Environmental and Engineering Consultants

GCS Water and Environmental Consultants

AIR QUALITY IMPACT ASSESSMENT

NEWCASTLE LANDFILL

May 2018

Rayten Project Number: RES-GCS-181718

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REVISION AND APPROVAL PAGE

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CONFIDENTIALITY

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	12/12/20/ or 12/9/11/L
NEAS Reference Number:	DEA/EIA
Date Received:	

Application for integrated environmental authorisation and waste management licence in terms of the-

(1) National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2014; and

(2) National Environmental Management Act: Waste Act, 2008 (Act No. 59 of 2008) and Government Notice 921, 2013

PROJECT TITLE

AIR QUALITY IMPACT ASSESSMENT REPORT FOR THE NEWCASTLE LANDFILL

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4.2 The specialist appointed in terms of the Regulations_

I, **Sarisha Perumal** , declare that --

General declaration:

I act as the independent specialist in this application;
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, 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 application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
all the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

Rayten Engineering Solutions CC

Name of company (if applicable):

10 May 2018

Date:

EXECUTIVE SUMMARY

Rayten Engineering Solutions was appointed by GCS to compile an Air Quality Impact Assessment report for the proposed Newcastle Landfill Site in the KwaZulu Natal Province. The main objective of the Air Quality Impact Assessment is to determine the potential impact of emissions from the construction and operational activities associated with the proposed project on ambient air quality in terms of the criteria air pollutants.

As part of the Air Quality Impact Assessment, a Baseline Air Quality Assessment was undertaken to determine the prevailing meteorological conditions at the site, establish baseline concentrations of key air pollutants of concern, identify existing sources of emissions and identify key sensitive receptors surrounding the project site. MM5 meteorological data for the project area for the period 01 January 2015 – 31 December 2017 was used. The Air Quality Impact Assessment consisted of an emissions inventory and subsequent dispersion modelling simulations to determine TSP (as dust fallout), PM_{10}, $PM_{2.5}$, BTEX and H_2S concentrations associated with proposed activities during the construction and operational phases of the project. Comparison of the modelled concentrations were made with the South African Ambient Air Quality Standards to determine compliance.

The proposed study site is approximately 780 ha. The proposed infill area of the landfill where waste will be disposed is expected to occupy an area of ± 5 ha. The landfill site including associated infrastructure (leachate dames, and buffer zones) is anticipated to occupy an area of ± 180 ha. The site is accessible via a gravel road off the N11 located on the east side of the proposed site. The land use within a 20 km radius around the proposed project site consists predominantly of grassland and cultivated land, with some mining activity to the south-east of the proposed landfill site. Urban residential areas are concentrated in the north-east region of the proposed site.

The closest town to the study site is Newcastle, located north-north-east of the proposed landfill site. There are, a number of schools/educational facilities and two medical facility located within a 10km radius of the landfill. Sensitive receptors located near to the study site may be impacted by emissions from operations at the proposed Newcastle Landfill due to the close proximity of these sites.The existing air quality situation is usually evaluated using available monitoring data from permanent ambient air quality monitoring stations, and dust fallout networks operated near the project site. Baseline air quality in the area was assessed using secondary data sources from the Amajuba District Municipality Air Quality Management Plan (AQMP). In 2014 there were three (3) privately owned continuous monitoring stations operating in the district and passive monitoring was conducted by the Department of Environmental Affairs for NO_2, SO_2, O_3 and benzene. There were no exceedances of NO_2, SO_2, O_3 recorded during the DEA passive monitoring campaign. Due to the disjointed and limited periods of monitoring, it is not possible to infer trends from the existing data.

Landfilling operations at the proposed Newcastle Landfill Site are mainly associated with emissions of PM, BTEX, Methane, H_2S and odour impacts. The anticipated impact of activities at the proposed Newcastle Landfill Site were quantitatively assessed through dispersion modelling.

Dust and gaseous emissions will be emitted from the following key sources listed below. Only activities that occurred on site were considered in this study.

- **Dust and Particulate Emissions:**
  - Construction;

- **Gaseous Emissions**
    - Decomposition of landfill waste.

Based on the dispersion modelling results, the following comments are made:

- Predicted incremental dust fallout rates and toluene concentrations comply with the applicable standards beyond 1km from the landfill boundary;
- No exceedances of the limits are recorded for xylene, ethylbenzene and benzene predicted incremental concentrations;
- Predicted incremental concentrations for PM_{10} and $PM_{2.5}$ exceed the applicable limits beyond the site boundary, however, exceedances of the limits at surrounding sensitive receptors are only observed for PM_{10} daily concentrations;
- H_2S is associated with an odour. Predicted incremental H_2S concentrations do not exceed the applicable Canadian guidelines outside the site boundary; with relatively low concentrations observed beyond 1km from the landfill boundary.

In conclusion the dispersion modelling results indicate relatively low incremental concentrations for BTEX, H_2S and dust fallout rates beyond the landfill boundary. Under the worst-case scenario, relatively high PM_{10} and $PM_{2.5}$ concentrations may result due to heavy construction activity during the construction phase. Although these impacts are short term and are limited to the construction phase of the project, dust mitigation measures should be implemented during construction activity to reduce dust emissions. This can be achieved by water spraying, which has an associated emission control efficiency of 50% control. A dust management plan will need to be developed and implemented during the construction phase of the project.

For the operational phase, managed landfill sites can mitigate their emissions through better management of the landfill site, and through the recovery and flaring of landfill gas for later use. Additionally, alternative options for the disposal of waste should be investigated, to allow for organic waste to be diverted, and to be used elsewhere, such as for composting (DEA, 2014). Furthermore, the landfill can implement a waste sorting procedure, whereby recyclable materials are removed, baled on site and sent to recycling facilities. This will allow the landfill to reduce the amount of waste entering the landfill and thus resulting in lower emissions. It is recommended that the landfill develops an emission reduction management plan that can consider some of the mitigation options discussed in Section 6 of the report. The choice of mitigation measures will depend on the availability of resources, practicality, effectiveness and affordability.

Based on the above information, Rayten believes that the proposed development can go ahead if the recommended mitigation measures are implemented during the construction phase. Furthermore, it is recommended that an emission reduction plan be developed for the operational phase of the proposed development.

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LIST OF ABBREVIATIONS

AEL	Atmospheric Emissions License
AQA	Air Quality Act
AQIA	Air Quality Impact Assessment
AQMP	Air Quality Management Plan
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
$CO_{2\text{-eq}}$	Carbon dioxide equivalent
DEA	Department of Environmental Affairs
GHG	Greenhouse gas
GMT	Greenwich Meridian Time
HFC	Hydrofluorocarbons
LFG	Landfill Gas
NAEIS	National Atmospheric Emissions Inventory System
NEMA	National Environmental Management Act
NPI	National Pollutant Inventory
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
N_2O	Nitrous Oxide
Mtpa	Million tonnes per annum
O_3	Ozone
PBL	Planetary Boundary Layer
PFC	Perfluorocarbons
PCD	Pollution Control Dam
PRA	Prospecting Right Area
PM_{10}	Particulate Matter, aerodynamic diameter equal to or size less than 10µm
$PM_{2.5}$	Particulate Matter, aerodynamic diameter size equal to or less than 2.5µm
PRIME	Plume Rise Model Enhancements
H_2S	Hydrogen sulphide
SAAQIS	South African Air Quality Information System
SF_6	Sulphur hexafluoride
SO_2	Sulphur Dioxide
TSP	Total Suspended Particles
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds

1. INTRODUCTION

Rayten Engineering Solutions CC (hereafter referred to as "Rayten") was appointed by Groundwater Consulting Services (GCS) to compile an Air Quality Impact Assessment (AQIA) report for the proposed Newcastle landfill site in the Amajuba District Municipality, KwaZulu-Natal Province, South Africa. The main objective of the Air Quality Impact Assessment is to determine the potential impact of emissions from the construction and operational activities associated with the landfill on ambient air quality in terms of the criteria air pollutants and dust fallout.

As part of the Air Quality Impact Assessment, a baseline air quality assessment is undertaken through a review of meteorological monitoring data, available air quality monitoring data, air quality legislation and the identification of nearby sensitive receptors and existing emissions sources surrounding the project site. The main objective of the baseline air quality assessment was to determine the prevailing meteorological conditions at the site, establish baseline concentrations of key air pollutants of concern, identify existing sources of emissions and identify key sensitive receptors surrounding the project site.

The potential impact of emissions from the construction and operational activities on air quality is evaluated through the compilation of an emissions inventory and subsequent dispersion modelling simulations using AERMOD. Comparison of predicted concentrations for key criteria air pollutants is made with the South African Ambient Air Quality Standards and the South African National Dust Control Regulations, where applicable. Comparison of non-criteria air pollutant concentrations was also made with the Government of Alberta Canada's Ambient Air Quality Guidelines (Alberta,2017).

1.1 Project Detail

Applicant	Newcastle Local Municipality
Physical Address	27° 50' 53.6" S and 29° 55' 12.2" E
AEL number	No AEL
EA reference number	Currently in process of applying for EA
Modelling contractor	Rayten Engineering Solutions CC Please refer to appendix C for specialist CV and company profile.

1.2 Brief Project Description

The following landfilling operations will occur at the proposed Newcastle Landfill Site and are mainly associated with emissions of Particulate Matter (PM) and gaseous compounds:

- Waste reception,
- Waste processing,
- Waste deposition,
- Waste compaction and
- covering of waste.

Eventual demolition and rehabilitation activities will involve final capping and vegetation of the deposited wastes, excavating and removing contaminated soil (if any), demolishing redundant infrastructure, scarifying and vegetating exposed compacted areas and would have dust generation impacts similar to those of the construction phase. A map indicating the proposed landfill area and basic site layout is given in Figure 1-1.

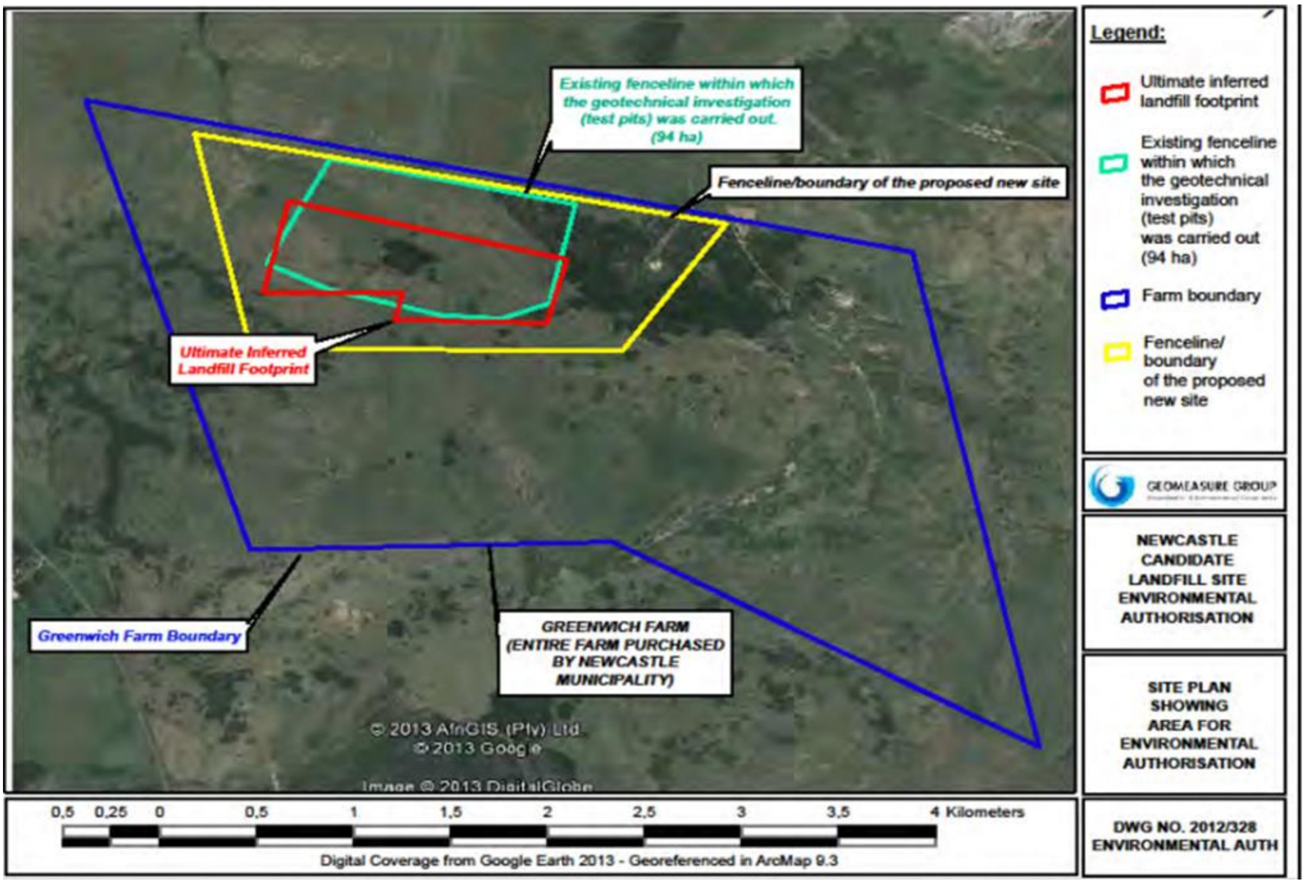


Figure 1-1: Proposed Newcastle Landfill Site Layout Diagram.

1.3 Terms of Reference

The scope of work for the Air Quality Impact Assessment is as follows:

1.3.1 Air Quality Impact Assessment

- A review of the study site and proposed activities;
- An overview of the prevailing meteorological conditions in the area which influence the dilution and dispersion of pollutants in the atmosphere;
- The identification of existing sources of emissions;
- The identification of key air pollutants of concern that may be emitted from proposed activities (criteria air pollutants);
- Characterisation of the ambient air quality within the area using available air quality monitoring data;
- A review of the current South African legislative and regulatory requirements for air quality;
- The identification of sensitive receptors, such as local communities, surrounding the study area;

- The compilation of a detailed emission inventory for key sources of emissions;
- Dispersion modeling simulations of ground level particulate and gaseous emissions for incremental impacts; and
- Provision of general recommendations for the mitigation and management of identified potential impacts. This does not include a detailed dust management plan.

1.4 Outline of Report

An overview of the site location including surrounding receptors is given in **Section 2**. National ambient air quality standards, dust fallout regulations and associated health impacts for the relevant criteria pollutants are provided in **Section 3**. The local meteorological conditions and baseline air pollutants concentrations are provided in **Section 4**. Potential emissions and their impact on air quality associated with proposed operations are outlined in **Section 5**. Mitigation measures, recommendations and a summary report are provided in **Section 6**.

2 SITE CHARACTERISTICS

2.1 Site Location

The proposed general waste landfill site is to be constructed on a portion of the Farm Greenwich 8784, Newcastle, Kwa-Zulu Natal Province. The Site coordinates are 27° 50’ 53.6” S and 29° 55’ 12.2” E. The proposed site is located approximately 11 km south of Newcastle Local Municipality in the Amajuba District Municipality, KZN.

2.2 Surrounding Land Use

The proposed study site is approximately 780 ha. The proposed infill area of the landfill where waste will be disposed is expected to occupy an area of ± 5 ha. The landfill site including associated infrastructure (leachate dames, and buffer zones) is anticipated to occupy and area of ± 180 ha. The site is accessible via a gravel road off the N11 located East on the east side of the proposed site.

The land use within a 20 km radius around the proposed project site consists predominantly of grassland and cultivated land, with some mining activity to the south east of the proposed landfill site. Urban residential areas are concentrated in the north-east region of the proposed site (Figure 2-1.)

2.3 Topography

The topography surrounding the proposed landfill site is shown in Figure 2-3. Surrounding elevations range from approximately 743 – 2 339m above sea level. The project site is situated approximately 1440m above sea level; with increasing elevation towards the north-west.

2.4 Sensitive Receptors

A sensitive receptor is defined as a person or place where involuntary exposure to air pollutants released by the site’s activities could take place. Identified urban/residential areas which are located within 10km from the proposed landfill site boundary are given in

There are residential receptors located within a 10km radius of the proposed landfill site. These are predominantly in the town of Newcastle, north of the site. In addition, there are schooling/educational/raining facilities, and two health care facilities located within 10km of the proposed landfill site. No old age homes were identified during the desktop exercise to fall within 10km of the site.

Table 2-1: Discrete receptors within 10km of the proposed landfill site. Receptors were identified through a desktop study.

Receptor	Co-ordinate		Elevation	Type	Approx. Distance	Direction from project site
	x	Y	m		km	
Hosp 1	209684.29	6925315.59	1 224	Residential	15.5	E
Hosp 2	789422.44	6925669.20	1 220	Residential	10.3	N
Hosp 3	788957.08	6924979.16	1 226	Residential	9.8	N
Edu 1	792433.74	6917281.23	1 353	Residential	4.58	NE
Edu 2	784618.50	6920302.03	1 348	Residential	5.64	NW
Edu 3	793438.81	6911102.50	1 411	Residential	7.32	SW
Edu 4	783568.93	6910955.21	1 416	Residential	6.16	S
Notes: Edu = school / training / educational facility Hosp = hospital / clinic / healthcare facility Distance = indicated from centre of landfill site						

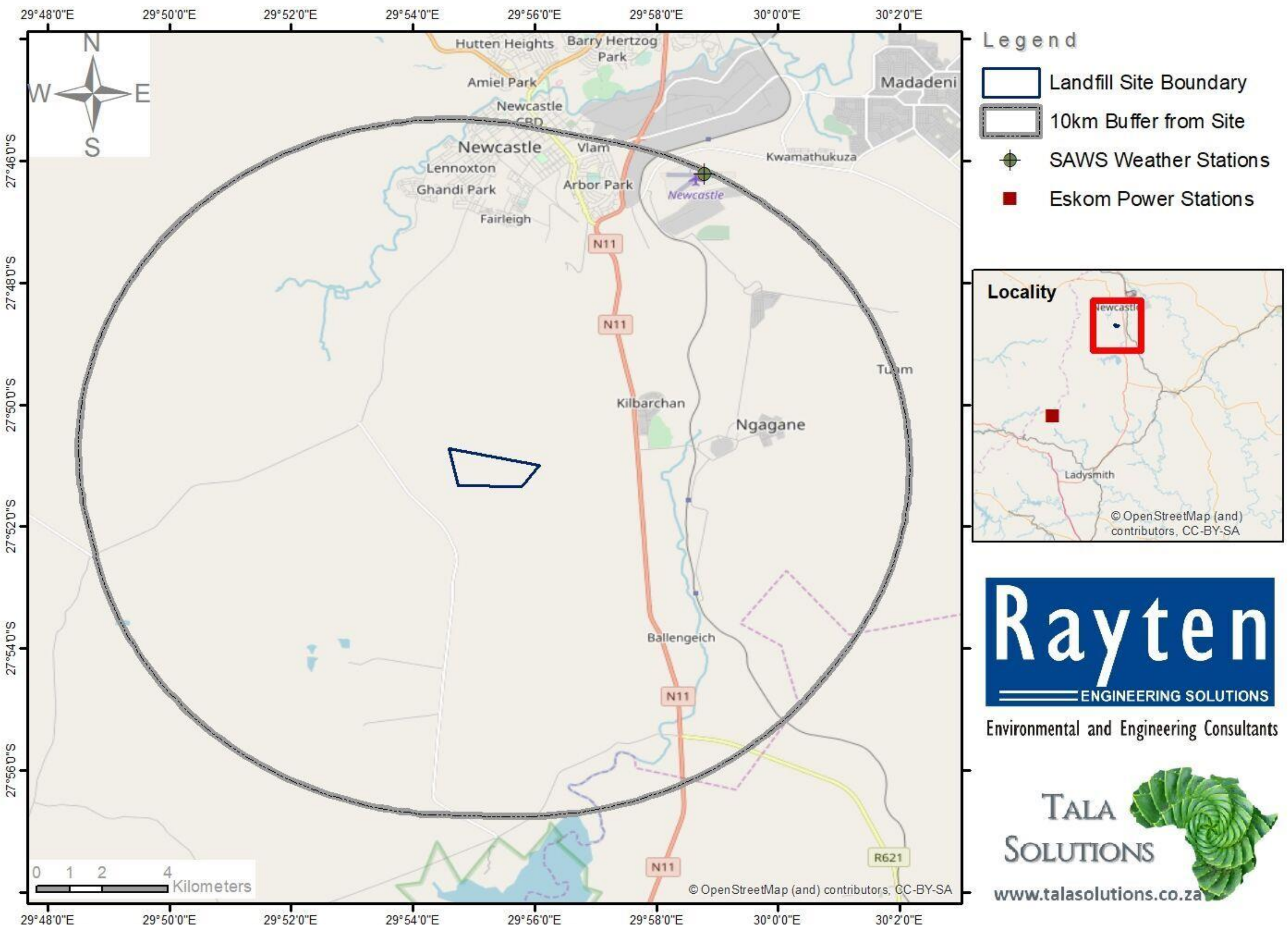


Figure 2-1: Site Locality for the proposed Newcastle Landfill Site.

