ENVIROLUTION CONSULTING

SCOPING REPORT FOR THE PROPOSED SITES FOR THE PROPOSED LANDFILL SITE IN LEPHALALE

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Contact Details

Name: Nokulunga Ngcukana
Postal Address: P.O. Box 158, Florida HIlls, 1716
Telephone: +27 11 472 3112
Cell: +27 83 209 1715
Email: lunga@gesza.co.za

EXECUTIVE SUMMARY

Gondwana Environmental Solutions (GES) was appointed by Envirolution Consulting to undertake an air quality impact assessment of the proposed construction of a general landfill and a hazardous waste storage facility (near) in Lephalale in the Limpopo Province. This will form part of the Environmental Impact Assessment (EIA) required in terms of the new NEMA regulations. The main objective of the assessment was to determine the potential emissions and impact of the proposed landfill site.

An initial scoping exercise was undertaken to select suitable sites for the proposed landfill. This included:

- Site visit to the proposed sites.
- Analysis of meteorological data from the Agricultural Research Council (ARC) for the period 1 January 2006 – 31 December 2008.
- Desktop literature review of the Limpopo regional and local air quality.

The predominant wind direction at Lephalale is north-north-east (10 %) with a lesser wind component from the north-east (9.5%) and north (6.5%). Wind speeds are generally slow to moderate with no wind speeds exceeding 6 m/s being recorded. Wind speeds of less than 1 m/s, which are designated as calm, occur 47.18 % of the time.

A significant diurnal variation in wind direction is observed at Lephalale. Between 00:00 – 06:00, winds are predominantly from the north-east (7.5 %) with an additional component from the north-north-east (4.8 %). Between 06:00 – 12:00 winds are predominantly from the north-north-east (13 %), with additional components from the north-east (11.8 %) and north (9%). Winds remain from the north-north-east (14%) during the afternoon (12:00 – 18:00), with additional components from north (12.1 %) and north-north-west (11.6 %). During the evening (18:00 – 24:00), winds blow from the north-east (9%) and north-north-east (7.9 %). An increase in calm conditions is observed during the night (61.61%).

A significant seasonal variation in wind direction is observed at Lephalale. During summer (DJF), winds are predominantly from the north-east (13 %) with an additional component from the north-north-east (12.2 %). Autumn (MAM) is also characterised by winds that are predominantly from the north-east

(7 %), with additional components from the north (4.3 %), north-north-west (4.3%) and north-west (4.3%). Winds blow from the north-north-east (7.5%) during the winter season (JJA) with additional components from north (5.5 %) and north-east (5.8 %). During the Spring (SON) a similar pattern is observed with winds remaining from the north-north-east (14.8%), north-east (12 %) and north (10%) with a component from the north-north-west (7%). An increase in calm conditions is observed during the winter season (59.06%).

The following potential sites for the proposed landfill were evaluated; Sites 1 – 4 (Grootvallei) and Site 5 (Matimba Power Station). The air quality site screening process concluded that Sites 1, 2 and 4 had a medium health risk. These sites do not pose a high health and nuisance risk to people due to it being located south of residential areas. However these sites will have a cumulative (over the life-span) impact on the air quality in the area due to the daily distance that will have to be travelled by the trucks that will be transporting the waste. Site 3 has been allocated the score of low health risk due to its location in close proximity to power line servitude and the power stations, and Site 5 has a high health risk due to it being located north-east of the Medupi Power Station. Due to the predominant wind direction being east-north-east, this could potentially impact on the people working and living on the construction site and village as all dust fallout and odour from the landfill will be blown in that direction.

Based on the scoping criterion provided by Eskom, baseline information and Gondwana Environmental Solutions experience with similar operations we are of the opinion that in terms of minimal impact on the air quality, the optimal site for the location of the landfill is Site 3. This Site is located adjacent to a power line servitude implying that there are no residential areas in close proximity, and therefore no anticipated health impacts. In addition this site has the shortest distance from the power stations and therefore the pollution footprint (vehicle tail-pipe emissions) from the trucks transporting the waste will be reduced.

