Class.

The Monin-Obukhov length (L_{Mo}) provides a measure of the importance of buoyancy generated by the heating of the ground and mechanical mixing generated by the frictional effect of the earth's surface. Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC, 2004). The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface. Night-times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds and lower dilution potential.

Diurnal variation in atmospheric stability, as calculated from on-site data, and described by the inverse Monin-Obukhov length and the boundary layer depth is provided in Figure 9. The highest concentrations for ground level, or near-ground level releases from non-wind dependent sources would occur during weak wind speeds and stable (night-time) atmospheric conditions.

For elevated releases, unstable conditions can result in very high concentrations of poorly diluted emissions close to the stack. This is called *looping* (Figure 9 (c)) and occurs mostly during daytime hours. Neutral conditions disperse the plume fairly equally in both the vertical and horizontal planes and the plume shape is referred to as *coning* (Figure 9 (b)). Stable conditions prevent the plume from mixing vertically, although it can still spread horizontally and is called *fanning* (Figure 9 (a)) (Tiwary & Colls, 2010).

For ground level releases such as fugitive dust the highest ground level concentrations will occur during stable night-time conditions.

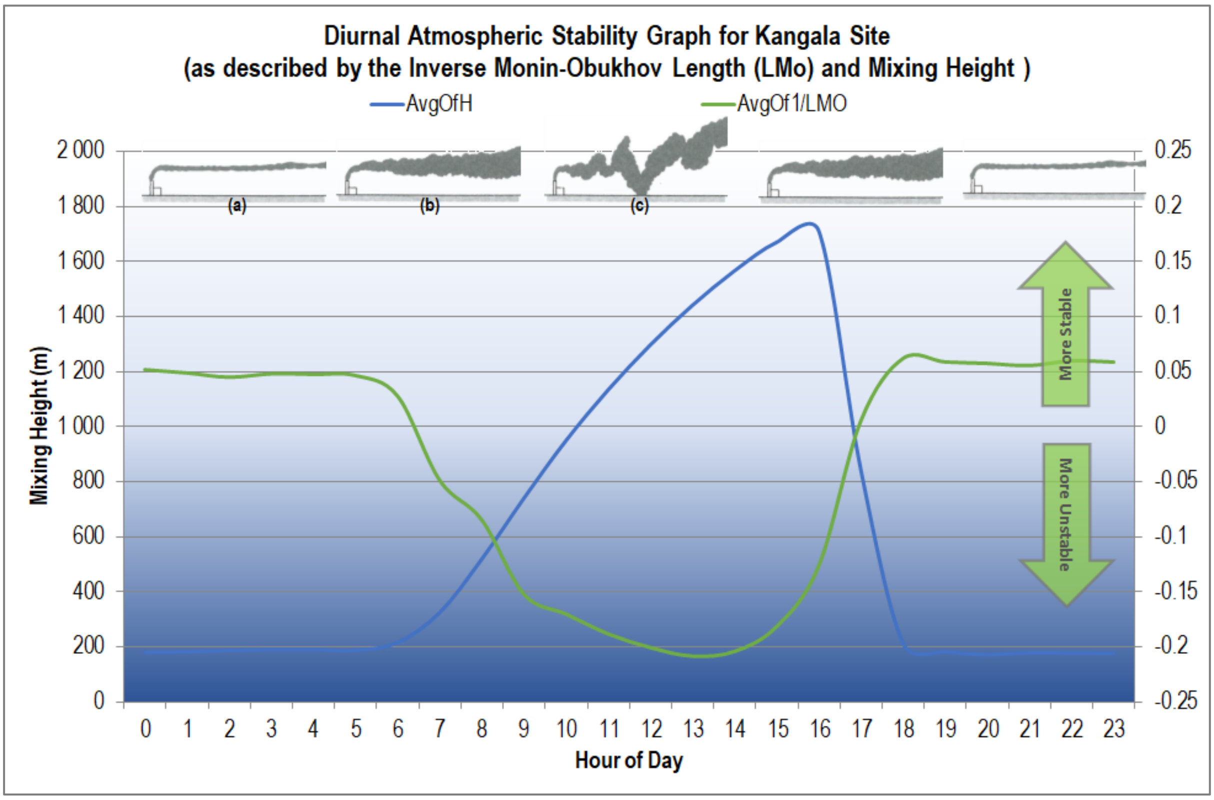


Figure 9: Diurnal atmospheric stability (MM5 modelled data for the study site, 2015 to 2017)

3.3 Receiving Environment

AQSRs primarily refer to places where people reside; however, it may also refer to other sensitive environments that may adversely be affected by air pollutants. Ambient air quality guidelines and standards, as discussed under Section 2, have been developed to protect human health. Ambient air quality, in contrast to occupation exposure, pertains to areas outside of an industrial site/mine boundary where the public has access to and according to the NEMAQA, excludes areas regulated under the Occupational Health and Safety Act (Act No 85 of 1993) (Dept of Labour, 1993).

The nearest receptors to the project location are farmsteads, residential areas, schools, a hospital, agricultural holdings, Eloff Landgoed and Eloff (Afgri) silo (Figure 10).

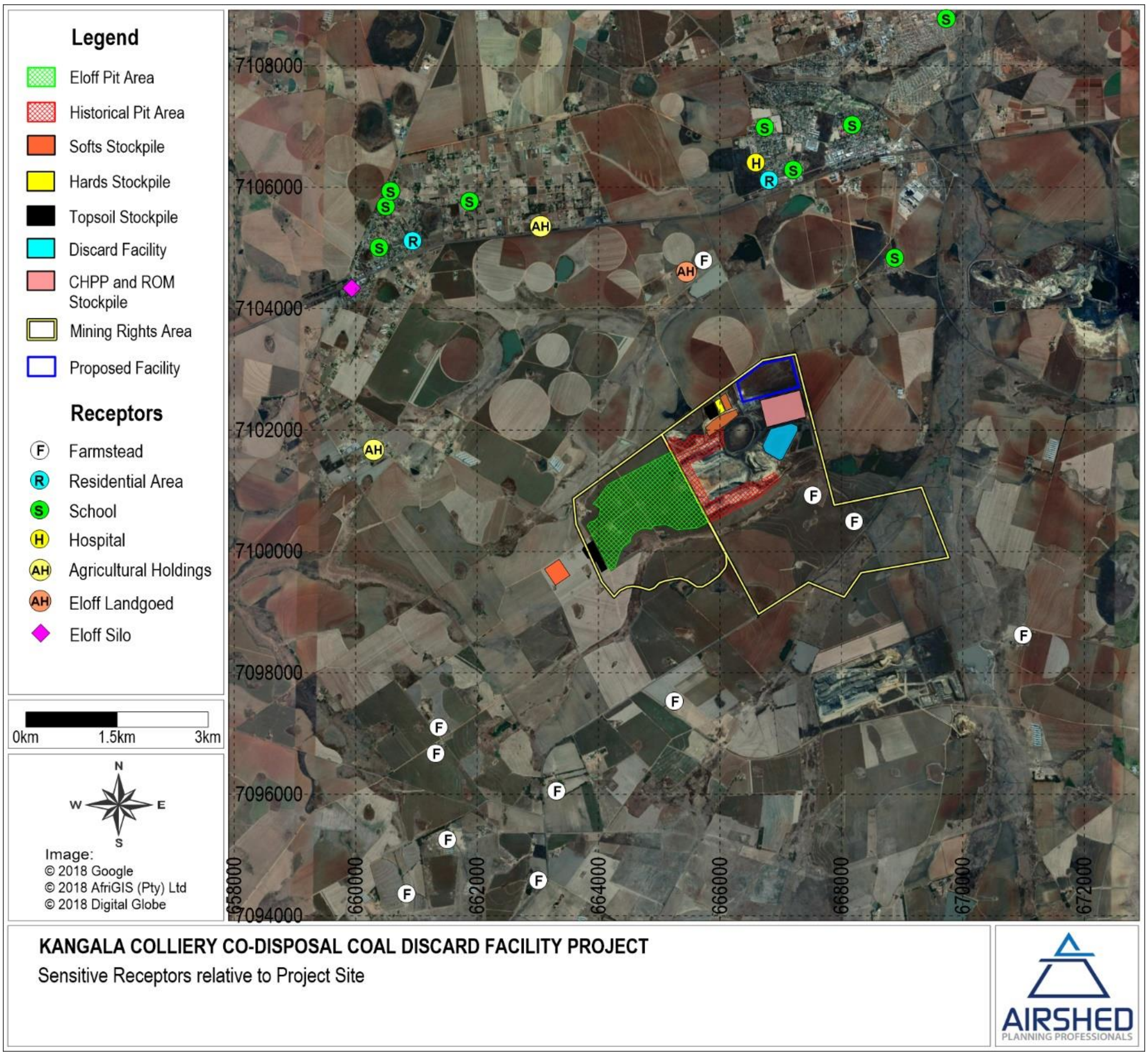


Figure 10: Location of sensitive receptors relative to the Project

3.4 Existing Sources of Emissions in the Region

Power generation, mining activities, farming and residential land-uses occur in the vicinity of the Project. These land-uses contribute to baseline pollutant concentrations via vehicle tailpipe emissions, household fuel combustion, biomass burning and various fugitive dust sources. Long-range transport of particulates, emitted from remote tall stacks and from large-scale biomass burning in countries to the north of South Africa, has been found to contribute to background fine particulate concentrations within the South African boundary (Andreae, et al., 1996; Garstang, Tyson, Swap, & Edwards, 1996; Piketh, Annegarn, & Kneen, 1996; Swap *et al*, 2003).

3.4.1 Power Generation

The closest power station is Kendal Power Station, situated approximately 32 km to the north-east of the Project site. Processing emissions and fugitive emission sources from these operations mainly comprise of boiler operations, materials handling operations (i.e. tipping, off-loading and loading, conveyor transfer points), vehicle entrainment from plant roads and windblown dust from open areas. These activities result in PM, NO_x, CO, SO_2, VOC and diesel particulate matter (DPM) releases.

3.4.2 Metallurgical Manufacturing

There are metallurgical manufacturing operations located in the vicinity of the Project. Processing emissions and fugitive emission sources from these operations mainly comprise of dryer and smelter operations, materials handling operations (i.e. tipping, off-loading and loading, conveyor transfer points), vehicle entrainment from plant roads and windblown dust from open areas. These activities result in PM, NO_x, CO, SO_2, VOC, DPM and trace metal releases.

3.4.3 Mining Operations

There are numerous existing and proposed mines located in the vicinity of the Project. Fugitive emissions sources from mining operations mainly comprise of land clearing operations (i.e. scraping, dozing and excavating), materials handling operations (i.e. tipping, off-loading and loading, conveyor transfer points), vehicle entrainment from haul roads, wind erosion from open areas and drilling and blasting. These activities mainly result in fugitive PM releases with NO_x, CO, SO_2, VOC and DPM being released during blasting operations as well as a result of diesel combustion and storage.

The closest mines are Leeuwpan and Stuart opencast coal mines to the north-east at distances of 7 km and 11.5 km respectively.

3.4.4 Agricultural operations

Agriculture is a land-use within the area surrounding the site. Particulate matter is the main pollutant of concern from agricultural activities as particulate emissions are deriving from windblown dust, burning crop residue, and dust entrainment as a result of vehicles travelling along dirt roads. In addition, pollen grains, mould spores and plant and insect parts from agricultural activities all contribute to the particulate load. Should chemicals be used for crop spraying, they would typically result in odoriferous emissions. Crop residue burning is an additional source of particulate emissions and other toxins.

3.4.5 Miscellaneous Fugitive Dust Sources

Fugitive PM emissions are generated through entrainment from local paved and unpaved roads, and erosion of open or sparsely vegetated areas. The extent of particulate emissions from the main roads will depend on the number of vehicles using the roads and on the silt loading on the roadways. The extent, nature and duration of road-use activity and the moisture and silt content of soils are required to be known in order to quantify fugitive emissions from this source. The quantity of windblown dust is similarly a function of the wind speed, the extent of exposed areas and the moisture and silt content of such areas.

3.4.6 Vehicle Tailpipe Emissions

Air pollution from vehicle emissions may be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly into the atmosphere, and secondary, those pollutants formed in the atmosphere as a result of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. Notable primary pollutants emitted by vehicles include CO_2, CO, hydrocarbons (HCs), SO_2, NO_x, DPM and Pb. Secondary pollutants include: NO_2, photochemical oxidants (e.g. ozone), HCs, sulphur acid, sulphates, nitric acid, nitric acid and nitrate aerosols. Hydrocarbons emitted include benzene, 1.2-butadiene, aldehydes and polycyclic aromatic hydrocarbons (PAH). Benzene represents an aromatic HC present in petrol, with 85% to 90% of benzene emissions emanating from the exhaust and the remainder from evaporative losses. Vehicle tailpipe emissions are localised sources and unlikely to impact far-field.

The R555 and R42 provincial roads are in close proximity to the project area and are both busy roads. The R42 provincial road crosses through the centre of the Eloff Project area in a north-east to south-west direction. The R555 provincial road runs along the north western boundary of the Eloff Project area.

3.4.7 Household Fuel Burning

Energy use within the residential sector is given as falling within three main categories, viz.: (i) traditional - consisting of wood, dung and bagasse, (ii) transitional - consisting of coal, paraffin and liquefied petroleum gas (LPG), and (iii) modern - consisting of electricity (increasingly this includes the use of renewable energy). The typical universal trend is given as being from (i) through (ii) to (iii). Pollutants include products of combustion (CO, NO_x, SO_2 and VOC), unburned HC and PM.

3.5 Measured Baseline Air Quality

Particulates represent the main pollutant of concern in the assessment of mining operations. The 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.

3.5.1 Measured Ambient Air Pollutant Concentrations

A Met-One E-Sampler is used to measure PM_{10} concentrations at Kangala Colliery. The E-Sampler was installed on 22 April 2015 at the main truck entrance near a security booth on the border of the mine. On 12 April 2016, the E-sampler was relocated to the nearby training centre (-26.202342°S; 28.677159°E) which is located further away from the main truck entrance (see Figure 3). The E-Sampler was relocated as per the request of the client due to its close proximity to the haul road (Rayten Engineering Solutions, Air Quality Monthly Monitoring Report, 14 October 2016).

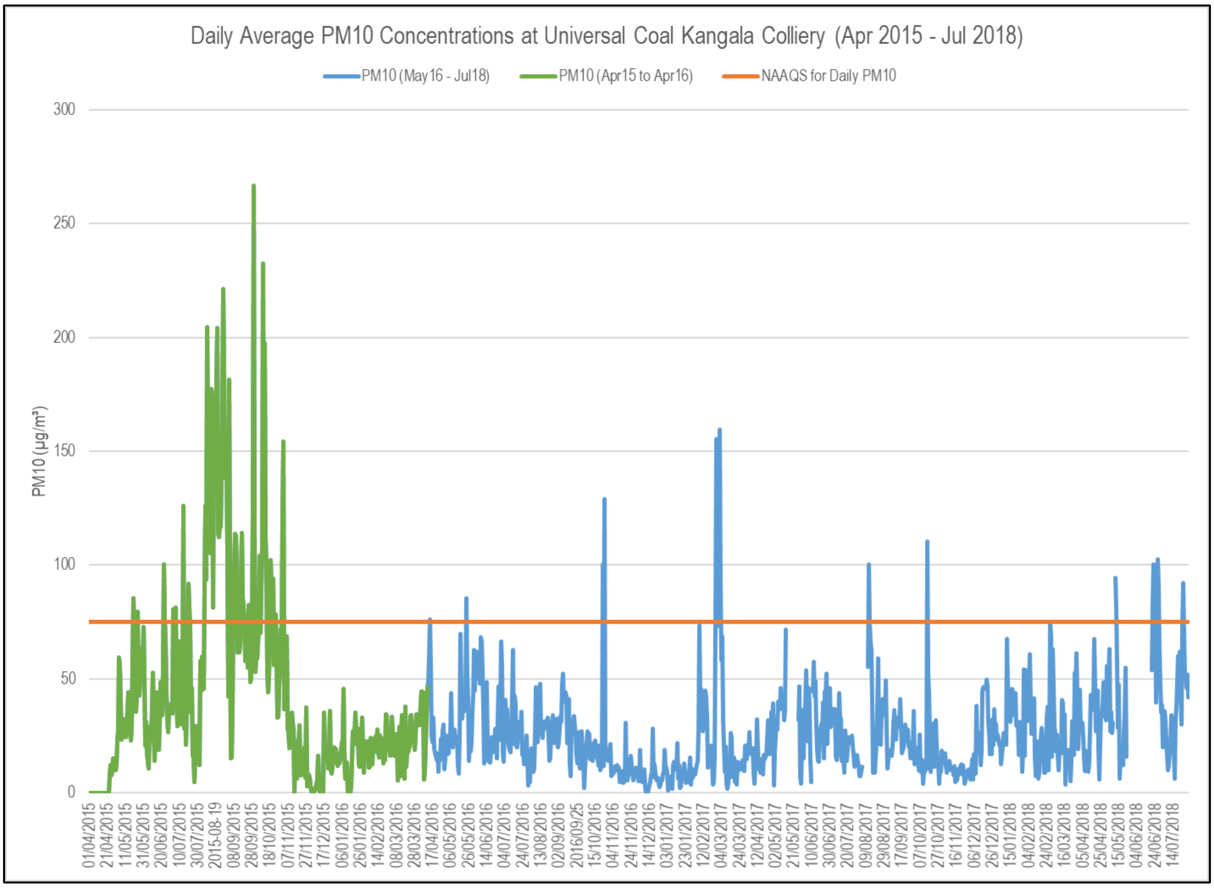


Figure 11: Measured daily PM_{10} concentrations for the Kangala Colliery monitoring station for the period April 2015 – July 2018

The PM_{10} concentrations that were measured between 22 April 2015 and 30 April 2016 regularly exceeded the daily NAAQS during the May to October period (65 exceedances). After the relocation of the monitoring station to UD-001 the frequency of exceedance was reduced to 13 exceedances between 1 May 2016 and 30 April 2017; 3 exceedances between 1 May 2017 and 30 April 2018; and 9 exceedances in the 3-month period 1 May 2018 to 31 July 2018. The annual average concentration was calculated from the daily concentrations over the measuring period and was estimated to be 46 µg/m³ (2015/2016); 23 µg/m³ (2016/2017); and 26 µg/m³ (2017/2018).

3.5.2 Modelled Ambient Air Pollutant Concentrations

The Project is located within the Highveld Priority Area, but outside the modelled ambient "hotspot" areas where annual concentrations due to industrial sources exceed the PM_{10} NAAQS (Figure 12). The modelled PM_{10} predictions as provided in the Highveld Priority Area Management Plan (which excluded the mining operations and domestic fuel burning operations) shows that the project is located outside the areas where more than 4 days of exceedance per year may be expected.

