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ATMOSPHERIC IMPACT REPORT: Proposed Combined Cycle Power Plant (CCPP) and associated infrastructure, near Richards Bay, KwaZulu-Natal Province

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

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Report Details

Project Name	Atmospheric Impact Report: Proposed Combined Cycle Power Plant (CCPP) and associated infrastructure, near Richards Bay, KwaZulu-Natal Province
Client	Savannah Environmental (Pty) Ltd
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Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	I, Theresa Bird, as authorised representative of Airshed Planning Professionals (Pty) Ltd hereby confirm my independence as a specialist and declare that neither I nor Airshed Planning Professionals (Pty) Ltd have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which Airshed Planning Professionals (Pty) Ltd was appointed as air quality specialists in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998); other than fair remuneration for worked performed, specifically in connection with the assessment summarised in this report. I also declare that I have expertise in undertaking the specialist work as required, possessing working knowledge of the acts, regulations and guidelines relating to the application. I further declare that I am able to perform the work relating to the application in an objective manner, even if this result in views and findings that is not favourable to the application; and that I am confident in the results of the studies undertaken and conclusions drawn as a result of it – as is described in this report.
Copyright Warning	
Acknowledgements	Mrs Sandy Caminga and the RBCAA is acknowledged for: • arranging access to the data from the RBCAA air quality monitoring stations; and, • facilitating access to the baseline dispersion modelling study conducted by WSP. Dr Lisa Ramsay and Mr Hasheel Tularam, from WSP, for providing the CALPUFF output for simulated annual average pollutant concentrations for PM_{10}, SO_2 and NO_2 from the Richards Bay baseline dispersion modelling assessment.

Revision Record

Revision Number	Date	Reason for Revision
Draft	February 2018	First draft for client review
Rev 1	March 2018	Updated with client comments
Rev 2	May 2018	Updated with client comments
Rev 3 Final	February 2019	Finalised with client comments

Abbreviations

AEL	Atmospheric Emissions Licence
AIR	Atmospheric Impact Report
Airshed	Airshed Planning Professionals (Pty) Ltd
AMS	American Meteorological Society
AQMS	Air Quality Monitoring Stations
AQO	Air Quality Officer
AQSRs	Air Quality Sensitive Receptors
ARM	Ambient Ratio Method
ASTM	American Society of the International Association for Testing and Materials
CBD	Central Business District
CCPP	Combined Cycle Power Plant
DEA	Department of Environmental Affairs
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
FOE	Frequency of Exceedance
HRSG	Heat Recovery Steam Generators
LDAR	Leak Detection and Repair (programme)
LNG	Liquified Natural Gas
MES	(National) Minimum Emission Standard(s) (as defined in Section 21 of the National Environmental Management: Air Quality Act)
NAAQS	National Ambient Air Quality Standards
NEM:AQA	National Environmental Management: Air Quality Act 2004
NDCR	National Dust Control Regulations
RBCAA	Richards Bay Clean Air Association
WRF	Weather Research and Forecasting model

Glossary

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

<u>Notes:</u>

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

Symbols and Units

°C	Degree Celsius
CO	Carbon monoxide
g	Gram(s)
g/m²	Grams per square metre
g/s	Grams per second
g/s.m²	Grams per second per square metre
HAP	Hazardous air pollutants
kg	Kilograms
kg/day	Kilograms per day
km	Kilometre
kPa	Kilopascal
kV	Kilo Volt
kW	Kilo Watt
K	Temperature in Kelvin
1 kilogram	1 000 grams
m	Metre
m/s	Metres per second
mamsl	Metres above mean sea level
µg	Microgram(s)
µg/m³	Micrograms per cubic metre
m²	Square metre
m³	Cubic metre
m³/hr	Cubic metre per hour
mg/m².day	Milligram per square metre per day
mg/Am³	Milligram per actual cubic metre
mg/Nm³	Milligram per normal cubic metre (normalised at 273 K; 101.3 kpa)
MW	Mega Watt
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
O_2	Oxygen
O_3	Ozone
ppm	Parts per million
PM	Particulate matter
$PM_{2.5}$	Inhalable particulate matter (aerodynamic diameter less than 2.5 µm)
PM_{10}	Thoracic particulate matter (aerodynamic diameter less than 10 µm)
SO_2	Sulfur dioxide
t/a	Tonnes per annum
TOC	Total organic compounds
TSP	Total suspended particulates
TVOCs	Total volatile organic compounds

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

Executive Summary

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Savannah Environmental (Pty) Ltd (Savannah) to assess the impact of the proposed 3 000 MW Combined Cycle Power Plant (CCPP) near Richards Bay, KwaZulu-Natal. The CCPP will use piped natural gas for power generation. Diesel will be used as a back-up resource for power generation in emergencies when the natural gas is unavailable and will be stored in on-site storage tanks. The CCPP will include gas turbines, Heat Recovery Steam Generators (HRSGs), steam turbines, exhaust and by-pass stacks, cooling systems, diesel storage, ancillary infrastructure, offices and other buildings.

The assessment of the impact of the project assumed that emissions from the power station would primarily be vented to the atmosphere via the main stacks where the emissions would meet the minimum emission standards (MES) for Subcategory 1.4 – Gas Combustion facilities. By-pass stacks are proposed for when the heat recovery steam generators are unavailable. Three types of potential emergency events were identified:

1. HRSG and steam turbines are not available and combustion off-gases from the gas turbines are vented to the atmosphere via the by-pass stacks;
2. The CCPP runs on stored diesel via all eight turbines in conjunction with the HRSG and steam turbines to vent via the main stack;
3. The gas turbines operate on stored diesel but vent via the by-pass stacks (when HRSG and steam turbines are not available).

Emergency operations were assumed to occur for a total of 88 hours per year (1%); and for no longer than eight consecutive hours per event.

Simulated meteorological data for the Richards Bay area was acquired for the period 2013 to 2015. The wind field showed generally north to north-easterly co-dominance with south and south-westerly component.

Baseline air quality in Richards Bay, for the period mid-2013 to mid-2016, was assessed for thoracic particulates (with a diameter less than 10 µm) and sulfur dioxide (SO_2) at the monitoring stations managed by the Richards Bay Clean Air Association (RBCAA). Non-compliance with daily PM_{10} NAAQS was recorded at Brackenham (6 days) and CBD (5 days) stations during 2015. Annual compliance with NAAQS is noted at all stations for PM_{10} and SO_2 across the period assessed. Nitrogen dioxides (NO_2) is not monitored within the RBCAA network.

The impact of the proposed project on ambient air quality was simulated using the US EPA CALPUFF modelling suite. Simulated pollutant concentrations were compared against the NAAQS, international health-effect screening levels, and odour detection thresholds. Simulated nuisance dust-fall rates were compared against the National Dust Control Regulations (NDCR) for non-residential and residential areas.

The main findings of the simulated incremental assessment were:

1. Compliance with daily and annual PM_{10} NAAQS during the construction phase, if emissions are mitigated using water sprays and active (cleared) areas are kept as small as possible (monthly average area).
2. Compliance with daily and annual PM_{10} and $PM_{2.5}$ NAAQS under normal operations and emergency events.
3. Using emission factors for gas turbines combusting natural gas, compliance was simulated for hourly and daily SO_2 NAAQS. <u>It is unlikely that gas combustion will result in SO_2 emissions at the emission standard used to assess the</u>

maximum potential impact of the proposed facility, and therefore the focus of assessment was on the (lower) estimated emissions based on emission factors.

4. Compliance with annual SO_2 NAAQS under normal operations.
5. Compliance with NO_2 hourly and annual NAAQS under normal operations.
6. Based on emission factor estimates, and comparison with emission reports from two of Eskom's Peaking Power Stations combusting diesel, the proposed Richards Bay CCPP is likely to comply with NO_2 MES and NAAQS during Emergency 3-type events.
7. Compliance with NDCR, odour thresholds, and toluene health-effect screening levels due to fugitive emission sources.
8. Annual SO_2 concentrations, simulated using MES, may impact productivity of various vegetation types up to 10 km from the proposed facility (using the United Nations Economic Commission for Europe (UNECE) Convention on Long Range Trans-boundary Air Pollution Limits). Using emission factors for gas turbines combusting natural gas, annual SO_2 concentrations are not likely to impact vegetative productivity.

Impact Assessment Rating

The simulated non-compliance short-term SO_2 concentrations resulted in a "medium" significance on the local area. However, confidence that this would materialise from normal operations is low. Operating below the SO_2 emission limits, which is possible due to very low sulfur content of natural gas, would increase the significance based on higher probability. Due to the very low simulated concentrations for the gaseous pollutants (PM, NO_2, TVOCs, and odour) resulted in a "low" impact significance rating. The no-go option (baseline) was calculated to have a "medium" impact due to the duration, spatial extent, and the probability of maintaining the baseline if the proposed facility did not go ahead.

Conclusion

From an air quality perspective, it is recommended that the project go ahead, on condition that:

- Emissions due to construction activities be mitigated using good practise guidelines.
- Maintain SO_2 and NO_X emissions near the emission factor estimates.
- To limit the possibility of off-site SO_2 exceedances during emergency events, it is suggested that Emergency 2-type events be avoided as far as practically possible, by using low sulfur (50 ppm) diesel only, when diesel is used as energy source.

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Specialist report requirements

	A specialist report prepared in terms of the Environmental Impact Regulations of 2014 must contain:	Section in report
a	details of- (i) the specialist who prepared the report; and (ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	Report details (page i) Appendix C
b	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Report details (page i)
c	an indication of the scope of, and the purpose for which, the report was prepared;	Purpose and Scope (Page 1)
d	the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	A site visit was not conducted for the air quality impact assessment. Adequate project information was provided by Eskom. Ambient air quality monitoring data was shared by the RBCAA. A site visit will not have yielded any significant additional information from the baseline information received.
e	a description of the methodology adopted in preparing the report or carrying out the specialised process;	Section 5.1.1 – Study Methodology (Page 20)
f	the specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;	Section 1.3 (Page 4)
g	an identification of any areas to be avoided, including buffers;	Not Applicable
h	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 1.3 (Page 4)
i	a description of any assumptions made and any uncertainties or gaps in knowledge;	Assumptions and limitations (Page 1)
j	a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment;	Section 5.3 – Main Findings and Conclusions (Page 63)
k	any mitigation measures for inclusion in the EMPr;	
l	any conditions for inclusion in the environmental authorisation;	
m	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Emissions monitoring and testing as per conditions in AEL (to be confirmed by Authority)
n	a reasoned opinion- (i) as to whether the proposed activity or portions thereof should be authorised; and (ii) if the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 5.3 – Main Findings and Conclusions (Page 63)
o	a description of any consultation process that was undertaken during the course of preparing the specialist report;	Not Applicable
p	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Not Applicable
q	any other information requested by the competent authority.	Not Applicable

PREFACE

Background and Context

Eskom proposes to develop and operate a 3 000 MW Combined Cycle Power Plant (CCPP) near Richards Bay, KwaZulu-Natal Province. Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Savannah Environmental (Pty) Ltd to address potential impacts on the atmospheric environment by conducting a comprehensive air quality impact assessment for the CCPP Project (hereafter referred to as 'the project'). The project entails the development of the gas-fired power station and associated infrastructure (including on-site diesel storage tanks for alternative energy; gas supply pipelines; access roads; dirty-water dam for storage of process and storm water prior to the water treatment facility, switchyards, and overhead power line). A detailed process description is provided in Section 2.2. The format of the assessment meets the prescribed format of an Atmospheric Impact Report (AIR), as set out in the Regulations gazetted on 11th of October 2013 (Gazette No. 36904). Typically, an AIR would accompany the application for, an Atmospheric Emissions License (AEL). An Impact Assessment Rating is included in this report as required by the Environmental Impact Assessment (EIA) process.

Terms of Reference for EIA Phase – Air Quality Impact Assessment

The Terms of Reference, as a list of tasks, for the Air Quality Study portion of the EIA phase of the project will include:

- The compilation of a baseline emissions inventory for existing facilities within Richards Bay based on a recent Richards Bay Clean Air Association (RBCAA) inventory;
- The establishment of an emissions inventory by referring to minimum emissions standards (MES) and emission factors for combustion processes, fuel storage; and, fugitive dust;
- Atmospheric dispersion simulations for the baseline, incremental, and cumulative scenarios using the CALPUFF atmospheric dispersion model;
- A human health risk and nuisance impact screening assessment based on dispersion simulation results;
- A comprehensive air quality impact assessment report in the format prescribed by the Department of Environmental Affairs (DEA) in support of the Atmospheric Emission License (AEL) application.
    - Impact Significance rating according to the method provided by Savannah Environmental (Pty) Ltd.

Assumptions and Limitations

1. The AIR is limited to the proposed facility during construction, normal operation, and defined emergency events only. The Liquefied Natural Gas (LNG) terminal infrastructure at the port; the gas supply pipeline to the boundary fence; and, the associated powerline development did not form part of the scope of this assessment as this project focuses only on the footprint activities inside the proposed CCPP boundary fence.
2. Emissions associated with the construction phase were based on the conservative US EPA emission factor.
    a. The average monthly area in which construction would occur was calculated assuming the full facility extent (71 ha) and the planned number of months of construction.
    b. It was assumed that construction would extend over a 36 to 48-month period based on 9 hours per day and 21 days per month.
    c. It was assumed that water sprays would be used to mitigate the emissions associated with construction activities would occur.
3. The power station will operate 16 hours per day, 5 days per week (provided by Eskom).
4. Normal operations were assumed to occur 99% of the operating period and emergency events for the remaining 1%.

5. Emergency events would persist for no longer than 8 consecutive hours and for a total of less than 88 hours per year.
6. All eight units would continue to operate during emergency events.
7. The parameters of the by-pass stacks will result in enhanced dispersion of pollutants due to high exit temperatures and velocities. However, the use of in-line steam turbines and subsequent release of the off-gas via the main stacks increase the overall efficiency of the power station. The lower temperatures and velocities associated with the main stacks are therefore considered to be a limitation to normal operation of the facility.
8. Building downwash was included in the model as required for the diesel storage tanks. Sufficient information was not available to include building downwash associated with the 60 m main- and by-pass stacks, however, due to their height, they are unlikely to have substantive building downwash effects.
9. Where not indicated on the site layout locations of the sources of atmospheric pollutants were assumed.
10. Diesel refilling activities would match diesel consumption rates during emergency events. Diesel would be delivered in double-tanker trucks.
11. Diesel sulfur content was assumed to be 500 ppm. Diesel with lower sulfur content (for example 50 ppm) would lower off-site SO_2 concentrations during emergency events.
12. The dirty water dam was assumed to be the only potential source of odourous hydrogen sulfide (H_2S) because of sulfur in the boiler blowdown water (0.34 g/m^3) at full dam capacity (300 000 m^3).

1 ENTERPRISE DETAILS

1.1 Enterprise Details

The details of the proposed project operations are summarised in Table 1-1. The contact details of the responsible person are provided in Table 1-2.

Table 1-1: Enterprise details

Enterprise Name	Eskom Holdings (SOC) Ltd
Trading as	Eskom Holdings (SOC) Ltd
Type of Enterprise	State-owned Enterprise
Company Registration Number	2002/015527/06
Registered Address	Megawatt Park 2 Maxwell drive Sunninghill Sandton 2157
Telephone Number (General)	011-800-8111
Industry Type/Nature of Trade	Power generation
Land Use Zoning as per Town Planning Scheme	Industrial (Site 1D Richards Bay IDZ)
Land Use Rights if Outside Town Planning Scheme	n/a

Table 1-2: Contact details of responsible person

Responsible Person	To be confirmed
Telephone Number	To be confirmed
Cell Number	To be confirmed
Fax Number	To be confirmed
Email Address	To be confirmed
After Hours Contact Details	To be confirmed

1.2 Location and Extent of the Plant

Table 1-3: Location and extent of the plant

Physical Address of the Plant	Site 1D Richards Bay IDZ Western Arterial Road Alton Richards Bay 3900
Description of Site (Where no Street Address)	ERF 4/11376 and ERF 2/11376
Coordinates of Approximate Centre of Operations	28.769758 S; 31.985328E
Extent	~71 ha
Elevation Above Sea Level	~30 m
Province	KwaZulu-Natal
Metropolitan/District Municipality	King Cetshwayo District Municipality (previously known as the uThungulu District Municipality)
Local Municipality	City of uMhlathuze
Designated Priority Area	None

1.3 Description of Surrounding Land Use (within 5 km radius)

The City of uMhlathuze Local Municipality falls within the King Cetshwayo District Municipality (previously known as the uThungulu District Municipality) and includes the towns of Richards Bay, Empangeni as well as the surrounding rural and tribal areas. The topography of the area is flat, comprising of hills, ridges and undulating plains. The relief ranges from sea level on the eastern side to 296 metres above mean sea level (mamsl) on the western side. The current land uses in the region include industrial and commercial activities, surface mining activities, agricultural activities (mainly sugar cane), forestry, and formal and small residential communities. Figure 1-1 shows the location of all the main industries in the region. The proposed project site is located approximately 7 km south east of the Richards Bay Central Business District (CBD), and is located adjacent to the Mondi Richards Bay facility.

The National Ambient Air Quality Standards (NAAQS) (detailed in Section 5.1.2.2) are based on human exposure to specific criteria pollutants and as such, sensitive receptors were identified where the public is likely to be unwittingly exposed. NAAQS are enforceable outside of the property boundary of the licensed facility, therefore the sensitive receptors identified (Table 1-4) included the nearby residential areas, hospitals and schools. The nearest large residential areas to the project site are Bhiliya (6.5 km south); Empangeni (6.6 km west); Richards Bay CBD (6.9 km east); Wild-en-Weide (7.8 km north-east); Arboretum (8.4 km east); Felixton (9.8 km south-west); and Nseleni A (10.5 km north). There are some individual homesteads within 5 km of the proposed location. There are several schools, hospitals and clinics located within 5 km of the proposed location mostly to the north-east (Figure 1-1). Industrial areas (Mpangene, Kuleka, ZSM Industrial, Alton, and the Richards Bay Harbour) are located within 5 km of the proposed project.

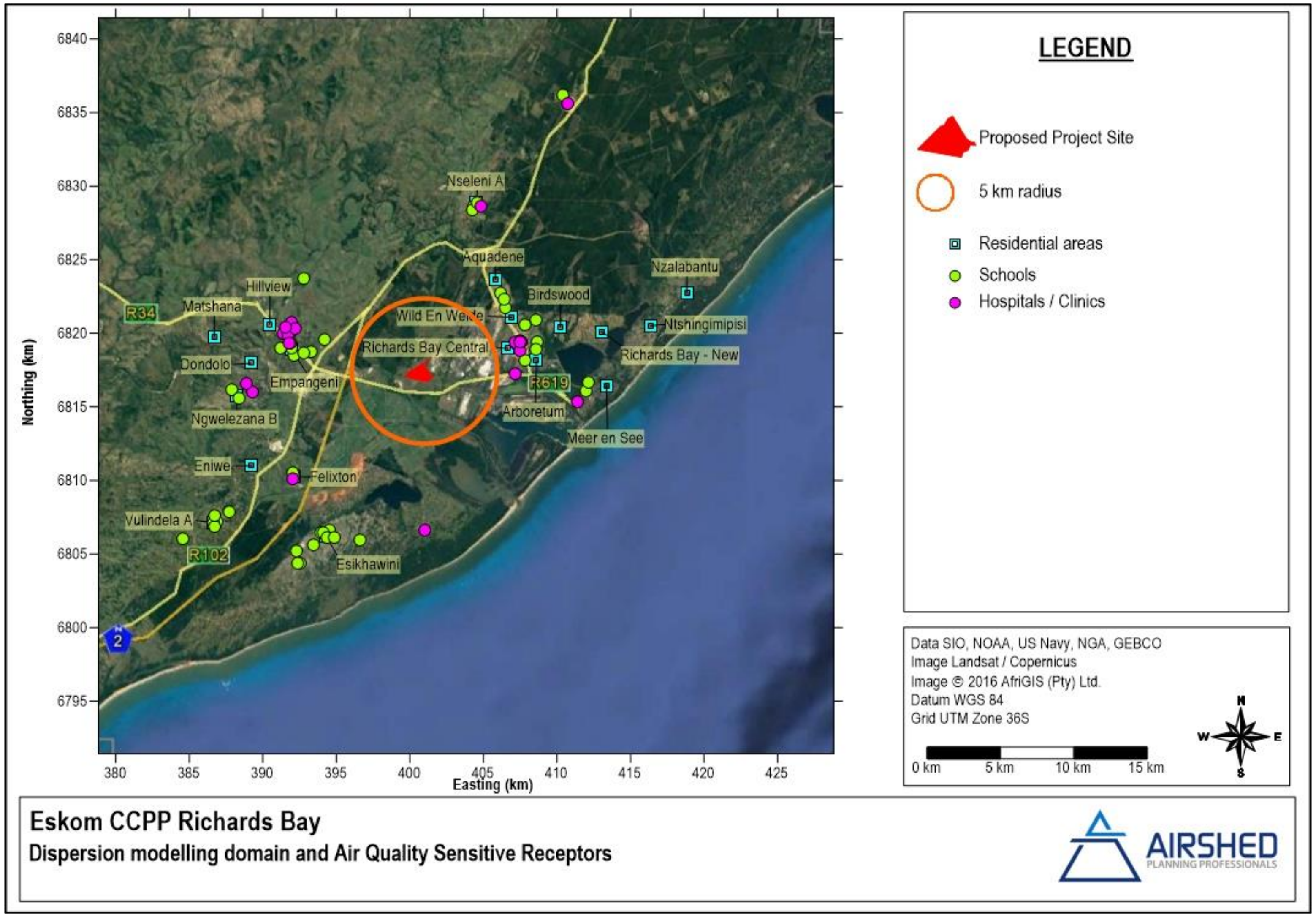

Figure 1-1: Location of the proposed project in relation to the air quality sensitive receptors (AQSRs)

Table 1-4: Distance to nearby air quality sensitive receptors

Air Quality Monitoring Station Name	Distance from proposed site (km)	Direction from proposed site
Airport	8.8	NNE
Arboretum	5.4	NNE
Bayside	1.4	SE
Brackenham	5.5	NE
CBD	5.2	NE
Esikhawini	14.1	SSW
Felixton	13.2	SW
Harbour West	1.8	SE
Mtunzini	31.2	SW
RBM	15.4	NE
Scorpio	2.0	E
St Lucia	59.4	NE
Receptor name / details	**Distance from proposed site (km)**	**Direction from proposed site**
Richards Bay Municipal Clinic	3.4	E
Richards Bay Central (CBD)	3.8	NE
Umhlathuze Dental	4.3	NE
John Ross College	4.4	NE
Men's Clinic International - Richards Bay	4.4	NE
Better2Know Private STD Health Centre Richards Bay	4.5	NE
The Bay Hospital	4.8	NE
Richards Bay Medical Institute	4.8	NE
Mandlazini Clinic	4.8	NE
Arboretum (residential area)	5.1	E
Arboretum Primary School	5.3	NE
Wild en Weide (residential area)	5.6	NE
Richardsbaai Hoërskool	5.7	E
Veldenvlei Primary School	5.8	NE
Richards Bay Secondary School	5.9	NE
Brackenham Primary School	6.4	NE
Richards Bay Christian School	6.5	NE
Bay Primary School	6.7	NE
Aquadene (residential area)	7.5	N
Birdswood (residential area)	7.6	NE
Headache Clinic | Bay Chiropractic | Smile Dent	7.7	E
Richards Bay Primary School	8.1	E
St Francis Pre-Primary School	8.3	E
Meer en See (residential area)	9.5	E
Richards Bay – New (residential area)	9.9	NE

1.4 Atmospheric Emission Licence and other Authorisations

The proposed project is a new facility and does not yet have an Atmospheric Emissions License (AEL). As a gas-fired power station with capacity greater than 50 MW, the project will require an AEL to operate (Subcategory 1.4; Section 21 of the National Environmental Management: Air Quality Act (NEM:AQA)). Emissions from the proposed power station will be required to comply with the new plant Minimum Emission Standards (MES). The applicable listed activities categories will include: Subcategory 1.4 (Gas Combustion Installations), and possibly during emergency periods Subcategory 1.2 (Liquid Fuel Combustion Installations) when diesel will be used as an alternative fuel source. The storage and handling of diesel qualifies as a listed activity, due to the tank volumes proposed (two storage tanks with a combined capacity of 10 800 m^3) and will be required to comply with the special conditions stipulated for Subcategory 2.4.

2 Nature of the Process

2.1 Listed Activities

All potential listed activities, as per Section 21 of NEM:AQA, proposed for the project are given in Table 2-1.

Table 2-1: Listed activities at the proposed project

Section 21 Subcategory	Listed Process Description:
1.4	Gas combustion installations
1.2	Liquid fuel combustion installations (when combusting diesel in emergency events only)
2.4	Storage and Handling of petroleum products

2.2 Process Description

The Richards Bay Combined Cycle Power Plant (CCPP) involves the construction of a gas-fired power station which will provide mid-merit power supply to the electricity grid. The weekly mid-merit power supply will be between a range of 20% to 70% of the total electricity supply produced by the Richards Bay CCPP. The power station will have an installed capacity of up to 3 000 MW, to be operated on natural gas, with diesel as a back-up fuel. The natural gas is to be supplied by potential gas suppliers via a gas pipeline to the CCPP from the supply take-off point at the Richards Bay Harbour. The Liquefied Natural Gas (LNG) terminal infrastructure at the port and the gas supply pipeline to the boundary fence of the Richards Bay CCPP does not form part of the scope of this assessment as this project focuses only on the footprint activities inside Eskom's boundary fence on site 1D of the Richards Bay Industrial Development Zone (IDZ).

The main infrastructure associated with the facility includes the following:

- Gas turbines for the generation of electricity through the use of natural gas or diesel (back-up resource).
- Heat recovery steam generators (HRSG) to capture heat from high temperature exhaust gases to produce high temperature and high-pressure dry steam to be utilised in the steam turbines.
- Steam turbines for the generation of additional electricity through the use of dry steam generated by the HRSG.
- By-pass stacks associated with each gas turbine.
- Dirty Water Retention Dams.
- Exhaust stacks for the discharge of combustion gases into the atmosphere.
- A water treatment plant for the treatment of potable water and the production of demineralised water (for steam generation).
- Water pipelines and water tanks to transport and store water of both industrial quality and potable quality (to be supplied by the Local Municipality).
- Dry-cooled system consisting of air-cooled condenser fans situated in fan banks.
- Closed Fin-fan coolers to cool lubrication oil for the gas and steam turbines.
- A gas pipeline and a gas pipeline supply conditioning process facility for the conditioning and measuring of the natural gas prior to being supplied to the gas turbines. It must be noted however that the environmental permitting processes for the gas pipeline construction and operation will be undertaken under a separate EIA Process
- Diesel off-loading facility and storage tanks.

- Ancillary infrastructure including access roads, warehousing, buildings, access control facilities and workshop area, storage facilities, emergency back-up generators, firefighting systems, laydown areas and 132 kV and 400 kV switchyards.
- A power line to connect the Richards Bay CCPP to the national grid for the evacuation of the generated electricity. It must be noted however that the due environmental permitting processes for the development of the power line component are being undertaken under a separate EIA Process.

From an air quality perspective, the CCPP involves the installation and operation of (eight) gas turbine units, (four) heat recovery steam generators (HRSGs) and (four) steam turbines for a total installed generating capacity of 3 000 MW. The operation of the power station will include the following:

- **Gas Turbines** using natural gas (or diesel, as back-up) as fuel to generate electricity, where compressed air is mixed with combustion fuel to produce very high temperature combustion gases. The hot combustion gases pass through the gas turbine blades, making them spin. The fast-spinning turbines drive a generator that converts a portion of the spinning energy into electricity. Each gas turbine is proposed to have a 60-metre-high by-pass stack for use during emergency events (refer to Section 4.4) when heat recovery in a steam turbine is not possible.
- During normal operations a **Heat Recovery Steam Generator** (HRSG) will capture heat from the combustion gas stream to produce high temperature and high-pressure dry steam, which is then supplied to a steam turbine. The combustion gases will be discharged into the atmosphere via the main exhaust stacks (60 metres high).
- The **Steam turbine** uses the dry steam to drive its turbine to generate electrical power. The condenser will convert exhaust steam from the steam turbine back into water through a cooling process.

Diesel, to be used as back-up fuel, will be off-loaded by truck and stored in on-site storage tanks which will hold sufficient capacity for 8 hours of operation. Two storage tanks, each with a capacity of 5 200 m^3, are planned.

Primary pollutants from gas turbines will be oxides of nitrogen (NO_x), carbon monoxide (CO), and, to a lesser extent, volatile organic compounds (VOCs). Particulate matter (PM) is also a primary pollutant for gas turbines using liquid fuels – in this case back-up diesel. NO_x formation is strongly dependent on the high temperatures developed in the combustor. CO, VOC, hazardous air pollutants (HAP), and PM are primarily the result of incomplete combustion. Trace to low quantities of HAP and sulfur dioxide (SO_2) are emitted from gas turbines. SO_2 emissions are directly related to the sulfur content of the fuel (US EPA, 2000). In addition to the above, VOC emissions will also be released from diesel storage tanks vents as well as the delivery, off-loading and handling of diesel fuel. Similarly, VOCs could be released from the natural gas should leaks develop along the length of the gas pipeline. Air pollutants associated with all phases of the proposed facility are given in Table 2-2.