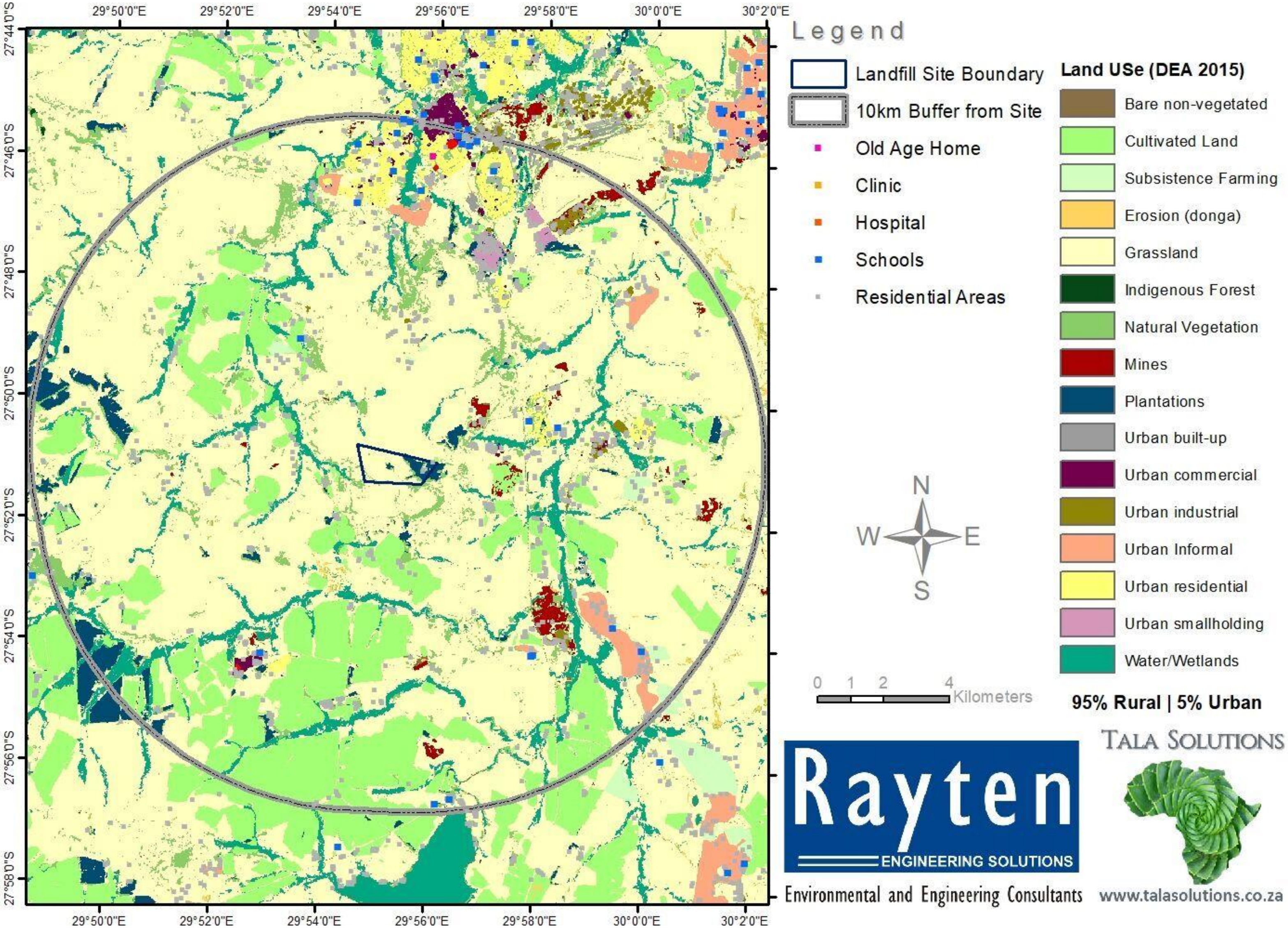


Figure 2-2: Land use surrounding the proposed Newcastle Landfill Site.

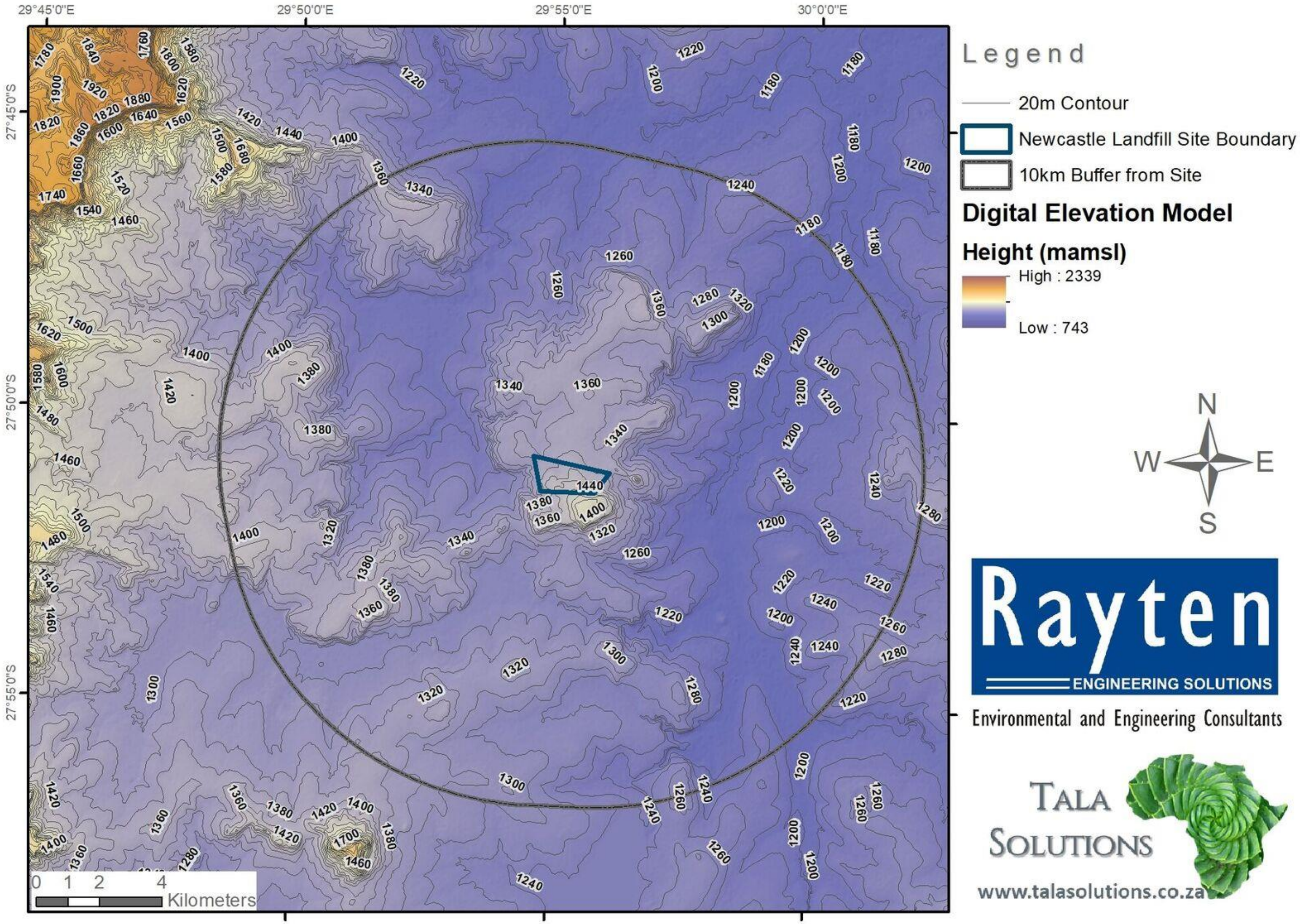


Figure 2-3: Topography surrounding the proposed Newcastle Landfill Site.

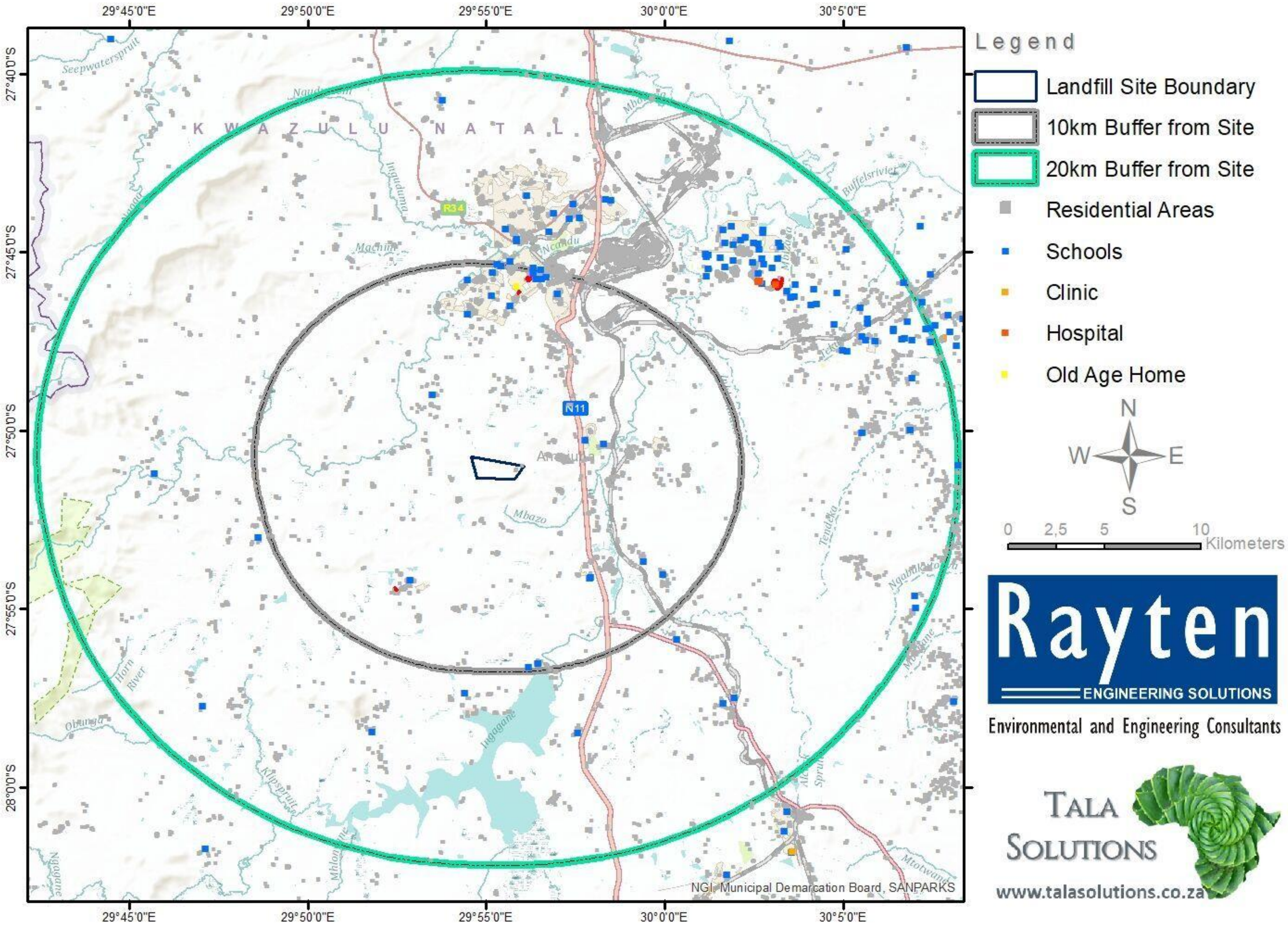


Figure 2-4: Residential receptors surrounding the proposed Newcastle Landfill Site.

3 LEGISLATION, POLICIES AND GUIDELINES

3.1 National Environmental Management: Air Quality Act

The National Environmental Management: Air Quality Act (NEM: AQA) No. 39 of 2004, has shifted the approach of air quality management from source-based control to receptor-based control. The main objectives of the Act are to;

- Give effect to everyone's right "to an environment that is not harmful to their health and wellbeing".
- Protect the environment by providing reasonable legislative and other measures that;

    i. Prevent pollution and ecological degradation,
    ii. Promote conservation, and
    iii. Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

The Act makes provisions for the setting and formulation of National ambient air quality standards for "substances or mixtures of substances which present a threat to health, well-being or the environment". More stringent standards can be established at the provincial and local levels.

The control and management of emissions in the NEM: AQA relates to the listing of activities that are sources of emissions and the issuing of emission licences. Listed activities are defined as activities which "result in atmospheric emissions and are regarded as having a significant detrimental effect on the environment, including human health". Listed activities have been identified by the Minister of the Department of Environmental Affairs (DEA) and atmospheric emission standards have been established for each of these activities. These listed activities now require an AEL to operate. The issuing of AELs for listed activities will be the responsibility of the Metropolitan and District Municipalities.

In addition, the Minister may declare and substance contributing to air pollution as a priority pollutant. Any industries or industrial sectors that emit these priority pollutants will be required to implement a Pollution Prevention Plan. Municipalities are required to "designate an air quality officer to be responsible for co-ordinating matters pertaining to air quality management in the Municipality". The appointed Air Quality Officer is responsible for the issuing of atmospheric emission licences.

3.2 Listed Activities and Minimum Emission Standards

The NEM: AQA requires all persons undertaking listed activities in terms of Section 21 of the Act to obtain an AEL. The listed activities and associated minimum emission standards were issued by the DEA on 31 March 2010 (Government Gazette No. 33064 of 31 March 2010) and were amended in 2013 (Government Gazette No. 37054 of 22 November 2013) and 2015 (Government Gazette No. 38863 of 12 June 2015).

Should the landfill wish to commence with any of the listed activities; an Atmospheric Emission Licence would need to be applied for prior to the commencement of the activity. Minimum emission standards identified in terms of Section 21 of the National Environmental Management: Air Quality

Act (Act No. 39 of 2004) and stipulated in GNR 893 must be complied with for any listed activities that may become relevant in the future.

South Africa launched an online national reporting system, reffered to as the National Atmospheric Emissions Inventory System (NAEIS). The AQA requires all emission source groups identified in terms of the National Atmospheric Reporting Regulations (Government Gazette No. 38633 of 02 April 2015), to register and report emissions on the NAEIS.

3.3 Ambient Air Quality Standards

National ambient air quality standards, including allowable frequencies of exceedance and compliance timeframes, were issued by the Minister of Water and Environmental Affairs on 24 December 2009 (Table 3-1). National standards for $PM_{2.5}$ were established by the Minister of Water and Environmental Affairs on 29 June 2012.

Table 3-1: National Ambient Air Quality Standards for Criteria Pollutants.

POLLUTANT	AVERAGING PERIOD	CONCENTRATION ($\mu g/m^3$)	FREQUENCY OF EXCEEDANCE
Sulphur dioxide (SO_2)	10 minutes	500 (191)	526
	1 hour	350 (134)	88
	24 hours	125 (48)	4
	1 year	50 (19)	0
Nitrogen dioxide (NO_2)	1 hour	200 (106)	88
	1 year	40 (21)	0
Particulate Matter (PM_{10})	24 hours	75	4
	1 year	40	0
Particulate Matter ($PM_{2.5}$)	24 hours	40(1) 25(2)	0
	1 year	20(1) 15(2)	0
Ozone (O_3)	8 hours (running)	120 (61)	11
Benzene (C_6H_6)	1 year	5 (1.6)	0
Lead (Pb)	1 year	0.5	0
Carbon monoxide (CO)	1 hour	30 000 (26 000)	88
	8 hour (calculated on 1 hourly averages)	10 000 (8 700)	11

Notes:

*Values indicated in blue are expressed in PPB.

(1) Compliance required by 1 January 2016 – 31 December 2029.

(2) Compliance required by 1 January 2030.

3.4 Dust Deposition Standards

The Department of Environmental Affairs has issued National dust control regulations on 1 November 2013 (Table 3-2). The purpose of the regulations is to prescribe general measures for the control of dust in all areas. The regulations prohibit activities which give rise to dust in such quantities and concentrations that the dust fall at the boundary or beyond the boundary of the premises where it originates exceeds -

a) 600 mg/m^2/day averaged over 30 days in residential areas measured using reference method ASTM D1739.
b) 1200 mg/m^2/day averaged over 30 days in non-residential areas measured using reference method ASTM D1739.

Table 3-2: South African Dust Fallout Regulations.

RESTRICTION AREAS	DUST FALLOUT RATE (D) (1)	REQUENCY OF EXCEEDANCE
Residential Areas	D < 600	Two within a year, no two sequential months (2)
Non-residential areas	600 < D < 1200	Two within a year, no two sequential months (2)

Notes:

(1) Averaged over 1 month (30±2-day average) (mg/m^2/day)

(2) Per dust fallout monitoring site.

Any person who has exceeded the dust fallout standard must, within three months after submission of a dust fallout monitoring report, develop and submit a dust management plan to the air quality officer for approval. The dust management plan must:

a) Identify all possible sources of dust within the affected site;
b) Detail the best practicable measures to be undertaken to mitigate dust emissions;
c) Develop an implementation schedule;
d) Identify the line management responsible for implementation;
e) Incorporate the dust fallout monitoring plan;
f) Establish a register for recording all complaints received by the person regarding dust fall, and for recording follow up actions and responses to the complainants.

The dust management plan must be implemented within a month of the date of approval. An implementation progress report must be submitted to the air quality officer at agreed time intervals.

3.5 GHG Emissions

On 14 March 2014, the following six greenhouse gases were declared as priority air pollutants in South Africa:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF_6)

National GHG Emission Reporting Regulations (Government Gazette No. 40762 of 3 April 2017), were published by the Department of Environmental Affairs. A person identified as a Category A data provider in terms Annexure 1 of these regulations, must register their facilities by filling in the form under Annexure 2 and must submit a GHG emissions inventory and activity data in the required format given under Annexure 3 on an annual basis.

Updated draft National Pollution Prevention Plan Regulations (Draft Gazette No. 40996) were published on 21 July 2017 by the Department of Environmental Affairs (DEA). A pollution prevention plan will be required should the proposed development:

a) Undertake any of the following activities identified in Annexure A of the National GHG Emission Reporting Regulations (Government Gazette No. 40762 of 3 April 2017), which involves the direct emission of GHG in excess of 0.1 Megatonnes (Mt) annually measured as carbon dioxide equivalents ($CO_{2\text{-}eq}$); or
b) Undertake any of the following activities identified in Annexure A of the Draft National Pollution Prevention Plan Regulations (Gazette No. 40996 of 21 July 2017) as a primary activity.

<u>Annexure A activities in terms of the Draft National Pollution Prevention Plan Regulations include:</u>

- Coal mining
- Production and /or refining of crude oil
- Production and/or processing of natural gas
- Production of liquid fuels from coal or gas
- Cement production
- Glass production
- Ammonia production
- Nitric acid production
- Carbon black production
- Iron & steel production
- Ferro-alloys production
- Aluminium production
- Polymers production
- Pulp and paper production
- Electricity production

A person identified as a Category A data provider in terms of these regulations must register their facilities by filling in the form under Annexure 2 and must submit a GHG emissions inventory and activity data in the required format given under Annexure 3. All data must be provided annually, by the 31 Marchof the following year. Data providers are required to register on the NAEIS and report on their direct GHG emissions on an annual basis and comply with the reporting requirements as detailed in the National GHG Emission Reporting Regulations.

3.6 Human Health Effects

3.6.1 Dust Fallout (TSP)

Dust fallout are particles with an aerodynamic diameter greater than 20µm that have been entrained into the air by a physical process such as wind, movement of vehicles, stack emissions and from fugitive dust. These particles are generally too heavy to remain in suspension in the air for any period of time and fall out of the air over a relatively short distance depending on a combination of various factors such as particle size, density, temperature (of the air and particle), emission velocity or method, ambient wind speed and humidity. These particles are therefore commonly known as "dust fallout". Particulates in this range are generally classified as a nuisance dust and can cause physical damage to property and physical irritation to plants, animals and humans.

3.6.2 Particulates (PM_{10} & $PM_{2.5}$)

Particles can be classified by their aerodynamic properties into coarse particles, PM10 (particulate matter with an aerodynamic diameter equal to or less than 10 µm) and fine particles, PM2.5 (particulate matter with an aerodynamic diameter equal to or less than 2.5 µm). The fine particles mostly contain secondary formed aerosols such as sulphates and nitrates, combustion particles and re-condensed organic and metal vapours. The coarse particles mostly contain earth crust materials and fugitive dust from roads and industries (Harrison *et al.,* 2014).

In terms of health impacts, particulate air pollution is associated with effects on the respiratory system (WHO, 2000). Particle size is important for health because it controls where in the respiratory system a given particle deposits. Fine particles are thought to be more damaging to human health than coarse particles as larger particles do not penetrate deep into the lungs compared to smaller particles. Larger particles are deposited into the extra thoracic part of the respiratory tract while smaller particles are deposited into the smaller airways leading to the respiratory bronchioles (WHO, 2000).

Recent studies suggest that short-term exposure to particulate matter leads to adverse health effects, even at low concentrations of exposure (below 100 µg/m^3). Morbidity effects associated with short-term exposure to particulates include increases in lower respiratory symptoms, medication use and small reductions in lung function. Long-term exposure to low concentrations (~10 µg/m^3) of particulates is associated with mortality and other chronic effects such as increased rates of bronchitis and reduced lung function (WHO, 2000). Those most at risk include the elderly, individuals with pre-existing heart or lung disease, asthmatics and children.

3.6.3 BTEX Compounds

Benzene is a known carcinogen, with residence times varying between one day and two weeks in the atmosphere, depending on the environment, the climate and the concentration of other pollutants (WHO, 2000). Inhalation accounts for more than 95–99 % of the benzene exposure of the general population (WHO, 2000). Chronic benzene exposure can result in bone marrow depression expressed as leukopenia, anaemia and/or thrombocytopenia, leading to pancytopenia and aplastic anaemia (WHO, 2000). Benzene is 'isolated' from a range of aromatic hydrocarbons as a compound known to affect people's health adversely (the effect of other aromatic hydrocarbons is not yet fully quantified), and countries around the world have established protective guidelines and air quality standards relating to this substance. (DEA, 2009).

3.6.3.1 Benzene

Benzene is a known carcinogen, with residence times varying between one day and two weeks in the atmosphere, depending on the environment, the climate and the concentration of other pollutants (WHO, 2000). Inhalation accounts for more than 95–99 % of the benzene exposure of the general population (WHO, 2000). Chronic benzene exposure can result in bone marrow depression expressed as leukopenia, anaemia and/or thrombocytopenia, leading to pancytopenia and aplastic anaemia (WHO, 2000). Benzene is 'isolated' from a range of aromatic hydrocarbons as a compound known to affect people's health adversely (the effect of other aromatic hydrocarbons is not yet fully quantified), and countries around the world have established protective guidelines and air quality standards relating to this substance. (DEA, 2009).