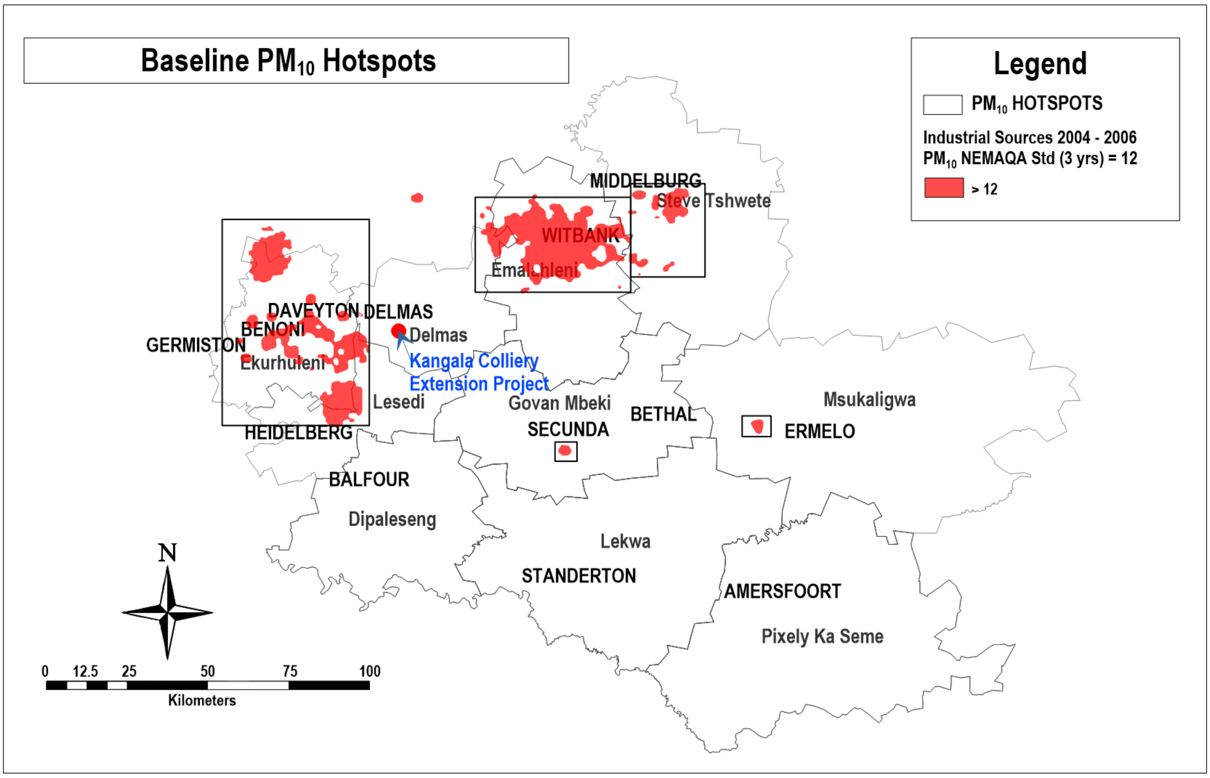


Figure 12: Modelled frequency of exceedance of 24-hour ambient PM_{10} standards in the Highveld Priority Area, indicating the modelled Air Quality Hot Spot areas

3.5.3 Dustfall Rates

The dustfall monitoring network consists of five buckets (shown in Figure 3). Both dustfall and PM_{10} is measured at UD-001, which is located within the mining rights area. Dustfall rates as measured during the period January 2015 to June 2018 are shown in Figure 13. The residential limit of 600 mg/m²/day was exceeded at UD-003 more than twice per year, and for sequential months, during the 2015/2016, 2016/2017, and 2017/2018 sampling periods. The only other monitoring stations where exceedances were recorded are UD-001 and UD-004; however, the exceedances were not in sequential months.

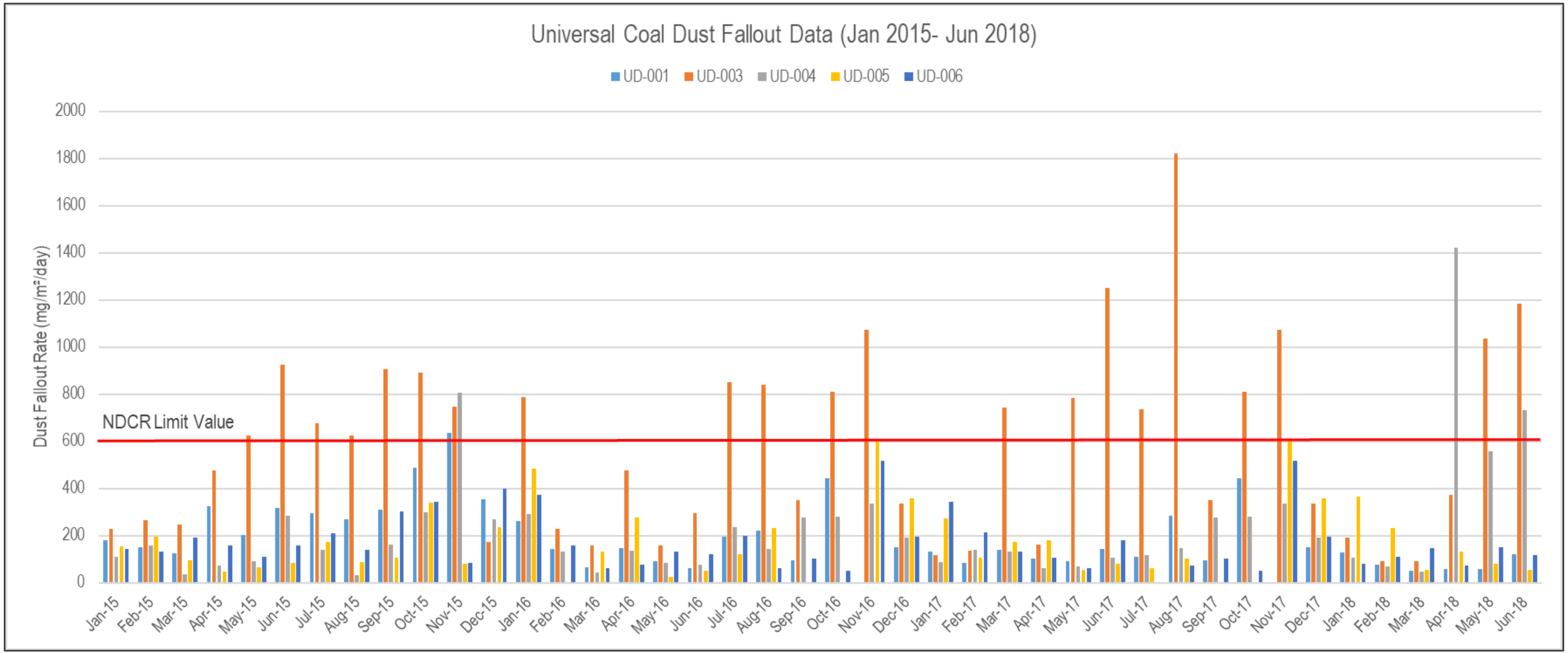


Figure 13: Monthly dustfall rates sampled at Kangala Colliery (January 2015 – June 2018)

4 Impact Assessment

The emissions inventory, dispersion modelling and results are discussed in Sections 4.1, 4.2 and 4.3 respectively.

4.1 Atmospheric Emissions

4.1.1 Construction Phase

A detailed construction plan for the construction of the new co-disposal facility is required to quantitatively assess the impacts from this phase. Due to the lack of detailed information and the relatively short duration of most of the activities associated with the construction phase, no dispersion simulations were undertaken, and a qualitative assessment was done.

Since only limited construction activities will be required at the site, the impacts due to construction activities are likely to be localised and of low magnitude.

4.1.2 Operational Phase

To determine the significance of air pollution impacts from the proposed Project, two scenarios were taken into account:

- **Baseline scenario (Scenario 1)** – representative of maximum throughput from opencast mining activities at the Eloff Project area (in the year 2026), with discard throughput and site design as used in the 2018 study; and
- **Project scenario (Scenario 2)** – representative of maximum throughput from opencast mining activities at the Eloff Project area (in the year 2026) with the most recently provided discard throughput and site design (including topsoil, soft waste and hard waste stockpiles, roads, and the new co-disposal facility).

The baseline scenario emissions and impacts were used as is and no remodelling was done. The emission equations used to quantify emissions from the proposed activities (Scenario 2) are shown in Table 6. Both unmitigated and mitigated activities were assessed. The estimated control factors for the various mining operations are listed in Table 8. The estimated emissions from baseline and Project mining operations are provided in Table 9 and Table 10 respectively.

Table 6: Emission equations used to quantify fugitive dust emissions from the proposed Project

Activity	Emission Equation	Source	Information assumed/provided
Materials handling (including conveyor transfer tips)	$$E = 0.0016 \frac{\left(U/_{2.2}\right)^{1.3}}{\left(M/_{2}\right)^{1.4}}$$ Where, E = Emission factor (kg dust / t transferred) U = Mean wind speed (m/s) M = Material moisture content (%) The $PM_{2.5}$, PM_{10} and TSP fraction of the emission factor is 5.3%, 35% and 74% respectively. An average wind speed of 3.22 m/s was used based on the modelled MM5 data for the period 2015 – 2017.	US-EPA AP42 Section 13.2.4	The moisture content of materials are as follows: *Overburden*: 7.9% (US EPA default mean moisture content, Table 11.9-3) *ROM coal*: 4.82% (EIA and EMP Report for Kangala Coal Mine, December 2014) *Washed coal*: 5.42% (EIA and EMP Report for Kangala Coal Mine, December 2014) From the 2018 study, the respective throughput of materials at the Eloff opencast area was calculated as 113 tph (ROM) and 304 tph (overburden). The throughput at the CHPP was calculated as: *ROM*: 5 232 449 tpa *Discard*: 459 190 tpa *Eskom product*: 2 004 000 tpa *Kusile product*: 2 769 259 tpa For the current study, the throughput of discard was provided as 67 700 tpm, which translates to 812 400 tpa. The throughput of ROM, overburden, Eskom product and Kusile product was assumed to be the same as for the previous assessment. Hours of operation: Opencast area – 4 shifts (20 hours operation) CHPP area – 4 shifts (20 hours operation)
Vehicle entrainment on unpaved surfaces (mine roads)	$$E = k \left(\frac{s}{12}\right)^{a} \left(\frac{W}{3}\right)^{b} \cdot 281.9$$ Where, E = particulate emission factor in grams per vehicle km travelled (g/VKT) k = basic emission factor for particle size range and units of interest s = road surface silt content (%)	US-EPA AP42 Section 13.2.2	In the absence of site-specific silt data, use was made of US EPA default mean silt content of 8.4%. Operational transport activities onsite include in-pit haul roads, hauling of ROM coal to the ROM stockpile at the CHPP area, hauling of discard to the co-disposal facility and the transport of coal offsite. Hours of operation were given as 20 hrs per day, 7 days per week.

Activity	Emission Equation	Source	Information assumed/provided
	W = average weight (tonnes) of the vehicles travelling the road = 50 t The particle size multiplier (k) is given as 0.15 for $PM_{2.5}$ and 1.5 for PM_{10}, and as 4.9 for TSP The empirical constant (a) is given as 0.9 for $PM_{2.5}$ and PM_{10}, and 4.9 for TSP. The empirical constant (b) is given as 0.45 for $PM_{2.5}$, PM_{10} and TSP.		The capacity of the haul trucks to be used was given as 65 t. (coal haulers) and 100 t (waste haulers) An updated (more detailed) layout of the roads was provided and was used in the current study. A new road from the CHPP to the proposed co-disposal facility was modelled. The width of the roads was determined from Google Earth as 25 m (on-site roads) and 10 m (off-site roads).
Drilling	$E_{TSP} = 0.59\,kg/hole\ drilled$ $E_{PM_{10}} = 0.31\,kg/hole\ drilled$ $E_{PM_{2.5}} = 0.31\,kg/hole\ drilled$	NPI Section: Mining	Number of drill holes per day was assumed to be the same as the previous study, viz. 100 (for waste rock) and 100 (for ore) (under the assumption of drilling areas of 2000 m² and spacing between drill holes of 4.5 m). Hours of operation were given as 20 hours per day, 7 days a week.
Blasting	$E = 0.00022 \cdot (A)^{1.5}$ Where, E = Emission factor (kg dust / t transferred) A = Blast area (m²) The $PM_{2.5}$, PM_{10} and TSP fraction of the emission factor is 5.3%, 35% and 74% respectively.	NPI Section: Mining	Blasting was assumed to be the same as the previous study. The blast area was assumed as 2000 m² (for waste rock) and 2000 m² (for ore) respectively. The number of blasts for waste rock and ore was given as 3 blasts per week each, on alternate days.
Grading	$E_{TSP} = 0.0034(S)^{2.5}\ kg/VKT$ $E_{PM10} = 0.0056(S)^{2.0}\ kg/VKT$ Where, E = Emission factor (kg dust / t transferred) S = Mean vehicle speed (km/h) Fraction of $PM_{2.5}$ assumed to be 10% of PM_{10}	US-EPA AP42 Section 11.9.1	The speed of the grader was assumed to be 11.4 km/hr. The grader blade width was assumed to be 4.0 m and the grader blade depth was assumed to be 0.4 m. The VKT was calculated as 4.11 km per day. Hours of operation were assumed as 20 hrs per day, 7 days per week.

Activity	Emission Equation	Source	Information assumed/provided
Crushing and screening	Primary: $$E_{TSP} = 0.01\ kg/t\ material\ processed$$ $$E_{PM10} = 0.004\ kg/t\ material\ processed$$ Secondary: $$E_{TSP} = 0.03\ kg/t\ material\ processed$$ $$E_{PM10} = 0.012\ kg/t\ material\ processed$$ Where, E = Default emission factor for high moisture content ore (>4%) Fraction of $PM_{2.5}$ taken from US-EPA crushed stone emission factor ratio for tertiary crushing	NPI Section: Mining	The throughput of material was assumed to be the same as the previous study, viz. 4 077 502 tpa coal (crush and screen plant) and 1 154 946 tpa coal (DMS plant). Hours of operation were given as 20 hrs per day, 7 days per week.
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	Wind erosion was modelled for the ROM, soft overburden, hard overburden, topsoil and discard stockpiles. This includes the stockpiles modelled for the 2018 assessment, as well as the stockpiles shown in the updated site layout. The particle size distribution for the various materials was obtained from similar processes (see Table 7). The moisture contents of ROM ore, overburden, topsoil and discard were assumed as 0.1%, 0.001%, 0.1% and 1% respectively. The particle densities of ROM ore, soft overburden, hard overburden, topsoil and discard were assumed as 1.6 t/m³, 2.2 t/m³, 3.8 t/m³, 1.8 t/m³ and 1.6 t/m³ respectively. Layout of ROM, overburden, topsoil and discard stockpiles was provided. Hourly emission rate file was calculated and simulated.
Wind-blown dust from conveyor	$$E_{TSP} = c\ (u^* - u^t)\ (\text{in g/metre of conveyor})$$	GHD/Oceanics (1975)	The section of the conveyor belt that emerges from the underground area to the ROM stockpiles was modelled as an area source. The width of the conveyor belt was assumed as 1.35 m. The length of the conveyor belt

Activity	Emission Equation	Source	Information assumed/provided
	where the dust emission rate E is equivalent to a constant c multiplied by the difference between the friction velocity (u*) and the threshold friction velocity of the coal (u*t). An estimate for the constant (c) has been made on data reported by GHD/Oceanics (1975) for measured conveyor emissions at a wind speed of 10 m/s. The PM10 fraction has been estimated as 45% of the TSP. The PM2.5 fraction has been assumed as 50% of the PM10. The approach is conservative since it assumes emissions from a conventional conveyor and based on emission factors provided for coal dust. A control efficiency of 65% for roofing and one side coverage of the conveyor was factored into the emissions calculation under the mitigated scenario. No mitigation measures were applied under the unmitigated scenario.		(open to wind erosion) was determined through on-screen digitising as 275 m. Typical values for particle density and particle size were assumed. The wind speed profile was created from modelled MM5 data for the study site for the period 2015-2017.

Table 7: Particle size distribution of ROM, product, discard, overburden and topsoil material (given as a fraction) (from similar processes)

Product/ Discard		ROM/ Overburden		Topsoil	
Size µm	Mass Fraction	Size µm	Mass Fraction	Size µm	Mass Fraction
1000	0	2000	0.158	2000	0.056
425	0.914	1000	0.211	1000	0.067
75	0.055	425	0.447	425	0.389
40	0	75	0.079	75	0.189
30	0	40	0.026	40	0.033
10	0	30	0.053	30	0.067
4	0.031	10	0.026	10	0.067
2	0	4	0	4	0.044
		2	0	2	0.089

The estimated control factors for the various mining operations are given in Table 8 below[5].

Table 8: Estimated control factors for various mining operations (NPi, 2012)

Operation/Activity	Control method and emission reduction
Drilling	No control
Blasting	No control
Windblown dust from stockpiles	No control
Windblown dust from conveyor	65% CE for enclosed side and roof
Unpaved haul roads	75% CE for water sprays; 90% CE for water sprays and chemical suppression[6]
Materials handling (loading and unloading)	50% CE for water sprays
Materials handling (covered conveyor tipping points)	70% CE for enclosure
Crushing and screening	50% CE for water sprays
Grading	50% CE for water sprays

Note: CE is Control Efficiency

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[5] Design mitigated activities include: 75% CE on unpaved haul roads; 50% CE on materials handling; 50% CE on crushing and screening; 50% CE on grading activities; 70% CE on covered conveyor tipping points and 65% on windblown dust from conveyor belt with enclosed side and roof.

[6] Additional mitigation includes design mitigation and 90% CE on unpaved haul roads.