1. INTRODUCTION

Eskom has proposed the construction of a landfill and the hazardous waste storage facility. Eskom envisage constructing and operating the proposed development within a 30km radius of the existing Matimba and Medupi Power Stations and the Eskom construction village. The proposed development will also cater for two future power stations proposed in the Waterberg area. The proposed location for this development is within the boundaries of Eskom owned property. Gondwana Environmental Solutions (GES) was appointed by Envirolution Consulting to undertake an air quality assessment of the proposed development. The main objective of the project is to provide an air quality impact assessment of the potential impact of the proposed development on the surrounding ambient air quality.

In terms of the Environmental Impact Assessment (EIA) Regulations published in terms of Section 24(5) of the National Environmental Management Act (NEMA, No 107 of 1998), Eskom requires authorization from the National Department of Environmental Affairs and Tourism (DEAT) for the undertaking of the proposed project. As part of this process, a specialist air quality investigation is required.

A qualitative desktop assessment of the possible gaseous compounds and particulate matter which may be released from the proposed landfill site and associated processes is included in the report. An initial baseline assessment is undertaken which includes a review of available meteorological data. The most significant potential pollutants emitted from the landfill site and associated processes are inhalable particulates (PM10), and TSP (Total Suspended Particulates). These particulate emissions will be generated from dust during the construction phase and from vehicle entrainment from the trucks transporting the construction material. In addition, there will be vehicle tailpipe emissions from the trucks. Pollutants from vehicle tailpipe emissions include sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2) and small amounts of volatile organic compounds (VOC's). During the operational phase, the main pollutant will be particulate matter (PM) and dust fallout.

1.1. Outline of Report

An introduction to the proposed construction of the landfill and overview of the site location is discussed in **Sections 1 and 2.** The South African air quality legislation is provided in **Section 3**. **Section 4** describes the health impacts of the criteria pollutants. The baseline assessment which includes the meteorological overview is provided in **Section 5**. The conclusions and recommendations are discussed in **Section 6**.

2. BACKGROUND

2.1. Site Location and Description

Eskom is presently constructing a 6 x 800 MW (4800 MW total capacity) coal fired power station known as the Medupi Power Station. The power station is located 15 km from the town of Lephalale, Limpopo Province. The construction of the Medupi Power Station results in the generation of waste (both general and hazardous). It should be noted that the waste dump which exists at the town of Lephalale is not licensed and therefore, in terms of Eskom's Safety Health and Environment (SHE) Policy and commitment to legal compliance, cannot be utilised for the disposal of the waste generated.

The proposed site screening exercise narrowed the geographical alternatives to the Farm Grootvallei 515 LQ (Figure 1). This farm is adjacent to the Medupi Power Station which is currently under construction. In addition to this, a site has similarly been identified within Matimba Power Station i.e. the Farm Grootestryd. The proposed facility will be designed such that it will accommodate the general as well as hazardous waste from the Medupi and Matimba Power Stations, as well as the anticipated Waterberg Power Stations and the nearby Eskom construction village in Marapong. The facility will comprise of amongst others access roads, water pipelines for potable water, the waste disposal site, and distribution lines for providing electricity to the facility.