3.6.3.2 Ethylbenzene

Ethylbenene is a common compound in ambient air and primarily results from vehicle emissions and ndustrial activities. Petrol contains around 1 to 2 % ethylbenzene. At urban sites, concentrations can be as much as 0.1 to 83 ppb; whereas, levels in rural areas are generally low. Exposure to ethylbenzene can irritate the eyes, nose and throat. High concentration can cause an individual to become dizzy, light headed, or to pass out. Very high levels can cause paralysis, trouble breathing and death. (NPI, 2014).

3.6.3.3 Toluene

Toluene is a colourless, water-insoluble liquid with the smell associated with paint thinners. It is a mono-substituted benzene derivative. Toluene is most commonly used in industrial solvents for the manufacturing of paints, chemicals, pharmaceuticals and rubber (McKeown, 2015). Short term exposure to high levels of toluene in the air can result in light-headedness and euphoria, followed by dizziness, sleepiness and unconsciousness. Long term exposures at low levels in the air can cause effects to the kidneys (NPI, 2014).

3.6.3.4 Xylene

Xylene is a compound primarily released from industrial sources and motor vehicle exhausts (NPI, 2014). In urbanised areas, xylene concentrations of up to 178 ppb have been recorded. Ambient air concentrations of xylene are on average 0.23 ppb and can be up to three times higher in suburban areas. Exposure routes primarily occur via inhalation, ingestion as well as via eye or skin contact. Xylene adverse health effects can be both acute and chronic in nature, depending on concentration levels and exposure times. In addition, individuals also react differently to varying levels of xylene exposure (Phoslab, 2017)

3.6.3.5 Hydrogen Sulphide (H2S)

H2S is a colourless, poisonous, corrosive flammable gas which has a distinct sulphur, “rotten egg” smell (CPCB, 2017). It occurs naturally in crude oil and natural gas but may also be produced by the breakdown of organic matter in the absence of oxygen as well as human or animal wastes. (OSHA, 2005). Health effects vary greatly depending on the time and level of exposure. At low concentrations there may be irritation of the eyes, nose, throat, or respiratory system. At moderate concentrations, a person may experience more severe eye and respiratory effects, headaches, dizziness, nausea, vomiting, coughing, and difficulty breathing (OSHA, 2005).

4 BASELINE ASSESSMENT

4.1 Meteorological Overview

Meteorological processes will determine the dispersion and dilution potential of pollutants emitted into the atmosphere. The vertical dispersion of pollution is governed by the stability of the atmosphere and the depth of the surface mixing layer. Horizontal dispersion of pollution is defined by dominant wind fields. Therefore, meteorological parameters including temperature, precipitation, wind speed and wind direction are of significance as they will influence the degree to which pollution will accumulate or disperse in the atmosphere.

As per the Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa (DEA, 2014), representativeness of the meteorological data is influenced by the following four factors:

- Proximity of the meteorological site to the area being modelled;
- Complexity of the terrain;
- Exposure of the meteorological measurement site; and
- Period of data collection.

A comprehensive meteorological dataset, considering the above-mentioned factors for the project area could not be obtained, therefore, MM5 modeled meteorological data was used for the project area. MM5 meteorological data was obtained from Lakes Environmental for the period January 2015 to December 2017. MM5 is a PSU/NCAR meso-scale model used to predict meso-scale and regional-scale atmospheric circulation. The model provides integrated model meteorological data, which can be used in a wide range of applications. This model is often used to create weather forecasts and climate projections. Details of the meteorological data obtained is summarised in Table 4-1.

Table 4-1: Meteorological Data Details.

Meteorological Data Details	
Met Data Information	**Description**
Met data type	MM5 AERMET-Ready (Surface & Upper Air Data)
Datum	WGS 84
Closest Town	Newcastle - South Africa
Latitude	27.859086
Longitude	29.924121
Time zone	UTC/GMT UTC + 2 hour (s)
Period of record	Jan 01, 2015 – Dec 31, 2017
Met Station Parameters	**Description**
Anemometer height	14 m
Station base elevation	1 352 m
Upper air adjustment	-2 hour (s)
Grid Cell Information	
Cell centre	27.859086, 29.924121
Cell dimension	12km x 12km
Surface Met Data	**Description**
File format	SAMSON file
Output interval	Hourly
Upper Air Data	**Description**
Format	TD-6201- Fixed Length
Reported in	GMT
Output interval	00Z and 12Z
Models used to process met data	
Model used to process data for wind roses	WR Plot
Model used to process data for AERMOD	AERMET

4.1.1 Local Wind Field

Figure 4 1 provides the period wind rose plot for the period January 2015 to December 2017. The predominant wind directions for the period are observed from the west (~11.1%), and east (~9% of the time). Wind speeds for the three-year period are generally moderate to fast with calm conditions, defined as wind speeds less than 1 m/s, observed for 7.99 % of the time (Figure 4 1).

The morning (AM) and evening (PM) period wind rose plots for the period January 2015 to December 2017 are given in Figure 4 2 and show diurnal variation in the wind field data. During the morning (AM) period, high frequency winds are observed from the west; as opposed to the evening (PM) period, where winds are predominantly observed from the east (Figure 4 2).

Seasonal variation in winds at the Newcastle Landfill Site is shown in Figure 4 3. During the winter and autumn seasons, winds originate predominantly from the east, west and and south westerly directions, respectivley. Easterly winds are frequent in summer. Spring months, in particular, exhibit more variation in wind direction, with prevailing winds observed from the east and westerly quadrants.

Based on the prevailing wind fields for the period January 2015 to December 2017, emissions from operations at the proposed Newcastle Landfill Site will likely be transported towards the easterly, and westerly sectors. Moderate to fast wind speeds observed during all time periods may result in effective dispersion and dilution of emissions from proposed landfill activitis; however, higher winds speeds can also facilitate fugitive dust emissions from open exposed areas.

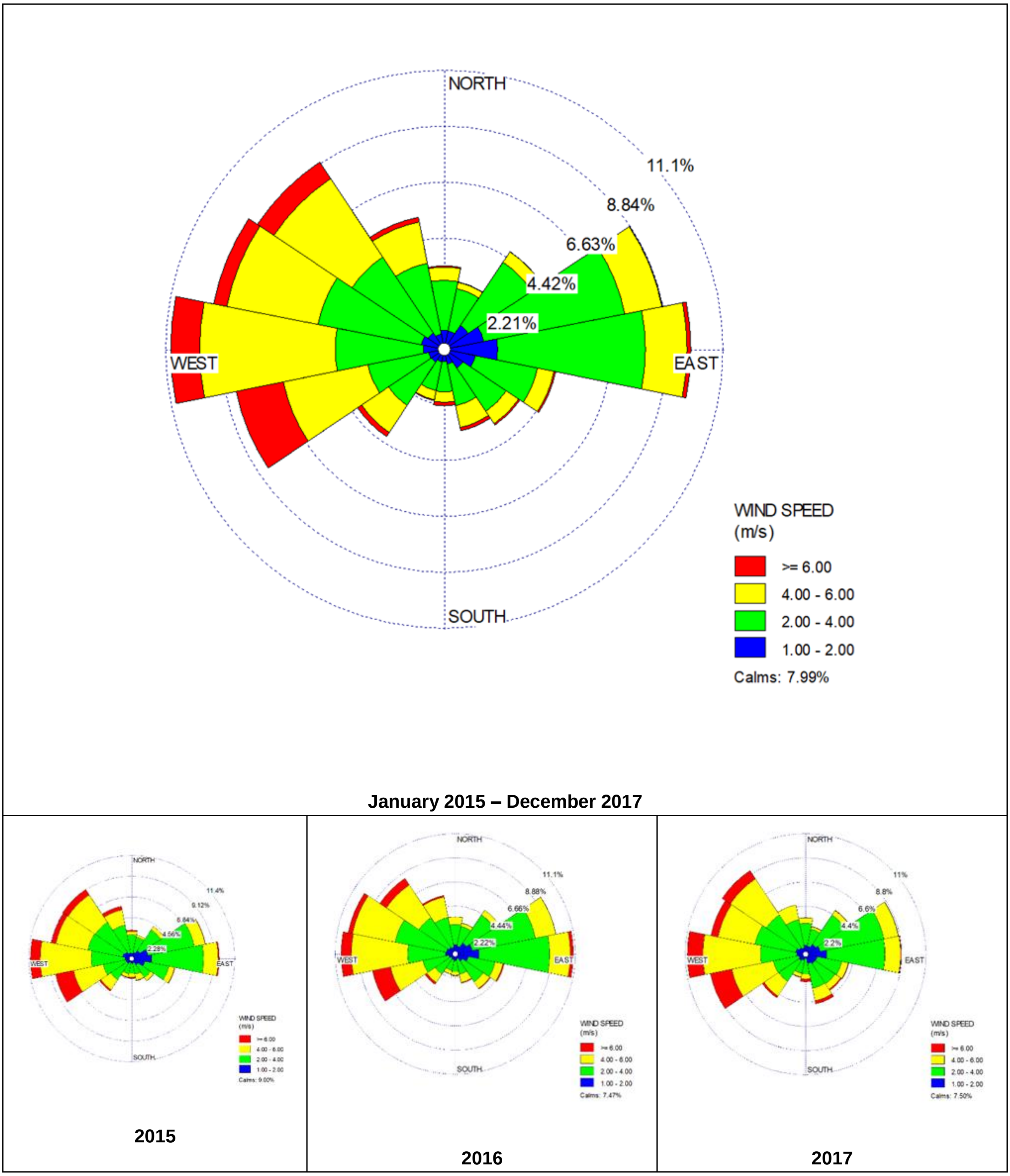
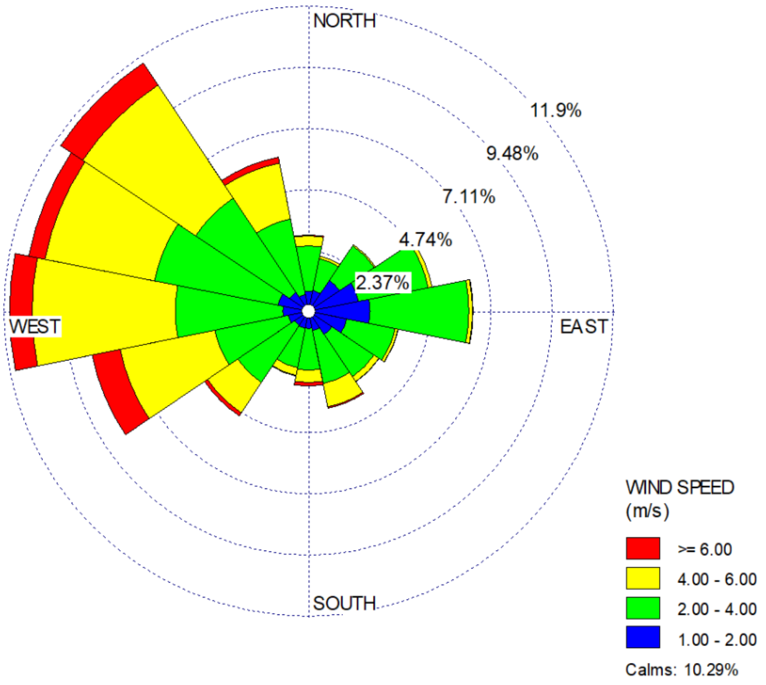
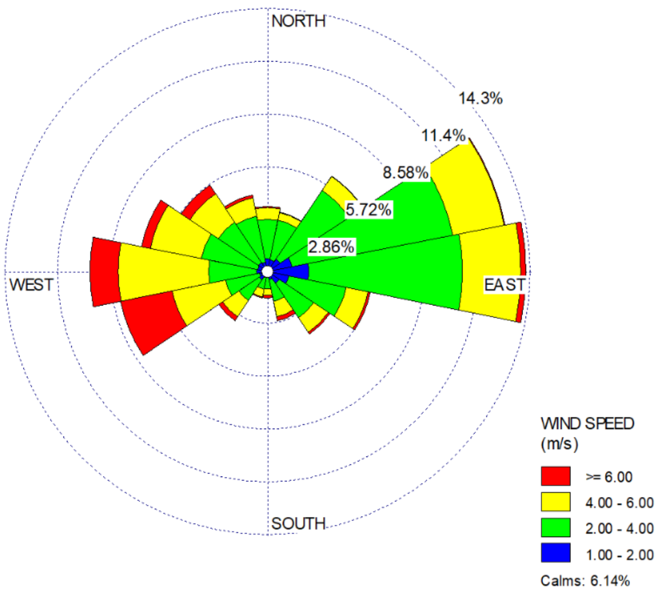


Figure 4-1: Period Wind Rose Plots for the project site for the period January 2015 - December 2017.



Morning (AM) (00:00 – 12:00)



Evening (PM) (12:00 – 23:00)

Figure 4-2: Morning (AM) (00:00 - 12:00) and Evening (PM) (12:00 - 23:00) Period Wind Rose Plots for the project site for the Period January 2015 - December 2017.

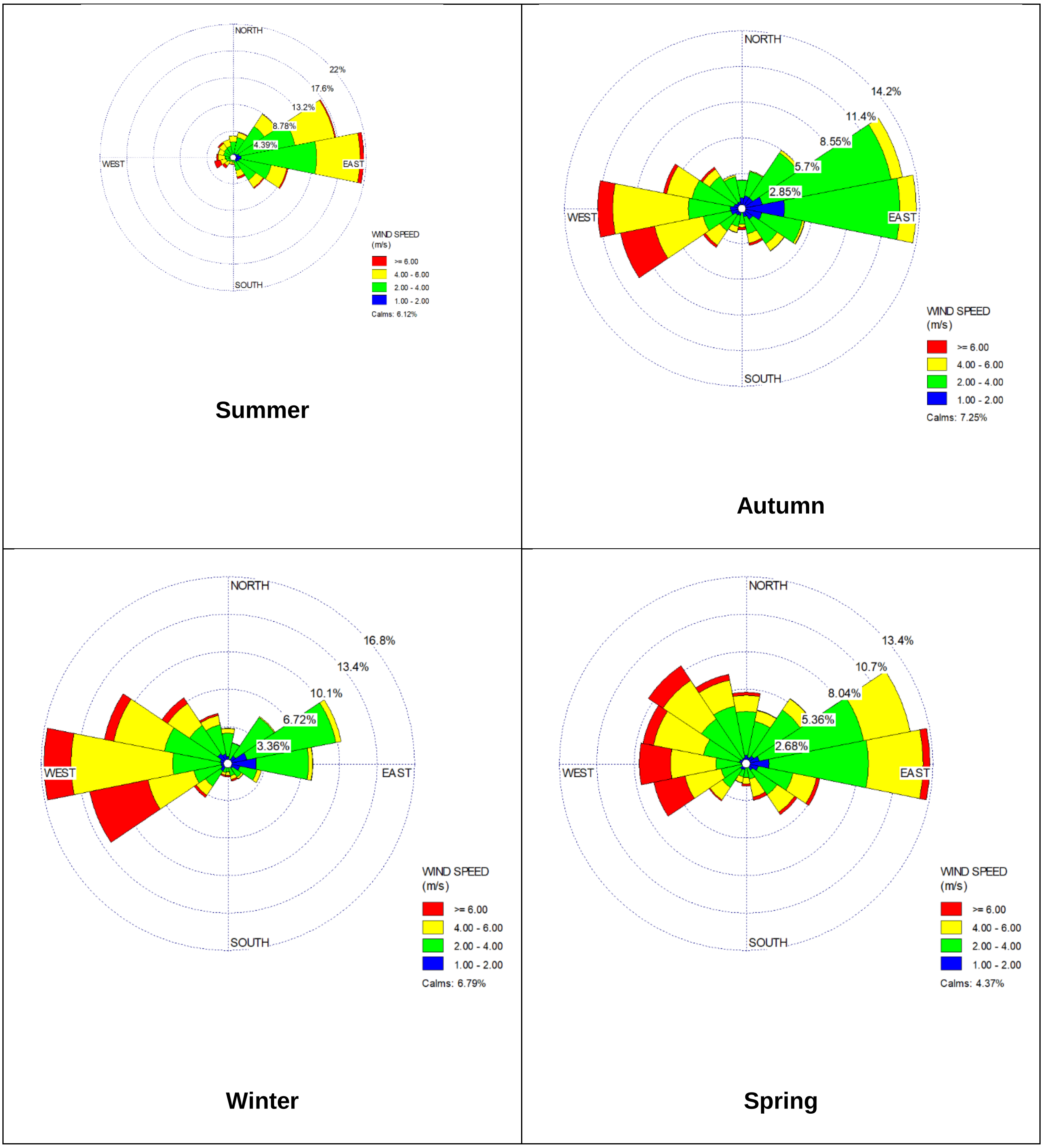


Figure 4-3: Seasonal Variation of Winds for the Project Site for the Period January 2015 - December 2017.

4.1.2 Temperature and Relative Humidity

Temperature affects the formation, action and interactions of pollutants in various ways. Temperature provides an indication of the rate of development and dissipation of the mixing layer, which is largely controlled by surface inversions. Surface temperature inversions play a major role in air quality, especially during the winter months when these inversions are the strongest. Higher ambient temperatures will facilitate the dispersion of air pollutants which can result in lower ambient concentrations.

Chemical reaction rates also tend to increase with temperature and the warmer the air, the more water it can hold and therefore the higher the humidity. When relative humidity exceeds 70%, light scattering by suspended particles begins to increase, as a function of increased water uptake by the particles. This results in decreased visibility due to the resultant haze. Many pollutants may also dissolve in water to form acids.

The north-western region of KwaZulu-Natal generally experiences a varied climate with warm summers and mild winters. Monthly average temperatures and relative humidity profiles at the project site for the period January 2015 to December 2017 are presented in Figure 4 4. Average monthly temperatures range from 8.1 – 34.4 ºC (Table 4 2). Highest temperatures are observed during the summer months (December – February) and minimum temperatures are observed during the winter months (June – August). Relative humidity is highest in winter (i.e. May – July), and lower but consistent for the rest of the year (i.e. August – April).

Table 4-2: Hourly Minimum, Maximum and Monthly Average Temperatures for January 2014 - December 2016.

MINIMUM, MAXIMUM AND MONTHLY AVERAGE TEMPERATURES (ºC)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Minimum	8.1	11.5	9.6	4.2	2.6	0.6	0.1	0.6	3.5	2.5	3.9	9.5
Maximum	34.4	31.1	29.6	29.1	23.8	21.8	20.6	26.5	28.9	31.5	32.6	33.1
Average	21.2	21.0	20.0	17.0	14.2	11.2	11.1	13.7	16.8	18.4	19.5	21.7

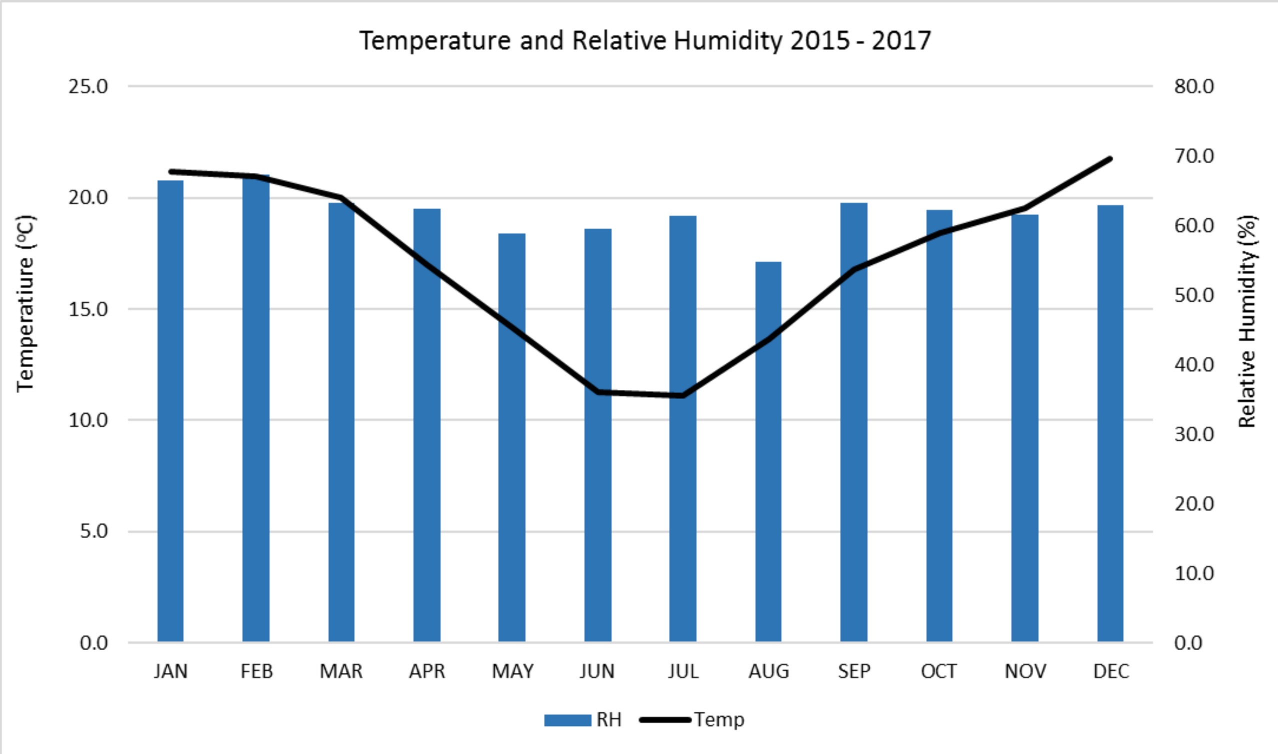


Figure 4-4: Monthly Average Temperature and Relative Humidity profiles for the project site for January 2015 - December 2017.