Table 9: Calculated emission rates due to operations at Eloff Colliery (in tpa) (from the 2018 assessment)

Highest Daily	SC1a – Unmitigated			SC1b – Design Mitigated			SC1c – Additional Mitigation		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Opencast (including drilling)	69.96	503.51	907.79	33.81	143.28	244.52	33.81	143.28	244.52
Blasting	0.18	3.19	6.14	0.18	3.19	6.14	0.18	3.19	6.14
Grading	0.11	1.09	2.23	0.05	0.54	1.12	0.05	0.54	1.12
Materials handling	1.10	7.27	15.38	0.55	3.64	7.69	0.55	3.64	7.69
Crushing and screening	24.73	49.47	123.67	12.37	24.73	61.83	12.37	24.73	61.83
Vehicle entrainment	94.13	941.31	3302.32	23.53	235.33	825.58	9.41	94.13	330.23
Wind erosion	11.14	28.42	187.83	10.67	27.49	185.77	10.67	27.49	185.77
Total	**202**	**1 535**	**4 547**	**81**	**438**	**1 333**	**67**	**297**	**837**

Table 10: Calculated emission rates due to proposed operations at Eloff Colliery (in tpa) (current assessment)

Highest Daily	SC2a – Unmitigated			SC2b – Design Mitigated			SC2c – Additional Mitigation		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Opencast (including drilling)	69.97	503.54	907.82	33.81	143.29	244.53	33.81	143.29	244.53
Blasting	0.18	3.19	6.14	0.18	3.19	6.14	0.18	3.19	6.14
Grading	0.11	1.09	2.23	0.05	0.54	1.12	0.05	0.54	1.12
Materials handling	1.13	7.65	15.80	0.57	3.83	7.90	0.57	3.83	7.90
Crushing and screening	24.73	49.47	123.67	12.37	24.73	61.83	12.37	24.73	61.83
Vehicle entrainment	116.98	1169.77	4103.79	29.24	292.44	1025.95	11.70	116.98	410.38
Wind erosion	9.37	34.49	409.27	8.65	33.05	406.07	8.65	33.05	406.07
Total	**222**	**1 769**	**5 569**	**85**	**501**	**1 754**	**67**	**326**	**1 138**

4.1.3 Closure and Decommissioning Phase

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 rehabilitation efforts during closure. Aspects and activities associated with the closure phase of the proposed operations are listed in Table 11. Simulations of the closure phase were not included in the current study due to its temporary impacting nature.

Table 11: Activities and aspects identified for the closure and decommissioning phase

Impact	Source	Activity
Generation of $PM_{2.5}$ and PM_{10}	Stockpiles and mine pit	Dust generated during rehabilitation activities
Generation of $PM_{2.5}$ and PM_{10}	Plant and infrastructure	Demolition of the process plant and infrastructure
Gas emissions	Vehicles	Tailpipe emissions from vehicles utilised during the closure phase

4.1.4 Post-Closure Phase

The post-closure phase is predominantly a monitoring activity with occasional repair and maintenance. There is no significant equipment use. Providing that a permanent method of rehabilitation of stockpiles and other exposed surfaces has been established, in the form of vegetative cover for example, no air quality impacts are expected, other than the existing (status quo) situation.

4.2 Atmospheric Dispersion Modelling

The impact assessment of the project's operations on the environment is discussed in this section. To assess impact on human health and the environment the following important aspects need to be considered:

- The criteria against which impacts are assessed (Section 2);
- The potential of the atmosphere to disperse and dilute pollutants emitted by the project (Section 3.1);
- The AQSRs in the vicinity of the proposed mine (Section 3.1); and
- The methodology followed in determining ambient pollutant concentrations and dustfall rates (Section 1.4).

The impact of proposed operations on the atmospheric environment was determined through the simulation of ambient pollutant concentrations. Dispersion models simulate ambient pollutant concentrations as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations arising from the emissions of various sources. Increasing reliance has been placed on concentration estimates from models as the primary basis for environmental and health impact assessments, risk assessments and emission control requirements. It is therefore important to carefully select a dispersion model for the purpose.

4.2.1 Dispersion Model Selection

Gaussian-plume models are best used for near-field applications where the steady-state meteorology assumption is most likely to apply. One of the most widely used Gaussian plume model is the US EPA AERMOD model that was used in this study. AERMOD is a model developed with the support of 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).

AERMOD is an advanced new-generation model. It is designed to predict pollution concentrations from continuous point, flare, area, line, and volume sources. AERMOD offers new and potentially improved algorithms for plume rise and buoyancy, and the computation of vertical profiles of wind, turbulence and temperature however retains the single straight-line trajectory limitation. AERMET is a meteorological pre-processor for AERMOD. Input data can come from hourly cloud cover observations, surface meteorological observations and twice-a-day upper air soundings. Output includes surface meteorological observations and parameters and vertical profiles of several atmospheric parameters. AERMAP is a terrain pre-processor designed to simplify and standardise the input of terrain data for AERMOD. Input data includes receptor terrain elevation data. The terrain data may be in the form of digital terrain data. The output includes, for each receptor, location, and height scale, which are elevations used for the computation of air flow around hills.

A disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. Input data types required for the AERMOD model include: source data, meteorological data (pre-processed by the AERMET model), terrain data, information on the nature of the receptor grid and pre-development or background pollutant concentrations or dustfall rates. Version 7.2.5 of AERMOD and its pre-processors were used in the study.

4.2.2 Meteorological Requirements

For the current study, use was made of 2015-2017 modelled MM5 data for the study site (Section 3.3).

4.2.3 Source Data Requirements

The AERMOD model can model point, jet, area, line, and volume sources. Sources were modelled as follows:

- Open pit – modelled as open pit source;
- Grading – modelled as area source;
- Materials handling – modelled as volume sources;
- Crushing and screening – modelled as volume sources;
- Unpaved roads – modelled as area sources; and
- Windblown dust from stockpiles and conveyor – modelled as area sources.

4.2.4 Modelling Domain

The dispersion of pollutants expected to arise from proposed activities was modelled for an area covering 15 km (east-west) by 15 km (north-south). The area was divided into a grid matrix with a resolution of 100 m by 100m, with the project located centrally. AERMOD calculates ground-level (1.5 m above ground level) concentrations and dustfall rates at each grid and discrete receptor points (AQSRs).

4.3 Dispersion Modelling Results

Dispersion modelling was undertaken to determine highest daily and annual average ground level concentrations. Averaging periods were selected to facilitate the comparison of predicted pollutant concentrations to relevant ambient air quality and inhalation health criteria as well as dustfall regulations.

Pollutants with the potential to result in human health impacts which are assessed in this study include $PM_{2.5}$ and PM_{10}. Dustfall is assessed for its nuisance potential. Results are primarily provided in form of isopleths to present areas of exceedance of assessment criteria. Ground level concentration isopleths presented in this section depict interpolated values from the concentrations simulated by AERMOD for each of the receptor grid points specified.

Isopleth plots reflect the incremental ground level concentrations (GLCs) for $PM_{2.5}$ and PM_{10} where exceedances of the relevant NAAQSs were simulated. Due to the unavailability of ambient baseline concentrations, the total cumulative pollutant concentrations could not be quantitatively determined but qualitative commentary is provided in the discussion of impact significance in Section 4.4.

It should also be noted that ambient air quality criteria apply to areas where the Occupational Health and Safety regulations do not apply, thus outside the property or lease area. Ambient air quality criteria are therefore not occupational health indicators but applicable to areas where the general public has access i.e. off-site. In the context of this project, ambient air quality guidelines and dustfall regulations would apply to any area outside the mining right area.

4.3.1 Scenario 1 – Eloff Baseline operations (current co-disposal facility)

Activities associated with open pit mining for year 2026 (and with the existing co-disposal facility) were simulated for the 2018 study. The isopleth plots are provided in Appendix C (Figure 22 to Figure 23 for PM_{10}, Figure 24 to Figure 27 for $PM_{2.5}$, and Figure 28 for dustfall). The GLCs and dustfall rates at each of the AQSRs are provided in Appendix C in Table 23 (PM_{10}), Table 24 ($PM_{2.5}$) and Table 25 (dustfall levels) respectively.

The main findings were:

- The daily ***PM_{10}*** SA NAAQS is exceeded at all AQSRs (25) for unmitigated activities. For the design mitigated scenario, simulated PM_{10} concentrations exceed the daily SA NAAQS at 6 AQSRs, over an area up to up to 2.8km to the southwest, 2.4km to the south, 2.4km to the east and 3.0km to the north from the mining boundary. With additional mitigation, the footprint is reduced to half of the impact for the design mitigated scenario where 3 AQSRs are non-compliant. Over an annual average unmitigated PM_{10} impacts exceed the annual NAAQS at 2 AQSRs. With design mitigation applied, there were still exceedances at 2 AQSRs, and with additional mitigation applied, PM_{10} impacts are in non-compliance with the annual NAAQS at only one AQSR.
- ***$PM_{2.5}$*** daily GLCs, with no mitigation in place, are likely to be in non-compliance with the 2030 NAAQSs at 14 AQSRs. Simulated impacts are reduced when design mitigation is applied with exceedance of the 2030 NAAQS simulated at two AQSRs. With additional mitigation, simulated $PM_{2.5}$ daily GLCs are still in non-compliance at two AQSRs. Over an annual average design mitigated simulated GLCs are within compliance currently and after 2030.
- The simulated maximum daily **dustfall rates** due to the unmitigated scenario exceed the NDCR for residential areas at one AQSR. Simulated dustfall rates exceed the NDCR for residential areas at one AQSR for the design mitigated scenario but are well within the residential limit for the additionally mitigated scenario.

4.3.2 Scenario 2 – Eloff Project operations (proposed co-disposal facility)

Activities associated with open pit mining for year 2026 (and the new co-disposal facility) were simulated. The results are provided in Figure 14 to Figure 15 for PM_{10}, Figure 16 to Figure 19 for $PM_{2.5}$, and Figure 20 for dustfall. The simulated GLCs and dustfall rates at each of the AQSRs are provided in Table 12 (PM_{10}), Table 13 ($PM_{2.5}$) and Table 14 (dustfall levels) respectively.

Scenario 2a represents unmitigated Eloff operations, whereas Scenarios 2b and 2c represent mitigated Eloff operations. Mitigation measures assumed during mitigated Eloff opencast operations are described in Table 8 and footnotes 5 and 6.

The main findings are:

- From Table 12, the daily ***PM_{10}*** SA NAAQS is exceeded at all AQSRs (27) for unmitigated activities. The area of exceedance for the combined design mitigated and additionally mitigated scenarios is shown in Figure 14. For the design mitigated scenario, simulated PM_{10} concentrations exceed the daily SA NAAQS at 6 AQSRs. With additional mitigation, the footprint is reduced to half of the impact for the design mitigated scenario where 3 AQSRs are non-compliant. Over an annual average unmitigated PM_{10} impacts exceed the annual NAAQS at 2 AQSRs (Table 12). With design mitigation applied, exceedances were simulated at 2 AQSRs; with additional mitigation applied, PM_{10} impacts are in non-compliance with the annual NAAQS at only one AQSR (Figure 15).
- ***$PM_{2.5}$*** GLCs – simulated concentrations for the unmitigated, design mitigated, and additionally mitigated scenarios are shown in Table 13. $PM_{2.5}$ daily GLCs, with no mitigation in place, are likely to be in non-compliance with the 2030 NAAQSs at 14 AQSRs. Simulated impacts are reduced when design mitigation is applied with exceedance of the 2030 NAAQS simulated at two AQSRs (Figure 16). With additional mitigation, simulated $PM_{2.5}$ daily GLCs are still in non-compliance at two AQSRs (Figure 18). Over an annual average design mitigated simulated GLCs as provided in Figure 17, and additionally mitigated GLCs as provided in Figure 19, are within compliance currently and after 2030.
- Isopleth plots showing the area of exceedance of the residential limit due to design mitigated ***dustfall rates*** are shown in Figure 20. The simulated maximum daily dustfall rates due to the unmitigated scenario exceed the NDCR for residential areas at one AQSR (Table 14). Simulated dustfall rates exceed the NDCR for residential areas at one AQSR for the design mitigated scenario, but are well within the residential limit for the additionally mitigated scenario. The low dustfall rates simulated at AQSR 27 (Eloff silo) suggests that the grain from the AFGRI silos will not be affected adversely by the proposed development.

The simulated footprint areas of exceedance for PM_{10} and $PM_{2.5}$ impacts, as indicated in the isopleth contour plots, are larger for Scenario 2 (Eloff Project – proposed co-disposal facility) than for Scenario 1 (Eloff Baseline – existing co-disposal facility). Even with additional mitigation applied on haul roads to achieve a control efficiency of 90% the area of exceedance of the daily PM_{10} NAAQS extends well beyond the mining rights boundary. This increase in magnitude may be explained by the higher throughput of monthly discard tonnages for the Eloff Project, the inclusion of additional stockpiles and roads in the model based on a more detailed site layout, and more vehicle entrained dust from the haul road to the proposed co-disposal facility. Materials handling emissions are also slightly higher for the Eloff Project because of the change in meteorological data period[7] (slightly higher wind speeds).

In light of the large footprint area of exceedance of daily PM_{10} impacts, it is recommended that UCD1 apply additional mitigation on unpaved haul roads, to ensure that people (and livestock) not be exposed to ambient air quality that may be harmful to human health.

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[7] Meteorological data for 2015 to 2017 were used in the model to comply with Regulations for Dispersion Modelling, whereas the previous dataset spanned the period 2014 to 2016.

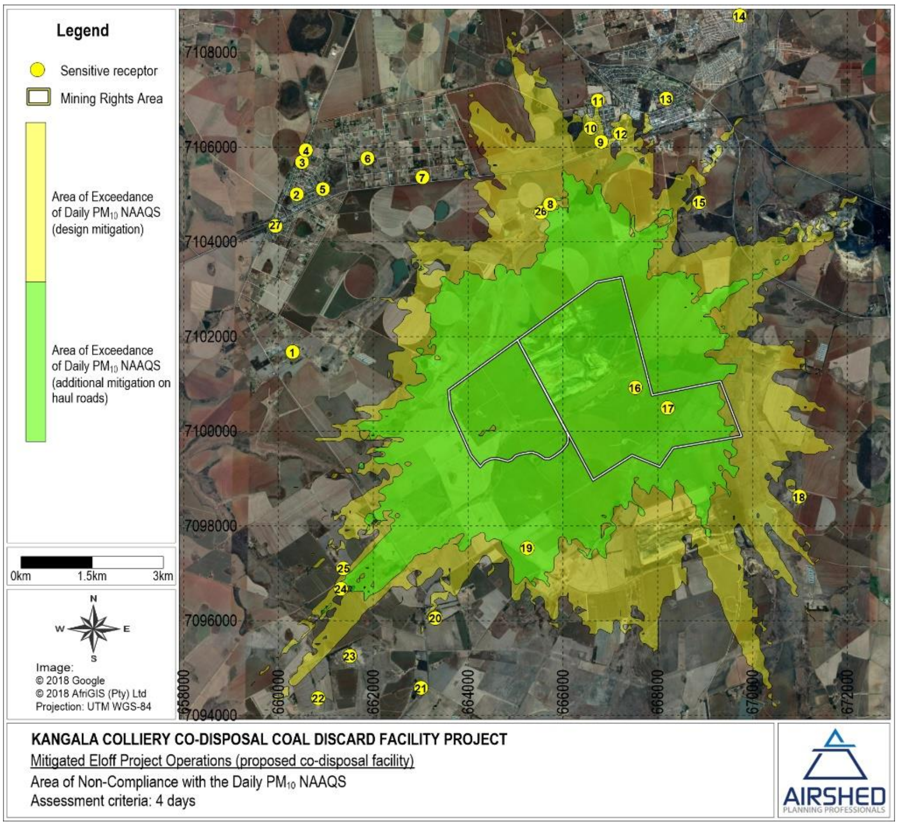

Figure 14: Area of non-compliance of PM_{10} 24-hour NAAQS due to design mitigated and additionally mitigated Eloff project operations

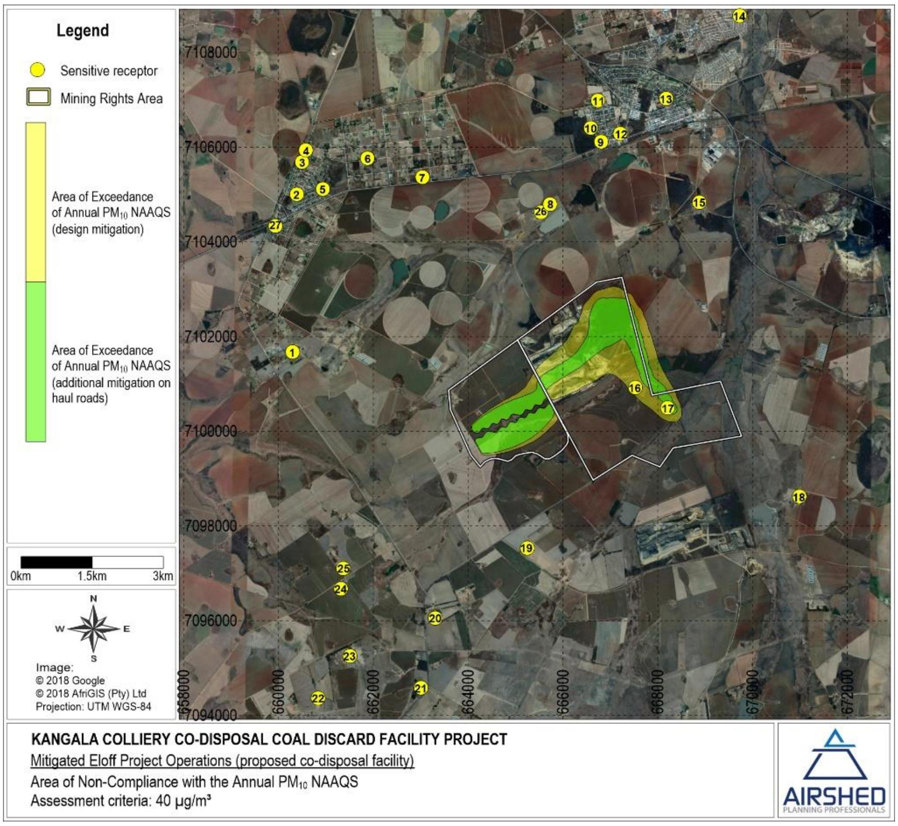

Figure 15: Area of non-compliance of PM_{10} annual NAAQS due to design mitigated and additionally mitigated Eloff project operations