Table 2-2: Identified air quality aspects

Aspect or Project Phase	Expected Atmospheric Sources of Emissions and Associated Pollutants						Rationale
	Source	CO	NO_x	PM[a]	SO_2	VOC	
The construction phase of the CCPP	Fugitive dust from civil and building work such as excavations, piling, foundations and buildings	n/a	n/a	✓	n/a	n/a	The nature of emissions from construction activities is highly variable in terms of temporal and spatial distribution and is also transient. Detail regarding the extent of construction activities and equipment movements was not available for inclusion in the study. Fugitive dust emissions are however mostly generated by land-clearing and bulk earthworks.
	Exhaust gases from mobile diesel construction equipment and trucks delivering materials.	✓	✓	✓	✓	✓	
The normal operation phase of the CCPP	Exhaust gases from the proposed turbine units	✓	✓	✓[c]	✓	✓	The project is designed to operate on either natural gas or diesel. Natural gas will be used for normal operation while diesel will be used as back-up. Emissions from the combustion of natural gas are notably lower than from the combustion of diesel. The focus of the assessment is on the operation of the proposed turbine units and fuel storage since it triggers Subcategory 1.2, 1.4 and 2.4 MES.
	Diesel storage (10 800 m^3 combined storage capacity)	n/a	n/a	n/a	n/a	✓	
CCPP upset conditions that may result in atmospheric impacts	Unstable combustion conditions within turbine units	✓	✓	✓[c]	✓	✓	Incomplete diesel combustion and unstable combustion temperatures may result in higher than normal PM, CO, NO_x and VOC emissions. SO_2 emissions may exit as elemental or organic sulfur. Additional VOC emissions because of the volatilisation of spilled diesel may occur. The vapour pressure of diesel is however very low which limits the potential for fugitive VOC emissions. Vehicle entrainment and exhaust emissions are also likely during diesel refilling events.
	Fuel delivery trucks exhaust gases	✓	✓	✓	✓	✓	
	Diesel fuel spillages	n/a	n/a	n/a	n/a	✓	
Regular Shutdowns	Diesel storage	n/a	n/a	n/a	n/a	✓	During shutdowns there will not be any emissions from the gas turbine units. Emissions from diesel storage tanks as per normal operations. Emissions may result from diesel delivery trucks, if refilling of storage tanks is required.
	Fuel delivery trucks exhaust gases	✓	✓	✓	✓	✓	
Decommissioning phase of the project	Fugitive dust from civil work such as rehabilitation and demolition.	n/a	n/a	✓	n/a	n/a	The nature of emissions from decommissioning activities is highly variable in terms of temporal and spatial distribution and is also transient. Detail regarding the extent of decommissioning activities and equipment movements was also not available for inclusion in the study. Fugitive dust emissions are however mostly generated by demolition and rehabilitation activities.
	Exhaust gases from diesel mobile equipment and trucks removing materials.	✓	✓	✓	✓	✓	

Notes:

(a) PM includes PM_{10} and $PM_{2.5}$

(b) n/a – not applicable

(c) neg. negligible for natural gas

2.3 Unit Processes

The unit processes associated with the listed activities (as per Section 21 of NEM:AQA) and proposed for the project are listed in Table 2-3.

Table 2-3: The unit processes for the proposed project

Unit Process	Function of Unit Process	Batch or Continuous Process
Power Station Gas Turbines	Gas combustion to generate electricity	Continuous (16 hours per day; 5 days per week)
Power Station HRSGs	Combustion off-gas heat recovery	Continuous (16 hours per day; 5 days per week)
Power Station Steam turbines	Steam turbine uses recovered heat from HRSG to generate electricity	Continuous (16 hours per day; 5 days per week)
Water treatment	Processing of water to appropriate quality for use in turbines	Continuous
Diesel storage	Storage of distillate fuel (diesel) for emergency periods for use when natural gas is unavailable	Continuous

3 TECHNICAL INFORMATION

Raw material consumption rates are tabulated in Table 3-1. The proposed project has an installed generation capacity of 3 000 MW of electricity, with waste streams of heated water and, off-gases.

3.1 Raw Material Consumption Rates

Table 3-1: Raw materials used

Raw Material Type Alternatives	Design Consumption Rate (Quantity)	Units (quantity/period)
Natural gas	8 900 to 9 500	tonnes per day
Diesel fuel	560	m³ per hour of emergency event (all 8 units)
Municipal-quality water	2 000 – 5 000	kilo-litres per day

3.2 Production Rates

Table 3-2: Future production rates

Production Name	Maximum Production Capacity Permitted (Quantity)	Design Production Capacity (Quantity)	Actual Production Capacity (Quantity)	Units (Quantity/Period)
Electricity	3 000	3 000	To be confirmed	MW

Table 3-3: By-products

By-Product Name	Maximum Production Capacity Permitted (Quantity)	Design Production Capacity (Quantity)	Actual Production Capacity (Quantity)	Units (Quantity/Period)
None				

4 ATMOSPHERIC EMISSIONS

The establishment of a comprehensive emissions inventory, for the project, formed the basis for the assessment of air quality impacts from the proposed project operations on the receiving environment. All stack parameters were provided by Eskom. The power station is planned to have eight gas turbines and steam turbine generating units venting off-gases via the main stacks, with a release height of 60 m. The operating cycle of the proposed CCPP, to meet mid-merit electricity demand, is 16 hours per day, 5 days per week. Normal operations are assumed to occur 99% of the operating cycle and were assessed in two emission scenarios: (1) at the Minimum Emission Standards (Table 4-3), and (2) using Australian National Pollution Inventory (NPI) emission factors for natural gas turbines (Table 4-5), as representations of the maximum allowable emissions (without being considered an emergency) and typical operating emissions, respectively.

Three types of emergency event (Table 4-1) are provided for.

Table 4-1: Emergency event scenarios

Emergency Scenario Identifier	Fuel	HRSG and steam turbines status	Vented to atmosphere via
Emergency type 1	Gas	Off-line	By-pass stacks
Emergency type 2	Diesel	On-line	Main stacks
Emergency type 3	Diesel	Off-line	By-pass stacks

Fugitive particulate emissions are likely to result from: vehicle exhaust and entrainment emissions during delivery of diesel; and, ventilation emissions from the diesel storage tanks.

The following sections describe the location and parameters of the individual sources associated with the proposed project (as per the prescribed format of an AIR - Gazette No. 36904, 2013).

4.1 Point Sources

One main stack per unit is proposed to vent off-gases from each of the eight gas turbine units under normal operations. Eight by-pass stacks, one per gas turbine with stacks heights of 60 m, are proposed for use during emergency conditions when the HRSG and/or steam turbines are not available for use (Sections 4.4 and 4.5).

Table 4-2: Parameters for point sources of atmospheric pollutant emissions at the proposed project

Point Source code	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)
MAIN1	Main stack 1	-28.76808	31.98735	60	50	9	99	4 580 442	20.0
MAIN2	Main stack 2	-28.76841	31.98718	60	50	9	99	4 580 442	20.0
MAIN3	Main stack 3	-28.76906	31.98684	60	50	9	99	4 580 442	20.0
MAIN4	Main stack 4	-28.76941	31.98665	60	50	9	99	4 580 442	20.0
MAIN5	Main stack 5	-28.77001	31.98621	60	50	9	99	4 580 442	20.0
MAIN6	Main stack 6	-28.77044	31.98612	60	50	9	99	4 580 442	20.0
MAIN7	Main stack 7	-28.77115	31.98576	60	50	9	99	4 580 442	20.0
MAIN8	Main stack 8	-28.77123	31.98521	60	50	9	99	4 580 442	20.0
BY1	By-pass stack Unit 1	-28.76789	31.98694	60	50	9	600	10 305 995	45.0
BY2	By-pass stack Unit 2	-28.76822	31.98676	60	50	9	600	10 305 995	45.0
BY3	By-pass stack Unit 3	-28.76883	31.98643	60	50	9	600	10 305 995	45.0
BY4	By-pass stack Unit 4	-28.76920	31.98625	60	50	9	600	10 305 995	45.0
BY5	By-pass stack Unit 5	-28.76992	31.98588	60	50	9	600	10 305 995	45.0
BY6	By-pass stack Unit 6	-28.77022	31.98569	60	50	9	600	10 305 995	45.0
BY7	By-pass stack Unit 7	-28.77087	31.98538	60	50	9	600	10 305 995	45.0
BY8	By-pass stack Unit 8	-28.77123	31.98521	60	50	9	600	10 305 995	45.0

4.2 Point Source Maximum Emission Rates during Normal Operating Conditions - MES

Table 4-3: Atmospheric pollutant emission rates for the proposed project (MES)

Point Source code	Pollutant Name	Maximum Release Rate				Emissions Hours	Type of Emissions (Continuous / Routine but Intermittent / Emergency Only)
		mg/Nm³	mg/Am³⁽ᵃ⁾	g/s	Averaging period		
MAIN 1-8	Particulates	10	7.3	9.34	Hourly	16 hours per day; 5 days per week	Continuous during operation
	Sulfur dioxide (SO_2)	400	293.6	373.77	Hourly	16 hours per day; 5 days per week	Continuous during operation
	Oxides of Nitrogen (NO_x)	50	36.7	46.72	Hourly	16 hours per day; 5 days per week	Continuous during operation
Note: (a) Varies depending on actual temperature							

Table 4-4: Point Source Emission Estimation Information during Normal Operating Conditions (MES)

Point Source code	Basis for Emission Rates
MAIN 1- 8	Minimum Emission Standards for Subcategory 1.4 – Gas Combustion Installations (as per Section 21 NEM:AQA)

4.3 Point Source Maximum Emission Rates during Normal Operating Conditions – based on emission factors

Table 4-5: Atmospheric pollutant emission rates for the proposed project (Emission Factors)

Point Source code	Pollutant Name	Maximum Release Rate				Emissions Hours	Type of Emissions (Continuous / Routine but Intermittent / Emergency Only)
		mg/Nm³	mg/Am³⁽ᵃ⁾	g/s	Averaging period		
MAIN 1-8	Particulates	0.06	0.04	0.204	Hourly	16 hours per day; 5 days per week	Continuous during operation
	Sulfur dioxide (SO_2)	36.79	27.00	0.055	Hourly	16 hours per day; 5 days per week	Continuous during operation
	Oxides of Nitrogen (NO_x)	0.22	0.16	34.375	Hourly	16 hours per day; 5 days per week	Continuous during operation
Note: (a) Varies depending on actual temperature							

Table 4-6: Point Source Emission Estimation Information during Normal Operating Conditions (Emission Factors)

Point Source code	Basis for Emission Rates
MAIN 1- 8	Australian National Pollutant Inventory Emission estimation technique manual for Combustion engines, Version 3.0, June 2008; Table 51: Emission factors (kg/kWh) for uncontrolled gas turbines natural gas engines, assuming that the sulfur content of natural gas is 4 mg/m³; and, a lower heating value of 38.9 MJ/Nm³).

4.4 Point Sources – Emergency Events

Eight by-pass stacks (one per gas turbine) are proposed for use during emergency conditions when the HRSG and/or steam turbines are not available for use. Three types of potential emergency events were identified (Table 4-1). Emergency operations were assumed to occur for a total of 88 hours per year (1%); and for no longer than eight consecutive hours per event.

4.5 Point Source Maximum Emission Rates during Emergency Events

Table 4-7: Atmospheric pollutant emission rates for the proposed project

Point Source code	Fuel type	Pollutant Name	Maximum Release Rate				Emissions Hours	Type of Emissions (Continuous / Routine but Intermittent / Emergency Only)
			mg/Nm^3	$mg/Am^{3(a)}$	g/s	Averaging period		
BY1 – 8	Natural gas	Particulates	10	3.1	8.96	Hourly per unit	Maximum 88 per year; maximum 8 hours per event	Emergency only
		Sulfur dioxide (SO_2)	400	125.1	358.44	Hourly per unit		
		Oxides of Nitrogen (NO_X)	50	15.6	44.81	Hourly per unit		
MAIN 1- 8	Diesel	Particulates	50	36.7	46.72	Hourly all units		
		Sulfur dioxide (SO_2)	500	367.0	467.21	Hourly all units		
		Oxides of Nitrogen (NO_X)	250	183.5	223.61	Hourly all units		
BY1 – 8	Diesel	Particulates	50	15.6	44.81	Hourly per unit		
		Sulfur dioxide (SO_2)	500	156.4	448.05	Hourly per unit		
		Oxides of Nitrogen (NO_X)	250	78.2	224.03	Hourly per unit		

Note:
(a) Varies depending on actual temperature

Table 4-8: Point Source Emergency Event Emission Estimation Information

Point Source code	Fuel type	Basis for Emission Rates
BY1 – 8	Natural gas	Minimum Emission Standards for Subcategory 1.4 – Gas Combustion Installations (as per Section 21 NEM:AQA)
MAIN 1-8 & BY1 – 8	Diesel	Minimum Emission Standards for Subcategory 1.2 – Liquid fuel Combustion Installations (as per Section 21 NEM:AQA)

4.6 Point Source VOC Emissions from Fixed-Roof Tanks

Parameters and emission rates for the point source VOC emissions from the diesel storage tanks are given in Table 4-9, Table 4-10, and Table 4-11.

Table 4-9: Tank point source parameters

Unique Source ID	Source Name	Source Description	Latitude (decimal degrees)	Longitude (decimal degrees)	Tank wall height (m)	Tank roof height (m)	Tank diameter (m)	Vent diameter (m)	Vent height (m)
TK1	Diesel Tank 1	Diesel storage tank	-28.771785	31.982570	2.32	18.5	21.0	0.001	20.32
TK2	Diesel Tank 1	Diesel storage tank	-28.771853	31.982995	2.32	18.5	21.0	0.001	20.32

Table 4-10: Tank parameters provided for the quantification of tank VOC emissions

Tank name	Annual throughput (m^3)	Compound stored	Tank type	Roof type	Tank roof height (m)	Tank height (m)	Tank diameter (m)	Tank volume (m^3)	Working volume (m^3)	Heated tank	Vapour pressure (kPa)	Tank colour	Vent diameter (m)
TK1	29 700	Diesel	Vertical fixed-roof	Dome	2.32	18.5	21.0	5 888	5 400	No	0.069	White	0.001
TK2	29 700	Diesel	Vertical fixed-roof	Dome	2.32	18.5	21.0	5 888	5 400	No	0.069	White	0.001

Table 4-11: Tank point source emissions during normal operating conditions for tanks calculated using the US EPA TANKS model

Tank source	Pollutant Name	Maximum Release Rate (g/s)	Average Annual Release Rate (t/a)	Emission Hours	Type of Emission (Continuous / Intermittent)	Wind Dependent (Yes / No)
TK1	Total VOC	5.56×10^{-3}	0.18	24 hours	Continuous	Yes
TK2	Total VOC	5.56×10^{-3}	0.18	24 hours	Continuous	Yes

Table 4-12: Tank point source emission estimation information

Area Source	Basis for Emission Rates
All tanks	US EPA AP-42 TANKS Software, based on AP-42 Section 7.1, Organic Liquid Storage Tanks

4.7 Fugitive Sources

Fugitive sources include the paved access road along which vehicle exhaust and entrainment emissions are likely to occur. The route of delivery vehicles was assumed based on site layout provided (access via the northern boundary) to the near existing road intersection (on Western Arterial road). Only emissions from diesel delivery activities were estimated as other traffic, during normal operations, was assumed to be of low volumes using cars and light delivery vehicles only.

Table 4-13: Area and/or line source parameters

Area Source code	Source name	Source Description	Latitude (decimal degrees) of SW corner	Longitude (decimal degrees) of SW corner	Height of Release Above Ground (m)	Length of Area (m)	Width of Area (m)	Angle of Rotation from True North (°)
PVRD1	Access road portion 1	Vehicle exhaust gases and entrainment of particulates along access road during diesel delivery activities.	-28.77054	31.99390	0.5 m	230.4	10	-170.0
PVRD2	Access road portion 2		-28.77016	31.99158	0.5 m	129.2	10	-158.8
PVRD3	Access road portion 3		-28.76973	31.99035	0.5 m	81.2	10	-131.9
PVRD4	Access road portion 4		-28.76918	31.98980	0.5 m	405.6	10	-122.6
PVRD5	Access road portion 5		-28.76608	31.98759	0.5 m	177.8	10	113.1
PVRD6	Access road portion 6		-28.76755	31.98686	0.5 m	70.6	10	-156.4
PVRD7	Access road portion 7		-28.76729	31.98620	0.5 m	528.5	10	114.3
PVRD8	Access road portion 8		-28.77162	31.98393	0.5 m	15.9	10	64.1
PVRD9	Access road portion 9		-28.77175	31.98400	0.5 m	23.6	10	99.0

Table 4-14: Area source emissions (vehicle exhaust and entrainment emissions)

Area Source code	Pollutant Name	Maximum Hourly Release Rate (g/s.m²)	Maximum Daily Release Rate (kg/day)	Average Annual Release Rate (t/a)	Emission Hours (e.g. 07h00 – 17h00)	Type of Emission (Continuous / intermittent)	Wind Dependent (yes/no)
PVRD1-9	Particulates (total suspended particulates)	$1.39x10^{-5}$	6.6	0.07	08h00 to 16h00	Intermittent	No
	Particulates (PM_{10})	$6.77x10^{-6}$	1.28	0.04			
	Particulates ($PM_{2.5}$)	$4.44x10^{-6}$	0.31	0.02			
	SO_2	$4.71x10^{-8}$	0.02	$2.48x10^{-4}$			
	NO_X	$6.73x10^{-5}$	32.2	0.35			
	TVOC	$3.06x10^{-6}$	1.5	0.02			
	CO	$2.87x10^{-5}$	13.8	0.15			

Table 4-15: Area Source Emission Estimation Information

Area Source code	Basis for Emission Rates
PVRD1-9	US EPA AP 42, 5th Edition, Volume I, Chapter 13: Miscellaneous Sources, 13.2.1 Paved Roads (2011) using the default silt content of 0.6 g/m² for ubiquitous silt content with fewer than 500 vehicles on-site per hour. Assuming: • Diesel re-filling time will match diesel consumption rate during emergency events • 11 x 8-hour emergency events per year, for a total of 88 hours of emergency diesel use (1% of the year) • Double tanker trucks carrying a payload with 32 m³ moving 26.24 tonnes of diesel per trip
	NPI single valued emission factors (NPI, 2008), assuming: • Sulfur content of diesel fuel was conservatively assumed to be 500 ppm • Engine capacity of horse pulling tankers – 366 kW • 11 x 8-hour refilling events per year (total of 88 hours of refilling activities)

5 IMPACT OF ENTERPRISE ON THE RECEIVING ENVIRONMENT

5.1 Analysis of Emissions' Impact on Human Health

5.1.1 Study Methodology

The study methodology may conveniently be divided into a "preparatory phase" and an "execution phase".

The preparatory phase included the following basic steps prior to performing the actual dispersion modelling and analyses:

1. Understand Scope of Work
2. Review of legal requirements (e.g. dispersion modelling guideline) (see Section 5.1.2)
3. Decide on Dispersion Model (see Section 5.1.1.1)

The Regulations Regarding Air Dispersion Modelling (Gazette No 37801 published 11 July 2014) was referenced for the dispersion model selection.

Three levels of assessment are defined in the Regulations regarding Air Dispersion Modelling of which a Level 3 assessment was suitable for the project since these assessments require more sophisticated dispersion models (and corresponding input data, resources and model operator expertise) in situations:

- where a detailed understanding of air quality impacts, in time and space, is required;
- where it is important to account for causality effects, calms, non-linear plume trajectories, spatial variations in turbulent mixing, multiple source types, and chemical transformations;
- when conducting permitting and/or environmental assessment process for large industrial developments that have considerable social, economic and environmental consequences;
- when evaluating air quality management approaches involving multi-source, multi-sector contributions from permitted and non-permitted sources in an airshed; or,
- when assessing contaminants resulting from non-linear processes (e.g. deposition, ground-level ozone (O_3), particulate formation, visibility).

The models recommended for Level 3 assessments are CALPUFF or SCIPUFF. In this study, CALPUFF was selected for the following reasons:

- Since the dispersion model formulation in CALPUFF is based on a Lagrangian Gaussian Puff model, it is well-suited for complex modelling terrain when used in conjunction with CALMET. The latter code includes a diagnostic wind field model which contains treatment of slope flows, valley flows, terrain blocking effects and kinematic effects. This Lagrangian Gaussian Puff model is well suited to simulate low or calm wind speed conditions. Alternative regulatory models such as the US EPA AERMOD model treat all plumes as straight-line trajectories, which under calm wind conditions grossly over-estimate the plume travel distance.
- The dispersion of pollutants in CALPUFF is simulated as discrete "puffs" of pollutants emitted from the modelled sources. These puffs are tracked until they have left the modelling domain while calculating dispersion, transformation and removal along the way. An important effect of non-steady-state dispersion is that the puff can change direction with changing winds, allowing a curved trajectory. The winds can therefore vary spatially as well as with time; with the former typically as the result of topographical features.
- CALPUFF is able to perform chemical transformations, such as the conversion of nitrogen oxide (NO) to NO_2 and the secondary formation of particulate matter from SO_2 and NO_2 emissions.
- As well as sea- and land-breeze circulation systems, the significant differences between the boundary layers of marine and overland can result in distinct changes occur to a dispersing plume moving from land to sea. The CALPUFF modelling system is well suited to handling these complex phenomena. The effects of land/sea breeze

circulations on transport of the plume are addressed through use of the mesoscale prognostic meteorological data.

- Stagnation conditions, i.e. when the wind is zero or near to zero.

The execution phase (i.e. dispersion modelling and analyses) involves gathering specific information in relation to the emission source(s) and site(s) to be assessed. This includes:

- Source information: Emission rate, exit temperature, volume flow, exit velocity, etc.;
- Site information: Site building layout, terrain information, land use data;
- Meteorological data: Wind speed, wind direction, temperature, cloud cover, mixing height;
- Receptor information: Locations using discrete receptors and/or gridded receptors.

The model uses this specific input data to run various algorithms to estimate the dispersion of pollutants between the source and receptor. The model output is in the form of a predicted time-averaged concentration at the receptor. These predicted concentrations are compared with the relevant ambient air quality standard or guideline. Post-processing can be carried out to produce percentile concentrations or contour plots that can be prepared for reporting purposes.

5.1.1.1 Dispersion Model Selection

The model is intended for use on scales from tens of metres to hundreds of kilometres from a source (US EPA, 1998). The CALPUFF model allows the user to select from many calculation options, including a choice of dispersion coefficient and chemical transformation formulations. The different dispersion coefficient approaches accommodated in the CALPUFF model include:

- stability-based empirical relationships such as the Pasquill-Gifford or McElroy-Pooler dispersion coefficients;
- turbulence-based dispersion coefficients (based on measured standard deviations of the vertical and crosswind horizontal components of the wind); and
- similarity theory to estimate the turbulent quantities using the micrometeorological variables calculated by CALMET

The most desirable approach is to use turbulence-based dispersion coefficients using measured turbulent velocity variances or intensity components, if such data are readily available and they are of good quality. However, since reliable turbulent measurements are generally not available, the next best recommendation is to use the similarity approach.

CALPUFF includes parameterized chemistry modules for the formation of secondary sulfate and nitrate from the oxidation of the emitted primary pollutants, SO_2 and NO_x. The conversion processes are assumed to be linearly dependent (first-order) on the relevant primary species concentrations. Two options are included, namely the MESOPUFF II and RIVAD/ARM3 chemistry options. In both options, a fairly simple stoichiometric thermodynamic model is used to estimate the partitioning of total inorganic nitrate between gas-phase nitric acid and particle-phase ammonium nitrate. Ammonia and ozone (O_3) concentrations are required as background values to the model.

5.1.1.1.1 Nitrogen Dioxide Formation

Of the several species of nitrogen oxides, only NO_2 is specified in the NAAQS. Since most sources emit varying ratios of these species and these ratios change further in the atmosphere due to chemical reactions, a method for determining the amount of NO_2 in the plume must be selected. Estimation of this conversion normally follows a tiered approach, as discussed in the Regulations Regarding Air Dispersion Modelling (Government Gazette No. 37804, published 11 July 2014), which presents a scheme for <u>annual</u> averages:

<u>Tier 1: Total Conversion Method</u>

Use any of the appropriate models recommended to estimate the maximum annual average NO_2 concentrations by assuming a total conversion of NO to NO_2. If the maximum NO_x concentrations are less than the NAAQS for NO_2, then no further refinement of the conversion factor is required. If the maximum NO_x concentrations are greater than the NAAQS for NO_2, or if a more "realistic" estimate of NO_2 is desired, proceed to the second-tier level.

<u>Tier 2: Ambient Ratio Method (ARM) - Multiply NO_x by a national ratio of NO_2/NO. = 0.80</u>

Assume a wide area quasi-equilibrium state and multiply the Tier 1 empirical estimate NO_x by a ratio of NO_2/NO_x = 0.80. The ratio is recommended for South Africa as the conservative ratio based on a review of ambient air quality monitoring data from the country. If representative ambient NO and NO_2 monitoring data is available (for at least one year of monitoring), and the data is considered to represent a quasi-equilibrium condition where further significant changes of the NO/NO_2 ratio is not expected, then the NO/NO_2 ratio based on the monitoring data can be applied to derive NO_2 as an alternative to the national ratio of 0.80.

The Ambient Ratio Method (ARM), i.e. the second version of the DEA Tier 2 option, was selected for the proposed facility. The ARM ambient ratio method is based upon the premise that the NO_2/NO_x ratio in a plume changes as it is transported but attains an equilibrium value some distance away from the source (Scire and Borissova, 2011). In their study, Scire and Borissova analysed hourly monitored NO_2 and NO_x data for 2006 at 325 monitoring sites throughout USA, which amounted to approximately 2.8 million data points for each species. These observations were grouped into several concentration ranges (bins), and the binned data were used to compute bin maximums and bin average curves. Short-term (1-hr) NO_2/NO_x ratios were subsequently developed based on bin-maximum data. Similarly, long-term (annual average) NO_2/NO_x ratios were based on bin-averaged data. The method was tested using the NO_2/NO_x ratios applied to the observed NO_x at selected stations to predict NO_2, and then compared to observed NO_2 concentrations at that station. The comparison of NO_2 derived from observed NO_x using these empirical curves was shown to be a conservative estimate of observed NO_2, whilst at the same time arriving at a more realistic approximation than if simply assuming a 100% conversion rate. The adopted conversion factors are given in Appendix D.

5.1.1.1.2 Wet and Dry Deposition

CALPUFF uses dry deposition velocities to calculate the dry deposition of gaseous and particulate pollutants to the surface. These dry deposition velocities can either be user-specified or calculated internally in CALPUFF. A resistance-based model is used for the latter option. For gaseous pollutants, the resistances that are considered are the atmospheric resistance, the deposition layer resistance, and the canopy resistance. For particles, a gravitational settling term is included, and the canopy resistance is assumed to be negligible. CALPUFF uses the scavenging coefficient approach to parameterize wet deposition of gases and particles. The scavenging coefficient depends on pollutant characteristics (e.g., solubility and reactivity), as well as the precipitation rate and type of precipitation. The model provides default values for the scavenging coefficient for various species and two types of precipitation (liquid and frozen); which were applied for the proposed facility.

CALPUFF also has the capability to model the effects of vertical wind shear by explicitly allowing different puffs to be independently advected by their local average wind speed and direction, as well as by optionally allowing well-mixed puffs to split into two or more puffs when across-puff shear becomes important. Another refinement is an option to use a probability density function (pdf) model to simulate vertical dispersion during convective conditions.

5.1.1.1.3 Secondary Particulates

CALPUFF includes two chemical transformation schemes for the calculation of sulfate and nitrate formation from SO_2 and NO_x emissions. These are the MESOPUFF II and the RIVAD / ARM3 chemical formulations. Whist the former scheme is not specifically restricted to urban or rural conditions; the latter was developed for use in rural conditions. Since the study area could be classified as urban, the RIVAD / ARM3 chemical formulations should not be used. The chemical transformation scheme chosen for this analysis was therefore the MESOPUFF II scheme. As described in the CALPUFF User Guide it is a "pseudo first-order chemical reaction mechanism" and involves five pollutant species namely SO_2, sulfates (SO_4), NO_x, nitric acid (HNO_3) and particulate nitrate (NO_3). CALPUFF calculates the rate of transformation of SO_2 to SO_4, and the rate of transformation of NO_x to NO_3, based on environmental conditions including the ozone concentration, atmospheric stability, solar radiation, relative humidity, and the plume NO_x concentration. The daytime reaction formulation depends on solar radiation and the transformation increases non-linearly with the solar radiation (see the SO_2 to SO_4 transformation rate equation (equation 2-253 in the CALPUFF User Guide). At night, the transformation rate defaults to a constant value of 0.2% per hour. Calculations based on these formulas show that the transformation rate can reach about 3 per cent per hour at noon on a cloudless day with 100 ppb of ozone.