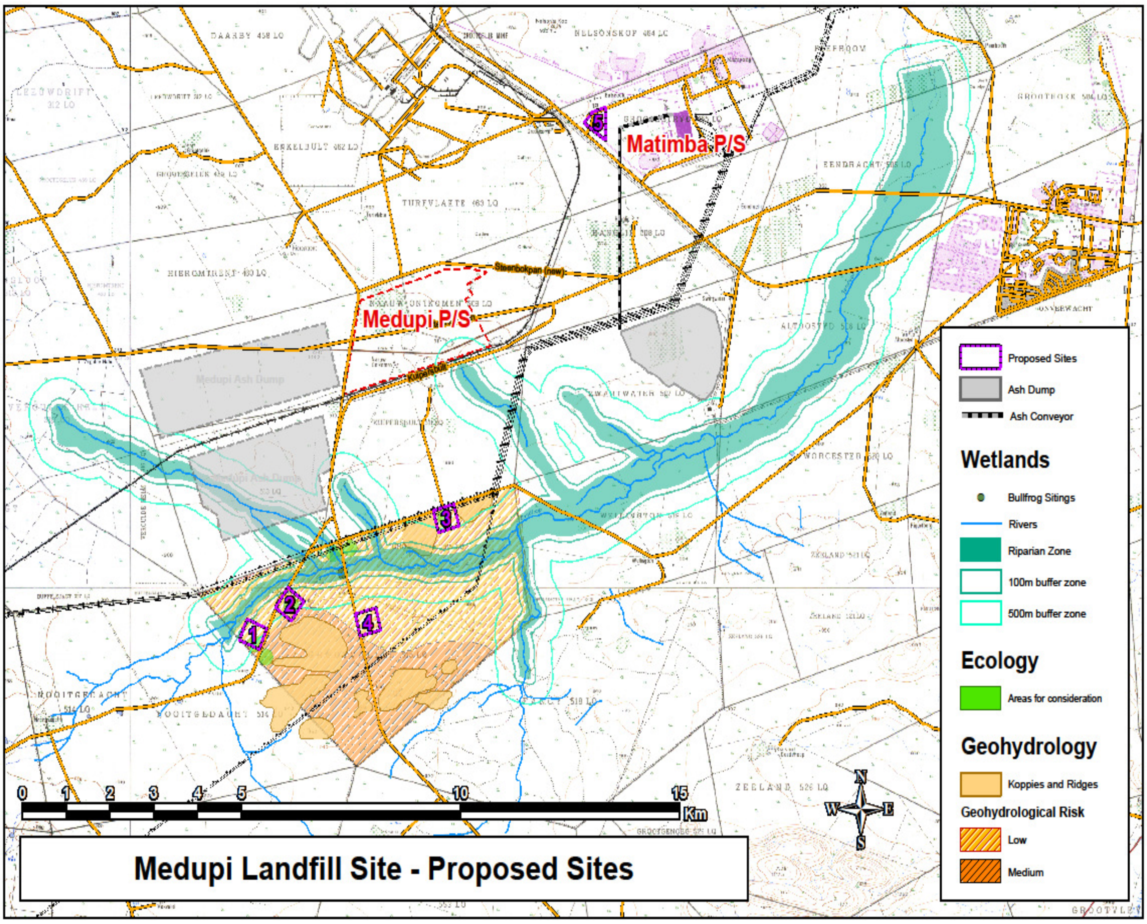

Figure 1: **Medupi Landfill proposed sites**

During the construction of the Medupi Power Station, it is anticipated that construction waste will be generated until 2014 after which the station will transition into an operational phase. Approximately half of this will be hazardous waste, and half general waste. It is anticipated that the existing Matimba Power Station will generate the same amount of waste, with a 50% split between hazardous and general waste for the remainder of its operating life, whereas the two proposed Waterberg Coal Fired Power Stations are anticipated to generate waste volumes that are slightly higher than that for the Medupi Power Station. These power plants are anticipated to have a life span of 50 years. The total anticipated waste generated from the four power stations over their total life i.e. 50 years, is expected to be approximately 1,200,000 m^3 of waste split between general and hazardous waste.

Table 1: Breakdown of proposed waste at the Medupi Landfill Site.

LANDFILL SITE	Total Waste (m^3)	Hazardous %	General %
Medupi	1,200,000	50	50

3. AIR QUALITY STANDARDS AND HEALTH IMPACTS

Air quality limits and thresholds are fundamental to effective air quality management, providing the link between the potential source of atmospheric emissions and the user of that air at the downwind receptor site. Ambient air quality limits indicate generally safe exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality limits are typically set for common air pollutants which cause widespread exposures. Suspended fine particulate matter, sulphur dioxide, nitrogen dioxide, carbon monoxide, lead and ozone are classified by most countries as 'criteria pollutants' with air quality limits being set for these pollutants. Ambient air quality limits are not published for all possible air pollutants to which the public may be exposed. Such limits are typically only set for commonly occurring air pollutants that result in relatively widespread public exposures. For constituents for which no air quality limits are promulgated reference may be made to dose-response thresholds published by health organisations such as the World Health Organisation (WHO) as discussed below.