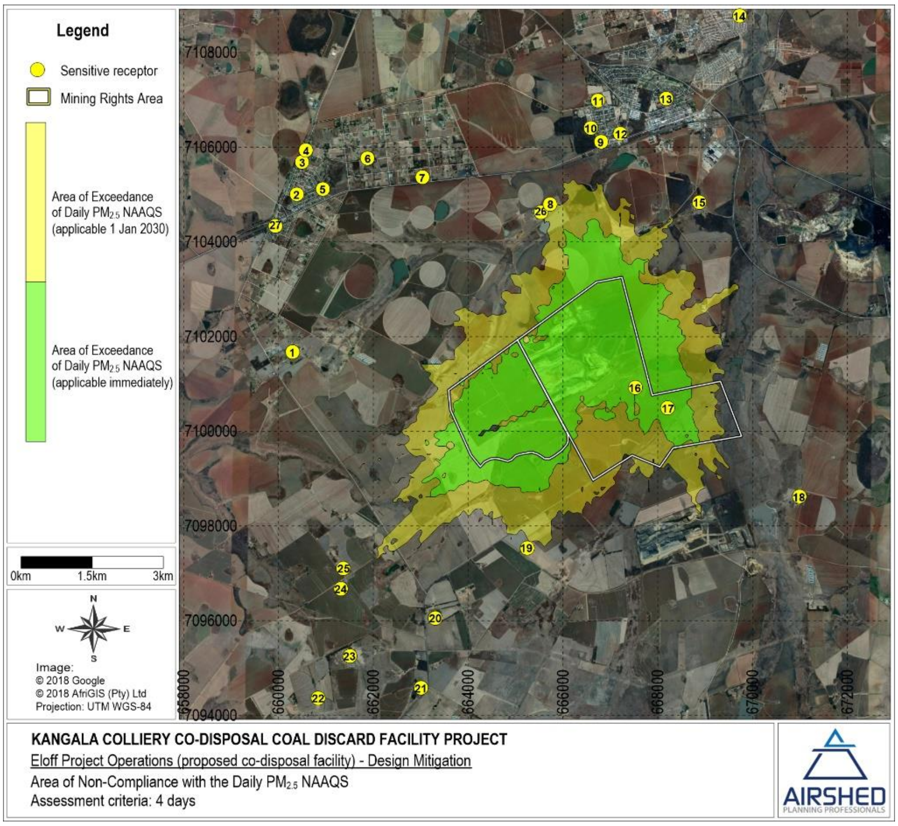

Figure 16: Area of non-compliance of $PM_{2.5}$ 24-hour NAAQS due to design mitigated Eloff project operations

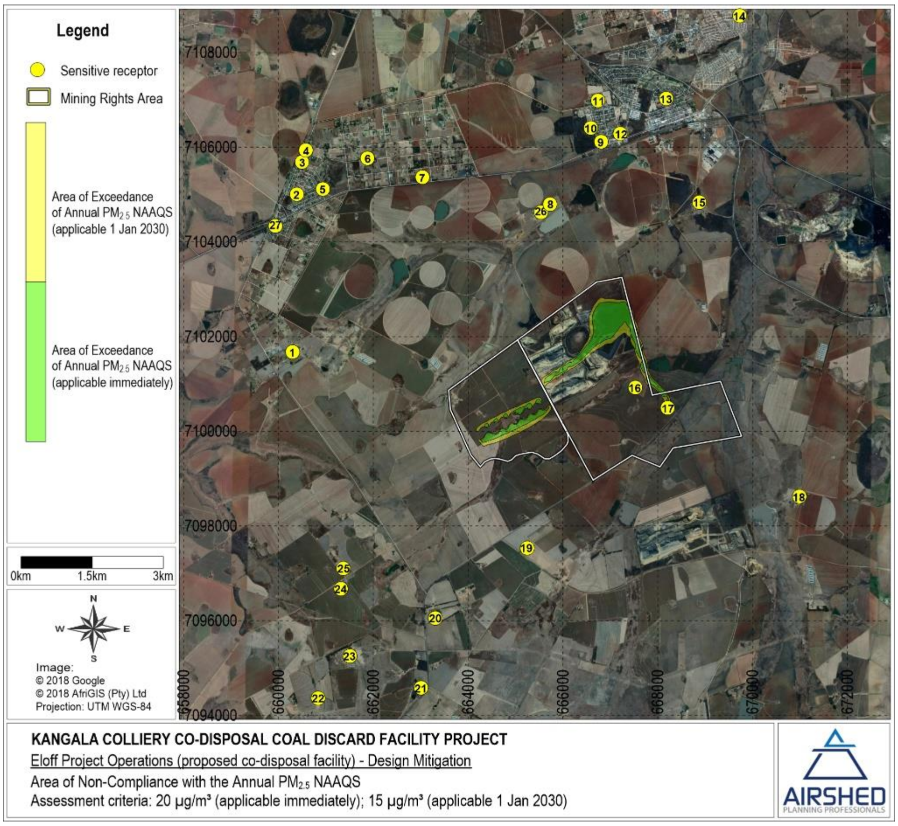

Figure 17: Area of non-compliance of $PM_{2.5}$ annual NAAQS due to design mitigated Eloff project operations

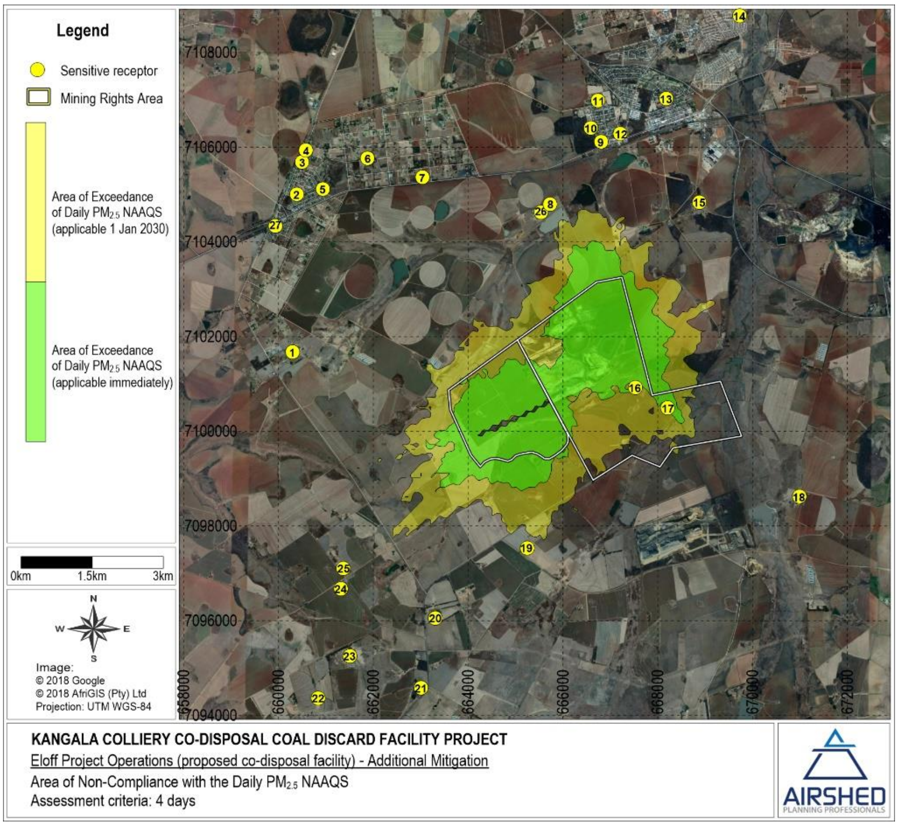

Figure 18: Area of non-compliance of $PM_{2.5}$ 24-hour NAAQS due to additionally mitigated Eloff project operations

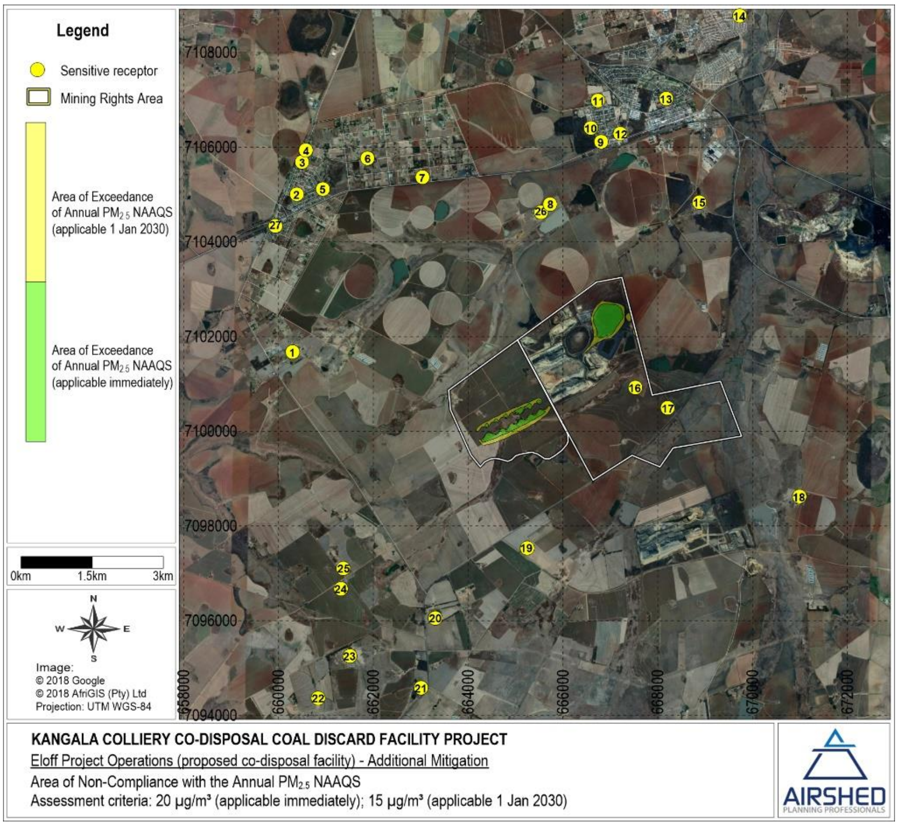

Figure 19: Area of non-compliance of $PM_{2.5}$ annual NAAQS due to additionally mitigated Eloff project operations

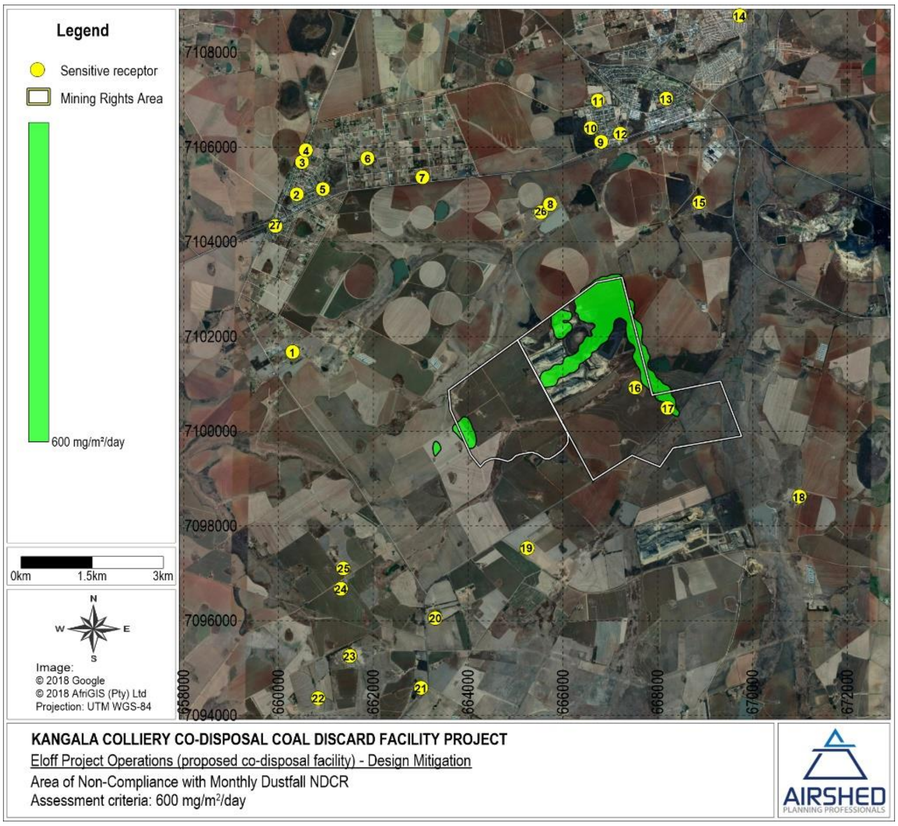

Figure 20: Simulated dustfall deposition rates due to design mitigated Eloff project operations

Table 12: Simulated AQSR PM$_{10}$ concentrations (in µg/m^3) for unmitigated, design mitigated and additionally mitigated Eloff project operations

AQ SR	AQSR Type	Scenario 2a – Unmitigated				Scenario 2b – Design mitigated				Scenario 2c – Additional mitigation			
		Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)
1	Agric. Holding	226	8	18	**No**	61	2	1	Yes	42	2	0	Yes
2	School	202	6	9	**No**	56	2	0	Yes	38	1	0	Yes
3	School	169	6	9	**No**	45	2	0	Yes	38	1	0	Yes
4	School	185	6	9	**No**	49	2	0	Yes	38	1	0	Yes
5	Residential	217	7	10	**No**	60	2	0	Yes	41	1	0	Yes
6	School	201	7	13	**No**	56	2	0	Yes	42	1	0	Yes
7	Agric. Holding	289	10	21	**No**	77	3	2	Yes	51	2	1	Yes
8	Farmstead	581	21	34	**No**	175	6	15	**No**	104	4	2	Yes
9	Residential	580	13	20	**No**	150	4	6	**No**	82	2	2	Yes
10	Hospital	522	12	21	**No**	137	3	5	Yes	70	2	0	Yes
11	School	357	10	15	**No**	99	3	3	Yes	56	2	0	Yes
12	School	488	12	22	**No**	127	3	4	Yes	66	2	1	Yes
13	School	330	9	16	**No**	90	2	3	Yes	45	1	1	Yes
14	School	165	4	6	**No**	47	1	1	Yes	42	1	0	Yes
15	School	399	11	20	**No**	109	3	3	Yes	74	2	1	Yes
16	Farmstead	1704	186	278	**No**	426	48	111	**No**	208	22	41	**No**
17	Farmstead	4138	435	323	**No**	1040	110	213	**No**	430	45	97	**No**
18	Farmstead	594	12	23	**No**	154	3	4	Yes	67	2	0	Yes
19	Farmstead	509	31	61	**No**	143	9	8	**No**	124	6	7	**No**
20	Farmstead	444	15	22	**No**	123	4	4	Yes	94	3	1	Yes
21	Farmstead	306	10	11	**No**	83	3	1	Yes	48	2	0	Yes
22	Farmstead	283	6	11	**No**	77	2	0	Yes	56	1	0	Yes
23	Farmstead	347	8	12	**No**	94	2	1	Yes	64	2	0	Yes
24	Farmstead	537	10	15	**No**	145	3	6	Yes	101	2	4	Yes
25	Farmstead	505	10	16	**No**	137	3	2	Yes	97	2	2	Yes
26	Eloff Landgoed	863	23	34	**No**	238	6	15	**No**	121	4	2	Yes
27	Eloff Silo	194	6	8	**No**	54	2	0	Yes	31	1	0	Yes

Table 13: Simulated AQSR $PM_{2.5}$ concentrations (in µg/m³) for unmitigated, design mitigated and additionally mitigated Eloff project operations

AQSR	AQSR Type	Scenario 2a – Unmitigated				Scenario 2b – Design mitigated				Scenario 2c – Additional mitigation			
		Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No) (a)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No) (a)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No) (a)
1	Agric. Holding	29	1	2	Yes	11	0	0	Yes	9	0	0	Yes
2	School	27	1	2	Yes	10	1	0	Yes	9	0	0	Yes
3	School	22	1	0	Yes	9	1	0	Yes	9	0	0	Yes
4	School	23	1	0	Yes	9	1	0	Yes	9	0	0	Yes
5	Residential	30	1	2	Yes	11	0	0	Yes	10	0	0	Yes
6	School	26	1	2	Yes	11	0	0	Yes	9	0	0	Yes
7	Agric. Holding	35	1	6	**No**	13	1	0	Yes	12	0	0	Yes
8	Farmstead	99	3	19	**No**	34	1	3	Yes	25	1	2	Yes
9	Residential	65	2	11	**No**	24	1	0	Yes	19	1	0	Yes
10	Hospital	61	2	10	**No**	19	1	0	Yes	17	0	0	Yes
11	School	51	1	7	**No**	17	0	0	Yes	14	0	0	Yes
12	School	56	2	7	**No**	19	1	1	Yes	15	0	0	Yes
13	School	44	1	3	Yes	15	0	0	Yes	10	0	0	Yes
14	School	24	1	0	Yes	11	0	0	Yes	9	0	0	Yes
15	School	53	1	5	**No**	21	0	1	Yes	19	0	0	Yes
16	Farmstead	204	21	135	**No**	74	6	27	**No**	57	4	13	**No**
17	Farmstead	428	45	247	**No**	116	12	72	**No**	58	5	17	**No**
18	Farmstead	67	2	5	**No**	19	1	0	Yes	13	0	0	Yes
19	Farmstead	68	4	20	**No**	30	2	2	Yes	28	1	2	Yes
20	Farmstead	59	2	6	**No**	24	1	0	Yes	21	1	0	Yes
21	Farmstead	39	1	1	Yes	13	1	0	Yes	11	0	0	Yes
22	Farmstead	36	1	2	Yes	14	0	0	Yes	12	0	0	Yes
23	Farmstead	43	1	3	Yes	16	0	0	Yes	13	0	0	Yes
24	Farmstead	66	1	7	**No**	26	1	3	Yes	22	0	0	Yes
25	Farmstead	63	1	6	**No**	25	0	1	Yes	21	0	1	Yes
26	Eloff Landgoed	120	3	19	**No**	41	1	3	Yes	29	1	1	Yes
27	Eloff Silo	26	1	2	Yes	10	0	0	Yes	7	0	2	Yes

Notes: **(a)** These reflect compliance with the 1 Jan 2030 NAAQSs

Table 14: Simulated AQSR total dustfall rates (in mg/m²/day) for unmitigated, design mitigated and additionally mitigated Eloff project operations

AQSR	AQSR Type	Scenario 2a – Unmitigated) (a)	Scenario 2b – Design mitigated) (a)	Scenario 2c – Additional mitigation) (a)
1	Agric. Holding	17	5	3
2	School	11	3	2
3	School	10	4	3
4	School	9	5	4
5	Residential	12	3	2
6	School	11	7	7
7	Agric. Holding	17	9	9
8	Farmstead	42	15	11
9	Residential	24	16	15
10	Hospital	21	11	10
11	School	17	10	10
12	School	26	20	19
13	School	34	28	26
14	School	11	8	7
15	School	27	13	11
16	Farmstead	500	135	65
17	Farmstead	**2851**	**713**	286
18	Farmstead	17	5	3
19	Farmstead	60	25	20
20	Farmstead	30	13	11
21	Farmstead	21	9	8
22	Farmstead	10	5	4
23	Farmstead	13	6	6
24	Farmstead	15	5	4
25	Farmstead	19	5	3
26	Eloff Landgoed	41	15	13
27	Eloff Silo	11	3	2

Notes: **(a)** Screened against the residential dustfall limit of 600 mg/m²/day

4.4 Impact on Animals and Vegetation

The simulated dustfall rates provided in Table 14 shows that, under unmitigated circumstances, the crops at the on-site farmsteads (AQSRs No 16 and 17) may be exposed to dustfall rates greater than 400 mg/m²/day[8]. With mitigation applied the simulated dustfall rates at both farmsteads fall below 400 mg/m²/day. At these dustfall levels the crops are not expected to be adversely affected by project activities.