4.1.3 Precipitation

Precipitation has an overall dilution effect and cleanses the air by washing out particles suspended in the atmosphere. Monthly total rainfall at the project site for the period January 2015 to December 2017 is presented in Table 4-3. The area receives most of its rainfall during the spring, summer and early autumn seasons during the months September - March. Little to no rainfall is observed during the late autumn and winter seasons from May to July (Table 4-3). Removal of particulates via wet depositional processes would be evident during the spring and summer seasons thus lower ambient concentrations of dust could be expected during these seasons. Over the remainder of the year higher ambient concentrations of particulates could be expected.

Table 4-3: Total Monthly Rainfall for January 2015 - December 2017.

TOTAL MONTHLY RAINFALL (mm)												
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2015	110.6	71.6	107.95	32.5	4.6	0	19.3	3.6	43	170	104.6	166.9
2016	110.9	105.9	146.304	24.4	4.3	1.5	28.4	15.7	79.2	68.1	204.2	134.1
2017	230.9	253.2	37.338	12.2	10.7	0.3	0	2.3	29.4	106.9	136.7	259.8

4.2 Baseline Air Quality Concentrations

The existing air quality situation is usually evaluated using available monitoring data from permanent ambient air quality monitoring stations and dust fallout networks operated near the project site. Baseline air quality in the area was assessed using secondary data sources from the Amajuba District Municipality Air Quality Management Plan (ADM,2014). It was not possible to identify seasonal trends of pollutants of concern due to the scarcity of data.

4.2.1 Baseline NO_2, SO_2, O_3 and benzene Concentrations

The results of the passive monitoring campaign conducted by provincial officials are shown below in Figures below.

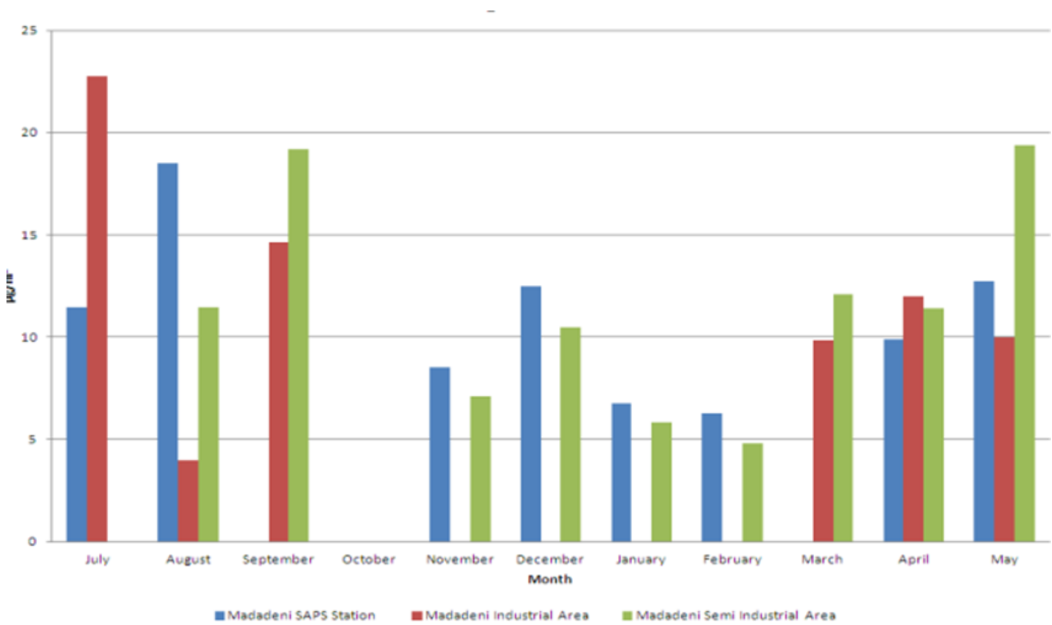


Figure 4-5 Monthly average NO_2 concentrations (July 2012 – May 2013) (ADM,2014).

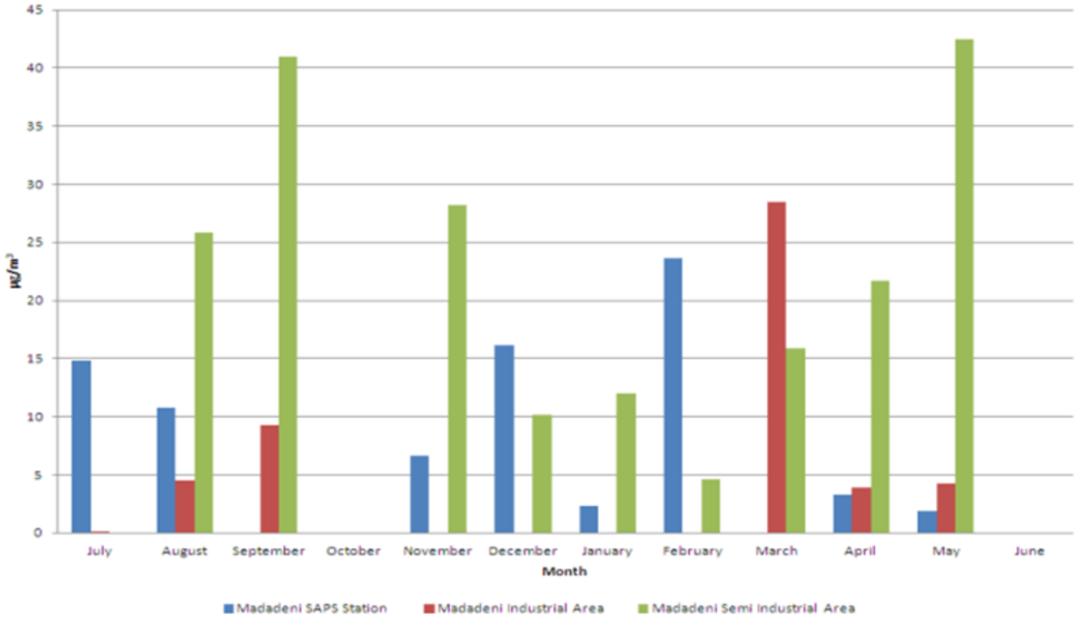


Figure 4-6 Monthly average SO_2 concentrations (July 2012 – May 2013) (ADM,2014).

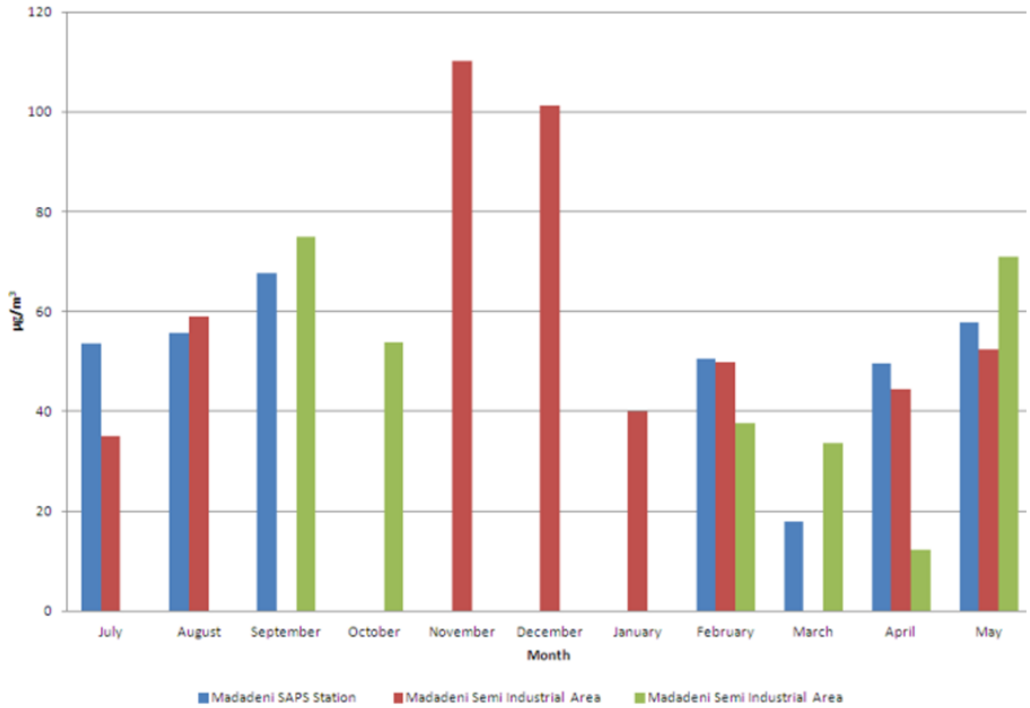


Figure 4-7: Monthly average O_3 concentrations (July 2012 – May 2013) (ADM,2014).

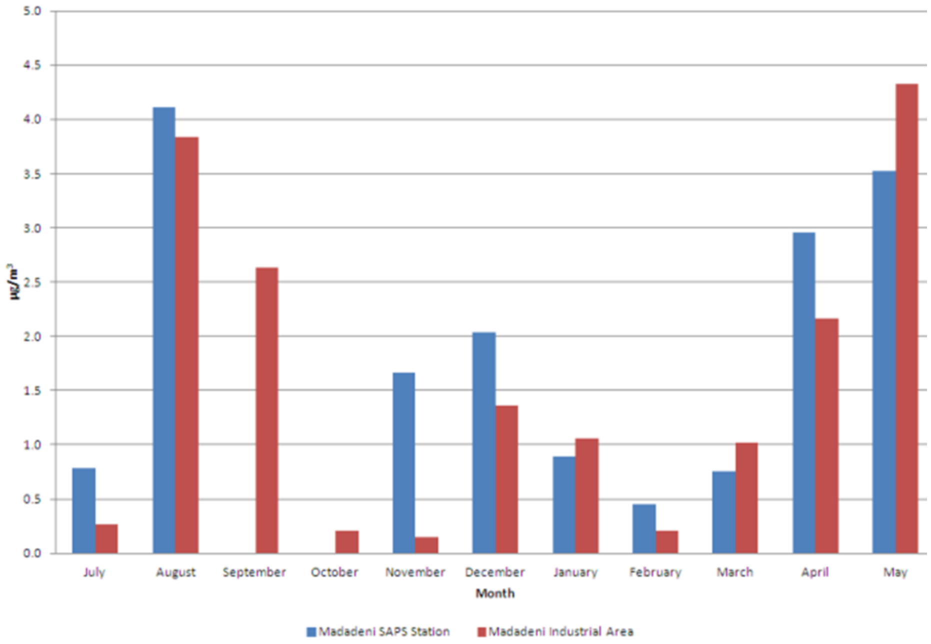


Figure 4-8: Monthly average benzene concentrations (July 2012 – May 2013) (ADM,2014).

4.3 Surrounding Sources of Air Pollution

Existing key sources of air pollution surrounding the project site were identified during a desktop exersise and were identified to be:

- Mining Activity;
- Vehicle dust entrainment on unpaved roads;
- Wind erosion from exposed areas (e.g. open cast pits, stockpiles, open storage piles, exposed cultivated fields, degraded land, etc.);
- Potential veld fires;
- Emissions from fuels used in surrounding informal settlements;
- Sewage works/treatment plant;
- Agricultural activity and biomass burning.

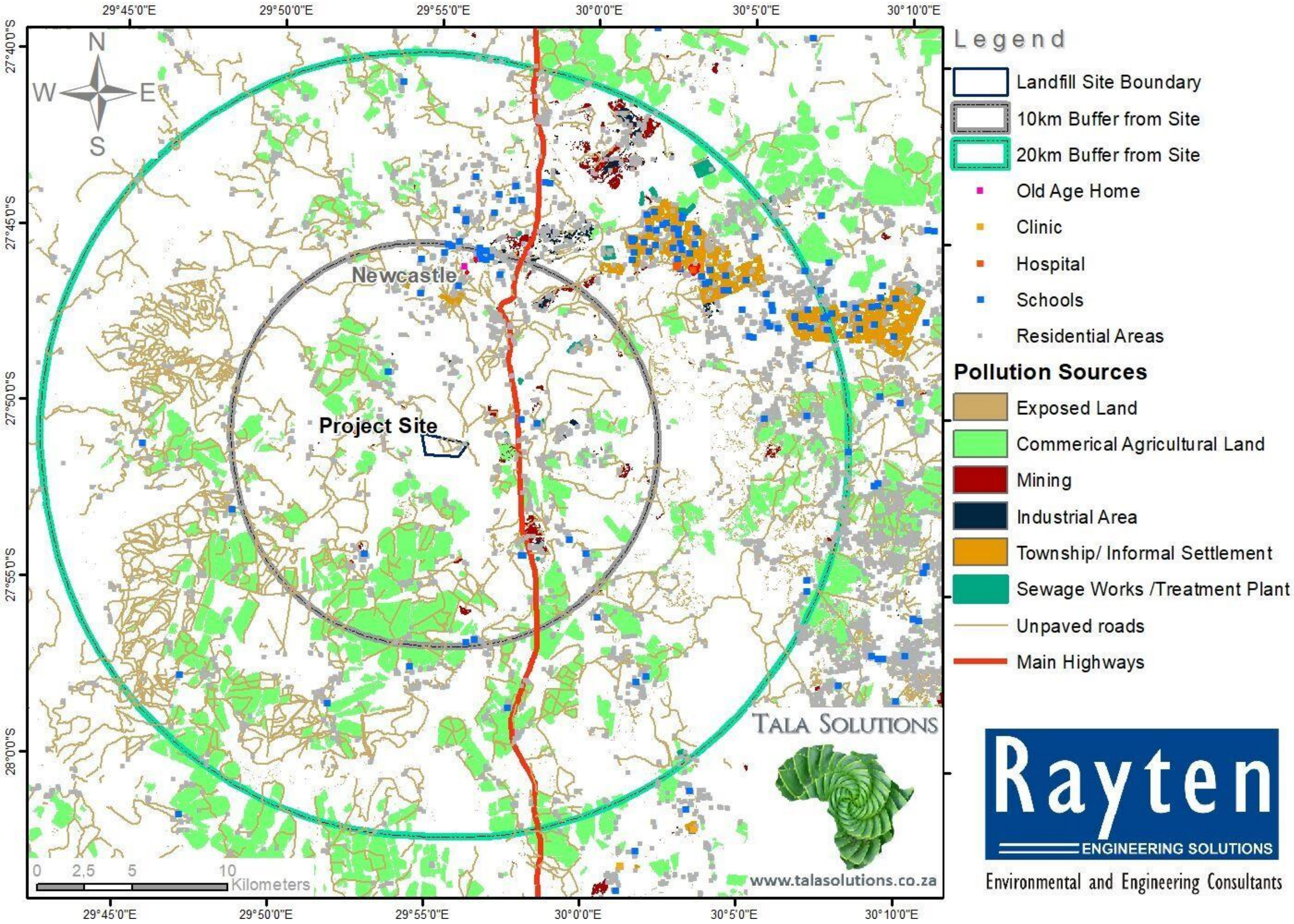


Figure 4-9: Identified surrounding emission sources within 20km of the proposed Landfill Site.

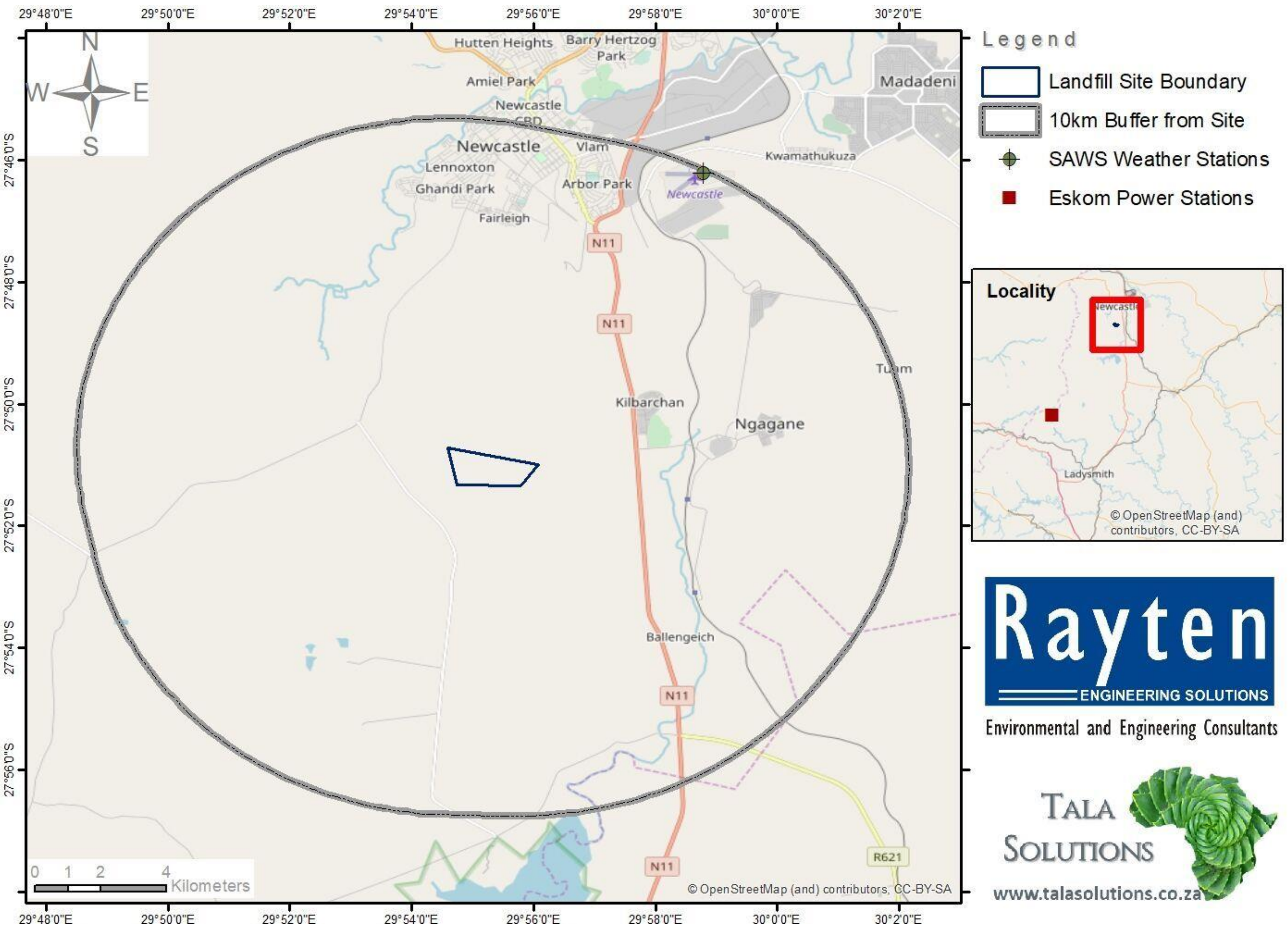


Figure 4-10: Identified surrounding emission sources within 10km of the proposed landfill site.

4.3.1 Mining Activity

There are existing mining operations surrounding the site. The following activities are a key source of emissions at mines:

- Material handling, storage and processing
- Crushing and screening
- Combustion processes (e.g. gas, diesel & oil combustion)
- Processing plant operations and associated combustion processes
- Blasting and drilling
- Excavation, bull dozing, grading
- Removal of material (e.g. topsoil, overburden, ore)
- Wind erosion from exposed areas (e.g. open pits, stockpile and storage piles)
- Conveying of material (material transfer)
- Vehicle dust entrainment due to truck hauling activities on unpaved roads
- Truck and mining equipment exhaust emissions

Mining activity taking place at and near to the project site is a key source of dust in the area.

4.3.2 Vehicle Entrainment on Unpaved Roads

Vehicle-entrained dust emissions from the surrounding unpaved roads in the area potentially represent a source of fugitive dust. When a vehicle or truck travels on an unpaved road, the force of the wheels on the road surface causes the pulverisation of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed.

4.3.3 Wind Erosion from Exposed Areas

There are open exposed areas such as bare soil, eroded natural land, etc. and stockpiles/storage piles associated with existing mining activity surrounding the project site which represent a source of dust in the area. Dust emissions due to the erosion of open storage piles and exposed areas occur when the threshold wind speed is exceeded. The threshold wind speed is dependent on the erosion potential of the exposed surface, which is expressed in terms of the availability of erodible material per unit area (mass/area). Any factor which binds the erodible material or otherwise reduces the availability of erodible material on the surface thus decreases the erosion potential of the surface. Studies have shown that when the threshold wind speeds are exceeded, particulate emission rates tend to decay rapidly due to the reduced availability of erodible material.

4.3.4 Veld Fires

Veld fires could occur in surrounding open areas. Veld fires are a source of air pollutants, such as particulate matter, VOCs and CO. The intensity and frequency of veld fires depends on meteorological conditions, plant material characteristics and amount of combustible material over an area. Over most parts of South Africa, a higher frequency of veld fire incidents occurs during the dry winter season, when there is a greater amount of combustible plant material (fuel load) associated with a low moisture content. Although veld fires are a naturally occurring phenomenon, they are a key source of emissions that contribute to background air pollution.

4.3.5 Agricultural activity and biomass burning

There are several agricultural areas surrounding the project site. Emissions from agricultural activities are difficult to control due to the seasonality of emissions and the large surface area producing emissions. Expected emissions resulting from agricultural activities include particulates associated with wind erosion and burning of crop residue, chemicals associated with crop spraying and odiferous emissions resulting from manure, fertilizer and crop residue. Dust associated with agricultural practices may contain seeds, pollen and plant tissue, as well as agrochemicals, such as pesticides. The application of pesticides during temperature inversions increases the drift of the spray and the area of impact.

Dust entrainment from farming vehicles travelling on gravel roads may also cause increased particulates in an area. Dust from traffic on gravel roads increases with higher vehicle speeds, more vehicles and lower moisture conditions. The seasonal burning of the veld from July to September for field clearing in preparation for planting is also a source of smoke. The nature of the activity has a potential impact on air quality in the area.