Air quality indexing systems are frequently used to communicate the extent and acceptability of air pollution levels in a concise and readily understandable manner. Such systems are able to integrate information across a range of compounds and averaging periods. The banding approach adopted in the United Kingdom for example facilitates the classification of days into "low", "medium", high" and "very high" air pollution days. Although various air pollution indexing systems are currently in use in various parts of South Africa no system has yet been adopted for national implementation.

3.1. Air Quality Limits for Criteria Pollutants

National air quality standards are given in Schedule 2 of the National Environmental Management: Air Quality Act, Act 39 of 2004. These standards which largely reflect the national air quality guideline values established in the 1990s are considered to be dated and in need of revision.

The Department of Environmental Affairs and Tourism (DEAT) is in the process of reviewing and revising the national air quality standards published in the Air Quality Act with the purpose of ensuring that these limits are protective of human health and welfare. The review process was initiated by the gazetting of a new interim guideline for sulphur dioxide in December 2001, with these revised sulphur dioxide limits having been included in the Air Quality Act. Subsequently the Department engaged the South African Bureau of Standards (SABS) to facilitate the further development of health-based ambient air quality standards. Two documents were compiled during this process, viz. (i) SANS 69 - South African National Standard - Framework for setting & implementing national ambient air quality standards, and (ii) SANS 1929 - South African National Standard - Ambient Air Quality - Limits for common pollutants. The latter document includes air quality limits for particulate matter less than 10 µm in aerodynamic diameter (PM10), dustfall, sulphur dioxide, nitrogen dioxide, ozone, carbon monoxide, lead and benzene. The SANS documents were finalised and published during the last quarter of 2004. The adoption of the air quality limits documented in SANS 1929 is under consideration by the Department. In finalising these standards it is expected that permissible frequencies of exceedance and compliance timeframes will need to be established.

The health impacts of criteria pollutants are briefly discussed in subsequent subsections and national air quality limits published locally for such pollutants compared to widely-referenced limits published by various other countries and international organisations[1].

Suspended Particulate Matter

The impact of particles on human health is largely depended on (i) particle characteristics, particularly particle size and chemical composition, and (ii) the duration, frequency and magnitude of exposure. The potential of particles to be inhaled and deposited in the lung is a function of the aerodynamic

[1] More detailed information on the health and ecological impacts of common pollutants are documented in the DEAT's publication series, specifically Publication Series 4: Book 5 – Impacts of Air Pollutants (DEAT, 2006).

characteristics of particles in flow streams. The aerodynamic properties of particles are related to their size, shape and density. The deposition of particles in different regions of the respiratory system depends on their size.

The nasal openings permit very large dust particles to enter the nasal region, along with much finer airborne particulates. Larger particles are deposited in the nasal region by impaction on the hairs of the nose or at the bends of the nasal passages. Smaller particles (PM10) pass through the nasal region and are deposited in the tracheobronchial and pulmonary regions. Particles are removed by impacting with the wall of the bronchi when they are unable to follow the gaseous streamline flow through subsequent bifurcations of the bronchial tree. As the airflow decreases near the terminal bronchi, the smallest particles are removed by Brownian motion, which pushes them to the alveolar membrane (CEPA/FPAC Working Group, 1998; Dockery and Pope, 1994).

Air quality guidelines for particulates are given for various particle size fractions, including total suspended particulates (TSP), inhalable particulates or PM10 (i.e. particulates with an aerodynamic diameter of less than 10 µm), and respirable particulates of PM2.5 (i.e. particulates with an aerodynamic diameter of less than 2.5 µm). Although TSP is defined as all particulates with an aerodynamic diameter of less than 100 µm, and effective upper limit of 30 µm aerodynamic diameter is frequently assigned. PM10 and PM2.5 are of concern due to their health impact potentials. As indicated previously, such fine particles are able to be deposited in, and damaging to, the lower airways and gas-exchanging portions of the lung.