It is not expected that the project will have any significant impact on livestock at the surrounding farms. As explained in Section 2.3, animal studies presented by CEPA (1998) found that the particle mass concentration levels at which exposure of test animals resulted in significant compromises in lung function (> 1 mg/m³), greatly exceeded levels reported in the ambient environment.[9]

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[8] While there is little direct evidence of the impact of dustfall on vegetation in the South African context (and thus no regulatory value for comparison), 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, 1993). An IAP (AFGRI) required an expert opinion that the Kangala co-disposal facility would not adversely affect the nearby grain silos. The nearest silo (Eloff silo) was included in the simulations and dust deposition was evaluated at this receptor. There are no dustfall limits for grain and it is therefore only possible to screen it against the "residential dustfall limit".

[9] The adjacent landowner at Eloff Landgoed requested a separate study on the potential air impact on the farm's crops as well as on the nearby chicken broilers. The location of the farm was included as an AQSR and the simulated dust deposition and $PM_{2.5}$ and PM_{10} concentrations at Eloff Landgoed were reported on.

5 Impact Significance Rating

The significance of air quality impacts was assessed according to the methodology provided to this study (refer to Appendix B of this report for the methodology).

5.1 Incremental Impacts

The environmental risk of the air quality impacts due to project activities were found to be:

- **Construction phase** (Eloff Project, proposed co-disposal facility) (Table 15) ***Low*** for unmitigated activities and ***Low*** with mitigation applied. This applies to $PM_{2.5}$ and PM_{10} concentrations and dustfall rates.
- **Operational phase** (Eloff Project, proposed co-disposal facility) (Table 16 and Table 17) ***High*** for design mitigated and ***Medium*** for additionally mitigated activities (based on PM_{10} impacts). The highest impacts are mainly due to unpaved roads and in-pit activities.
- **Decommissioning/Closure Phase** (Eloff Project) (Table 18): the impacts are expected to be ***Low*** for unmitigated activities and ***Low*** with mitigation applied**.** This applies to $PM_{2.5}$ and PM_{10} concentrations and dustfall rates.
- **Post-Closure Phase** (Eloff Project) (Table 19): the impacts are expected to be ***Low*** for unmitigated and mitigated activities**.** This applies to $PM_{2.5}$ and PM_{10} concentrations and dustfall rates.

5.2 Cumulative impacts

In order to prioritise the simulated impacts, it is necessary to assess the potentially significant impacts in terms of cumulative impacts and the degree to which the impact may cause irreplaceable loss of resources, as well as taking the public opinion and sentiment regarding the prospective development into account (see Appendix D for the methodology used to prioritise impacts).

There are two public respondents (PR) who have raised objections towards the proposed Kangala extension project; it was assumed that PR is **High** (3). The assessment of whether the loss of resources due to the proposed development is irreversible (LR), is considered **Low** (1) for construction and decommissioning, and **Low to Medium** (2) for the operational phase. The cumulative impacts (CI) with respect to the Eloff Colliery construction and decommissioning phases are both assessed as **Low** (1), and the CI with respect to Eloff Colliery operational phase is assessed as **Medium** (2) for both design-mitigated operations and additionally mitigated operations. The priority score is determined by adding the scores for PR, CI and LR, giving a prioritisation factor (PF) of 1.33 for the construction, decommissioning/closure and post-closure phases, and 1.67 for the operational phase.

The final impact significance associated with the proposed Eloff Colliery development is determined by multiplying the PF with the ER of the post-mitigation scoring, viz. **Low** for the construction phase (Table 15), decommissioning phase (Table 18) and post-closure phase (Table 19), **High** for the operational phase (with design mitigation applied) (Table 16) and **Medium** for the operational phase (additional mitigation applied) (Table 17).

Table 15: Significance rating for the Eloff Project (Construction)

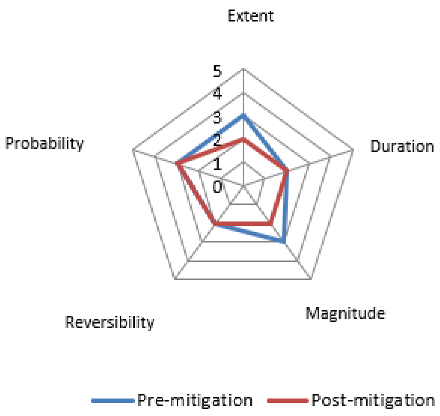
<table>
<tr><td rowspan="21">Impact Table
 </td><td>Impact Name</td><td colspan="5">Decline in Air Quality: Eloff Project</td></tr>
<tr><td>Phase</td><td colspan="5">Construction</td></tr>
<tr><td colspan="6">Environmental Risk</td></tr>
<tr><td>Attribute</td><td>Pre-mitigation</td><td>Post-mitigation</td><td>Attribute</td><td>Pre-mitigation</td><td>Post-mitigation</td></tr>
<tr><td>Nature of Impact</td><td>-1</td><td>-1</td><td>Magnitude of Impact</td><td>3</td><td>2</td></tr>
<tr><td>Extent of Impact</td><td>3</td><td>2</td><td>Reversibility of Impact</td><td>2</td><td>2</td></tr>
<tr><td>Duration of Impact</td><td>1</td><td>1</td><td>Probability</td><td>3</td><td>3</td></tr>
<tr><td colspan="5">Environmental Risk (Pre-mitigation)</td><td>-6.75</td></tr>
<tr><td colspan="6">Mitigation Measures</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="5">Environmental Risk (Post-mitigation)</td><td>-5.25</td></tr>
<tr><td colspan="5">Degree of confidence in impact prediction:</td><td>Medium</td></tr>
<tr><td colspan="6">Impact Prioritisation</td></tr>
<tr><td colspan="5">Public Response</td><td>3</td></tr>
<tr><td colspan="6"><i>Issue has received an intense meaningful and justifiable public response (adjacent landowner and AFGRI grain silos)</i></td></tr>
<tr><td colspan="5">Cumulative Impacts</td><td>1</td></tr>
<tr><td colspan="6"><i>Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.</i></td></tr>
<tr><td colspan="5">Degree of potential irreplaceable loss of resources</td><td>1</td></tr>
<tr><td colspan="6"><i>The impact is unlikely to result in irreplaceable loss of resources.</i></td></tr>
<tr><td colspan="5">Prioritisation Factor</td><td>1.33</td></tr>
<tr><td colspan="5">Final Significance</td><td>-8.00</td></tr>
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Table 16: Significance rating for the Eloff Operational Phase (with proposed co-disposal facility) – Design Mitigation

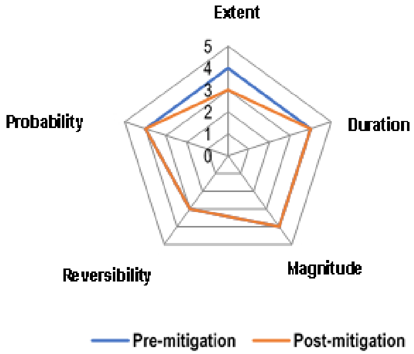
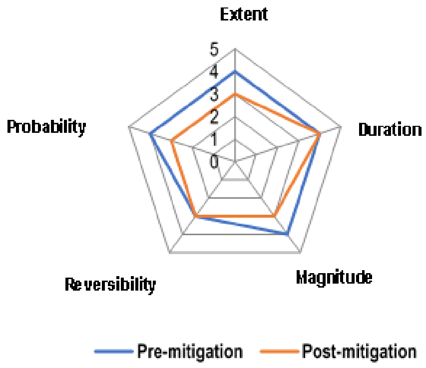
Impact Table	**Impact Name**	**Decline in Air Quality: Eloff Project**				
	**Phase**	**Operation - Design Mitigation**				
	Environmental Risk					
	Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
	Nature of Impact	-1	-1	Magnitude of Impact	4	4
	Extent of Impact	4	3	Reversibility of Impact	3	3
	Duration of Impact	4	4	Probability	4	4
	Environmental Risk (Pre-mitigation)					-15.00
	Mitigation Measures					
	Environmental Risk (Post-mitigation)					-14.00
	Degree of confidence in impact prediction:					Medium
	Impact Prioritisation					
	Public Response					3
	Issue has received an intense meaningful and justifiable public response (adjacent landowner and AFGRI grain silos)					
	Cumulative Impacts					2
	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.					
	Degree of potential irreplaceable loss of resources					2
	The impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.					
	Prioritisation Factor					1.67
	Final Significance					-23.33

Table 17: Significance rating for the Eloff Operational Phase (with proposed co-disposal facility) – Added Mitigation)

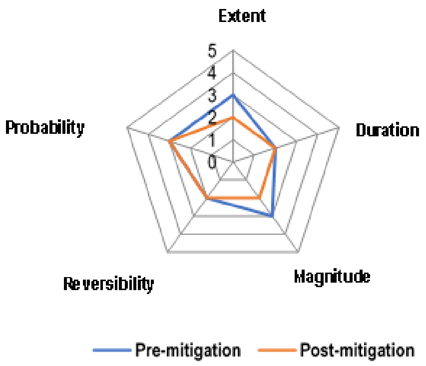
Impact Table



Impact Name	**Decline in Air Quality: Eloff Project**				
Phase	**Operation - Added Mitigation**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	4	4
Extent of Impact	4	3	Reversibility of Impact	3	3
Duration of Impact	4	4	Probability	4	4
Environmental Risk (Pre-mitigation)					-15.00
Mitigation Measures					
Environmental Risk (Post-mitigation)					-9.75
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					3
Issue has received an intense meaningful and justifiable public response (adjacent landowner and AFGRI grain silos)					
Cumulative Impacts					2
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					2
The impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.					
Prioritisation Factor					1.67
Final Significance					-16.25

Table 18: Significance rating for the Eloff Project (Decommissioning)

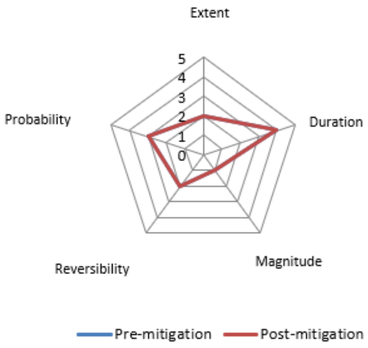
Impact Table



Impact Name	**Decline in Air Quality: Eloff Project**				
Phase	**Decommissioning**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	3	2
Extent of Impact	3	2	Reversibility of Impact	2	2
Duration of Impact	2	2	Probability	3	3
Environmental Risk (Pre-mitigation)					-7.50
Mitigation Measures					
Environmental Risk (Post-mitigation)					-6.00
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					3
Issue has received an intense meaningful and justifiable public response (adjacent landowner and AFGRI grain silos)					
Cumulative Impacts					1
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					1
The impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.33
Final Significance					-8.00

Table 19: Significance rating for the Eloff Project (Post-Closure)

Impact Table



Impact Name	**Decline in Air Quality: Eloff Project**				
Phase	**Post-Closure**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	1	1
Extent of Impact	2	2	Reversibility of Impact	2	2
Duration of Impact	4	4	Probability	3	3
Environmental Risk (Pre-mitigation)					-6.75
Mitigation Measures					
Environmental Risk (Post-mitigation)					-6.75
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					3
Issue has received an intense meaningful and justifiable public response (adjacent landowner and AFGRI grain silos)					
Cumulative Impacts					1
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					1
The impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.33
Final Significance					-9.00

6 Recommended Air Quality Management Measures

In the light of the Project being in the Highveld Priority Area, and close to various mining and power generation activities, it is recommended that air quality management planning forms part of the operational phase and decommissioning of the Project. The air quality management plan provides options on the control of dust at the main sources with the monitoring network designed as such to track the effectiveness of the mitigation measures. The sources need to be ranked according to sources 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.

The main objective of the proposed air quality management measures for the project is to ensure that operations result in ambient air concentrations (specifically $PM_{2.5}$ and PM_{10}) and dustfall rates that are within the relevant ambient air quality standards and regulations outside the mining area and at the relevant AQSRs. In order to define site specific management objectives, the main sources of pollution need to be identified. Once the main sources have been identified, target control efficiencies for each source can be defined to ensure acceptable cumulative ground level concentrations.

6.1 Ranking of Sources

The ranking of sources serves to confirm the current understanding of the significance of specific sources, and to evaluate the emission reduction potentials required for each. Sources ranking can be established on:

- Emissions ranking; based on the comprehensive emissions inventory established for the operations (Section 4.1); and
- Impacts ranking; based on the simulated pollutant GLCs.

Ranking of sources based on emissions, are as follows:

- **Scenario 1**: the main source of emissions for design mitigated $PM_{2.5}$ is in-pit operations (42%) followed by unpaved roads (29%); unpaved roads for PM_{10} (54%) and TSP (62%), followed by in-pit operations for PM_{10} (33%) and TSP (18%).
- **Scenario 2**: similar as for Scenario 1, the main source of emissions for design mitigated $PM_{2.5}$ is in-pit operations (40%) followed by unpaved roads (34%); unpaved roads for PM_{10} (58%) and TSP (59%), followed by in-pit operations for PM_{10} (29%) and wind erosion for TSP (23%).

Ranking of sources based on impacts, are as follows:

- **Scenario 1**: the main source of impact for design mitigated PM_{10} due to Eloff Colliery operations is vehicle entrained dust from unpaved roads, ranging in contribution to total simulated GLCs between 39% and 98%. The secondary source of impact for design mitigated PM_{10} is in-pit operations, ranging in contribution to total simulated GLCs between 1% and 53%. For design mitigated $PM_{2.5}$, in-pit operations were the main source of impact at 14 AQSRs, ranging in contribution between 2% and 63%, followed by crushing operations, ranging in contribution between 6% and 45%. The main source of impact for design mitigated dust fallout is vehicle entrained dust from unpaved roads, ranging in contribution between 17% and 98%.

The secondary source of impact for dust fallout is windblown dust from the discard stockpile and topsoil stockpile, ranging in contribution between 1% and 75%.

- **Scenario 2**: the main source of impact for design mitigated PM_{10} due to Eloff Colliery operations is vehicle entrained dust from unpaved roads, ranging in contribution to total simulated GLCs between 44% and 98%. The secondary source of impact for design mitigated PM_{10} is in-pit operations, ranging in contribution to total simulated GLCs between 1% and 49%. For design mitigated $PM_{2.5}$, vehicle entrained dust was the main source of impact ranging in contribution between 11% and 93%, followed by in-pit operations ranging in contribution between 1% and 61%. The main source of impact for design mitigated dust fallout is vehicle entrained dust from unpaved roads, ranging in contribution between 32% and 99%. The secondary source of impact for dust fallout is windblown dust, ranging in contribution between 0% and 58%.
- **Decommissioning/Closure**: Likely activities to result in dust impacts during decommissioning/closure are:
    - infrastructure removal/demolition;
    - topsoil recovered from stockpiles for rehabilitation and re-vegetation of surroundings; and
    - vehicle entrainment on unpaved road surfaces during rehabilitation – once that is done, vehicle activity associated with the mining operations should cease.
- **Post-Closure**: No impacts are expected post-closure provided the rehabilitation of final land forms is successful.

Table 20: Air Quality Management Plan – Operation Phase

Aspect	Impact	Management Actions/Objectives	Responsible Person(s)	Target Date
Vehicle activity on unpaved roads	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Regular water sprays and chemical suppression on unpaved roads to ensure at least 90% control efficiency. • Monthly physical inspection of road surface, daily visual observation of entrained dust emissions from unpaved road surfaces.	Environmental Manager	On-going during operational phase
Drilling & Blasting	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Controlled blasting techniques to be used to ensure minimal dust generation. • Blasting only to be conducted on cloudless days, if possible. • Water sprays on drilling activities. • Addition of chemical surfactants to water sprays to lower water surface tension and increase binding properties. • Drilling to be controlled through water sprays or vacuum packs	Mine Production Engineer Drill Rig Operator Environmental Officer	On-going during operational phase
Materials Handling	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Increase in-pit material moisture content. • Drop height from excavator into haul trucks to be kept at a minimum for ore and waste rock. • Tipping onto ROM storage piles to be controlled through water sprays, should significant amounts of dust be generated. • Keep material handled by dozers and wheeled loaders moist to achieve a control efficiency of 50%, especially during dry periods. • Regular clean-up at loading areas.	Mine Production Engineer Environmental Officer	On-going during operational phase
Wind Erosion	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Water sprays at ROM stockpile can achieve 50% control efficiency. Increase in moisture content provides higher threshold friction velocity and ensures that particulates are not as easily entrained due to high surface winds. • Reshape all disturbed areas to their natural contours. • Cover disturbed areas with previously collected topsoil and replant native species. • Rock cladding with larger pieces of waste rock is recommended to reduce wind erosion emissions from the overburden storage piles. • Revegetation of overburden stockpile is recommended.	Mining Engineer Environmental Officer	On-going during operational phase
Crushing	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Water sprays at the crushers to achieve at least 50% control efficiency.	Mining Engineer Environmental Officer	On-going during operational phase

Table 21: Air Quality Management Plan - Decommissioning and Closure Phases

Aspect	Impact	Management Actions/Objectives	Responsible Person(s)	Target Date
Wind erosion from exposed areas	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	Demolition of infrastructure to have water sprays where vehicle activity is high. Rehabilitation and vegetation of mined area.	Contractor(s) Environmental Manager	Post-operational, can cease once rehabilitation is in place

6.2 Ambient Monitoring

Environmental indicators are used in Environmental Land Use Planning and Management to simplify environmental assessments.

Indicators are defined as a single measure of a condition of an environmental element that represents the status or quality of that element. An index is a combination of a group of indicators to measure the overall status of an environmental element, and a threshold is the value of an indicator or index. For example, ambient PM_{10} concentrations monitored within a specific area will be the indicator, with the NAAQS being the threshold.

It is recommended that the existing dustfall monitoring network be expanded for the proposed Eloff project to continue the dustfall monitoring program during the operation of the mine.

The location of the new dust buckets EL-001 to EL-003 is provided in Figure 21. Should dustfall at the Delmas residential receptor (EL-003) exceed the NDCR, it is recommended that a 3-month PM_{10} sampling campaign be undertaken to assess whether a permanent PM_{10} sampler should be installed and to inform decision-making on additional mitigation measures that may be applied to the activities at the Eloff block mine and Kangala Colliery.