4.3.6 Sewage treatment plants

There are sewage treatment plants surrounding the project site. Operation of such treatment plants triggers the direct emission of greenhouse gases such as CO_2, CH_4, and nitrous oxide (N_2O) from biological processes. Hydrogen sulphide is also produced as a by-product of decomposition of organic material. Sewage treatment works are generally associated with odour impacts.

4.3.7 Industrial Activities

There are industrial areas identified surrounding the project site. The following activities are some common sources of air pollutants in industrial areas:

- Boiler stack emissions
- Mobile equipment exhaust emissions (forklifts, front-end-loaders, bull dozers, etc.)
- Furnaces (e.g. foundries, metallurgical plants, etc.)
- Material handling & storage
- Fuel combustion installations & activity
- Material incineration
- Chemical treatment and processes
- Crushing & screening of dry material

Emissions from urban industrial activities can be controlled by use of suitable, specific abatement equipment and implementation of air pollution control measures. Expected emissions resulting from urban industrial activities include particulates, VOCs and gases such as NOx, SO_2 and CO.

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4.3.8 Domestic fuel burning

There are townships/informal settlements (that were identified during the desktop study) located within a 20km radius north-east of the site. Domestic fuel combustion is prevalent in informal settlements where solid fuels are mostly used for cooking and indoor heating purposes. Indoor heating occurs more frequently in the cold late autumn to early spring months. Emissions from the solid fuels are thus expected to be high during the same months, and comparatively low during the warm spring and summer months. Combustion of domestic solid fuels results mainly in production of CO and particulates. If coal is being used, SO_2 and H_2S might be additionally emitted in relatively smaller quantities.

5 AIR QUALITY IMPACT ASSESSMENT

Dust and gaseous emissions are identified for proposed onsite operations will be emitted from the following key sources:

Dust and particulate emissions:

- Heavy construction activities

Gaseous emissions:

- Waste reception
- Waste processing
- Waste deposition
- Waste compaction
- Waste recovery.

The above-mentioned sources were identified for the proposed landfill site based on the information provided by the client. A detailed questionnaire was given to the client prior to modelling to obtain specific details needed for input into the model and for calculation of emission rates. The worst-case scenario was assumed where information was not known for input into the model.

To investigate the potential impacts of operations associated with the proposed landfill on local ambient air quality, the following air pollutants were chosen in the quantification of emissions associated with the construction and operation phases:

- Dust Fallout (TSP);
- Particulate Matter (PM10 and PM2.5);
- Hydrogen Sulphide (H2S);
- Benzene, Toluene, Ethylbenzene, Xylene (BTEX)

In the quantification of emissions for the construction phase of the landfill use was made of published predictive emission factor equations given in the United States Environmental Protection Agency (USEPA) AP-42 documents. The South African Regulations regarding Air Dispersion Modelling recommends the use of published emission factors for national consistency, such as the USEPA AP-42 emissions factors.

An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. Emission factors are always expressed as a function of the weight, volume, distance or duration of the activity emitting the pollutant. The general equation used for the estimation of emissions is:

$$\mathrm{E} = \mathrm{A} \times \mathrm{EF} \times \left(1 - \frac{\mathrm{ER}}{100}\right)$$

Where:
E = emission rate
A = activity rate
EF = emission factor
ER = overall emission reduction efficiency (%)

In the quantification of emissions for the operational phase of the landfill use was made of the LandGEM-Landfill Gas Emissions Model (Version 3.02).

The emission factors and equations used in the assessment for the landfill are described in the section 5.1 below. Modelling was conducted for the construction and operational phase of the project. Only activities that occurred within the site boundary and associated with the landfill were considered for input into the model.

5.1 Construction Phase

5.1.1 Construction Activities

The USEPA provides an emissions equation for general heavy construction operations. Dust is the main pollutant of concern emitted during heavy construction activities. The impact of dust emissions associated with heavy construction is generally limited to the period of construction where the impact is significantly reduced once construction activities have stopped. Dust emissions from construction activities is associated with land clearing, ground excavation, drilling and blasting, cut and fill operations, vehicle dust entrainment from trucks and the construction of infrastructure. Dust emissions from construction activities will vary depending on the level of activity and prevailing meteorological conditions (USEPA, 1995).

Emissions from the construction activities were calculated using the following equation:

$$E = 2.69 \text{ Mg/hectare/month of activity}$$

The emission factor and equation used to estimate emissions from construction activities were obtained from the USEPA AP-42 document, Section 13.2.3 Heavy Construction Operations (USEPA, 1995). The value is most applicable to construction operations with medium activity level, moderate silt contents and semi-arid climate. Construction was assumed to occur for 10 hours a day for 5 days a week. In addition, it was assumed that no dust suppression measures would be implemented during construction activities. Input parameters for construction activities are summarised in Table 5-1. The input parameters and dimensions were based on the information provided by the client.

Table 5-1: Input parameters for Heavy Construction Activities.

SOURCE	EMISSION RATE (g/s)		
	TSP	PM_{10}	$PM_{2.5}$
Cell 1	13,9415	6,9707	0,6971
Cell 2	15,2315	7,6158	0,7616
Cell 3	18,7873	9,3936	0,9394
Cell 4	22,765	11,3825	1,1383
Cell 5	25,1817	12,5908	1,2591
Cell 6	30,5735	15,2868	1,5287
Cell 7	36,2064	18,1032	1,8103

Notes:

- Area dimensions and footprint based on Google Earth files provided
- No dust suppression considered
- Construction hours assumed to occur 10 hours/day for 5 days per week

5.1.2 Operational Phases

The LandGEM-Landfill Gas Emissions Model (Version 3.02) developed by the U.S Environmental Protection agency was used to quantify emissions from the decomposition of landfilled waste at the proposed Newcastle Landfill Site based on waste acceptance rates. LandGEM is based on the gas generated from anaerobic decomposition of landfilled waste which has a methane content between 40 and 60 percent. The emissions were calculated based on the following landfill characteristics:

- Landfill open year: 2019
- Landfill closure year: 2056
- Waste design capacity: 375 tonnes/day
- Operational hours: 260 days/annum

The average emissions for all seven cells over the lifespan of the landfill are shown in Table 5-2 below.

Table 5-2: Landfilling activities from the proposed Newcastle Landfill Site.

SOURCE	SIZE OF LANDFILL AREA	EMISSION RATE (g/s)				
		H_2S	Benzene	Toluene	Ethylbenzene	Xylene
Operation Phase						
Decomposition of landfill waste	1 855 m^2	0,07793	0,05458	0,9949	0,03102	80,9193
Notes: Area size provided by client.						

5.2 Model Overview

5.2.1 AERMOD View

AERMOD, a state-of-the-art Planetary Boundary Layer (PBL) air dispersion model, was developed by the American Meteorological Society and USEPA Regulatory Model Improvement Committee (AERMIC). AERMOD utilizes a similar input and output structure to ISCST3 and shares many of the same features, as well as offering additional features. AERMOD fully incorporates the PRIME building downwash algorithms, advanced depositional parameters, local terrain effects, and advanced meteorological turbulence calculations.

The AERMOD atmospheric dispersion modelling system is an integrated system that includes three modules:

- A steady-state dispersion model designed for short-range (up to 50 km) dispersion of air pollutant emissions from stationary industrial sources.
- A meteorological data pre-processor (AERMET) for surface meteorological data, upper air soundings, and optionally, data from on-site instrument towers. It then calculates atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux.
- A terrain pre-processor (AERMAP) which provides a physical relationship between terrain features and the behaviour of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

AERMOD includes Plume Rise Model Enhancements (PRIME) building downwash algorithms which provide a more realistic handling of building downwash effects. PRIME algorithms were designed to address two fundamental features associated with building downwash; enhanced plume dispersion coefficients due to the turbulent wake and to reduce plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment in the wake.
AERMOD is suitable for a wide range of near field applications in both simple and complex terrain. The evaluation results for AERMOD, particularly for complex terrain applications, indicate that the model represents significant improvements compared to previously recommended models (USEPA, 2005).

AERMOD has been used in various dispersion modelling studies in the United States and around the world (Perry *et al*., 2004). Ventrakam (2003) investigated the ability of AERMOD to model the dispersion of an inert gas, released as a line source, in an urban environment. Comparing monitored and modelled concentrations at 24 receptor locations it was found that the model over predicted average 30-minute concentrations near source and under predicted concentrations further away. The study also found that at night the correlation of measured and modelled concentrations at the closest receptor points to the source were poor. However, the agreement improved with distance (Holmes and Morawska, 2006).

5.2.2 Model Requirements

The approach to this dispersion modelling study is based on the Code *of Practice for Air Dispersion Modelling in Air Quality Management in South Africa* (DEA, 2014). As per the *Code of Practice*, this assessment is a Level 2 assessment. Level 2 assessments should be used for air quality impact assessment in standard/generic licence or amendment processes where:

- The distribution of pollutant concentrations and depositions are required in time and space;
- Pollutant dispersion can be reasonably treated by a straight-line, steady-state, Gaussian plume model with first order chemical transformation. Although more complicated processes may be occurring, a more complicated model that explicitly treats these processes may not be necessary depending on the purposes of the modelling and the zone of interest.
- Emissions are from sources where the greatest impacts are in the order of a few kilometres (less than 50 km) downwind.

A summary of the key variables input into the AERMOD model is given in Table 5-3. Data input into the model includes MM5 modelled meteorological data (surface and upper air) for 01 January 2015 – 31 December 2017. Terrain data at a resolution of 90 m (SRTM90) is used for input into the model, as generated by the terrain pre-processor, AERMAP. A modelling domain of 15km × 15km is used. A multi-tier grid was used.

Table 5-3: Key Variables to be used in the modelling study.

Parameter	Model Input
Model	**Input**
Assessment level	Level 2
Dispersion model	AERMOD Version 9.4
Supporting models	AERMET Version 9.4 AERMAP Version 9.4
Emissions	**Input**
Pollutants to be modelled	Dust Fallout (TSP), PM_{10}, $PM_{2.5}$, BTEX and H_2S
Scenarios	Construction and Operational
Chemical transformations	N/A
Exponential decay	Rural
Settings	**Input**
Terrain setting	Elevated
Terrain data	SRTM90
Terrain data resolution (m)	90
Land characteristics	Cultivated land
Grid receptors	**Input**
Modelling domain (km)	15km x 15km
Fine grid resolution (m)	*100*
Medium grid resolution (m)	250
Large grid resolution (m)	1000

5.3 Dispersion Modelling Results

Dispersion simulations were undertaken for the following scenarios to determine:

- Predicted ground-level impacts from all key sources for TSP (as dust fallout), PM_{10} and $PM_{2.5}$ for proposed construction activities associated with the Newcastle Landfill.
- Predicted ground-level impacts from all key sources of H_2S and BTEX associated with the Newcastle Landfill.

The Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa (DEA, 2014), recommends the use of the 99th percentile concentrations for short-term assessment with the National Ambient Air Quality Standards since the highest predicted ground-level concentrations can be considered outliers due to complex variability of meteorological processes. This might cause exceptionally high concentrations that the facility may never actually exceed in its lifetime.

Isopleth plots of predicted concentrations for dust fallout, PM_{10} and $PM_{2.5}$ for the construction phase are given in Figure 5-1 to Figure 5-5. Isopleth plots of predicted concentrations for H_2S and BTEX concentrations for the operational phase are given in Figure 5-6 to Figure 5-13. For short term averaging periods, the predicted 99th percentile concentrations are provided.

Comparison of the predicted benzene ambient annual concentration was made with the South African National ambient air quality standard of 5µg/m^3 to determine complaince. There are no South African ambient air quality standards for H_2S or toluene, ethylbenzene and xylene. As such, applicable international guidelines developed by the Government of Alberta Canada (2017) were used. Comparison of the predicted TSP (as dust fallout) rates are made with the South African National Dust Control Regulations to determine compliance. In determining compliance, predicted incremental concentrations (as determined beyond the sites boundary) are compared against the applicable standards. Inside the site boundary, air pollutant concentrations are required to comply with occupational health and safety standards.

The maximum predicted H_2S and BTEX concentrations and dust fallout rates at the identified nearby sensitive receptors for the construction and operational phases of the landfill are given in Table 5-4 to Table 5-5.

5.3.1 Construction Phase

5.3.1.1 Dust Fallout

Predicted incremental dust fallout rates associated with proposed construction activity at the landfill are given in Figure 5-1.

- Predicted incremental dust fallout rates:
    - Comply with the non-residential standard of 1 200 mg/m^2/day beyond the site boundary (Figure 5-1).
    - Exceed the residential standard of 600 mg/m^2/day beyond the western and northern boundaries, however, these occur within 1km of the the boundary line.
    - No exceedances of the dust fallout limits are observed at surrounding sensitive receptors.

5.3.1.2 PM_{10} Concentrations

Predicted incremental PM_{10} concentrations associated with proposed construction activity at the landfill are given in Figure 5-2 and Figure 5-3.

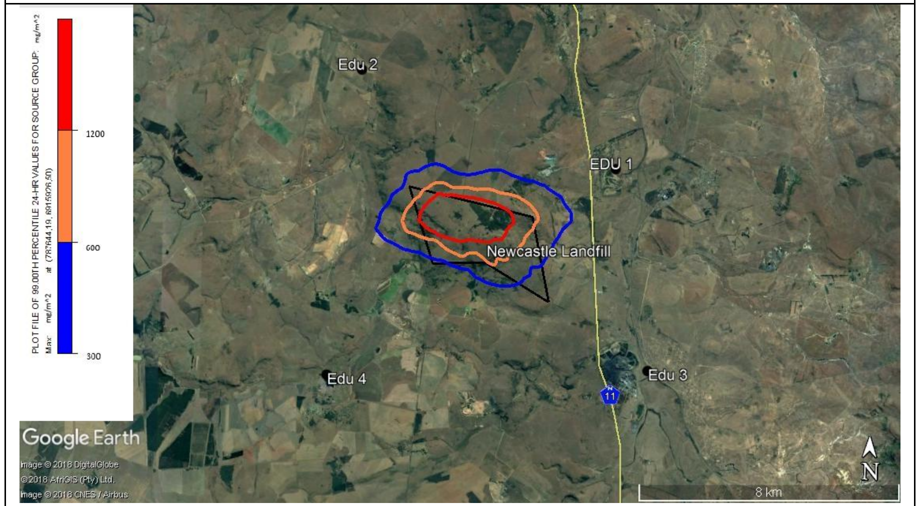
- Predicted incremental PM_{10} concentrations:
    - Under the worst-case scenario are shown to be relatively high, with exceedances of the daily limit of 75µg/m^3 observed over most of the project area (Figure 5-2).
    - Comply with the annual limit of 40 µg/m^3 beyond 3km from the landfill boundary line (Figure 5-3).
    - Predicted incremental annual average concentrations comply with the annual average limit at identified nearby sensitive receptors, however, the predicted daily average concentrations exceed the daily limit at eight (8) of the nearby sensitive receptors (Table 5-4).

5.3.1.3 $PM_{2.5}$ Concentrations

Predicted incremental $PM_{2.5}$ concentrations associated with proposed construction activity at the landfill are given in Figure 5-4 and Figure 5-5.

- Predicted incremental $PM_{2.5}$ concentrations:
  - Comply with the daily average standard of 40 µg/m^3 beyond 3km from the site boundary line (Figure 5-4).
  - Comply with the annual average standard of 20 µg/m^3 beyond all site boundaries, however, exceedances of the standards are observed within 500m of the western and northern boundaries (Figure 5-5).
  - Predicted incremental daily and annual concentrations at the identified nearby sensitive receptors comply with the applicable limits (Table 5-4).

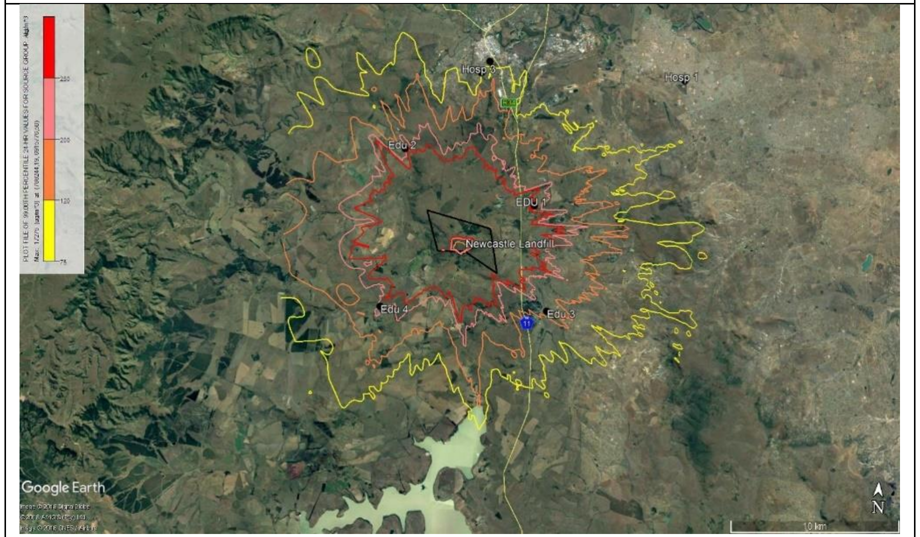
Predicted Incremental Dust Fallout (TSP) Rates (Construction Phase)



COMMENTS:		
Orange band - exceedances of the residential area standard of 600 mg/m²/day. Red band - exceedances of the non-residential area standard of 600 mg/m²/day.	**GRID SIZE:** 15 x 15 km	**MODEL:** AERMOD View
	GRID: Multi-tier – 2 tiers	**OUTPUT TYPE:** 99th Percentile Deposition Rates
	NUMBER OF SOURCES: X 7 area	**ASSUMPTIONS:** No dust suppression
	DUST FALLOUT STANDARD: 1200 mg/m²/day (non-residential areas) 600 mg/m²/day (residential areas) **DATE:** 09/04/2018	

Figure 5-1: Predicted incremental Dust Fallout (TSP) Rates at Newcastle Landfill– Construction Phase.

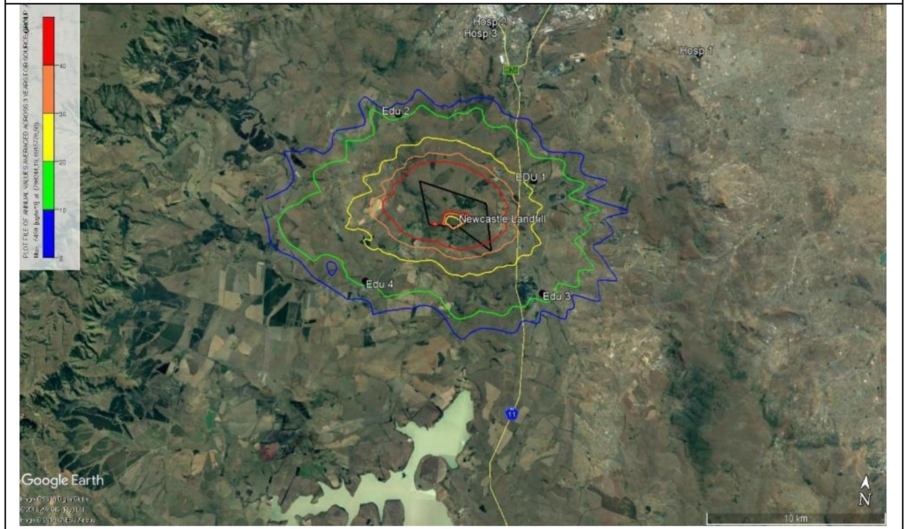
Predicted Incremental 24-Hour PM_{10} Concentrations (Construction Phase)



COMMENTS:		
All band - exceedances of the SA-daily PM10 standard of 75 µg/m³.	**GRID SIZE:** 15 x 15 km	**MODEL:** AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 7 area	**ASSUMPTIONS:** No dust suppression
	AMBIENT STANDARD: 75 µg/m³ (SA 24-Hour standard) **DATE:** 09/04/2018	

Figure 5-2: Predicted incremental Daily Average PM_{10} Concentrations at Newcastle Landfill – Construction Phase.

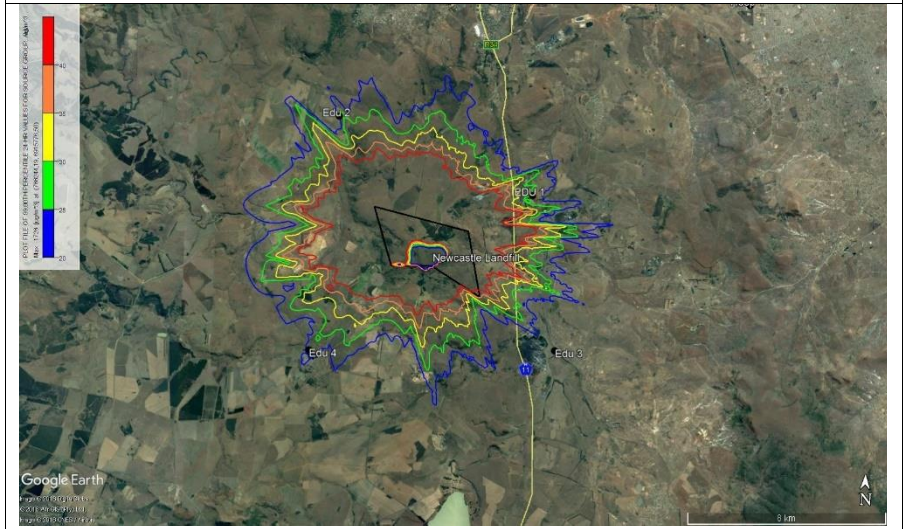
Predicted Incremental Annual PM_{10} Concentrations (Construction Phase)



COMMENTS:	GRID SIZE:	MODEL:
Red band - exceedances of the SA-annual PM10 standard of 40 µg/m³.	**GRID SIZE:** 15 x 15 km	**MODEL:** AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** Ground Level Concentrations
	NUMBER OF SOURCES: X 7 area	**ASSUMPTIONS:** No dust suppression
	AMBIENT STANDARD: 40 µg/m³ (SA annual standard) **DATE:** 09/04/2018	

Figure 5-3: Predicted incremental Annual Average PM_{10} Concentrations at Newcastle Landfill – Construction Phase.