With the MESOPUFF-II mechanism, NO_x transformation rates depend on the concentration levels of NO_x and O_3 (equations 2-254 and 2-255 in the CALPUFF User Guide) and both organic nitrates (RNO_3) and HNO_3 are formed. According to the scheme, the formation of RNO_3 is irreversible and is not subject to wet or dry deposition. The formation of HNO_3, however, is reversible and is a function of temperature and relative humidity. The formation of particulate nitrate is further determined through the reaction of HNO_3 and NH_3. Background NH_3 concentrations are therefore required as input to calculate the equilibrium between HNO_3 and particulate nitrate. At night, the NO_x transformation rate defaults to a constant value of 2.0% per hour. Hourly average ozone and ammonia concentrations were included as input in the CALPUFF model to facilitate these sulfate and nitrate formation calculations. Background ozone and ammonia concentrations used for this project in CALPUFF are provided in Appendix D.

The limitation of the CALPUFF model is that each puff is treated in isolation, i.e. any interaction between puffs from the same or different points of emission is not accounted for in these transformation schemes. CALPUFF first assumes that ammonia reacts preferentially with sulfate, and that there is always sufficient ammonia to react with the entire sulfate present within a single puff. The CALPUFF model performs a calculation to determine how much NH_3 remains after the particulate sulfate has been formed and the balance would then be available for reaction with NO_3 within the puff. The formation of particulate nitrate is subsequently limited by the amount of available NH_3. Although this may be regarded a limitation, in this application the particulate formation is considered as a group and not necessarily per species.

5.1.1.1.4 CALPUFF Modelling System

The CALPUFF modelling system consists of several software components, as summarised in Table 5-1, however only CALMET and CALPUFF contain the simulation engines to calculate the three-dimensional atmospheric boundary layer conditions and the dispersion and removal mechanisms of pollutants released into this boundary layer. The other components are mainly used to assist with the preparation of input and output data. Table 5-1 also includes the development versions of each of the codes used in this investigation.

Table 5-1: Summary description of CALPUFF/CALMET model suite with versions used in the investigation

Module	Version	Description
CALMET	v6.334	Three-dimensional, diagnostic meteorological model

Module	Version	Description
CALPUFF	v6.42	Non-steady-state Gaussian puff dispersion model with chemical removal, wet and dry deposition, complex terrain algorithms, building downwash, plume fumigation and other effects.
CALPOST	V6.292	A post-processing program for the output fields of meteorological data, concentrations and deposition fluxes.
CALSUM	v1.4 (1)	Sums and scales concentrations or wet/dry fluxes from two or more source groups from different CALPUFF runs
PRTMET	v 4.495(1)	Lists selected meteorological data from CALMET and creates plot files
POSTUTIL	v1.641(1)	Processes CALPUFF concentration and wet/dry flux files. Creates new species as weighted combinations of modelled species; merges species from different runs into a single output file; sums and scales results from different runs; repartitions nitric acid/nitrate based on total available sulfate and ammonia.
TERREL	v3.69(1)	Combines and grids terrain data
CTGPROC	v3.5(1)	Processes and grids land use data
MAKEGEO	v3.2(1)	Merges land use and terrain data to produce the geophysical data file for CALMET

Note (1): These modules indicate version number as listed on http://www.src.com/calpuff/download/mod6_codes.htm (for CALPro Plus v6) [version number not given in graphical interface or 'About' information].

A summary of the CALMET and CALPUFF control options used in this project are given in Appendices C and D, respectively.

5.1.2 Legal Requirements

5.1.2.1 Atmospheric Impact Report

According to the NEM:AQA, an Air Quality Officer (AQO) may require the submission of an AIR in terms of Section 30, if:

- The AQO reasonably suspects that a person has contravened or failed to comply with the AQA or any conditions of an AEL and that detrimental effects on the environment occurred or there was a contribution to the degradation in ambient air quality.
- A review of a provisional AEL or an AEL is undertaken in terms of Section 45 of the AQA.

The format of the Atmospheric Impact Report is stipulated in the Regulations Prescribing the Format of the Atmospheric Impact Report, Government Gazette No. 36904, Notice Number 747 of 2013 (11 October 2013).

5.1.2.2 National Ambient Air Quality Standards

Modelled concentrations were assessed against NAAQS (Table 5-2) as prescribed by South African legislation. Due to the operational life-time of the proposed CCPP the most stringent $PM_{2.5}$ NAAQS were referred to which are enforceable from 1 January 2030.

Table 5-2: National Ambient Air Quality Standards applicable for the assessment of the proposed facility

Pollutant	Averaging Period	Concentration (µg/m³)	Frequency of Exceedance	Compliance Date
Benzene (C_6H_6)	1 year	5	0	Currently enforceable
Carbon Monoxide (CO)	1 hour	30 000	88	Currently enforceable
	8 hour[(a)]	10 000	11	Currently enforceable
Nitrogen Dioxide (NO_2)	1 hour	200	88	Currently enforceable
	1 year	40	0	Currently enforceable
Inhalable particulate matter less than 2.5 µm in diameter ($PM_{2.5}$)	24 hours	40	4	Enforceable until 31 December 2029
	24 hours	25	4	1 January 2030
	1 year	20	0	Enforceable until 31 December 2029
	1 year	15	0	1 January 2030
Inhalable particulate matter less than 10 µm in diameter (PM_{10})	24 hours	75	4	Currently enforceable
	1 year	40	0	Currently enforceable
Sulfur Dioxide (SO_2)	10 minutes	500	526	Currently enforceable
	1 hour	350	88	Currently enforceable
	24 hours	125	4	Currently enforceable
	1 year	50	0	Currently enforceable

5.1.2.3 National Dust Control Regulations

The National Dust Control Regulations (NDCR) was gazetted on 1 November 2013 (No. 36974). The purpose of the regulations is to prescribe general measures for the control of dust in all areas including residential and light commercial areas. The standard for acceptable dustfall rate is set out in Table 5-3. The method to be used for measuring dustfall rate and the guideline for locating sampling points shall be ASTM D1739: 1970, or equivalent method approved by any internationally recognized body. It is important to note that dustfall is assessed for nuisance impact and not inhalation health impact.

Table 5-3: Acceptable dustfall rates

Restriction Area	Dustfall Rate (mg/m².day; 30-day average)	Permitted Frequency of Exceeding Dustfall Rate
Residential area [(a)]	D<600	Two in a year, not sequential months
Non-residential area [(b)]	600<D<1200	Two in a year, not sequential months
Notes: (a) Applicable at the sensitive receptors and residential areas near the proposed facility (b) Applicable within the power station property boundaries		

5.1.2.4 Odour Thresholds

In the assessment of potential odour impacts use was made of the 50% recognition threshold odour concentrations (TOCs) published by Verscheuren (1996) (Table 5-4) over 1-hour. The 50% recognition threshold is the concentration at which 50% of an odour panel defined the odour as being representative of the odorant being studied.

Table 5-4: 50% Recognition odour threshold concentrations (Verscheuren, 1996)

Compound	TOC (µg/m³)
Hydrogen sulfide	10

5.1.2.4.1 Odour Unit Calculation - Approach for Current Study

The NSW-EPA approach (NSW-EPA, 2006a and 2006b) was adopted for use in the current study and the approach can be summarised as follows:

(a) Calculation of the 1-hour average air pollutant concentrations;
(b) Recognition of the odour detection for a substance (Table 5-4);
(c) Calculation of odour units by calculating ratios between the 99.9th percentile 1-hour average air pollutant concentrations and the respective detection limits; and
(d) The application of the odour performance criteria set out by the NSW-EPA (Table 5-5).

Table 5-5: NSW-EPA odour assessment criteria (NSW-EPA, 2006)

Population of Affected Community	Odour Assessment Criteria (OU)
Rural single residence (≤2)	7.0
~ 10	6.0
~ 30	5.0
~ 125	4.0
~ 500	3.0
Urban area (≥ 2 000) and/or schools and hospitals	**2.0**
Notes: **Bold** text indicates assessment criteria used for the current study	

5.1.2.5 Listed Activities and Minimum Emission Standards

The minister, in accordance with the National Environmental Management Air Quality Act (NEM:AQA) (Act No. 39 of 2004), published a list of activities which result in atmospheric emissions and which are believed to have significant detrimental effects on the environment and human health; and, social welfare. The Listed Activities and MES were published on the 31st of March 2010 (Government Gazette No. 33064) and the revised MES on 22 November 2013 (Government Gazette No. 37054). MES applicable to the proposed CCPP include:

- **Gas Combustion Installations**– Gas combustion used primarily for steam raising or electricity generation (more than 50 MW) heat input per unit). MES subcategory 1.4 are applicable (Table 5-6) during normal operating conditions using natural gas.
- **Liquid fuel Combustion Installations** – Liquid fuel combustion used primarily for steam raising or electricity is generated (more than 50 MW heat input per unit). MES for liquid fuel combustion installations (Subcategory 1.2) are applicable (Table 5-7) during emergency periods when diesel will be used instead of natural gas.
- **Diesel Storage** – The storage and handling of petroleum products within permanent immobile liquid tanks larger than

1 000 m3 in total triggers Subcategory 2.4 (Table 5-8). Subcategory 2.4 MES distinguishes between petroleum products with various vapour pressures. The vapour pressure of diesel is notably lower than 14 kPa.

Table 5-6: MES for gas combustion installations

Subcategory 1.4: Gas Combustion Installations		
Description	Gas combustion (including gas turbines burning natural gas) used primarily for steam raising or electricity generation.	
Application	All installations with design capacity equal to or greater than 50 MW heat input per unit based on the lower calorific value of the fuel used.	
Substance or mixture of substances		**mg/Nm³ under normal conditions of 3% O_2, 273 K and 101.3 kPa**
Common Name	**Chemical Symbol**	**New plant**
Particulate matter (PM)	Not applicable	10
Sulfur dioxide	SO_2	400
Oxides of nitrogen	NO_x expressed as NO_2	50

Notes:

(a) The following special arrangement shall apply:

i. Reference conditions for gas turbines shall be 15% O_2, 273 K and 101.3 kPa; and

ii. Where co-feeding with waste materials with calorific value allowed in terms of the Waste Disposal Standards published in terms of the Waste Act, 2008 (Act No.59 of 2008) occurs, additional requirements under subcategory 1.6 shall apply.

Table 5-7: MES for liquid fuel combustion installations

Subcategory 1.2: Liquid fuel combustion installations		
Description	Liquid fuel combustion installations used primarily for steam raising or electricity generation.	
Application	All installations with design capacity equal to or greater than 50 MW heat input per unit based on the lower calorific value of the fuel used.	
Substance or mixture of substances		**mg/Nm³ under normal conditions of 3% O_2, 273 K and 101.3 kPa**
Common Name	**Chemical Symbol**	**New plant**
Particulate matter (PM)	Not applicable	50
Sulfur dioxide	SO_2	500
Oxides of nitrogen	NO_x expressed as NO_2	250

Notes:

(a) The following special arrangement shall apply:

i. Reference conditions for gas turbines shall be 15% O_2, 273 K and 101.3 kPa.

ii. Continuous monitoring of PM, SO_2 and NOx is required, however, installations less than 100MW heat input per unit must adhere to periodic emission monitoring as stipulated in Part 2 of this notice.

iii. Where co-feeding with waste materials with calorific value allowed in terms of the Waste Disposal Standards published in terms of the Waste Act, 2008 (Act No.59 of 2008) occurs, additional requirements under subcategory 1.6 shall apply.

Table 5-8: MES for the storage and handling of petroleum products

(a) The following transitional arrangement shall apply for the storage and handling of raw materials, intermediate and final products with a vapour pressure greater than 14 kPa at operating temperature: – Leak detection and repair (LDAR) program approved by licensing authority to be instituted, by 01 January 2014.

(b) The following special arrangements shall apply for control of TVOCs from storage of raw materials, intermediate and final products with a vapour pressure of up to 14 kPa at operating temperature, except during loading and offloading. (Alternative control measures that can achieve the same or better results may be used) –

i. Storage vessels for liquids shall be of the following type:

True vapour pressure of contents at storage temperature	Type of tank or vessel
Type 1: Up to 14 kPa (applicable to diesel)	Fixed-roof tank vented to atmosphere, or as Type 2 and 3
Type 2: Above 14 kPa up to 91 kPa with a throughput of less than 50 000 m³ per annum	Fixed-roof tank with Pressure Vacuum Vents fitted s a minimum, to prevent "breathing" losses, or as per Type 3
Type 3: Above 14 kPa up to 91 kPa with a throughput greater than 50 000 m³ per annum	a) External floating roof tank with primary and secondary rim seals for tank diameter larger than 20 m, or b) fixed roof tank with internal floating deck / roof fitted with primary seal, or c) fixed roof tank with vapour recovery system
Type 4: Above 91 kPa	Pressure vessel

ii. The roof legs, slotted pipes and/or dipping well on floating roof tanks (except for domed floating roof tanks or internal roof tanks) shall have sleeves fitted to minimise emissions.

iii. Relief valves on pressurised storage should undergo periodic checks for internal leaks. This can be carried out using portable acoustic monitors or if venting to atmosphere with an accessible open end, tested with a hydrocarbon analyser as part of an LDAR programme.

(c) The following special arrangements shall apply for control of TVOCs from storage, loading and unloading of raw materials, intermediate and final products with a vapour pressure of more than 14 kPa at operating temperatures, except during loading and unloading. Alternative control measures that can achieve the same or better results may be used:

i. All installations with a throughput of 5 000 m³ per annum of products with a vapour pressure greater than 14 kPa, must be fitted with vapour recover / destruction units. Emission limits are set out in the table below –

Description	Vapour Recovery Units (not applicable for diesel)	
Application	All loading/ offloading facilities with a throughput greater than 50 000 m³	
Substance or mixture of substances		**mg/Nm³ under normal conditions of 273 K and 101.3 kPa**
Common Name	**Chemical Symbol**	**New plant**
Total volatile organic compounds (VOCs) from vapour recovery/destruction units (non-thermal treatment)	Not applicable	150
VOCs from vapour recovery/destruction units (thermal treatment)	Not applicable	40 000

5.1.3 Atmospheric Dispersion Potential

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. The horizontal dispersion of pollution is largely a function of the wind field. The wind speed determines both the distance of downward transport and the rate of dilution of pollutants.

This study accessed three sets of meteorological data: simulated meteorological data for the Richards Bay airshed, and, measured meteorological data at two locations in the Richards Bay domain. For the purposes of CALPUFF dispersion modelling, Weather Research and Forecasting model (WRF) data for the period 2013 to 2015 on a 4 km horizontal resolution for a 50 km by 50 km domain was used. Two RBCAA air quality monitoring stations (AQMS) (Airport and Harbour West) were included for comparison to assess how representative the WRF data set is for the proposed project site. Harbour West was selected as representative for comparison with the simulated meteorology for the project site as it is one of the closest full (meteorology and air pollutant concentrations) AQMS stations to the proposed project site.

5.1.3.1 Local Wind Field

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

5.1.3.1.1 Simulated Wind-field for the Proposed Project Site

The predominant wind direction at the proposed project site, from the simulated WRF meteorological data, is from the north and north-east (Figure 5-1). Southerly and south-westerly winds are also fairly common. There is a slight dominance for northerly night-time winds and north-easterlies during the day-time. High speed winds (greater than 10 m/s) are more likely to originate from the south-west during the day. Calm conditions (when wind speeds are less than 1 m/s) occur approximately on 3% of the time and wind speeds frequently exceed 5 m/s.

The seasonal variation in the wind field shows a slight northerly dominance in autumn and winter and while north-easterlies is more dominant in summer and spring (Figure 5-2). Southerly and south-westerly winds are more frequent in winter and spring. Calm conditions are more frequent in summer and least common in spring. Highest wind speeds are likely in spring.

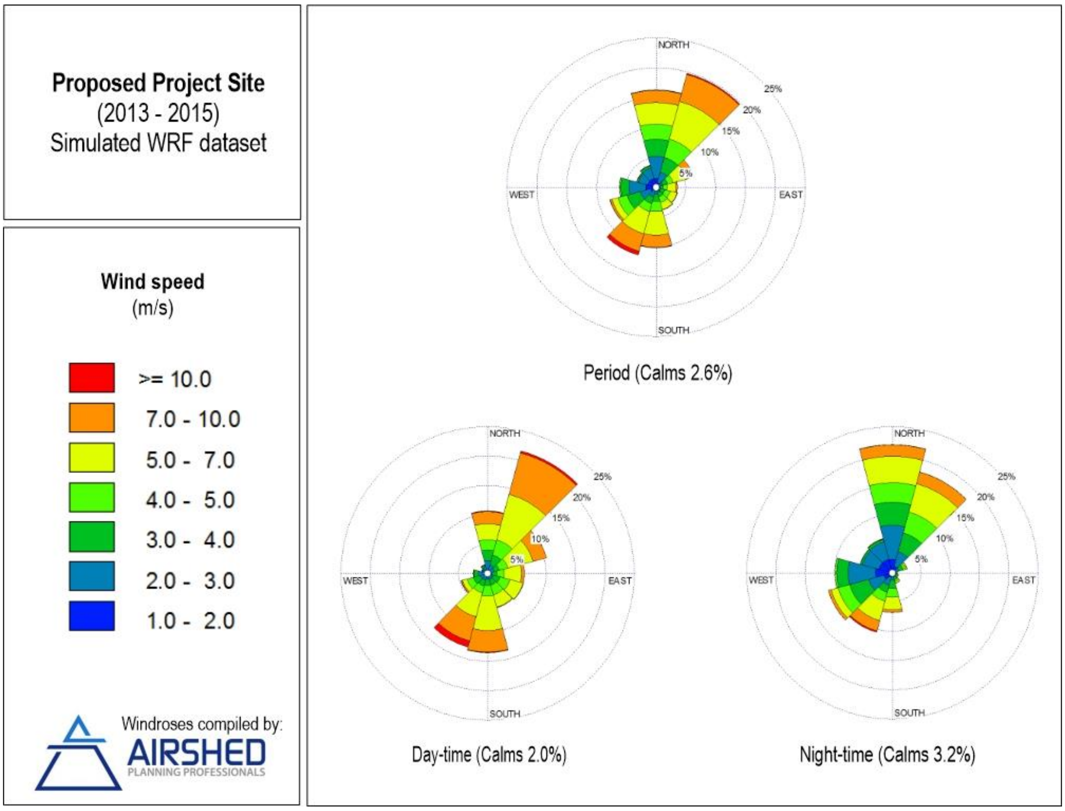

Figure 5-1: Diurnal wind-field for the proposed project site (using the simulated WRF dataset 2013 - 2015)

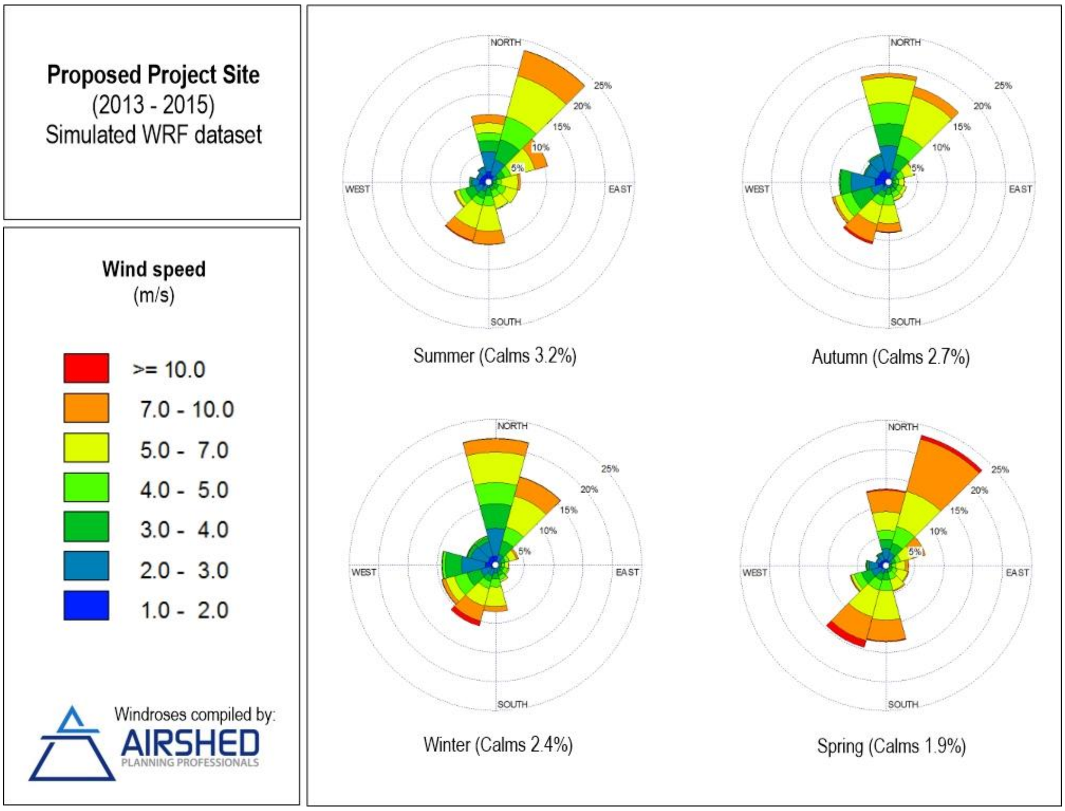

Figure 5-2: Seasonal wind-field for the proposed project site (using the simulated WRF dataset 2013 - 2015)

5.1.3.1.2 Measured Wind-field at the Richards Bay Airport

The wind-field based on measured data at the Richards Bay Airport is similar to the simulated WRF data at the proposed project site. The predominant wind direction at the Airport is from the north (Figure 5-3). North easterly and south-westerly winds are also fairly common. There is a slight dominance of northerly night-time winds. High speed winds (greater than 10 m/s) are more likely to originate from the south and south-west during the day. Calm conditions (when wind speeds are less than 1 m/s) occur approximately on 5% of the time, more commonly at night.

The seasonal variation in the wind field shows a northerly dominance in all seasons, most frequently (more than 20% of the time) in autumn (Figure 5-4). North-easterlies are more dominant in spring. Southerly and south-westerly winds are more frequent in spring. Calm conditions are more frequent in summer and least common in spring. Highest wind speeds are likely in spring.

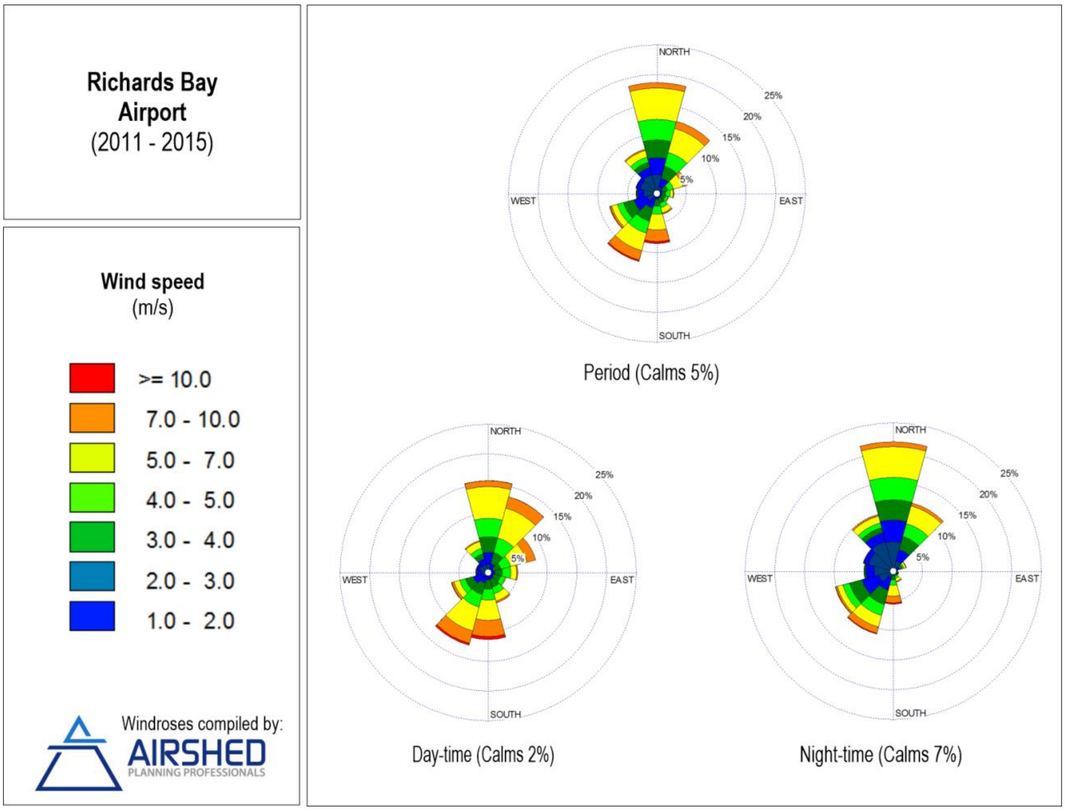

Figure 5-3: Diurnal wind-field for the Richards Bay Airport (measured data 2013 - 2015)

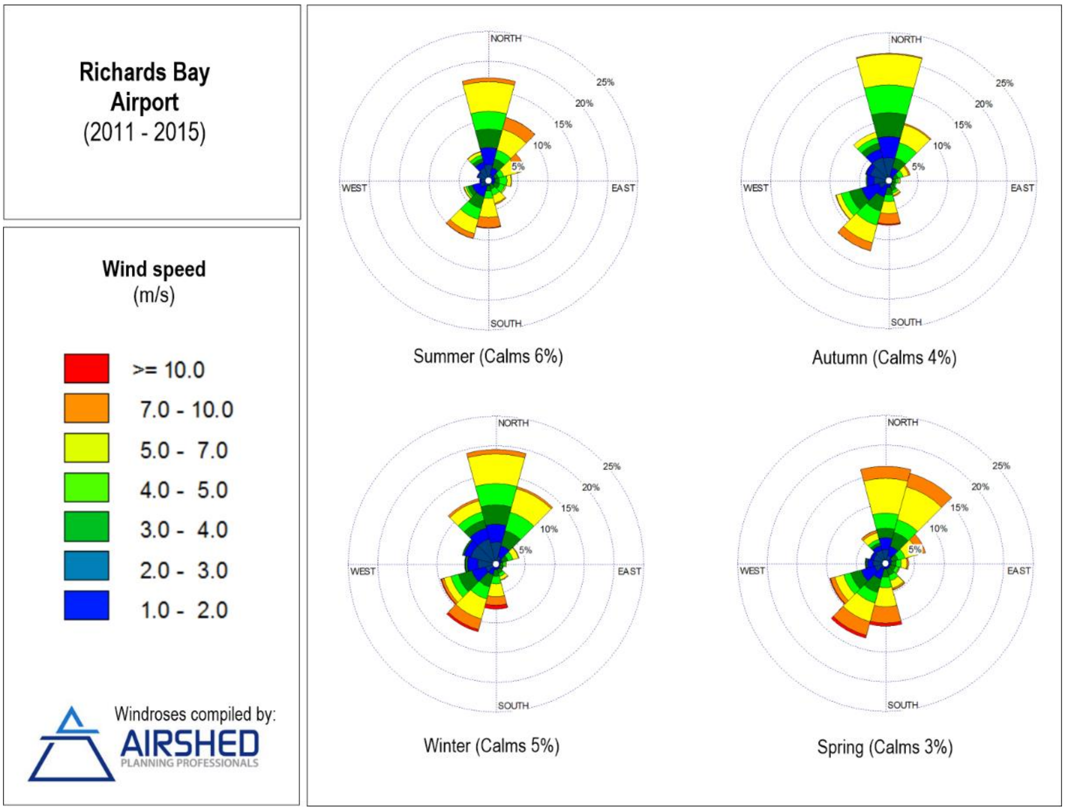

Figure 5-4: Seasonal wind-field for the Richards Bay Airport (measured data 2013 - 2015)

5.1.3.1.3 Measured Wind-field at the Harbour West Air Quality Monitoring Station

The wind-field based on measured data at the Harbour West AQMS is more like the simulated WRF data at the proposed project site. The predominant wind direction at the Airport is from the north and north-east (Figure 5-5). Southerly and south-westerly winds are also fairly common. North-easterly winds dominate the Harbour West wind-field at night. High speed winds (greater than 10 m/s) are more likely to originate from the south and south-west during the day. Calm conditions (when wind speeds are less than 1 m/s) occur approximately on 5% of the time, more commonly during the day. The increased frequency of day-time calm conditions in dissimilar to both the simulated data for the proposed project site and for the Airport, however; night-time wind speeds at the Harbour West AQMS are lower than day-time average wind speeds.

The seasonal variation in the wind field shows a north-easterly dominance in all seasons however the frequency of north-easterly and south-westerly winds is largest in spring (Figure 5-6). The frequency of calm conditions is lowest in summer and highest in winter. Highest wind speeds are likely in spring.