PM10 limits and standards issued nationally and abroad are documented in Table 2. In addition to the PM10 standards published in Schedule 2 of the Air Quality Act, the Act also includes standards for total suspended particulates (TSP), viz. a 24-hour average maximum concentration of 300 µg/m^3 not to be exceeded more than three times in one year and an annual average of 100 µg/m^3.

During the 1990s the World Health Organisation (WHO) stated that no safe thresholds could be determined for particulate exposures and responded by publishing linear dose-response relationships for PM10 and PM2.5 concentrations (WHO, 2005). This approach was not well accepted by air quality managers and policy makers. As a result the WHO Working Group of Air Quality Guidelines recommended that the updated WHO air quality guideline document contain guidelines that define concentrations which, if achieved, would be expected to result in significantly reduced rates of adverse health effects. These guidelines would provide air quality managers and policy makers with an explicit objective when they were tasked with setting national air quality standards. Given that air pollution levels in developing countries frequently far exceed the recommended WHO air quality guidelines (AQGs), the Working Group also proposed interim targets (IT) levels, in excess of the WHO AQGs themselves, to promote steady progress towards meeting the WHO AQGs (WHO, 2005). The air quality guidelines and interim targets issued by the WHO in 2005 for particulate matter are given in Tables 3 and 4.

Table 2: Air quality standard for inhalable particulates (PM10).

Authority	Maximum 24-hour Concentration (µg/m³)	Annual Average Concentration (µg/m³)
SA standards (Air Quality Act)[(2)]	180(a)	60
RSA SANS limits (SANS:1929,2004)	75(b) 50(c)	40(d) 30(e)
Australian standards	50(f)	-
European Community (EC)	50(g)	30(h) 20(i)
World Bank (General Environmental Guidelines)	70(j)	50(j)
World Bank (Thermal Power Guidelines)	150(k)	50(k)
United Kingdom	50(l)	40(m)
United States EPA	150(n)	50(o)
World Health Organisation	(p)	(p)

Notes:
(a) Not to be exceeded more than three times in one year.
(b) Limit value. Permissible frequencies of exceedance, margin of tolerance and date by which limit value should be complied with not yet set.
(c) Target value. Permissible frequencies of exceedance and date by which limit value should be complied with not yet set.
(d) Limit value. Margin of tolerance and date by which limit value should be complied with not yet set.
(e) Target value. Date by which limit value should be complied with not yet set.
(f) Australian ambient air quality standards. (http://www.deh.gov.au/atmosphere/airquality/standards.html). Not to be exceeded more than 5 days per year. Compliance by 2008.
(g) EC First Daughter Directive, 1999/30/EC (http://europa.eu.int/comm/environment/air/ambient.htm). Compliance by 1 January 2005. Not to be exceeded more than 25 times per calendar year. (By 1 January 2010, no violations of more than 7 times per year will be permitted.)
(h) EC First Daughter Directive, 1999/30/EC (http://europa.eu.int/comm/environment/air/ambient.htm). Compliance by 1 January 2005
(i) EC First Daughter Directive, 1999/30/EC (http://europa.eu.int/comm/environment/air/ambient.htm). Compliance by 1 January 2010
(j) World Bank, 1998. Pollution Prevention and Abatement Handbook. (www.worldbank.org). Ambient air conditions at property boundary.
(k) World Bank, 1998. Pollution Prevention and Abatement Handbook. (www.worldbank.org). Ambient air quality in Thermal Power Plants.
(l) UK Air Quality Objectives. www.airquality.co.uk/archive/standards/php. Not to be exceeded more than 35 times per year. Compliance by 31 December 2004
(m) UK Air Quality Objectives. www.airquality.co.uk/archive/standards/php. Compliance by 31 December 2004
(n) US National Ambient Air Quality Standards (www.epa.gov/air/criteria.html). Not to be exceeded more than once per year.
(o) US National Ambient Air Quality Standards (www.epa.gov/air/criteria.html). To attain this standard, the 3-year average of the weighted annual mean PM10 concentration at each monitor within an area must not exceed 50 µg/m³.
(p) WHO (2000) issued linear dose-response relationships for PM10 concentrations and various health endpoints with no specific guideline provided. WHO (2005) made available during early 2006 proposes several interim target levels (see subsequent tables).