Predicted Incremental 24-Hour $PM_{2.5}$ Concentrations (Construction Phase)



COMMENTS:	GRID SIZE:	MODEL:
Red band - exceedances of the SA-24H PM2.5 standard of 40 µg/m³.	**GRID SIZE:** 15 x 15 km	**MODEL:** AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 7 area	**ASSUMPTIONS:** No dust suppression
	AMBIENT STANDARD: 40 µg/m³ (SA 24-Hour standard) (current) 25 µg/m³ (SA 24-Hour standard) (By 1 Jan 2030) **DATE:** 09/04/2018	

Figure 5-4: Predicted incremental Daily Average $PM_{2.5}$ Concentrations at Newcastle Landfill – Construction Phase.

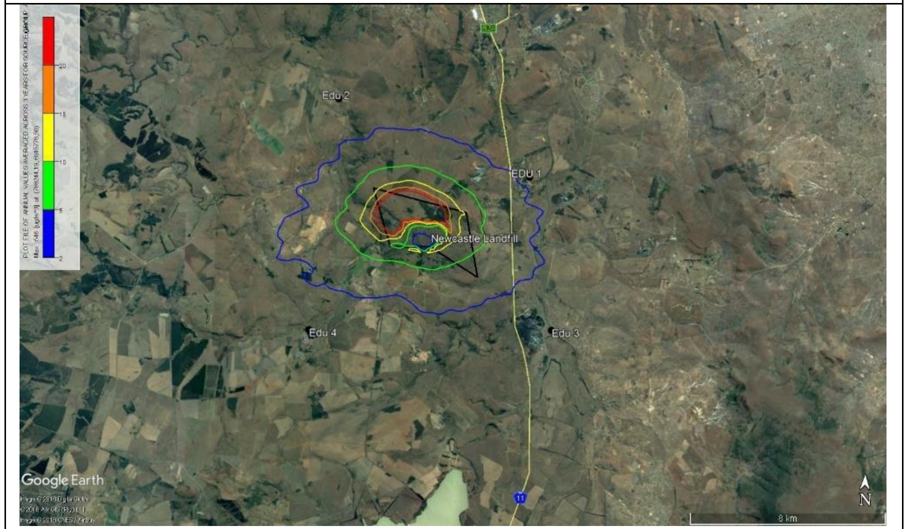
Predicted Incremental Annual $PM_{2.5}$ Concentrations (Construction Phase)		
		
COMMENTS: Red band - exceedances of the SA PM2.5 annual standard of 20 µg/m³.	**GRID SIZE:** 15 x 15 km	**MODEL:** AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** Ground Level Concentrations
	NUMBER OF SOURCES: X 7 area	**ASSUMPTIONS:** No dust suppression
	AMBIENT STANDARD: 20 µg/m³ (SA annual standard) (Current) 15 µg/m³ (SA annual standard) (By 1 Jan 2030) **DATE:** 09/04/2018	

Figure 5-5: Predicted incremental Annual Average $PM_{2.5}$ Concentrations phase at Newcastle Landfill – Construction Phase.

Table 5-4: Maximum predicted incremental PM_{10}, $PM_{2.5}$ concentrations and Dust Fallout rates at nearby sensitive receptors, Construction Phase.

INCREMENTAL CONCENTRATIONS (µg/m³)							
SENSITIVE RECEPTOR	Co-ordinates		PM2.5		PM10		DUST FALLOUT (mg/m²/day)
			DAILY AVERAGE	ANNUAL AVERAGE	DAILY AVERAGE	ANNUAL AVERAGE	
STANDARD (µg/m³)	X	Y	40	20	75	40	Residential: 600 mg/m²/day Non-residential: 1200 mg/m²/day
Construction Phase							
Edu1	784754,95	6919647,35	22.94	1.16	229.39	11.65	67.44
Area 1	799824,22	6927465,59	3.10	0.16	30.99	1.58	8.89
Edu 2	788134,43	6925776,81	5.96	0.28	59.57	2.83	15.22
Edu 3	792301,86	6917298,25	26.19	1.71	261.88	17.06	122.56
Edu 4	783679,59	6910184,88	14.72	0.86	147.18	8.55	37.12
Edu 5	791870,75	6910113,03	10.02	0.97	100.23	9.73	64.93
Edu 6	794457,43	6911047,11	13.29	0.94	132.86	9.39	43.44
Edu 7	789212,21	6905801,89	9.37	0.48	93.66	4.76	17.97
Health 1	799871,71	6925607,77	4.36	0.19	43.57	1.90	10.97
Health 2	800717,04	6925269,64	2.83	0.17	28.31	1.73	10.35
Area 1	795306,97	6928059,21	3.27	0.17	32.66	1.67	7.81
Area 3	801562,36	6922902,74	3.58	0.21	35.82	2.12	18.59
Fernwood	785681,26	6924407,02	8.24	0.37	82.43	3.67	20.98
Arbor Park	790850,32	6924504,92	7.71	0.36	77.09	3.36	12.78

Notes:

- Edu = educational facility/school/training centre
- Old = old age home
- Hosp = hospital/clinic/health care facility
- + = and
- Area = unknown name area identified as a nearby receptor

5.3.2 Operational Phase

5.3.2.1 Benzene

Predicted incremental benzene concentrations associated with proposed operational activities at the landfill are given in Figure 5-6.

- Predicted incremental benzene concentrations:
  - Comply with the SA annual average standard of 5 µg/m³, with no exceedances observed. A maximum predicted incremental concentration of 1 µg/m³ was recorded (Figure 5-6).
  - Predicted incremental concentrations at identified surrounding receptors are shown to be very low (Table 5-5).

5.3.2.2 Toluene Concentrations

Predicted incremental toluene concentrations associated with proposed operational activities at the landfill are given in Figure 5-7 and Figure 5-8.

- Predicted incremental toluene concentrations:
  - Comply with the Alberta Canadian hourly guideline of 1880 µg/m³ beyond the landfill site boundary (Figure 5-7).
  - Comply with the Alberta Canadian daily guideline of 400 µg/m³ beyond the southern and eastern site boundaries. Exceedances of the guideline occur near to the site, within 800m of the boundary line (Figure 5-8).
  - No exceedances of the hourly and daily guidelines occur at identified surrounding receptors (Table 5-5).

5.3.2.3 Xylene Concentrations

Predicted incremental xylene concentrations associated with proposed operational activities at the landfill are given in Figure 5-8 and Figure 5-9. No exceedances of the Alberta Canadian hourly and guideline of 2300 µg/m³ and daily guideline of 700 µg/m³ were observed. A maximum hourly average modelled concentration of 539 µg/m³ and daily concentration of 202 µg/m³ were recorded.

5.3.2.4 Ethylbenzene Concentrations

Predicted incremental ethylbenzene concentrations associated with proposed operational activities at the landfill are given in Figure 5-11. No exceedances of the Alberta Canadian hourly guideline of 2000 µg/m³ were observed, with a maximum modelled concentration of 215 µg/m³ recorded.

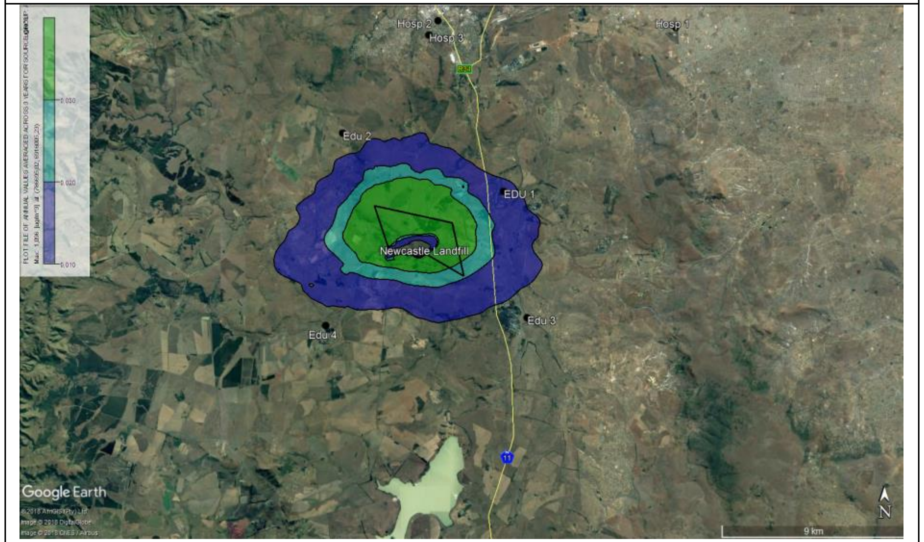
5.3.2.5 H_2S concentrations:

Predicted incremental H_2S concentrations associated with proposed operational activities at the landfill are given in Figure 5-12 and Figure 5-13.

- Predicted incremental concentrations:
  - Comply with Alberta Canadian hourly and daily guidelines of 14 µg/m³ and 4 µg/m³.

- Predicted incremental concentrations at surrounding sensitive receptors comply the above-mentioned guidelines (Table 5-5).

Predicted Incremental benzene concentrations (Operational Phase)

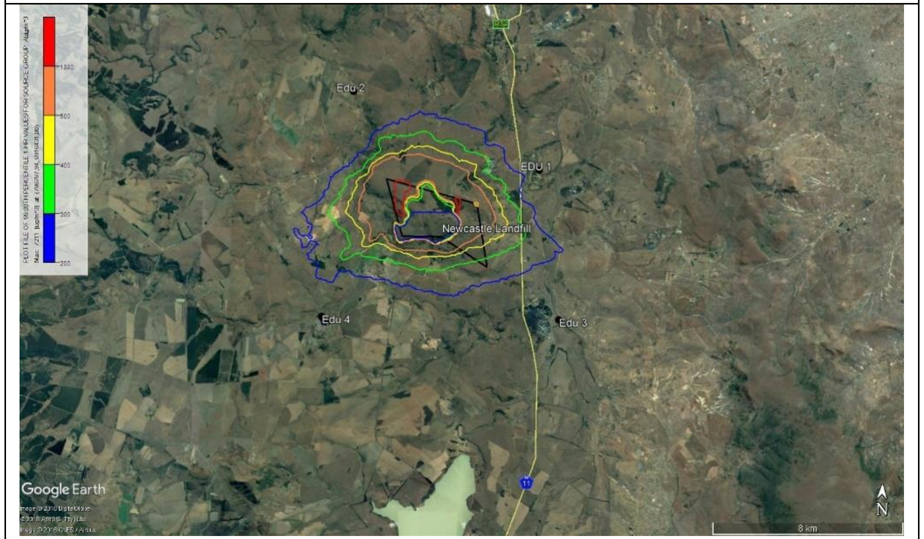


<table>
<tr><td rowspan="4"><u>COMMENTS:</u>

No exceedances of the SA Benzene annual standard of 5 µg/m³.</td><td><u>GRID SIZE:</u>
15 x 15 km</td><td><u>MODEL:</u>
AERMOD View</td></tr>
<tr><td><u>GRID:</u>
Multi-tier – 3 tiers</td><td><u>OUTPUT TYPE:</u>
99th Percentile Deposition Rates</td></tr>
<tr><td><u>NUMBER OF SOURCES:</u>
X1 area</td><td><u>ASSUMPTIONS:</u>
Modelled last cell as if operating at end of life of landfill.</td></tr>
<tr><td colspan="2"><u>BENZENE STANDARD:</u>
SA annual standard 5 µg/m³.
<u>DATE:</u>
12/04/2017</td></tr>
</table>

Figure 5-6: Predicted incremental annual benzene concentrations at Newcastle Landfill – Operational Phase.

Predicted Incremental 1-Hour toluene Concentrations (Operational Phase)

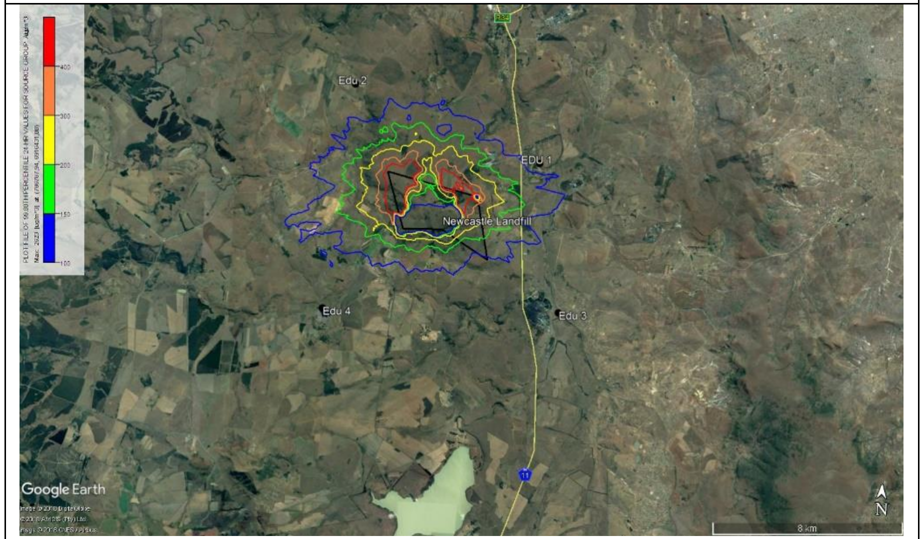


<table>
<tr><td rowspan="4"><u>COMMENTS:</u>

Red band - exceedances of the Alberta Canada hourly guideline of 1880 µg/m³.</td><td><u>GRID SIZE:</u>
15 x 15 km</td><td><u>MODEL:</u>
AERMOD View</td></tr>
<tr><td><u>GRID:</u>
Multi-tier – 3 tiers</td><td><u>OUTPUT TYPE:</u>
99th Percentile Ground Level Concentrations</td></tr>
<tr><td><u>NUMBER OF SOURCES:</u>
X 1 area</td><td><u>ASSUMPTIONS:</u>
Modelled last cell as if operating at end of life of landfill.</td></tr>
<tr><td colspan="2"><u>AMBIENT STANDARD:</u>
Alberta Ambient Air Quality Guideline of 1 880 µg/m³
<u>DATE:</u>
12/04/2017</td></tr>
</table>

Figure 5-7: Predicted incremental hourly toluene concentrations at Newcastle Landfill - Operational Phase.

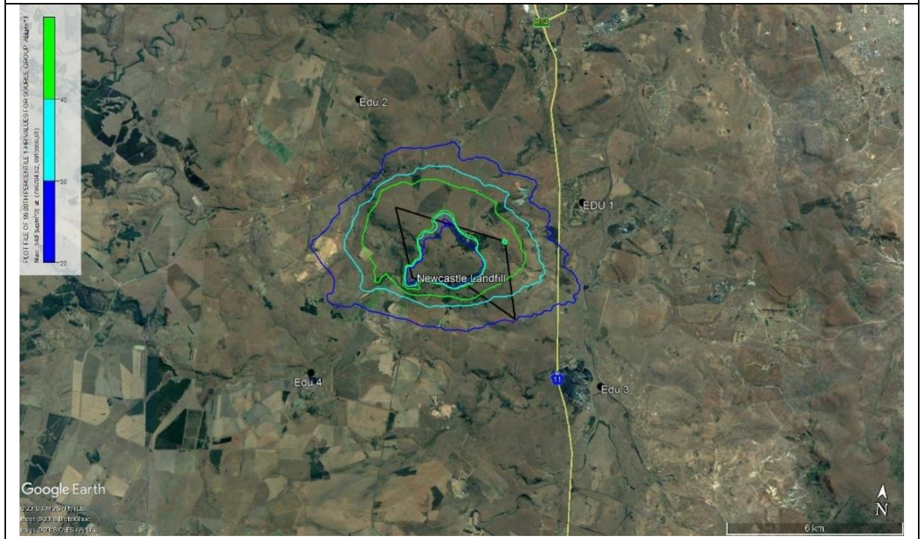
Predicted Incremental 24-hour toluene Concentrations (Operational Phase)



COMMENTS:	GRID SIZE:	MODEL:
Red band - exceedances of the Alberta Canada daily guideline of 400 µg/m³.	15 x 15 km	AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 1 area	**ASSUMPTIONS:** Modelled last cell as if operating at end of life of landfill.
	AMBIENT STANDARD: 400 µg/m³ (Alberta Canada annual guideline) **DATE:** 12/04/2017	

Figure 5-8: Predicted daily average toluene Concentrations at Newcastle Landfill - Operational Phase.

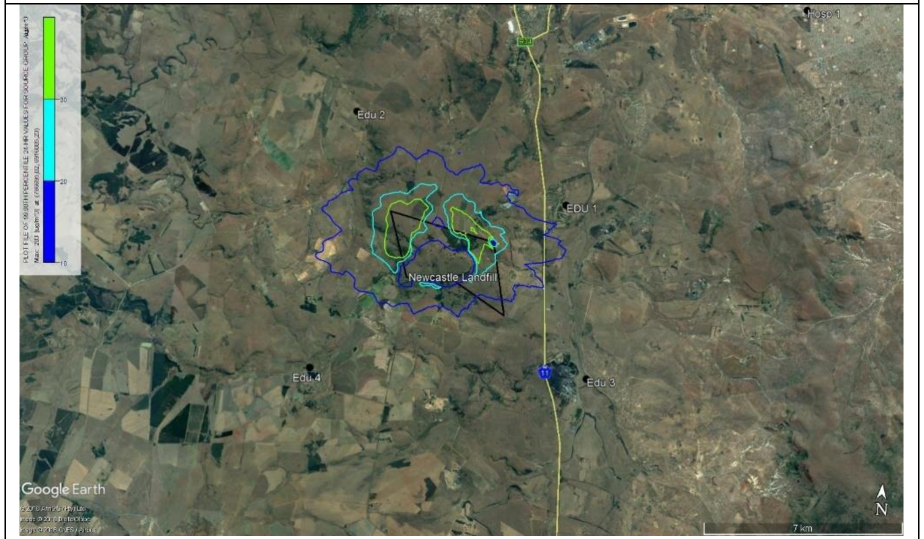
Predicted Incremental 1-Hour xylene Concentrations (Operational Phase)



COMMENTS:	GRID SIZE:	MODEL:
No exceedances of the Alberta Canada 1-hour guideline of 2300 µg/m³.	15 x 15 km	AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 1 area	**ASSUMPTIONS:** Modelled last cell as if operating at end of life of landfill.
	AMBIENT STANDARD: 2300 µg/m³ (Alberta Canada 1-Hour standard) **DATE:** 12/04/2018	

Figure 5-9: Predicted hourly average xylene Concentrations at Newcastle Landfill - Operational Phase.

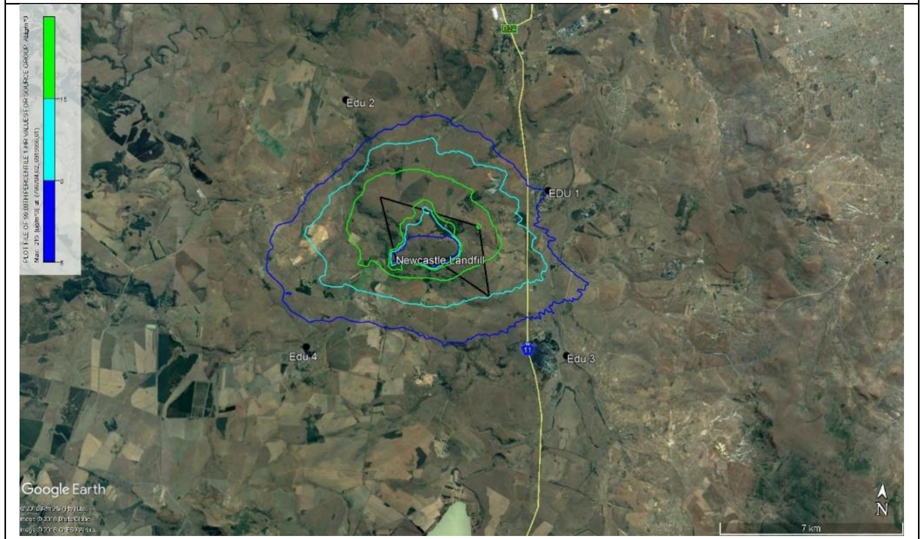
Predicted Incremental 24-hour xylene Concentrations (Operational Phase)



COMMENTS:	GRID SIZE:	MODEL:
No exceedances of the Alberta Canada guideline of 700 µg/m^3.	15 x 15 km	AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** Ground Level Concentrations
	NUMBER OF SOURCES: X 1 area	**ASSUMPTIONS:** Modelled last cell as if operating at end of life of landfill.
	AMBIENT STANDARD: 700 µg/m^3 (Alberta Canada 24H Guideline) **DATE:** 12/04/2018	

Figure 5-10: Predicted daily average xylene concentrations at Newcastle Landfill - Operational Phase.