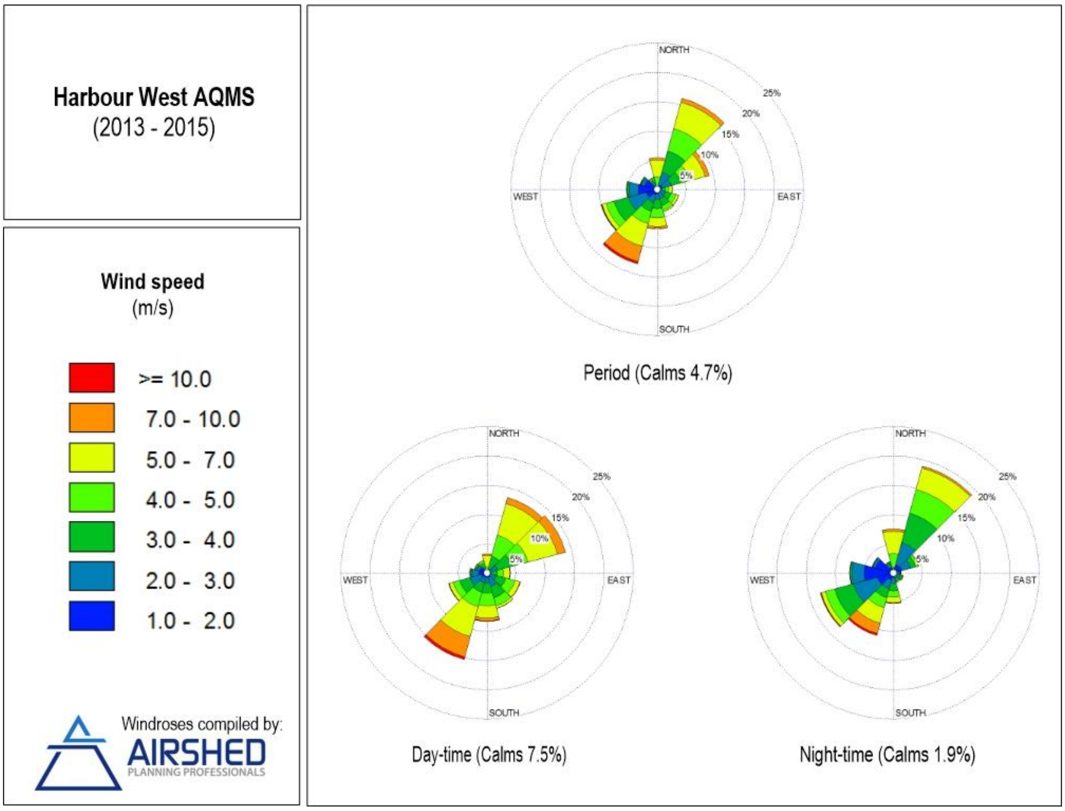

Figure 5-5: Diurnal wind-field for the Harbour West AQMS (measured data 2013 - 2015)

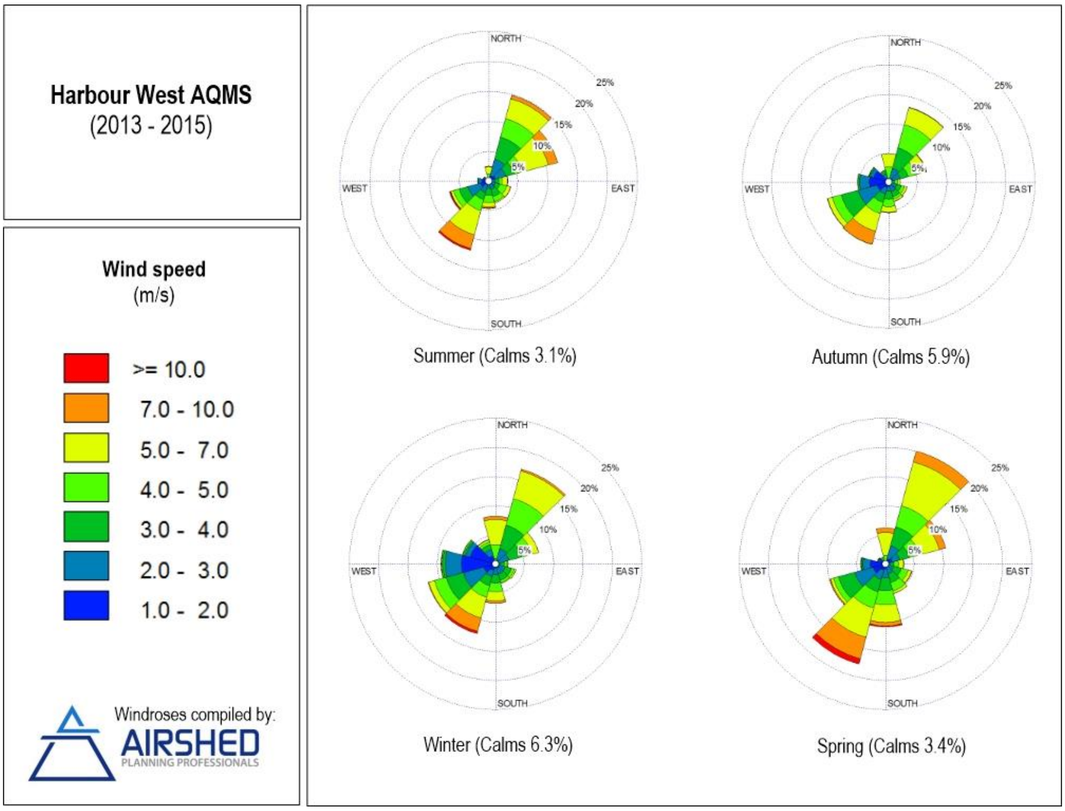

Figure 5-6: Seasonal wind-field for the Harbour West AQMS (measured data 2013 - 2015)

5.1.3.2 *Ambient Temperature (Simulated WRF Temperatures at the proposed project site)*

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

Monthly mean, maximum and minimum temperatures from the simulated WRF meteorology for the proposed project site are provided in Table 5-9. Diurnal temperature variability is presented in Figure 5-7. Temperatures ranged between 7.3°C and 44.7°C. During the day, temperatures increase to reach maximum near 14:00 in the afternoon; however, elevated temperatures (above 24°C) can persist between 10:00 and 19:00 in the evening. Ambient air temperature decreases to reach a minimum at between 01:00 and 07:30 in the morning, seldom dropping below 10°C.

Table 5-9: Monthly temperature summary (WRF data, proposed project site)

Monthly Minimum, Maximum and Average Temperatures (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	16.2	14.6	14.9	10.7	10.6	7.3	7.9	8.5	9.7	12.4	12.7	13.1
Average	24.5	24.3	23.8	21.3	20.3	18.3	18.0	19.6	21.0	21.2	22.3	23.5
Maximum	37.3	37.0	37.4	34.5	33.0	34.6	33.1	35.0	40.6	44.7	36.9	40.8

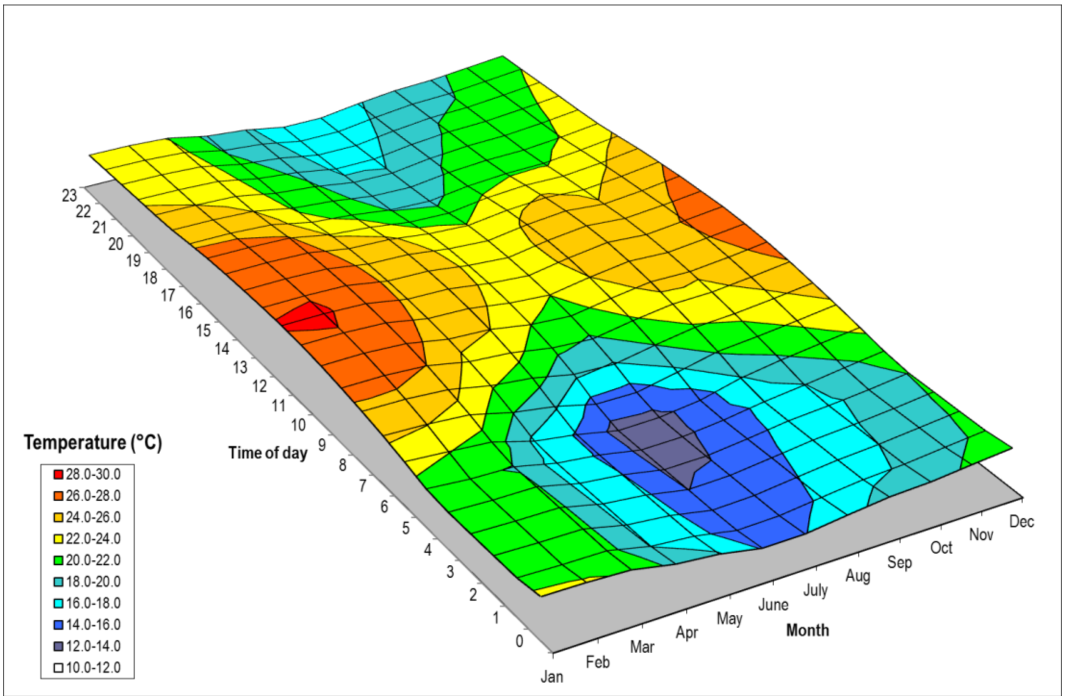

Figure 5-7: Diurnal temperature profile (WRF data)

5.1.3.3 *Ambient Air Quality Monitoring Data*

The RBCAA operates 12 ambient monitoring stations, measuring meteorological parameters and ambient SO_2, total reduced sulfur, and PM_{10} concentrations (Table 5-10 and Figure 5-8). Hourly data from all stations was provided by the RBCAA for the period January 2014 to December 2017[1]. The closest RBCAA stations to the project site are Brackenham, Scorpio, Harbour West, and Bayside; of which Brackenham is the most representative of the project site. One station – St Lucia – was excluded from assessment as it is located outside of the 50 x 50 km modelling domain.

Table 5-10: RBCAA ambient monitoring network with parameters measured at each station

RBCAA Monitoring Station	Meteorology	SO_2	TRS	PM_{10}
Airport (at Richards Bay Airport)	√			
Arboretum	√	√		
Bayside (next to Bayside Aluminium)	√			
Brackenham	√	√		√
CBD (situated in the Sports Complex)	√	√	√	√
Esikhawini	√	√	√	√
Felixton		√		
Harbour West (near the western entrance to the harbour)	√	√		
Mtunzini	√			√
RBM (situated at Richards Bay Minerals)	√			
Scorpio (intersection of John Ross Highway and West Central Arterial)		√		
St Lucia[(a)]	√			√
Notes: (a) Excluded from results summary as the station is located outside of the modelling domain				

[1] The data was analysed in March 2018 and was up to date at the time of analysis. To the authors knowledge there has not been substantive change to the emissions or receiving environment since Revision 2 of the Air Quality specialist report (May 2018).

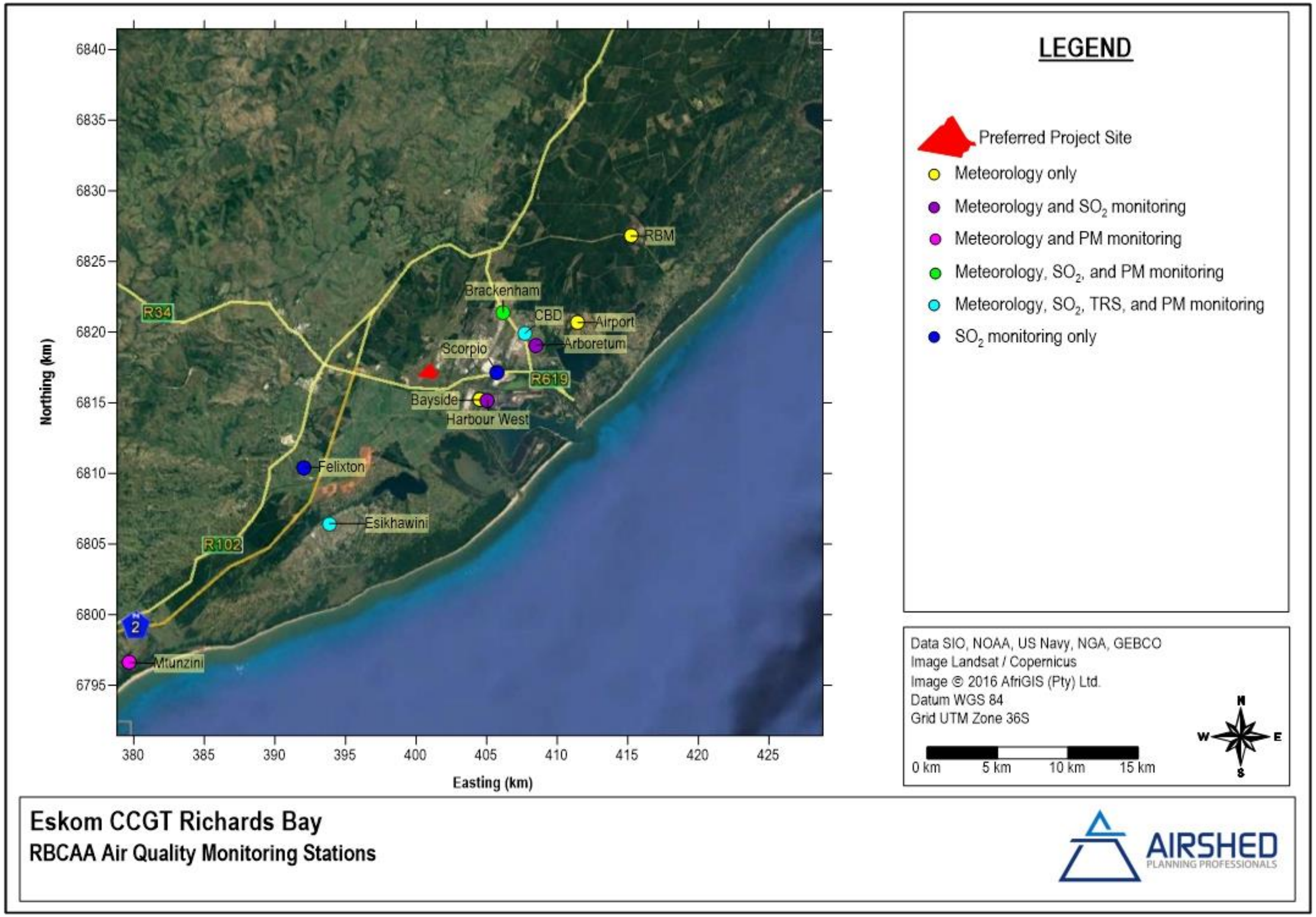

Figure 5-8: RBCAA ambient monitoring network in relation to the proposed project site

5.1.3.3.1 Ambient PM_{10} Concentrations

The daily PM_{10} concentrations – for the data period provided (January 2014 to December 2017) – indicate non-compliance with the daily PM_{10} NAAQS at Brackenham and CBD stations during 2015, where daily average concentrations measured exceeded 75 µg/m³ on more than four occasions during the year (Table 5-11). The number of exceedances at Esikhawini and Mtunzini remained consistent, and compliant with NAAQS, between years. Annual average PM_{10} concentrations were compliant with the NAAQS at all stations and similarity between years at each station is noted (Figure 5-9).

Table 5-11: Frequency of exceedance of daily PM_{10} limit concentration at four stations where PM_{10} is monitored (bold text indicates non-compliance with daily PM_{10} NAAQS)

Year	Frequency of Exceedance of daily limit concentration			
	Brackenham	CBD	Esikhawini	Mtunzini
2014[(a)]	-	3	1	1
2015	**6**	**5**	1	1
2016	0	1	0	1
2017	0	2	1	1

Notes:
(a) Daily limit concentration 120 µg/m³ valid until 1 January 2015; thereafter daily limit concentration of 75 µg/m³ applies

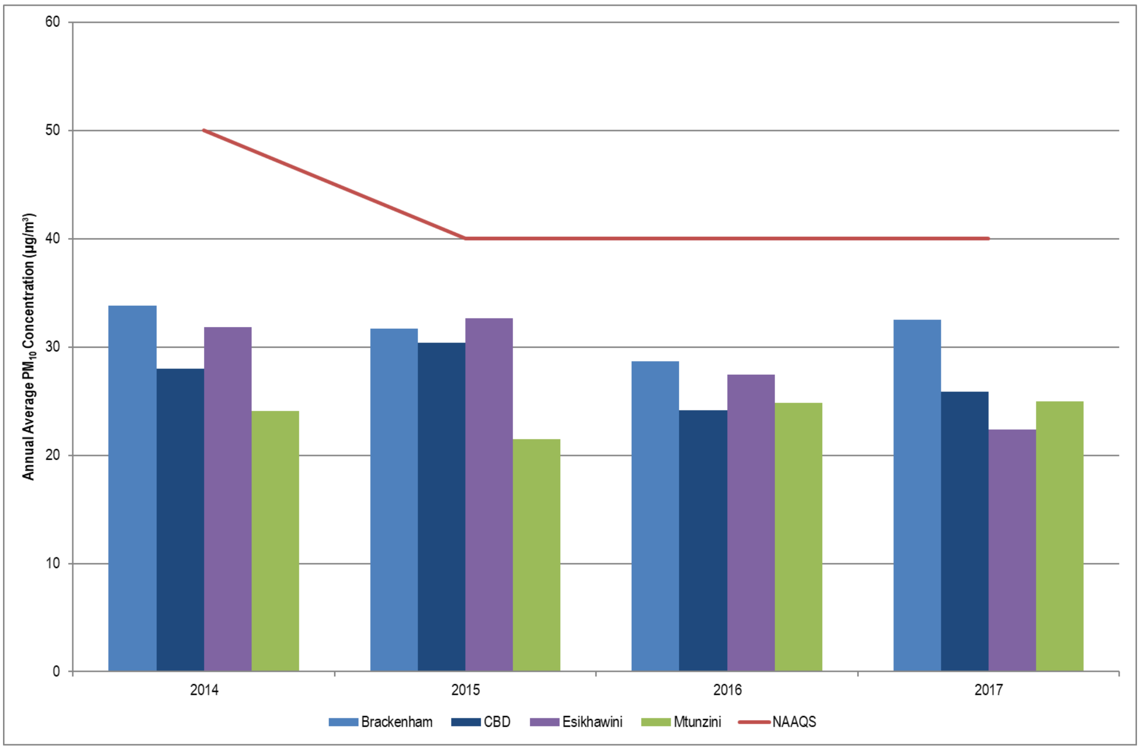

Figure 5-9: Annual average PM_{10} concentrations (June 2013 to June 2016)

The 'openair' statistical package (Carslaw & Ropkins, 2012; Carslaw, 2014) was used to plot the PM_{10} concentrations measured at the RBCAA stations. Polar plots can provide an indication of the directional contribution as well as the dependence of concentrations on wind speed, by providing a graphical impression of the potential sources of a pollutant at a specific location. The directional display is fairly obvious, i.e. when higher concentrations are shown to occur in a certain sector, e.g. south-west of Brackenham (Figure 5-10(a)), it is understood that most of the high concentrations occurred when winds blew from that sector. The dotted circular lines indicate the wind-speed with which the concentrations are associated – not distance from the monitoring station. At all four stations analysed elevated PM_{10} concentrations were recorded when wind speeds exceeded 8 m/s. The directional contributions, however, varied between the stations, where the contributors at high wind speeds are located: to the south-west of Brackenham station; to the south and north-north-east of the CBD station; to the west and north-west of the Esikhawini station; and, to the east-north-east, north and, south of the Mtunzini station.

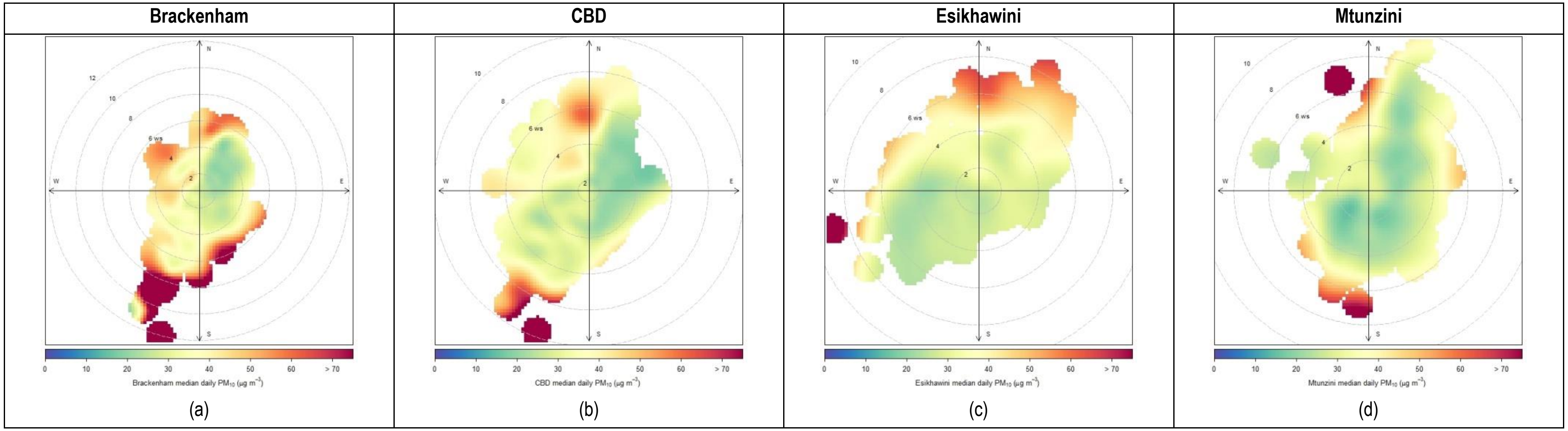

Figure 5-10: Polar plots of median daily PM_{10} concentrations for four RBCAA stations

5.1.3.3.2 Ambient SO_2 Concentrations

Hourly SO_2 concentrations recorded at seven RBCAA stations complied with the hourly NAAQS for all years in the data set (Table 5-12). Scorpio AQMS had the largest number of hourly exceedances of the limit concentration, 5 hours in 2014. The NAAQS allows for 88 hours exceeding the limit concentration per year (350 µg/m³). Although the daily average SO_2 concentrations exceeded the limit concentration at Scorpio for two days during 2014 no further daily exceedances at the Scorpio (or other AQMS) have been recorded. Annual average SO_2 at all stations was compliant with the NAAQS (Figure 5-11) with a slight trend towards improvement (lower SO_2 concentrations) at all stations.

Table 5-12: Frequency of exceedance of the hourly and daily SO_2 NAAQS at seven stations where SO_2 is measured (bold text indicates non-compliance with applicable NAAQS)

Year	RBCAA monitoring station						
	Arboretum	Brackenham	CBD	Esikhawini	Felixton	Harbour West	Scorpio
Frequency of Exceedance of hourly limit concentration (350 µg/m³)							
2014	-	-	-	-	-	2	5
2015	-	-	-	-	-	-	-
2016	-	-	1	-	-	1	2
2017	-	-	-	-	-	-	-
Frequency of Exceedance of daily limit concentration (125 µg/m³)							
2014	-	-	-	-	-	-	2
2015	-	-	-	-	-	-	-
2016	-	-	1	-	-	-	-
2017	-	-	-	-	-	-	-

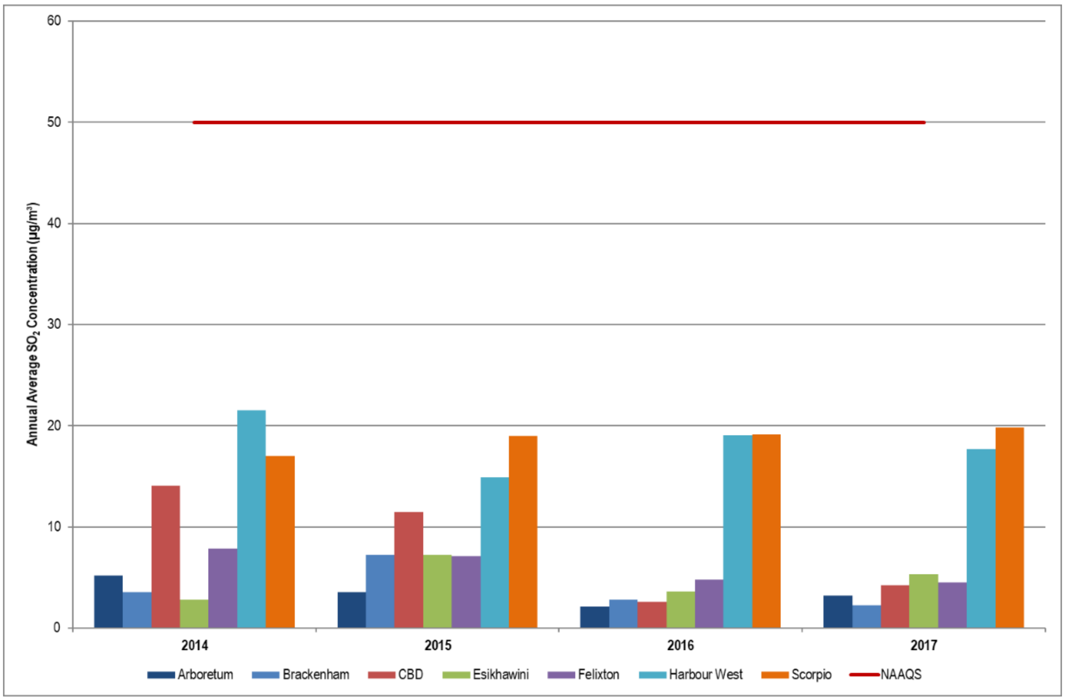

Figure 5-11: Annual average SO_2 concentrations (June 2013 to June 2016) [*indicates incomplete dataset; calculated average may not be accurate based on 50% data availability or less]

Polar plots were generated for five of the RBCAA stations where both SO_2 and meteorological parameters are recorded (Figure 5-12). At the Arboretum AQMS elevated SO_2 contributions originated to the south-west of the station at wind speeds between 2 and 10 m/s. Sources of SO_2 are located to the south of the Brackenham AQMS and contributed at wind speeds between 5 and 15 m/s. The median hourly SO_2 concentrations at the Arboretum and Brackenham stations were similar, generally below 20 µg/m³. The CBD and Harbour West AQMS recorded similar median hourly SO_2 concentrations however the directional contributions differ. At the CBD station SO_2 sources were located to the south-west of the station where elevated SO_2 concentrations contributed at wind speeds between 2 and 12 m/s. The Harbour West AQMS recorded elevated SO_2 concentrations from the north-west and north-east at low wind speeds (less than 10 m/s). The Esikhawini station recorded the lowest median hourly SO_2 concentrations and the polar plot shows that elevated concentrations originate to the north-west (at wind speeds above 4 m/s) and north-east (at wind speeds above 10 m/s) of the station.

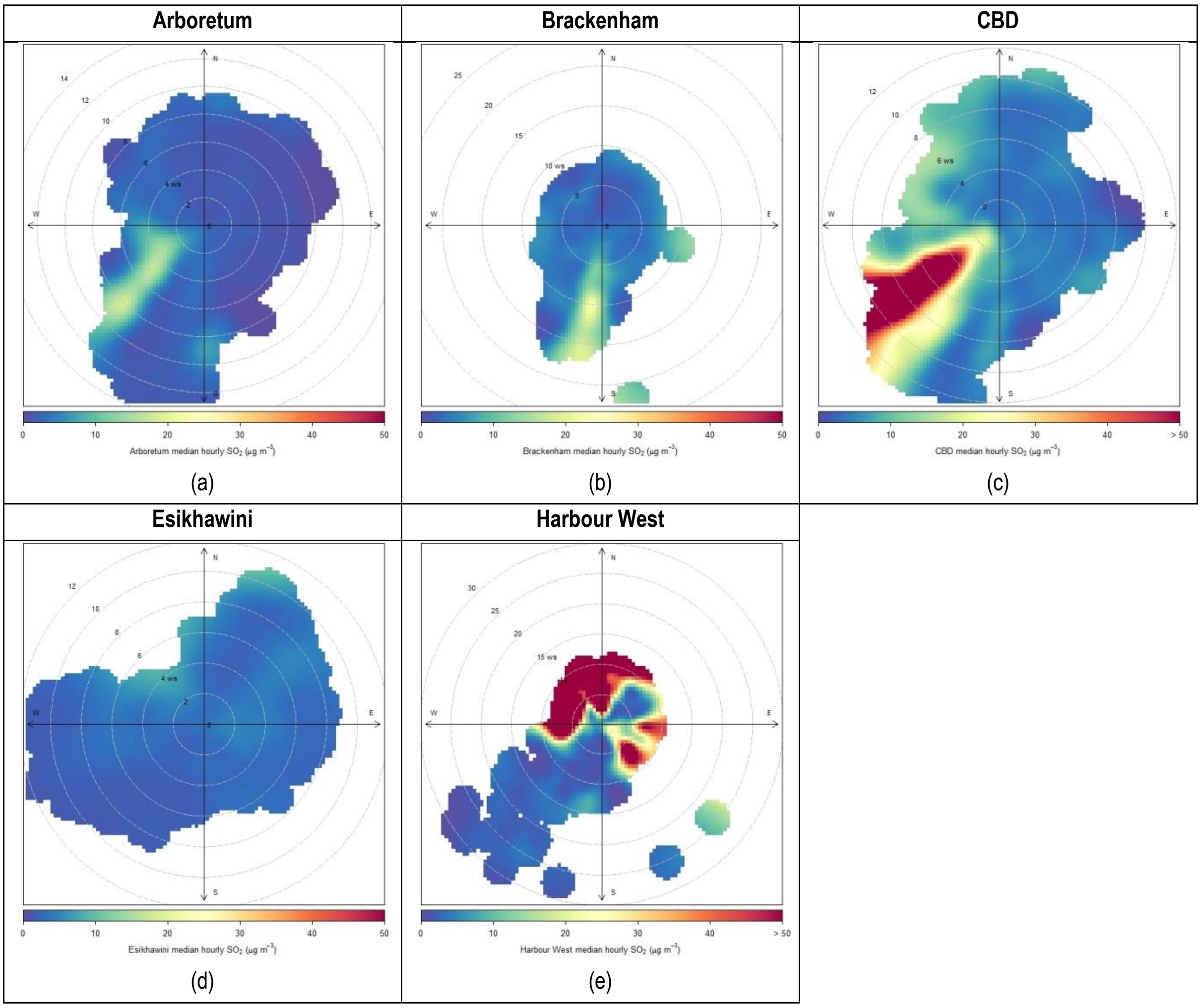

Figure 5-12: Polar plots of median hourly SO_2 concentrations for five RBCAA stations

5.1.4 Dispersion Modelling of Baseline Pollutant Concentrations

A recent air quality dispersion modelling study assessing the cumulative impact of operations within the Richards Bay domain was consulted with permission of the authors (WSP Environment and Energy) and the RBCAA (under request for confidentiality of its members). The report is considered by the RBCAA to be the most comprehensive assessment of normal operations of the industries in the Richards Bay airshed, although limitations of the assessment are detailed in the report. These include omission of some industrial sources (where information was not available); exclusion of vehicular traffic emissions; and intermittent sources such as sugarcane burning. Simulated annual average concentrations of PM_{10}, NO_2, and SO_2 were provided for cumulative assessment of the baseline conditions and the proposed facility.

