ATMOSPHERIC IMPACT REPORT
in support of

The EIA for the Proposed Gas to Power Plant in Zone 1F of the Richards Bay IDZ

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EXECUTIVE SUMMARY

Richards Bay Gas Power 2 (Pty) Ltd, an Independent Power Producer (IPP), is proposing the establishment of a gas to power plant and associated infrastructure on a site located within the Richards Bay Industrial Development Zone - Zone 1F, located within the uMhlathuze Municipality, KwaZulu-Natal Province. The power station will have a capacity of up to 400MW and is to be developed in two phases to operate with liquid fuel such as diesel or Liquefied Petroleum Gas (LPG) in Phase 1 and ultimately with Liquid Natural Gas (LNG) or Natural Gas (NG) in Phase 2. It is anticipated that 300MW will be fuel/ gas generated energy and 100MW will be heat/ steam generated energy.

This project is to be developed in response to the Department of Energy's (DoE's) request for projects to be developed by IPP's in order to provide alternative power generation technologies as part of the technology mix for the country.

The approach to the dispersion modelling in this assessment is based on the requirements of the Department of Environmental Affairs (DEA) regulations regarding air dispersion modelling. This assessment is considered to be a Level 2 assessment, according to the definition on the air dispersion modelling regulations. The United States Environmental Protection Agency (USEPA) approved and DEA recommended California Puff (CALPUFF) suite of models and USEPA TANKS software was therefore used.

Two operational scenarios are assessed for the proposed gas to power plant generating the maximum output of 400MW:

Scenario 1: Power generation using diesel, which includes stack emissions and fugitive emissions from the diesel storage tanks

Scenario 2: Power generation using LNG, which only includes stack emissions as LNG will be piped in.

The effects of emissions of SO_2, NO_X, PM_{10}, CO and benzene from these operational scenarios on the existing state of air quality are assessed by adding the predicted concentrations to the existing baseline, i.e. assessing the additive effect.

The air quality impact assessment is based on dispersion model results and ambient air quality data from monitoring sites in the vicinity of the proposed gas to power plant. The environmental assessment framework for the assessment of impacts and the relevant criteria were applied to evaluate the significance of the potential impacts. A summary of the potential negative impacts identified in the air quality impact assessment for the construction, operation and decommissioning phase are presented in Tables 1-3 and a summary of the cumulative impacts is provided in Table 4.

Table 1: Summary of air quality impacts during construction phase

CONSTRUCTION PHASE		
Impact	**Significance without Mitigation**	**Significance with Mitigation**
Negative Impacts		
Direct impacts from dust generation during the construction phase	Low (24)	Low (12)

Table 2: Summary of air quality impacts during operation phase

OPERATION PHASE		
Impact	**Significance without Mitigation**	**Significance with Mitigation**
Negative Impacts		
Direct impacts from the combustion of diesel fuel at the proposed gas to power plant (Scenario 1)	Low (27)	Low (27)
Direct impacts from the combustion of LNG fuel at the proposed gas to power plant (Scenario 2)	Low (27)	Low (27)
Indirect impacts from the combustion of diesel fuel at the proposed gas to power plant (Scenario 1) in terms of acid rain	Low (12)	Low (12)
Indirect impacts from the combustion of diesel fuel at the proposed gas to power plant (Scenario 1) in terms of South Africa's CO_2/greenhouse gas emissions and global warming	Low (16)	Low (16)
Indirect impacts from the combustion of LNG fuel at the proposed gas to power plant (Scenario 2) in terms of acid rain	Low (12)	Low (12)
Indirect impacts from the combustion of LNG fuel at the proposed gas to power plant (Scenario 2) in terms of South	Low (16)	Low (16)

Africa's CO_2/greenhouse gas emissions and global warming		

Table 3: Summary of air quality impacts during decommissioning phase

DECOMMISSIONING PHASE		
Impact	**Significance without Mitigation**	**Significance with Mitigation**
Negative Impacts		
Direct impacts from dust generation during the decommissioning phase	Low (24)	Low (12)

Table 4: Summary of cumulative air quality impacts

CUMULATIVE IMPACTS		
Cumulative Impact	**Overall impact of the proposed project considered in isolation**	**Cumulative impact of the project and other projects in the area**
Negative Cumulative Impacts		
Cumulative impacts from dust generation during the construction phase	Low (24)	Low (12)
Cumulative impacts from dust generation during the decommissioning phase	Low (24)	Low (12)
Cumulative impacts from the combustion of diesel fuel at the proposed gas to power plant (Scenario 1)	Low (27)	Low (27)
Cumulative impacts from the combustion of LNG fuel at the proposed gas to power plant (Scenario 2)	Low (27)	Low (27)
Cumulative impacts from the combustion of diesel fuel at the proposed gas to power plant (Scenario 1) in terms of acid rain	Low (12)	Low (12)
Cumulative impacts from the combustion of diesel fuel at the proposed gas to power plant (Scenario 1) in terms of South Africa's CO_2/greenhouse gas	Low (16)	Low (16)

emissions and global warming		
Cumulative impacts from the combustion of LNG fuel at the proposed gas to power plant (Scenario 2) in terms of acid rain	Low (12)	Low (12)
Cumulative impacts from the combustion of LNG fuel at the proposed gas to power plant (Scenario 2) in terms of South Africa's CO_2/greenhouse gas emissions and global warming	Low (16)	Low (16)

Key findings

From an air quality perspective it is concluded that the project is supported, but that mitigation measures should be implemented and adhered to. Negative air quality impacts have been identified. However, the assessment of the key issues indicated that there are no negative impacts that can be classified as fatal flaws and which are of such significance that they cannot be successfully mitigated.

In this study, direct impacts will result from exposure to dust generated from the construction and decommissioning phase of the proposed gas to power plant. Direct impacts will also result from the inhalation of SO_2, NO_2, PM_{10}, CO and benzene emitted during the operational phase of the proposed gas to power plant.

Indirect impacts resulting from emissions of SO_2 and NO_2 from power plants include their contribution to acidification in both dry and wet (acid rain) deposition, during the operational phase. Further indirect effects during the operational phase are associated emissions of CO and CO_2. CO_2 is a GHG, adding to the global concentrations. CO is not considered a GHG, but is a strong precursor in the formation of ozone in the troposphere.

Ambient air quality in Richards Bay is influenced by a number of sources of air pollution, including large and smaller industry, transportation, agricultural burning, mining and the long range transport of pollutants from the interior. The proposed gas to power plant is located in an area where there are many notable sources of SO_2, NO_2, PM_{10}, CO and benzene (to a lesser extent) in the immediate vicinity of the site.

According to the model results, the 99th percentile of the predicted 1-hour and 24-hour and annual average SO_2, NO_2, PM_{10}, CO and benzene concentrations from the proposed gas to power plant are well below the respective National Ambient Air Quality Standards (NAAQS) and World Health Organisation (WHO) guidelines for Scenario 1 and Scenario

2. Predicted ambient concentrations are localised and very low for the modelled scenarios. The contribution to ambient concentrations beyond the immediate vicinity of the proposed gas to power plant is therefore small. The additive effect of these concentrations to the ambient environment is therefore highly unlikely to make a significant contribution to the cumulative impacts of SO_2, NO_2, PM_{10}, CO and benzene in the ambient environment. Impacts in terms of predicted concentrations of SO_2, NO_2, PM_{10}, CO and benzene from the operational scenarios will however last for the full period of the proposed gas to power plant. The duration of direct, indirect and cumulative impacts from the operational scenarios are therefore expected to be long-term. The significance of all impacts for the two operational scenarios is low.

Construction and decommissioning activities will result in the emission of low quantities of terrestrial and construction dust, not expected to pose a health risk. Furthermore, dust emissions will not travel over vast distances, but will most likely settle within 100m to 1km of the proposed development site. A temporary nuisance impact may be experienced in parts of the RBIDZ Zone 1F, the property on which the site is to be constructed. Construction and decommissioning impacts will last for a relatively short period as these activities occur for the duration of these activities only. It is predicted that the significance of all impacts during the construction and decommissioning phase is low. No mitigation is necessary, however, measures are suggested to minimise the nuisance impacts arising from these activities.

In this assessment, two NO_X emission mitigation strategies have been tested for the proposed gas to power plant. These include the water-steam injection and lean-premix mechanism. If NO_X mitigation strategies are implemented at the proposed gas to power plant, this will result in significantly lower NO_2 concentrations during the operational phase for all scenarios. Impacts from SO_2 emissions can be further reduced by decreasing the sulphur content of the diesel and LNG. However, this is not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current SO_2 content levels are already low. Due to the low predicted impacts, no mitigation measures are suggested for operational activities, in other words, mitigation measures to control SO_2 and NO_X, or even PM_{10}, CO and benzene are not necessary for the normal operations of the proposed gas to power plant. The significance rating will remain low during the operational phase for all scenarios, with or without mitigation.

The operation of the proposed gas to power plant is a Listed Activity in terms of the NEM: AQA. Requirements for environmental management will be dictated by the conditions in the Atmospheric Emission License (AEL). These are likely to include:

i. Annual emission measurements to assess compliance with the Minimum Emission Standards for Listed Activities (Government Gazette 37054, Notice No. 893 of 22 November 2013);
ii. The maintenance of an emission inventory with registration on the National Atmospheric Emission Inventory System (NAEIS) and annual

reporting of emissions to the NAEIS (Government Gazette 38633, Notice No. R 283 of 2 April 2015).

Further environmental management requirements should address the control of emissions during operations through routine maintenance and operation according to specification.

Recommendations

According to the dispersion modelling results and air quality impact assessment, the site operations is expected to generate low emissions, low ambient concentrations, and low environmental impacts for both Scenario 1 and Scenario 2. It is therefore recommended that the proposed mitigation measures for the construction, operation and decommissioning phases are implemented to limit the negative impacts.

Overall Conclusion

It is predicted with confidence, that the site operations will generate low emissions, low ambient concentrations, and low environmental impacts for the construction, operation and decommissioning phase. The proposed development and associated infrastructure is unlikely to result in permanent damage to the environment. Mitigation measures are recommended for the construction and decommissioning phase only. It is a reasonable opinion that the project should be authorised considering the outcomes of this impact assessment.

List of Abbreviations

AEL	Atmospheric Emission License
AIR	Atmospheric Impact Report
API	American Petroleum Institute
AQO	Air Quality Officer
CCGT	Combined Cycle Gas Turbine
C_6H_6	Benzene
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
EIA	Environmental Impact Assessment
ECO	Emission Control Officer
GHG	Greenhouse Gases
HRSG	Heat recovery steam generator
IDP	Integrated Development Plan
IDZ	Industrial Development Zone
IPP	Independent Power Producer
LNG	Liquefied Natural Gas is natural gas stored as a super-cooled (cryogenic) liquid
LPG	Liquefied Petroleum Gas consists mainly of propane, propylene, butane, and butylene in various mixtures. It is produced as a by-product of natural gas processing and petroleum refining
NAAQS	National Ambient Air Quality Standards
NEMA	National Environmental Management Act (Act No. 107 of 1998)
NEM: AQA	National Environmental Management: Air Quality Act (Act No. 39 of 2004)
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen (NO_X = NO + NO_2)
PM_{10}	Particulate matter with a diameter less than 10 microns
$PM_{2.5}$	Particulate matter with a diameter less than 2.5 microns
RBCAA	Richards Bay Clean Air Association
RBGP2	Richards Bay Gas Power 2 (Pty) Ltd
RLNG	Regasified liquid natural gas
SAAQIS	South African Air Quality Information System
SAWB	South African Weather Bureau
SAWS	South African Weather Service
SO_2	Sulphur dioxide
TVOC	Total volatile organic compounds
UDM	uThungulu District Municipality
µm	Micro meters (1 µm = 10^{-6} m)
US-EPA	United States Environmental Protection Agency
VOC	Volatile organic compounds
WHO	World Health Organisation

Acknowledgements

Sandy Camminga and Francois Nel of the RBCAA and Lindiwe Khumalo and Gugu Gazu of the uMhlathuze Municipality are thanked for providing hourly ambient monitoring data for their respective stations.

South African Weather Service (SAWS) is thanked for providing hourly surface meteorological data from Richards Bay Airport.

Declaration

Atmospheric Impact Report in support of the EIA for the proposed Gas to Power Plant in Zone 1F of the Richards Bay IDZ

Specialist:	uMoya-NILU Consulting (Pty) Ltd		
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Project Consultant:	uMoya-NILU Consulting (Pty) Ltd		
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I, MARK ZUNCKEL, declare that –
I act as the independent specialist in this matter;

- I do not have and will not have any vested interest (either business, financial, personal or other) in the undertaking of the proposed activity, other than remuneration for work performed in compiling the Atmospheric Impact Report;
- That there are no circumstances that may compromise my objectivity in performing the work;
- I have expertise in compiling the Atmospheric Impact Report, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the Atmospheric Impact Report by the competent authority;
- All the particulars furnished by me in the Atmospheric Impact Report are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Signature of the specialist:
Name of company: uMoya-NILU Consulting (Pty) Ltd
Date: 26 April 2016

Table of Contents

List of Tables

List of Figures

1. INTRODUCTION

Richards Bay Gas Power 2 (Pty) Ltd (RBGP2), an Independent Power Producer (IPP), is proposing the establishment of a gas to power plant and associated infrastructure on a site located within the Richards Bay Industrial Development Zone (RBIDZ) Zone 1F, located within the uMhlathuze Municipality, KwaZulu-Natal Province. The power station will have a capacity of up to 400MW and is to be developed in two phases to operate with liquid fuels such as diesel or Liquefied Petroleum Gas (LPG)[1] in Phase 1 and ultimately with Liquid Natural Gas (LNG) or Natural Gas (NG) in Phase 2. It is anticipated that 300MW will be fuel/ gas generated energy and 100MW will be heat/ steam generated energy.

This project is to be developed in response to the Department of Energy's request for projects to be developed by IPP's in order to provide alternative power generation technologies as part of the technology mix for the country.

1.1 Enterprise Details

Entity details for Richards Bay Gas Power 2 (Pty) Ltd are listed in Table 1.1.

Table 1.1: Entity details

Entity Name:	Richards Bay Gas Power 2 (Pty) Ltd
Type of Entity, e.g. Company/Close Corporation/Trust, etc.:	Company
Company/Close Corporation/Trust Registration Number (Registration Numbers if Joint Venture):	2014/185927/07
Registered Address:	P O Box 2524 Florida Hills, 1716
Postal Address:	P O Box 2524 Florida Hills, 1716
Telephone Number (General):	
Fax Number (General):	086 276 4016
Company Website:	
Industry Type/Nature of Trade:	Power generation

[1] In response to comments received on the draft scoping report, Light Fuel Oil (LFO) and Heavy Fuel Oil (HFO) have been excluded as fuel sources due to their high emissions.

Name of the Landowner/s or Landlord/s:	City of uMhlathuze (in the process of being transferred to: Richards Bay Industrial Development Zone Company SOC Ltd)
Name of Mortgage Bondholder/s (if any):	
Deeds Office Registration Number of Mortgage Bond:	
Land Use Zoning as per Town Planning Scheme:	Special Economic Zone
Land Use Rights if outside Town Planning Scheme:	

1.2 Location and extent

The development site for the proposed gas to power plant falls within the Richards Bay Industrial Development Zone (IDZ) Zone 1F. Zone 1F is located in the Alton North area, a few kilometres to the north of the other IDZ sites (Figure 1.1). The land is currently vacant, borders Tata Steel on the south and zoned as IDZ Industry. The broader area is characterised by intense past land-use modifications from agriculture, mining, tourism, residential, recreational and industrial development activities. The study area within the RBIDZ Zone 1F is bordered by mixed-use of industrial developments as well as residential areas and open areas. The Nsezi Rail Yard lies immediately to the west of this zone. The Richards Bay Cemetery lies to the north-east. The area to the south-east of the site is used for light industrial development.

The site for the proposed power plant is situated south of the North Central Arterial and to the west of Alton on Erven 17455, 17443 and 17442. To the west are formal Eucalyptus plantations on Transnet owned property, while the eastern edge is industry linked with Alumina Alley. The land for the development of the power plant is currently owned by the City of uMhlathuze but is in the process of being transferred to the Richards Bay Industrial Development Zone Company SOC Ltd.

Site information is provided in Table 1.2. Receptors within a 5 and 15km radius of the proposed plant are shown in Figure 1.2.

Table 1.2: Site information

Physical Address of the Licenced Premises:	Erven 17455, 17443 and 17442 within the Richards Bay IDZ Zone 1F, KwaZulu-Natal
Description of Site (Where No Street Address):	Erven 17455, 17443 and 17442 within the Richards Bay IDZ Zone 1F, KwaZulu-Natal
Property Registration Number (Surveyor-General Code):	NOGVO04210000881800000 NOGVO04210000882000000 NOGVO04210000881900000
Coordinates (latitude, longitude) of Approximate Centre of Operations (Decimal Degrees):	28° 44.4’ S 32° 01.57’ E
Coordinates (UTM) of Approximate Centre of Operations:	404918.30 m E (36J) 6820424.57 m S (36J)
Extent (km^2):	0.073
Elevation Above Mean Sea Level (m)	49m
Province:	KwaZulu-Natal
District/Metropolitan Municipality:	uThungulu District Municipality
Local Municipality:	uMhlathuze Municipality
Designated Priority Area (if applicable):	N/A

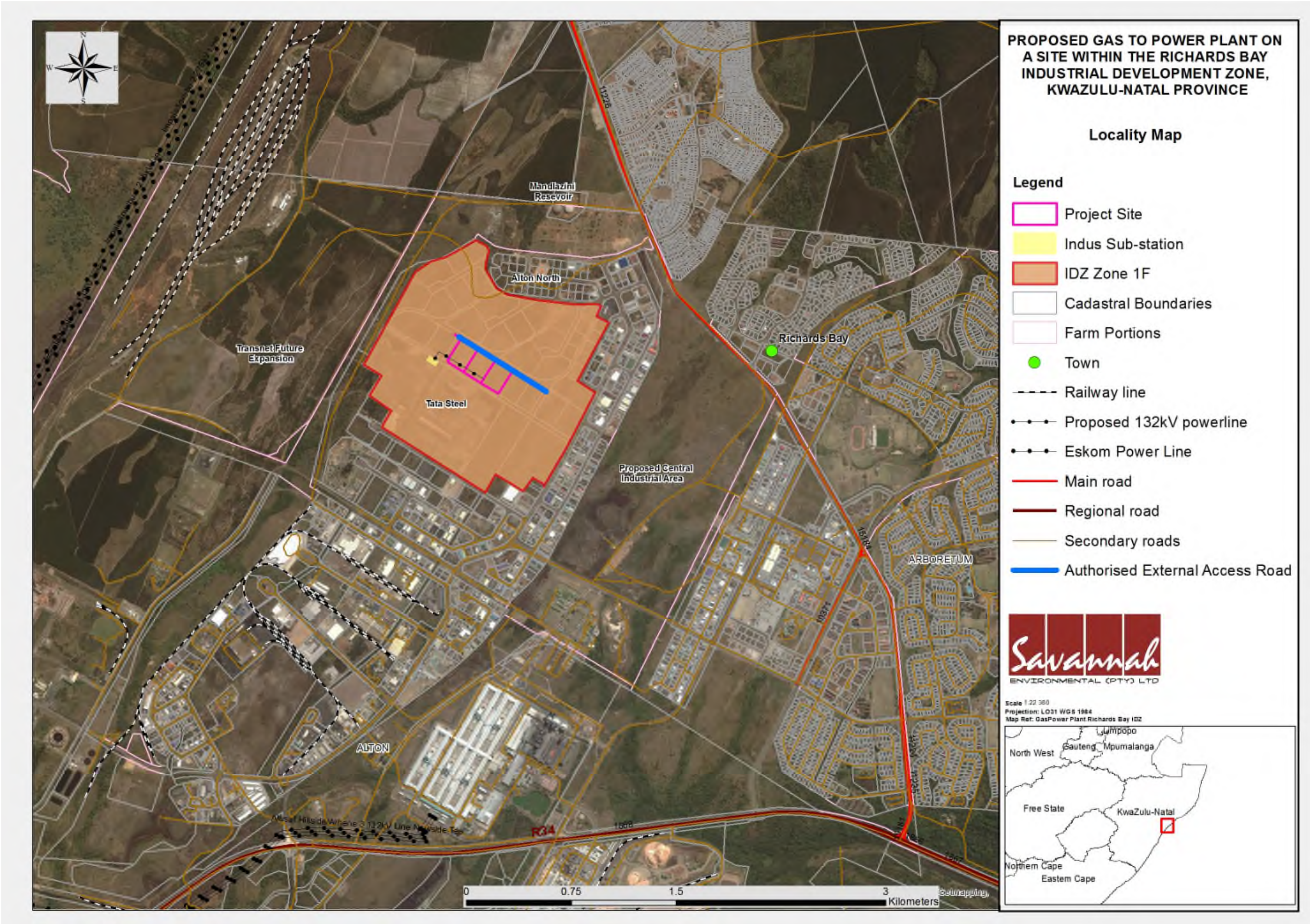
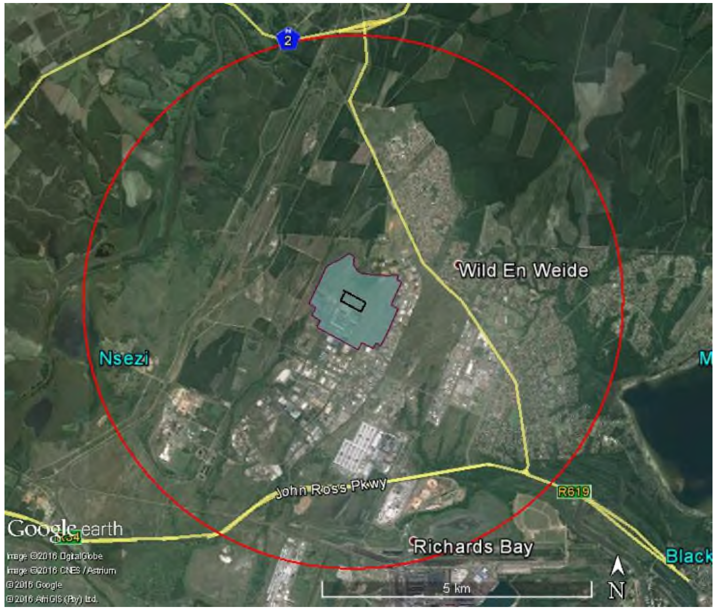


Figure 1.1: Proposed location of the gas to power plant within the Richards Bay IDZ



Receptor	Distance	Direction	Receptor	Distance	Direction
Alton (commercial)	800 m	S	Port of Richards Bay (commercial)	5.6 km	SSW
Brakenham (residential)	1.5 km	NE	Nseleni (residential)	7 km	N
Wild En Weide (residential)	1.8 km	ENE	Meer En See (residential)	8 km	ESE
Richards Bay CBD (commercial)	2 km	ENE	Richards Bay Minerals (industrial)	12 km	NE
Hillside Aluminium (industrial)	2.3 km	S	Empangeni (residential/commercial)	12 km	W
Arboretum (residential)	4 km	ESE	Esikhaleni (residential)	14 km	SSW
Mondi (industrial)	3.8 km	SW			
Birdswood (residential)	4.6 km	E			

Figure 1.2: Receptors within 5km (left) and up to 15km (right) from the proposed gas to power plant in Zone 1F of the Richards Bay IDZ

1.3 Nature of the Process

1.3.1 Overview

The proposed gas to power plant Project involves the construction of a gas-fired power station to provide electrical power to the national grid. It will have a capacity of up to 400 MW and will be developed in two phases. It will operate using liquid fuels such as diesel or LPG[2] in Phase 1 and ultimately LNG or NG in Phase 2. It is anticipated that 300MW will be fuel/ gas generated energy and 100MW will be heat/ steam generated energy.

While various generation technologies are being considered, it is most likely that combined cycle gas turbines (CCGTs) will be used to generate electricity. A CCGT power plant combines the procedures of both a gas turbine and a steam power plant. In the first stage the turbine compresses air and mixes it with fuel that is heated to a very high temperature. The hot air-fuel mixture moves through the gas turbine blades, making them spin. The fast-spinning turbine drives a generator that converts a portion of the spinning energy into electricity. In the second stage, a Heat Recovery Steam Generator (HRSG) captures exhaust heat from the gas turbine that would otherwise escape through the exhaust stack. The HRSG creates steam from this heat and delivers it to the steam turbine. The steam turbine sends its energy to the generator drive shaft, where it is converted into additional electricity. The process is shown schematically in Figure 1.3.

[2] In response to comments received on the draft scoping report, Light Fuel Oil (LFO) and Heavy Fuel Oil (HFO) have been excluded as fuel sources due to their high emissions.

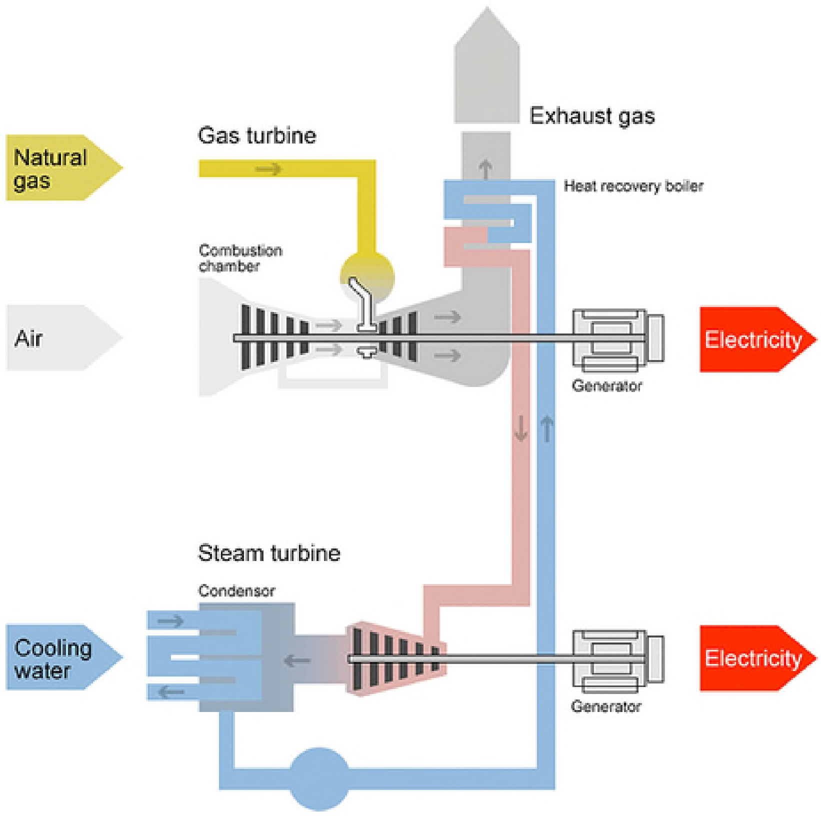


Figure 1.3: Mode of operation of CCGT power plants (http://www.eon.com/en/business-areas/power-generation)

The gas turbine is one of the most efficient technologies available, for converting gas fuels to mechanical power or electricity. The use of distillate liquid fuels, usually diesel, is common as an alternate fuel.

For Phase 1 three 2 000m^3 diesel (liquid fuel) storage tanks will be constructed and operated. In Phase 2 when gaseous fuels will be used LNG / NG will be supplied from the LNG import and storage facility located at the Port of Richards Bay.

Generated electricity will be evacuated from the power station via a 132 kV power line which will connect the on-site sub-station into the municipal grid, at the Indus Substation bordering the site.

1.3.2 Air pollutants resulting from power generation

The air pollutants that result from fuel combustion for electricity generation depend on the combustion temperature and on the type of fuel that is being combusted. The carbon in the fuel gives rise to CO and CO_2 emissions. Nitrogen in the fuel and the abundance of nitrogen in the atmosphere result in emissions of oxides of nitrogen (NO_X = NO and NO_2). Thermal produced NO_X results during the combustion process when nitrogen and oxygen are present at elevated temperatures. Sulphur in the fuel gives rise to sulphur dioxide (SO_2) when the fuel is combusted. Particulate emissions also result from the combustion process through unburnt fuel and the formation of aerosols in the flue gas.