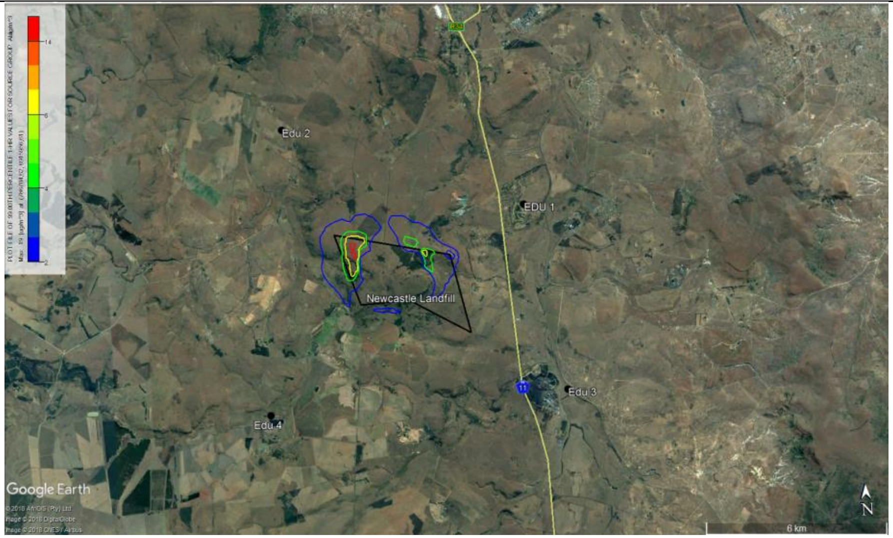
Predicted Incremental 1-Hour ethylbenzene Concentrations (Operational Phase)



COMMENTS:	GRID SIZE:	MODEL:
No exceedances of the Alberta Canada 1-hour guideline of 2000 µg/m^3.	15 x 15 km	AERMOD View
	GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
	NUMBER OF SOURCES: X 1 area	**ASSUMPTIONS:** Modelled last cell as if operating at end of life of landfill.
	AMBIENT STANDARD: 2 000 µg/m^3 (Alberta Canada 1-Hour guideline) **DATE:** 12/04/2018	

Figure 5-11: Predicted hourly average ethylbenzene concentrations at Newcastle Landfill - Operational Phase.

Predicted Incremental 1-hour hydrogen sulphide Concentrations (Operational Phase)



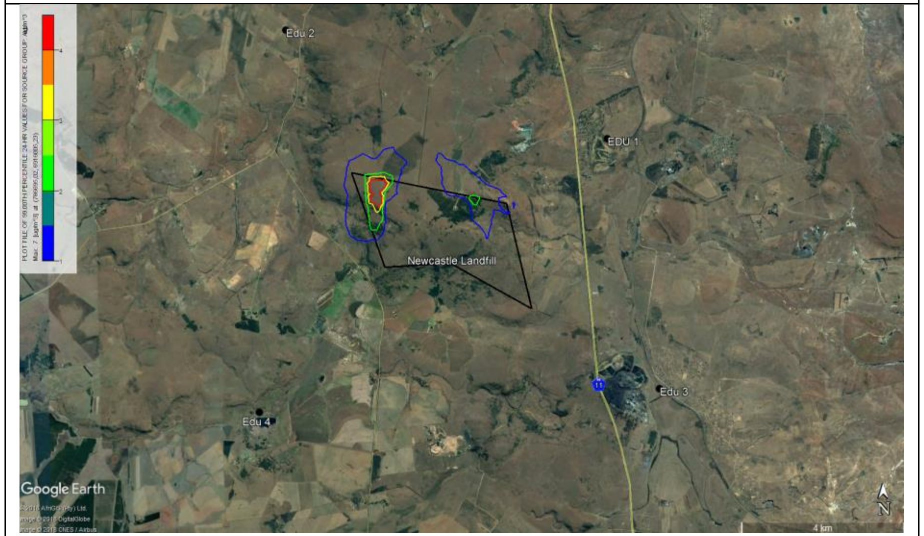
COMMENTS:

Red band - exceedances of the Alberta Canada guideline of 14 µg/m³.

GRID SIZE: 15 x 15 km	**MODEL:** AERMOD View
GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
NUMBER OF SOURCES: X 1 area	**ASSUMPTIONS:** Modelled last cell as if operating at end of life of landfill.
AMBIENT STANDARD: 14 µg/m³ (Alberta Canada 1H Guideline) **DATE:** 12/04/2018	

Figure 5-12: Predicted hourly average hydrogen sulphide Concentrations at Newcastle Landfill - Operational Phase.

Predicted Incremental 24-Hour hydrogen sulphide Concentrations (Operational Phase)



COMMENTS:

All band - exceedances of the Alberta Canada 24-hour guideline of 4 µg/m³.

GRID SIZE: 15 x 15 km	**MODEL:** AERMOD View
GRID: Multi-tier – 3 tiers	**OUTPUT TYPE:** 99th Percentile Ground Level Concentrations
NUMBER OF SOURCES: X 1 area	**ASSUMPTIONS:** Modelled last cell as if operating at end of life of landfill.
AMBIENT STANDARD: 4 µg/m³ (Alberta Canada 24 Hour standard) **DATE:** 12/04/2018	

Figure 5-13: Predicted daily average hydrogen sulphide concentrations at Newcastle Landfill - Operational Phase.

Table 5-5: Maximum Predicted Incremental BTEX and H_2S concentrations in µg/m³ at nearby sensitive receptors, Operational Phase.

Sensitive receptors	Coordinates		AIR QUALITY GUIDELINES (µg/m³)							
			Benzene	Toluene		Ethylbenzene	Xylene		Hydrogen sulphide	
	X	Y	Annual	1-Hour	24-Hour	1-hour	1-hour	24-hour	1-hour	24-hour
			5	1880	400	2000	2300	700	14	4
Edu1	784754,95	6919647,35	0.009	81.30	78.09	2.53	6.37	6.12	0.22	0.2
Area 1	799824,22	6927465,59	0.001	10.05	10.21	0.31	0.79	0.8	0.027	0.03
Edu 2	788134,43	6925776,81	0.002	14.13	25.80	0.44	1.11	2.02	0.039	0.07
Edu 3	792301,86	6917298,25	0.01	160.95	78.06	5.02	12.61	6.11	0.44	0.2
Edu 4	783679,59	6910184,88	0.006	72.64	49.37	2.26	5.69	3.87	0.2	0.13
Edu 5	791870,75	6910113,03	0.007	87.70	40.03	2.73	6.87	3.14	0.2	0.1
Edu 6	794457,43	6911047,11	0.006	70.50	39.21	2.20	5.52	3.07	0.19	0.1
Edu 7	789212,21	6905801,89	0.003	29.68	34.58	0.93	2.33	2.71	0.08	0.09
Health 1	799871,71	6925607,77	0.001	9.80	13.38	0.31	0.77	1.05	0.03	0.04
Health 2	800717,04	6925269,64	0.001	9.62	10.29	0.30	0.75	0.81	0.03	0.03
Area 1	795306,97	6928059,21	0.001	7.87	9.97	0.25	0.62	0.78	0.02	0.03
Area 3	801562,36	6922902,74	0.001	13.30	14.14	0.41	1.04	1.11	0.04	0.04
Fernwood	785681,26	6924407,02	0.003	20.12	29.91	0.63	1.58	2.34	0.05	0.08
Arbor Park	790850,32	6924504,92	0.002	15.63	31.72	0.49	1.22	2.48	0.04	0.09

5.4 Assumptions, Limitations and Exclusions

The following key assumptions, limitations and exclusions of the study are given below:

Assumptions

- Data/information provided by the client and used as input into the model were assumed to be accurate and complete at the time of modelling;
- Assumed the worst-case scenario, thus no mitigation measures were considered.

Limitations

- LandGEM is considered a screening tool, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate.
- The study is limited by the amount of detailed information that could be provided at the time of modelling.

Exclusions

- Fugitive dust emissions from landfill operations, dust entrainment from trucks hauling waste and from landfill closure were not modelled in this impact assessment. These impacts will result in similar impact as heavy construction activity (which is modelled in construction phase) and are often limited to near the site.

5.5 Impact assessment ratings

The level of impact of proposed construction and operational activities associated with the landfill is assessed in the tables below. The method for determining the level of impact was based on an impacting rating method developed by GCS. Each impact identified was rated according the expected magnitude, duration, scale and probability of the impact. Each impact identified will be assessed in terms of scale (spatial scale), magnitude (severity) and duration (temporal scale). Consequence is then determined as follows:

Consequence = Severity + Spatial Scale + Duration

The Risk of the activity is then calculated based on frequency of the activity and impact, how easily it can be detected and whether the activity is governed by legislation. Thus:
Likelihood = Frequency of activity + frequency of impact + legal issues + detection

The risk is then based on the consequence and likelihood.
Risk = Consequence x likelihood

In order to assess each of these factors for each impact, the ranking scales in the tables below were used.

Table 5-6: Severity

Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful / within a regulated sensitive area	5

Table 5-7: Spatial Scale- How big is the area that the aspect is impacting on

Area specific (at impact site)	1
Whole site (entire surface right)	2
Local (within 5km)	3
Regional / neighboring areas (5km to 50km)	4
National	5

Table 5-8: Frequency of the activity-How often do you do the specific activity?

Annually or less	1
6 monthly	2
Monthly	3
Weekly	4
Daily	5

Table 5-9: Frequency of the incident/impact - How often does the activity impact on the environment?

Almost never / almost impossible / >20%	1
Very seldom / highly unlikely / >40%	2
Infrequent / unlikely / seldom / >60%	3
Often / regularly / likely / possible / >80%	4
Daily / highly likely / definitely / >100%	5

Table 5-10: Legal Issues - How is the activity governed by legislation?

No legislation	1
Fully covered by legislation	5

Table 5-11: Detection - How quickly/easily can the impacts/risks of the activity be detected on the environment, people and property?

Immediately	1
Without much effort	2
Need some effort	3
Remote and difficult to observe	4
Covered	5

Environmental effects will be rated as either of high, moderate or low significance on the basis provided below.

Table 5-12: Impact Ratings.

RATING	CLASS
1 – 55	(L) Low Risk
56 – 169	M) Moderate Risk
170 – 600	(H) High Risk

Table 5-13 Impact Rating Table for unmitigated scenario.

Phases	Activity	Aspect (cause of the impact)	Impact	Severity rating	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	+/-	Risk Rating
Construction	Infrastructure establishment	Heavy construction activity - dust emissions	Dust fallout (daily)	1	3	2	6	5	5	5	2	17	102	-	M
Construction	Infrastructure establishment	Heavy construction activity - dust emissions	PM10-daily	3	4	2	9	5	5	5	3	18	162	-	M
Construction	Infrastructure establishment	Heavy construction activity - dust emissions	PM10-annual	2	3	2	7	5	5	5	3	18	126	-	M
Construction	Infrastructure establishment	Heavy construction activity - dust emissions	PM2.5-daily	3	4	2	9	5	5	5	3	18	162	-	M
Construction	Infrastructure establishment	Heavy construction activity - dust emissions	PM2.5-annual	2	3	2	7	5	5	5	3	18	126	-	M
Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	Benzene- annual	1	3	4	8	5	5	5	4	19	152	-	M
Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	Toluene-hourly	1	3	4	8	5	5	1	4	15	120	-	M
Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	Toluene-daily	1	3	4	8	5	5	1	4	15	120	-	M
Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	Ethylbenzene- hourly	1	3	4	8	5	5	1	4	15	120	-	M
Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	Xylene-hourly	1	3	4	8	5	5	1	4	15	120	-	M
Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	Xylene-daily	1	3	4	8	5	5	1	4	15	120	-	M
Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	hydrogen sulphide-hourly	1	1	4	5	5	5	1	2	13	65	-	M
Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	hydrogen sulphide-daily	1	1	4	6	5	5	1	2	13	78	-	M

Table 5-14 Impact Rating Table for mitigated scenario.

Impact description					Impact after mitigation												Confidence level	Mitigation measures	Action plan	Responsible person
No.	Phases	Activity	Aspect (cause of the impact)	Impact	Severity rating	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	+/-	Risk Rating				
	Construction	Infrastructure establishment	Heavy construction activity - dust emissions	Dust fallout (daily)	1	2	2	5	5	5	5	2	17	85	-	M	50%	water spraying for dust suppression	dust management plan to be implemented during construction phase	Onsite construction manager & SHEQ officer
	Construction	Infrastructure establishment	Heavy construction activity - dust emissions	PM10-daily	3	3	2	8	5	5	5	3	18	144	-	M	50%	water spraying for dust suppression	dust management plan to be implemented during construction phase	Onsite construction manager & SHEQ officer
	Construction	Infrastructure establishment	Heavy construction activity - dust emissions	PM10-annual	2	2	2	6	5	5	5	3	18	108	-	M	50%	water spraying for dust suppression	dust management plan to be implemented during construction phase	Onsite construction manager & SHEQ officer
	Construction	Infrastructure establishment	Heavy construction activity - dust emissions	PM2.5-daily	3	3	2	8	5	5	5	3	18	144	-	M	50%	water spraying for dust suppression	dust management plan to be implemented during construction phase	Onsite construction manager & SHEQ officer
	Construction	Infrastructure establishment	Heavy construction activity - dust emissions	PM2.5-annual	2	2	2	6	5	5	5	3	18	108	-	M	50%	water spraying for dust suppression	dust management plan to be implemented during construction phase	Onsite construction manager & SHEQ officer
	Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	Benzene- annual	1	3	4	8	5	5	5	4	19	152	-	M	50%	Reduce waste storage quantities through onsite recycling	Implement a waste sorting programme at landfill. Can purchase a bale machine to recover & bale recyclable materials in order to reduce the amount of waste to storage	Landfill manager
	Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	Toluene-hourly	1	3	4	8	5	5	1	4	15	120	-	M	50%	Reduce waste storage quantities through onsite recycling	Implement a waste sorting programme at landfill. Can purchase a bale machine to recover & bale recyclable materials in order to reduce the amount of waste to storage	Landfill manager
	Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	Toluene-daily	1	3	4	8	5	5	1	4	15	120	-	M	50%	Reduce waste storage quantities through onsite recycling	Implement a waste sorting programme at landfill. Can purchase a bale machine to recover & bale recyclable materials in order to reduce the amount of waste to storage	Landfill manager
	Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	Ethylbenzene- hourly	1	3	4	8	5	5	1	4	15	120	-	M	50%	Reduce waste storage quantities through onsite recycling	Implement a waste sorting programme at landfill. Can purchase a bale machine to recover & bale recyclable materials in order to reduce the amount of waste to storage	Landfill manager
	Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	Xylene-hourly	1	3	4	8	5	5	1	4	15	120	-	M	50%	Reduce waste storage quantities through onsite recycling	Implement a waste sorting programme at landfill. Can purchase a bale machine to recover & bale recyclable materials in order to reduce the amount of waste to storage	Landfill manager
	Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	Xylene-daily	1	3	4	8	5	5	1	4	15	120	-	M	50%	Reduce waste storage quantities through onsite recycling	Implement a waste sorting programme at landfill. Can purchase a bale machine to recover & bale recyclable materials in order to reduce the amount of waste to storage	Landfill manager
	Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	hydrogen sulphide-hourly	1	1	4	6	5	5	1	2	13	78	-	M	50%	Reduce waste storage quantities through onsite recycling	Implement a waste sorting programme at landfill. Can purchase a bale machine to recover & bale recyclable materials in order to reduce the amount of waste to storage	Landfill manager
	Operation	Waste site operation	Storage of general waste at landfill - gaseous emissions	hydrogen sulphide-daily	1	1	4	6	5	5	1	2	13	78	-	M	50%	Reduce waste storage quantities through onsite recycling	Implement a waste sorting programme at landfill. Can purchase a bale machine to recover & bale recyclable materials in order to reduce the amount of waste to storage	Landfill manager

6 MITIGATION MEASURES

The mitigation measures below are given within a general content. The choice of mitigation measures to be implemented at the site will depend on a number of factors such as practically, feasibility, appropriateness and availability of resources.

6.1 Construction Phase

Fugitive dust emissions during the construction phase can be minimised with wet suppression, wind speed reduction methods or chemical suppression. Wet suppression is the most common and affordable control method although it only provides temporary dust control.

Wet suppression of unpaved areas can achieve dust emission reductions of approximately 70% or more, which can be increased by up to 95% through the use of chemical stabilisation. The use of chemicals provides for longer dust suppression but is costlier and may have adverse environmental effects. Windbreaks and source enclosures are often impractical because of the size of fugitive dust sources (USEPA, 1995). Wet suppression is the recommended method to control dust emissions during the construction phase of the substation and powerlines.

A summary of the available dust control measures during the construction phase of the project is given in the table below. A dust management should be developed for the construction phase of the project and take into account some of the below mitigation options for dust control.

Table 6-1 Dust control measures that can be implemented during construction activity.

DUST CONTROL MEASURE	DESCRIPTION
Limit Cleared Areas	Before the commencement of any site works and during the operation, as much vegetation as possible should be retained, including patches and strips to minimise dust. Dust emissions can be controlled using the following procedures: • Before any site works commence, plan and locate the vegetation cover that needs to be retained; • Protect this vegetation by fencing or blocking off from the rest of the site operations; • In other areas, maintain the original vegetation cover for as long as possible; • Avoid clearing the entire site at once, instead clear areas as required in stages of the operation. Retaining the original trees, shrubs and grasses is one of the most efficient and effective ways of minimising dust emissions. Even low or sparse vegetation can be very effective at dissipating wind velocity at the ground surface, where dust lift off occurs.
Vegetative Stabilisation	Vegetation is a very effective form of reducing dust emissions. The following procedures should be considered in minimising dust emissions: • Retain as much existing vegetation as possible; • If an area needs to be cleared, transplant established plants that must be disturbed to areas that need vegetation; • If existing vegetation must be removed and cannot be immediately transplanted elsewhere, remove and maintain them for replanting at project completion. If trees and plants must be removed and it is not possible for them to be replanted, consider chipping and using the material as mulch – the advantage is that reseeding of original vegetation can occur. Where possible, restore vegetation that is native to the area to maximise plant success and improve environmental conditions.
Timing of Development	Activities with high dust-causing potential, such as topsoil stripping, should not be carried out in sensitive areas during adverse wind conditions. When necessary, topsoil should be stripped in discrete sections, allowing buffer strips (windbreaks) between clearings.
Wind Barriers	Having appropriate wind barriers can be an effective measure for the control of dust over short distances. Wind barriers provide protection against the movement and impact of dust on nearby land uses. Wind barriers should be placed on site before commencement of works and when it is apparent that one is required during the phase of the operation. Consider the following options when placing barriers to prevent dust emissions: • Wind barriers are most effective when placed perpendicular to the direction of the prevailing wind, but will have little or no effect when the wind direction is parallel to the fence; • When choosing wind barriers it has been observed that solid barriers provide significant reductions in wind velocity for relatively short leeward distances, whereas porous barriers provide smaller reductions in velocity for more extended distances; • Wind barriers should be at least 2 meters high; • The screening material should have a porosity of 50% or less.
Earth Moving Management	Earth-moving works have the potential to generate large amounts of dust. Planning earth-moving works particularly at the start of an operation can reduce dust emissions by limiting the time the site is exposed. Options for dust control can include the following:

	• Plan earth-moving works so that they are completed just prior to the time they are needed; • Observe weather conditions and do not commence or continue earth moving works if conditions are unsuitable e.g., under conditions of strong winds; • Reduce off-site hauling via balanced cut and fill operations; • Pre-water areas to be disturbed.
Stockpiles	Material stockpiles are capable of generating large amounts of dust. In particular, fine materials stored in stockpiles can be subject to dust pick-up. Materials being loaded onto conveyor belts or into trucks are also potential sources of dust emissions. Dust emissions from material stockpiles can be minimised through the use of the following procedures: • Locate stockpiles in sheltered areas. Otherwise, stockpiles should be covered; • Where stockpiles are located in open areas, limit the height and slope of the stockpiles to reduce wind pick up, orient stockpiles lengthwise into the wind so they offer the minimum cross-sectional area to prevailing winds, install wind barriers on three sides of the stockpile; • Limit activity to the downwind side of the stockpile; • Limit drop heights from loading facilities and use closed conveyors where possible; • Transfer points should also be minimised.
Watering	Watering is applicable to almost every aspect of site operations, from reducing dust lift off from roads and other traffic areas and during earthworks, to controlling dust during movement of materials such as loading/offloading and transportation of materials. Watering is a very effective short-term measure. However, its efficiency decreases as wind velocity and evaporation rate increase. Dust emissions can be minimised using the following watering procedures: • The surface should be dampened to prevent dust from becoming airborne but should not be wet to the extent of producing run-off. Alternatively, wetting agents could be used, particularly for non-wetting soils; • Watering is more effective when undertaken prior to strong breezes; • Use watering sprays on materials to be loaded and during loading; • Real time automated response systems to turn on water cannon systems in response to dust levels or high wind speeds could be used. These can help save water by only turning on water cannons during adverse conditions and also help reduce the possibility of operator error; • In cases where severe water restrictions are imposed, other measures like the use of wetting agents such as chemical stabilisation or hydro mulch, could be considered.
Chemical Stabilisation	Chemical stabilisers provide immediate coverage and protection and are effective in areas that receive little traffic or disturbance. They provide a longer-term solution compared to watering, although it may be necessary for the chemical ingredients to be evaluated with regard to their environmental effects. Chemical stabilisers work by binding the soil particles together to create an artificial crust on the soil surface that is less prone to disturbance by wind. The following options should be considered when using chemical stabilisers to reduce dust emissions: • Physical barriers or other methods of preventing traffic access should be used to protect stabilised areas; • The manufacturer's instructions should be followed to optimise performance.
Maintenance	The following routine maintenance procedures should also be implemented as a dust control measure: • There should be a nominated person with the responsibility for dust management;

	• All staff should be aware of the potential for dust generation and inducted on dust minimising practice;. • Dust control equipment should be inspected regularly and defects repaired promptly. Spares should be kept on site for critical items of control equipment, such as water pumps for dust suppression sprays; • Trucks carrying contaminated soil from the site for disposal off-site should be washed down prior to leaving the site to prevent spreading contamination off-site.

6.2 Operational Phase

Managed landfill sites can mitigate their emissions through better management of the landfill site, and through the recovery and flaring of landfill gas (LFG) for later use. Additionally, alternative options for the disposal of waste should be investigated, to allow for organic waste to be diverted, and to be used elsewhere, such as for composting (DEA, 2014).