5.1.4.1 Emissions Quantification

Emissions were quantified from 11 industries within the Richards Bay airshed, based on information provided by the industries and the AELs. Total annual point source emissions for the pollutants of concern are summarised in Table 5-13.

Table 5-13: Baseline annual pollutant emission rates in the Richards Bay airshed

Source group	Annual emission rates (tonnes per year)		
	SO_2	NO_X	PM_{10}
Point sources	23 252.97	8.452.15	3 411.15
Area sources	(not reported)		

5.1.4.2 Simulated Annual Average Respirable Particulate Matter (PM_{10})

The baseline operations were simulated to result in exceedances of the currently enforceable NAAQS (40 µg/m³) across much of the port area and adjacent areas mainly due to coal stockpiling and handling operations (Figure 5-13).

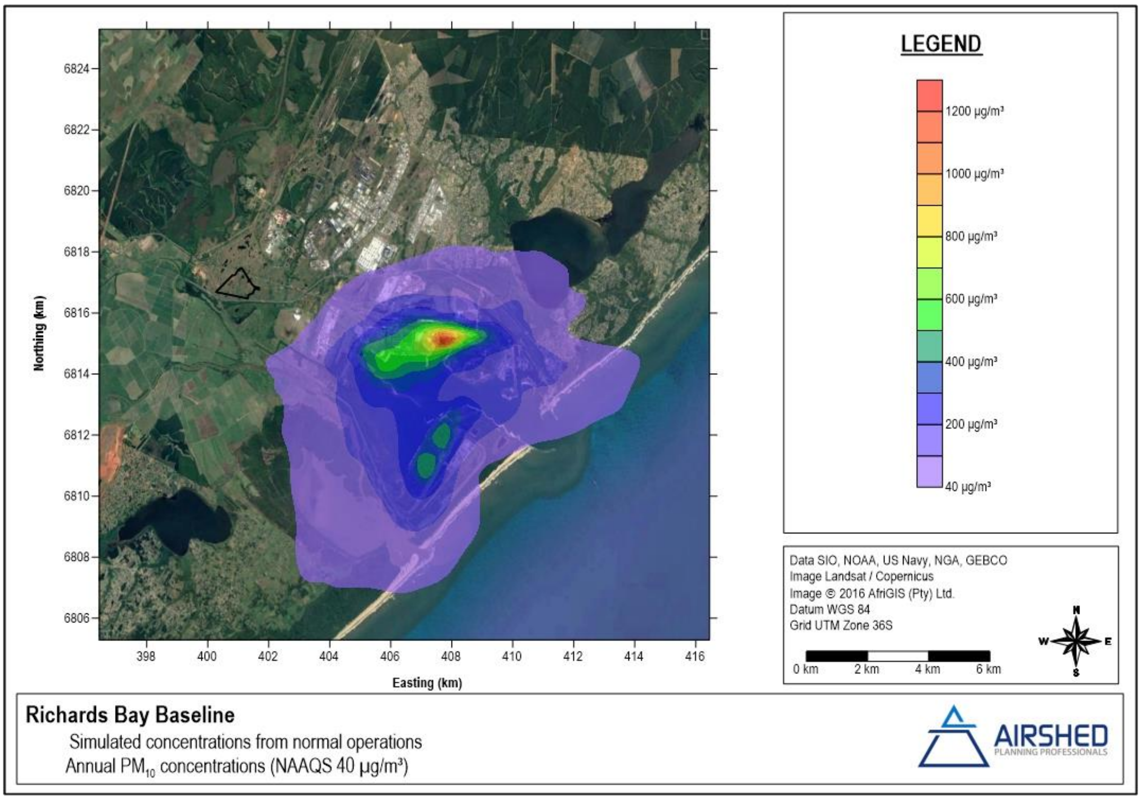

Figure 5-13: Simulated annual average PM_{10} concentrations for the Richards Bay baseline

5.1.4.3 Simulated Annual Average Sulfur dioxide (SO_2)

Annual average SO_2, due to normal operations of the industrial sources in Richards Bay, were simulated to comply with the NAAQS across the domain, where the highest concentrations are expected close to Richards Bay central, Alton, and Brackenham (Figure 5-14).

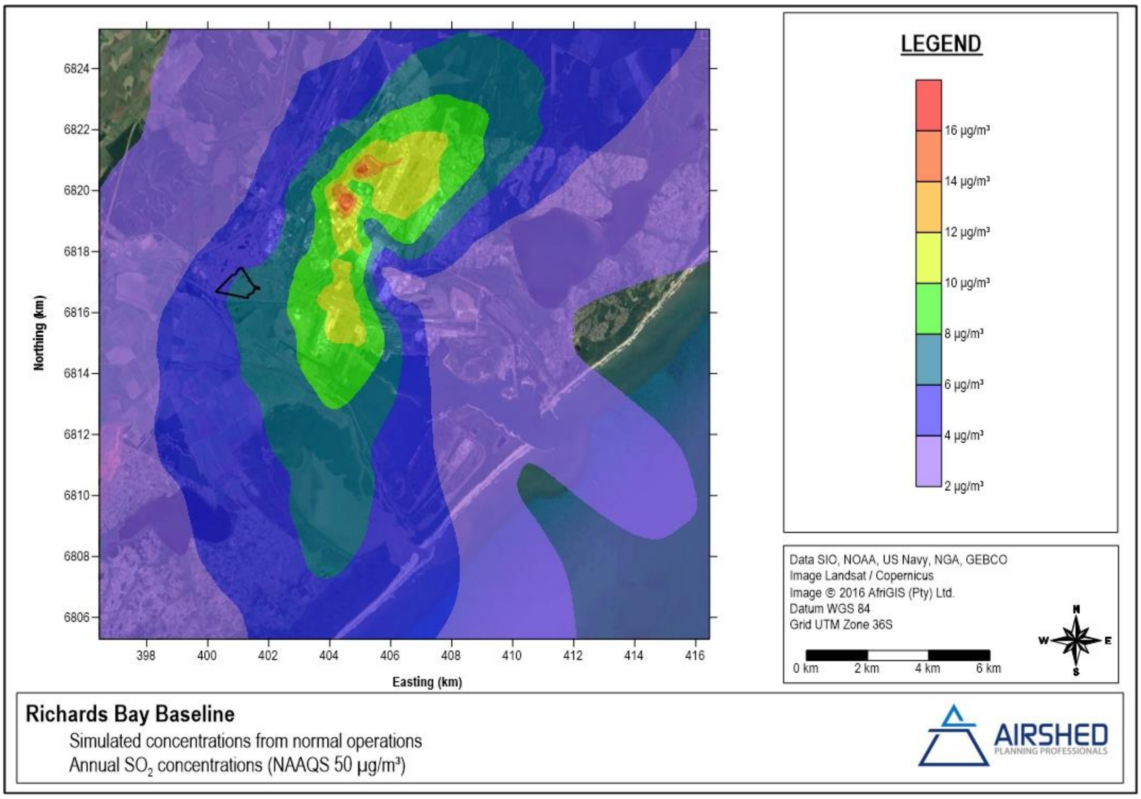

Figure 5-14: Simulated annual average SO_2 concentrations for the Richards Bay baseline

5.1.4.4 Simulated Annual Average Nitrogen dioxide (NO_2)

Annual average NO_2 was simulated to comply with the NAAQS across the domain for normal operation of the industries operating in Richards Bay, with maximum concentrations occurring near Alton and Richards Bay Central (Figure 5-15).

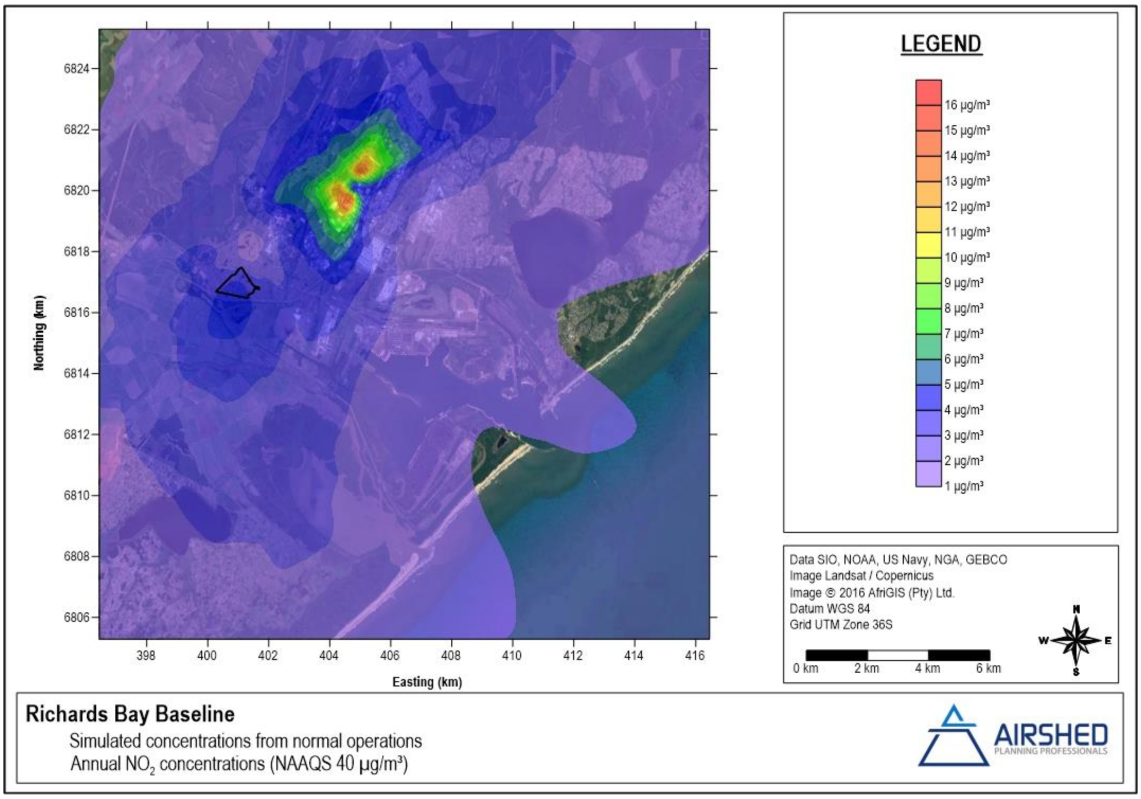

Figure 5-15: Simulated annual average NO_2 concentrations for the Richards Bay baseline

5.1.5 Dispersion Modelling of Proposed Facility

5.1.5.1 Emission Scenarios

<u>Construction Phase</u>

Construction operations are potentially significant sources of dust emissions that may have a substantial temporary impact on local air quality. Emissions during construction would result from general site preparation for the development, where activities contributing would typically include: land clearing and demolition activities, excavation, material handling activities, wheel entrainment, operation of diesel or petrol engines etc. If not properly mitigated, construction sites could generate high levels of dust (typically from concrete, cement, wood, stone, and, silica) and this has the potential to travel for large distances.

Large quantities of the dust emissions result from construction vehicle traffic over temporary and/or unpaved roads at construction sites. Dust emissions can also vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing meteorological conditions. It is therefore often necessary to estimate area-wide construction emissions, without regard to the actual plans of any individual construction process.

The US-EPA has defined an emissions factor with the aim of providing a general rule-of-thumb as to the magnitude of emissions which may be anticipated from construction operations. The quantity of dust emissions is assumed to be proportional to the area of land being worked and the level of construction activity. Based on field measurements of total suspended particulate (TSP) concentrations surrounding construction projects, the generalised emission factor for construction activity is given as:

E_{TSP} = *2.69 Mg/hectare/month of activity (269 g/m²/month)*

The PM_{10} (particulate matter with an aerodynamic diameter of less than 10 µm) fraction is given as approximately 35% of the US-EPA total suspended particulate factor. These emission factors are most applicable to construction operations with (i) medium activity levels, (ii) moderate silt contents, and (iii) semiarid climates. The emission factor is based on 42 hours of work per week of construction activity. Test data were not sufficient to derive the specific dependence of dust emissions on correction parameters. Because the above emission factor is referenced to TSP, use of this factor to estimate PM_{10} emissions will result in conservatively high estimates. Also, because derivation of the factor assumes that construction activity occurs 30 days per month, the above estimate is somewhat conservatively high for TSP as well.

In estimating emissions due to construction activities, it was assumed that the full extent of the proposed facility (approximately 60 hectares) would be cleared before the various construction activities started. Construction was assumed to occur 9-hours per day (equivalent to 45 hours per week) for 21 days per month and for a period between 36 and 48 months, where annual emissions because of construction activities are given in Table 5-14. Mitigation using watering, especially on open areas and unpaved roads was assumed to control emissions by 50% during construction operations for quantification and modelling. All potential mitigation options are discussed in the relevant sections below.

Table 5-14: Annual emissions due to construction activities

Annual emissions (tonnes/annum)	TSP	PM_{10}
	7 480.8	2 618.3

Operational Phase

Impact of the operational phase was simulated using the parameters and emission rates given in Sections 4.1, 4.6, 4.7 (Table 4-2, Table 4-3, Table 4-9, Table 4-10, Table 4-11, Table 4-13 and Table 4-14). Annual average concentrations were estimated assuming that normal operations (gas combustion venting through the main stacks) occurred 99% of the operational cycle. Emergency events were assumed to cumulatively account for the remainder of the operational cycle, such that no emergency event would persist for longer than eight continuous hours.

The emissions of hydrogen sulfide (H_2S) as an odourous gas assumed a sulfide concentrations in the dirty water dam of 0.34 g/m³ based on the sulfur content of the boiler blow-down water, and the dam at full capacity (300 000 m³).

Emergency Events

Three types of potential emergency events were simulated (Section 4.4) using the parameters defined in Table 4-2 and Table 4-7. All emergency events assumed all eight units would remain operational. Based on the provision that emergency events would persist for no longer than eight continuous hours, only hourly average pollutant concentrations were assessed for worst-hour impacts.

5.1.5.2 Dispersion Modelling Results – Incremental Impacts

Isopleth plots are only included the subsections below for short-term concentrations where exceedances of the NAAQS were simulated. Short-term (hourly or daily) concentrations were extracted at the 99th percentile, to account for the number of exceedances allowed by the NAAQS. All annual concentrations are provided in isopleth plots.

During emergency events, only the simulated hourly concentrations are plotted as the emergency events are unlikely to occur for more than eight continuous hours.

5.1.5.2.1 Simulated PM Concentrations

<u>Construction phase</u>

Construction activities are likely to vary in location and duration in the short term. The unmitigated emissions associated with construction of the proposed project may impact daily PM_{10} concentrations up to 400 m off-site (Figure 5-16). Compliance with annual PM_{10} NAAQS off-site is likely (Figure 5-17). Dust control measures that can be implemented during the construction phase are outlined in Table 5-15. Control techniques for fugitive dust sources generally involve watering, chemical stabilization, keeping cleared area as small as possible to limit exposed area, and the reduction of surface wind speed though the use of windbreaks and source enclosures.

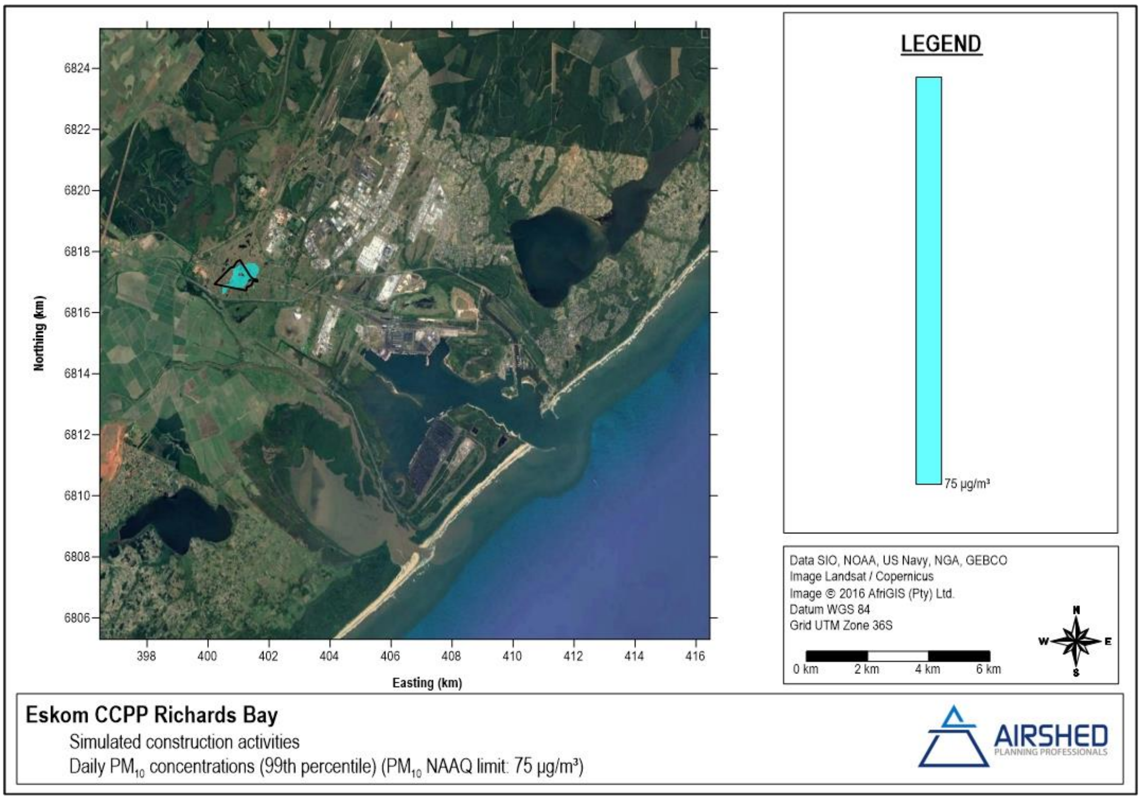

Figure 5-16: Simulated daily average PM_{10} concentrations due to construction activities

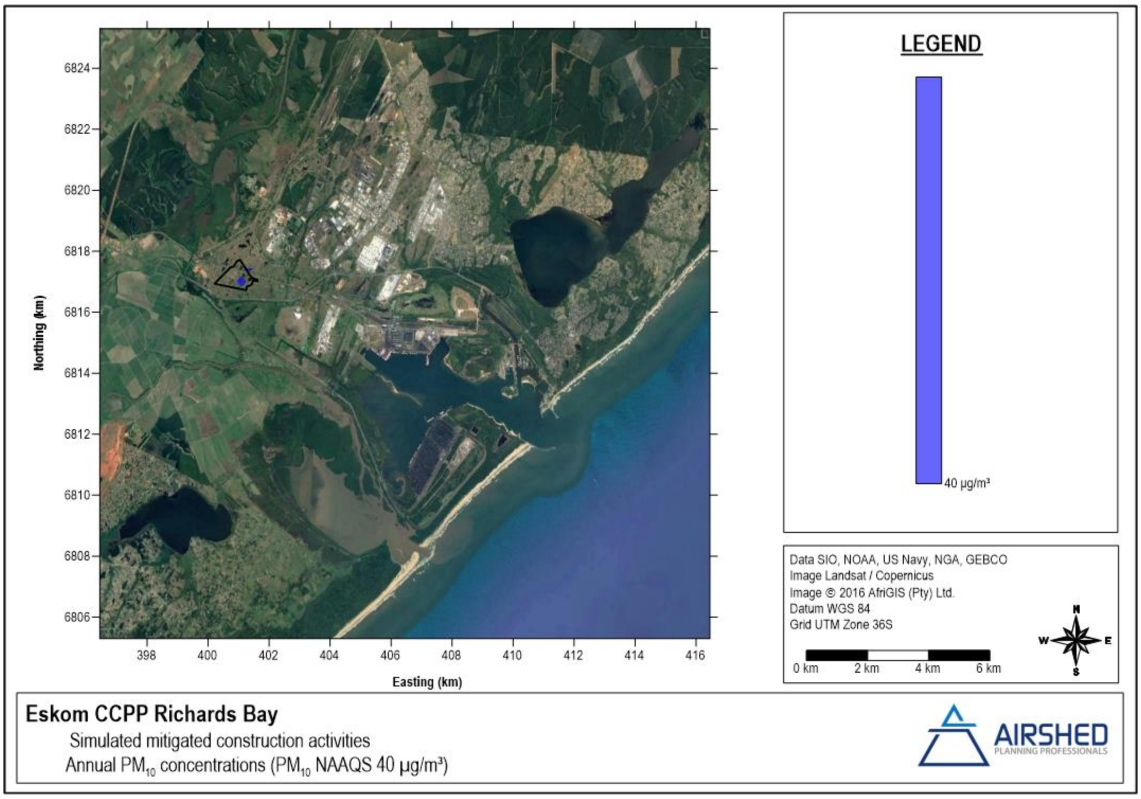

Figure 5-17: Simulated annual average PM_{10} concentrations due to construction activities

Table 5-15: Dust control measures that can be implemented during construction activities

Construction Activity	Recommended Control Measure(s)
Debris handling	Wet suppression (hourly watering recommended)
Truck transport and road dust entrainment	Wet suppression (hourly watering recommended) or chemical stabilization of unpaved roads.
	Haul trucks to be restricted to specified haul roads using the most direct route.
	Reduction of unnecessary traffic
	Strict on-site speed control (i.e. 40 km/hr for haul trucks)
Materials storage, handling and transfer operations	Wet suppression where feasible, possibly using continuous sprays
Earthmoving operations	Wet suppression (hourly watering recommended) where feasible
	Limited area of bulk earthworks
Open areas (wind-blown emissions)	Reduction of extent of open areas to minimise the time between clearing and infrastructure construction; and/or use wind breaks and water suppression to reduce emissions from open areas
	Restriction of disturbance to periods of low wind speeds (less than 5 m/s)
	Stabilisation (chemical, rock cladding or vegetative) of disturbed soil
	Re-vegetation of cleared areas as soon as practically feasible

Operational phase

For particulate matter, NAAQS are available for PM_{10} and $PM_{2.5}$. Ambient air quality impacts for both particulate fractions (i.e. PM_{10} and $PM_{2.5}$) thus need to be considered. Simulated concentrations of particulate matter (PM), including secondary particulates (as per the explanation in Section 5.1.1.1.3), are conservatively assumed to be entirely either PM_{10} or $PM_{2.5}$.

No exceedances of the daily PM_{10} NAAQS were simulated across the modelling domain due to the project, based on MES. Annual PM_{10} concentrations were simulated to be less than 3 µg/m³ across the domain (Figure 5-18).

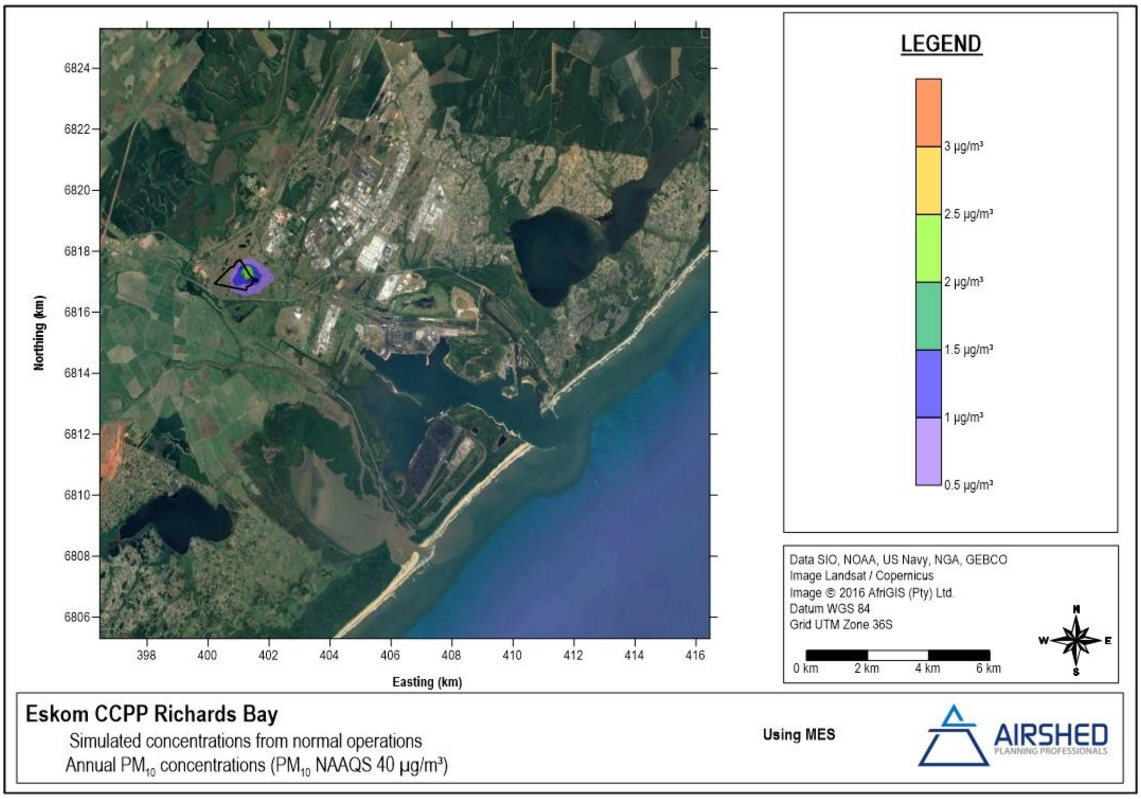

Figure 5-18: Simulated annual PM_{10} concentrations due to the proposed facility based on MES

No exceedances of the most stringent daily $PM_{2.5}$ NAAQS (25 µg/m³ enforceable from 1 January 2030) were simulated across the modelling domain due to the project. The maximum 99th percentile simulated daily average concentration was 9.1 µg/m³ (less than 40% of the daily $PM_{2.5}$ NAAQS). Annual concentrations were simulated to be less than 2.8 µg/m³ across the domain (Figure 5-19).

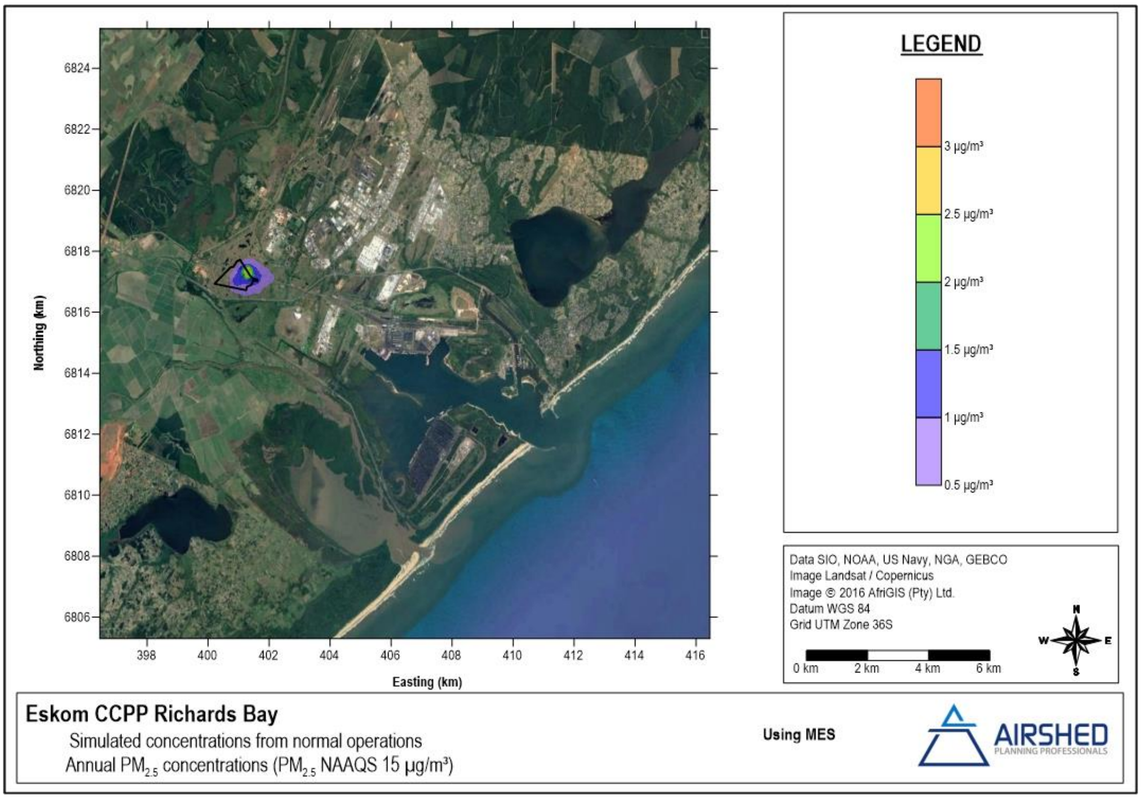

Figure 5-19: Simulated annual $PM_{2.5}$ concentrations due to the proposed facility based on MES

Emergency events

Under the three emergency scenarios assessed, daily PM concentrations were simulated to be a less than (Emergency 1) 2.0 µg/m³; (Emergency 2) 3.6 µg/m³; and (Emergency 3) 2.5 µg/m³, respectively. Emergency events are expected to occur less than 88 hours per year, therefore annual concentrations are not presented.