Fuels may be classified as dirty or clean based on their sulphur content and their potential to produce particulate emissions. Solid fuels such as wood and coal, and some liquid fuels, are regarded as dirty fuels. Liquid fuels may fall into either category. Gaseous fuels are generally clean fuels having a very low sulphur content, sometimes negligible, and result in very low particulate emissions.

The pollutants typically associated with the liquid and gaseous fuels that might be used at the proposed gas to power plant are discussed here:

Diesel: Diesel is a mixture of hydrocarbons obtained by distillation of crude oil. The important properties which are used to characterize diesel fuel include fuel volatility, density, viscosity, cold behaviour and sulphur content. Diesel fuel specifications differ for various fuel grades and in different countries. The diesel available in South Africa is 500 ppm (0.05%) or 50 ppm (0.005%) sulphur. Diesel is therefore regarded as a relatively clean fuel. The combustion of diesel results in the emission SO_2, NO_X, particulates, CO and benzene.

Liquefied petroleum gas (**LPG)**, also referred to as simply propane or butane. LPG is not made or manufactured, it is found naturally in combination with other hydrocarbons. LPG is considered a clean fuel because it does not produce visible emissions. However, gaseous pollutants such as nitrogen oxides (NO_X), carbon monoxide (CO), and organic compounds are produced. Small amounts of SO_2 and particulate matter are also produced. NO_X emissions are a function of a number of variables, including temperature, excess air, fuel and air mixing, and residence time in the combustion zone. The amount of SO_2 emitted is directly proportional to the amount of sulphur in the fuel. PM emissions are very low and result from soot and aerosols formed by condensable emitted species.

Liquefied natural gas (**LNG**) is natural gas consisting predominantly methane (CH_4) that has been converted to liquid form by cooling it to −161°C, at which point it becomes a liquid. This reduces the volume of the natural gas by a factor of more than 600, which facilitates economical storage and transport. LNG has little or no sulphur and is regarded as a clean fuel. The combustion of LPG results in the emission CO and NO_X, and small amounts of particulates, SO_2 and benzene. **RLNG** refers to the regasification of LNG where it is transformed back into its gaseous state.

Natural gas (NG) is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, but may include a small percentage of CO_2, nitrogen, or hydrogen sulphide (H_2S). Natural gas has little or no sulphur and is regarded as a clean fuel. Its combustion results in the emission CO and NO_X, and small amounts of particulates, SO_2 and benzene.

1.4 Emission Control Officer

The gas to power plant Project is a proposed development. An Emission Control Officer (ECO) has not yet been appointed.

1.5 Authorisation Details

Power generation has been declared as a national priority. The competent authority is therefore the National Air Quality Officer (AQO) (refer to the National Environmental Management: Air Quality Amendment Act, Act No. 20 of 2014). The National AQO is Dr Thuli Mdluli (Tel: 012 399 9188, email: TNMdluli@environment.gov.za).

1.6 Modelling contractor

The dispersion modelling for the AIR and the AEL application for the proposed gas to power plant in Zone 1F of the IDZ is conducted by:

Company:	uMoya-NILU Consulting (Pty) Ltd
Modellers:	Dr Mark Zunckel and Atham Raghunandan
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	Cell: 083 690 2728
	Email: mark@umoya-nilu.co.za or atham@umoya-nilu.co.za

Dr Zunckel's curriculum Vitae are included in Appendix 1.

1.7 Terms of Reference

The terms of reference for this study is to:

i. Engage with the proponent to agree on appropriate generation technology options for the assessment;
ii. Use available data and information to description of current state of the receiving atmospheric environment in Richards Bay and surrounds. Sources of data will include the City of uMhlathuze, the Richards Bay Clean Air Association (RBCAA) and the South Africa Weather Service;
iii. Provide an overview of the legal environment including regulations under the NEM:AQA and the Air Quality Management Plans (AQMP) for the uThungulu District Municipality and the City of uMhlathuze;
iv. For Phase 1 and Phase 2 and the agreed power generation option:
    a. Develop of an atmospheric emission inventory;
    b. Predict ambient concentrations of pollutants resulting from the emissions using the DEA recommended CALPUFF dispersion model and according to the DEA guideline for dispersion modelling (DEA, 2012). CALPUFF is recommended as it is consider more appropriate than other dispersion modes as it has the capability to deal with the complexities associated

with the land-sea interface. Cumulative impacts will be assessed by including representative background concentrations obtained from the RBCAA in the dispersion modelling. The so-called additive effects.

c. Assess of air quality impacts of the proposed operations and the implications for human health by evaluating predicted ambient concentrations of air pollutants with the National Ambient Air Quality Standard (NAAQS) and using EIA criteria prescribed by Savannah Environmental;
d. Prepare and submitted a draft AIR to Savannah Environmental for review with the proponent

v. Finalise the AIR.

vi. Following the completion of the draft assessment report:
   i. Prepare the draft AEL application;
   ii. Provide input to Savannah on the content of the required notice of the intention to apply for an AEL in two local newspapers.
   iii. Finalise the AEL application following comments received and submit to Savannah for signature by the proponent and submission to the NAQO.

1.8 Assumptions

The following assumptions and limitations are associated with this study:

- The assessment is based only on emissions from the gas to power station, which include stacks and storage tanks. The additive impact is assessed by considering background concentrations (to account for "nearby" and "other" background sources). The dispersion modelling is based on stack heights of 15m. The developer has indicated that stack heights will be 20m. Stacks with greater height (e.g. 20m) would result in far less impacts.
- Emission factors used to develop the emission inventory are adopted from the USEPA AP42 Compilation of Air Pollutant Emission Factors.
- A human health risk assessment (HHRA) study is not undertaken in this assessment. Health impacts are assessed against South African Air Quality Standards (NAAQS) and World Health Organisation (WHO) guidelines.

2. LEGAL REQUIREMENTS

2.1 National Environmental Management Act

Section 28 of the National Environmental Management Act (NEMA) (Act No. 107 of 1998) addresses the duty of care and remediation of environmental damage. Sub-section 1 and 3 apply to the proposed gas to power plant and air quality management. These are:

Sub-section 1: Every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such pollution or degradation of the environment.

Sub-section 3: The measures required in terms of the above may include the following:

i) Investigate, assess and evaluate the impact on the environment;
ii) Inform and educate employees about the environmental risks of their work and the manner in which their tasks must be performed in order to avoid causing significant pollution or degradation of the environment;
iii) Cease, modify or control any act, activity or process causing the pollution or degradation;
iv) Contain or prevent the movement of pollutants or the cause of degradation;
v) Eliminate any source of the pollution or degradation;
vi) Remedy the effects of the pollution or degradation.

2.2 The Air Quality Act

2.2.1 Listed activities and Minimum Emission Standards

Listed Activities are activities that the Minister (or MEC) reasonably believes have or may have a significant detrimental effect on the environment (Section 21(1)(a) of the NEM: AQA). Minimum emission standards have been set for most Listed Activities.

Combustion installations used primarily for steam raising or electricity generation are Listed Activities (Category 1) in term of Section 21 of the NEM: AQA. Facilities with a design capacity equal to or greater than 50 MW and using liquid fuels are Sub-category 1.2 Listed Activities, while those using gaseous fuels are Sub-category 1.4 Listed Activities. Minimum emission standards for these sub-categories are defined in Government Notice 893 (Government Gazette 37054 of 22 November 2016) (Table 2.1).

Table 2.1: Minimum emission standards for Liquid (Sub-category 1.2) and Gas Combustion (Sub-category 1.4) Installations with a design capacity equal to or greater than 50 MW heat input per unit

	MES (mg/Nm^3) under normal conditions of 15% O_2, 273 K and 101.3 kPa	
Substance	**Sub-category 1.2 (Phase 1)**	**Sub-category 1.4 (Phase 2)**
SO_2	500	400
NO_X expressed as NO_2	250	50
Particulate matter	50	10

The storage and handling of petroleum products at facilities with a combined storage capacity of 1 000 m^3 is a Listed Activity (Category 2, sub-category 2.4) (Government Notice 893, Government Gazette 37054 of 22 November 2016). Special arrangements apply for Sub-category 2.4 Listed Activities depending on the vapour pressure of products being stored.

RBGP2 propose to store diesel in Phase 1. The vapour pressure of diesel at typical ambient temperatures is low and less than 14 kPa. For the control of Total Volatile Organic Compounds (TVOC) emissions from the storage of more than 1 000 m^3 of such products, Special Condition b(i) requires as a minimum, fixed roof-tanks that are vented to the atmosphere, or tanks with more sophisticated emission control designs and technology such as pressure vacuum vents or floating roofs with primary and secondary seals.

2.2.2 Atmospheric Emission Licence (AEL)

The consequence of listing an activity is described in Section 22 of the NEM: AQA, i.e. that no person may conduct a Listed Activity without a provisional Atmospheric Emission License or an Atmospheric Emission License that has been issued by the competent authority. The AEL application process is described in Section 37 of the NEM: AQA and in the National Environmental Management: Air Quality Amendment Act, Act No. 20 of 2014).

In cases where the Listed Activity forms part of a matter declared as a national priority, the licensing authority is the National Air Quality Officer, Dr Thuli Mdluli (refer to the National Environmental Management: Air Quality Amendment Act, Act No. 20 of 2014) (Tel: 012 399 9188, email: TNMdluli@environment.gov.za).

Regulations prescribing the AEL processing fee were gazetted on 11 March 2016 (DEA, 2016). The processing fee for new Listed Activities of R10 000 per Listed Activity should be paid on or before the date of the submission of the application.

2.2.3 Ambient air quality standards

The effects of air pollutants on human health occur in a number of ways with short-term or acute effects, and chronic or long-term effects. Different groups of people are affected differently, depending on their level of sensitivity, with the elderly and young children being more susceptible. Factors that link the concentration of an air pollutant to an observed health effect are the level and the duration of the exposure to that particular air pollutant.

Criteria pollutants occur ubiquitously in urban and industrial environments. Their effects on human health and the environment are well documented (e.g. WHO, 1999; 2003; 2005). South Africa has established national ambient air quality standards for the criteria pollutants, i.e. SO_2, nitrogen dioxide (NO_2), CO, respirable particulate matter (PM_{10}), ozone (O_3), lead (Pb) and benzene (C_6H_6) (DEA, 2009) and $PM_{2.5}$ (DEA, 2012a). The National Ambient Air Quality Standards for SO_2, NO_2, PM_{10}, $PM_{2.5}$, CO and benzene are listed in Table 2.2.

The national ambient air quality standard consists of a limit value and a permitted frequency of exceedance. The limit value is the fixed concentration level aimed at reducing the harmful effects of a pollutant. The permitted frequency of exceedance represents the tolerated exceedance of the limit value and is equivalent to the 99th percentile, accounting for outliers in the data. Compliance with the ambient standard implies that the frequency of exceedance of the limit value does not exceed the permitted tolerance. Being a health-based standard, ambient concentrations below the standard imply that air quality is acceptable and poses little or no risk to human health; while exposure to ambient concentrations above the standard implies that there is a risk to human health.

Table 2.2: National ambient air quality standards for SO_2, NO_2, CO, benzene and PM_{10} (DEA, 2009) and $PM_{2.5}$ (DEA, 2012a)

Pollutants	Averaging period	Limit value (µg/m³)	Number of permissible exceedances per annum
SO_2	1 hour	350	88
	24 hour	125	4
	1 year	50	0
NO_2	1 hour	200	88
	1 year	40	0
CO	1-hour	30 000	0
	8-hour running mean	10 000	0
Benzene	1 year	5	0
PM_{10}	24-hour	75	4
	1 year	40	0
$PM_{2.5}$	24-hour	40 (25)[1]	0
	1 year	20 (15)[1]	0

1: Implementation date 1 January 2030

2.3 AQMP for the uThungulu District Municipality

The vision of the Air Quality Management Plan (AQMP) for uThungulu District Municipality (UDM) (uMoya-NILU, 2014) is "*Clean air for a healthy uThungulu*". It is supported by the following mission statement:

"*The uThungulu DM ensures clean, healthy air for all residents to preserve the integrity of ecosystems and enables economic growth and development through the ongoing* *implementation of the air quality management plan, co-operative governance and active stakeholder engagement*"

The five goals to achieve the vision of the AQMP are:

> Goal 1: The air quality management capacity in the UDM meets all the requirements of their mandate, which refers to the critical importance of an effective and efficient AQM staff complement and competence to fulfil the requirements of the NEM: AQA.
>
> Goal 2: Air quality management in UDM is enhanced through co-operative governance, which refers to the importance of co-operative governance, with a particular emphasis on inter-governmental cooperation and interdisciplinary exchange to ensure that air quality issues are considered in planning and development decision making.
>
> Goal 3: UDM has the systems and tools for effective air quality management, which refers to UDM having a system to manage air quality. These components include but are not limited to: a dispersion modelling capacity, an emission inventory, an ambient monitoring network, an AEL processing system and a complaints management system.
>
> Goal 4: Air Quality Management in the UDM considers the development objectives of the region, which recognises that there is a need for strategic management of the air shed, considering economic growth and hot spot areas with large concentrations of polluting activities such as in the IDZ. There is also a need to explore potential air quality risks in parts of the district that have not been researched and address these accordingly.
>
> Goal 5: AQM is understood throughout UDM, which refers to active and inclusive stakeholder engagement with a focus on effective implementation of the AQMP and enhancing awareness of AQM in the UDM.

The AQMP is integrated into the Municipal Integrated Development Plan (IDP) with an associated 5-year implementation plan with short, medium and longer term objectives. Goal 2 and Goal 4 are relevant to the proposed gas to power plant.

Goal 2, amongst others, concerns co-operative governance and ensuring that air quality issues are addressed in planning and development decision making. The National AQO is the designated authority for this application. Important here is co-operation between the National AQO and the UDM AQO to ensure alignment with National goals and Municipal objectives.

Goal 4 considers the development objectives of the region, including the IDZ. Co-operation between the designated authority and the Richards Bay IDZ is important in upholding the intention and objective of Goal 4.

3. PROCESS SUMMARY

A summary of the different unit processes is provided in Table 3.1 for Phase 1 (diesel) and for Phase 2 (LNG). A schematic of process flow is illustrated in Figure 3.1 and the relative location of the process units is shown in Figure 3.2.

Table 3.1: Unit processes at the gas to power plant for Phase 1 and 2

Unit Process	Function of Unit Process	Batch or Continuous Process
Phase 1		
Open Cycle Gas Turbine (GT01)	Generation of electricity from diesel	Continuous
Open Cycle Gas Turbine (GT02)	Generation of electricity from diesel	Continuous
Open Cycle Gas Turbine (GT03)	Generation of electricity from diesel	Continuous
Open Cycle Gas Turbine (GT04)	Generation of electricity from diesel	Continuous
Open Cycle Gas Turbine (GT05)	Generation of electricity from diesel	Continuous
Open Cycle Gas Turbine (GT06)	Generation of electricity from diesel	Continuous
Phase 2		
Open Cycle Gas Turbine (GT01)	Generation of electricity from LNG	Continuous
Open Cycle Gas Turbine (GT02)	Generation of electricity from LNG	Continuous
Open Cycle Gas Turbine (GT03)	Generation of electricity from LNG	Continuous
Open Cycle Gas Turbine (GT04)	Generation of electricity from LNG	Continuous
Open Cycle Gas Turbine (GT05)	Generation of electricity from LNG	Continuous
Open Cycle Gas Turbine (GT06)	Generation of electricity from LNG	Continuous

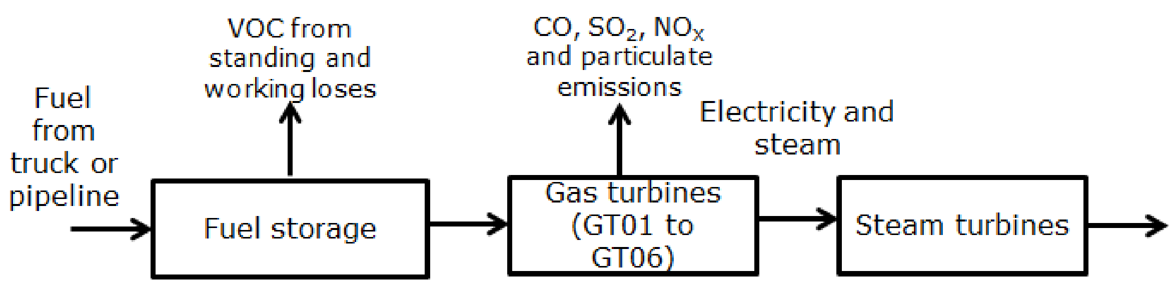


Figure 3.1: A basic block flow diagram for the operation at gas to power plant

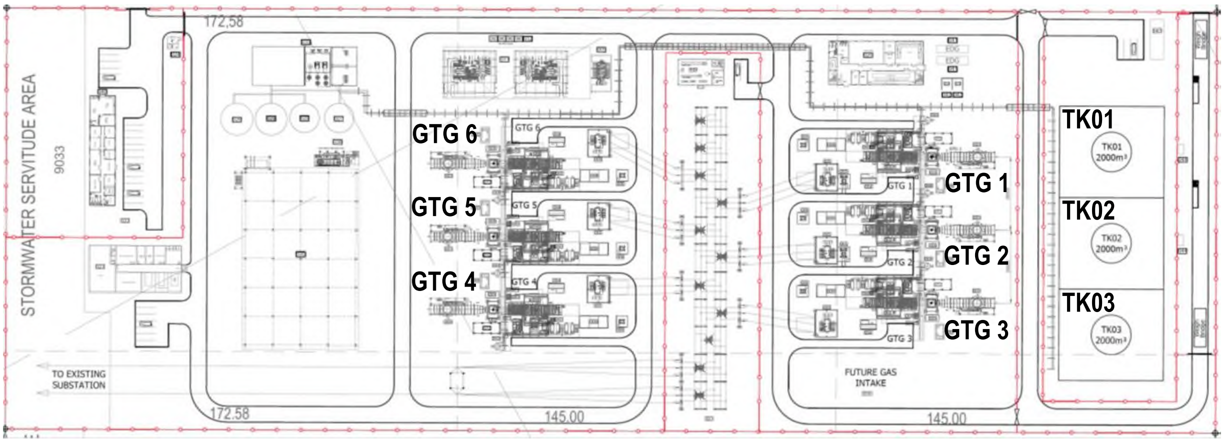


Figure 3.2: Relative location of the different process units at the proposed Gas to Power Plant

4. RAW MATERIALS AND PRODUCTS

The raw materials consumption rate at the proposed gas to power plant are listed in Tables 4.1 to 4.3.

Table 4.1: Raw material used at the proposed gas to power plant

Raw material	Maximum consumption rate	Units (quantity / period)
Diesel (Phase 1)	610[1]	tons/annum
LNG (Phase 2)	606[1]	tons/annum
1: Based on baseload operation at 98% availability		

Table 4.2: Production rates at the proposed gas to power plant

Product/by-product	Maximum Production capacity	Units (quantity / period)
Electricity	400	MW

Table 4.3: Energy sources used at the proposed gas to power plant

Energy source	Sulphur content of fuel (%)	Ash content of fuel (%)	Maximum permitted consumption rate (Volume)	Units (quantity / period)
Sav. Env to provide info.				

5. ATMOSPHERIC EMISSIONS

5.1 Pollutants emitted at proposed gas to power plant

Pollutants emitted from the proposed gas to power plant are from the combustion of diesel fuel or LNG fuel to generate electricity. These include SO_2, NO_X, particulates, CO and benzene. The potential health effect of these pollutants is described here.

Sulphur dioxide (SO_2)

On inhalation, most SO_2 penetrates as far as the nose and throat, with minimal amounts reaching the lungs, unless the person is breathing heavily, breathing only through the mouth, or if the concentration of SO_2 is high (CCINFO, 1998). The acute response to SO_2 is rapid, within 10 minutes in people suffering from asthma (WHO, 2005). Effects such as a reduction in lung function, an increase in airway resistance, wheezing and shortness of breath, are enhanced by exercise that increases the volume of air inspired, as it allows SO_2 to penetrate further into the respiratory tract (WHO, 1999). SO_2 reacts with cell moisture in the respiratory system to form sulphuric acid. This can lead to impaired cell function and effects such as coughing, broncho-constriction, exacerbation of asthma and reduced lung function. The South African national ambient standard for SO_2 is listed in Table 2.2.

Nitrogen dioxide (NO_2)

The route of exposure to NO_2 is inhalation and the seriousness of the effects depend more on the concentration than on the length of exposure. The site of deposition for NO_2 is the distal lung where NO_2 reacts with moisture in the fluids of the respiratory tract to form nitrous and nitric acids. About 80 to 90% of inhaled NO_2 is absorbed through the lungs (CCINFO, 1998). Nitrogen dioxide (present in the blood as the nitrite ion) oxidises unsaturated membrane lipids and proteins, which then results in the loss of control of cell permeability. Nitrogen dioxide caused decrements in lung function, particularly increased airway resistance. People with chronic respiratory problems and people who work or exercise outside will be more at risk to NO_2 exposure (EAE, 2006). The South African national ambient standard for NO_2 is listed in Table 2.2.

Particulate matter

Particulate matter is a broad term used to describe the fine particles found in the atmosphere, including soil dust, dirt, soot, smoke, pollen, ash, aerosols and liquid droplets. The most distinguishing characteristic of PM is the particle size and the chemical composition. Particle size has the greatest influence on the behaviour of PM in the atmosphere with smaller particles tending to have longer residence times than larger ones. PM is categorised, according to particle size, into TSP, PM_{10} and $PM_{2.5}$.

Total suspended particulates (TSP) consist of all sizes of particles suspended within the air smaller than 100 micrometres (μm). TSP is useful for understanding nuisance effects of PM, e.g. settling on houses, deposition on and discolouration of buildings, and reduction in visibility.

PM_{10} describes all particulate matter in the atmosphere with a diameter equal to or less than 10 μm. Sometimes referred to simply as coarse particles, they are generally emitted from motor vehicles (primarily those using diesel engines), factory and utility smokestacks, construction sites, tilled fields, unpaved roads, stone crushing and burning of wood. Natural sources include sea spray, windblown dust and volcanoes. Coarse particles tend to have relatively short residence times as they settle out rapidly and PM_{10} is generally found relatively close to the source except in strong winds.

$PM_{2.5}$ describes all particulate matter in the atmosphere with a diameter equal to or less than 2.5 μm. They are often called fine particles, and are mostly related to combustion (motor vehicles, smelting, incinerators), rather than mechanical processes as is the case with PM_{10}. $PM_{2.5}$ may be suspended in the atmosphere for long periods and can be transported over large distances. Fine particles can form in the atmosphere in three ways: when particles form from the gas phase, when gas molecules aggregate or cluster together without the aid of an existing surface to form a new particle, or from reactions of gases to form vapours that nucleate to form particles.

Particulate matter may contain both organic and inorganic pollutants. The extent to which particulates are considered harmful depends on their chemical composition and size, e.g. particulates emitted from diesel vehicle exhausts mainly contain unburned fuel oil and hydrocarbons that are known to be carcinogenic. Very fine particulates pose the greatest health risk as they can penetrate deep into the lung, as opposed to larger particles that may be filtered out through the airways' natural mechanisms.

In normal nasal breathing, particles larger than 10 μm are typically removed from the air stream as it passes through the nose and upper respiratory airways, and particles between 3 μm and 10 μm are deposited on the mucociliary escalator in the upper airways. Only particles in the range of 1 μm to 2 μm penetrate deeper where deposition in the alveoli of the lung can occur (WHO, 2003). Coarse particles (PM_{10} to $PM_{2.5}$) can accumulate in the respiratory system and aggravate health problems such as asthma. $PM_{2.5}$, which can penetrate deeply into the lungs, are more likely to contribute to health effects (e.g. premature mortality and hospital admissions) than coarse particles (WHO, 2003). The national 24-hour and annual ambient standard for PM_{10} and $PM_{2.5}$ is indicated in Table 2.2.

Carbon monoxide

When inhaled, CO enters the blood stream by crossing the alveolar, capillary and placental membranes. In the bloodstream approximately 80-90% of absorbed CO binds with haemoglobin to form carboxyhaemoglobin. The haemoglobin affinity for CO is approximately 200-250 times higher than that of oxygen. Carboxyhaemoglobin reduces the oxygen carrying capacity of the blood and reduces the release of oxygen from haemoglobin, which leads to tissue hypoxia. This may lead to reversible, short lived neurological effects and sometimes delayed severe neurological effects that may include impaired coordination, vision problems, reduced vigilance and cognitive ability, reduced manual dexterity, and difficulty in performing complex tasks (WHO, 1999).

People with existing heart conditions such as angina, clogged arteries, or congestive heart failure are particularly sensitive. In these cases, CO may induce chest pain and lead to the development of other cardiovascular effects such as myocardial infarction, and cardiovascular mortality (WHO, 1999).

Benzene

After exposure to benzene, several factors determine whether harmful health effects will occur, as well as the type and severity of such health effects. These factors include the amount of benzene to which an individual is exposed and the length of time of the exposure. For example, brief exposure (5–10 minutes) to very high levels of benzene (14 000 – 28 000 µg/m^3) can result in death (ATSDR, 2007). Lower levels (980 - 4 200 µg/m^3) can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. In most cases, people will stop feeling these effects when they are no longer exposed and begin to breathe fresh air.

People who inhale benzene for long periods may experience harmful effects in the tissues that form blood cells, especially the bone marrow. These effects can disrupt normal blood production and cause a decrease in important blood components. A decrease in red blood cells can lead to anaemia. Excessive exposure to benzene can be harmful to the immune system, increasing the chance for infection and perhaps lowering the body's defence against cancer. Both the International Agency for Cancer Research and the Environmental Protection Agency (US-EPA) have determined that benzene is carcinogenic to humans as long-term exposure to benzene can cause leukaemia, a cancer of the blood-forming organs.

5.2 Point source emissions

The physical data for the stacks (point sources) at proposed gas to power plant are listed in Table 5.1.

Table 5.1: Point sources at the proposed gas to power plant

Source ID	Stack height (m)	Stack diameter (m)	Stack base-height above sea level (m)	Emission release temperature (K)	Emission exit velocity (m/s)	Gas flow rate (kg/h)
Stack 1	15	2.743	48	750	48	516,925
Stack 2	15	2.743	48	750	48	516,925
Stack 3	15	2.743	48	750	48	516,925
Stack 4	15	2.743	48	750	48	516,925
Stack 5	15	2.743	48	750	48	516,925
Stack 6	15	2.743	48	750	48	516,925

Stack emission testing is generally considered to be the most accurate method for estimating emissions, as it entails the direct measurement of pollutant concentrations. In the absence of emission testing data, the alternate method is to use fuel consumption data and apply appropriate emission factors to estimate emissions. This section describes the methodology used to estimate emission rates of SO_2, NO_X, PM_{10}, CO and benzene from each of the scenarios.

An emissions factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., kg of particulate emitted per ton of coal burned). Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category.

The general equation for emissions estimation is: $E = A \times EF \times (1-ER/100)$, where:

E = emissions;

A = activity rate;

EF = emission factor; and

ER = overall emission reduction efficiency (%)

The emission factors used for the calculation of SO_2, NO_X, PM_{10}, CO and benzene from gas turbines running on diesel (distillate oil) or LNG are the most recent factors published in the United States Environmental Protection Agency (US EPA), AP 42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources. The chapters of interest include Chapter 3: Stationary Internal Combustion Sources (Section 3.1 Stationary Gas Turbines) (USEPA, 2016). Table 5.2 contains gaseous and particulate emission factors for the pollutants discussed above, expressed in units of pounds per million British thermal unit (lb/MMBtu) and kilograms per million British thermal unit (kg/MMBtu).