Transfer stations can also help reduce the amount of waste reaching the landfill. This reduces the cost of hauling the waste, reduces traffic around the landfill, and generated many opportunities for recycling. Recycling encourages public participation, and can result in the growth of local business, such as with recycling agencies. Through this, the local community can be educated in terms of waste reduction.

Incineration has the advantage of reducing the amount of waste that needs to be disposed of, which ultimately results in less land used for the landfill, while at the same time providing the opportunity for electricity generation. Incineration also reduces the spread of disease. However, certain environmental licences, such as an Atmospheric Emission Licence, may be required in order to operate an incinerator. An AEL for instance will require the landfill to measure the emissions from the incinerator annually and may require the landfill to install emission control equipment, which can result in unforeseen expenses.

Disposal of waste is the final step in the waste lifecycle, therefore consideration should be given to the selected methods for disposal, such as baling (compacting waste into blocks), which reduces the amount of cover material required for the landfill, reduces litter that can be blown around, reduces pests such as rats, reduces leachate generation, etc. (CSIR, 2010).

A summary of mitigation opportunities is given below.

Mitigation opportunity		Reasons for inclusion in management of landfill
1.	Landfill Gas (LFG) recovery – flaring [greatest mitigation potential].	Important mitigation measure; gas generation is generally high enough to run a gas engine. *Gas recovery (from landfill CH_4) reduces emissions. Reduction of CH_4 fulfils a country's commitment to the UNFCCC.
2.	Capping with gas recovery - electricity	Capping can be used to generate electricity; Potential to reduce about 70% of LFG generated at a landfill; Gas recovered can be used for nearby homes or industrial sites, fed into a pipeline, or for steam production.
3.	Capping with gas recovery - preventative	Can mitigate underground gas migration, which has the potential to cause explosions if it migrates under nearby buildings;
4.	Incineration - energy from waste	Incineration reduces the amount of waste and can be combined with energy recovery from the combustion process.
5.	Source-separated collection and composting	Estimated 70% of waste food and garden waste can be captured via source-separated collection, which assists in reducing GHG emissions; waste food and garden waste can be used for composting soil – returning organic matter back to the soil. Compacting waste at the landfill removes oxygen, which causes anaerobic breakdown of the material, and ultimately methane generation.
6.	Source-separated waste – dry recyclable products including paper	Use material recycling facilities which take dry recyclables collected; revenue can be generated here from the sale of the dry recycled materials, such as paper products; The use of products from recycled paper almost matches that of virgin paper. Can have an onsite bale machine to bale recycle materials such as plastic and paper.
7.	Waste wood	Some wood waste can be used as fuel for boilers.

8.	Alternative fuel	Waste with a high calorific value may be utilised in cement kilns as an alternative fuel;
9.	Toxins drained in pipes and discharged	Toxins such as mercury can be released and seep into soil and groundwater. This can be drained with a number of pipes and discharged into a sewer system to be incinerated or converted to fertilizer.
10.	Leachate treatment	Leachate (liquid formed when waste breaks down and is combined with water such as rain onsite) can be treated biologically or chemically to remove nitrogen and other biological and organic compounds before groundwater and soil is further contaminated.

The recovery of methane to produce energy, as well as the recycling of waste are the 2 main approaches to methane emission reduction in landfills. Gas from landfills is extracted by drilling into the landfill and installing wells. To extract the gas through the wells, negative pressure is applied, after which the extracted gas is processed to remove contaminants and water. This extracted landfill gas can be used to generate energy, which can ultimately be used to offset the cost of the gas recovery (USEPA, 2017). The table below summarises different ways that landfill gas can be used as an energy source.

Electricity generation	Methane recovered can be used to run a generator, and the power used onsite or sold. The waste heat produced when generating this power can also be recovered and used for general heating purposes;
Landfill gas	Landfill gas can be used for steam generation in industrial systems, or for general heating and cooling. This recovered gas can also be used as a fuel for boilers, as well as for residential and industrial uses.
Natural gas	Landfill gas can be treated to produce gas with over 95% methane concentration, which can be piped;

6.2.1 Air Quality Monitoring Recommendations

General waste landfill sites are a key source of H_2S and BTEX air pollutant compounds, which can have a negative impact on human health when inhaled at above threshold concentrations over a period of time. Landfilling operations and vehicle dust entrainment due to truck activity can also result in fugitive dust emissions. Therefore, it is recommended that the Newcastle landfill implement an air quality monitoring programme at the landfill during the construction and operational phases of the project. The following air quality monitoring options are given below. The choice of monitoring option will depend on practicality and affordability.

Air Quality Monitoring Option		Details	Advantages	Disadvantages	Monitoring Frequency	Reporting Frequency	Air Quality Standards to compare to
1.	Fence line passive badge monitoring of H_2S and BTEX Compounds Operational phase	- Passive badge samplers can be used to measure the ambient concentration of H_2S and BTEX compounds. - They can be placed along the fence line of the landfill facility to monitor concentrations at different points. - An average concentration value is provided per badge for the period that the badge was left exposed in the field for. - The badges are easy to handle and can be used to monitor concentrations at several points. - The concentration values can assist in identifying periods of high concentrations, areas of high concentrations, etc. - The data can also be used in the event there is a complaint.	- The badges are easy to handle and can be used to monitor concentrations at several different points along the fence line or at identified sensitive receptors. - Easy to maintain and relatively cheaper compared to purchasing an instrument. - Can be used to compare concentrations against long term average air quality standards (e.g. benzene annual standard of 5µg/m^3). - Easy to replace in case of damage or theft.	- Does not provide real time concentrations. - Can only provide one average value for period of exposure. As such, it is not useful to measure concentrations for the purposes of comparing them against short term average air quality standards (i.e. daily and hourly limits). - Logistical delays i.e. results can take a while to get from the laboratory.	- Monthly - Do monthly change-over of passive badges. **monthly monitoring is required to compare against the Benzene annual average standard.	- Quarterly or bi-annually	See notes below

2.	Installation of an air quality monitoring instrument capable of measuring H_2S and BTEX compounds Operational Phase	- An instrument that can monitor H_2S and BTEX compounds can be purchased and installed at the landfill site. - The instrument can measure real time ambient concentrations of these pollutants at the site. - The site can compare measured concentrations with ambient air quality limits on a continuous basis. - Exceedances of the ambient air quality limits could require the landfill to implement further investigation or corrective actions in terms of landfill management	- Provides real time concentrations. - Can be used to compare concentrations with short term air quality limits (10-min, hourly and daily standards) to assess compliance. - Provides accurate data. - Data can be accessed quickly using online platforms.	- Expensive to purchase. - Requires continual maintenance. - Can only measure concentrations at one location. - Difficult to fix or expensive to replace in the event of damage or theft. - No data available if the instrument is not working.	- Continuous	- Quarterly	See notes below
3.	Dust fallout monitoring Construction & operational phase	- Dust fallout buckets can be placed along the fence line and at other identified points. - Useful to identify areas on site that are associated with high fugitive dust emissions. - Help assist in identifying which areas require dust suppression. - Dust fallout rates can be compared with the National Dust Control Regulations. - Exceedances of the dust control regulations of 1200mg/m^2/day would require further investigation and corrective actions, such as further dust suppression at key areas (e.g. truck haul route).	- Easy to install and can be placed at several points. - Easy to maintain. - Easy to replace in the event of theft or damage.	- Monthly monitoring results have cost implications. - Logistical requirements (the movement of bucket samples)	- Monthly - Do monthly bucket change over.	- Quarterly or bi-annually	See notes below
4.	Surface Methane Monitoring using portable methane	- Measure the concentration of methane above landfill surface (approx. 5 cm)	- Easy to undertake the monitoring and purchase equipment.	- Cost implications to implement monitoring program.	- Monthly	- Monthly internal reporting	See notes below

	instrument or monitor. Operational Phase	where intermediate or final covering or capping occurs (www.epa.nsw.gov.au, 2016) - Measurements can be done in a grid with 25m spacing between each grid. - Areas where methane concentrations exceeding 500 ppb require further investigation and corrective actions such as repairing the cover material. - Monitoring should be undertaken on a relatively calm weather day (low speed winds). Monitoring of methane in office buildings, small enclosed spaces onsite should also be done. These areas should be fitted with methane monitoring devices to ensure that concentrations don't accumulate to a level that could potentially result in a hazard.	- Useful to assist with management of landfill gas emissions. - Instrument easy to calibrate.	- Onsite personnel safety risks			
5.	Field Odour Surveys Operational Phase	- Conduct regular field odour surveys along the landfill fence line/site boundary or at nearby identified sensitive receptors. - Field surveys should be undertaken under the following weather conditions: a) early morning calm, b) middle day hot and c) downwind of prevailing wind direction. - Odour impacts can be rated by the field group using a	- Easy to implement - Does not require any expensive equipment	- Safety risk for field observers at the landfill	Quarterly or bi-annually	Quarterly or bi-annually	n/a

		predetermined scale and odour descriptive words. - Field observations can be compared with real-time concentrations if a monitoring instrument is available. - An odour complaints register should also be placed at the landfill site office. Relevant details, such as date, time, nature of complaint, etc. should be captured in the event there is a complaint.					

Notes:

1) South African National Ambient Air Quality Standard for Benzene = 5µg/m³ (annual standard). There are no South African ambient air quality standards for any other BTEX compounds or H_2S.
2) Alberta ambient air quality objectives and guidelines for H_2S and BTEX compounds:
    a. Benzene: 1-hour = 30µg/m³
    b. Ethylbenzene: 1-hour = 2000µg/m³
    c. Toluene: 1-hour = 1880µg/m³
    d. Toluene: 24-hour = 400µg/m³
    e. Xylene: 1-hour = 2300µg/m³
    f. Xylene: 24-hour = 700µg/m³
3) South African National Dust Control Regulations:
    a. Residential area standard: 600 mg/m²/day
    b. Non-residential area standard: 1200 mg/m²/day
4) Environmental Guidelines for Solid Waste Landfills, Second Edition, EPA (2016): states a 500 ppb threshold limit to initiate further investigation or corrective action.

6.3 Summary and Conclusions

Rayten Engineering Solutions was appointed by GCS to compile an Air Quality Impact Assessment report for the proposed Newcastle Landfill Site in the KwaZulu Natal Province. The main objective of the Air Quality Impact Assessment is to determine the potential impact of emissions from the construction and operational activities associated with the proposed project on ambient air quality in terms of the criteria air pollutants.

As part of the Air Quality Impact Assessment, a Baseline Air Quality Assessment was undertaken to determine the prevailing meteorological conditions at the site, establish baseline concentrations of key air pollutants of concern, identify existing sources of emissions and identify key sensitive receptors surrounding the project site. MM5 meteorological data for the project area for the period 01 January 2015 – 31 December 2017 was used. The Air Quality Impact Assessment consisted of an emissions inventory and subsequent dispersion modelling simulations to determine TSP (as dust fallout), PM_{10}, $PM_{2.5}$, BTEX and H_2S concentrations associated with proposed activities during the construction and operational phases of the project. Comparison of the modelled concentrations were made with the South African Ambient Air Quality Standards to determine compliance.

The proposed study site is approximately 780 ha. The proposed infill area of the landfill where waste will be disposed is expected to occupy an area of ± 5 ha. The landfill site including associated infrastructure (leachate dames, and buffer zones) is anticipated to occupy an area of ± 180 ha. The site is accessible via a gravel road off the N11 located on the east side of the proposed site. The land use within a 20 km radius around the proposed project site consists predominantly of grassland and cultivated land, with some mining activity to the south-east of the proposed landfill site. Urban residential areas are concentrated in the north-east region of the proposed site.

The closest town to the study site is Newcastle, located north-north-east of the proposed landfill site. There are, a number of schools/educational facilities and two medical facility located within a 10km radius of the landfill. Sensitive receptors located near to the study site may be impacted by emissions from operations at the proposed Newcastle Landfill due to the close proximity of these sites.The existing air quality situation is usually evaluated using available monitoring data from permanent ambient air quality monitoring stations, and dust fallout networks operated near the project site. Baseline air quality in the area was assessed using secondary data sources from the Amajuba District Municipality Air Quality Management Plan (AQMP). In 2014 there were three (3) privately owned continuous monitoring stations operating in the district and passive monitoring was conducted by the Department of Environmental Affairs for NO_2, SO_2, O_3 and benzene. There were no exceedances of NO_2, SO_2, O_3 recorded during the DEA passive monitoring campaign. Due to the disjointed and limited periods of monitoring, it is not possible to infer trends from the existing data.

Landfilling operations at the proposed Newcastle Landfill Site are mainly associated with emissions of PM, BTEX, Methane, H_2S and odour impacts. The anticipated impact of activities at the proposed Newcastle Landfill Site were quantitatively assessed through dispersion modelling.

Dust and gaseous emissions will be emitted from the following key sources listed below. Only activities that occurred on site were considered in this study.

- **Dust and Particulate Emissions:**
    - Construction;

- **Gaseous Emissions**
    - Decomposition of landfill waste.

Based on the dispersion modelling results, the following comments are made:

- Predicted incremental dust fallout rates and toluene concentrations comply with the applicable standards beyond 1km from the landfill boundary;
- No exceedances of the limits are recorded for xylene, ethylbenzene and benzene predicted incremental concentrations;
- Predicted incremental concentrations for PM_{10} and $PM_{2.5}$ exceed the applicable limits beyond the site boundary, however, exceedances of the limits at surrounding sensitive receptors are only observed for PM_{10} daily concentrations;
- H_2S is associated with an odour. Predicted incremental H_2S concentrations do not exceed the applicable Canadian guidelines outside the site boundary; with relatively low concentrations observed beyond 1km from the landfill boundary.

In conclusion the dispersion modelling results indicate relatively low incremental concentrations for BTEX, H_2S and dust fallout rates beyond the landfill boundary. Under the worst-case scenario, relatively high PM_{10} and $PM_{2.5}$ concentrations may result due to heavy construction activity during the construction phase. Although these impacts are short term and are limited to the construction phase of the project, dust mitigation measures should be implemented during construction activity to reduce dust emissions. This can be achieved by water spraying, which has an associated emission control efficiency of 50% control. A dust management plan will need to be developed and implemented during the construction phase of the project.

For the operational phase, managed landfill sites can mitigate their emissions through better management of the landfill site, and through the recovery and flaring of landfill gas for later use. Additionally, alternative options for the disposal of waste should be investigated, to allow for organic waste to be diverted, and to be used elsewhere, such as for composting (DEA, 2014). Furthermore, the landfill can implement a waste sorting procedure, whereby recyclable materials are removed, baled on site and sent to recycling facilities. This will allow the landfill to reduce the amount of waste entering the landfill and thus resulting in lower emissions. It is recommended that the landfill develops an emission reduction management plan that can consider some of the mitigation options discussed in Section 6 of the report. The choice of mitigation measures will depend on the availability of resources, practicality, effectiveness and affordability.

Based on the above information, Rayten believes that the proposed development can go ahead if the recommended mitigation measures are implemented during the construction phase. Furthermore, it is recommended that an emission reduction plan be developed for the operational phase of the proposed development.

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APPENDIX A

AIR DISPERSION MODELLING CHECKLIST

Table A 1: Information Required in Air Dispersion Modelling Report.

Information Required in Plan of Study Report				
Description	**Included (Y/N)**	**Section**	**Page no.**	**Comments**
1. Facility and Modellers Information				
Project Identification Information				
Applicant details	Y	1.1	1	
Facility Identification	Y	1.1	1	
Physical address of facility	Y	1.1	1	
AEL number	N			Not applicable
EIA reference	N			Not applicable
Modelling contractors	Y	1.1	1	
Project Background				
Objectives of Baseline Assessment	Y	1	1	
Process description	Y	1.2	1-2	
Project Location				
Site layout plan	Y	1.2	2	
Regional map	Y	2	5	
Adjacent area map	Y	2	8	
Surrounding land use map	Y	2	6	
Elevation data (DEM)	Y	2	7	
2. Emission Characterisation				
Proposed emissions & source parameters				
All identifiable emissions listed	Y	5	30-33	
Parameters for each operating scenario	Y	5	30-33	
Proposed emissions calculations	Y	5	30-33	
3. Meteorological Data				
Surface Data				
Source of data	Y	4.1	16	
Seasonal wind roses	Y	4.1	20	
3-year representative data	Y	4.1	18	
Program used to process data	Y	4.1	16	
Description of station	Y	4.1	16	

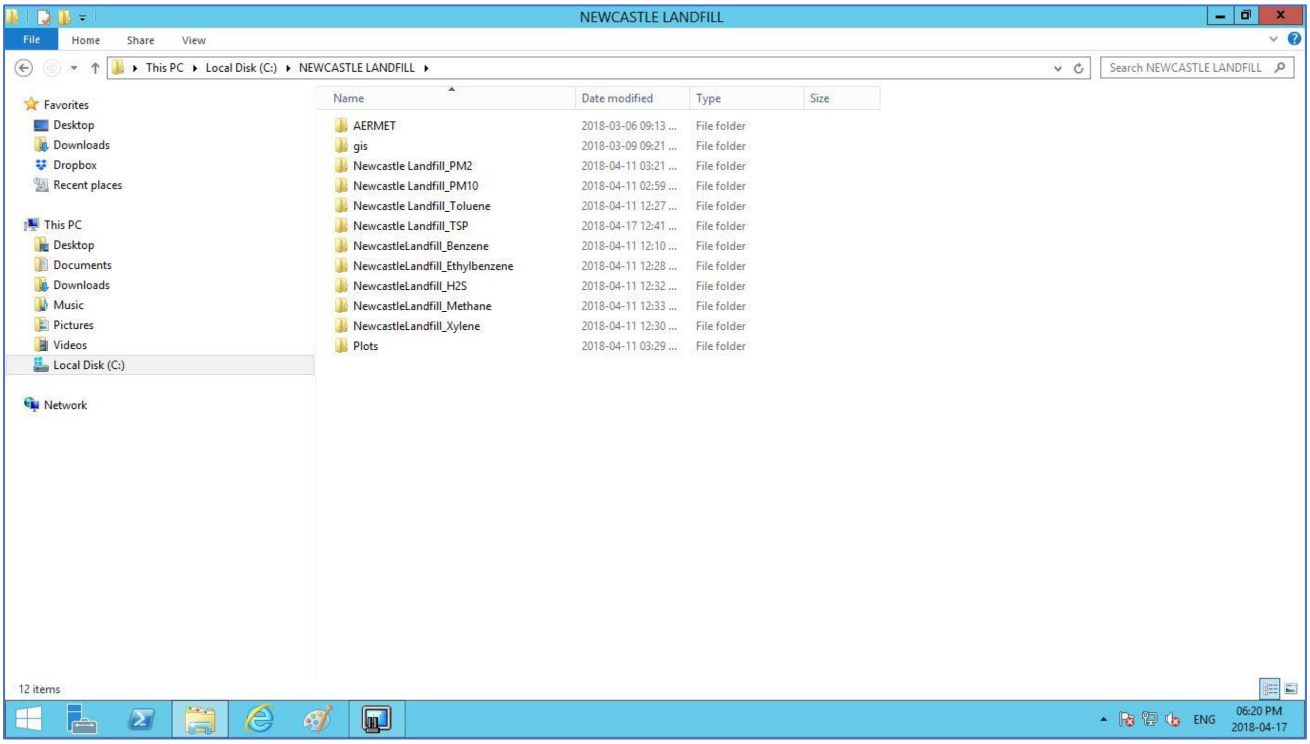
Period of record	Y	4.1	16	
Spatial representativeness	Y	4.1	16	
Data complies with Code of Practice	Y	4.1	16	
Upper Air Data				
Source of data	Y	4.1	16	
4. Ambient Impact Analysis and Ambient Levels				
Standard Levels				
National Ambient Air Quality Standards	Y	3.3	10	
Background Concentrations				
Background values specified	Y	4.2.	23-24	
5. Modelling Procedures				
Proposed Model				
Assessment level proposed	Y	5.2	34	
Dispersion model to be used	Y	5.2	33-34	
Supporting models to be used	Y	5.2	35	
Version of models to be used	Y	5.2	35	
Proposed Emissions to be Modelled				
Pollutants specified	Y	5.2	35	
Scenarios to be modelled	Y	5	35	
Conversion factor utilized	N			Not used
Proposed Settings				
Settings to be utilized	Y	5.2	35	
Terrain settings	Y	5.2	35	
Land characteristics	Y	5.2	35	
Grid Receptors				
Property line resolution	Y	5.2	34-35	
Fine grid resolution	Y	5.2	34-35	
Medium grid resolution	Y	5.2	34-35	
Large grid resolution	Y	5.2	34-35	
6. Ambient Impact Results Documentation				
Tables of Modelling Results				
Pollutant	Y	5.3	35-48	
Averaging time	Y	5.3	35-48	
Operating scenario	Y	5.3	35-48	
Maximum modelled concentration	Y	5.3	35-48	
Receptor location	Y	5.3	35-48	
Receptor elevation	Y	5.3	35-48	
Date of maximum impact	N			Can be provided upon request
Name of output e-files	Y	Appendix B		
Source Impact Area Figures				

UTM co-ordinates	Y	5.3	35-48	
Modelled facility	Y	5.3	35-48	
Topography features	Y	2	7	
Isopleths	Y	5.3	35-48	
Value of maximum impact	Y	5.3	35-48	
Value of maximum cumulative impact	N			No background data available
7. Ambient Impact Supporting Documentation				
Electronic Files				
Electronic files can be provided upon request				
Input & output files for models	Y	Appendix B		name of files specified
Input & output files for pre-processors	Y	Appendix B		name of files specified
Input & output files for post-processors	Y	Appendix B		name of files specified
Digital terrain files	N			
Plot files	Y	Appendix B		name of files specified
Final report	Y			

APPENDIX B

OUTPUT E-FILES

Table C1: List of output e-files used.



Note: a copy of the modelling files can be provided upon request.

APPENDIX C

SPECIALIST CVS AND COMPANY PROFILE

Please refer to separate attached pdf documents