5.1.5.2.2 Simulated SO_2 Concentrations

Operational phase

Normal operation of the facility was simulated based on emissions were calculated from emission factors (Section 4.3). Simulated hourly SO_2 concentrations for the proposed facility operating based on emission factors are likely to result in compliance with hourly (domain maximum: 0.7 µg/m³), daily (domain maximum: 0.21 µg/m³) and annual NAAQS (domain maximum: 0.07 µg/m³; Figure 5-20).

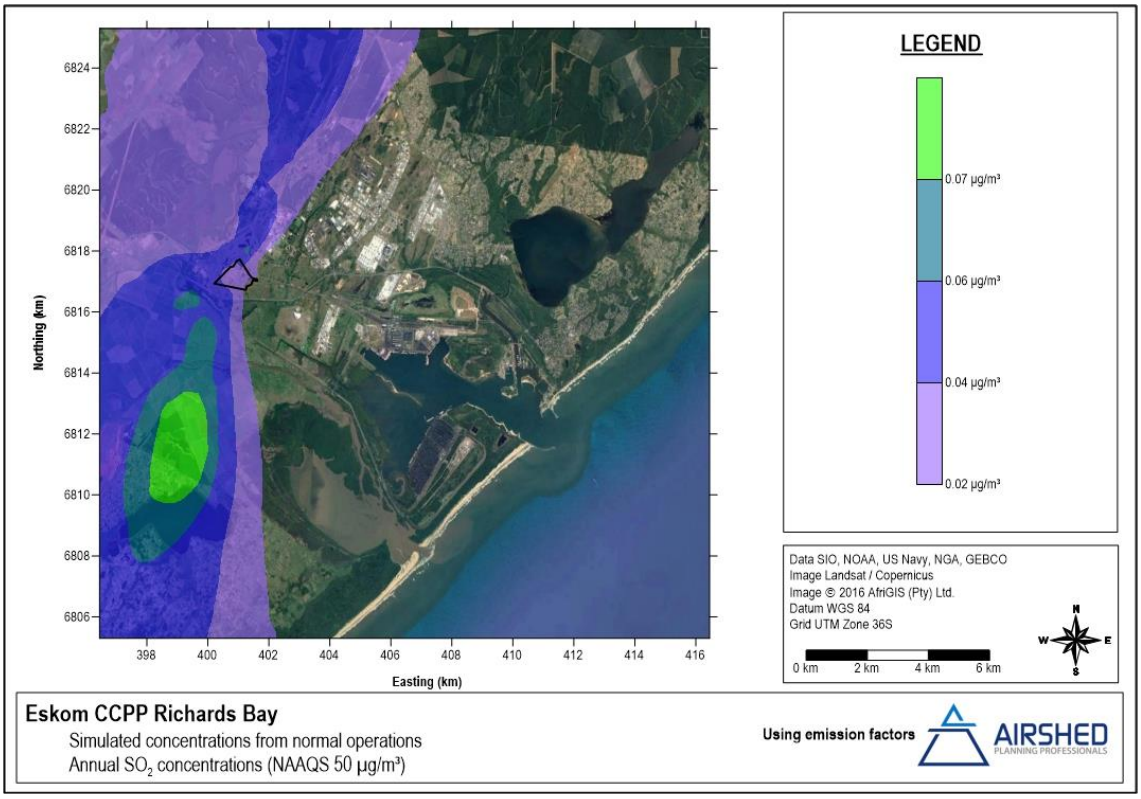

Figure 5-20: Simulated annual average SO_2 concentrations due to normal operations – using Emission Factors

If the facility operates at the regulated emission limits for Subcategory 1.4 (Table 5-6) exceedances of the hourly and daily SO_2 NAAQS could occur off-site (results not shown). However, natural gas inherently has a very low sulfur content, most of which is intentionally added as an odourant for detection during leakage events. It is therefore highly probable that the normal operation of the facility will be much lower than the emission limits.

Emergency events

The highest hourly SO_2 concentrations (903.8 µg/m³) were simulated for the Emergency 2-type events (diesel combustion venting through the main stacks) (Figure 5-22), resulting in exceedance of the hourly NAAQ limit concentration. Emission reports from two of Eskom's Peaking Power Stations combusting low sulfur (50 ppm) diesel during periods of peak electricity demand show that these power stations operate well below the MES applicable to liquid combustion installations (Table 4-7), where the measured emission concentrations were 16 mg/Nm^3 SO_2 at both Ankerlig and Gourikwa. Similarly, the proposed Richards Bay CCPP is likely to comply with MES and NAAQS during Emergency 2-type events if using low sulfur diesel.

Compliance with the hourly SO_2 NAAQS is likely for Emergency 1- (Figure 5-21) and Emergency 3-type events (Figure 5-23) where the maximum simulated concentrations were 207.4 µg/m³, and 259.5 µg/m³, respectively. Emergency 1- and Emergency 3-type events vent flue-gas via the by-pass stacks which enhance pollutant dispersions due to the increased buoyance of a high temperature and velocity flue-gas stream.

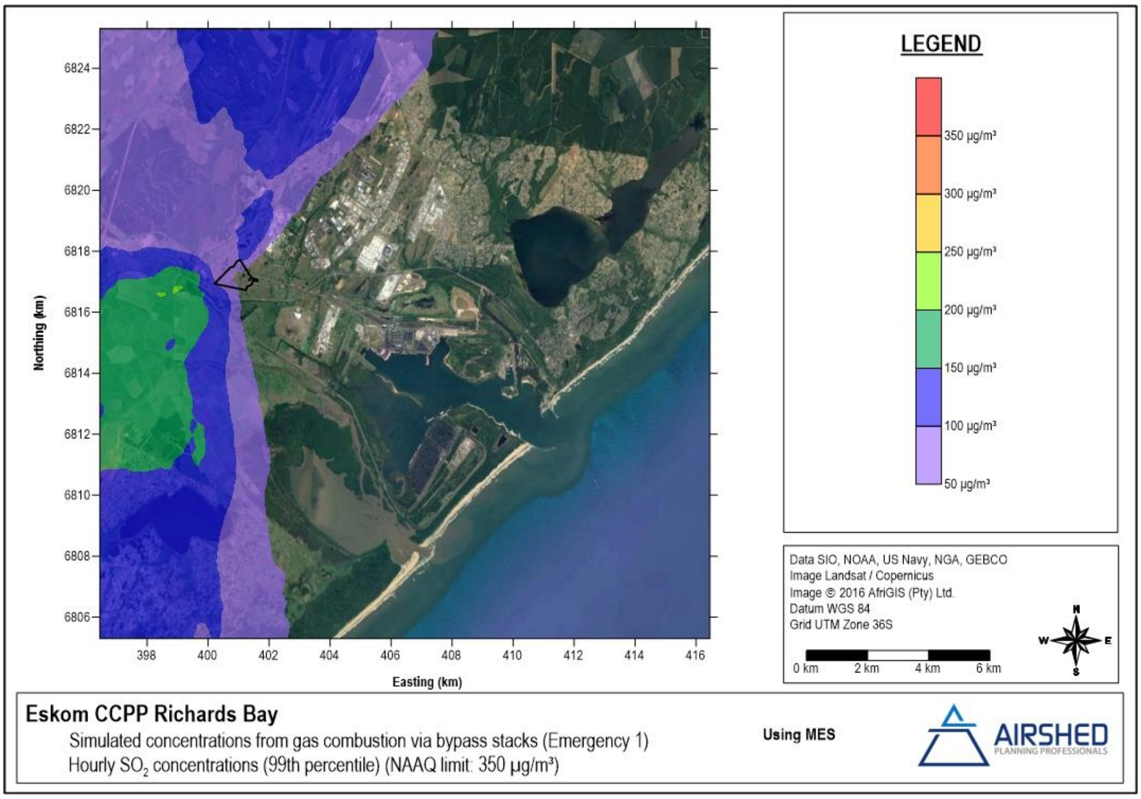

Figure 5-21: Simulated hourly SO_2 concentrations due to Emergency 1 type events

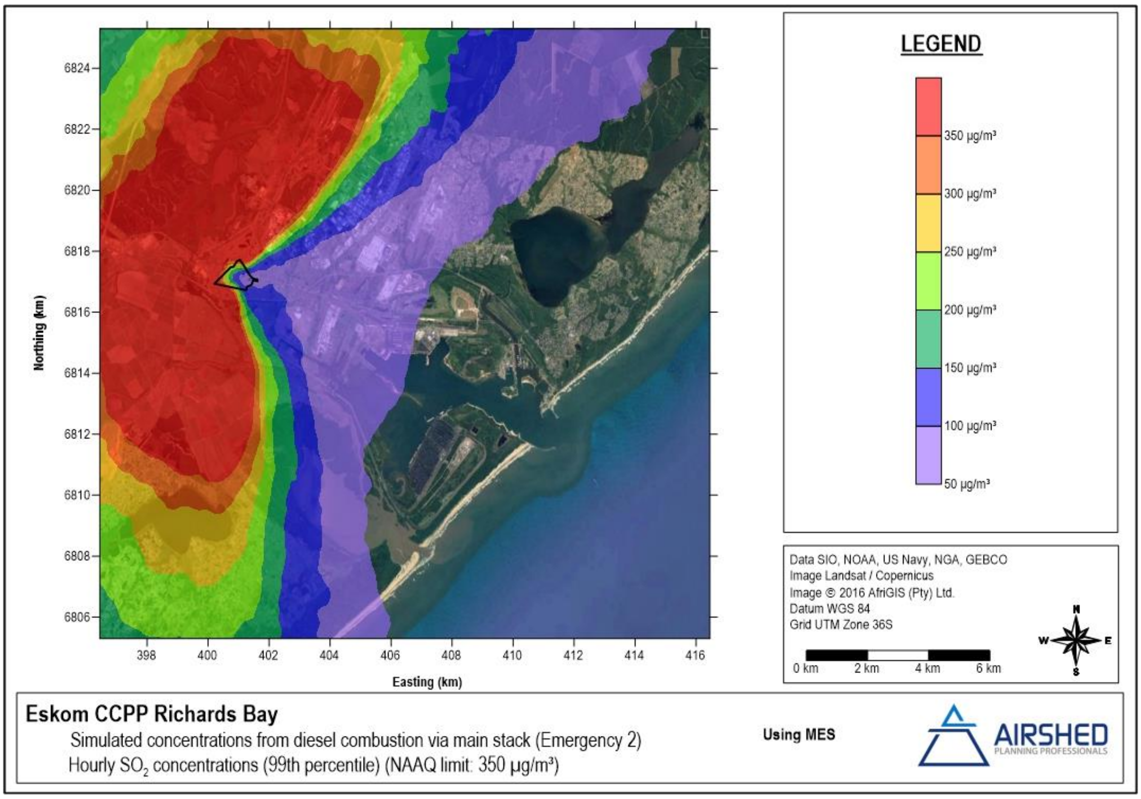

Figure 5-22: Simulated hourly SO_2 concentrations due to Emergency 2 type events

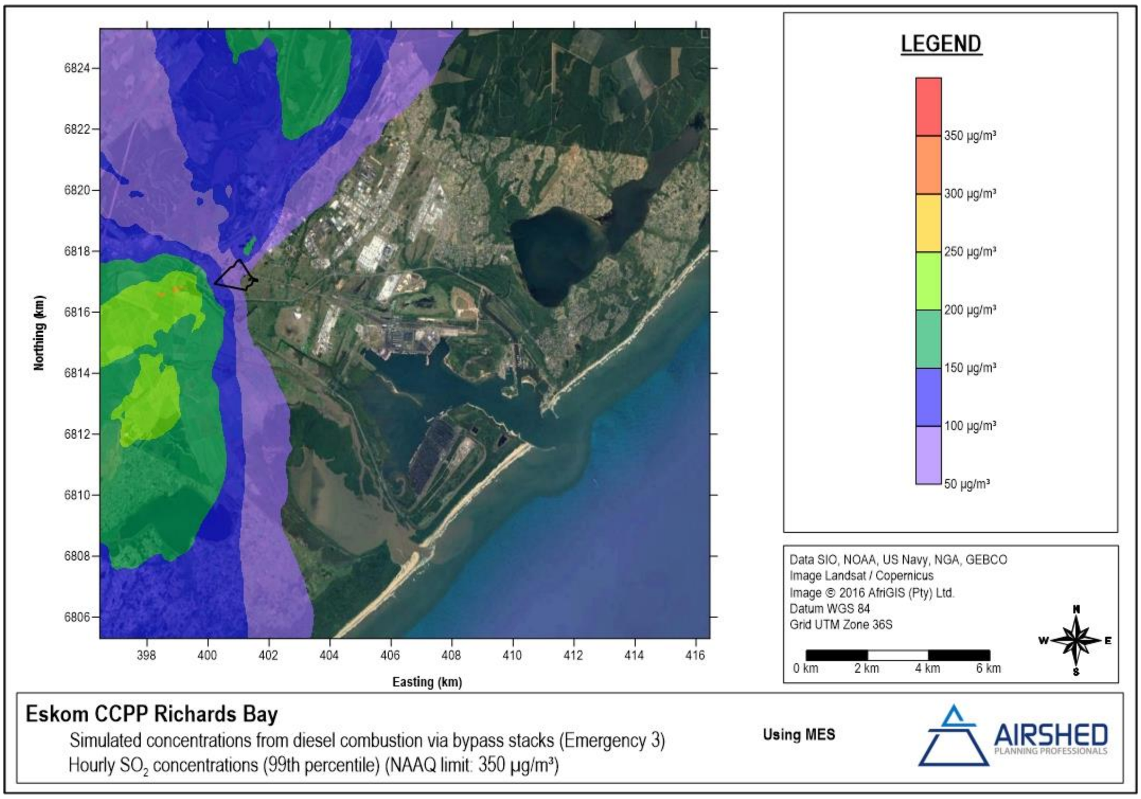

Figure 5-23: Simulated hourly SO_2 concentrations due to Emergency 3 type events

5.1.5.2.3 Simulated NO_2 Concentrations

The impact area of NO_X emissions was estimated as ground-level NO_2 concentrations using the ambient ratio method (Scire & Borissova, 2011) (Appendix D).

Operational phase

No exceedances of the hourly NO_2 NAAQS (200 µg/m³) were simulated across the modelling domain due to the project. The 99th percentile simulated daily average concentration was less than 80 µg/m³ (40% of the hourly NO_2 NAAQS). Annual concentrations were simulated to be less than 23 µg/m³ across the domain (Figure 5-24).

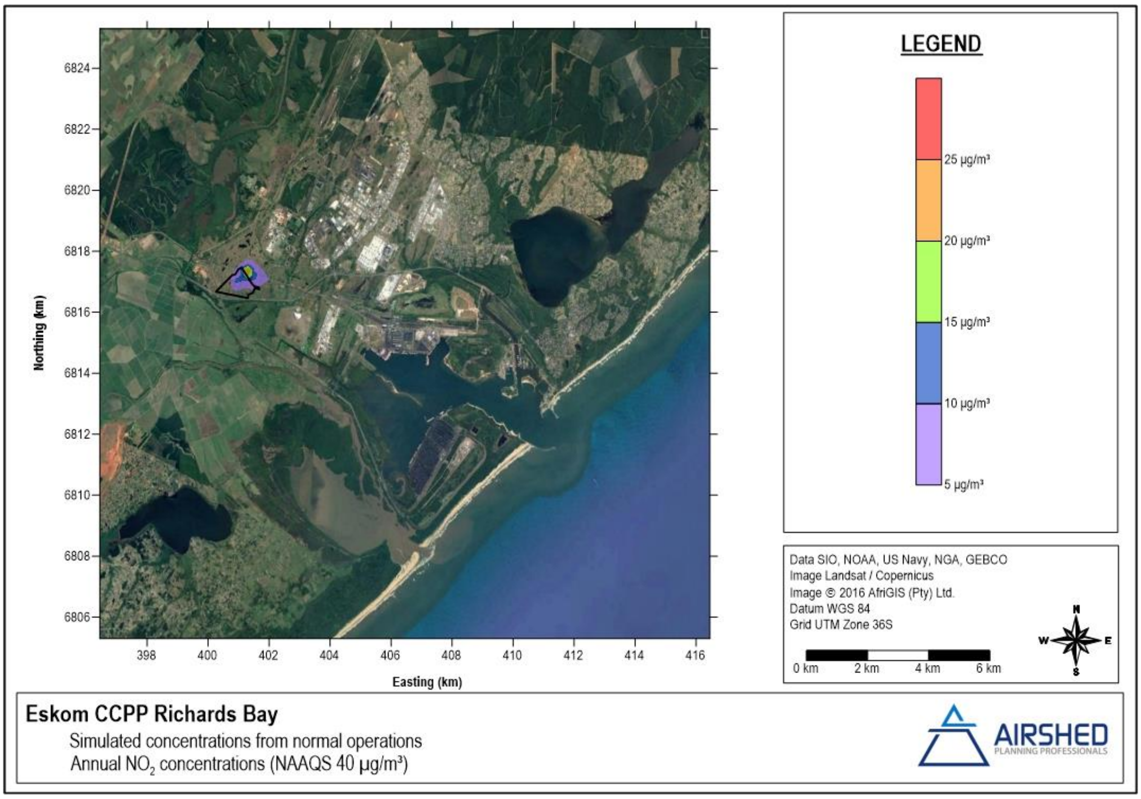

Figure 5-24: Simulated annual average NO_2 concentrations due to normal operations

Emergency events

Simulated hourly NO_2 concentrations for Emergency 1- and Emergency 2-type events were lower than the hourly NO_2 NAAQ limit concentration (200 µg/m³); 25.0 µg/m³ and 179.9 µg/m³, respectively. Emergency 3-type events may however result in off-site exceedances of the NAAQS by up to 3.5 km (Figure 5-25). Emission reports from two of Eskom's Peaking Power Stations combusting diesel during periods of peak electricity demand show that these power stations operate well below the MES applicable to liquid combustion installations (Table 4-7), where measured emission concentrations were: 169 and 148 mg/Nm^3 NO_X (at Ankerlig and Gourikwa respectively). Therefore, the proposed Richards Bay CCPP is likely to comply with MES and NAAQS during Emergency 3-type events if a similar emission concentration is achieved.

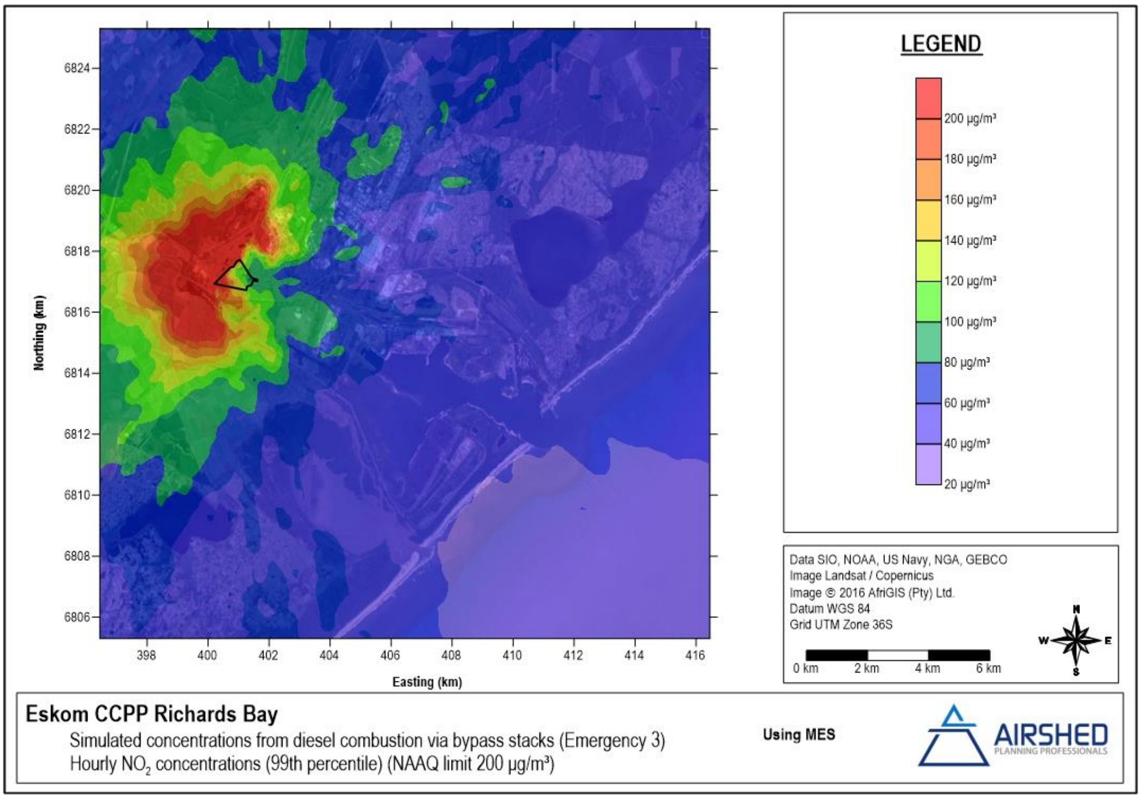

Figure 5-25: Simulated hourly NO_2 concentrations due to Emergency 3 type events

5.1.5.2.4 Simulated TVOC Concentrations

Emissions due to evaporative, loading, and unloading losses of TVOCs from the diesel storage tanks are likely to result in annual average concentrations less than 1.5 µg/m³. Benzene content in diesel is very low and therefore the NAAQS for benzene was assumed to be too conservative. Toluene was assumed to be more likely pollutant emitted from these sources. Simulated annual average TVOC concentrations were much lower than the most stringent inhalation toxicity guidance value for toluene (300 µg/m³ as defined by the Californian Environmental Protection Agency Office of Environmental Health Hazard Assessment's Chronic Reference Exposure Levels[2]).

[2] Sourced from the Risk Assessment Information System profile for toluene (https://rais.ornl.gov/tools/profile.php)

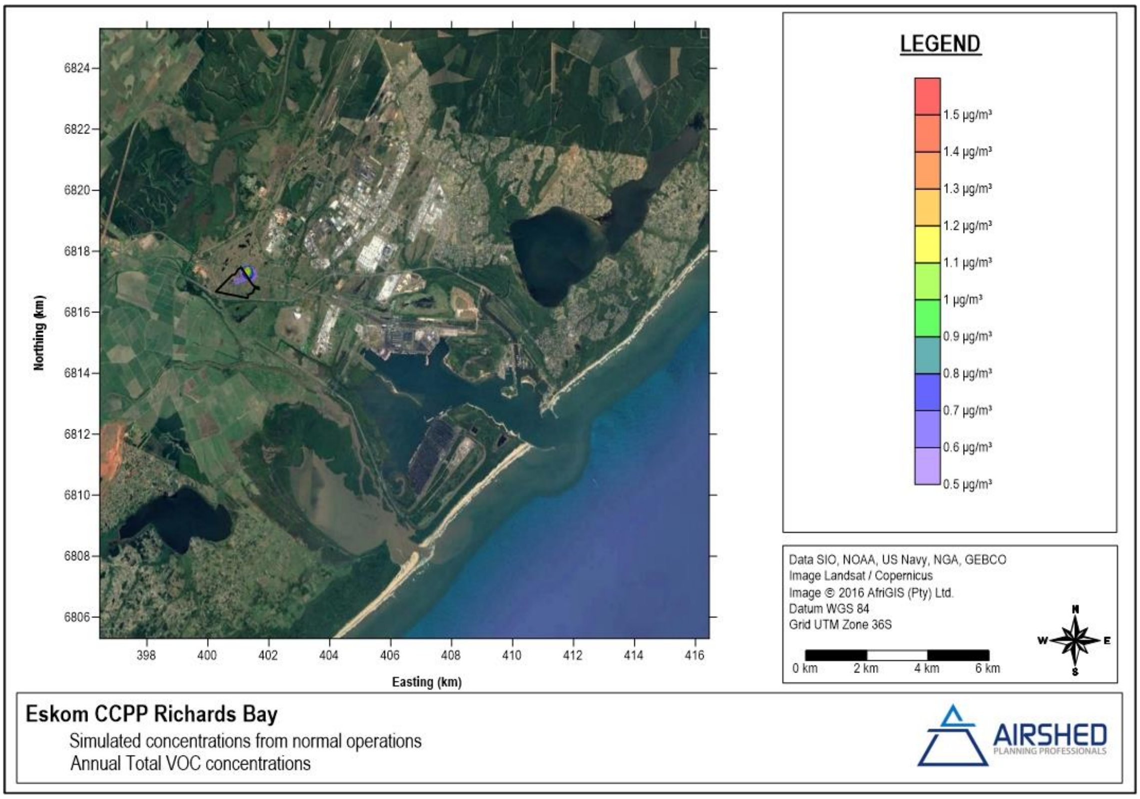

Figure 5-26: Simulated annual average TVOC concentrations to the proposed facility

5.1.5.2.5 Simulated Odour Impacts

Emissions of hydrogen sulfide (H_2S) as an odourous gas from the dirty water dam were simulated to result in less than 1 OU (odour unit) (Section 5.1.2.4) and therefore below the 2 OU criterion set for the current assessment.

5.1.6 Dispersion Modelling Results – Cumulative

The simulated Richards Bay baseline annual average pollutant concentrations (Section 5.1.4) were added to the incremental annual average concentrations (Section 5.1.5) due to the normal operation of the proposed facility.

5.1.6.1 Cumulative annual PM Concentrations

Cumulative annual PM concentrations were simulated to exceed the $PM_{2.5}$ and PM_{10} annual NAAQS for up to 10 km from the port – the major source of particulates in the domain (compare Figure 5-27 and Figure 5-13). Concentrations in the vicinity of the proposed facility will be lower than 15 µg/m³.

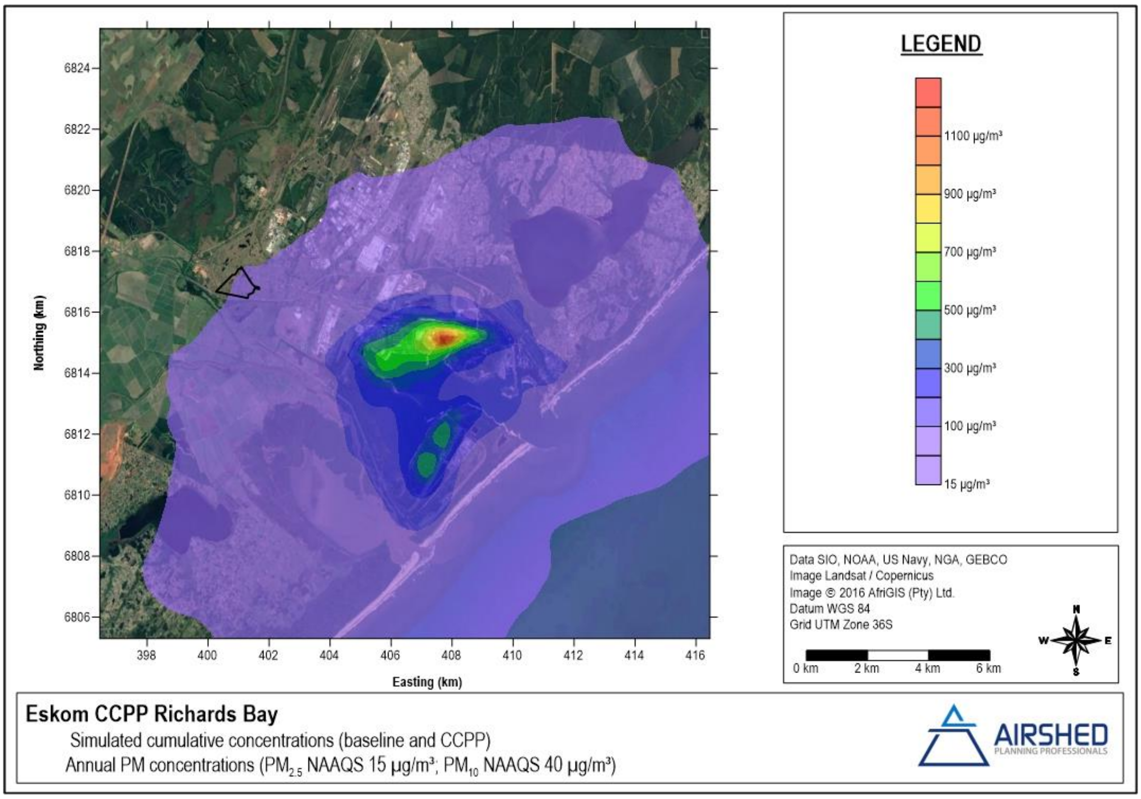

Figure 5-27: Simulated cumulative PM concentrations for the Richards Bay baseline and the proposed facility (compare with Figure 5-13)

5.1.6.2 Cumulative annual SO_2 Concentrations

Cumulative annual average SO_2 concentrations are likely to comply with annual SO_2 NAAQS across the domain (compare Figure 5-28 with Figure 5-14 and Figure 5-20).