Table 5.2: Emission factors for SO_2, NO_X, PM_{10}, CO and benzene from gas turbines

Emission factors	Diesel		LNG	
Pollutant	(lb/mmBtu)	(kg/mmBtu)	(lb/mmBtu)	(kg/mmBtu)
SO_2	1.01xS1	0.459xS1	0.94xS2	0.43xS2
NO_X, uncont.	0.88	0.04	0.32	0.15
NO_X, cont^A.	0.24	0.11	0.13	0.06
NO_X, cont$_B$.	No data	No data	0.099	0.045
PM (total)	0.012	0.00545	0.0066	0.0030
CO, uncont	0.0033	0.0015	0.082	0.037
Benzene	0.000055	0.000025	0.000012	0.000005

Notes:

uncont.	Uncontrolled emission factor
uncont.	Controlled emission factor
S1	sulphur content in diesel
S2	sulphur content in LNG
A	NO_X control mechanism – Water-Steam Injection
B	NO_X control mechanism – Lean-Premix

Emission concentrations and emission rates for maximum generation using diesel and LNG are shown in Table 5.3.

Table 5.3: Emission concentrations and rates for the stacks at the proposed gas to power plant

Pollutant	**Source**	**Scenario 1 - Diesel**		**Scenario 2 - LNG**	
		Conc. (mg/Nm^3)	Rate (t/a)	Conc. (mg/Nm^3)	Rate (t/a)
SO_2	Stack 1		187.90		89.47
	Stack 2		187.90		89.47
	Stack 3		187.90		89.47
	Stack 4		187.90		89.47
	Stack 5		187.90		89.47
	Stack 6		187.90		89.47
NO_X, uncont.	Stack 1		1637.11		609.18
	Stack 2		1637.11		609.18
	Stack 3		1637.11		609.18
	Stack 4		1637.11		609.18
	Stack 5		1637.11		609.18
	Stack 6		1637.11		609.18
NO_X, cont^A.	Stack 1		446.48		247.48
	Stack 2		446.48		247.48
	Stack 3		446.48		247.48

Pollutant	Source	Scenario 1 - Diesel		Scenario 2 - LNG	
		Conc. (mg/Nm^3)	Rate (t/a)	Conc. (mg/Nm^3)	Rate (t/a)
	Stack 4		446.48		247.48
	Stack 5		446.48		247.48
	Stack 6		446.48		247.48
NO_X, cont[B].	Stack 1		No data		188.46
	Stack 2		No data		188.46
	Stack 3		No data		188.46
	Stack 4		No data		188.46
	Stack 5		No data		188.46
	Stack 6		No data		188.46
PM_{10}	Stack 1		22.32		12.56
	Stack 2		22.32		12.56
	Stack 3		22.32		12.56
	Stack 4		22.32		12.56
	Stack 5		22.32		12.56
	Stack 6		22.32		12.56
CO, uncont.	Stack 1		6.14		156.10
	Stack 2		6.14		156.10
	Stack 3		6.14		156.10
	Stack 4		6.14		156.10
	Stack 5		6.14		156.10
	Stack 6		6.14		156.10
Benzene	Stack 1		0.10		0.02
	Stack 2		0.10		0.02
	Stack 3		0.10		0.02
	Stack 4		0.10		0.02
	Stack 5		0.10		0.02
	Stack 6		0.10		0.02

Notes:

uncont. Uncontrolled emission rate

uncont. Controlled emission rate

A NO_X control mechanism – Water-Steam Injection

B NO_X control mechanism – Lean-Premix

5.3 Emissions from storage tanks

Fugitive emissions at proposed gas to power plant result from working and standing losses at the fuel storage tanks. The USEPA TANKS software (US-EPA, 2006) model was used to estimate emissions from storage tanks. The equations used in the USEPA TANKS software (US-EPA, 2006) model to calculate emissions were developed by the American Petroleum Institute (API). API retains the copyright to these equations and the TANKS model is available for public use. TANKS allows the input of specific information concerning storage tanks (e.g. tank type, dimensions, construction, paint condition), liquid fuel contents, handling protocols (e.g. type of fuel, volume of fuel handled monthly) and site-specific ambient meteorological information. Speciation of the product into its resultant emissions is based on the composition of the emitted chemical compounds in the product. The model also requires the input of representative meteorological data.

Emissions of TVOC and benzene were estimated for three fixed roof vertical tanks, each 11.5 m high with a diameter of 17 m and an annual throughput of 254 194 m^3. Climatologically representative data for TANKS for Richards Bay was obtained from the South African Weather Service climate statistics (SAWB, 1988; 1992). This included monthly average wind speed, temperature, pressure and solar radiation data for Hammersdale. The resultant estimates are provided in Table 5.4 in kg per annum.

Table 5.4: Annual emission rates for the diesel (liquid fuel) storage tanks at the proposed gas to power plant

	TVOC emission (kg/annum)			Benzene emission (kg/annum)		
Storage tank	**Working losses**	**Breathing losses**	**Total**	**Working losses**	**Breathing losses**	**Total**
Storage tank (TK01)	447.04	66.51	513.55	0.86	0.13	0.99
Storage tank (TK02)	447.04	66.51	513.55	0.86	0.13	0.99
Storage tank (TK03)	447.04	66.51	513.55	0.86	0.13	0.99

6. RECEIVING ENVIRONMENT

6.1 Climatic conditions

The temperate sub-tropical climate experienced at Richards Bay is attributed to its sub-tropical latitudes, the location adjacent to the warm Indian Ocean and the low elevation, and the relative position and strength of the semi-permanent high-pressure system resident over the Indian Ocean. Collectively these factors results in generally warm and sunny conditions throughout the year. These conditions are occasionally interrupted in winter by the passage of coastal lows and cold front systems that move up the coast, introducing cooler temperatures and cloudy conditions with strong winds.

The average monthly maximum and minimum temperatures are shown in Figure 6.1 with the average monthly rainfall per month. The average summer maximums exceed 28 °C from December to March, when it is also very humid. Winters are mild with the average minimum temperature of 17.3 °C (SAWB, 1998). The average annual rainfall at Richards Bay is 1 228 mm (SAWB, 1998). The majority of rainfall occurs from October to March and this period is usually associated with convective summer storms. Winter rainfall is not uncommon and is associated with the passage of cold fronts.

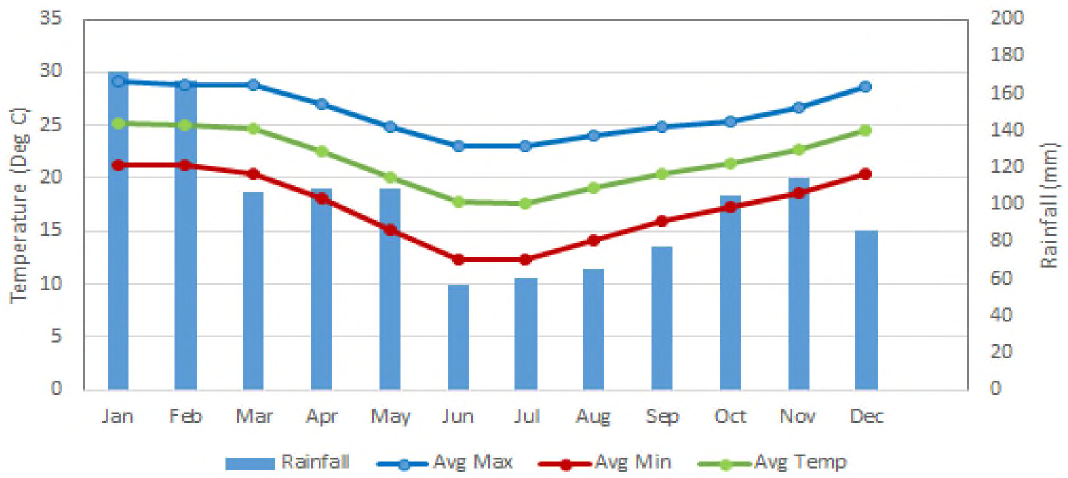


Figure 6.1: Average monthly maximum, minimum and daily temperature at Richards Bay (SAWB, 1992) and the average monthly rainfall in mm (SAWB, 1998)

Wind at Richards Bay is best described by windroses. Windroses simultaneously depict the frequency of occurrence of hourly winds from the 16 cardinal wind directions and in different wind speed classes. Wind direction is given as the direction from which the wind blows, i.e., southwesterly winds blow from the southwest. Wind speed is given in m/s, and each arc in the windrose represents a percentage frequency of occurrence (5% in this case).

The South African Weather Services (SAWS) station at the Richards Bay Airport provides a good representation of the prevailing wind direction across the region. The windrose at Richards Bay Airport for the 5-year period 1 January 2010 to 31 December 2014 is shown in Figure 6.2. The predominant winds are associated with the Indian Ocean high pressure system and its movement relative to Richards Bay, with coastal lows and the passage of frontal systems. The winds are generally aligned with the coastline and at Richards Bay winds occur predominantly in the sector north to north-northeast and in the sector south to southwest. 32% of all winds occur from the northerly sector. Most of these winds are light to moderate with just 6% exceeding 8.8 m/s. The winds from the south to south-west account for 17% of all winds. While these winds are generally light to moderate, they are strong at time and exceed 11.1 m/s on occasions. These strong winds are usually associated with the passage of deep coastal lows ahead of cold frontal systems.

The windrose also indicates mesoscale time land and sea breeze circulation. The land breeze is shown by the light off-shore winds from the west and northwest. These occur mostly at night time in the winter. The sea breeze is also a winter time feature and is shown by the onshore easterly to northeasterly winds. The sea breeze is a daytime feature and is somewhat stronger than the land breeze.

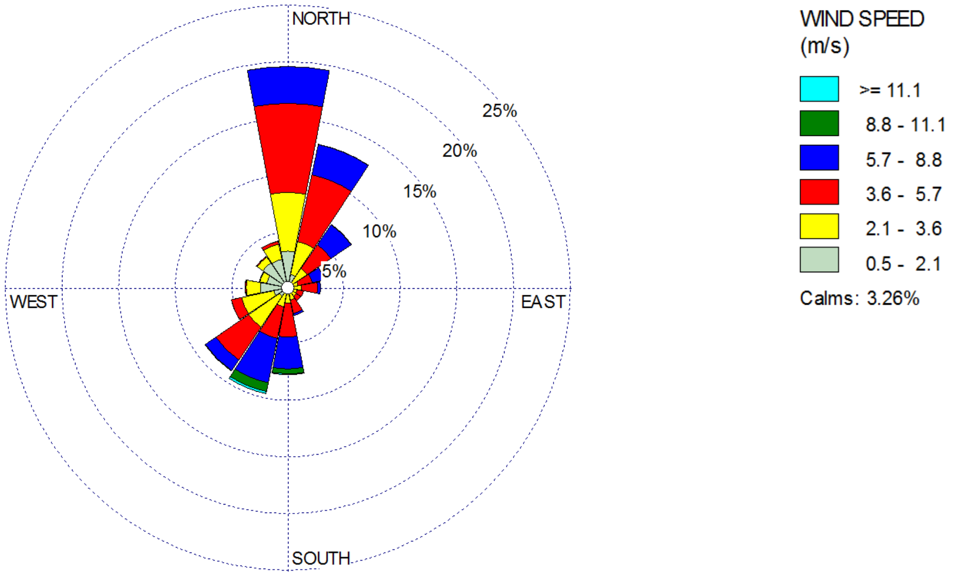


Figure 6.2: Windrose at Richards Bay Airport for 2010 to 2014

The atmospheric dispersion potential of an area relates to the stability (or instability) of the atmosphere, which in turn, is a function of wind speed and insolation (solar radiation). Stable conditions relate to poor atmospheric dispersion and generally coincide with low wind speeds and no insolation (night) or weak insolation due to overcast conditions which limits dilution of pollutants. Conversely, unstable conditions are conducive to good dispersion potential and occur with moderate winds and strong insolation. The wind disperses pollutants horizontally and unstable conditions dilute pollutants in a deeper layer of the atmosphere. The relationship between stability and wind speed and insolation is commonly conveyed through the Pasquill-Gifford stability classes from A to F, shown in Table 6.1.

The atmospheric dispersion potential in Richards Bay is expected to be effective for a lot of the time due to the frequent moderate to strong winds. Poor dispersion conditions are most likely to occur at night when cool temperatures coincide with light or calm winds. The poorest dispersion conditions are likely to occur between May and August when the coldest night time temperatures occur.

Table 6.1: Pasquill-Gifford stability classes

Stability classification	***Stability class***	***Atmospheric conditions***
A	Very stable	Calm wind, clear and hot daytime conditions
B	Moderately stable	Light wind, clear and hot daytime conditions
C	Unstable	Moderate wind, cloudy daytime conditions
D	Neutral	Strong wind, cloudy skies and at night
E	Stable	Moderate wind, cloudy and at night
F	Very stable	Low wind, clear skies, cold night time conditions

6.2 Ambient air quality

Ambient air quality in Richards Bay is influenced by a number of sources of air pollution, including large and smaller industry, transportation, agricultural burning, mining and the long range transport of pollutants from the interior. Emissions from industrial facilities include SO_2, NO_X, particulate matter and fluoride. Operations at the Port of Richards Bay include the ore export terminal and the coal terminal, which is a source of particulates. Other activities at the port include the handling of break bulk cargo and petrochemical products which emit particulates and volatile organic compounds (VOCs). Emissions from shipping and port side vehicles and equipment are also sources of SO_2, NO_X, particulates and VOCs.

The effect of these emissions on ambient air quality is determined through ambient air quality monitoring. The Richards Bay Clean Air Association (RBCAA) and the uMhlathuze Municipality (UM) conduct ambient air quality monitoring (Table 6.2) in the area. Monitoring is also done by some industrial facilities. Data collected by the RBCAA is reported monthly to the South African Ambient Air Quality Information System (SAAQIS) which is hosted and managed by SAWS. This data and that is collected by industry are reported quarterly to the UDM's AQO in terms of conditions of their respective AELs.

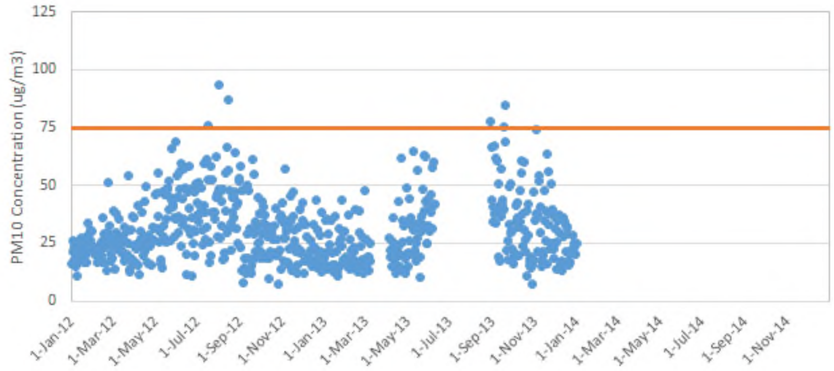
Table 6.2: Ambient air quality monitoring in Richards Bay (www.saaqis.org.za) and UDM

Facility	Sites	Parameters
RBCAA	Arboretum	SO_2, wind, temperature
	Brackenham	PM_{10}, SO_2, wind, temperature
	CBD	PM_{10}, SO_2, TRS, wind, temperature
	Harbour West	SO_2, wind, temperature
	Scorpio	SO_2, wind, temperature, rainfall
	Mtunzini	PM_{10}, wind, temperature
	St Lucia	PM_{10}, wind, temperature
	Richards Bay Airport	Meteorology
	RBM	PM_{10}, wind, temperature
	Esikhaleni	PM_{10}, SO_2, TRS, wind, temperature
UDM	Arboretum	SO_2, NO, NO_2, NO_X, O_3, PM_{10}, $PM_{2.5}$, meteorology
	Brackenham	SO_2, NO, NO_2, NO_X, O_3, PM_{10}, $PM_{2.5}$, meteorology
	Esikhaleni	SO_2, NO, NO_2, NO_X, O_3, PM_{10}, $PM_{2.5}$, meteorology

The RBCAA monitoring stations that are closest to the proposed gas to power plant site are Brakenham, the CBD and Arboretum. These monitoring stations provided a measure of exposure to air pollutants in the closest residential areas. The ambient monitoring data for 2012, 2013 and 2014 at these monitoring stations is used to describe the status of ambient air quality in vicinity of the project site.

The NAAQS provides a tolerance of four (4) exceedances for the daily PM_{10} limit value of 75 $\mu g/m^3$ in a year. The daily average ambient PM_{10} data at Brakenham and the CBD for 2012, 2013 and 2014 are compared with the limit value of the SAAQS in Figure 6.3**.** At Brakenham three exceedances of the limit value were recorded in 2012 and in 2013. No data was recorded in 2014. At the CBD monitoring station there was one exceedance of the daily PM_{10} limit value in 2012 and one in 2013. In 2014 there was non-compliance with the NAAQS with six exceedances of the daily limit value.

There is a clear seasonal trend in the ambient PM_{10} concentrations with higher values in winter than in summer. The exceedances of the limit value of the NAAQS in 2012, 2013 and 2014 all occur in winter. This is expected as a result of more stable winter meteorology and the increase in regional scale contribution to particulate concentrations resulting from long range atmospheric transport of particulates from the interior. It is noteworthy that the background PM_{10} concentrations along the KwaZulu-Natal coast are relatively high as a result of this transport. In eThekwini for example, the background PM_{10} concentrations is about 16 $\mu g/m^3$ (uMoya-NILU, 2015).



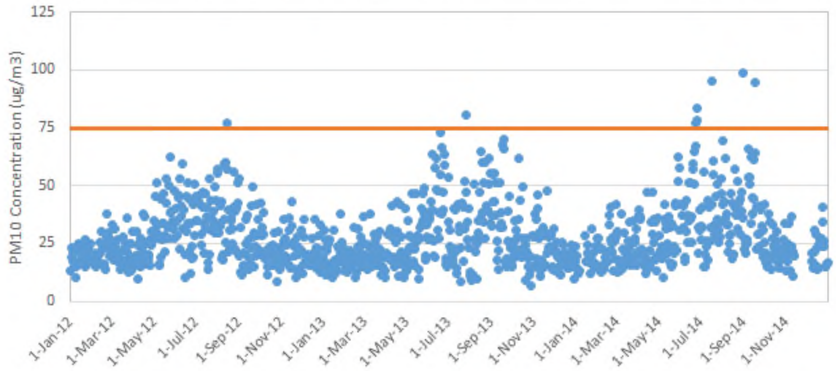


Figure 6.3: Daily average PM_{10} concentrations at Brakenham (top) and the CBD (bottom) for 2012, 2013 and 2014 showing the limit value of the NAAQS of 75 μg/m^3 (data provided by the RBCAA)

The NAAQS provides a tolerance for 88 exceedances of the hourly SO_2 limit value of 350 μg/m^3 in a year. The hourly SO_2 concentrations measured at Brakenham, Arboretum and the CBD in 2012, 2013 and 2014 are compared with the limit value of the NAAQS in Figure 6.4. At all monitoring stations there was compliance with the NAAQS with just one exceedance of the limit value at Brakenham in 2013 and eight exceedances in 2014. As with PM_{10} there is also a clear seasonal cycle in SO_2 concentrations with higher values in winter. This is attributed to the stable winter meteorology that inhibits dispersion.

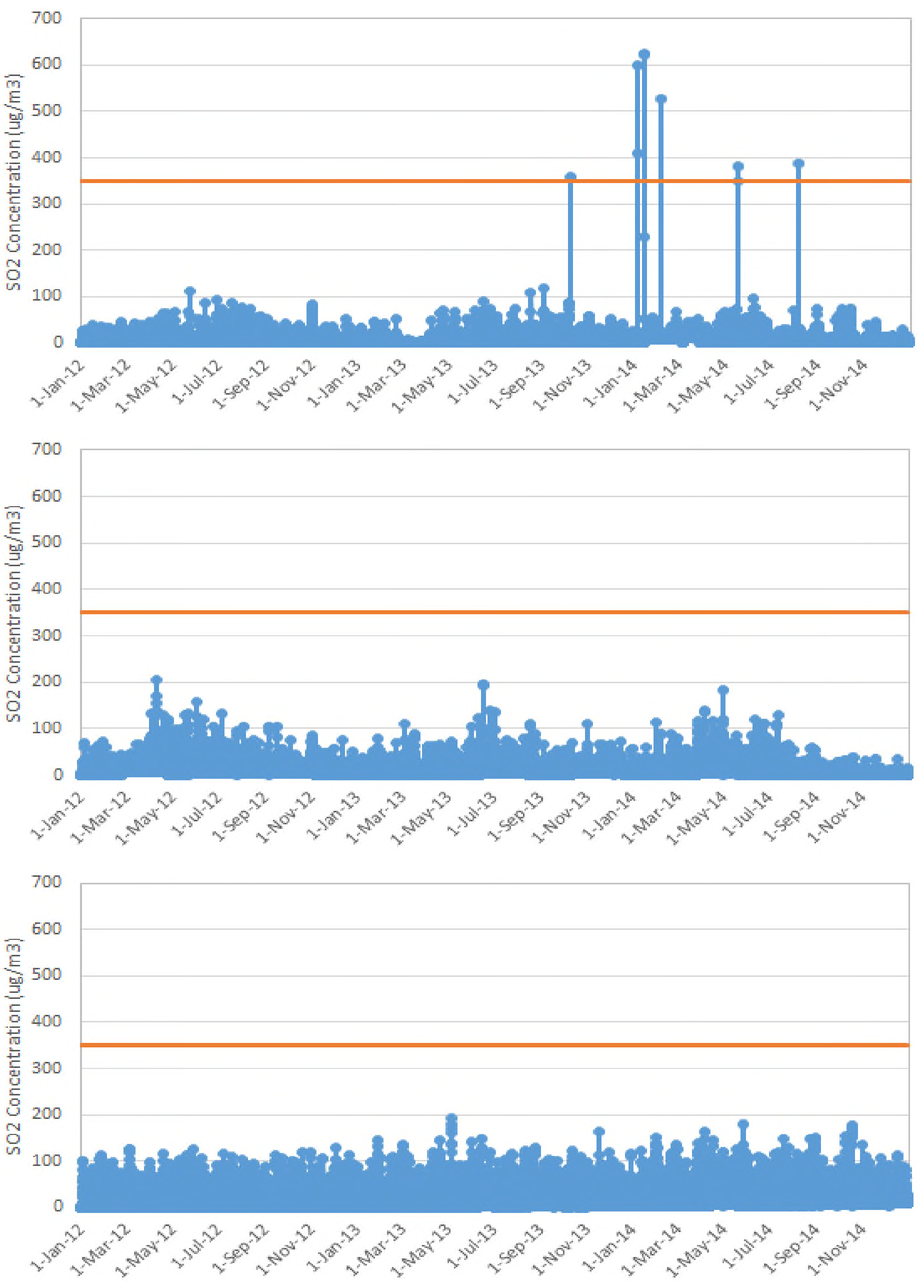


Figure 6.4: Hourly SO_2 concentrations at Brakenham (top), Arboretum (middle) and the CBD (bottom) for 2012, 2013 and 2014 showing the limit value of the NAAQS of 350 µg/m^3 (data provided by the RBCAA)

Brakenham is the closest of uMhlathuze Municipality's three monitoring sites to the proposed gas to power plant site (Table 6.2). Ambient concentrations of SO_2 and NO_2 measured at Arboretum are well below the respective NAAQS in 2015 (Figure 6.5).

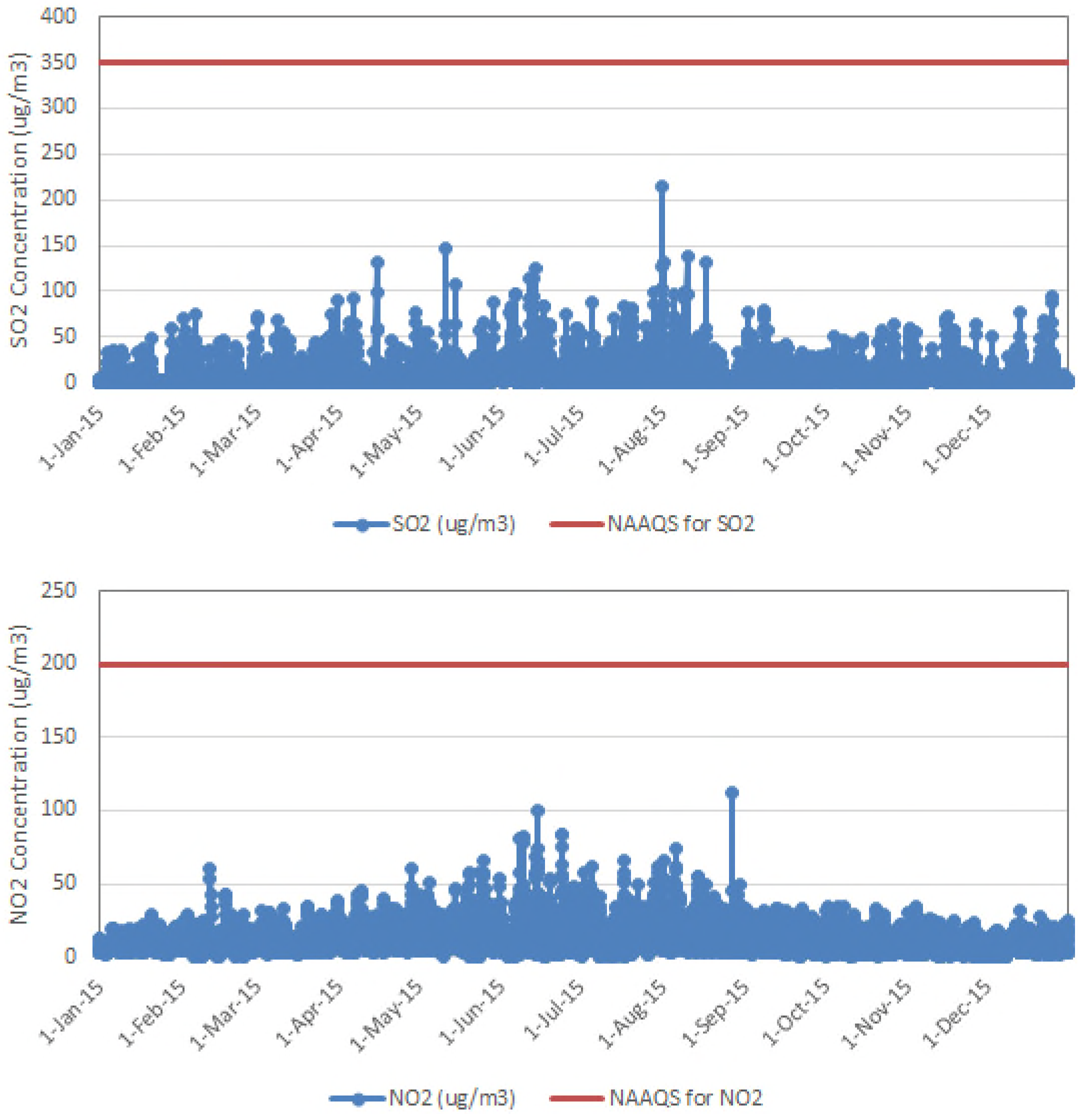


Figure 6.5: Ambient SO_2 (top) and NO_2 (bottom) concentrations at Arboretum in ug/m^3 (data provided by uMhlathuze Municipality)

7. DISPERSION MODELLING METHODOLOGY

The approach to the dispersion modelling in this assessment is based on the requirements of the DEA regulations regarding air dispersion modelling (DEA, 2014). The dispersion modelling approach for proposed gas to power plant is provided here.

7.1 Models used

A number of models with different features are available for air dispersion studies. The selection of the most appropriate model for an air quality assessment needs to consider the complexity of the problem and factors such as the nature of the development and its sources, the physical and chemical characteristics of the emitted pollutants and the location of the sources.

This assessment is considered to be a Level 2 assessment, according to the definition on the air dispersion modelling regulations (DEA, 2014). The CALPUFF suite of models (http://www.src.com/calpuff/calpuff1.htm) were therefore used. The U.S. EPA Guideline of Air Quality Models also provides for the use of CALPUFF on a case-by-case basis for air quality estimates involving complex meteorological flow conditions, where steady-state straight-line transport assumptions are inappropriate.

CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation and removal. CALPUFF can be applied on scales of tens to hundreds of kilometres. It includes algorithms for sub-grid scale effects (such as terrain impingement), as well as, longer range effects (such as pollutant removal due to wet scavenging and dry deposition, chemical transformation, and visibility effects of particulate matter concentrations).

The Air Pollution Model (TAPM) (Hurley, 2000; Hurley *et al*., 2001; Hurley *et al*., 2002) is used to model surface and upper air metrological data for the study domain. TAPM uses global gridded synoptic-scale meteorological data with observed surface data to simulate surface and upper air meteorology at given locations in the domain, taking the underlying topography and land cover into account. The global gridded data sets that are used are developed from surface and upper air data that are submitted routinely by all meteorological observing stations to the Global Telecommunication System of the World Meteorological Organisation.

TAPM has been used successfully in Australia where it was developed (Hurley, 2000; Hurley *et al*., 2001; Hurley *et al*., 2002), and in South Africa (Raghunandan *et al*., 2007). It is considered to be an ideal tool for modelling applications where meteorological data does not adequately meet requirements for dispersion modelling. TAPM modelled output data is therefore used to augment the site specific surface meteorological data for input to CALPUFF.

7.2 Model parameterisation

In Richards Bay TAPM is set-up in a nested configuration of three domains, centred on the Port of Richards Bay. The outer domain is 480km by 480km with a 24km grid resolution, the middle domain is 240km by 240km with a 12km grid resolution and the inner domain is 60km by 60km with a 3km grid resolution (Figure 7.1). Three years (2012-2014) of hourly observed meteorological data from the SAWS station at the Richards Bay Airport are used to 'nudge' the modelled meteorology towards the observations. The nesting configuration ensures that topographical effects on meteorology are captured and that meteorology is well resolved and characterised across the boundaries of the inner domain. Twenty seven (27) vertical levels are modelled in each nest from 10m to 5 000m, with a finer resolution in the lowest 1 000m. The 27 vertical levels are 10, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, 750, 1000, 1250, 1500, 1750, 2000, 2250, 2500, 3000, 3500, 4000, 4500 and 5000m.

The 3-dimensional TAPM meteorological output on the inner grid includes hourly wind speed and direction, temperature, relative humidity, total solar radiation, net radiation, sensible heat flux, evaporative heat flux, convective velocity scale, precipitation, mixing height, friction velocity and Obukhov length. The spatially and temporally resolved TAPM surface and upper air meteorological data is used as input to the CALPUFF meteorological pre-processor, CALMET.

A CALPUFF modelling domain of 900km^2 is 30km (west-east) by 30km (north-south) and is centred on the Port of Richards Bay (Figure 7.1). It consists of a uniformly spaced receptor grid with 0.25km spacing, giving 14 400 grid cells (120 X 120 grid cells).

The topographical and land use data for the respective TAPM modelling domains is obtained from the dataset accompanying the CSIRO's TAPM modelling package. This dataset includes global terrain elevation and land use classification data on a longitude/latitude grid at 30-second grid spacing from the US Geological Survey, Earth Resources Observation Systems (EROS) Data Centre Distributed Active Archive Centre (EDC DAAC).

The land use data for CALMET is based on the Global Land Cover Characterisation (GLCC) Version 2 dataset, which has a horizontal grid spacing of 30 arc-seconds (~1 km resolution). The digital terrain data is based on the Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global elevation data. It was collected during the Shuttle Radar Topography Mission and has a horizontal grid spacing of 1 arc-second (~30m resolution).

The parameterisation of key variables that are applied in CALMET and CALPUFF are indicated in Table 7.1 and Table 7.2.

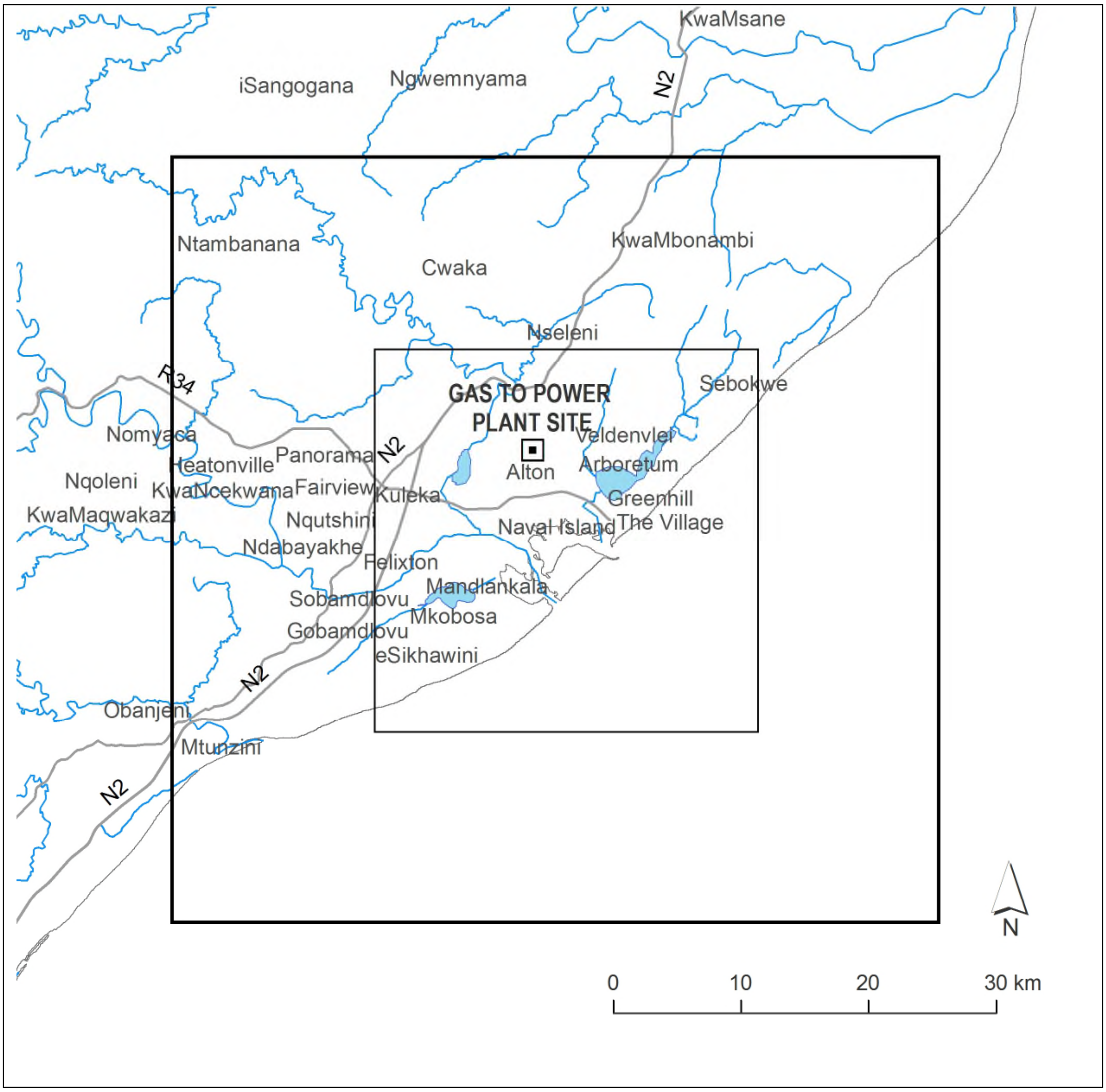


Figure 7.1: TAPM and CALPUFF modelling domains for the proposed Gas to Power Plant Project

Table 7.1: Parameterisation of key variables for CALMET

Parameter	Model value
12 vertical cell face heights (m)	0, 20, 40, 80, 160, 320, 640, 1000, 1500, 2000, 2500, 3000, 4000
Coriolis parameter (per second)	0.0001
Empirical constants for mixing height equation	Neutral, mechanical: 1.41 Convective: 0.15 Stable: 2400 Overwater, mechanical: 0.12
Minimum potential temperature lapse rate (K/m)	0.001
Depth of layer above convective	200

Parameter	Model value
mixing height through which lapse rate is computed (m)	
Wind field model	Diagnostic wind module
Surface wind extrapolation	Similarity theory
Restrictions on extrapolation of surface data	No extrapolation as modelled upper air data field is applied
Radius of influence of terrain features (km)	5
Radius of influence of surface stations (km)	Not used as continuous surface data field is applied

Table 7.2: Parameterisation of key variables for CALPUFF

Parameter	Model value
Chemical transformation	Default NO_2 conversion factor of 0.8 is applied (DEA, 2014).
Wind speed profile	Rural
Calm conditions	Wind speed < 0.5 m/s
Plume rise	Transitional plume rise, stack tip downwash, and partial plume penetration is modelled
Dispersion	CALPUFF used in PUFF mode
Dispersion option	Dispersion coefficients use turbulence computed from micrometeorology
Terrain adjustment method	Partial plume path adjustment

7.3 Model accuracy

Air quality models attempt to predict ambient concentrations based on "known" or measured parameters, such as wind speed, temperature profiles, solar radiation and emissions. There are however, variations in the parameters that are not measured, the so-called "unknown" parameters as well as unresolved details of atmospheric turbulent flow. Variations in these "unknown" parameters can result in deviations of the predicted concentrations of the same event, even though the "known" parameters are fixed.

There are also "reducible" uncertainties that result from inaccuracies in the model, errors in input values and errors in the measured concentrations. These might include poor quality or unrepresentative meteorological, geophysical and source emission data, errors in the measured concentrations that are used to compare with model predictions and inadequate model physics and formulation used to predict the concentrations. "Reducible" uncertainties can be controlled or minimised. This is achieved by making use of the most appropriate input data, preparing the input files correctly, checking and re-checking for errors, correcting for odd model behaviour, ensuring that the errors in the measured data are minimised and applying appropriate model physics.

Models recommended in the DEA regulations regarding air dispersion modelling (DEA, 2014) have been evaluated using a range of modelling test kits (http://www.epa.gov./scram001). It is therefore not mandatory to perform any modelling evaluations. Rather the accuracy of the modelling in this assessment is enhanced by every effort to minimise the "reducible" uncertainties in input data and model parameterisation.

For the proposed gas to power plant, the reducible uncertainty in CALMET and CALPUFF is minimised by:

» Using representative quality controlled observed hourly meteorological data to nudge the meteorological processor to the actual values;
» Using 3-years of spatially and temporally continuous surface and upper air meteorological data field for the modelling domain;
» Appropriate parameterisation of both models (Tables 7.1 and 7.2);
» Using representative emission data;
» Applying representative background concentrations to include the contribution of other sources; and
» Using a competent modelling team with considerable experience using CALPUFF.

8. ASSESSMENT OF IMPACTS

The impacts on air quality as a result of construction activities and decommissioning of the proposed gas to power plant, and various operational scenarios are described in this section.

8.1 Construction

Construction work will entail building of new infrastructure and heavy construction work with concrete, steel, piping, etc. Dust emissions during construction result mainly from earth moving activities (scraping, compacting, excavation, grading), movement of construction vehicles and back-fill operations. Dust emissions during decommissioning result from the demolition of structures, earth moving activities (scraping, compacting, excavation, grading), movement of construction vehicles and back-fill operations. All aspects of the construction inherently generate dust, but the movement of construction vehicles on paved and unpaved surfaces at the construction site are generally the largest source of dust. Construction vehicles will be in operation for the duration of the construction and decommissioning. Dust is also easily entrained from exposed areas by wind.

The impact of dust is more of a nuisance nature and does not typically pose a health risk due to its typically coarse size. The impact of dust from the construction and decommissioning activities on air quality is expected to be relatively short lived, i.e.

limited to the duration of the construction or decommissioning. The impacts are also expected to be localised and limited to the area adjacent to the activity.

8.2 Modelled operational scenarios

Two operational scenarios are assessed for the proposed gas to power plant generating the maximum output of 400 MW. These scenarios are:

Scenario 1: Power generation using diesel, which includes stack emissions and fugitive emissions from the diesel storage tanks

Scenario 2: Power generation using LNG, which only includes stack emissions as LNG will be piped in.

Scenario 1 which involves power generation using diesel is a worse case scenario. A scenario for power generation using LNG was not modelled or assessed. Emission factors for LNG can be applied to LPG. This means that results and impacts for LPG will be relatively similar to that of LNG provided that a similar quantity of LPG fuel is used and as long as the maximum sulphur content for the LPG fuel remains the same.

The effects of emissions of these operational scenarios on the existing state of air quality are assessed by adding the predicted concentrations to the existing baseline, i.e. assessing the additive effect.

The 99th percentile predicted ambient SO_2, NO_2 and PM_{10} concentrations from the dispersion modelling for the proposed gas to power plant using diesel and LNG are presented as isopleth maps over the modelling domain. The 99th percentile predicted ambient CO and benzene concentrations from the dispersion modelling are available, but are not presented as isopleth maps due to the values being extremely low when compared to the NAAQS. The DEA (2014) recommends the 99th percentile concentrations for short-term assessment with the NAAQS since the highest predicted ground-level concentrations can be considered outliers due to complex variability of meteorological processes. In addition, the limit value in the NAAQS is the 99th percentile.

The impact assessment then compares the predicted 99th percentile concentrations with the respective ambient air quality standards (limit values and the permitted frequency of exceedance) with consideration of populated areas in the modelling domain.

8.3 Annual and 99th percentile concentrations

The predicted annual average concentration and the 99th percentile concentration at the points of maximum ground-level impact for Actual Emissions are presented in Table 8.1.

Table 8.1: Maximum predicted annual average concentration and the highest 99th percentile concentration at the points of maximum ground-level impact

	SO_2 (µg/m³)	
	Scenario 1: Diesel	**Scenario 2: LNG**
1-hour	7.19	3.43
24-hour	3.01	1.43
Annual	0.25	0.12
	NO_2, uncont. (µg/m³)	
	Scenario 1: Diesel	**Scenario 2: LNG**
1-hour	50.15	18.66
Annual	1.71	0.64
	NO_2, cont^A. (µg/m³)	
	Scenario 1: Diesel	**Scenario 2: LNG**
1-hour	13.68	7.58
Annual	0.47	0.26
	NO_X, cont^B. (µg/m³)	
	Scenario 1: Diesel	**Scenario 2: LNG**
1-hour	No data	5.77
Annual	No data	0.20
	PM_{10} (µg/m³)	
	Scenario 1: Diesel	**Scenario 2: LNG**
24-hour	0.36	0.20
Annual	0.03	0.02
	CO, uncont. (µg/m³)	
	Scenario 1: Diesel	**Scenario 2: LNG**
1-hour	0.24	5.98
8-hr mean	0.19	4.77
	Benzene (µg/m³)	
	Scenario 1: Diesel	**Scenario 2: LNG**
Annual	0.00137	0.00133

Notes:

uncont.	Uncontrolled ambient concentrations
uncont.	Controlled ambient concentrations
A	NO_X control mechanism – Water-Steam Injection
B	NO_X control mechanism – Lean-Premix

8.3.1 Predicted SO_2 concentrations

The predicted 99th percentile 1-hour and 24-hour SO_2 concentrations for Scenario 1 (diesel) and Scenario 2 (LNG) are presented as isopleths in Figure 8.1 and Figure 8.2 respectively, and compared with the NAAQS of 350 µg/m³ and 125 µg/m³ respectively.

Predicted annual average SO_2 concentrations are also presented as isopleths in Figure 8.3, and compared to the NAAQS of 50 µg/m^3.

1-hour SO_2 (Figure 8.1)

The 99th percentile of the predicted 1-hour SO_2 concentrations are well below the NAAQS of 350 µg/m^3 for Scenario 1 and Scenario 2, with a maximum concentration of 7.19 µg/m^3 and 3.43 µg/m^3 respectively.

24-hour SO_2 (Figure 8.2)

The 99th percentile of the predicted 24-hour SO_2 concentrations are well below the NAAQS of 125 µg/m^3 for Scenario 1 and Scenario 2, with a maximum concentration of 3.01 µg/m^3 and 1.43 µg/m^3 respectively.

The 24-hour WHO ambient air quality guideline of 20 µg/m^3 is more stringent than the NAAQS of 125 µg/m^3. The 99th percentile of the predicted 24-hour SO_2 concentrations still remains well below the WHO ambient air quality guideline for Scenario 1 and Scenario 2.

Annual average SO_2 (Figure 8.3)

The predicted annual average SO_2 concentrations are well below the annual average NAAQS of 50 µg/m^3 for Scenario 1 and Scenario 2, with a maximum concentration of 0.25 µg/m^3 and 0.12 µg/m^3 respectively.

For all averaging periods, the highest concentrations in each scenario are located close to the proposed development site. No exceedance of the NAAQS is predicted within the proposed development site or in residential areas around the site. The predicted SO_2 concentrations therefore comply with the NAAQS in the ambient environment. The SO_2 concentrations predicted in Scenario 2 are lower than Scenario 1. The resultant SO_2 concentration for each scenario is directly related to the sulphur content of the fuel used, with very low sulphur in diesel (Scenario 1), and even lower sulphur in LNG (Scenario 2).

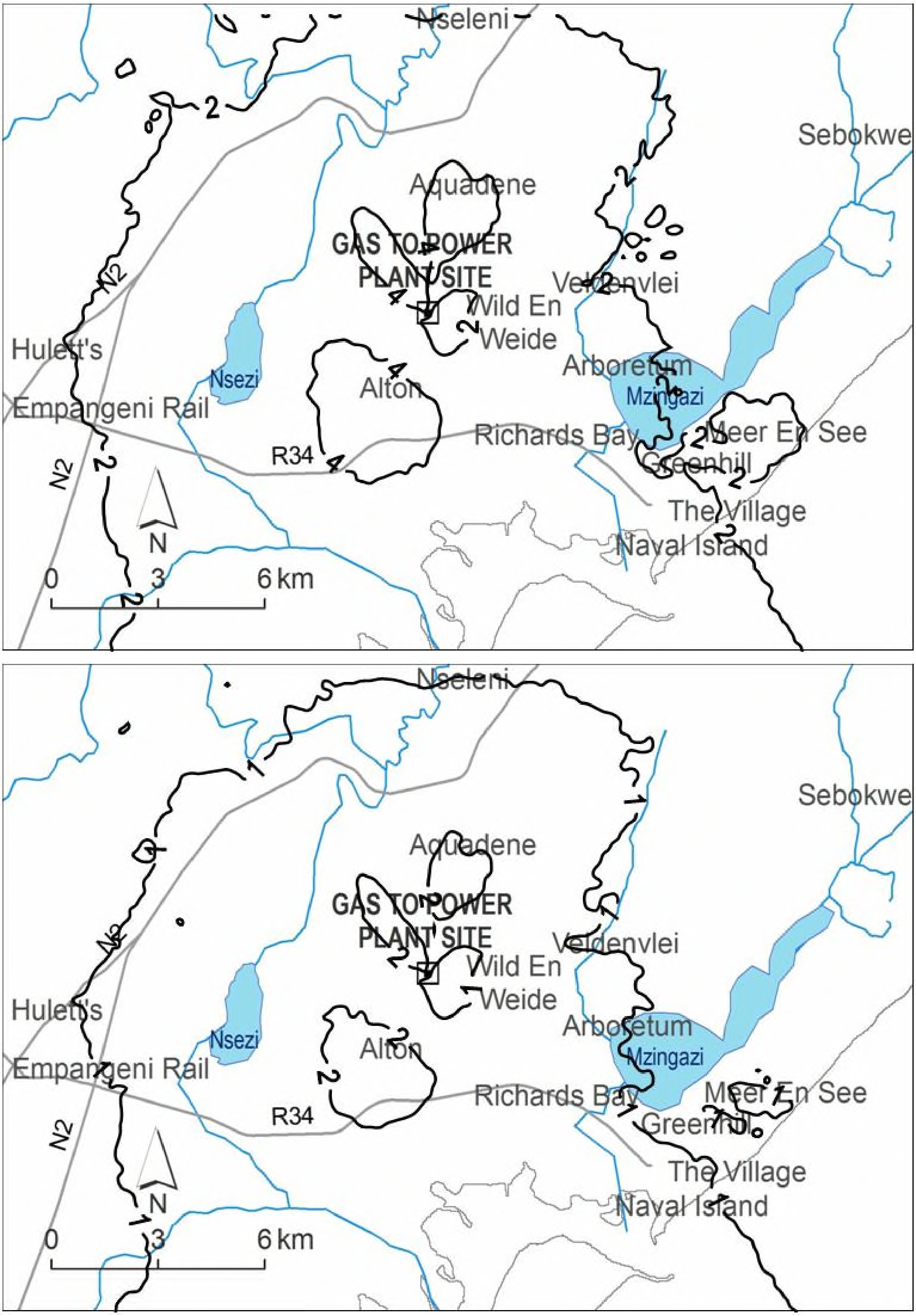


Figure 8.1: 99th percentile of the predicted 1-hour SO_2 concentrations (μg/m^3) resulting from emissions from the proposed gas to power plant for Scenario 1 (top) and Scenario 2 (bottom).

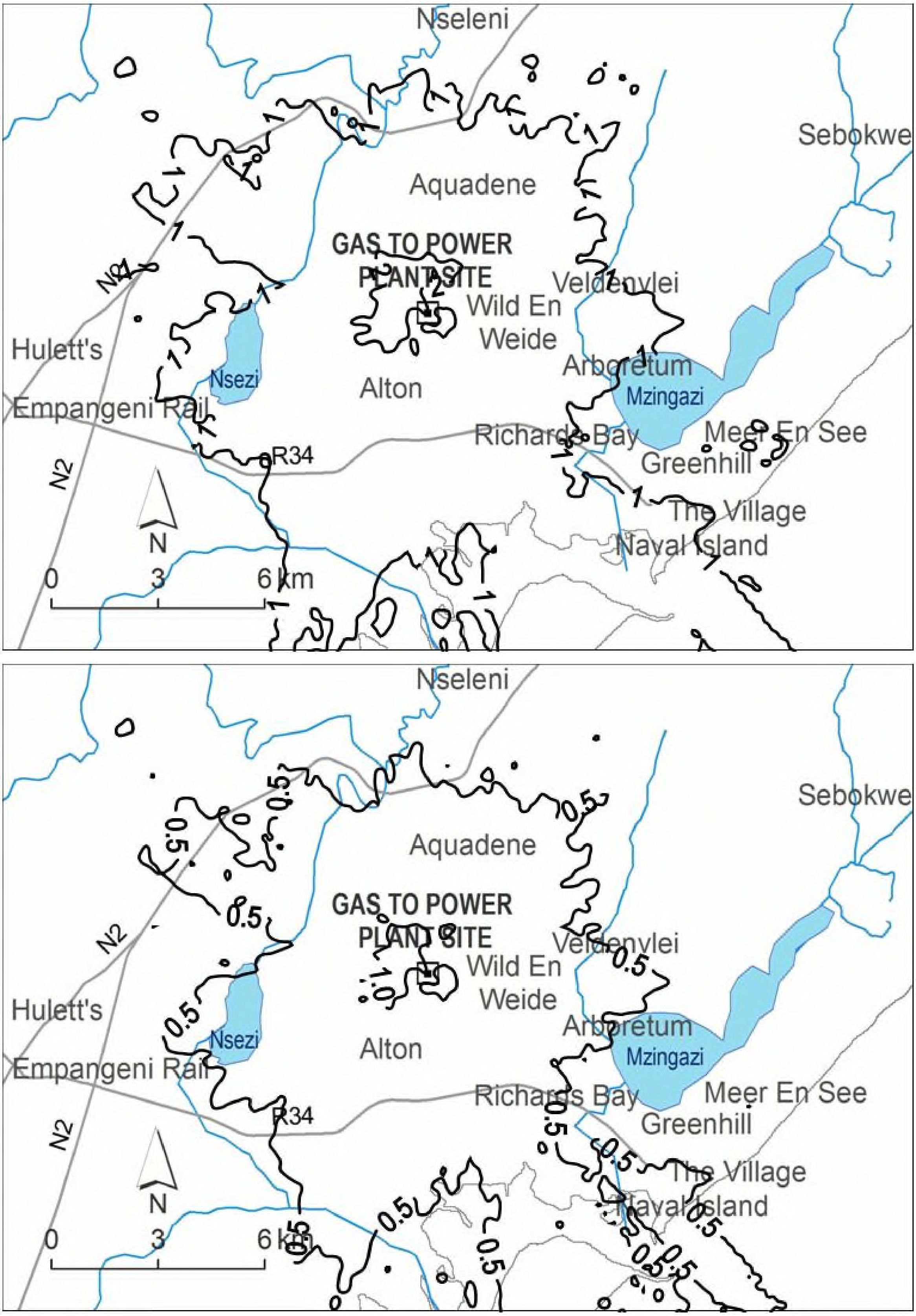


Figure 8.2: 99th percentile of the predicted 24-hour SO_2 concentrations (µg/m^3) resulting from emissions from the proposed gas to power plant for Scenario 1 (top) and Scenario 2 (bottom)

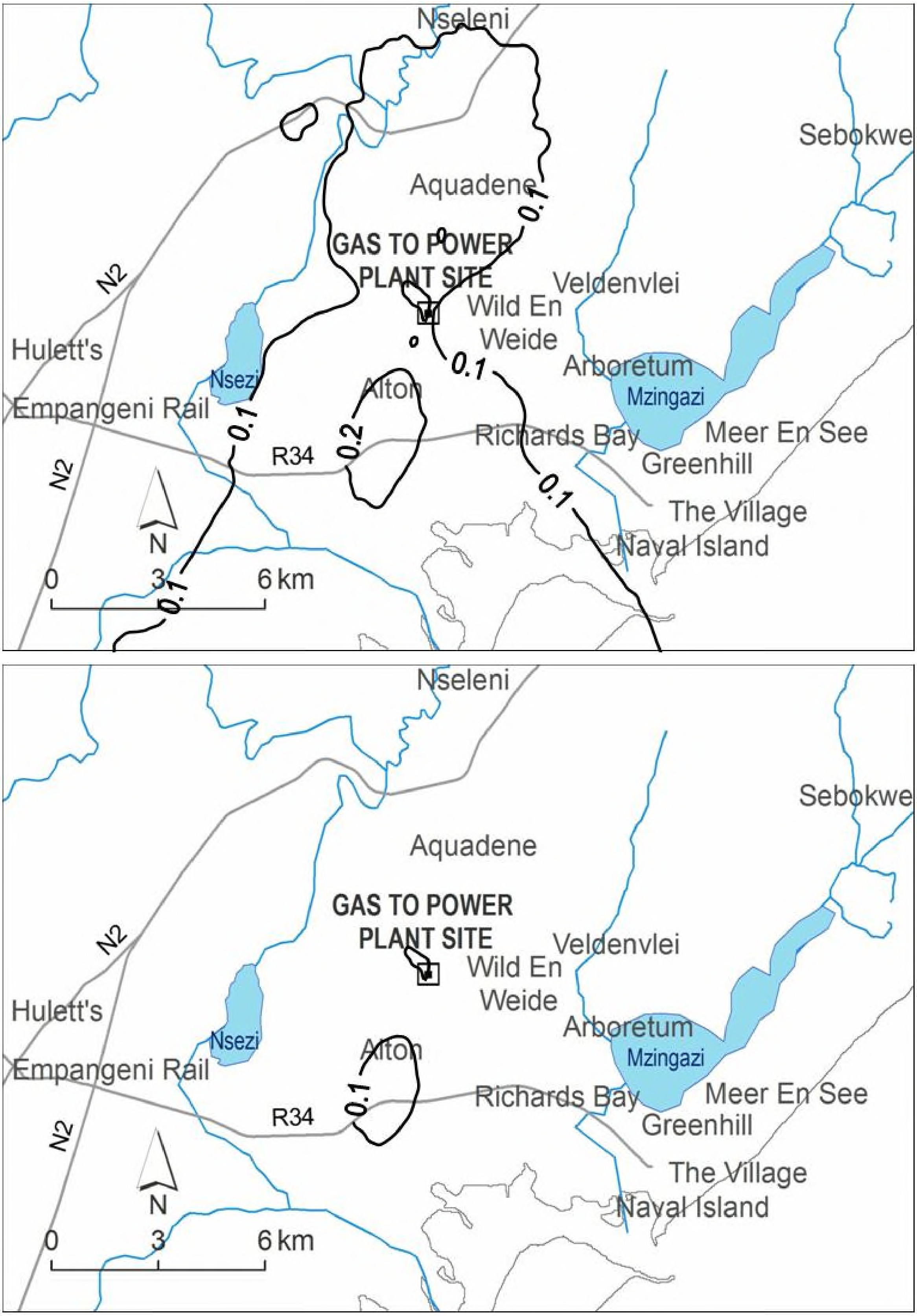


Figure 8.3: Predicted annual average SO_2 concentrations (µg/m^3) resulting from emissions from the proposed gas to power plant for Scenario 1 (top) and Scenario 2 (bottom)

8.3.2 Predicted NO_2 concentrations

Ambient concentrations of NO_2 are predicted from emissions of NO_X (NO_X=NO+NO_2). Emissions from combustion processes are dominated by NO_2, and furthermore, NO converts rapidly to NO_2 in the presence of N in the atmosphere. Comparing the predicted concentrations of NO_2 to the NAAQS is therefore conservative.