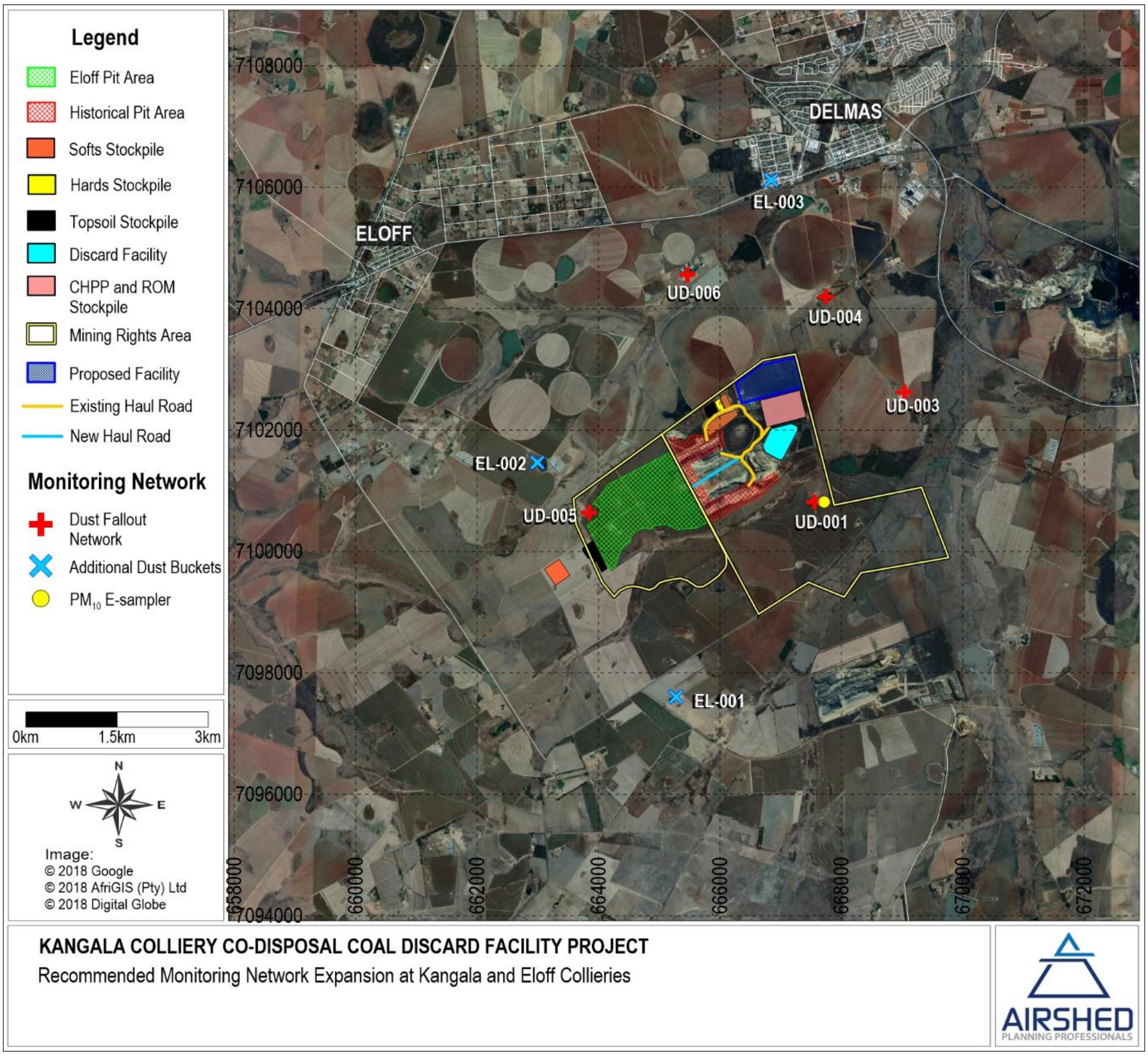


Figure 21: Recommended expansion of monitoring network at the Eloff pit area and Kangala Colliery

The recommended performance assessment and reporting programme for dustfall monitoring is given in Table 22.

Table 22: Ambient air monitoring, performance assessment and reporting programme

Monitoring Strategy Criteria	Dustfall Monitoring
Monitoring objectives	- Assessment of compliance with dust control regulations. - Facilitate the measurement of progress against environmental targets. - Temporal trend analysis to determine the potential for nuisance impacts. - Tracking of progress due to pollution control measure implementation. - Informing the public of the extent of localised dust nuisance impacts occurring in the vicinity of the operations.
Monitoring location(s)	Three extra single dust buckets with recommended positions as provided in the section above. Should dustfall at the Delmas residential receptor (EL-003) exceed the NDCR, it is recommended that a 3-month PM_{10} sampling campaign be undertaken to assess whether a permanent PM_{10} sampler should be installed.
Sampling techniques	*Single Bucket Dustfall Monitors* Dustfall sampling measures the fallout of windblown settleable 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 ±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 annual average 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 interested and affected parties (I&APs). 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.

7 Conclusions

The main objective of the investigation was to quantify the potential impacts resulting from the proposed co-disposal facility on the surrounding environment and human health. As part of the air quality assessment, a good understanding of the regional climate and local dispersion potential of the site is necessary as well as an understanding of existing sources of air pollution in the region and the current and potential future air quality. The findings are based on the qualitative assessment of the potential impacts.

7.1 Main Findings

The findings from the baseline assessment can be summarised as follows:

- Particulates represent the main criteria pollutant of concern in the assessment of operations from the Project.

- The wind field is dominated by winds from the north and north-northeast with an average wind speed of 3.22 m/s. Wind speeds exceeding 5 m/s occurred for 14.4% of the time. During the day, northerly wind flow is more frequent whereas at night, north-northeasterly wind flow becomes more frequent.

- The topography of the study area is fairly flat, comprising of undulating terrain slightly increasing in height above mean sea level to the northeast of the area. An analysis of topographical data indicated a slope of less than 1:10 over most of the project area. Average total annual rainfall for the study region is in the range of 681 mm. The climate is classified as warm and temperate. The region is the coldest during August with a minimum temperature of -1.2°C during the night and warmest during January when temperatures reach 31°C during the day.

- Based on the nature of the project and expected air quality impacts, a study area of 15 km east-west by 15 km north-south, with the Project site located centrally, was selected. Air quality sensitive receptors (AQSR) within the study area include farmsteads, residential areas, schools, a hospital, agricultural holdings and Afgri silos.

- Existing sources of air emissions include power generation, agricultural activities, metallurgical manufacturing processes, opencast coal mining and residential fuel burning.

- The measured PM_{10} daily ground level concentrations from the Kangala PM_{10} monitoring station for the period May 2016 to July 2018 regularly exceeded the daily NAAQS. The PM_{10} annual concentrations (calculated from the daily concentrations for the monitoring period) were 46 µg/m³ (2015/2016); 23 µg/m³ (2016/2017); and 26 µg/m³ (2017/2018).

- Monitored dustfall levels at the UD-003 monitoring station exceeded the residential limit of 600 mg/m²/day more than twice per year, and for sequential months, during the 2015/2016, 2016/2017, and 2017/2018 sampling periods. This may be due to its close proximity to the R42 road.

- The Project is located within the Highveld Priority Area, in close proximity to Leeuwpan and Stuart (opencast) collieries.

To determine the significance of air pollution impacts from the proposed Project, two scenarios were taken into account:

- **Baseline scenario (Scenario 1)** – representative of maximum throughput from opencast mining activities at the Eloff Project area (in the year 2026), with discard throughput and site design as used in the 2018 study; and
- **Project scenario (Scenario 2)** – representative of maximum throughput from opencast mining activities at the Eloff Project area (in the year 2026), with additional activities in the form of windblown dust from the new co-disposal facility, truck activity on onsite unpaved roads (transporting coarse discard and slurry to the co-disposal facility); and materials handling at the CHPP and new co-disposal facility. Waste and ROM throughputs were assumed to be the same as that used in the baseline scenario, but a higher volume of discard was used according to the latest information that was provided. Additional roads and waste stockpiles were identified from the latest site design that was provided and included in the model.

The baseline scenario emissions and impacts were used from the 2018 study and no remodelling was done. Emission equations were used to quantify emissions from the proposed activities (Scenario 2) and both unmitigated and mitigated activities were assessed. Each of the baseline and project scenarios had 3 sub-scenarios, namely (a) unmitigated operations, (b) design mitigated operations and (c) additionally mitigated operations.

Estimated emissions were higher for the Project scenario than for the Baseline scenario due to the updating of the model to include the latest information (discard throughput and additional sources identified from the latest site layout). Emissions due to materials handling were also slightly higher because of higher wind speeds in the meteorological dataset that was used. (Meteorological data for 2015 to 2017 were used in the model to comply with Regulations for Dispersion Modelling, whereas the previous dataset spanned the period 2014 to 2016).

The main findings for the Project Scenario (proposed co-disposal facility) were as follows:

- The daily **PM_{10}** SA NAAQS was exceeded at all AQSRs (27) for unmitigated activities. For the design mitigated scenario, simulated PM_{10} concentrations exceeded the daily SA NAAQS at 6 AQSRs. With additional mitigation, non-compliances were still simulated at 3 AQSRs. Over an annual average unmitigated PM_{10} impacts exceeded the annual NAAQS at 2 AQSRs. These impacts were reduced when design mitigation is applied, with exceedances simulated at only one AQSR and no exceedances for additionally mitigated activities.
- **$PM_{2.5}$** daily GLCs, with no mitigation in place, were in non-compliance with the 2030 NAAQSs at 4 AQSRs. Simulated impacts were reduced when design mitigation is applied with exceedance of the 2030 NAAQS simulated at two AQSRs. With additional mitigation, simulated $PM_{2.5}$ daily GLCs were within compliance at all AQSRs. Over an annual average design mitigated simulated GLCs and additionally mitigated GLCs, were within compliance currently and after 2030.

- The simulated maximum daily **dustfall** rates due to the unmitigated scenario exceeded the NDCR for residential areas at only one AQSR. Simulated dustfall rates at all AQSRs were well within the residential limit for the design mitigated and additionally mitigated scenarios.
- Both Baseline and Project operations resulted in **High** significance for design mitigated operations and **Medium** significance for additionally mitigated operations. The highest PM_{10} and $PM_{2.5}$ impacts were mainly due to vehicle entrained dust from unpaved roads, whereas the highest dustfall impacts were due to windblown dust.

Simulated results from the impact assessment due to the Baseline and Project did not show any significant differences with respect to compliance of PM_{10} and $PM_{2.5}$ ground level concentrations with the SA NAAQS and compliance of simulated dustfall levels with the NDCR for residential areas. Simulated footprint areas of exceedance for PM_{10} and $PM_{2.5}$ impacts due to Project operations were slightly bigger than those due to Baseline operations. Two additional AQSRs were included in the model to assess impacts at Eloff Landgoed and Eloff Silo.

7.2 Recommendations

The proposed Eloff Project is located within the Highveld Priority Area and close to various mining and power generation sources. The management plan objectives for this priority area are to minimise impacts on the surrounding environment. It is therefore recommended that air quality management measures be implemented to ensure the lowest possible impacts on the surrounding environment from the mining operations. These measures should include:

- Implementation and monitoring of design mitigation measures. Additional mitigation measures are recommended to ensure mining related impacts remain within the Mine License Area. Based on the ranking of the main sources, these include:
  - Frequent water sprays (> 2 litres/m²/hr) on the in-pit roads to ensure a control efficiency of at least 75% and chemical suppressants on the unpaved haul roads to ensure a control efficiency of more than 90%;
  - Temporary wind breaks to be installed onto the topsoil stockpile (30% control efficiency) and vegetation cover to be established on the dormant areas and side slopes (40% control efficiency) (NPI, 2011).
- To ensure the impacts on the surrounding environment and human health remain acceptable throughout the Life of Mine (LoM), 3 dustfall units are recommended to be added to the existing dustfall monitoring network. Should dustfall at the Delmas residential receptor (EL-003) exceed the NDCR, it is recommended that a 3-month PM_{10} sampling campaign be undertaken to assess whether a permanent PM_{10} sampler should be installed.

7.3 Conclusions

The planned operations would likely not have a significant *incremental* impact (over and above the baseline) on the surrounding environment and human health during the operational phase, provided additional mitigation measures are applied. The application of additional mitigation on haul roads is recommended to ensure that people (and livestock) not be exposed to ambient air quality that may be harmful to human health. The low dustfall rates that were simulated at the closest AFGRI site suggests that the grain from the AFGRI silos and the crops at the nearby farms will not be affected adversely by the proposed development.

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9 Appendix A – Specialist Curriculum Vitae

CURRICULUM VITAE

Name	Rochelle Bornman
Date of Birth	24 August 1974
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Air Quality Specialist
Profession	Scientist
Years with Firm	13

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Member of National Association for Clean Air (NACA)

EXPERIENCE

- Emissions inventory compilation
- Meteorological, topographical and land use data processing and preparation
- Dispersion modelling experienced in SCREEN, AERMOD, ADMS, CALINE and CALPUFF dispersion models.
- Impact and compliance assessment
- Air quality and dust management plan preparation
- Atmospheric emission license application
- Industry sectors in which experience have been gained with specific reference to air quality include:
    - Opencast and underground mining of: copper, platinum, gold, iron, and coal.
    - Production of: copper, platinum, gold, base metals, iron, steel, and tyre pyrolysis.
    - Biomass to Energy production
    - Fire behaviour modelling

SOFTWARE PROFICIENCY

- Atmospheric Dispersion Models: AERMOD, ISC, CALPUFF, ADMS (United Kingdom), TANKS
- Other: Golden Software Surfer, Lakes Environmental WRPlot, MS Word, MS Excel, MS PowerPoint, ArcMap, ArcView

EDUCATION

- B. Land Surveying: 1997, *University of Pretoria*
- MPhil: (Geographical Information Systems and Remote Sensing) 1998, *University of Cambridge*

COURSES COMPLETED AND CONFERENCES ATTENDED

- NACA Conference 2010, 2011
- Laboratory Systems Course (ISO 17025: 2017) March 2018

COURSES PRESENTED

- Geodesy and Land Surveying at the University of Pretoria (1999)

COUNTRIES OF WORK EXPERIENCE

- South Africa, Namibia, Mozambique, Saudi Arabia, Mali

LANGUAGES

Language	Proficiency
English	Full professional proficiency
Afrikaans	Full professional proficiency

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CERTIFICATION

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

25 May 2021

10 Appendix B – Detailed Description of Mining and Processing Activities at Kangala Colliery

10.1 Mining Method

The mining method that has been applied during the Eloff project is standard truck and shovel strip mining, which is described as follows:

- The topsoil is removed by truck and shovel and stored at the designated area.
- Thereafter, the softs will be removed by truck and shovel and stored at the designated material stockpiles.
- Next, cast blasting of the hard overburden material will be employed.
- Roll-over dozing of the hard overburden material will follow, where practical.
- Truck and shovel mining techniques are then applied to remove the hard overburden material in order to expose the various coal seams.
- Finally, the coal seams will be excavated by truck and shovel mining techniques.
- Any parting or inter-burden material between the coal seams will be drilled and blasted before being removed by the truck and shovel technique.

The process is repeated on a strip-by-strip basis. Material (apart from the topsoil) will then be rolled-over into the void created by the removal of the waste and coal in the previous bench, with the hard overburden and parting/ inter-burden forming the base, followed by the softs, levelled, and finally topsoil will be placed and seeded.

10.2 Coal Handling Processing Plant

The Kangala Colliery CHPP consists of a (i) crushing and screening plant, where high-quality raw coal (from the MBC1 and MBC2 seams) are directly crushed and screened to the final Eskom product; and (ii) DMS plant, where lower-quality raw coal (from the MBAB and MBD seams) is crushed and screened and then washed to produce a higher grade coal that can be blended with the raw product to produce the final Eskom product, and MM seam coal is crushed, screened and washed for an export product.

10.3 Crushing and Screening Plant

Raw coal from the mining process is fed to the crush and screen plant by haul trucks that tip their loads into the crush and screen plant 100 cubic metres ($m^{3)}$ feed bin. From there, the coal is fed to the primary crusher via a vibrating feeder. A magnet installed before the primary crusher removes tramp metal to protect the crushers from damage. The feed to the crusher has a maximum top size of 600 mm and produces a top size of 100 mm.

From the primary crusher, the coal is fed to the scalping screen via the scalping screen conveyor. A sacrifice conveyor is installed underneath the vibrating feeder to collect all the fines from this section and deliver it to the scalping screen conveyor as part of the feed to the scalping screen.

The scalping screen separates at 50 mm size maximum, which is the final product specification. The oversize (plus) + 50 mm are fed to the secondary crusher and the (minus) - 50 mm reports to the first overland conveyor as the final product. This conveyor is fitted with a weightometer and an auto sampler to determine production rates and quality of the crush and screen plant.

At the secondary crusher, the + 50 mm coal is re-crushed to the desired - 50 mm product requirement. The product from the secondary crusher also reports to the scalping screen for final classification by means of the recirculating conveyor.

The final product is transferred to the second overland conveyor that delivers the product to the product stockpile slew conveyor. The second overland conveyor is also fitted with a weightometer and an auto sampler to determine coal production and quality to Eskom.

The final Eskom product from the DMS plant is also added at the second overland conveyor for blending into the final Eskom product. The slew conveyor places the final product into separate 6 000 tonne stockpiles for pre-certification, from where it is transported to Eskom using road transport. The coal is processed at 350 tph through the crush and screen plant.

10.4 Dense Medium Separation Plant

Raw coal from the mining process is fed to the DMS plant by the haul trucks that tip their load into the DMS dedicated 100 m^3 feed bin. From there, the coal is fed to the primary crusher by a vibrating feeder. The primary crusher is a rotary breaker that removes rock from the lower grade coal and improves the yield and life of the downstream process. The feed to the breaker has a maximum top size of 600 mm and produces a top size of 100 mm.

From the rotary breaker, the coal is fed by a conveyor to the scalping screen. A magnet on the scalping screen conveyor protects the plant from damage by removing tramp metal to the feed of the scalping screen.

The scalping screen is a double deck resonance screens that separate the coal at 50 mm maximum, which is the final product specification. The oversize + 50 mm is fed to the secondary crusher, while the -50 mm is fed, by a sacrifice conveyor, to the primary wash conveyor as the feed to the primary wash section. At the secondary crusher, the + 50 mm coal is re-crushed to the desired -50 mm product requirement.