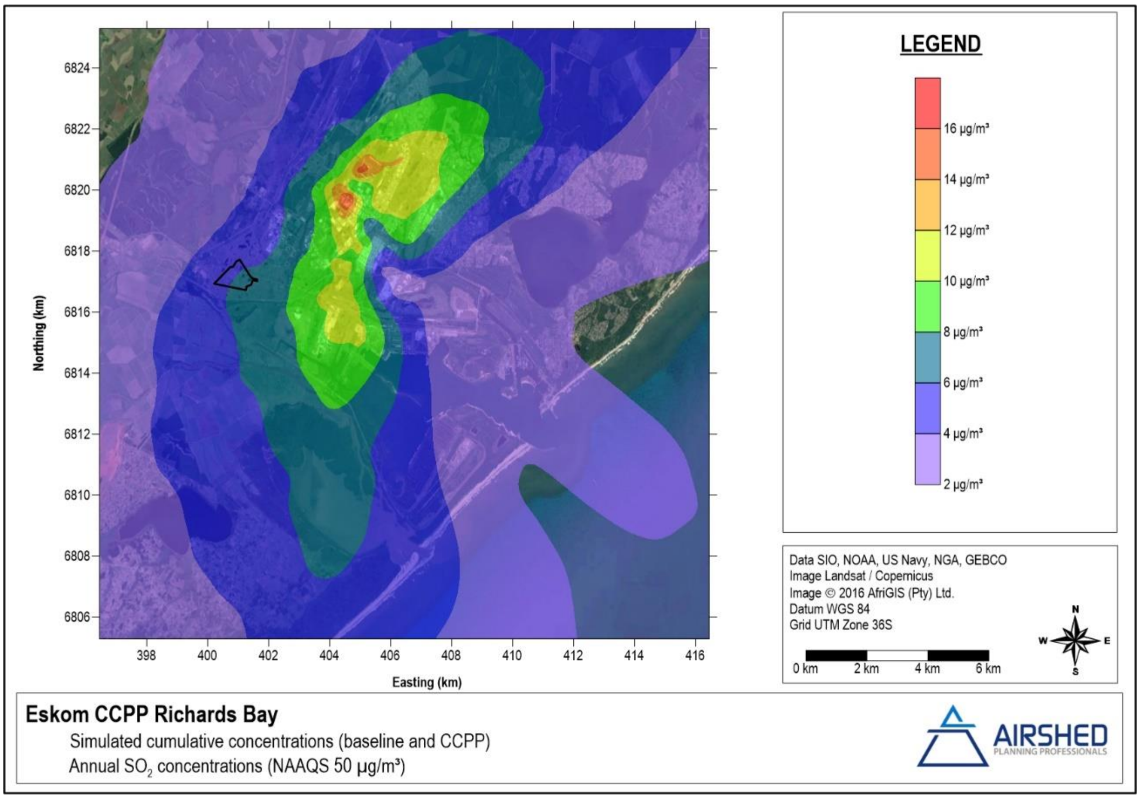

Figure 5-28: Simulated cumulative SO_2 concentrations for the Richards Bay baseline and the proposed facility (compare with Figure 5-14)

5.1.6.3 Cumulative annual NO_2 Concentrations

Cumulative annual NO_2 concentrations are likely to be compliant with the applicable NAAQS across the domain (Figure 5-29).

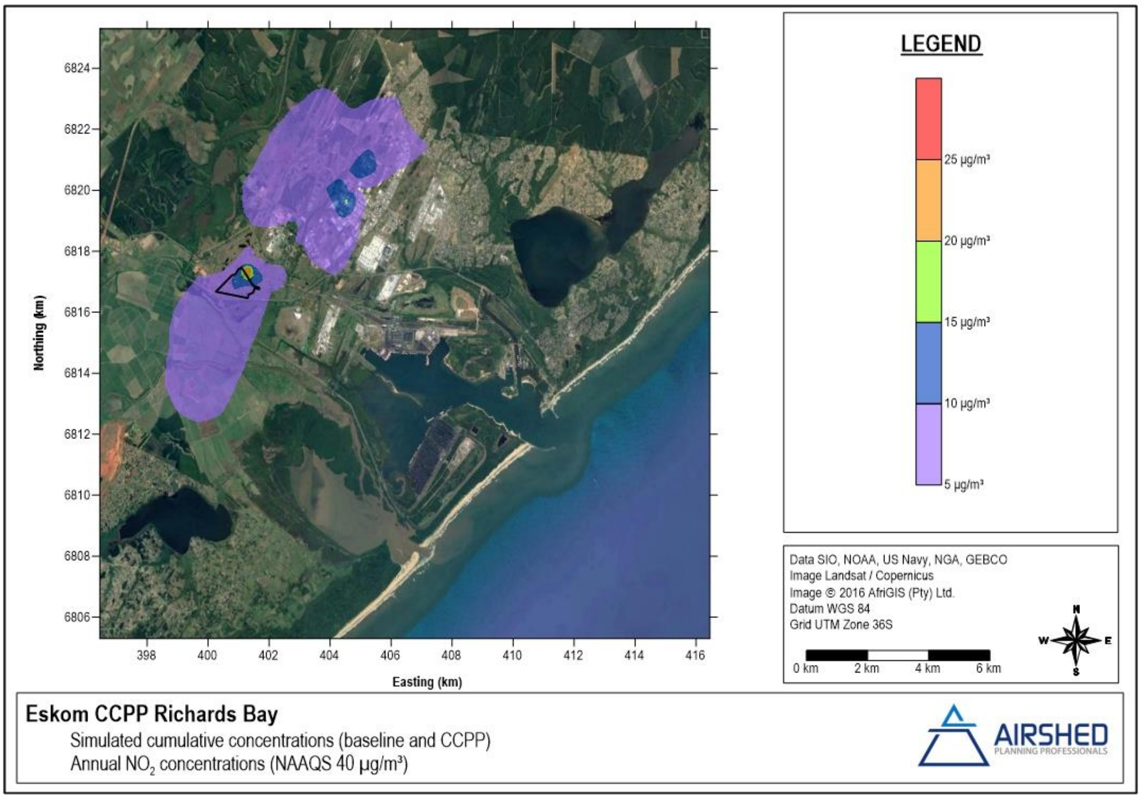

Figure 5-29: Simulated cumulative NO_2 concentrations for the Richards Bay baseline and the proposed facility (compare with Figure 5-15)

5.2 Analysis of Emissions' Impact on the Environment

In the absence of a prescribed methodology (in the Regulations Prescribing the Format of the Atmospheric Impact Report, Government Gazette No. 36904, Notice Number 747 of 2013; 11 October 2013), the impact of emissions from the proposed facility on the environment was assessed using the pollutant critical levels that may affect vegetative productivity, and nuisance dustfall. The same dispersion modelling approach was used as in the assessment of impact of the facility on human health (described in Section 5.1.1).

5.2.1 Critical Levels for Vegetation

The impact of emissions from the proposed facility on surrounding vegetation was assessed by comparing the simulated annual SO_2 and NO_2 concentrations for the operational phase scenario against the critical levels for vegetation as defined by the United Nations Economic Commission for Europe (UNECE) Convention on Long Range Trans-boundary Air Pollution Limits (CLRTAP, 2015) (Table 5-16).

Table 5-16: Critical levels for SO_2 and NO_2 by vegetation type (CLRTAP, 2015)

Pollutant	Vegetation type	Critical Level (µg/m³)	Time Period[(a)]
SO_2	Cyanobacterial lichens	10	Annual average
	Forest ecosystems (including understorey vegetation)	20	Annual average and Half-year mean (winter)
	(Semi-)natural vegetation	20	Annual average and Half-year mean (winter)
	Agricultural crops	30	Annual average and Half-year mean (winter)
NO_2	All	30	Annual average and Half-year mean (winter)
		75	Daily average

Notes:
(a) For the purposes of mapping of critical levels and exceedances CLRTAP recommend using only the annual average, due to increased reliability of mapped and simulated data for the longer period. It is also noted that long-term effects of NO_X are more significant than short-term effects (CLRTAP, 2015).

The simulated off-site annual concentrations of SO_2 for all emission scenarios are unlikely to exceed the levels (Table 5-16) for the most sensitive vegetation type (lichen) across the domain (Figure 5-20).

These simulations assume that the facility will operate near the calculated emission rates. Should the plant operate at the regulated emission limits for Subcategory 1.4 exceedances of the CLRTAP levels (Table 5-6) could affect vegetative productivity off-site. Natural gas inherently has a very low sulfur content and is therefore highly probable that the normal operation of the facility will be much lower than the emission limits.

Off-site NO_2 concentrations are likely to be below the critical levels for all vegetation types across the domain (data not plotted).

5.2.2 Dustfall Rates

Dustfall deposition rates were estimated because of TSP emissions from the quantified fugitive sources during the construction and operations phases of the project. The simulated TSP concentrations were converted to deposition rates by assuming a settling velocity of 3.24×10^{-2} m/s (based on a 30 µm particle with a density of 1.2 g/cm³). Simulated dustfall rates have been compared to the acceptable dustfall rate applicable to the restriction areas as defined by the NDCR (Table 5-3).

5.2.2.1 Construction Phase

Dustfall rates are likely to comply with those acceptable for residential and non-residential areas across the domain (Figure 5-30).

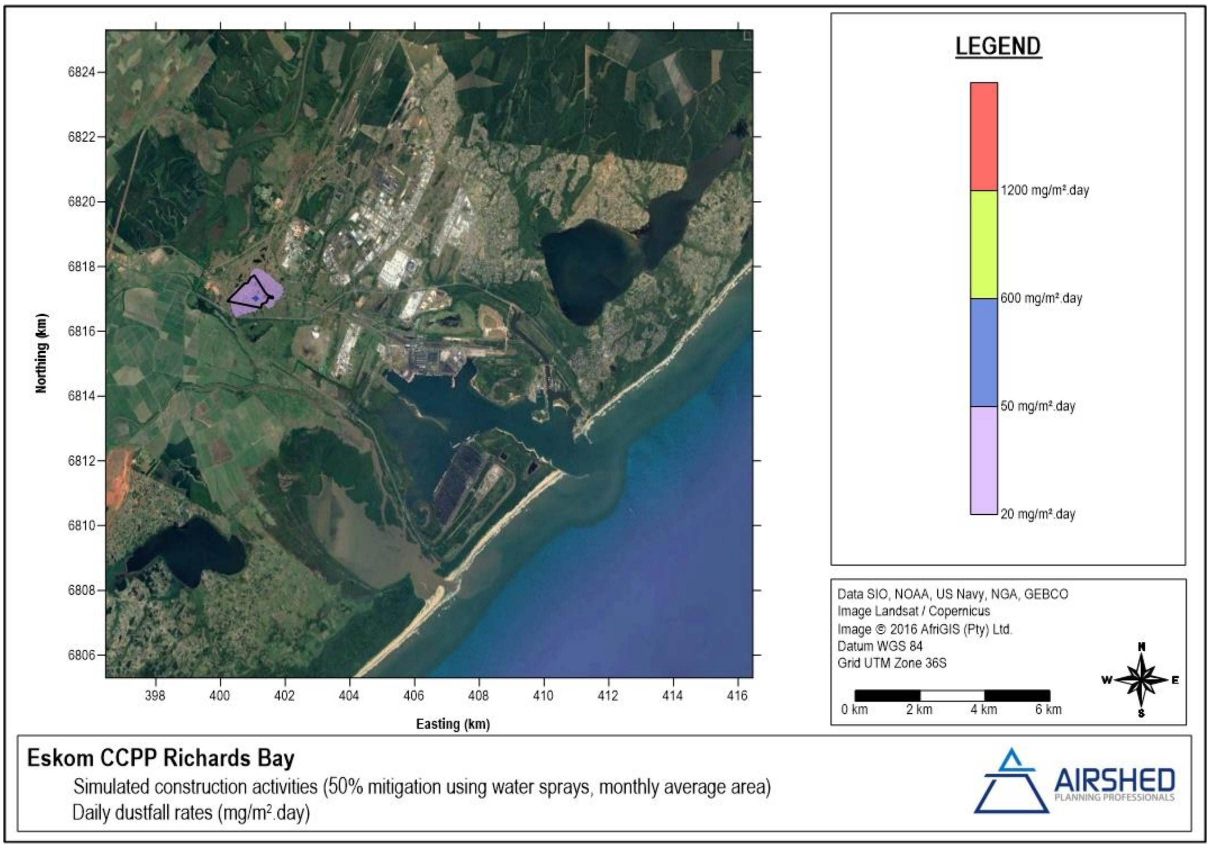

Figure 5-30: Simulated daily dustfall rates as a result of construction activities

5.2.2.2 Operational Phase

Daily dustfall rates as a result of the normal operations are likely to be lower than 10 mg/m^2.day; where the source will be entrainment of particulates by the diesel delivery vehicles.

5.3 Main Findings and Conclusions

The findings from the air quality impact assessment are:

1. Measured ambient air quality within the Richards Bay domain were non-compliant for daily PM_{10} at Brackenham and CBD stations during 2015. Annual PM_{10} compliance was recorded at all stations between 2014 and 2017.
2. Compliance for all RBCAA stations was reported for all stations in the Richards Bay domain for SO_2 for hourly, daily and annual averaging periods between 2014 and 2017.
3. The proposed CCPP facility was assessed for three operational phases:
   a. Construction phase, using
      i. emissions calculated based on MES
      ii. emissions calculated using emission factors;
   b. Operational phase (natural gas combustion venting through the main stacks); and,
   c. Three different emergency event types.
4. The simulated incremental impact of the proposed CCPP was assessed to include:
   a. Compliance with daily and annual PM_{10} NAAQS during the construction phase, if emissions are mitigated using water sprays and active (cleared) areas are kept as small as possible (monthly average area).
   b. Compliance with daily and annual PM_{10} and $PM_{2.5}$ NAAQS under normal operations and emergency events.
   c. Emissions at the Minimum Emission Standard (MES) for SO_2 will likely result in non-compliance with hourly and daily SO_2 NAAQS under normal operations and Emergency 2-type events. It is unlikely that gas combustion will result in SO_2 emissions at the emission standard used to assess the maximum potential impact of the proposed facility, and therefore this scale of impact is unlikely under normal operations. Using emission factors for gas turbines combusting natural gas, compliance was simulated for hourly and daily SO_2 NAAQS.
   d. Compliance with annual SO_2 NAAQS under normal operations.
   e. Compliance with NO_2 hourly and annual NAAQS under normal operations.
   f. Under the Emergency 3 (diesel combustion venting via the by-pass stacks) non-compliance with hourly NO_2 NAAQS is possibly if emissions are at MES. Using emission factors compliance with NAAQS is likely.
   g. Compliance with NDCR, odour thresholds, and toluene health-effect screening levels due to fugitive emission sources.
   h. Annual SO_2 concentrations, simulated using MES, may impact productivity of various vegetation types up to 10 km from the proposed facility (using the United Nations Economic Commission for Europe (UNECE) Convention on Long Range Trans-boundary Air Pollution Limits). These simulations assumed that the facility will operate at the regulated emission limits however it is highly probable that the normal operation of the facility will be much lower than the emission limits. Using emission factors for gas turbines combusting natural gas, annual SO_2 concentrations are not likely to impact vegetative productivity.

Conclusion

From an air quality perspective, it is recommended that the project go ahead, on condition that:

- Emissions due to construction activities be mitigated using good practise guidelines.
- Maintain SO_2 and NO_X emissions near the emission factor estimates.
- To limit the possibility of off-site SO_2 exceedances during emergency events, it is suggested that Emergency 2-type events be avoided as far as practically possible, by using low sulfur (50 ppm) diesel only, when diesel is used as energy source.

5.3.1 *Impact Assessment Rating*

The impact of the proposed project was assessed according to the methodology provided by Savannah (Appendix A). The no-go option (baseline) was calculated to have a "medium" impact due to the duration, spatial extent, and the probability of maintaining the status quo if the proposed facility did not go ahead (Table 5-17). A similar impact rating is expected for the closure phase of the project. The construction phase is likely to have a "medium" impact rating if unmitigated, however, suggested mitigation measures could reduce the incremental impact of construction to "low" (Table 5-18).

Operating below the SO_2 emission limits, at levels approximating calculated emission rates, the facility would have a "medium" impact on the surrounding area (due to small extent and high probability of impact) (Table 5-19). The very low simulated concentrations for the other pollutants (PM, NO_2, TVOCs, and odour) resulted in a "low" impact significance rating (Table 5-20). Cumulative impacts were rated on the basis of the most conservative Operational Phase rating the proposed facility (Table 5-19) in the context of the existing baseline air quality. A medium rating was assigned to the cumulative impact (Table 5-21).

Emergency events would have a "high" consequence rating. However, these events would only occur for very short durations and therefore an impact significance rating of "low" was assigned (like other unmitigated emissions of other atmospheric pollutants, as per Table 5-20).

Table 5-17: Impact significance ranking for the no-go alternative and closure phases

Nature: The No-Go option (development of the proposed facility does not go ahead) would result in ambient air pollutant concentrations like the existing baseline. The baseline assessment highlighted occasional short-term SO_2 exceedances and one annual exceedance of the PM_{10} NAAQS in the last four years. Increased ambient concentrations of fine particulates and gaseous pollutants may result in negative human health impacts. Impacts are likely across the Richards Bay airshed, with a hot spot area for PM_{10} located near the coal handling in the port.	
	Without mitigation
Extent	3 (Local / Richards Bay)
Duration	4 (Long-term)
Magnitude	2 (Minor)
Probability	4 (Highly probable)
Significance	**36**
	Medium
Status (positive or negative)	Negative
Reversibility	Reversible
Irreplaceable loss of resources?	No
Confidence in findings:	High, based on actual recorded ambient air quality
Can impacts be mitigated?	Yes, to some extent, with large cooperative effort from local government, industry, and residents. Although the extent of impact of mitigation is unknown.
Residual impacts:	
None	
Cumulative Impacts:	
None	

Table 5-18: Impact significance ranking for the Construction and Decommissioning phases

Nature:

Construction activities are likely to result in emissions of particulate and gaseous pollutants due to civil and building work and from vehicle traffic. The nature of emissions from construction activities is highly variable in terms of temporal and spatial distribution and is also transient. Increased ambient concentrations of fine particulates and gaseous pollutants may result in negative human health impacts. Increased nuisance dustfall is likely because of wind-blown dust emissions from the working areas. Increased nuisance dustfall rates will likely result in negative impact on dustfall at nearby residences and on potentially on plants.

Unmitigated particulate emissions were conservatively found to exceed assessment criteria for up to 3 km. Although residential areas may be affected, schools and medical facilities are unlikely to be affected by elevated concentrations. Areas to the south and east of the project site are more likely to be affected, especially in the short-term, due to the predominant winds. The impact of gaseous pollutants is likely to be minor.

	Without mitigation	With mitigation
Extent	3 (Local / Richards Bay)	1 (Site)
Duration	2 (Short)	2 (Short)
Magnitude	6 (Moderate)	4 (Low)
Probability	3 (Probable)	3 (Probable)
Significance	**33**	**21**
	Medium	**Low**
Status (positive or negative)	Negative	Negative
Reversibility	Reversible	Reversible
Irreplaceable loss of resources?	Unlikely	Unlikely
Confidence in findings:	Moderate due to conservative nature of the emission calculation method, and highly variable nature of construction activities.	
Can impacts be mitigated?	Yes, with minimum control efficiency of 50%.	

Proposed mitigation measures:

- Wet suppression at key handling points or cleared areas, and on unpaved roads.
- Haul trucks to be restricted to specified haul roads and using the most direct route.
- Reduce unnecessary traffic.
- Strict on-site speed control (40km/hr for haul trucks).
- Reduction of extent of open areas to minimise the time between clearing and infrastructure construction, and/or use of wind breaks and water suppression to reduce emissions from open areas.
- Restriction of disturbance to periods of low wind speeds (less than 5 m/s).
- Stabilisation of disturbed soil (for example, chemical, rock cladding, or vegetation).
- Re-vegetation of cleared areas as soon as practically feasible.

Residual impacts:

Expected to be low if mitigation measures are properly implemented.

Cumulative Impacts:

The cumulative impact is likely to show elevated concentrations at nearest air quality monitoring stations, especially in the short-term (daily) and during periods of high wind speeds.

Table 5-19: Impact significance ranking for the Operational Phase: Sulfur dioxide emissions

<table>
<tr><td colspan="3">Nature:

The normal operation of the proposed combined cycle power station will result in emission of gaseous SO_2. Increased ambient concentrations of these pollutants may result in negative human health impacts. If the facility normally operates at emissions rates approximating those calculated for natural gas, which is inherently very low in sulfur, it is improbable that the facility would approach the emission limits. Under normal operating conditions, off-site exceedances of the SO_2 NAAQS are unlikely.

The plant design, including fuel selection, already includes relevant mitigation technologies to meet emission standards under normal operations and therefore the significance rating for a scenario 'with mitigation' was the same as the 'without mitigation' rating.</td></tr>
<tr><td>Scenario</td><td>Without mitigation</td><td>With mitigation</td></tr>
<tr><td>SO_2 emission concentration</td><td>Emissions near emission factor estimations</td><td>Emissions near emission factor estimations</td></tr>
<tr><td>Extent</td><td>1 (Site)</td><td>1 (Site)</td></tr>
<tr><td>Duration</td><td>4 (Long-term)</td><td>4 (Long-term)</td></tr>
<tr><td>Magnitude</td><td>4 (Low)</td><td>4 (Low)</td></tr>
<tr><td>Probability</td><td>4 (Highly probable)</td><td>4 (Highly probable)</td></tr>
<tr><td rowspan="2">Significance</td><td>36</td><td>36</td></tr>
<tr><td>Medium</td><td>Medium</td></tr>
<tr><td>Status (positive or negative)</td><td>Negative</td><td>Negative</td></tr>
<tr><td>Reversibility</td><td>Reversible</td><td>Reversible</td></tr>
<tr><td>Irreplaceable loss of resources?</td><td>Unlikely</td><td>Unlikely</td></tr>
<tr><td>Confidence in findings:</td><td>Good, based on the low S content in natural gas and the probably of normal operating conditions emitting below the emission limit.</td><td>Good, based on the low S content in natural gas and the probably of normal operating conditions emitting below the emission limit.</td></tr>
<tr><td>Can impacts be mitigated?</td><td>Relevant mitigation technologies are built into the design of the facility to comply with emission and ambient standards. It is unlikely that the normal operation of the facility will result in emissions of SO_2 approaching the maximum allowable limit therefore no further mitigation is required.</td><td>Relevant mitigation technologies are built into the design of the facility to comply with emission and ambient standards. It is unlikely that the normal operation of the facility will result in emissions of SO_2 approaching the maximum allowable limit therefore no further mitigation is required.</td></tr>
<tr><td colspan="3">Mitigation measures:

• 99% of operational time combusting natural gas.
• Low S content natural gas.</td></tr>
<tr><td colspan="3">Residual impacts:
Expected to be low if mitigation measures are properly implemented.</td></tr>
<tr><td colspan="3">Cumulative Impacts:

The cumulative impact is likely to show elevated concentrations at nearest air quality monitoring stations, especially in the short-term (hourly and daily).</td></tr>
</table>

Table 5-20: Impact significance ranking for the Operational Phase: Other atmospheric pollutants

Nature: The normal operation of the proposed combined cycle power station will result in emission of gaseous and particulate pollutants including: NO_X, VOCs, and to a lesser extent PM and H_2S. Increased ambient concentrations of these pollutants may result in negative human health impacts, and nuisance odours. Increased nuisance dustfall is likely because of vehicle entrainment of particulates along access roads. Unmitigated emissions of these pollutants were found to comply with the assessment criteria and off-site impacts are unlikely. Residential receptors, schools, and medical facilities are unlikely to be affected. Areas to the north east of the project site are more likely to be affected in the long-term, due to the predominant winds.		
	Without mitigation	**With mitigation**
Extent	1 (Site)	1 (Site)
Duration	4 (Long-term)	4 (Long-term)
Magnitude	2 (Minor)	0 (Negligible)
Probability	3 (Probable)	3 (Probable)
Significance	**21**	**15**
	Low	**Low**
Status (positive or negative)	Negative	Negative
Reversibility	Reversible	Reversible
Irreplaceable loss of resources?	Unlikely	Unlikely
Confidence in findings:	Good.	
Can impacts be mitigated?	To some extent.	
Proposed mitigation measures: • Access roads are paved, and particulate content minimised through sweeping or watering. • Haul trucks to be restricted to specified haul roads and using the most direct route when making deliveries. Vehicles should not idle when stationary for extended periods of time. • Strict on-site speed control (40km/hr for heavy vehicles). • Control of odourous emissions from the dirty water dam through pH management, especially when sulfate loads are high.		
Residual impacts: Expected to be low if mitigation measures are properly implemented.		
Cumulative Impacts: The cumulative impact is likely to show elevated concentrations at nearest air quality monitoring stations, especially in the short-term (hourly and daily).		

Table 5-21: Impact significance ranking for the Cumulative impact

Nature: The Cumulative Impact of the proposed facility and the existing baseline would result in elevated ambient air pollutant concentrations. The normal operation of the proposed combined cycle power station will result in emission of gaseous and particulate pollutants including: SO_2, NO_X, VOCs, and to a lesser extent PM and H_2S. Increased ambient concentrations of these pollutants may result in negative human health impacts, and nuisance odours. Increased nuisance dustfall is likely because of vehicle entrainment of particulates along access roads. If the facility normally operates at emissions rates approximating those calculated for natural gas, which is inherently very low in sulfur, it is improbable that the facility would approach the emission limits. Under normal operating conditions, off-site exceedances of the SO_2 NAAQS are unlikely.	
	Cumulative impact of the project and other projects in the area
Extent	4 (Regional)
Duration	4 (Long-term)
Magnitude	4 (Low)
Probability	4 (Highly probable)
Significance	**48**
	Medium
Status (positive or negative)	Negative
Reversibility	Reversible
Irreplaceable loss of resources?	No
Confidence in findings:	Good, based on actual recorded ambient air quality, and the low S content in natural gas and the probably of normal operating conditions emitting below the emission limit.
Can impacts be mitigated?	Yes, to some extent, with large cooperative effort from local government, industry, and residents. Although the extent of impact of mitigation is unknown.

6 ANNEXURE A

DECLARATION OF ACCURACY OF INFORMATION – APPLICANT

Name of Enterprise: ______________________________

Declaration of accuracy of information provided:

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

I, [*duly authorised*], declare that the information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of the National Environmental Management: Air Quality Act (Act No. 39 of 2004).

Signed at on this day of

SIGNATURE

CAPACITY OF SIGNATORY

7 ANNEXURE B

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: Theresa Bird

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

Professional Registration No.: 114332

Declaration of independence and accuracy of information provided:

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

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

Signed at Midrand on this 18th day of February 2019

SIGNATURE

Principal Air Quality Scientist

CAPACITY OF SIGNATORY

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APPENDIX A: IMPACT ASSESSMENT METHODOLOGY

The potential significance of potential environmental impacts identified will be determined using the significance rating as described below.

Assessment of Impacts

Direct, indirect and cumulative impacts of the issues identified through the scoping study, as well as all other issues identified in the EIA phase must be assessed in terms of the following criteria:

- The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.
- The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high):
- The **duration**, wherein it will be indicated whether:
  - the lifetime of the impact will be of a very short duration (0–1 years) – assigned a score of 1;
  - the lifetime of the impact will be of a short duration (2-5 years) - assigned a score of 2;
  - medium-term (5–15 years) – assigned a score of 3;
  - long term (> 15 years) - assigned a score of 4; or
  - permanent - assigned a score of 5;
- The **consequences (magnitude)**, quantified on a scale from 0-10, where 0 is small and will have no effect on the environment, 2 is minor and will not result in an impact on processes, 4 is low and will cause a slight impact on processes, 6 is moderate and will result in processes continuing but in a modified way, 8 is high (processes are altered to the extent that they temporarily cease), and 10 is very high and results in complete destruction of patterns and permanent cessation of processes.
- The **probability** *of occurrence*, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1–5, where 1 is very improbable (probably will not happen), 2 is improbable (some possibility, but low likelihood), 3 is probable (distinct possibility), 4 is highly probable (most likely) and 5 is definite (impact will occur regardless of any prevention measures).
- the **significance**, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high; and
- the **status**, which will be described as either positive, negative or neutral.
- the degree to which the impact can be reversed.
- the degree to which the impact may cause irreplaceable loss of resources.
- the *degree* to which the impact can be *mitigated.*

The **significance** is calculated by combining the criteria in the following formula:

S=(E+D+M)P

S = Significance weighting

E = Extent

D = Duration

M = Magnitude

P = Probability

The **significance weightings** for each potential impact are as follows:

- < 30 points: Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),

- 30-60 points: Medium (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated),
- > 60 points: High (i.e. where the impact must have an influence on the decision process to develop in the area).