The predicted 99th percentile 1-hour NO_2 concentrations for Scenario 1 (diesel) and Scenario 2 (LNG) are presented as isopleths in Figure 8.4 for the uncontrolled NO_X emission case, Figure 8.5 for the controlled NO_X emission case using the water-steam injection mechanism and Figure 8.6 for the controlled NO_X emission case using the lean-premix mechanism; and compared with the NAAQS of 200 µg/m^3.

Predicted annual average NO_2 concentrations for Scenario 1 and Scenario 2 are also presented as isopleths in Figure 8.7 for the uncontrolled NO_X emission case, Figure 8.8 for the controlled NO_X emission case using the water-steam injection mechanism and Figure 8.9 for the controlled NO_X emission case using the lean-premix mechanism; and compared with the NAAQS of 40 µg/m^3.

1-hour NO_2 (Figure 8.3 – 8.6)

In the case of uncontrolled NO_X emissions, the 99th percentile of the predicted 1-hour NO_2 concentrations are well below the NAAQS of 200 µg/m^3 for Scenario 1 and Scenario 2, with a maximum concentration of 50.15 µg/m^3 and 18.66 µg/m^3 respectively.

In the case of the controlled NO_X emission case using the water-steam injection mechanism, the 99th percentile of the predicted 1-hour NO_2 concentrations are also well below the NAAQS of 200 µg/m^3 for Scenario 1 and Scenario 2, with a maximum concentration of 13.68 µg/m^3 and 7.58 µg/m^3 respectively.

In the case of the controlled NO_X emission case using the lean-premix mechanism, the 99th percentile of the predicted 1-hour NO_2 concentrations are again well below the NAAQS of 200 µg/m^3 for Scenario 2, with a maximum concentration of 5.77 µg/m^3. The lean-premix control mechanism for Scenario 1 is not available.

The WHO ambient air quality 1-hour guideline of 200 µg/m^3 is equivalent to the NAAQS of 200 µg/m^3. The predicted 1-hour NO_2 concentrations are therefore well below the WHO guideline for the uncontrolled and two controlled NO_X emission cases in Scenario 1 and Scenario 2.

Annual average NO_2 (Figure 8.7 – 8.9)

In the case of uncontrolled NO_X emissions, the annual average NO_2 concentrations are well below the NAAQS of 40 μg/m^3 for Scenario 1 and Scenario 2, with a maximum concentration of 1.71 μg/m^3 and 0.64 μg/m^3 respectively.

In the case of the controlled NO_X emission case using the water-steam injection mechanism, the annual average NO_2 concentrations are also well below the NAAQS of 40 μg/m^3 for Scenario 1 and Scenario 2, with a maximum concentration of 0.47 μg/m^3 and 0.26 μg/m^3 respectively.

In the case of the controlled NO_X emission case using the lean-premix mechanism, the annual average NO_2 concentrations are again well below the NAAQS of 40 μg/m^3 for Scenario 2, with a maximum concentration of 0.20 μg/m^3. The lean-premix control mechanism for Scenario 1 is not available.

The WHO ambient air quality annual average guideline of 40 μg/m^3 is equivalent to the NAAQS of 40 μg/m^3. The predicted annual average NO_2 concentrations are therefore well below the WHO guideline for the uncontrolled and two controlled NO_X emission cases in Scenario 1 and Scenario 2.

For all averaging periods, the highest concentrations in each scenario are located close to the proposed development site. No exceedance of the NAAQS is predicted within the proposed development site or in residential areas around the site. The predicted NO_2 concentrations therefore comply with the NAAQS in the ambient environment. LNG is a cleaner fuel than diesel; hence, NO_2 concentrations predicted in Scenario 2 are significantly lower than Scenario 1. This assessment has demonstrated that the use of NO_X control mechanisms has a potential to significantly reduce the amount of NO_2 released into the atmosphere from the gas to power plant under uncontrolled operating conditions. It is evident that NO_2 ambient concentrations are predicted to be low without the use of control mechanisms.

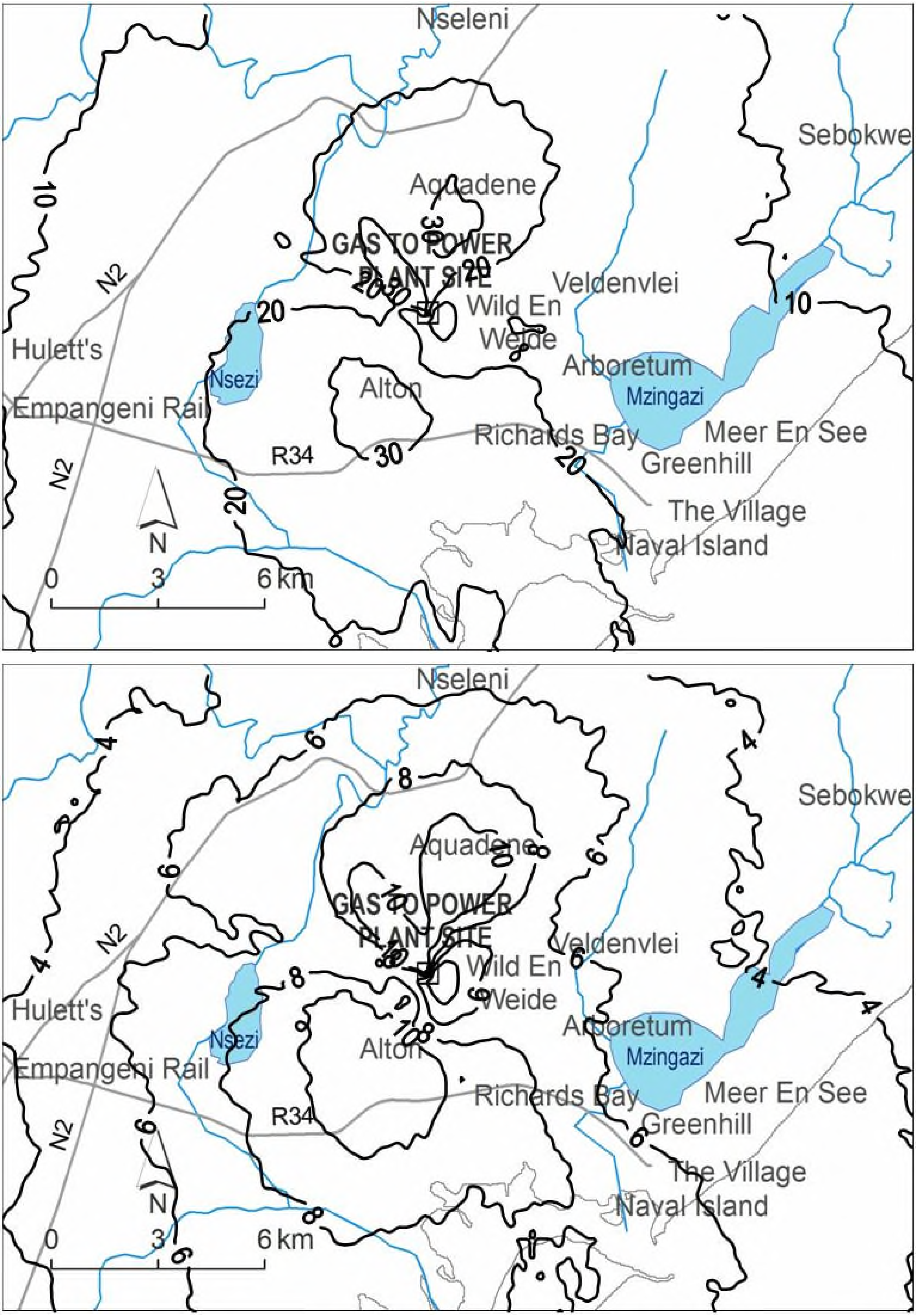


Figure 8.4: 99th percentile of the predicted 1-hour NO_2 concentrations ($\mu g/m^3$) resulting from uncontrolled emissions from the proposed gas to power plant for Scenario 1 (top) and Scenario 2 (bottom)

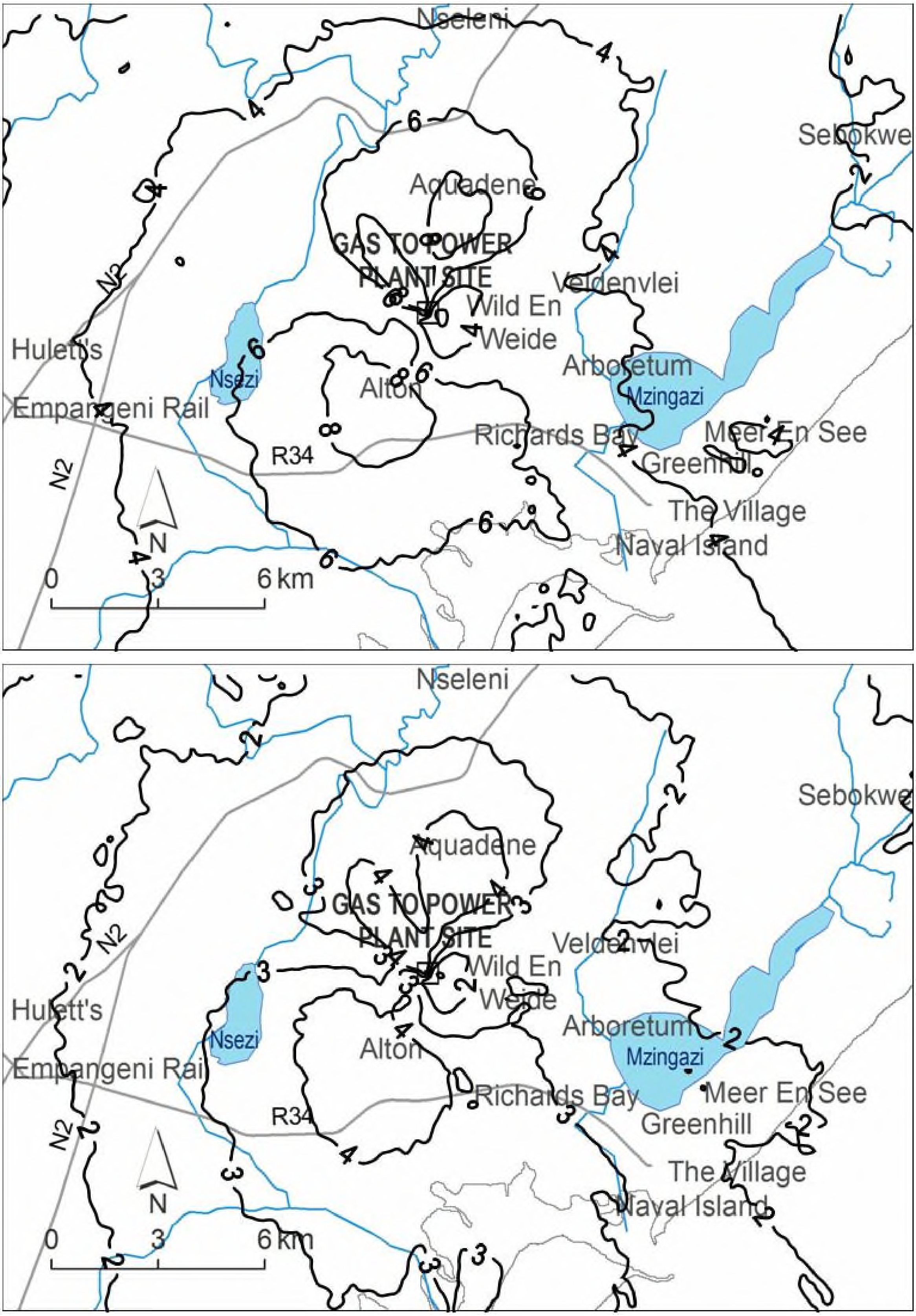
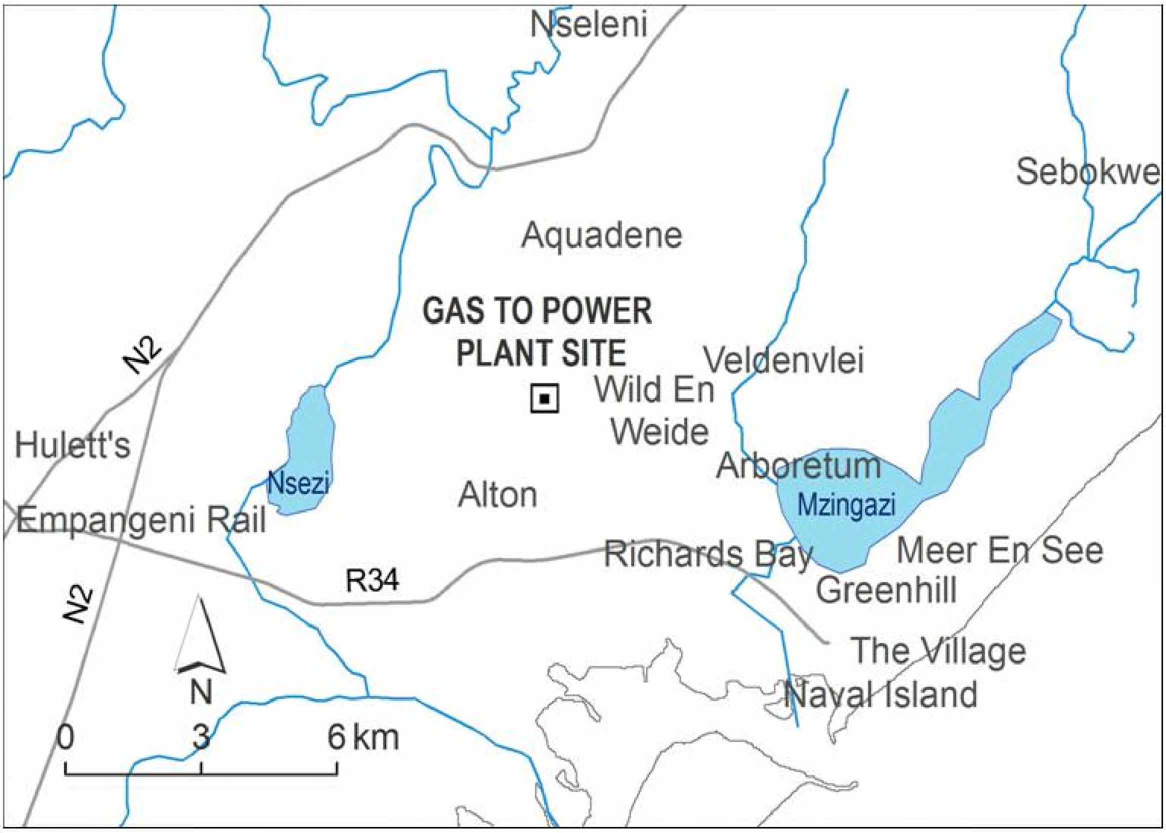


Figure 8.5: 99th percentile of the predicted 1-hour NO_2 concentrations ($\mu g/m^3$) resulting from controlled emissions (water-steam injection mechanism) from the proposed gas to power plant for Scenario 1 (top) and Scenario 2 (bottom)



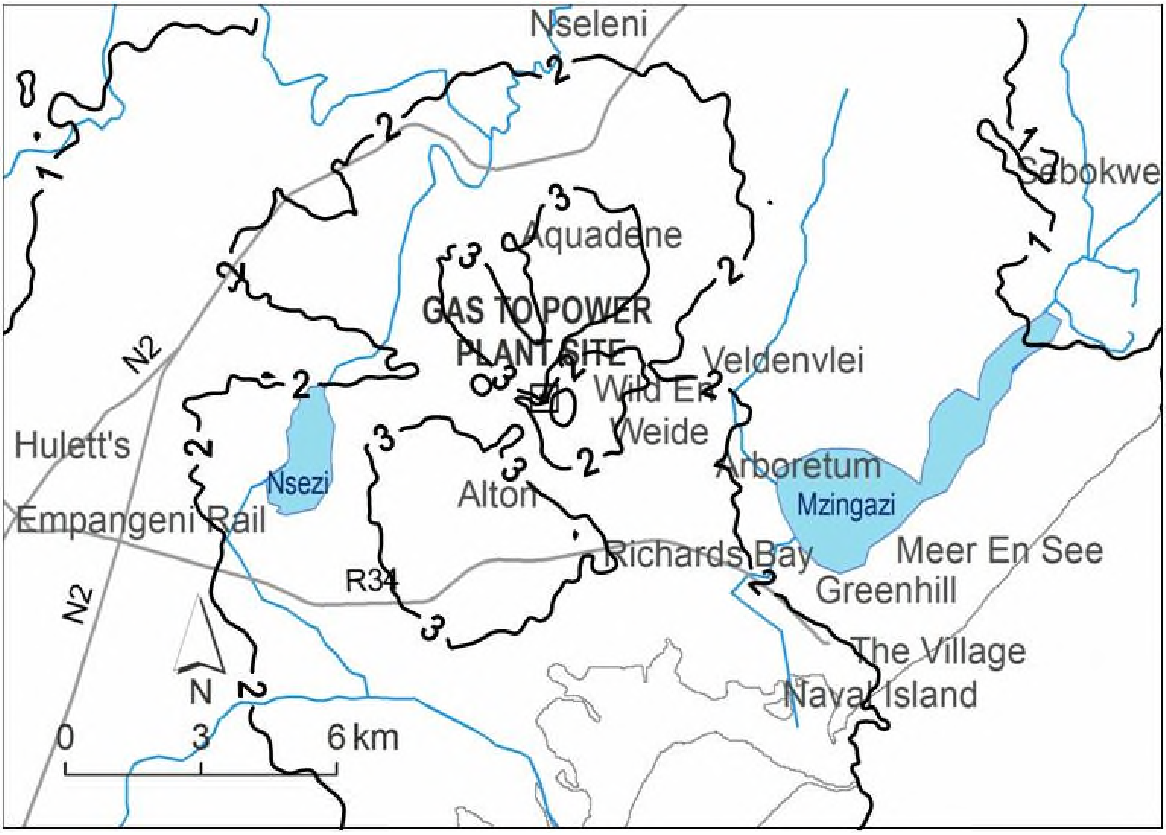


Figure 8.6: 99th percentile of the predicted 1-hour NO_2 concentrations ($\mu g/m^3$) resulting from controlled emissions (lean-premix mechanism) from the proposed gas to power plant for Scenario 1 (top) and Scenario 2 (bottom)

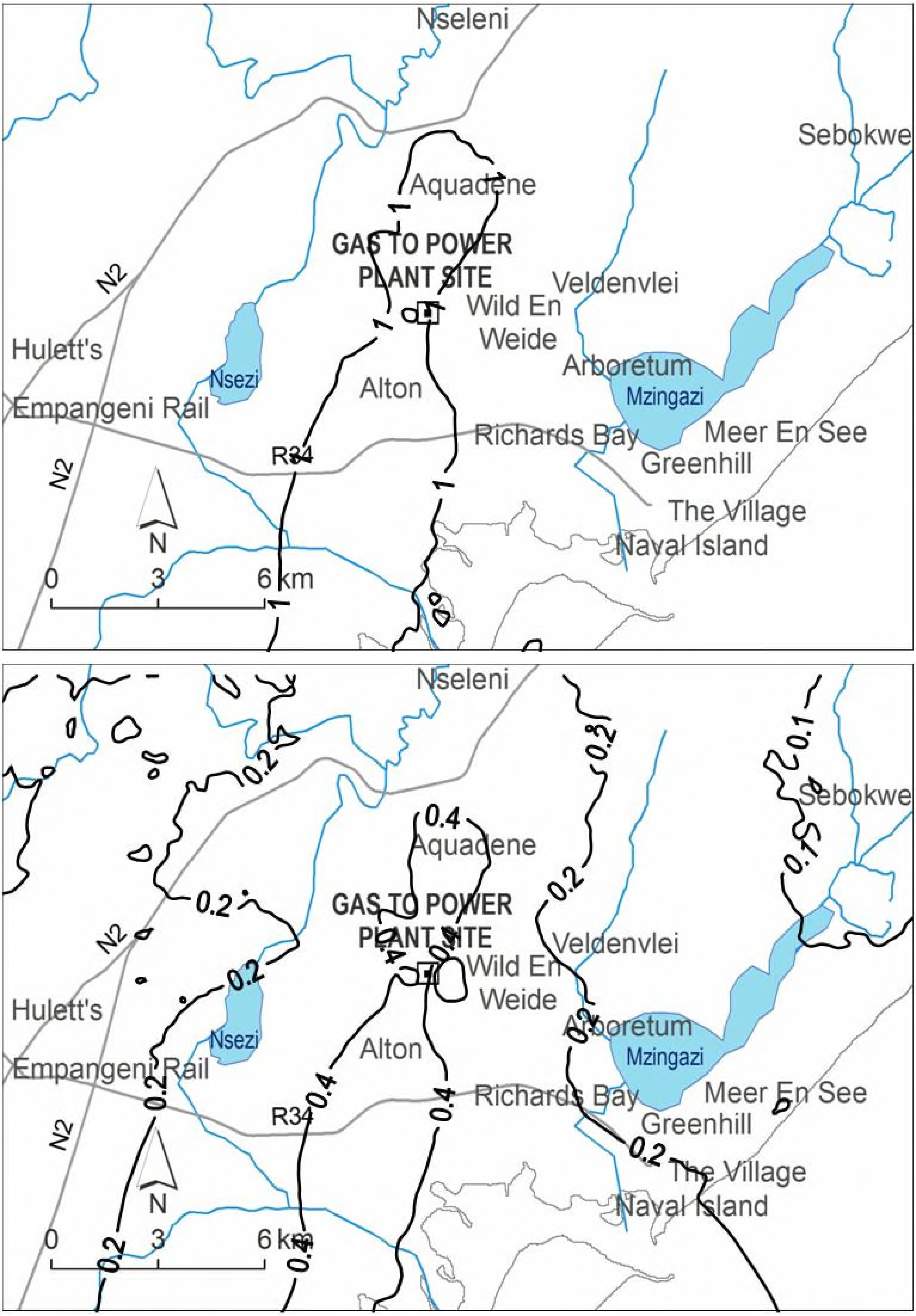
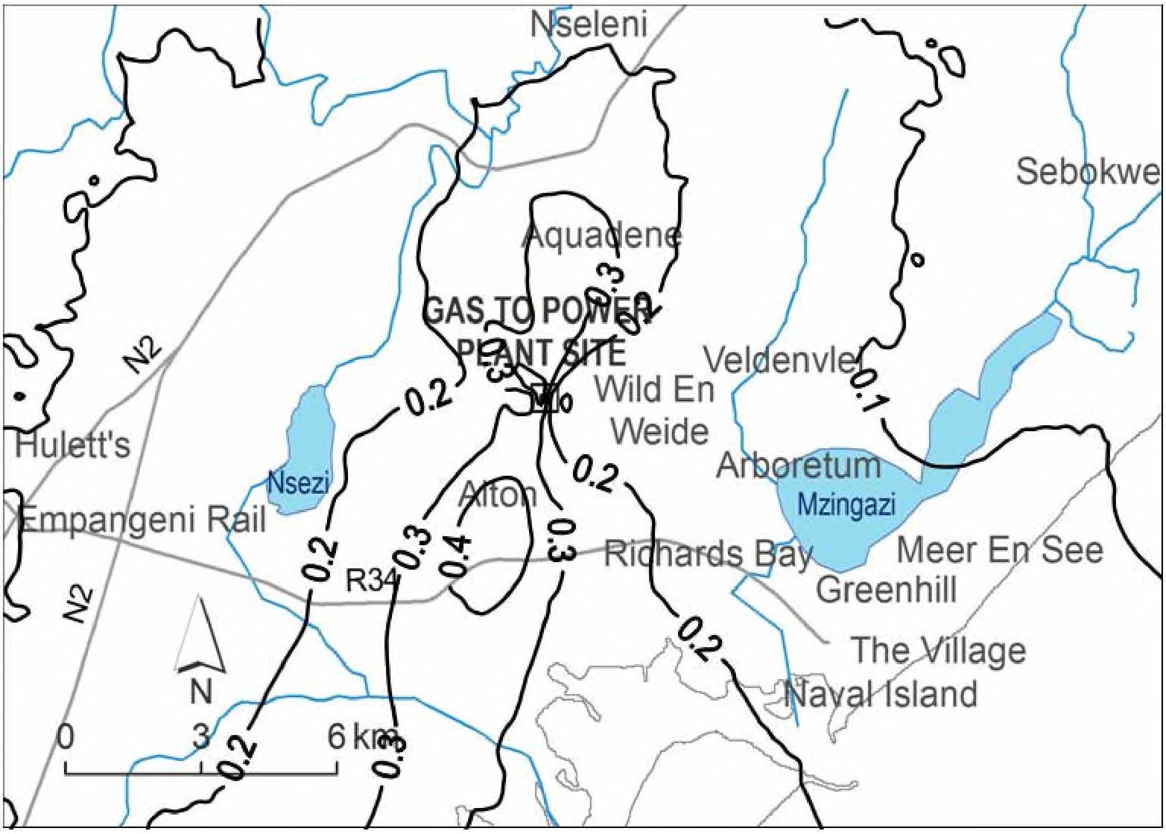


Figure 8.7: Predicted annual average NO_2 concentrations (µg/m^3) resulting from uncontrolled emissions from the proposed gas to power plant for Scenario 1 (top) and Scenario 2 (bottom)



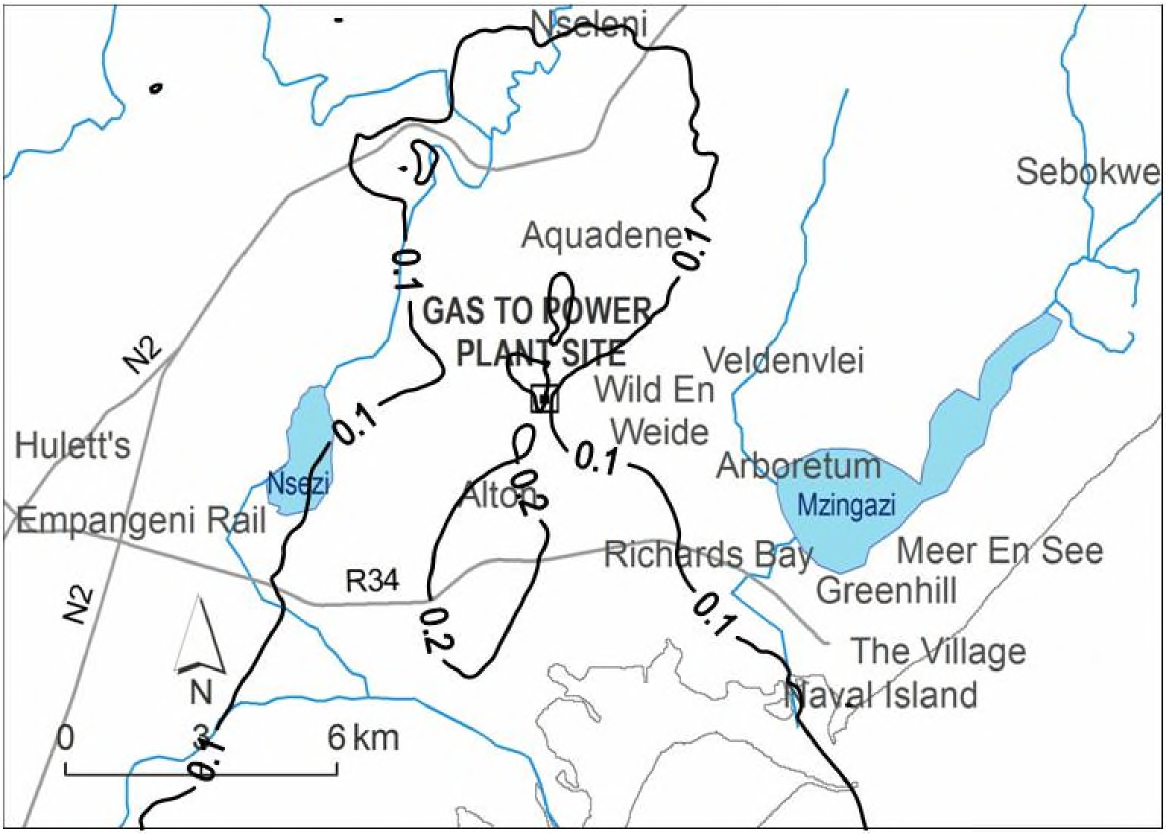


Figure 8.8: Predicted annual average NO_2 concentrations (μg/m^3) resulting from controlled emissions (water-steam injection mechanism) from the proposed gas to power plant for Scenario 1 (top) and Scenario 2 (bottom)