From the scalping screen, the coal is fed to the primary wash screen/ de-sliming screen via the de-sliming screen feed conveyor. This conveyor is fitted with a weightometer to determine the production rate of the DMS plant. The primary wash screen separates the - 1.0 mm fraction. Spray and dilution water are added to this screen to transport the coal further down the process.

The -1.0 mm fraction reports to the -1.0 mm tank from where it is pumped to the -1.0 mm spiral feed cyclone that separates at 125 microns. The -125 microns is fed to the thickeners. The underflow from the thickeners is pumped to the pollution control dam (PCD). The clean water from thickeners is collected in the clear water tank from where it is pumped to the process water tank for reuse in the process.

The + 125 micron – 1.0 mm fraction from the cyclone is fed to the spiral plant for separating the coal into the product and discard. Both the product and discard from the spirals are sent through dewatering cyclones and the water from the cyclones is returned to the –1.0 mm tank for reprocessing. Both the spiral product and discard is sent over dewatering screens for final dewatering. The spiral product reports to the product stockpiles and the spiral discard reports to the discard dump.

The + 1.0 mm - 50 mm fractions from the primary wash/ de-sliming screen are washed through the DMS cyclone plant following the normal process for such a plant. This would include dewatering of the product as well as discard and magnetite recovery.

The clean product coal is fed to either the product stockpile conveyor or the product transfer conveyor. From the product stockpile, conveyor product can be stockpiled and sold as export material or as an Eskom product. From the product transfer conveyor, the product is transferred to the overland conveyor. This conveyor is fitted with a weightometer and an auto sampler to determine the production rate and quality of the DMS plant.

The overland conveyor joins up with the overland conveyor from the crush and screen process where blending of the DMS and crush and screen coal takes place. The blended coal is then fed via the last overland conveyor to the slew conveyor for final stockpiling of the product, as per customer specification.

The discard from the DMS cyclone, after the drain and rinse and dewatering, is then transferred to the discard stockpile conveyor that feeds the discard bin from where the discard is removed by trucks to the discard dump. The discard stockpile conveyor is fitted with a weightometer to determine the production rate of discard.

11 Appendix C –Baseline Simulations

11.1 Isopleth contour plots and simulated impacts due to Eloff baseline operations

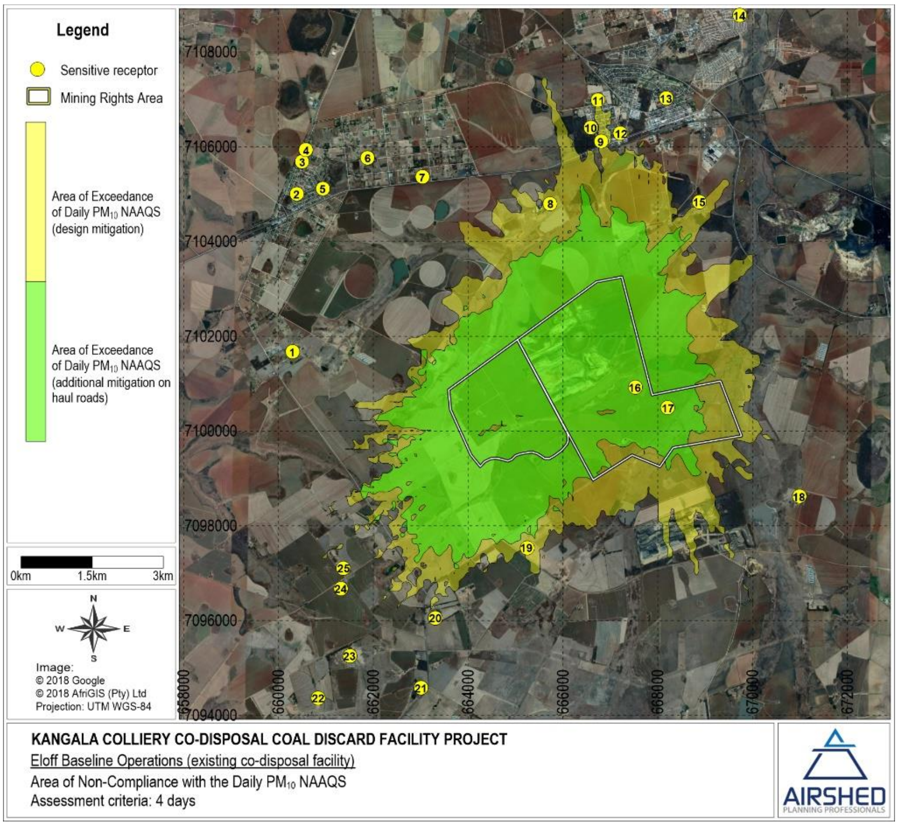


Figure 22: Area of non-compliance of PM_{10} 24-hour NAAQS due to design mitigated and additionally mitigated Eloff baseline operations (previous study)

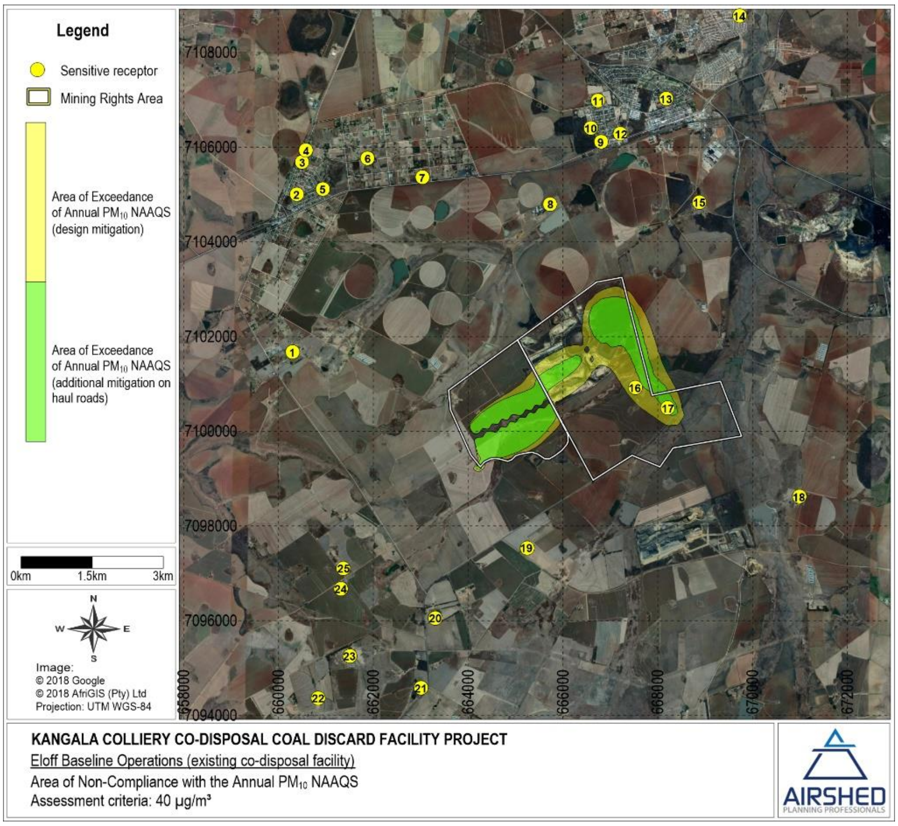


Figure 23: Area of non-compliance of PM_{10} annual NAAQS due to design mitigated and additionally mitigated Eloff baseline operations (previous study)

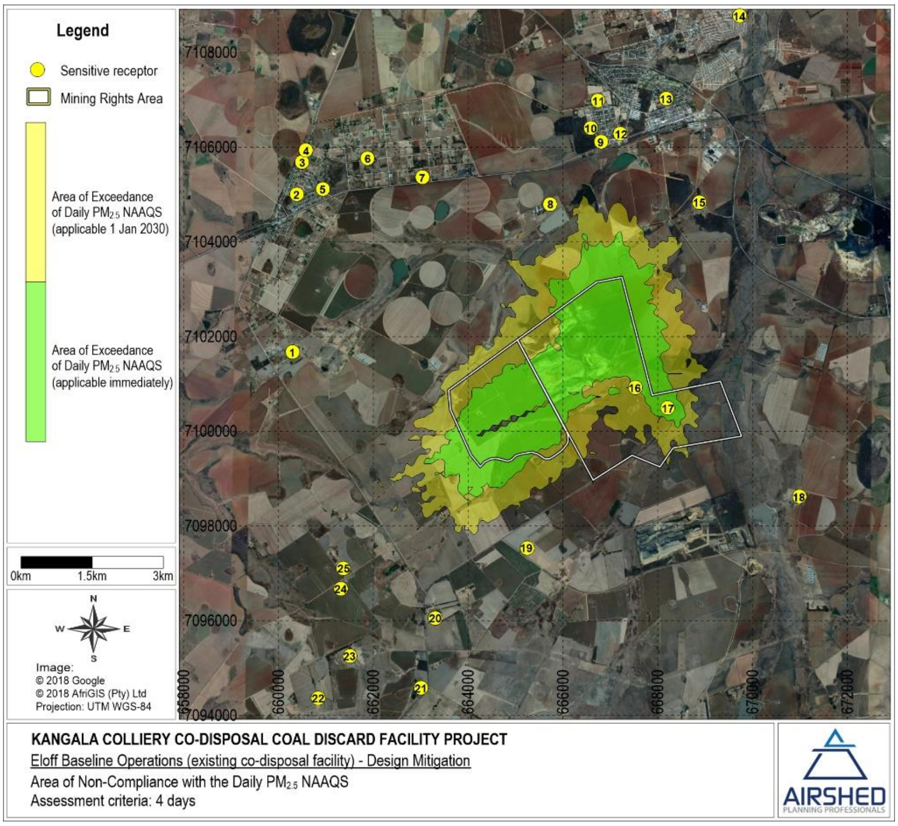


Figure 24: Area of non-compliance of $PM_{2.5}$ 24-hour NAAQS due to design mitigated Eloff baseline operations (previous study)

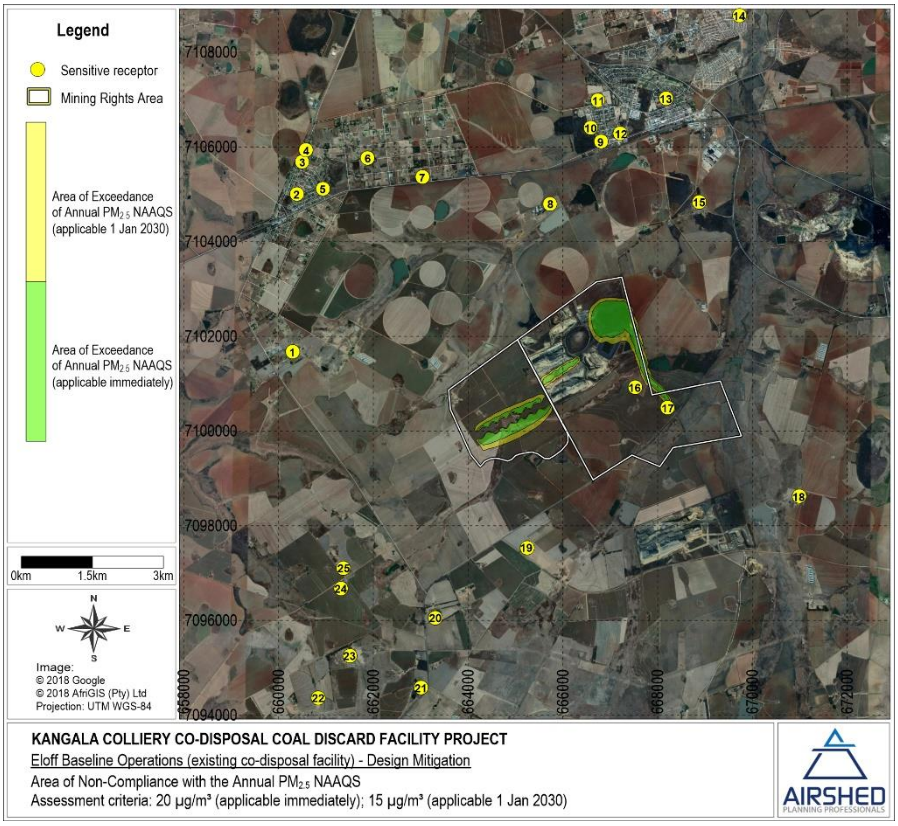


Figure 25: Area of non-compliance of $PM_{2.5}$ annual NAAQS due to design mitigated Eloff baseline operations (previous study)

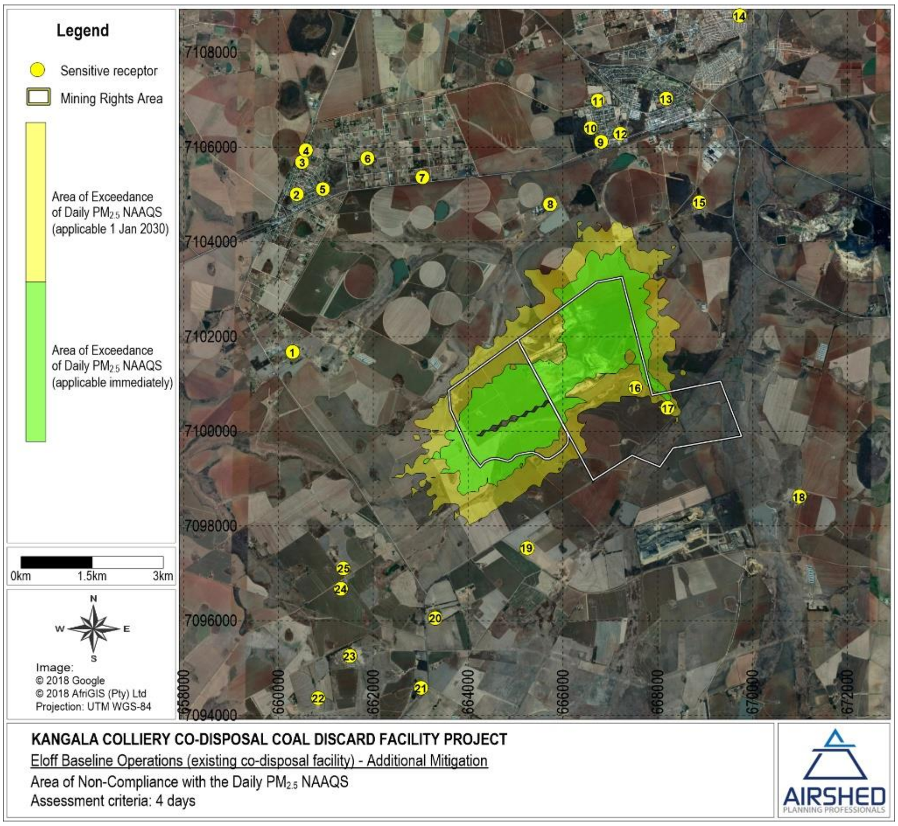


Figure 26: Area of non-compliance of $PM_{2.5}$ 24-hour NAAQS due to additionally mitigated Eloff baseline operations (previous study)

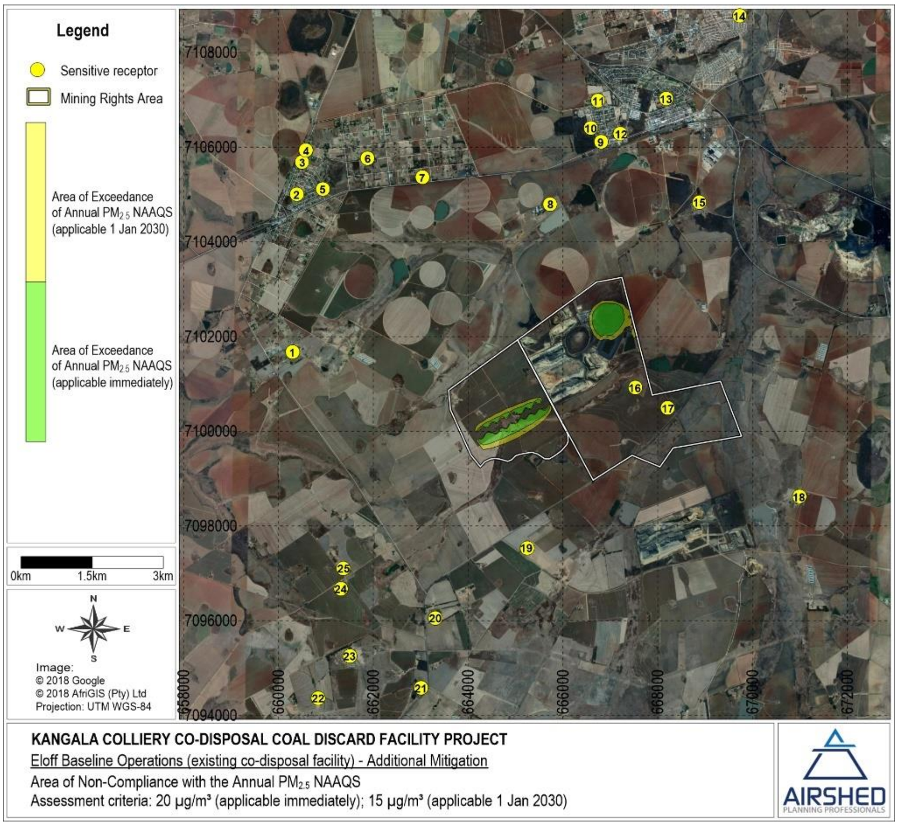


Figure 27: Area of non-compliance of $PM_{2.5}$ annual NAAQS due to additionally mitigated Eloff baseline operations (previous study)