Assessment of impacts must be summarised in the following table format. The rating values as per the above criteria must also be included. Complete a table and associated ratings for **each** impact identified during the assessment.

Example of Impact table summarising the significance of impacts (with and without mitigation)

Nature: **[Outline and describe fully the impact anticipated as per the assessment undertaken]**		
	Without mitigation	**With mitigation**
Extent	High (3)	Low (1)
Duration	Medium-term (3)	Medium-term (3)
Magnitude	Moderate (6)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Medium (36)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	Yes
Mitigation: "Mitigation", means to anticipate and prevent negative impacts and risks, then to minimise them, rehabilitate or repair impacts to the extent feasible. Provide a description of how these mitigation measures will be undertaken keeping the above definition in mind.		
Cumulative impacts: "Cumulative Impact", in relation to an activity, means the past, current and reasonably foreseeable future impact of an activity, considered together with the impact of activities associated with that activity, which in itself may not be significant, but may become significant when added to existing and reasonably foreseeable impacts eventuating from similar or diverse activities[3].		
Residual Risks: "Residual Risk", means the risk that will remain after all the recommended measures have been undertaken to mitigate the impact associated with the activity (Green Leaves III, 2014).		

Assessment of Cumulative Impacts

As per DEA's requirements, specialists are required to assess the cumulative impacts. In this regard, please refer to the methodology below that will need to be used for the assessment of Cumulative Impacts.

"Cumulative Impact", in relation to an activity, means the past, current and reasonably foreseeable future impact of an activity, considered together with the impact of activities associated with that activity, which in itself may not be significant, but may become significant when added to existing and reasonably foreseeable impacts eventuating from similar or diverse activities[4].

The role of the cumulative assessment is to test if such impacts are relevant to the proposed project in the proposed location (i.e. whether the addition of the proposed project in the area will increase the impact). This section should address whether the construction of the proposed development will result in:

- Unacceptable risk
- Unacceptable loss

3 Unless otherwise stated, all definitions are from the 2014 EIA Regulations, GNR 982
4 Unless otherwise stated, all definitions are from the 2014 EIA Regulations, GNR 982

» Complete or whole-scale changes to the environment or sense of place
» Unacceptable increase in impact

The specialist is required to conclude if the proposed development will result in any unacceptable loss or impact considering all the projects proposed in the area.

Example of a cumulative impact table:

Nature: Complete or whole-scale changes to the environment or sense of place (example)		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Low (1)	Low (1)
Duration	Medium-term (3)	Long-term (4)
Magnitude	Minor (2)	Low (4)
Probability	Improbable (2)	Probable (3)
Significance	**Low (12)**	**Low (27)**
Status (positive/negative)	Negative	Negative
Reversibility	High	Low
Loss of resources?	No	No
Can impacts be mitigated?	Yes	
Confidence in findings: High.		
Mitigation: "Mitigation", means to anticipate and prevent negative impacts and risks, then to minimise them, rehabilitate or repair impacts to the extent feasible. Provide a description of how these mitigation measures will be undertaken keeping the above definition in mind.		

Environmental Management Plan Table format

Measures for inclusion in the draft Environmental Management Programme must be laid out as detailed below:

OBJECTIVE: Description of the objective, which is necessary in order to meet the overall goals; these take into account the findings of the environmental impact assessment specialist studies

Project component/s	List of project components affecting the objective
Potential Impact	Brief description of potential environmental impact if objective is not met
Activity/risk source	Description of activities which could impact on achieving objective
Mitigation: Target/Objective	Description of the target; include quantitative measures and/or dates of completion

Mitigation: Action/control	**Responsibility**	**Timeframe**
List specific action(s) required to meet the mitigation target/objective described above	Who is responsible for the measures	Time periods for implementation of measures

Performance Indicator	Description of key indicator(s) that track progress/indicate the effectiveness of the management plan.
Monitoring	Mechanisms for monitoring compliance; the key monitoring actions required to check whether the objectives are being achieved, taking into consideration responsibility, frequency, methods and reporting

APPENDIX B: COMPARISON OF STUDY APPROACH WITH THE REGULATIONS PRESCRIBING THE FORMAT OF THE ATMOSPHERIC IMPACT REPORT AND THE REGULATIONS REGARDING AIR DISPERSION MODELLING (GAZETTE NO 37804 PUBLISHED 11 JULY 2014)

The Regulations prescribing the format of the Atmospheric Impact Report (AIR) (Government Gazette No 36094; published 11 October 2013) were referenced for the air dispersion modelling approach used in this study. Table B-1 compares the AIR Regulations with the approach used in Section 5.

The promulgated Regulations regarding Air Dispersion Modelling (Gazette No. 37804, vol. 589; 11 July 2014) were consulted to ensure that the dispersion modelling process used in this assessment agreed with the regulations. Table B-2 compares the Air Dispersion Modelling Regulations with the approach used in Section 5.

Table B-1: Comparison of Regulations for the AIR with study approach

Chapter	Name	AIR regulations requirement	Status in AIR
1	Enterprise details	• Enterprise Details • Location and Extent of the Plant • Atmospheric Emission Licence and other Authorisations	Enterprise details included. Location of plant included. New facility (authorisation process on-going)
2	Nature of process	• Listed Activities • Process Description • Unit Processes	All detail included in the regulated format
3	Technical Information	• Raw Materials Used and Production Rates • Appliances and Abatement Equipment Control Technology	Section 3.1 and 3.2. Details of abatement equipment details not yet available.

4	Atmospheric Emissions	• Point Source Emissions
		  • Point Source Parameters
		  • Point Source Maximum Emission Rates during Normal Operating Conditions
		  • Point Source Maximum Emission Rates during Start-up, Maintenance and/or Shut-down
		• Fugitive Emissions
		• Emergency Incidents
			Maximum release rates from point sources assumed to be the MES limits defined for the facility (Section 4.2 and 4.6). Types of emergency events were identified, and typical emission rates quantified (Sections 4.4 and 4.5).
			
			Emissions from fugitive sources was quantified (Section 4.7).

5	Impact of enterprise on receiving environment		
5.1	Analysis of emissions impact on human health	Must conduct dispersion modelling, must be done in accordance with Regulations; must use NAAQS	Completed as set out by the Regulations.
5.2	Analysis of emissions impact on environment	Must be undertaken at discretion of Air Quality Officer.	Nuisance dustfall for the construction and operational phases was quantified and assessed (Section 5.2.1)
6	Complaints	Details on complaints received for last two years	Proposed facility, no complaints received yet.
7	Current or planned air quality management interventions	Interventions currently being implemented and scheduled and approved for next 5 years.	Proposed facility; best available technology planned for development.
8	Compliance and enforcement history	Must set out all air quality compliance and enforcement actions undertaken against the enterprise in the last 5 years. Includes directives, compliance notices, interdicts, prosecution, fines	Proposed facility; no compliance and enforcement actions yet.
9	Additional information		Included polar plots as an additional visualisation means of ambient air quality as monitored. Dispersion modelling results for the Richards Bay baseline

Chapter	Name	AIR regulations requirement	Status in AIR
			included and used to assess cumulative impact of the proposed facility.

Table B-2: Comparison of Regulations regarding the Air Dispersion Modelling with study approach

AIR Regulations	Compliance with Regulations	Comment
Levels of assessment		
• Level 1: where worst-case air quality impacts are assessed using simpler screening models • Level 2: for assessment of air quality impacts as part of license application or amendment processes, where impacts are the greatest within a few kilometres downwind (less than 50km) • Level 3: requires more sophisticated dispersion models (and corresponding input data, resources and model operator expertise) in situations: – where a detailed understanding of air quality impacts, in time and space, is required; – where it is important to account for causality effects, calms, non-linear plume trajectories, spatial variations in turbulent mixing, multiple source types, and chemical transformations; – when conducting permitting and/or environmental assessment process for large industrial developments that have considerable social, economic and environmental consequences; – when evaluating air quality management approaches involving multi-source, multi-sector contributions from permitted and non-permitted sources in an airshed; or, – when assessing contaminants resulting from non-linear processes (e.g. deposition, ground-level ozone (O_3), particulate formation, visibility)	Level 3 assessment using CALPUFF	This Lagrangian Gaussian Puff model is well suited to simulate low or calm wind speed conditions, and for land-sea breeze interactions. CALPUFF is able to perform chemical transformations. In this study the conversion of NO to NO_2 and the secondary formation of particulate matter were accounted for in the simulations.
Model Input		
Source characterisation	Yes	Source characterisation provided in Section 4 and 5.1.5.1.
Emission rates: For new or modified existing sources the maximum allowed amount, volume, emission rates and concentration of pollutants that may be discharged to the atmosphere should be used	Yes	Emission rates used for each scenario are provided in 4 and 5.1.5.1.
Meteorological data		
Full meteorological conditions are recommended for regulatory applications.	Yes	WRF modelled meteorology (including upper air) (Section 5.1.3 and APPENDIX C: CALMET Model Control Options).
Data period	Yes	3 years (2013 to 2015)
Geographical Information		
Topography and land-use		Required for CALMET 3D meteorological file preparation (Section 5.1.3 and APPENDIX C: CALMET Model Control Options)

AIR Regulations	Compliance with Regulations	Comment
Domain and co-ordinate system	Yes	• Dispersion modelling domain: 50 x 50 km • UTM co-ordinate system (WGS84) (Section 5.1.3 and APPENDIX C: CALMET Model Control Options)
General Modelling Considerations		
Ambient Background Concentrations, including estimating background concentrations in multi-source areas	Yes	Section 5.1.3.3 and Section 5.1.4
NAAQS analyses for new or modified sources: impact of source modification in terms of ground-level concentrations should be assessed within the context of the background concentrations and the	Yes	Model predicted, 99th percentile ground-level concentrations compared against NAAQS (Section 5.1.5.2)
Land-use classification	Yes	Section 5.1.1.1 and APPENDIX C: CALMET Model Control Options
Surface roughness	Yes	Computed from Land-use categories in the CALMET pre-processing step (APPENDIX C: CALMET Model Control Options).
Albedo	Yes	Computed from Land-use categories in the CALMET pre-processing step (APPENDIX C: CALMET Model Control Options).
Temporal and spatial resolution		
Receptors and spatial resolutions	Yes	Sections 1.3
Building downwash	Yes	Building downwash was applied for the assessment of VOC emissions from the diesel storage tanks as per the Regulations Regarding Air Dispersion Modelling (Government Gazette No. 37804 Notice R533, 11 July 2014) applicable to modelling tanks. Insufficient building detail available to include building down wash for main and by-pass stacks. Main and by-pass stacks will be approximately 50 m higher than nearest buildings. Pollutant dispersion is therefore not likely to be affected by building downwash.
Chemical transformations	Yes	Sections 5.1.5.2.3 and APPENDIX D: CALPUFF Model Control Options.
General Reporting Requirements		
Model accuracy and uncertainty	No	
Plan of study	Yes	Section 5.1.1
Air Dispersion Modelling Study Reporting Requirements	Yes	As per the Regulations Prescribing the Format of the Atmospheric Impact Report, Government Gazette No. 36904, Notice Number 747 of 2013 (11 October 2013) and as per the Regulations Regarding Air Dispersion Modelling (Government Gazette No. 37804 Notice R533, 11 July 2014).
Plotted dispersion contours	Yes	Section 5.1.5 and 5.1.6

APPENDIX C: CALMET MODEL CONTROL OPTIONS

The CALMET run type selected for this assessment is summarised in Table C-1 below. Readily available terrain and land cover data was obtained from via the United States Geological Survey (USGS) via the Earth Explorer website (U.S. Department of the Interior, U.S. Geological Survey, 2016). Shuttle Radar Topography Mission (SRTM) (30 m resolution, 1 arc-sec) data and Global Land Cover Characterisation (GLCC) data for Africa were used.

Table C-1: CALMET model control options

Run Type	Description of Run Type	Ease of Use and Representativeness	Data availability	Advantages	Disadvantages
No Observations	•Prognostic model data, such as WRF to drive CALMET. •No surface or upper air observations input at all.	•Relatively simple to implement in model •Representative of regional meteorological conditions	WRF data (Lakes Environmental) for 2013, 2014 and 2015 at 4 km resolution for 50 km by 50 km study area.	•Simple to implement •Full spatial and temporal variability •No overwater data required •Cloud cover has spatial distribution •Eliminates need for complicated 7 user-input site-specific variables •Ideal as screening run as gives very good estimate	Resolution of prognostic data may potentially be too coarse to be representative of local conditions

Table C-2: CALMET vertical and horizontal resolutions

<table>
<tr><th>Dimension</th><th colspan="11">Resolution</th></tr>
<tr><td>Horizontal resolution</td><td colspan="11">WRF native resolution 4 km
CALMET refined resolution 0.5 km</td></tr>
<tr><td rowspan="2">Vertical resolution</td><td colspan="11">CALMET run with 11 vertical levels (m above surface):</td></tr>
<tr><td>0</td><td>20</td><td>40</td><td>80</td><td>160</td><td>300</td><td>600</td><td>1 000</td><td>1 500</td><td>2 200</td><td>3 500</td></tr>
</table>

APPENDIX D: CALPUFF MODEL CONTROL OPTIONS

The CALPUFF set-up parameters selected for this assessment are summarised in Table D-1 below. Due to the size of the modelling domain; limitations of CALPUFF; and, to add assess cumulative impact of the proposed facility and the simulated baseline, a nested grid was used with a 250 m resolution for 20 km x 20 km centred over the Richards Bay CBD; and, a 50 m resolution grid for 2.5 km x 2.5 km centred over the proposed facility.

Table D-1: CALPUFF model control options

Run Type	Description of Run Type	Ease of Use and Representativeness	Data availability	Model inputs used
Sampling Function Puff	This sampling scheme employs radically symmetric Gaussian puffs and is suitable for far field.			
Dispersion coefficients MDISP = 2	• Dispersion coefficients are computed from internally-calculated sigma-v, sigma-w using micrometeorological variables (u*, w*, L, etc.).	• This option can simulate AERMOD-type dispersion when the user also selects the use of PDF method for dispersion in the convective boundary layer (MPDF = 1). Note that when simulating AERMOD-type dispersion, the input meteorological data must be from CALMET and cannot be ISC-type ASCII format data. The user should also be aware that under this option the CALPUFF model will be more sensitive to the appropriateness of the land use characterization.	• The data is obtained from WRF input information.	• The coefficients are derived from other parameters.
Chemical transformation MESOPUFF II	• Pseudo-first-order chemical mechanism for SO_2, SO_4^{2-}, NO_x, HNO_3, and NO_3 – (MESOPUFF II method)	• MESOPUFF II is a 5-species scheme in which all emissions of nitrogen oxides are simply input as NO_x. • In the MESOPUFF II scheme, the conversion of SO_2 to sulfates is dependent on relative humidity (RH), with an enhanced conversion rate at high RH.	• The MESOPUFF II scheme assumes an immediate conversion of all NO to NO_2. • Two options are specified for the ozone concentrations: (1) hourly ozone concentrations from a network	• Monthly average ozone calculated from measured data at the Brackenham; Eskhaleni and Arboretum AQMS managed by the City of uMhlathuze for the year 2016 (Table D-2). • Monthly average ammonia (NH_3) concentrations estimated for Richards Bay

Run Type	Description of Run Type	Ease of Use and Representativeness	Data availability	Model inputs used
		• The conversion of NO_x to nitrates is RH-dependent.	of stations, or (2) a single user defined ozone value. • The background ammonia concentrations required for the HNO_3 /NH_4NO_3 equilibrium calculation can be user-specified or a default value will be used.	from the seasonal values given in Warner *et al.* (2016). • NO to NO_2 conversion.is not included in the model. NO_X to NO_2 conversions explained in Section 5.1.5.2.3 and Table D-3.

Table D-2: Monthly average ozone and ammonia concentrations used in the CALPUFF simulations

Pollutant	Month of year											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ozone	14.1	15.6	18.8	18.0	14.4	16.0	27.6	30.7	32.7	30.5	24.6	17.4
Ammonia	2.5	2.5	2	2	2	1	1	1	1.5	1.5	1.5	2.5

Table D-3: NO_2/NO_x conversation ratios applied to simulated hourly NO_X concentrations based on the ambient ratio method (ARM) of Scire and Borissova (2011)

Bin	Simulated Hourly NO_X Concentration (µg/m³)		NO_2/NOx Ratios		
			Scire and Borissova (2011)		Ratio applied for proposed facility
	Min	Max	Bin Average	1-Hour Max	
1	0	19	0.7980	0.9938	0.9938
2	19	38	0.8130	0.9922	0.9922
3	38	75	0.7306	0.9844	0.9844
4	75	113	0.5544	0.9094	0.9094
5	113	150	0.4370	0.7477	0.7477
6	150	188	0.3553	0.6085	0.6085
7	188	235	0.3013	0.4976	0.4976
8	235	282	0.2559	0.4173	0.4173
9	282	329	0.2276	0.3543	0.4[a]
10	329	376	0.2081	0.3056	0.4[a]
11	376	423	0.1852	0.2684	0.4[a]
12	423	470	0.1809	0.2404	0.4[a]
13	470	517	0.1767	0.2194	0.4[a]
14	517	564	0.1546	0.2035	0.4[a]
15	564	611	0.1524	0.1912	0.4[a]
16	611	658	0.1476	0.1813	0.4[a]
17	658	705	0.1402	0.1726	0.4[a]
18	705	752	0.1363	0.1645	0.4[a]
19	752	846	0.1422	0.1527	0.4[a]
20	846	940	0.1223	0.1506	0.4[a]
21	940	1128	0.1087	0.1474	0.4[a]
22	1128	1316	0.1110	0.1432	0.4[a]
23	1316	1504	0.1112	0.139	0.4[a]
24	1504	1786	0.1165	0.1337	0.4[a]

Note:
(a) based on personal communication with Dr J.S. Scire for conservative NO_2 estimation

APPENDIX E: CURRICULUM VITAE OF PROJECT TEAM

CURRICULUM VITAE

Name	Theresa (Terri) Leigh Bird
Date of Birth	8 November 1976
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Senior Consultant
Profession	Air Quality Specialist Consultant
Years with Firm	5 years

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- National Association for Clean Air (NACA), 2012 to present
- South African Council for Natural Science Professions (Pr.Sci.Nat.), 2016

EXPERIENCE

Projects contributing to Environmental Impact Assessments

Project type	Experience
Mining (including coal, platinum, tin, gold, and rare earth minerals)	▪ At least five proposed open-cast coal mining projects, mostly in South Africa and Botswana ▪ Air quality assessment for the expansion of an underground platinum mine to include a concentrator facility and tailings facility. ▪ Assessment of underground mining of cassiterite (the mineral ore mined for tin) in the Democratic Republic of Congo. The project included the assessment of emissions along a long-distance haul road from the mine to Mombasa for export. ▪ Assessment of open-cast and underground mining of gold-rich ore, including gold plant activities, in order to design an air quality monitoring network. ▪ Three rare earth mineral mining projects included dispersion model runs to assist the radiation specialist assessment of impact of radioactive compounds.

Projects contributing to Environmental Impact Assessments

Project type	Experience
Power Stations	▪ A project assessing the impact of Namibian coal-fired power station on urban air quality, in the context of many small industrial sources. ▪ The assessment of retrofitting improved particulate emission controls on an existing coal-fired power station on the Mpumalanga Highveld. ▪ The assessment of impact of a floating power plant, fuelled by various potential liquid fuels, docked in a port servicing an industrial development zone. ▪ Professional opinion on the impact of solar power facilities (one concentrated solar power (CSP) and one photovoltaic (PV)) on ambient air quality. ▪ The assessment of three coal-fired power stations in Botswana, including two projects where the assessment assessed the combined impact of an open-cast coal mine and the associated coal-fired power station.
Ash disposal facilities for coal-fired power stations	▪ Conducted the assessment of impact of ash disposal facilities coal-fired power stations requiring additional disposal area. Assessment included the estimation of increased life-time cancer risk as a result of exposure to carcinogenic metals in the wind-blown dust from the disposal facilities.
Tyre pyrolysis plant	▪ Assisted on an assessment of a plant that will use waste tyres as raw material to produce machine and vehicle oils.
Domestic waste landfill	▪ Assessing the health and odour impacts of a domestic waste landfill to support residential development plans for the area.
Marine Repair Facility	▪ The project quantified the impact on air quality of a marine vessel repair facility in the context of a busy port which includes an iron-ore transfer yard.

Air Quality Management Plans (AQMP)

Project type	Experience
Provincial Level AQMP	▪ Involvement included: - baseline assessment of climatic conditions and ambient air quality across the Province; - collation of questionnaires from point-source emission; - point-source emissions inventory database management ▪ Assisted with quantification of vehicle emissions and with dispersion modelling of baseline emissions. ▪ Main contributor to management plan write-up.

Air Quality Management Plans (AQMP)

Project type	Experience
	▪ The management intervention strategies proposed in the AQMP were a collaborative effort of the technical project team, which included the client and consultants.
Metropolitan city level AQMP	▪ Contributed to the emission inventory of industrial sources ▪ Collaborative project with the Council for Scientific Research (CSIR)
Platinum smelter complex	▪ Fugitive dust emissions from ground-level sources and materials handling were a concern for a platinum smelter complex. The project scope included the identification of all sources; the quantification and ranking of emissions; and proposed management strategies. A risk assessment model was used to assess where the variability of emission sources would constitute a risk if improperly managed.
Diamond mine	▪ The project scope for a Botswana-based diamond mine approaching end-of-life required the assessment of current and future impacts of operations on the ambient air quality; including the development of an air quality management plan and the proposal of an ambient air quality monitoring network, based on the findings of the impact assessment.

Atmospheric Impact Reports (AIR)

Project type	Experience
Coal-to-liquid fuel refineries	▪ Postponement application included four sites with multiple point-sources and modelling iterations for all sources emitting at four different levels for multiple pollutants. ▪ A collaborative project where responsibilities included: model simulations, post-processing and extractions; management of model extractions and management of file transfer for peer review process; graphic summaries results; mapping of results; and, graphic presentation of measured ambient air quality. My contributions to the written report included: report template sections (as per Government Gazette No. 36904: 747); summary of meteorological data used in the assessment; measured ambient air quality; results analysis, interpretation and write-up; and, a literature review of potential impacts of the operations on the environment. ▪ The assessment of impact of petroleum storage tanks storing products of the tar process on the ambient air quality, especially with respect to total volatile organic compounds (TVOCS).

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Atmospheric Impact Reports (AIR)

Project type	Experience
Crude oil refinery	▪ Postponement application included emissions from multiple point-sources, and fugitive emissions from storage tanks; modelling iterations for all sources emitting at two different levels for sulfur dioxide [from point sources] and total volatile organic compounds (TVOCS) [from tanks]. ▪ A collaborative project where I focused on the point-sources, including the model simulations; post-processing and extractions; graphic results summaries; and, graphic presentation of measured ambient air quality. Contributions to the written report included: report template sections; summary of meteorological data used in the assessment; measured ambient air quality; results analysis, interpretation and write-up.
Fertilizer production	▪ Assessment report (prepared as AIR) included emissions from multiple point-sources; modelling iterations for all sources emitting at two different levels for particulate matter and ammonia emissions. ▪ A collaborative project where my responsibilities included: model simulation setup, post-processing and extractions; graphic summaries results; mapping of results; and, graphic presentation of measured ambient air quality. My contributions to the written report included: report template sections (as per Government Gazette No. 36904: 747); summary of meteorological data used in the assessment; measured ambient air quality; results analysis, interpretation and write-up.
Platinum smelter	▪ Postponement application included emissions from the smelter furnace and converter; modelling iterations for the sources emitting at two different levels where the pollutant of concern was sulfur dioxide.

* all projects listed above supported the application for postponement of stricter Minimum Emissions Standards applicable to Listed Activities

Project type	Experience
Veterinary waste incinerator	▪ New Atmospheric Emissions License (AEL) application for a State Veterinary incinerator. The assessment included calculating emission rates from the incinerator; dispersion modelling; preparation of an AIR (as per Government Gazette No. 36904: 747); and completing the technical sections of the AEL application.
Galvanizing plant	▪ The project assessed the impact of a steel galvanising plant on air quality in a developing industrial development zone. Pollutants of concern included hydrochloric acid (HCl).
Secondary Aluminium Smelter	▪ A project involving the assessment of a secondary aluminium smelter in an already developed urban industrial area

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Ambient air quality monitoring projects

Project type	Comments regarding project details and involvement
Ferrochrome smelter complex	▪ Compiled reports for the dustfall monitoring campaign for a period of 12 months. Results were compared with the relevant legislation and recommendations made for source management as required.
Platinum smelter complex	▪ Project scope required monthly reports of the ambient sulfur dioxide concentrations downwind of a platinum smelter complex, for a 12 month reporting period. Report preparation included: data cleaning and filtering; data analysis, presentation; and report write-up.
Dustfall monitoring	▪ Collate, summarise and report on dustfall rates, and metal content, after laboratory analysis. Projects include: baseline monitoring prior to active coal mining; landfill dustfall monitoring; baseline dustfall monitoring for a residential development.
Ambient air quality monitoring	▪ Using radiello™ passive samplers to assess ambient pollutant concentrations. Projects include: volatile organic compounds around industrial waste water dams; pre-development levels near a medical waste incinerator; and pre-development levels near a coal-fired power station.

SOFTWARE PROFICIENCY

- Atmospheric Dispersion Models: AERMOD, CALPUFF, ADMS (United Kingdom), CALINE, GASSIM
- Graphical Processing: Surfer, ArcGIS (basic proficiency)
- R, especially with the package "openair"
- Other: MS Word, MS Excel, MS Outlook

EDUCATION

University of the Witwatersrand

Ph.D. (School of Animal, Plant and Environmental Sciences) (2006 - 2011)	Thesis title: **Some impacts of sulfur and nitrogen deposition on the soils and surface waters of the Highveld grasslands, South Africa.**
M.Sc. (School of Animal, Plant and Environmental Sciences) (1999 – 2001).	Dissertation title: **Some effects of prescribed understory burning on tree growth and nutrient cycling, in *Pinus patula* plantations.**

B.Sc. (Hons) (Botany) (1998)	Project title: **The rate of nitrogen mineralization in plantation soils, in the presence of *Eucalyptus grandis* wood chips.** *Courses*: Wetland ecology, Ecophysiology and Environmental studies.
B.Sc. (1995 – 1997)	Botany III, Geography III, Zoology II.

COURSES COMPLETED AND CONFERENCES ATTENDED

- Paper presented at the International Union of Air Pollution Prevention and Environmental Protection Associations World Clean Air Congress, 2013 in Cape Town, South Africa,29 September - 4th October 2013
  - *Paper entitled*: Nitrogen cycling in grasslands and commercial forestry plantations: the influence of land-use change
  - *Co-authors*: T.L. Bird, M.C. Scholes, Y. Scorgie, G. Kornelius, N.-M. Snyman, J. Blight, and S. Lorentz
- Paper prepared for the National Association for Clean Air (NACA) annual conference, 2012 in Rustenburg, South Africa, 1-2 November 2012, Rustenburg. Annual Conference Proceedings ISBN 978-0-620-53886-2, Electronic Proceedings ISBN 978-0-620-53885-5
  - *Paper entitled*: Developing an Air Quality Management Plan: Lessons from Limpopo
  - *Co-authors*: T. Bird, H. Liebenberg-Enslin*, R. von Gruenewaldt, D. Modisamongwe, P. Thivhafuni, and, T. Mphahlele

COURSES PRESENTED

Training organisation	Details of involvement
National Association for Clean Air (NACA)	▪ Presenting the module regarding the Development of Air Quality Management Plans ▪ Module forms part of a 5-day course presented annually
Centre for Environmental Management (CEM), University of the North-West (Potchefstroom)	▪ Presented two modules: 1. Development of Air Quality Management Plans 2. Air Pollution Meteorology ▪ Modules forms part of a 2-day course presented annually, or at special request

COUNTRIES OF WORK EXPERIENCE

South Africa, Botswana, Mozambique, Democratic Republic of Congo, Namibia, Tanzania

LANGUAGES

Language	Proficiency
English	Full professional proficiency
Afrikaans	Good understanding; fair spoken and written

REFERENCES

Name	Position	Contact Number
Dr. Gerrit Kornelius	Associate of Airshed Planning Professionals	+27 (82) 925 9569 gerrit@airshed.co.za
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Dr. Hanlie Liebenberg Enslin	Managing Director at Airshed Planning Professionals	+27 (83) 416 1955 hanlie@airshed.co.za

CERTIFICATION

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

18 August 2017