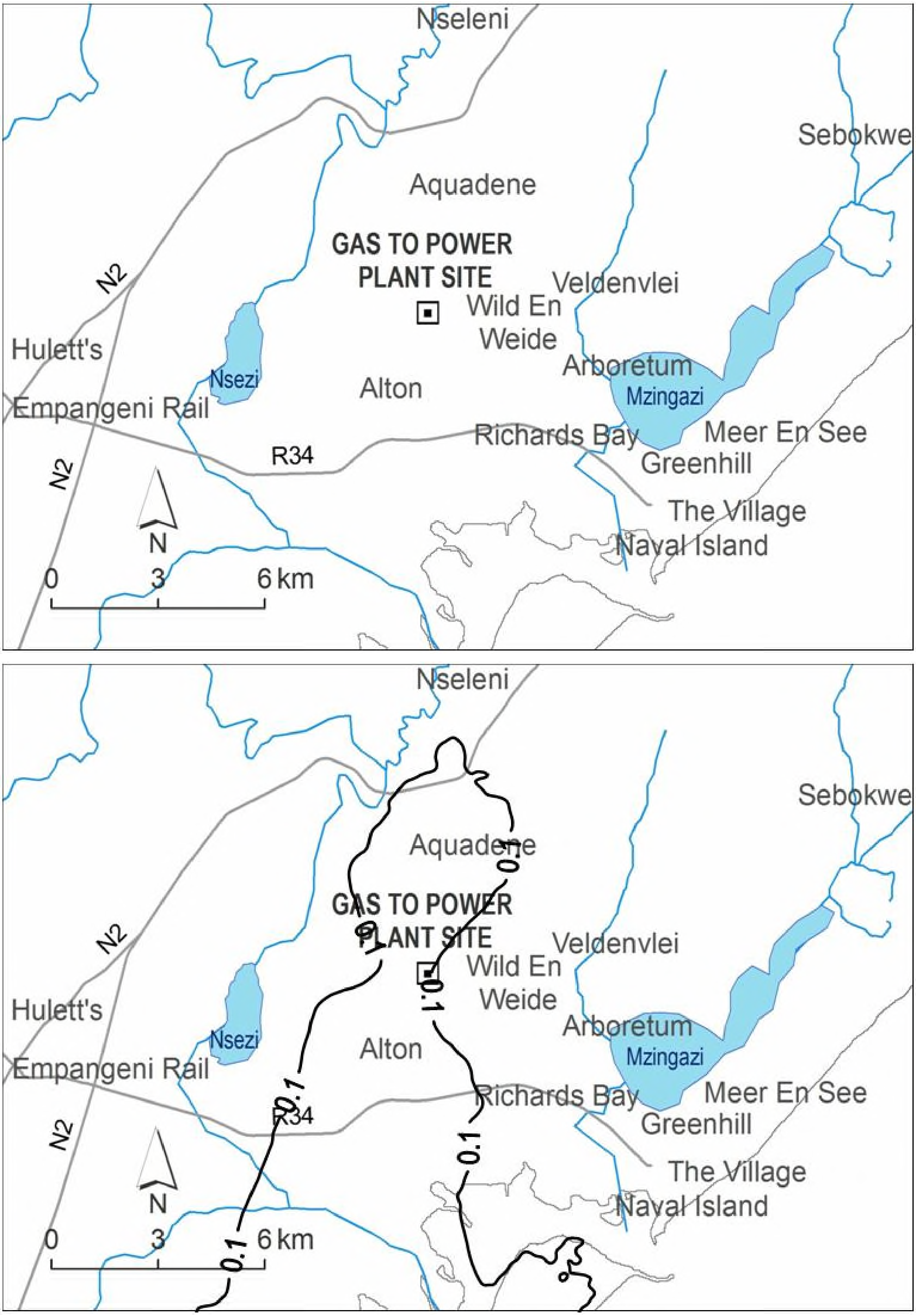


Figure 8.9: Predicted annual average NO_2 concentrations (µg/m^3) resulting from controlled emissions (lean-premix mechanism) from the proposed gas to power plant for Scenario 1 (top) and Scenario 2 (bottom)

8.3.3 Predicted PM_{10} concentrations

The predicted 99th percentile 24-hour PM_{10} concentrations for Scenario 1 (diesel) and Scenario 2 (LNG) are presented as isopleths in Figure 8.10, and compared with the NAAQS of 75 $\mu g/m^3$. Predicted annual average PM_{10} concentrations for Scenario 1 and Scenario 2 are also presented as isopleths in Figure 8.11, and compared to the NAAQS of 40 $\mu g/m^3$.

24-hour PM_{10} (Figure 8.10)

The 99th percentile of the predicted 24-hour PM_{10} concentrations are well below the NAAQS of 75 $\mu g/m^3$ for Scenario 1 and Scenario 2, with a maximum concentration of 0.36 $\mu g/m^3$ and 0.20 $\mu g/m^3$ respectively.

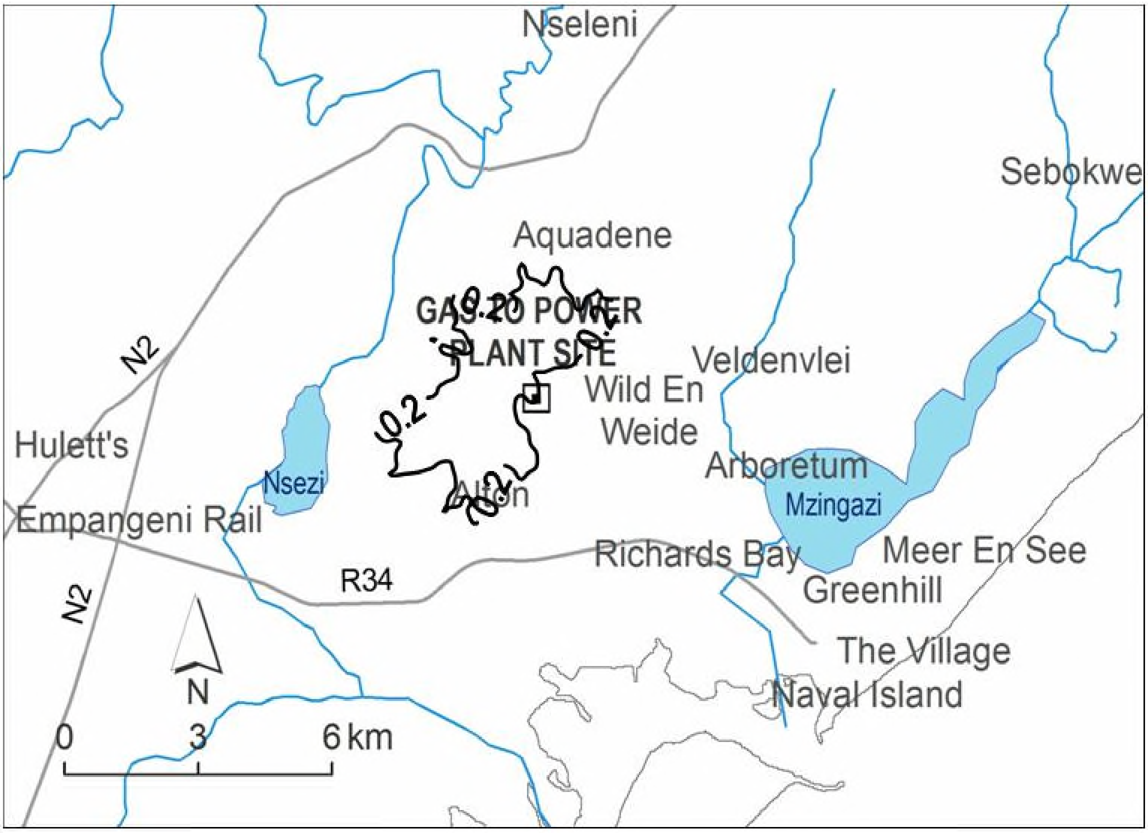
The 24-hour WHO ambient air quality guideline of 50 $\mu g/m^3$ is more stringent than the NAAQS of 75 $\mu g/m^3$. The 99th percentile of the predicted 24-hour PM_{10} concentrations still remains well below the WHO ambient air quality guideline for Scenario 1 and Scenario 2.

Annual average PM_{10} (Figure 8.11)

The predicted annual average PM_{10} concentrations are well below the annual average NAAQS of 40 $\mu g/m^3$ for Scenario 1 and Scenario 2, with a maximum concentration of 0.03 $\mu g/m^3$ and 0.02 $\mu g/m^3$ respectively.

The annual average WHO ambient air quality guideline of 20 $\mu g/m^3$ is more stringent than the NAAQS of 20 $\mu g/m^3$. The 99th percentile of the predicted 24-hour PM_{10} concentrations still remains well below the WHO ambient air quality guideline for Scenario 1 and Scenario 2.

For all averaging periods, the highest concentrations in each scenario are located close to the proposed development site. No exceedance of the NAAQS is predicted within the proposed development site or in residential areas around the site. The predicted PM_{10} concentrations therefore comply with the NAAQS in the ambient environment. LNG is a cleaner fuel than diesel; hence, PM_{10} concentrations predicted in Scenario 2 are significantly lower than Scenario 1.



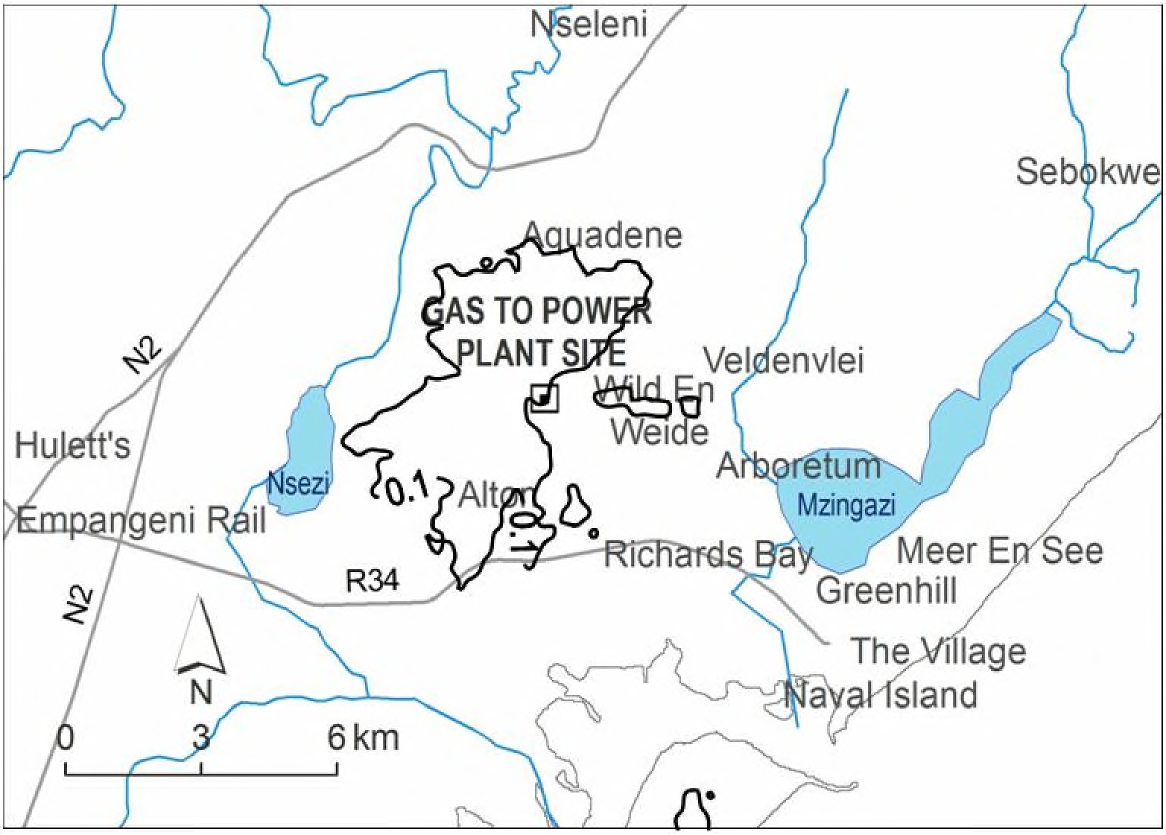


Figure 8.10: 99th percentile of the predicted 24-hour PM_{10} concentrations ($\mu g/m^3$) resulting from emissions from the proposed gas to power plant for Scenario 1 (top) and Scenario 2 (bottom)

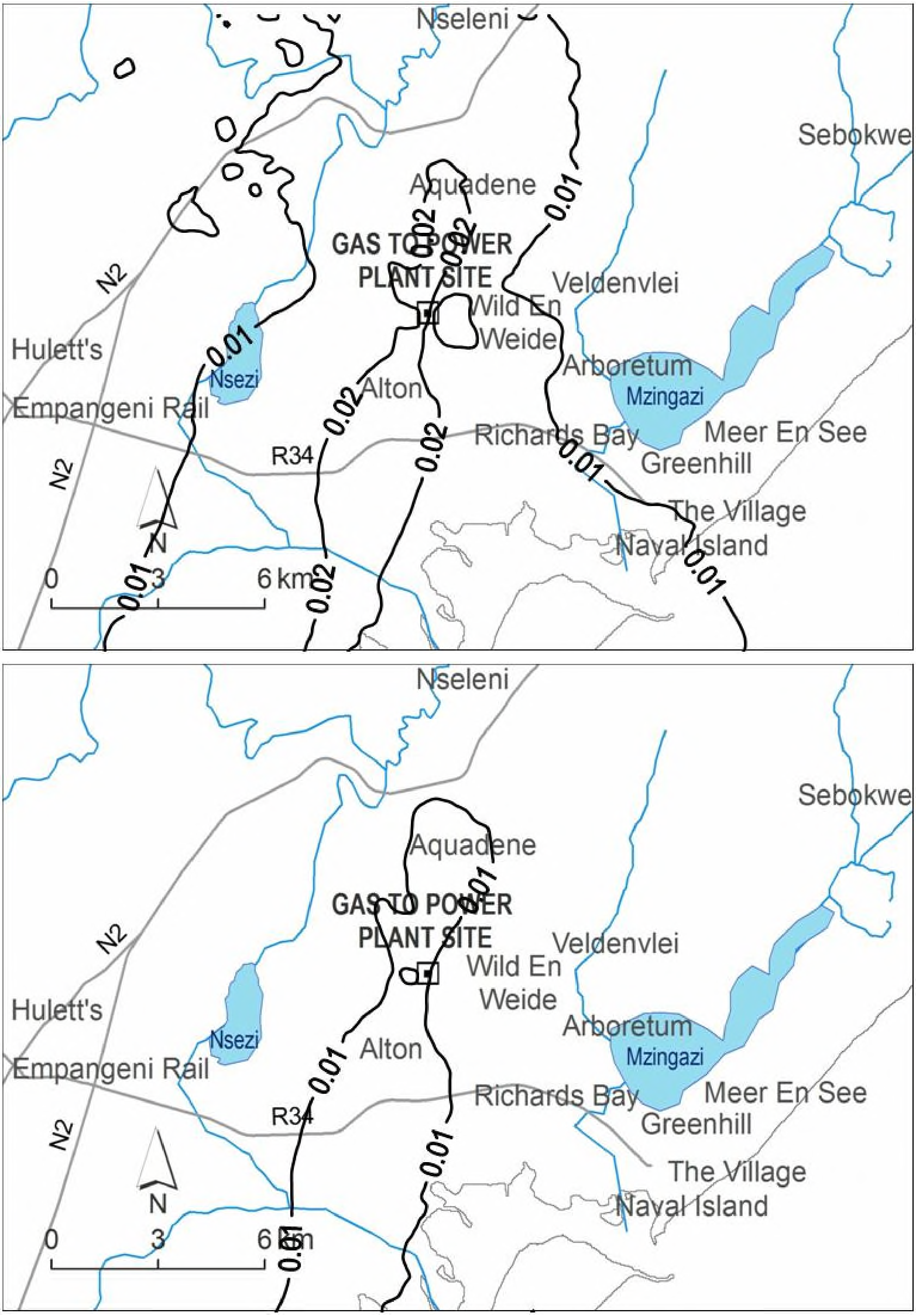


Figure 8.11: Predicted annual average PM_{10} concentrations ($\mu g/m^3$) resulting from emissions from the proposed gas to power plant for Scenario 1 (top) and Scenario 2 (bottom)

8.3.4 Predicted CO concentrations

The 99th percentile of the predicted 1-hour CO concentrations under uncontrolled operating conditions are well below the NAAQS of 30 000 µg/m^3 for Scenario 1 and Scenario 2, with a maximum concentration of 0.24 µg/m^3 and 5.98 µg/m^3 respectively.

The 99th percentile of the predicted 8-hour CO concentrations under uncontrolled operating conditions are well below the NAAQS of 10 000 µg/m^3 for Scenario 1 and Scenario 2, with a maximum concentration of 0.19 µg/m^3 and 4.77 µg/m^3 respectively.

For all averaging periods, the highest concentrations in each scenario are located close to the proposed gas to power plant site. The predicted concentrations are very low and orders of magnitude below the respective NAAQS. No exceedance of the NAAQS is predicted within the proposed gas to power plant site or in residential areas around the site. The predicted CO concentrations therefore comply with the NAAQS in the ambient environment. Although LNG is a cleaner fuel than diesel; the combustion of LNG in gas turbines results in comparatively higher CO concentrations than diesel combustion.

8.3.5 Predicted benzene concentrations

The predicted annual average benzene concentrations are well below the NAAQS of 5 µg/m^3 for Scenario 1 and Scenario 2, with a maximum concentration of 0.00137 µg/m^3 and 0.00133 µg/m^3 respectively.

The highest concentrations in each scenario are located close to the proposed development site. The predicted concentrations are very low and orders of magnitude below the NAAQS. No exceedance of the NAAQS is predicted within the proposed development site or in residential areas around the site. The predicted benzene concentrations therefore comply with the NAAQS in the ambient environment. Although LNG is a cleaner fuel than diesel, the combustion of LNG in gas turbines results in comparatively similar benzene concentrations to the combination of diesel combustion and the handling and storage of diesel in tanks.

9. IMPACT ASSESSMENT

Impacts can generally be categorised as direct, indirect or cumulative. Direct impacts are impacts that are caused directly by the project or activity in isolation of other sources and generally occur at the same time and place as the activity. Indirect impacts are indirect or induced changes that may occur as a result of the activity. These types of impacts include all the potential impacts that do not manifest immediately when the activity is undertaken or which occur at a different place as a result of the activity. Cumulative impacts are impacts that result from the incremental impact of the proposed activity on a common resource when added to the impacts of other past, present or reasonably foreseeable future activities.

9.1 Construction Phase – Direct Impacts

Direct impacts will result from exposure to dust generated from the construction of the proposed gas to power plant. Direct impacts associated with the construction phase are expected to be of short duration and temporary in nature. Indirect impacts during the construction phase are very improbable.

9.1.1 Direct impacts from dust generation during the construction phase

Construction work will entail building of new infrastructure and heavy construction work with concrete, steel, piping, etc. Dust emissions during construction results mainly from earth moving activities (scraping, compacting, excavation, grading), movement of construction vehicles and back-fill operations. All aspects of the construction inherently generate dust, but the movement of construction vehicles on paved and unpaved surfaces at the construction site are generally the largest source of dust. Construction vehicles will be in operation for the duration of the construction. Dust is also easily entrained from exposed areas by wind. The impact of dust is considered to be limited to the site and its immediate surroundings, is more of a temporary nuisance nature and does not typically pose a health risk due to its typically coarse size. Dust emissions will not travel over vast distances, but will most likely settle within 100 m to 1 km of the proposed gas to power plant site. Impact may be experienced in parts of the IDZ Zone 1F, the property on which the site is to be constructed.

Table 9.1: Assessment of direct impacts from dust generation during the construction phase of the proposed gas to power plant

Construction Phase		
Nature: Dust generated during the construction phase has a nuisance impact and negatively affects quality of life by causing soiling, contamination, structural corrosion and damage to precision equipment, machinery and computers.		
	Without mitigation	**With mitigation**
Extent	Local-regional (1)	Local-regional (1)
Duration	Very short term (1)	Very short term (1)
Magnitude	Low (4)	Low (4)
Probability	Highly probable (4)	Improbable (2)
Significance	**Low (24)**	**Low (12)**
Status (positive or negative)	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	N/A
Mitigation measures: » Implement traffic control measures to limit vehicle-entrained dust from unpaved		

roads by limiting vehicle speeds and by restricting traffic volumes. » Limit access to construction site to construction vehicles only. » Loading and unloading bulk construction material should be in areas protected from the wind or carried out in calm conditions. » Loads on vehicles carrying dusty construction materials should be covered. » Vehicles carrying dusty materials should be cleaned before leaving the site. » Unpaved road surfaces should be sprayed with a surfactant to ensure high moisture content which will bind the silt or maintain high moisture content on exposed surfaces and roads by spraying with water. » Stabilise open areas with dust palliative, gravel or similar.
Residual Impacts: No residual impacts are expected.

The impact is expected to be negative, local in extent, temporary in duration (limited to the duration of the construction), of low intensity, and improbable with mitigation measures implemented. The impact is therefore assessed to be of **low** significance to the decision making process with mitigation. This impact is expected to be direct with no residual impacts with mitigation. Indirect impacts during the construction phase are very improbable.

Although the significance of impacts during construction is low, a basic dust management plan is required to ensure the nuisance impacts are mitigated. This can be achieved by addressing dust management in the Environmental Management Plan for the proposed gas to power plant.

9.2 Operation Phase – Direct Impacts

Direct impacts will result from the inhalation of SO_2, NO_2, PM_{10}, CO and benzene emitted from the combustion of diesel fuel during Phase 1 and LNG during Phase 2 of the operational life of the proposed gas to power plant. Direct impacts associated with the operational phase are expected to last for the duration of operation, which is ~25-40 years. Emissions of SO_2, NO_2, PM_{10}, CO and benzene from the proposed gas to power plant increase the existing ambient concentrations of these pollutants in the immediate vicinity and the surrounding areas. The highest concentrations are located close to the proposed gas to power plant site. The predicted concentrations are very low (and in some cases orders of magnitude below) the NAAQS and WHO guidelines. No exceedance of the NAAQS is predicted within the proposed gas to power plant site or in residential areas around the site. The predicted ambient concentrations for all pollutants therefore comply with the NAAQS in the ambient environment.

Impacts which could arise as a result of the operation of the proposed project include the following:

9.2.1 Direct impacts from the combustion of diesel fuel at the proposed gas to power plant (Scenario 1)

Table 9.2: Assessment of direct impacts from emissions from the combustion of diesel fuel at the proposed gas to power plant

Operation Phase		
Nature: Emissions, including SO_2, NO_2, PM_{10}, CO and benzene, are released from the combustion of diesel at the gas to power plant. The inhalation of these emissions at concentrations exceeding health-based air quality standards, and which are greater than the permitted number of exceedances per year, will result in negative health impacts.		
	Without mitigation	**With mitigation**
Extent	Local-regional (1)	Local-regional (1)
Duration	Long term (4)	Long term (4)
Magnitude	Low (4)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Low (27)**	**Low (27)**
Status (positive or negative)	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	N/A
Mitigation measures: In this assessment, two NO_X emission mitigation strategies have been tested for the proposed gas to power plant using diesel fuel (Scenario 1) (refer to results section). These include the water-steam injection and lean-premix mechanism. If NO_X mitigation strategies are implemented at the proposed gas to power plant, this will result in significantly lower NO_2 concentrations during the operational phase. However, this is not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current NO_2 levels are already low and compliant with the NAAQS. Impacts from SO_2 emissions can be further reduced by decreasing the sulphur content of the diesel fuel. However, this is also not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current SO_2 levels are already low and compliant with the NAAQS.		
Residual Impacts: No residual impacts are expected.		

The impact is expected to be negative, local in extent, to last for the duration of operation, of low intensity and probable, without mitigation or with mitigation measures implemented. The impact is therefore assessed to be of low significance to the decision making process without mitigation or with mitigation. This impact is expected to be direct with no residual impacts, without mitigation or with mitigation**.**

9.2.2 Direct impacts from the combustion of LNG fuel at the proposed gas to power plant (Scenario 2)

Table 9.3: Assessment of direct impacts from emissions from the combustion of LNG fuel at the proposed gas to power plant

Operation Phase		
Nature: Air quality impacts are caused by the inhalation of SO_2, NO_2, PM_{10}, CO and benzene, which are contained in emissions from the combustion of LNG fuel at the proposed gas to power plant. The inhalation of the SO_2, NO_2, PM_{10}, CO and benzene at concentrations exceeding health-based air quality standards; and which are greater than the permitted number of exceedances per year, will result in negative health impacts.		
	Without mitigation	**With mitigation**
Extent	Local-regional (1)	Local-regional (1)
Duration	Long term (4)	Long term (4)
Magnitude	Low (4)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Low (27)**	**Low (27)**
Status (positive or negative)	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	N/A
Mitigation measures: In this assessment, two NO_X emission mitigation strategies have been tested for the proposed gas to power plant using LNG fuel (Scenario 2) (refer to results section). These include the water-steam injection and lean-premix mechanism. If NO_X mitigation strategies are implemented at the proposed gas to power plant, this will result in significantly lower NO_2 concentrations during the operational phase. However, this is not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current NO_2 levels are already low and compliant with the NAAQS. Impacts from SO_2 emissions can be further reduced by decreasing the sulphur content of the LNG fuel. However, this is also not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current SO_2 levels are already low and compliant with the NAAQS.		
Residual Impacts: No residual impacts are expected.		

The impact is expected to be negative, local in extent, to last for the duration of operation, of low intensity and probable, without mitigation or with mitigation measures implemented. The impact is therefore assessed to be of low significance to the decision making process without mitigation or with mitigation. This impact is expected to be direct with no residual impacts, without mitigation or with mitigation.