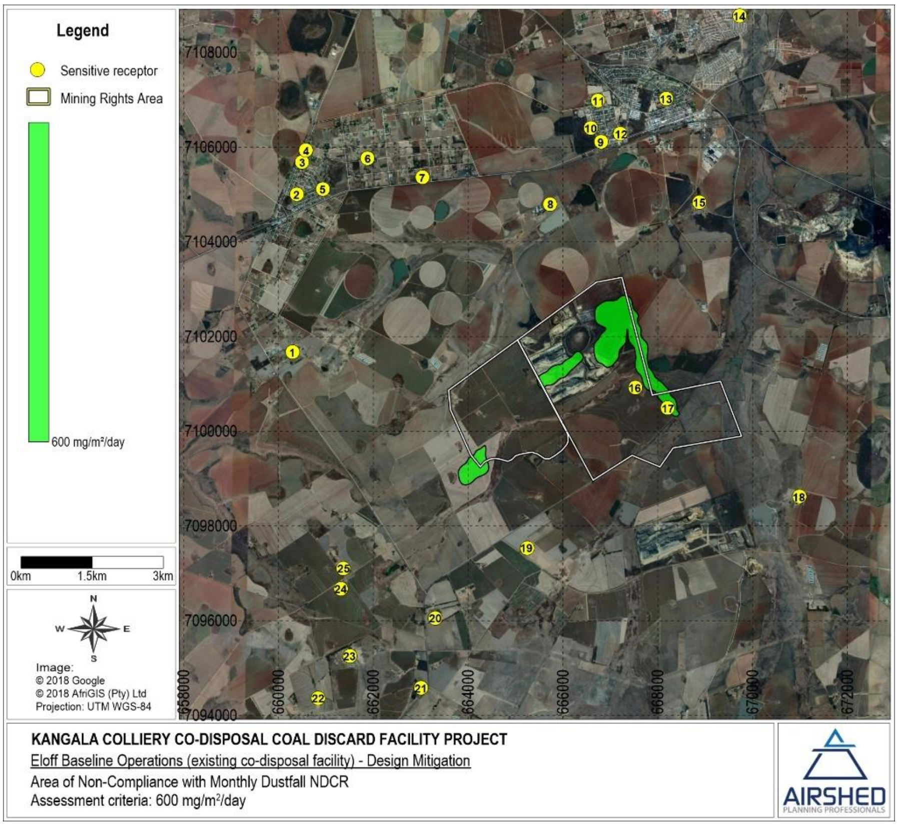


Figure 28: Simulated dustfall deposition rates due to design mitigated Eloff baseline operations (previous study)

Table 23: Simulated AQSR PM_{10} concentrations (in µg/m^3) for unmitigated, design mitigated and additionally mitigated Eloff baseline operations (previous study)

AQ SR	AQSR Type	Unmitigated				Design mitigated				Additional mitigation			
		Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)
1	Agric. Holding	206	9	12	**No**	56	3	0	Yes	39	2	0	Yes
2	School	190	7	10	**No**	52	2	0	Yes	38	1	0	Yes
3	School	150	6	8	**No**	42	2	0	Yes	38	1	0	Yes
4	School	183	6	9	**No**	50	2	0	Yes	38	1	0	Yes
5	Residential	192	7	11	**No**	54	2	0	Yes	41	1	0	Yes
6	School	188	8	13	**No**	53	2	0	Yes	42	2	0	Yes
7	Agric. Holding	286	11	20	**No**	79	3	1	Yes	51	2	0	Yes
8	Farmstead	581	19	31	**No**	154	5	10	**No**	79	4	4	Yes
9	Residential	552	13	22	**No**	143	4	5	**No**	76	2	4	Yes
10	Hospital	518	12	20	**No**	136	3	3	Yes	69	2	2	Yes
11	School	346	10	18	**No**	94	3	4	Yes	50	2	0	Yes
12	School	489	11	20	**No**	127	3	3	Yes	61	2	1	Yes
13	School	291	8	14	**No**	77	2	1	Yes	35	1	0	Yes
14	School	165	5	9	**No**	47	1	0	Yes	35	1	0	Yes
15	School	402	13	21	**No**	113	3	6	**No**	73	2	1	Yes
16	Farmstead	1703	217	259	**No**	446	57	99	**No**	208	26	26	**No**
17	Farmstead	4984	535	324	**No**	1270	135	212	**No**	536	56	88	**No**
18	Farmstead	473	13	20	**No**	123	4	3	Yes	56	2	0	Yes
19	Farmstead	474	36	55	**No**	135	10	7	**No**	108	8	0	Yes
20	Farmstead	426	17	25	**No**	119	5	2	Yes	90	4	0	Yes
21	Farmstead	225	12	17	**No**	63	3	0	Yes	45	2	0	Yes
22	Farmstead	254	8	11	**No**	70	2	0	Yes	54	2	0	Yes
23	Farmstead	317	10	13	**No**	87	3	1	Yes	67	2	0	Yes
24	Farmstead	490	12	13	**No**	134	3	4	Yes	102	2	0	Yes
25	Farmstead	553	12	16	**No**	157	3	3	Yes	120	2	0	Yes

Table 24: Simulated AQSR $PM_{2.5}$ concentrations (in $\mu g/m^3$) for unmitigated, design mitigated and additionally mitigated Eloff baseline operations (previous study)

AQ SR	AQSR Type	Unmitigated				Design mitigated				Additional mitigation			
		Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No) (a)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No) (a)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No) (a)
1	Agric. Holding	27	1	1	Yes	10	0	0	Yes	9	0	0	Yes
2	School	26	1	2	Yes	9	0	0	Yes	9	0	0	Yes
3	School	21	1	0	Yes	9	0	0	Yes	9	0	0	Yes
4	School	24	1	0	Yes	9	0	0	Yes	9	0	0	Yes
5	Residential	27	1	2	Yes	11	0	0	Yes	10	0	0	Yes
6	School	25	1	2	Yes	11	0	0	Yes	9	0	0	Yes
7	Agric. Holding	40	2	3	Yes	13	1	0	Yes	12	1	0	Yes
8	Farmstead	72	3	16	**No**	30	1	2	Yes	25	1	0	Yes
9	Residential	63	2	8	**No**	22	1	0	Yes	19	1	0	Yes
10	Hospital	60	2	8	**No**	19	1	0	Yes	16	1	0	Yes
11	School	46	1	7	**No**	16	1	0	Yes	14	0	0	Yes
12	School	56	2	8	**No**	17	1	0	Yes	15	1	0	Yes
13	School	35	1	6	**No**	12	0	0	Yes	9	0	0	Yes
14	School	24	1	0	Yes	11	0	0	Yes	9	0	0	Yes
15	School	58	2	9	**No**	24	1	0	Yes	21	0	0	Yes
16	Farmstead	204	25	129	**No**	69	7	25	**No**	63	4	12	**No**
17	Farmstead	534	55	244	**No**	145	14	70	**No**	72	6	15	**No**
18	Farmstead	54	2	5	**No**	16	1	0	Yes	12	0	0	Yes
19	Farmstead	68	5	17	**No**	29	2	2	Yes	26	2	2	Yes
20	Farmstead	57	2	5	**No**	24	1	0	Yes	21	1	0	Yes
21	Farmstead	30	2	3	Yes	12	1	0	Yes	11	1	0	Yes
22	Farmstead	33	1	2	Yes	14	0	0	Yes	12	0	0	Yes
23	Farmstead	41	1	3	Yes	17	1	0	Yes	15	0	0	Yes
24	Farmstead	65	2	6	Yes	27	1	2	Yes	24	1	0	Yes
25	Farmstead	75	2	5	Yes	31	1	2	Yes	27	1	1	Yes

Notes: **(a)** These reflect compliance with the 1 Jan 2030 NAAQSs

Table 25: Simulated AQSR total dustfall rates (in mg/m²/day) for unmitigated, design mitigated and additionally mitigated Eloff baseline operations (previous study)

AQSR	AQSR Type	Unmitigated) [(a)]	Design mitigated) [(a)]	Additional mitigation) [(a)]
1	Agric. Holding	15	4	3
2	School	9	3	2
3	School	8	2	1
4	School	7	2	1
5	Residential	9	3	1
6	School	8	2	1
7	Agric. Holding	10	3	2
8	Farmstead	23	12	12
9	Residential	16	7	6
10	Hospital	15	8	7
11	School	12	7	6
12	School	15	8	7
13	School	12	7	6
14	School	9	6	6
15	School	27	14	11
16	Farmstead	514	129	72
17	Farmstead	**2848**	**712**	285
18	Farmstead	15	4	2
19	Farmstead	47	19	16
20	Farmstead	26	10	9
21	Farmstead	17	6	5
22	Farmstead	9	3	3
23	Farmstead	11	5	4
24	Farmstead	12	4	3
25	Farmstead	14	4	3

Notes: **(a)** Screened against the residential dustfall limit of 600 mg/m²/day

11.2 Impact Significance Rating

The significance of air quality impacts was assessed according to the methodology provided to this study (refer to Appendix B of this report for the methodology).

11.2.1 Incremental Impacts

The environmental risk of the air quality impacts due to project activities were found to be:

- **Operational phase** (Eloff Project) (Table 26 and Table 27) ***High*** for design mitigated and ***Medium*** for additionally mitigated activities (based on PM_{10} impacts). The highest impacts are mainly due to unpaved roads and in-pit activities.

11.2.2 Cumulative impacts

The public response (PR) towards the proposed development was not known at the time of writing the report; it was assumed that PR is **Medium** (2). The assessment of whether the loss of resources due to the proposed development is irreversible (LR), was considered **Low to Medium** (2) for the operational phase. The cumulative impacts (CI) with respect to the Eloff Colliery operational phase was assessed as **Medium** (2) for both design-mitigated operations and additionally mitigated operations. The priority score is determined by adding the scores for PR, CI and LR, giving a prioritisation factor (PF) of 1.50 for the operational phase.

The final impact significance associated with the proposed Eloff Colliery development was determined by multiplying the PF with the ER of the post-mitigation scoring, viz. **High** for the operational phase (with design mitigation applied) and **Medium** for the operational phase (additional mitigation applied).

Table 26: Significance rating for the Eloff Operational Phase (with existing co-disposal facility) – Design Mitigation

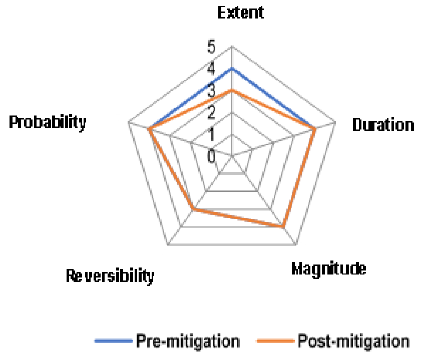
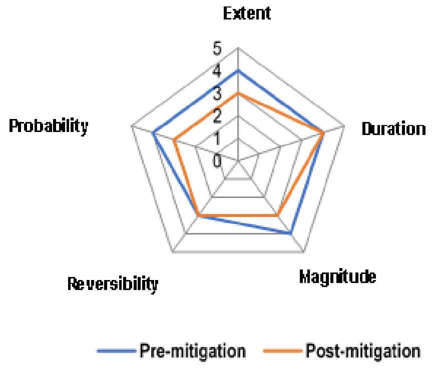
<table>
<tr><td rowspan="21">Impact Table
 </td><td>Impact Name</td><td colspan="5">Decline in Air Quality: Eloff Project</td></tr>
<tr><td>Phase</td><td colspan="5">Operation - Design Mitigation</td></tr>
<tr><td colspan="6">Environmental Risk</td></tr>
<tr><td>Attribute</td><td>Pre-mitigation</td><td>Post-mitigation</td><td>Attribute</td><td>Pre-mitigation</td><td>Post-mitigation</td></tr>
<tr><td>Nature of Impact</td><td>-1</td><td>-1</td><td>Magnitude of Impact</td><td>4</td><td>4</td></tr>
<tr><td>Extent of Impact</td><td>4</td><td>3</td><td>Reversibility of Impact</td><td>3</td><td>3</td></tr>
<tr><td>Duration of Impact</td><td>4</td><td>4</td><td>Probability</td><td>4</td><td>4</td></tr>
<tr><td colspan="5">Environmental Risk (Pre-mitigation)</td><td>-15.00</td></tr>
<tr><td colspan="6">Mitigation Measures</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="5">Environmental Risk (Post-mitigation)</td><td>-14.00</td></tr>
<tr><td colspan="5">Degree of confidence in impact prediction:</td><td>Medium</td></tr>
<tr><td colspan="6">Impact Prioritisation</td></tr>
<tr><td colspan="5">Public Response</td><td>2</td></tr>
<tr><td colspan="6"><i>Issue has received a meaningful and justifiable public response (assumption)</i></td></tr>
<tr><td colspan="5">Cumulative Impacts</td><td>2</td></tr>
<tr><td colspan="6"><i>Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.</i></td></tr>
<tr><td colspan="5">Degree of potential irreplaceable loss of resources</td><td>2</td></tr>
<tr><td colspan="6"><i>The impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.</i></td></tr>
<tr><td colspan="5">Prioritisation Factor</td><td>1.50</td></tr>
<tr><td colspan="5">Final Significance</td><td>-21.00</td></tr>
</table>

Table 27: Significance rating for the Eloff Operational Phase (with existing co-disposal facility) – Added Mitigation

<table>
<tr><td rowspan="21">Impact Table
 </td><td>Impact Name</td><td colspan="5">Decline in Air Quality: Eloff Project</td></tr>
<tr><td>Phase</td><td colspan="5">Operation - Added Mitigation</td></tr>
<tr><td colspan="6">Environmental Risk</td></tr>
<tr><td>Attribute</td><td>Pre-mitigation</td><td>Post-mitigation</td><td>Attribute</td><td>Pre-mitigation</td><td>Post-mitigation</td></tr>
<tr><td>Nature of Impact</td><td>-1</td><td>-1</td><td>Magnitude of Impact</td><td>4</td><td>4</td></tr>
<tr><td>Extent of Impact</td><td>4</td><td>3</td><td>Reversibility of Impact</td><td>3</td><td>3</td></tr>
<tr><td>Duration of Impact</td><td>4</td><td>4</td><td>Probability</td><td>4</td><td>4</td></tr>
<tr><td colspan="5">Environmental Risk (Pre-mitigation)</td><td>-15.00</td></tr>
<tr><td colspan="6">Mitigation Measures</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="5">Environmental Risk (Post-mitigation)</td><td>-9.75</td></tr>
<tr><td colspan="5">Degree of confidence in impact prediction:</td><td>Medium</td></tr>
<tr><td colspan="6">Impact Prioritisation</td></tr>
<tr><td colspan="5">Public Response</td><td>2</td></tr>
<tr><td colspan="6"><i>Issue has received a meaningful and justifiable public response (assumption)</i></td></tr>
<tr><td colspan="5">Cumulative Impacts</td><td>2</td></tr>
<tr><td colspan="6"><i>Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.</i></td></tr>
<tr><td colspan="5">Degree of potential irreplaceable loss of resources</td><td>2</td></tr>
<tr><td colspan="6"><i>The impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.</i></td></tr>
<tr><td colspan="5">Prioritisation Factor</td><td>1.50</td></tr>
<tr><td colspan="5">Final Significance</td><td>-14.63</td></tr>
</table>

12 Appendix D –Significance Rating Methodology

12.1 Impact Significance Rating Methodology

The impact assessment methodology is guided by the requirements of the NEMA EIA Regulations (2010). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/likelihood (P) of the impact occurring. This determines the environmental risk. In addition, other factors, including cumulative impacts, public concern, and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S).

Determination of Environmental Risk:

The significance (S) of an impact is determined by applying a prioritisation factor (PF) to the environmental risk (ER). The environmental risk is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and reversibility (R) applicable to the specific impact.

For the purpose of this methodology the consequence of the impact is represented by:

$$\mathbf{C = \frac{(E+D+M+R)}{4} \times N}$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 28.

Table 28: Criteria for determining impact consequence

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property boundary),
	3	Local (i.e. the area within 5 km of the site),
	4	Regional (i.e. extends between 5 and 50 km from the site
	5	Provincial / National (i.e. extends beyond 50 km from the site)
Duration	1	Immediate (<1 year)
	2	Short term (1-5 years),
	3	Medium term (6-15 years),
	4	Long term (the impact will cease after the operational life span of the project),
	5	Permanent (no mitigation measure of natural process will reduce the impact after construction).
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected),
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected),
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way),

Aspect	Score	Definition
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease), or
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease).
Reversibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring prohibitively high time and cost.
	5	Irreversible Impact

Once the C has been determined the ER is determined in accordance with the standard risk assessment relationship by multiplying the C and the P. Probability is rated/scored as per Table 29.

Table 29: Probability scoring

Probability	1	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%),
	2	Low probability (there is a possibility that the impact will occur; >25% and <50%),
	3	Medium probability (the impact may occur; >50% and <75%),
	4	High probability (it is most likely that the impact will occur- > 75% probability), or
	5	Definite (the impact will occur),

The result is a qualitative representation of relative ER associated with the impact. ER is therefore calculated as follows:

ER= C x P

Table 30: Determination of environmental risk

Consequence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
	Probability					

The outcome of the environmental risk assessment will result in a range of scores, ranging from 1 through to 25. These ER scores are then grouped into respective classes as described in Table 31.

Table 31: Significance classes

Environmental Risk Score	
Value	**Description**
< 9	Low (i.e. where this impact is unlikely to be a significant environmental risk),
≥9; <17	Medium (i.e. where the impact could have a significant environmental risk),

≥ 17	High (i.e. where the impact will have a significant environmental risk).

The impact ER will be determined for each impact without relevant management and mitigation measures (pre-mitigation), as well as post implementation of relevant management and mitigation measures (post-mitigation). This allows for a prediction in the degree to which the impact can be managed/mitigated.

Impact Prioritisation:

In accordance with the requirements of Regulation 31 (2)(l) of the EIA Regulations (GNR 543), and further to the assessment criteria presented in the Section above it is necessary to assess each potentially significant impact in terms of:

- Cumulative impacts; and
- The degree to which the impact may cause irreplaceable loss of resources.

In addition, it is important that the public opinion and sentiment regarding a prospective development and consequent potential impacts is considered in the decision-making process.

In an effort to ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impact ER (post-mitigation). This prioritisation factor does not aim to detract from the risk ratings but rather to focus the attention of the decision-making authority on the higher priority/significance issues and impacts. The PF will be applied to the ER score based on the assumption that relevant suggested management/mitigation impacts are implemented.

Table 32: Criteria for determining prioritisation

Public response (PR)	Low (1)	Issue not raised in public response.
	Medium (2)	Issue has received a meaningful and justifiable public response.
	High (3)	Issue has received an intense meaningful and justifiable public response.
Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/definite that the impact will result in spatial and temporal cumulative change.
Irreplaceable loss of resources (LR)	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.
	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table 32. The impact priority is therefore determined as follows:

Priority = PR + CI + LR

The result is a priority score which ranges from 3 to 9 and a consequent PF ranging from 1 to 2 (refer to Table 33).

Table 33: Determination of prioritisation factor

Priority	Ranking	Prioritisation Factor
3	Low	1
4	Medium	1.17
5	Medium	1.33
6	Medium	1.5
7	Medium	1.67
8	Medium	1.83
9	High	2

In order to determine the final impact significance the PF is multiplied by the ER of the post mitigation scoring. The ultimate aim of the PF is to be able to increase the post mitigation environmental risk rating by a full ranking class, if all the priority attributes are high (i.e. if an impact comes out with a medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential, significant public response, and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a high significance).

Table 34: Final environmental significance rating

Environmental Significance Rating	
Value	**Description**
< 10	Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),
≥10 <20	Medium (i.e. where the impact could influence the decision to develop in the area),
≥ 20	High (i.e. where the impact must have an influence on the decision process to develop in the area).