9.3 Operation Phase – Indirect Impacts

9.3.1 Indirect impacts from the combustion of diesel fuel (Scenario 1) during Phase 1 and LNG (Scenario 2) during Phase 2 at the proposed gas to power plant in terms of acid rain

Acid rain is a rain or any other form of precipitation that is unusually acidic, meaning that it has a low pH. It can have harmful effects on plants, aquatic animals and infrastructure. Acid rain is caused by emissions of SO_2 and NO_X, which react with the water molecules in the atmosphere to produce acids. The chemicals in acid rain can cause paint to peel, corrosion of steel structures such as bridges, and weathering of stone buildings and statues. Indirect impacts resulting from emissions of SO_2 and NO_X from the combustion of diesel fuel during Phase 1 and LNG during Phase 2 of the operational life of the proposed gas to power plant include their contribution to acidification in both dry and wet (acid rain) deposition. Indirect impacts associated with the operational phase are expected to last for the duration of operation, which is ~25-40 years. Impacts which could arise as a result of the operation of the proposed project include the following:

Table 9.4: Assessment of indirect impacts from emissions from the combustion of diesel fuel (Scenario 1) at the proposed gas to power plant which leads to acid rain

Operation Phase		
Nature: Emissions of SO_2 and NO_X from the combustion of diesel fuel contributes to acid rain		
	Without mitigation	**With mitigation**
Extent	Local-regional (2)	Local-regional (2)
Duration	Long term (4)	Long term (4)
Magnitude	Small impact (0)	Small Impact (0)
Probability	Improbable (2)	Improbable (2)
Significance	**Low (12)**	**Low (12)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	N/A
Mitigation measures: In this assessment, two NO_X emission mitigation strategies have been tested for the proposed gas to power plant using diesel fuel (Scenario 1) (refer to results section). These include the water-steam injection and lean-premix mechanism. If NO_X mitigation strategies are implemented at the proposed gas to power plant, this will result in significantly lower NO_2 concentrations during the operational phase. However, this is not		

necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current NO_2 levels are already low and compliant with the NAAQS. Impacts from SO_2 emissions can be further reduced by decreasing the sulphur content of the diesel fuel. However, this is also not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current SO_2 levels are already low and compliant with the NAAQS.
Residual Impacts: No residual impacts are expected.

The impact is expected to be negative, local-regional in extent, to last for the duration of operation, of small impact and improbable, without mitigation or with mitigation measures implemented. The impact is therefore assessed to be of low significance to the decision making process without mitigation or with mitigation. This impact is expected to be indirect with no residual impacts, without mitigation or with mitigation**.**

Table 9.5: Assessment of indirect impacts from emissions from the combustion of LNG fuel (Scenario 2) at the proposed gas to power plant which leads to acid rain

Operation Phase		
Nature: Emissions of SO_2 and NO_X from the combustion of LNG fuel contributes to acid rain		
	Without mitigation	**With mitigation**
Extent	Local-regional (2)	Local-regional (2)
Duration	Long term (4)	Long term (4)
Magnitude	Small impact (0)	Small Impact (0)
Probability	Improbable (2)	Improbable (2)
Significance	**Low (12)**	**Low (12)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	N/A
Mitigation measures: In this assessment, two NO_X emission mitigation strategies have been tested for the proposed gas to power plant using LNG fuel (Scenario 2) (refer to results section). These include the water-steam injection and lean-premix mechanism. If NO_X mitigation strategies are implemented at the proposed gas to power plant, this will result in significantly lower NO_2 concentrations during the operational phase. However, this is not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current NO_2 levels are already low and compliant with the NAAQS. Impacts from SO_2 emissions can be further reduced by decreasing the sulphur content of the LNG fuel. However, this is also not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current SO_2 levels are		

already low and compliant with the NAAQS.
Residual Impacts: No residual impacts are expected.

The impact is expected to be negative, local-regional in extent, to last for the duration of operation, of small impact and improbable, without mitigation or with mitigation measures implemented. The impact is therefore assessed to be of low significance to the decision making process without mitigation or with mitigation. This impact is expected to be indirect with no residual impacts, without mitigation or with mitigation**.**

9.3.2 Indirect impacts from the combustion of diesel fuel (Scenario 1) during Phase 1 and LNG (Scenario 2) during Phase 2 at the proposed gas to power plant in terms of South Africa's CO_2/greenhouse gas emissions and global warming

A greenhouse gas (GHG) is transparent to shortwave radiation emitted by the sun but has the ability to absorb the long wave radiation emitted by the surface of the earth, resulting in a warming of the atmosphere, producing what is known as the greenhouse effect. Examples of GHGs include water vapour, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO), ozone (O_3) and chlorofluorocarbons (CFCs). These pollutants have atmospheric lifetimes ranging from a few years to many decades. The individual effect of the wide range of GHGs is represented by a parameter known as the Global Warming Potential (GWP). The GWP is the ratio of the warming caused by a substance to the warming caused by a similar mass of CO_2 calculated over 100 years. Thus, the GWP of CO_2 is defined as 1. CO is not considered a GHG, but is a strong precursor in the formation of ozone in the troposphere. The global warming potential of tropospheric ozone is equivalent to between 918-1022 tons of CO_2.

In this impact assessment, indirect effects are assessed for emissions of CO_2 from the combustion of diesel fuel at the proposed gas to power plant. CO_2 has not been modelled but is assessed qualitatively.

According to Wikipedia, 2014 annual CO_2 emission estimates from South Africa amount to 392 000 000 tons. This information is based on the EDGAR database created by European Commission and Netherlands Environmental Assessment Agency, released in 2014. The CO_2 emissions data only considers certain forms of human activity. It includes burning of fossil fuels and cement manufacture, but not emissions from land use, land-use change and forestry. Emissions from international shipping or bunker fuels are also not included in the national figures.

It is predicted that ~292 000 tons of CO_2 will be emitted from the combustion of diesel fuel (Scenario 1) at the proposed gas to power plant. This means that the proposed gas to power plant will add 0.07% more CO_2 to South Africa's current total CO_2 emissions.

It is predicted that ~210 000 tons of CO_2 will be emitted from the combustion of LNG fuel (Scenario 2) at the proposed gas to power plant. This means that the proposed gas to power plant will add 0.05% more CO_2 to South Africa's current total CO_2 emissions.

Table 9.6: Assessment of indirect impacts from emissions from the combustion of diesel fuel (Scenario 1) at the proposed gas to power plant in terms of South Africa's CO_2/GHG emissions and global warming

Operation Phase		
Nature: Emissions of CO_2 from the combustion of diesel fuel leads to an increase in the South African CO_2/GHG emissions and global warming		
	Without mitigation	**With mitigation**
Extent	Local-regional (4)	Local-regional (4)
Duration	Long term (4)	Long term (4)
Magnitude	Small impact (0)	Small Impact (0)
Probability	Improbable (2)	Improbable (2)
Significance	**Low (16)**	**Low (16)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	No	N/A
Mitigation measures: Mitigation measures are not feasible at this scale of operations due to the national climate change response still being developed.		
Residual Impacts: No residual impacts are expected.		

The impact is expected to be negative, local-regional in extent, to last for the duration of operation, of small impact and improbable, without mitigation or with mitigation measures implemented. The impact is therefore assessed to be of low significance to the decision making process without mitigation or with mitigation. This impact is expected to be indirect with no residual impacts, without mitigation or with mitigation.

Table 9.7: Assessment of indirect impacts from emissions from the combustion of LNG fuel at the proposed gas to power plant in terms of South Africa's CO_2/GHG emissions and global warming

Operation Phase		
Nature: Emissions of CO_2 from the combustion of LNG fuel leads to an increase in the South African CO_2/GHG emissions and global warming		
	Without mitigation	**With mitigation**
Extent	Local-regional (4)	Local-regional (4)
Duration	Long term (4)	Long term (4)
Magnitude	Small impact (0)	Small Impact (0)

Probability	Improbable (2)	Improbable (2)
Significance	**Low (16)**	**Low (16)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	No	N/A
Mitigation measures: Mitigation measures are not feasible at this scale of operations due to the national climate change response still being developed.		
Residual Impacts: No residual impacts are expected.		

The impact is expected to be negative, local-regional in extent, to last for the duration of operation, of small impact and improbable, without mitigation or with mitigation measures implemented. The impact is therefore assessed to be of low significance to the decision making process without mitigation or with mitigation. This impact is expected to be indirect with no residual impacts, without mitigation or with mitigation**.**

9.4 Decommissioning Phase – Direct Impacts

Direct impacts will result from exposure to dust generated from decommissioning activities of the proposed gas to power plant. Direct impacts associated with the decommissioning phase are expected to be of short duration and temporary in nature. Indirect impacts during the decommissioning phase are very improbable.

9.4.1 Direct impacts from dust generation during the decommissioning phase

Dust emissions during decommissioning result from the demolition of structures, earth moving activities (scraping, compacting, excavation, grading), movement of construction vehicles and back-fill operations. All aspects of the decommissioning inherently generate dust, but the movement of construction vehicles on paved and unpaved surfaces at the site are generally the largest source of dust. Construction vehicles will be in operation for the duration of the decommissioning. Dust is also easily entrained from exposed areas by wind. The impact of dust is considered to be limited to the site and its immediate surroundings, is more of a temporary nuisance nature and does not typically pose a health risk due to its typically coarse size. Dust emissions will not travel over vast distances, but will most likely settle within 100 m to 1 km of the proposed gas to power plant site. Impacts may be experienced in parts of the IDZ Zone 1F, the property on which the site is to be constructed.

Table 9.8: Assessment of direct impacts from dust generation during the decommissioning phase of the proposed gas to power plant

Decommissioning Phase		
Nature: Dust generated during the decommissioning phase has a nuisance impact and negatively affects quality of life by causing soiling, contamination, structural corrosion and damage to precision equipment, machinery and computers.		
	Without mitigation	**With mitigation**
Extent	Local-regional (1)	Local-regional (1)
Duration	Very short term (1)	Very short term (1)
Magnitude	Low (4)	Low (4)
Probability	Highly probable (4)	Improbable (2)
Significance	**Low (24)**	**Low (12)**
Status (positive or negative)	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	N/A
Mitigation measures: Implement traffic control measures to limit vehicle-entrained dust from unpaved roads by limiting vehicle speeds and by restricting traffic volumes. Limit access to site to construction vehicles only. Loading and unloading bulk material should be in areas protected from the wind or carried out in calm conditions. Loads on vehicles carrying dusty materials should be covered. Vehicles carrying dusty materials should be cleaned before leaving the site. Unpaved road surfaces should be sprayed with a surfactant to ensure high moisture content which will bind the silt or maintain high moisture content on exposed surfaces and roads by spraying with water. Stabilise open areas with dust palliative, gravel or similar.		
Residual Impacts: No residual impacts are expected.		

The impact is expected to be negative, local in extent, temporary in duration (limited to the duration of the decommissioning), of low intensity, and highly probable without mitigation measures implemented. The impact is therefore assessed to be of low significance to the decision making process without mitigation. This impact is expected to be direct with no residual impacts, without mitigation. Indirect impacts during the decommissioning phase are very improbable.

The impact is expected to be negative, local in extent, temporary in duration (limited to the duration of the decommissioning), of low intensity, and improbable with mitigation measures implemented. The impact is therefore assessed to be of low significance to the decision making process with mitigation. This impact is expected to be direct with no residual impacts, with mitigation. Indirect impacts during the decommissioning phase are very improbable.

Although the significance of impacts during decommissioning is low, a basic dust management plan is required to ensure the nuisance impacts are mitigated. This can be achieved by addressing dust management in the Environmental Management Plan for the proposed gas to power plant.

9.5 Construction Phase – Cumulative Impacts

Cumulative impacts will result from exposure to dust generated from the construction of the proposed gas to power plant together with other existing sources of dust in the area. Cumulative impacts associated with the construction phase are expected to be of short duration and temporary in nature.

9.5.1 Cumulative impacts from dust generation during the construction phase

Ambient air quality in Richards Bay is influenced by a number of sources of air pollution. Large and small scale industrial facilities, transportation, agricultural activities, agricultural burning, domestic fuel burning, mining and open stockpiles in the area are identified as existing sources of dust. Emissions from operations at the Port of Richards Bay which include the ore export terminal, the coal terminal and handling of break bulk cargo is a potentially large source of dust. Another important source of dust is the long range transport of pollutants from the interior. There will thus be a cumulative impact with dust generated during the construction phase of the proposed gas to power plant and existing/future sources of dust in the area. The impact of dust is considered to be limited to the site and its immediate surroundings, is more of a temporary nuisance nature and does not typically pose a health risk due to its typically coarse size. Dust emissions will not travel over vast distances, but will most likely settle within 100 m to 1 km of the proposed gas to power plant site. Impacts may be experienced in parts of the IDZ Zone 1F, the property on which the site is to be constructed.

Table 9.9: Assessment of cumulative impacts from dust generation during the construction phase of the proposed gas to power plant

Construction Phase		
Nature: Dust generated during the construction phase has a nuisance impact and negatively affects quality of life by causing soiling, contamination, structural corrosion and damage to precision equipment, machinery and computers.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local-regional (1)	Local-regional (1)
Duration	Very short term (1)	Very short term (1)
Magnitude	Low (4)	Low (4)

Probability	Highly probable (4)	Improbable (2)
Significance	**Low (24)**	**Low (12)**
Status (positive or negative)	Negative	Negative
Reversibility	High	
Irreplaceable loss of resources?	No	
Can impacts be mitigated?	Yes	
Confidence in findings	High	
Mitigation measures: Implement traffic control measures to limit vehicle-entrained dust from unpaved roads by limiting vehicle speeds and by restricting traffic volumes. Limit access to construction site to construction vehicles only. Loading and unloading bulk construction material should be in areas protected from the wind or carried out in calm conditions. Loads on vehicles carrying dusty construction materials should be covered. Vehicles carrying dusty materials should be cleaned before leaving the site. Unpaved road surfaces should be sprayed with a surfactant to ensure high moisture content which will bind the silt or maintain high moisture content on exposed surfaces and roads by spraying with water. Stabilise open areas with dust palliative, gravel or similar.		
Residual Impacts: No residual impacts are expected.		

The impact is expected to be negative, local in extent, temporary in duration (limited to the duration of the construction), of low intensity, and highly probable if the proposed project is considered in isolation. The impact is therefore assessed to be of low significance to the decision making process if considered in isolation. This impact is expected to have no residual impacts.

The impact is expected to be negative, local in extent, temporary in duration (limited to the duration of the construction), of low intensity, and improbable if the proposed project is considered cumulatively with other projects in the area. The impact is therefore assessed to be of low significance to the decision making process if the proposed project is considered cumulatively with other projects in the area. This impact is expected to have no residual impacts.

Although the significance of impacts during construction is low (whether the proposed project is considered in isolation or cumulatively with other projects in the area), a basic dust management plan is required to ensure the nuisance impacts are mitigated. This can be achieved by addressing dust management in the Environmental Management Plan for the proposed gas to power plant.

9.6 Operation Phase – Cumulative Impacts

Cumulative impacts associated with the operational phase are expected to last for the duration of operation, which is ~25-40 years. Impacts which could arise as a result of the operation of the proposed project include the following:

9.6.1 Cumulative impacts from the combustion of diesel fuel (Scenario 1) and LNG (Scenario 2) at the proposed gas to power plant

The proposed gas to power plant is located in an area where there are many notable sources of SO_2, NO_2, PM_{10}, CO and benzene (to a lesser extent) in the immediate vicinity of the site, i.e. within a 5 km radius, and beyond. Motor vehicle traffic on the surrounding and nearby roads will have some influence on ambient air quality as will domestic fuel burning. Heavy industrial activities, particularly to the south of the proposed site and at the port is an important source of SO_2, NO_2, PM_{10}, CO and benzene at that locality. Emissions of SO_2, NO_2, PM_{10}, CO and benzene from the combustion of diesel fuel during Phase 1 and LNG during Phase 2 at the proposed gas to power plant will increase the existing ambient concentrations of these pollutants in the immediate vicinity and the surrounding areas. It is therefore expected that there will be compounding of effects and hence cumulative impacts during operation of the proposed gas to power plant.

Predicted ambient concentrations of SO_2, NO_2, PM_{10}, CO and benzene resulting from emissions from the proposed gas to power plant are relatively localised and are indicated as very low at the monitoring sites (See model results). The contribution to ambient concentrations beyond the immediate vicinity of the proposed gas to power plant will be small and is highly unlikely to make a significant contribution to the cumulative impacts of these pollutants in the area. It is highly unlikely that they will result in exceedances of the NAAQS at the monitoring sites, or elsewhere in the area.

Cumulative impacts will result from the inhalation of SO_2, NO_2, PM_{10}, CO and benzene emitted from the combustion of diesel fuel (Scenario 1) in Phase 1 and LNG (Scenario 2) in Phase 2 during the operational life of the proposed gas to power plant and existing/future sources of pollutants in the area.

Table 9.10: Assessment of cumulative impacts from emissions from the combustion of diesel fuel (Scenario 1) at the proposed gas to power plant

Operation Phase
Nature: Air quality impacts are caused by the inhalation of SO_2, NO_2, PM_{10}, CO and benzene, which are contained in emissions from the combustion of diesel fuel at the proposed gas to power plant. The inhalation of the SO_2, NO_2, PM_{10}, CO and benzene at concentrations exceeding health-based air quality standards; and which are greater than the permitted number of exceedances per year, will result in negative health impacts.

	Overall impact of the proposed project considered in isolation	Cumulative impact of the project and other projects in the area
Extent	Local-regional (1)	Local-regional (1)
Duration	Long term (4)	Long term (4)
Magnitude	Low (4)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Low (27)**	**Low (27)**
Status (positive or negative)	Negative	Negative
Reversibility	High	
Irreplaceable loss of resources?	No	
Can impacts be mitigated?	Yes	
Confidence in findings	High	
Mitigation measures: In this assessment, two NO_X emission mitigation strategies have been tested for the proposed gas to power plant using diesel fuel (Scenario 1) (refer to results section). These include the water-steam injection and lean-premix mechanism. If NO_X mitigation strategies are implemented at the proposed gas to power plant, this will result in significantly lower NO_2 concentrations during the operational phase. However, this is not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current NO_2 levels are already low and compliant with the NAAQS. Impacts from SO_2 emissions can be further reduced by decreasing the sulphur content of the diesel fuel. However, this is also not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current SO_2 levels are already low and compliant with the NAAQS.		
Residual Impacts: No residual impacts are expected.		

The impact is expected to be negative, local in extent, to last for the duration of operation, of low intensity and probable, whether the proposed project is considered in isolation or cumulatively with other projects in the area. The impact is therefore assessed to be of low significance to the decision making process whether the proposed project is considered in isolation or cumulatively with other projects in the area, and is expected to have no residual impacts.

Table 9.11: Assessment of cumulative impacts from emissions from the combustion of LNG fuel (Scenario 2) at the proposed gas to power plant

Operation Phase
Nature: Air quality impacts are caused by the inhalation of SO_2, NO_2, PM_{10}, CO and benzene, which are contained in emissions from the combustion of LNG fuel at the proposed gas to power plant. The inhalation of the SO_2, NO_2, PM_{10}, CO and benzene at

concentrations exceeding health-based air quality standards; and which are greater than the permitted number of exceedances per year, will result in negative health impacts.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local-regional (1)	Local-regional (1)
Duration	Long term (4)	Long term (4)
Magnitude	Low (4)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Low (27)**	**Low (27)**
Status (positive or negative)	Negative	Negative
Reversibility	High	
Irreplaceable loss of resources?	No	
Can impacts be mitigated?	Yes	
Confidence in findings	High	
Mitigation measures: In this assessment, two NO_X emission mitigation strategies have been tested for the proposed gas to power plant using LNG fuel (Scenario 2) (refer to results section). These include the water-steam injection and lean-premix mechanism. If NO_X mitigation strategies are implemented at the proposed gas to power plant, this will result in significantly lower NO_2 concentrations during the operational phase. However, this is not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current NO_2 levels are already low and compliant with the NAAQS. Impacts from SO_2 emissions can be further reduced by decreasing the sulphur content of the LNG fuel. However, this is also not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current SO_2 levels are already low and compliant with the NAAQS.		
Residual Impacts: No residual impacts are expected.		

The impact is expected to be negative, local in extent, to last for the duration of operation, of low intensity and probable, whether the proposed project is considered in isolation or cumulatively with other projects in the area. The impact is therefore assessed to be of low significance to the decision making process whether the proposed project is considered in isolation or cumulatively with other projects in the area, and is expected to have no residual impacts.

9.7 Operation Phase – Cumulative Impacts

9.7.1 Cumulative impacts from the combustion of diesel fuel (Scenario 1) during Phase 1 and LNG fuel (Scenario 2) during Phase 2 at the proposed gas to power plant (Scenario 1) in terms of acid rain

Cumulative impacts resulting from emissions of SO_2 and NO_X from the combustion of diesel fuel during Phase 1 and LNG fuel during Phase 2 of the operational life of the proposed gas to power plant include their contribution as well as other sources of SO_2 and NO_X in the area that lead to acidification in both dry and wet (acid rain) deposition. Quantification of the relative contribution of proposed gas to power plant to acidification is difficult, but it is considered to be relatively small in the national and global context.

Cumulative impacts associated with the operational phase are expected to last for the duration of operation, which is ~25-40 years. Impacts which could arise as a result of the operation of the proposed project include the following:

Table 9.12: Assessment of cumulative impacts from emissions from the combustion of diesel fuel (Scenario 1) at the proposed gas to power plant which leads to acid rain

Operation Phase		
Nature: Emissions of SO_2 and NO_X from the combustion of diesel fuel contributes to acid rain		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local-regional (2)	Local-regional (2)
Duration	Long term (4)	Long term (4)
Magnitude	Small impact (0)	Small Impact (0)
Probability	Improbable (2)	Improbable (2)
Significance	**Low (12)**	**Low (12)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	
Irreplaceable loss of resources?	No	
Can impacts be mitigated?	Yes	
Confidence in findings	High	
Mitigation measures: In this assessment, two NO_X emission mitigation strategies have been tested for the proposed gas to power plant using diesel fuel (Scenario 1) (refer to results section). These include the water-steam injection and lean-premix mechanism. If NO_X mitigation strategies are implemented at the proposed gas to power plant, this will result in		

significantly lower NO_2 concentrations during the operational phase. However, this is not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current NO_2 levels are already low and compliant with the NAAQS. Impacts from SO_2 emissions can be further reduced by decreasing the sulphur content of the diesel fuel. However, this is also not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current SO_2 levels are already low and compliant with the NAAQS.
Residual Impacts: No residual impacts are expected.

The impact is expected to be negative, local-regional in extent, to last for the duration of operation, of small impact and improbable, whether the proposed project is considered in isolation or cumulatively with other projects in the area. The impact is therefore assessed to be of low significance to the decision making process whether the proposed project is considered in isolation or cumulatively with other projects in the area, and is expected to have no residual impacts.

Table 9.13: Assessment of cumulative impacts from emissions from the combustion of LNG fuel at the proposed gas to power plant which leads to acid rain

Operation Phase		
Nature: Emissions of SO_2 and NO_X from the combustion of LNG fuel contributes to acid rain		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local-regional (2)	Local-regional (2)
Duration	Long term (4)	Long term (4)
Magnitude	Small impact (0)	Small Impact (0)
Probability	Improbable (2)	Improbable (2)
Significance	**Low (12)**	**Low (12)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	
Irreplaceable loss of resources?	No	
Can impacts be mitigated?	Yes	
Confidence in findings	High	
Mitigation measures: In this assessment, two NO_X emission mitigation strategies have been tested for the proposed gas to power plant using LNG fuel (Scenario 2) (refer to results section). These include the water-steam injection and lean-premix mechanism. If NO_X mitigation strategies are implemented at the proposed gas to power plant, this will result in significantly lower NO_2 concentrations during the operational phase. However, this is not		

necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current NO_2 levels are already low and compliant with the NAAQS. Impacts from SO_2 emissions can be further reduced by decreasing the sulphur content of the LNG fuel. However, this is also not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current SO_2 levels are already low and compliant with the NAAQS.
Residual Impacts: No residual impacts are expected.

The impact is expected to be negative, local-regional in extent, to last for the duration of operation, of small impact and improbable, whether the proposed project is considered in isolation or cumulatively with other projects in the area. The impact is therefore assessed to be of low significance to the decision making process whether the proposed project is considered in isolation or cumulatively with other projects in the area, and is expected to have no residual impacts.

9.7.2 Cumulative impacts from the combustion of diesel fuel (Scenario 1) during Phase 1 and LNG fuel (Scenario 2) during Phase 2 at the proposed gas to power plant in terms of South Africa's CO2/greenhouse gas emissions and global warming

Cumulative impacts resulting from emissions of CO_2 from the combustion of diesel fuel during Phase 1 and LNG fuel during Phase 2 of the operational life of the proposed gas to power plant include its contribution as well as other sources of CO_2 in the area that lead to the overall CO_2/GHG emission levels in South Africa, and global warming. The relative contribution of the proposed gas to power plant to the total national CO_2 emission is considered to be relatively small in the national and global context, since it may account for less than 1% of South Africa's current total CO_2 emissions.

Table 9.14: Assessment of cumulative impacts from emissions from the combustion of diesel fuel at the proposed gas to power plant in terms of South Africa's CO_2/GHG emissions and global warming

Operation Phase		
Nature: Emissions of CO_2 from the combustion of diesel fuel leads to an increase in the South African CO_2/GHG emissions and global warming		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local-regional (4)	Local-regional (4)
Duration	Long term (4)	Long term (4)
Magnitude	Small impact (0)	Small Impact (0)
Probability	Improbable (2)	Improbable (2)
Significance	**Low (16)**	**Low (16)**
Status (positive or negative)	Negative	Negative

Reversibility	Low
Irreplaceable loss of resources?	No
Can impacts be mitigated?	No
Confidence in findings	High
Mitigation measures: Mitigation measures are not feasible at this scale of operations due to the national climate change response still being developed.	
Residual Impacts: No residual impacts are expected.	

The impact is expected to be negative, local-regional in extent, to last for the duration of operation, of small impact and improbable, whether the proposed project is considered in isolation or cumulatively with other projects in the area. The impact is therefore assessed to be of low significance to the decision making process whether the proposed project is considered in isolation or cumulatively with other projects in the area, and is expected to have no residual impacts.

Table 9.15: Assessment of cumulative impacts from emissions from the combustion of LNG fuel at the proposed gas to power plant in terms of South Africa's CO_2/GHG emissions and global warming

Operation Phase		
Nature: Emissions of CO_2 from the combustion of LNG fuel leads to an increase in the South African CO_2/GHG emissions and global warming		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local-regional (4)	Local-regional (4)
Duration	Long term (4)	Long term (4)
Magnitude	Small impact (0)	Small Impact (0)
Probability	Improbable (2)	Improbable (2)
Significance	**Low (16)**	**Low (16)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	
Irreplaceable loss of resources?	No	
Can impacts be mitigated?	No	
Confidence in findings	High	
Mitigation measures: Mitigation measures are not feasible at this scale of operations due to the national climate change response still being developed.		
Residual Impacts: No residual impacts are expected.		

The impact is expected to be negative, local-regional in extent, to last for the duration of operation, of small impact and improbable, whether the proposed project is considered in isolation or cumulatively with other projects in the area. The impact is therefore assessed to be of low significance to the decision making process whether the proposed project is considered in isolation or cumulatively with other projects in the area, and is expected to have no residual impacts.

9.8 Decommissioning Phase – Cumulative Impacts

Cumulative impacts will result from exposure to dust generated from decommissioning activities of the proposed gas to power plant together with other existing sources of dust in the area. Cumulative impacts associated with the decommissioning phase are expected to be of short duration and temporary in nature.

9.8.1 Cumulative impacts from dust generation during the decommissioning phase

Ambient air quality in Richards Bay is influenced by a number of sources of air pollution. Large and small scale industrial facilities, transportation, agricultural activities, agricultural burning, domestic fuel burning, mining and open stockpiles in the area are identified as existing sources of dust. Emissions from operations at the Port of Richards Bay which include the ore export terminal, the coal terminal and handling of break bulk cargo is a potentially large source of dust. Another important source of dust is the long range transport of pollutants from the interior. There will thus be a cumulative impact with dust generated during the decommissioning phase of the proposed gas to power plant and existing/future sources of dust in the area. The impact of dust is considered to be limited to the site and its immediate surroundings, is more of a temporary nuisance nature and does not typically pose a health risk due to its typically coarse size. Dust emissions will not travel over vast distances, but will most likely settle within 100 m to 1 km of the proposed gas to power plant site. Impacts may be experienced in parts of the IDZ Zone 1F, the property on which the site is to be constructed.

Table 9.16: Assessment of cumulative impacts from dust generation during the decommissioning phase of the proposed gas to power plant

Decommissioning Phase		
Nature: Dust generated during the decommissioning phase has a nuisance impact and negatively affects quality of life by causing soiling, contamination, structural corrosion and damage to precision equipment, machinery and computers.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local-regional (1)	Local-regional (1)
Duration	Very short term (1)	Very short term (1)
Magnitude	Low (4)	Low (4)

Probability	Highly probable (4)	Improbable (2)
Significance	**Low (24)**	**Low (12)**
Status (positive or negative)	Negative	Negative
Reversibility	High	
Irreplaceable loss of resources?	No	
Can impacts be mitigated?	Yes	
Confidence in findings	High	
Mitigation measures: Implement traffic control measures to limit vehicle-entrained dust from unpaved roads by limiting vehicle speeds and by restricting traffic volumes. Limit access to site to construction vehicles only. Loading and unloading bulk material should be in areas protected from the wind or carried out in calm conditions. Loads on vehicles carrying dusty materials should be covered. Vehicles carrying dusty materials should be cleaned before leaving the site. Unpaved road surfaces should be sprayed with a surfactant to ensure high moisture content which will bind the silt or maintain high moisture content on exposed surfaces and roads by spraying with water. Stabilise open areas with dust palliative, gravel or similar.		
Residual Impacts: No residual impacts are expected.		

The impact is expected to be negative, local in extent, temporary in duration (limited to the duration of the decommissioning), of low intensity, and highly probable if the proposed project is considered in isolation. The impact is therefore assessed to be of low significance to the decision making process if considered in isolation. This impact is expected to have no residual impacts, without mitigation.

The impact is expected to be negative, local in extent, temporary in duration (limited to the duration of the decommissioning), of low intensity, and improbable if the proposed project is considered cumulatively with other projects in the area. The impact is therefore assessed to be of low significance to the decision making process if the proposed project is considered cumulatively with other projects in the area. This impact is expected to have no residual impacts, with mitigation.

Although the significance of impacts during decommissioning is low (whether the proposed project is considered in isolation or cumulatively with other projects in the area), a basic dust management plan is required to ensure the nuisance impacts are mitigated. This can be achieved by addressing dust management in the Environmental Management Plan for the proposed gas to power plant.

Assessment of Impacts for the No-go Option:

The impacts of pursuing the no-go option means that ambient air quality will remain as it is currently, hence there will neither be an increase or decrease in the pollutants emitted from the proposed gas to power station, in the ambient environment. Impacts will therefore be neutral.

Conclusion and Recommendations

The air quality impact assessment is based on dispersion model results and ambient air quality data from monitoring sites in the vicinity of the proposed gas to power plant. The environmental assessment framework for the assessment of impacts and the relevant criteria were applied to evaluate the significance of the potential impacts. A summary of the potential negative impacts identified in the air quality impact assessment for the construction, operation and decommissioning phase are presented in Tables 17-19 and a summary of the cumulative impacts is provided in Table 20.

Table 9.17: Summary of air quality impacts during construction phase

CONSTRUCTION PHASE		
Impact	**Significance without Mitigation**	**Significance with Mitigation**
Negative Impacts		
Direct impacts from dust generation during the construction phase	Low (24)	Low (12)

Table 9.18: Summary of air quality impacts during operation phase

OPERATION PHASE		
Impact	**Significance without Mitigation**	**Significance with Mitigation**
Negative Impacts		
Direct impacts from the combustion of diesel fuel at the proposed gas to power plant (Scenario 1)	Low (27)	Low (27)
Direct impacts from the combustion of LNG fuel at the proposed gas to power plant (Scenario 2)	Low (27)	Low (27)
Indirect impacts from the combustion of diesel fuel at the proposed gas to power plant	Low (12)	Low (12)

(Scenario 1) in terms of acid rain		
Indirect impacts from the combustion of diesel fuel at the proposed gas to power plant (Scenario 1) in terms of South Africa's CO_2/greenhouse gas emissions and global warming	Low (16)	Low (16)
Indirect impacts from the combustion of LNG fuel at the proposed gas to power plant (Scenario 2) in terms of acid rain	Low (12)	Low (12)
Indirect impacts from the combustion of LNG fuel at the proposed gas to power plant (Scenario 2) in terms of South Africa's CO_2/greenhouse gas emissions and global warming	Low (16)	Low (16)

Table 9.19: Summary of air quality impacts during decommissioning phase

DECOMMISSIONING PHASE		
Impact	**Significance without Mitigation**	**Significance with Mitigation**
Negative Impacts		
Direct impacts from dust generation during the decommissioning phase	Low (24)	Low (12)

Table 9.20: Summary of cumulative air quality impacts

CUMULATIVE IMPACTS		
Cumulative Impact	**Overall impact of the proposed project considered in isolation**	**Cumulative impact of the project and other projects in the area**
Negative Cumulative Impacts		
Cumulative impacts from dust generation during the construction phase	Low (24)	Low (12)
Cumulative impacts from dust generation during the	Low (24)	Low (12)

decommissioning phase		
Cumulative impacts from the combustion of diesel fuel at the proposed gas to power plant (Scenario 1)	Low (27)	Low (27)
Cumulative impacts from the combustion of LNG fuel at the proposed gas to power plant (Scenario 2)	Low (27)	Low (27)
Cumulative impacts from the combustion of diesel fuel at the proposed gas to power plant (Scenario 1) in terms of acid rain	Low (12)	Low (12)
Cumulative impacts from the combustion of diesel fuel at the proposed gas to power plant (Scenario 1) in terms of South Africa's CO_2/greenhouse gas emissions and global warming	Low (16)	Low (16)
Cumulative impacts from the combustion of LNG fuel at the proposed gas to power plant (Scenario 2) in terms of acid rain	Low (12)	Low (12)
Cumulative impacts from the combustion of LNG fuel at the proposed gas to power plant (Scenario 2) in terms of South Africa's CO_2/greenhouse gas emissions and global warming	Low (16)	Low (16)

Key findings

From an air quality perspective it is concluded that the project is supported, but that mitigation measures should be implemented and adhered to. Negative air quality impacts have been identified. However, the assessment of the key issues indicated that there are no negative impacts that can be classified as fatal flaws and which are of such significance that they cannot be successfully mitigated.

In this study, direct impacts will result from exposure to dust generated from the construction and decommissioning phase of the proposed gas to power plant. Direct impacts will also result from the inhalation of SO_2, NO_2, PM_{10}, CO and benzene emitted during the operational phase of the proposed gas to power plant.

Indirect impacts resulting from emissions of SO_2 and NO_2 from power plants include their contribution to acidification in both dry and wet (acid rain) deposition, during the operational phase. Further indirect effects during the operational phase are associated emissions of CO and CO_2. CO_2 is a GHG, adding to the global concentrations. CO is not considered a GHG, but is a strong precursor in the formation of ozone in the troposphere.

Ambient air quality in Richards Bay is influenced by a number of sources of air pollution, including large and smaller industry, transportation, agricultural burning, mining and the long range transport of pollutants from the interior. The proposed gas to power plant is located in an area where there are many notable sources of SO_2, NO_2, PM_{10}, CO and benzene (to a lesser extent) in the immediate vicinity of the site.

According to the model results, the 99^{th} percentile of the predicted 1-hour and 24-hour and annual average SO_2, NO_2, PM_{10}, CO and benzene concentrations from the proposed gas to power plant are well below the respective National Ambient Air Quality Standards (NAAQS) and World Health Organisation (WHO) guidelines for Scenario 1 and Scenario 2. Predicted ambient concentrations are localised and very low for the modelled scenarios. The contribution to ambient concentrations beyond the immediate vicinity of the proposed gas to power plant is therefore small. The additive effect of these concentrations to the ambient environment is therefore highly unlikely to make a significant contribution to the cumulative impacts of SO_2, NO_2, PM_{10}, CO and benzene in the ambient environment. Impacts in terms of predicted concentrations of SO_2, NO_2, PM_{10}, CO and benzene from the operational scenarios will however last for the full period of the proposed gas to power plant. The duration of direct, indirect and cumulative impacts from the operational scenarios are therefore expected to be long-term. The significance of all impacts for the two operational scenarios is low.

Construction and decommissioning activities will result in the emission of low quantities of terrestrial and construction dust, not expected to pose a health risk. Furthermore, dust emissions will not travel over vast distances, but will most likely settle within 100m to 1km of the proposed development site. A temporary nuisance impact may be experienced in parts of the RBIDZ Zone 1F, the property on which the site is to be constructed. Construction and decommissioning impacts will last for a relatively short period as these activities occur for the duration of these activities only. It is predicted that the significance of all impacts during the construction and decommissioning phase is low. No mitigation is necessary, however, measures are suggested to minimise the nuisance impacts arising from these activities.

In this assessment, two NO_X emission mitigation strategies have been tested for the proposed gas to power plant. These include the water-steam injection and lean-premix mechanism. If NO_X mitigation strategies are implemented at the proposed gas to power plant, this will result in significantly lower NO_2 concentrations during the operational phase for all scenarios. Impacts from SO_2 emissions can be further reduced by decreasing the sulphur content of the diesel and LNG. However, this is not necessary since the modelling results have demonstrated that the resultant ambient concentrations at the current SO_2 content levels are already low. Due to the low predicted impacts, no mitigation measures are suggested for operational activities, in other words, mitigation measures to control SO_2 and NO_X, or even PM_{10}, CO and benzene are not necessary for the normal operations of the proposed gas to power plant. The significance rating will remain low during the operational phase for all scenarios, with or without mitigation.

The operation of the proposed gas to power plant is a Listed Activity in terms of the NEM: AQA. Requirements for environmental management will be dictated by the conditions in the Atmospheric Emission License (AEL). These are likely to include:

iii. Annual emission measurements to assess compliance with the Minimum Emission Standards for Listed Activities (Government Gazette 37054, Notice No. 893 of 22 November 2013);
iv. The maintenance of an emission inventory with registration on the National Atmospheric Emission Inventory System (NAEIS) and annual reporting of emissions to the NAEIS (Government Gazette 38633, Notice No. R 283 of 2 April 2015).

Further environmental management requirements should address the control of emissions during operations through routine maintenance and operation according to specification.

Recommendations

According to the dispersion modelling results and air quality impact assessment, the site operations is expected to generate low emissions, low ambient concentrations, and low environmental impacts for both Scenario 1 and Scenario 2. It is therefore recommended that the proposed mitigation measures for the construction, operation and decommissioning phases are implemented to limit the negative impacts.

Overall Conclusion

It is predicted with confidence, that the site operations will generate low emissions, low ambient concentrations, and low environmental impacts for the construction, operation and decommissioning phase. The proposed development and associated infrastructure is unlikely to result in permanent damage to the environment. Mitigation measures are recommended for the construction and decommissioning phase only. It is a reasonable opinion that the project should be authorised considering the outcomes of this impact assessment.

10. REFERENCES

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Appendix A: Air Quality Environmental Management Programme (EMPr)

Construction Phase

OBJECTIVE 1 : Management of dust and emissions and damage to roads	
Project component/s	Construction of: » Gas turbines; » Steam turbines; » Engine halls and stacks; » HV-Yard and substation; » 132kV powerline; » Internal access roads; » Fuel tanks and unloading stations; » Water storage facilities (demineralisation, raw and fire water and partially treated water tanks); » Guard house, admin building, workshops and a warehouse; and » Associated infrastructures.
Potential Impact	» Heavy vehicles can generate noise and dust impacts. Movement of heavy vehicles can also damage roads; » Dust and particulates from vehicle movement to and on-site, foundation excavation, road construction activities, road maintenance activities, temporary stockpiles, and vegetation clearing affecting the surrounding residents (dust nuisance) and visibility » Release of minor amounts of air pollutants (for example NO_2, CO and SO_2) from vehicles and construction equipment;
Activities/risk sources	» The movement of heavy vehicles and their activities on the site can result in noise and dust impacts and damage roads. » Clearing of vegetation and topsoil. » Excavation, grading and scraping. » Transport of materials, equipment and components on internal access roads. » Re-entrainment of deposited dust by vehicle movements. » Wind erosion from topsoil and spoil stockpiles and unsealed roads and surfaces. » Fuel burning from construction vehicles with combustion engines.
Mitigation: Target/Objective	» To avoid and or minimise the potential noise and dust impacts associated with heavy vehicles, and also minimise damage to roads. » To ensure emissions from all vehicles are minimised, where

	possible, for the duration of the construction phase. » To minimise nuisance to the community and adjacent landowners from dust emissions and to comply with workplace health and safety requirements for the duration of the construction phase.

Mitigation: Action/control	**Responsibility**	**Timeframe**
Implement appropriate dust suppression measures on site such as wetting roads on a regular basis including during site clearing and periods of high winds (by using non-potable water as far as practically possible).	Contractor(s)	Construction
Haul vehicles moving outside the construction site carrying material that can be wind-blown should be covered with tarpaulins.	Contractor(s)	Duration of contract
Ensure vehicles adhere to speed limits on public roads and speed limits set within the site.	Contractor(s) / transportation contractor	Duration of contract
Disturbed areas must be re-vegetated as soon as practicable after construction is complete in an area.	Contractor(s)	At completion of the construction phase.
Vehicles and equipment must be maintained in a road-worthy condition at all times.	Contractor(s)	Prior to construction phase.
Ensure that damage to gravel public roads and access roads attributable to construction vehicles use for the construction of the Project is repaired before completion of construction phase.	Contractor(s)	Before completion of construction phase.
Regular dust control of materials (sand, soil, concrete) must be used at concrete batching plants on site.	Contractor(s)	Construction
Strictly control vibration pollution from compaction plant or excavation plant as far as practically possible.	Contractor(s)	Construction
Disturbed areas must be re-vegetated as soon as practicable.	Contractor(s)	At completion of the construction phase.
If monitoring results or complaints indicate inadequate performance against the criteria indicated, then the source of the problem will be	Contractor(s)	Duration of contract

Mitigation: Action/control	Responsibility	Timeframe
identified, and existing procedures or equipment modified to ensure the problem is rectified.		

Performance Indicator	» Appropriate dust suppression measures implemented on site during the construction phase. » Drivers made aware of the potential safety issues and enforcement of strict speed limits when they are employed or before entering the site. » Road worthy certificates in place for all heavy vehicles at outset of construction phase and up-dated on a monthly basis.
Monitoring and Reporting	» The Proponent and appointed ECO must monitor indicators listed above to ensure that they have been met for the construction phase. » Immediate reporting by personnel of any potential or actual issues with nuisance dust or emissions to the Site Manager. » An incident reporting system must be used to record non-conformances to the EMPr. » Public complaints register used to record complaints received.

Operation Phase

OBJECTIVE 2 : Management of emissions during the operation of the power plant.

SO_2, NO_2, PM_{10}, CO and benzene emissions are anticipated from the operation of the gas turbines.

Project component/s	» Operation of the power plant.
Potential Impact	» Release of minor amounts of air pollutants (SO_2, NO_2, PM_{10}, CO and benzene) from the proposed gas to power plant.
Activities/risk sources	» Emissions from proposed gas to power plant will increase the existing ambient concentrations of all pollutants in the immediate vicinity and the surrounding areas. Predicted ambient SO_2, NO_2, PM_{10}, CO and benzene concentrations are very low for all operational scenarios for the proposed gas to power plant.
Mitigation: Target/Objective	» To minimise the contribution to ambient concentrations beyond the immediate vicinity of the proposed gas to power plant.

Mitigation: Action/control	Responsibility	Timeframe
The developer must consider the use of the cleanest fuel economically available (natural gas is preferable to oil, which is preferable to coal). In this case, diesel and LNG would be preferred over LFO and HFO in Phase 1. The developer should switch over to LNG once available.	Proponent	Duration of operation
Selection of the best power generation technology for the fuel chosen to balance the environmental and economic benefits. Some examples include the use of higher energy-efficient systems, such as combined cycle gas turbine system for natural gas. The developer should consider use of combined heat and power.	Proponent	Pre-feasibility and feasibility stage
Designing stack heights according to Good International Industry Practice (GIIP) to avoid excessive ground level concentrations and minimize impacts.	Proponent	Design and planning
As stated in the IFC General Environmental, Health and Safety (EHS) Guidelines, emissions from a single project should not contribute more than 25% of the applicable ambient air quality standards to allow additional, future sustainable development in the same airshed.	Proponent, O&M Operator	Duration of operation
Sulphur Dioxide: » Consider the use of fuels with a lower content of sulphur where economically feasible.	Proponent	Design and planning
Nitrogen Oxides: » Consider the use of dry low-NO_X combustors for combustion turbines burning natural gas. » Optimization of operational parameters for existing reciprocating engines burning natural gas to reduce NO_X emissions.	Proponent	Design and planning
Fugitive Emissions (Volatile Organic Compounds (VOCs)) and particulate matter (PM): » Open burning of solid wastes, whether hazardous or non-hazardous, is not considered good practice and must not take place, as the generation of polluting emissions from this type of source cannot be controlled effectively. » Design and operate transport systems for the	Proponent, O&M Operator	Design and planning, and duration of operation

Mitigation: Action/control	Responsibility	Timeframe
delivery of fuel to site to minimize the generation and transport of dust on site. » Regularly monitor fugitive emissions from pipes, valves, seals, tanks, and other infrastructure components with vapour detection equipment, and maintenance or replacement of components as needed in a prioritized manner. » Maintain stable tank pressure and vapour space by: ∗ Coordinating filling and withdrawal schedules, and implementing vapour balancing between tanks, (a process whereby vapour displaced during filling activities is transferred to the vapour space of the tank being emptied or to other containment in preparation for vapour recovery); ∗ Using white or other colour paints with low heat absorption properties on exteriors of storage tanks for lighter distillates such as gasoline, ethanol, and methanol to reduce heat absorption. Potential for visual impacts from reflection of light off tanks should be considered; ∗ Selecting and designing storage tanks in accordance with internationally accepted standards to minimize storage and working losses considering, for example, storage capacity and the vapour pressure of materials being stored; ∗ Use supply and return systems, vapour recovery hoses, and vapour-tight trucks / railcars / vessels during loading and unloading of transport vehicles; ∗ Use bottom-loading truck / rail car filling systems; and ∗ Where vapour emissions contribute or result in ambient air quality levels in		

Mitigation: Action/control	Responsibility	Timeframe
excess of health based standards, install secondary emissions controls, such as vapour condensing and recovery units, catalytic oxidizers, vapour combustion units, or gas adsorption media.		
Venting and Flaring of LNG/ NG: Venting and flaring are an important operational and safety measure used in natural gas processing facilities to ensure gas is safely disposed of in the event of an emergency, power or equipment failure, or other plant upset conditions. » Optimize plant controls to increase the reaction conversion rates; » Recycle unreacted raw materials and by-product combustible gases in the process or utilize these gases for power generation or heat recovery, if possible; » Provide back-up systems to achieve as high a plant reliability as practical; and » Locate the flaring system at a safe distance from residential areas or other potential receptors, and maintain the system to achieve high efficiency.	Proponent, O&M Operator	Design and planning, and duration of operation
Annual Stack Emission Testing for SO_2, NO_X and PM. If Annual Stack Emission Testing results show constantly (3 consecutive years) and significantly (e.g. less than 75%) better than the required levels, frequency of Annual Stack Emission Testing can be reduced from annual to every two or three years.	Proponent, O&M Operator	Duration of operation
Emission Monitoring: NO_X: Continuous monitoring of either NO_X emissions or indicative NO_X emissions using combustion parameters if emissions are anticipated to be high. SO_2: Continuous monitoring if SO_2 control equipment is used and if emissions are anticipated to be high.	Proponent, O&M Operator	Duration of operation

Performance	» Results from emission testing of monitoring parameters.

Indicator	
Monitoring and Reporting	» Annual Stack Emission Testing for SO_2, NO_X and PM. » Emission monitoring for NO_X and SO_2.

Appendix B: Curriculum Vitae

MARK ZUNCKEL

Firm	:	uMoya-NILU (Pty) Ltd
Profession	:	Air quality consultant
Specialization	:	Air quality assessment, air quality management planning, air dispersion modelling, boundary layer meteorology, project management
Position in Firm	:	Managing director and senior consultant
Years with Firm	:	New firm started on 1 August 2007
Nationality	:	South African
Year of Birth	:	1959
Language Proficiency	:	English and Afrikaans

EDUCATION AND PROFESSIONAL STATUS

Qualification	Institution	Year
National Diploma (Meteorology)	Technikon Pretoria	1980
BSc (Meteorology)	Univ. of Pretoria	1984
BSc Hons (Meteorology)	Univ. of Pretoria	1988
MSc	Univ. of Natal	1992
PhD	Univ. Witwatersrand	1999

Registered Natural Scientist: South African Society for Natural Scientific Professionals

Council Member: National Association for Clean Air
Member: African Meteorological Society
Member: Air and Waste Management Association

EMPLOYMENT AND EXPERIENCE RECORD

Period	Organisation details and responsibilities/roles
1976 – May 1992	*South African Weather Bureau :* Observer, junior forecaster, senior forecast, researcher, assistant director
June 1992 – July 2007	*CSIR:* Consultant and researcher, Research group Leader:

	Atmospheric Impacts
August 2007 to present	*uMoya-NILU Consulting:* Managing Director and senior air quality consultant

Key and Recent Project Experience:

1996	Project leader & Principal researcher: Atmospheric impact assessment for the proposed Mozal aluminium smelter in Maputo, Mozambique.
1996	Project leader & Principal researcher: Dry sulphur deposition during the Ben MacDhui High Altitude Trace Gas and Transport Experiment (BATTEX) in the Eastern Cape.
1997	Project leader & Principal researcher: Atmospheric impact assessment of the proposed capacity expansion project for Alusaf in Richards Bay.
1997	Project leader & Principal researcher: The Uruguayan ambient air quality project with LATU.
1997	Principal researcher on the Air quality specialist study for the Strategic Environmental Assessment on the industrial and urban hinterland of Richards Bay.
1997	Project leader & Principal researcher: Feasibility study for the implementation of a fog detection system in the Cape Metropolitan area: Meteorological aspects.
2001	Project leader & Principal researcher: Air quality specialist study for the Environmental Impact Assessment for the proposed expansion of the Hillside Aluminium Smelter, Richards Bay.
2001-2003	Researcher: The Cross Border air Pollution Impact (CAPIA) project. A 3-year modelling and impacts study in the SADC region.
2002	Project leader & Principal researcher: Air quality assessment specialist study for the proposed Pechiney Smelter at Coega.
2002	Project leader & Principal researcher: Air quality assessment specialist study for the proposed N2 Wild Coast Toll Road.
2002-2005	Project leader on the NRF project – development of a dynamic air pollution prediction system
2004	Project leader on the specialist study for expansion at the Natal Portland Cement plant at Simuma, KwaZulu-Natal.
2004-2005	Researcher: National Air Quality Management Plan implementation project for Department Environmental Affairs and Tourism.
2005	Researcher in the assessment of air quality impacts associated with the expansion of the Natal Portland Cement plant at Port Shepstone.
2005	Technical assistance to the Department of Environment Affairs and Tourism in the implementation of the Air Quality Act
2006-2007	Project team leader of a multi-national team to develop the National

	Framework for Air Quality Management for the Department of Environment Affairs and Tourism
2007	Air quality assessment for Mutla Early Production System in Uganda for ERM Southern Africa on behalf of Tullow Oil.
2007-2010	Lead consultant on the development of a dust mitigation strategy fro the Bulk Terminal Saldanha and an ambient guideline for Fe_2O_3 dust for Transnet Projects and on-going monitoring.
2008	Lead consultant on the Air quality status quo assessment and scoping for the EIA for the Sonangol Refinery
2008-09	Lead consultant on the development of the air quality management plan for the Western Cape Provincial. Department of Environmental Affairs and Development Planning.
2008-10	Lead consultant on the development of the Highveld Priority Area air quality management plan for the Department of Environmental Affairs and Tourism.
2008	Lead consultant in the development of an odour management and implementation strategy for eThekwini.
2008 & 2010	Lead consultant on the Air Quality Specialist Study for the EIA for the proposed Kalagadi Manganese Smelter at Coega
2008	Lead consultant on the Air Quality Assessment for the Proposed Construction and Operation of a Second Cement Mill at NPC-Cimpor, Simuma near Port Shepstone.
2008	Lead consultant on the Air Quality Specialist Study Report for the New Multi-Purpose Pipeline Project (NMPP) for Transnet Pipelines.
2008	Lead consultant on the Air quality assessment for the proposed UTE Power Plant and RMDZ coal mine at Moatize, Mozambique for Vale.
2009	Lead consultant on the Air quality assessment for the development of the ETA STAR coal mine at Moatize, Mozambique for Impacto.
2008-09	Lead consultant on the Dust source apportionment study for the Coedmore region in Durban for NPC-Cimpor.
2009	Consultant on the Air quality specialist study for the upgrade of the Kwadukuza Landfill, KwaZulu-Natal
2009-10	Lead consultant on the Audit of ambient air quality monitoring programme and air quality training for air quality personnel at PetroSA
2010	Lead consultant on the Qualitative assessment of impact of dust on solar power station at Saldanha Bay
2010	Lead consultant on the Air quality specialist study for the EIA for the Kalagadi Manganese Smelter at Coega
2010	Lead consultant on the Qualitative air quality assessment for the EIA for the Sechaba Aphalt plant, Ferrobank
2009 – 2010	Lead consultant on the Air quality specialist study for the Environmental Management Framework for the Port of Richards Bay

2010	Lead consultant on the Air quality status quo assessment and abatement planning at Idwala Carbonates, Port Shepstone
2010	Lead consultant on the Air quality status quo assessment and abatement planning at Sappi Tugela, Mandeni
2010 – 2011	Air quality status quo assessment and revision of the Air Quality Management Plan for City of Johannesburg
2010	Lead consultant on the Air quality status quo assessment and abatement planning at First Quantum Mining's Bwana Mkubwa and Kansanshi mines, Zambia
2010 – 2011	Lead consultant on the Air quality specialist study for the EIA for the Alternative Fuel and Resources Project at Simuma, Port Shepstone
2010 – 2011	Lead consultant on the Air quality specialist study for the EIA for the Coke Oven re-commissioning at ArcelorMittal Newcastle
2010	Qualitative air quality assessment for the EIA for the Mozpel sugar to ethanol project , Mozambique
2011	Development of the South African Air Quality Information System – Phase II The National Emission Inventory
2011	Ambient baseline monitoring for Riversdale's Zambeze Coal Project in Tete, Mozambique
2010 - 2011	Ambient quality baseline assessment for the Ncondeze Coal Project, Tete Mozambique
2011-12	Air quality assessment for the mining and processing facilities at Longmin Platinum in Marikana
2012	Air quality assessment for the proposed LNG and OLNG plants in Mozambique
2012	Modelling study in Abu Dhabi for the transport and deposition of radio nuclides
2012	Air quality assessment for the proposed manganese ore terminal at the Ngqura Port
2012-13	Air quality management plan development for Stellenbosch Municipality
2012-12	Air quality management plan development for the Eastern Cape Province
2013	Air quality specialist for Tullow Oil Waraga-D and Kinsinsi environmental audit
2013	Air quality specialist study for the EIA for the Thabametsi IPP station
2013	Air quality specialist study for the EIA for the Mamathwane Common User facility
2013	Air quality management plan for the Ugu District Municipality
2013-14	Air quality specialist study for the application for postponement of the minimum emission standards for 9 Eskom power stations
2014	Air quality specialist study for the application for postponement of

	the minimum emission standards for the Engen Refinery in Merebank, Durban
2014-15	Baseline assessment and AQMP development for the uThungulu District Municipality
2013-15	Baseline assessment and air quality management plan for the Waterberg-Bojanala Priority Area
2014-15	AQMP review for eThekwini Municipality
2014-14	Dispersion modelling study for Richards Bay Minerals
2015	Air quality assessment for Rainbow Chickens at Hammersdale
2015	Air quality status quo assessment and planning for TNPA managed ports in South Africa

PUBLICATIONS

Author and co-author of 34 articles in scientific journals, chapters in books and conference proceedings. Author and co-author of more than 100 technical reports and presented 47 papers at local and international conferences. A full publications list is available on request.