[2] On 9 June 2006 the Department of Environmental Affairs and Tourism gazetted new air quality standards for public comment (90 day comment period given). The proposed PM10 standards are given as 75 µg/m³ for highest daily (compared to the current standard of 180 µg/m³) and 40 µg/m³ for annual averages (compared to 60 µg/m³ at present) (Government Gazette No. 28899, 9 June 2006).

Table 3: WHO air quality guideline and interim targets for particulate matter (annual mean) (WHO, 2005).

Annual Mean Level	PM10 (µg/m³)	PM2.5 (µg/m³)	Basis for the selected level
WHO interim target-1 (IT-1)	70	35	These levels were estimated to be associated with about 15% higher long-term mortality than at AQG
WHO interim target-2 (IT-2)	50	25	In addition to other health benefits, these levels lower risk of premature mortality by approximately 6% (2-11%) compared to WHO-IT1
WHO interim target-3 (IT-3)	30	15	In addition to other health benefits, these levels reduce mortality risks by another approximately 6% (2-11%) compared to WHO-IT2 levels.
WHO Air Quality Guideline (AQG)	**20**	**10**	These are the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase with more than 95% confidence in response to PM2.5 in the American Cancer Society (ACS) study (Pope *et al.*, 2002 as cited in WHO 2005). The use of the PM2.5 guideline is preferred.

Table 4: WHO air quality guideline and interim targets for particulate matter (daily mean) (WHO, 2005).

Annual Mean Level	PM10 (µg/m³)	PM2.5 (µg/m³)	Basis for the selected level
WHO interim target-1 (IT-1)	150	75	Based on published risk coefficients from multi-centre studies and meta-analyses (about 5% increase of short-term mortality over AQG)
WHO interim target-2 (IT-2)*	100	50	Based on published risk coefficients from multi-centre studies and meta-analyses (about 2.5% increase of short-term mortality over AQG)
WHO interim target-3 (IT-3)**	75	37.5	Based on published risk coefficients from multi-centre studies and meta-analyses (about 1.2% increase of short-term mortality over AQG)
WHO Air Quality Guideline (AQG)	**50**	**25**	Based on relation between 24-hour and annual levels

* 99th percentile (3 days/year)

** for management purposes, based on annual average guideline values; precise number to be determined on basis of local frequency distribution of daily means.

Air quality standards for PM2.5 have to date been set by various countries such as the US, Canada and Australia (Table 5). The EC is still in the process of developing their PM2.5 limit. No air quality limits have yet been published in South Africa for this particulate size fraction.

Table 5: Air quality standard for PM2.5.

Authority	Maximum 24-hour Concentration (µg/m³)	Annual Average Concentration (µg/m³)
Australian standards	25(a)	8(a)
United States EPA	35(b)	15
Canada	30	

Notes:
(a) Advisory reporting standards and goal for particles as PM2.5. Measure schedule commenced in 2005 (www.deh.gov.au/atmosphere/airquality/standards.html).
(b) To attain this standard, the 3-year average of the 98th percentile of the 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m³ (www.epa.gov/air/criteria.html).
(c) Canada-Wide Standards (CWS) issued by Canadian Council of Ministers of the Environment.

Sulphur Dioxide

SO_2 is an irritating gas that is absorbed in the nose and aqueous surfaces of the upper respiratory tract, and is associated with reduced lung function and increased risk of mortality and morbidity. Adverse health effects of SO_2 include coughing, phlegm, chest discomfort and bronchitis. Ambient air quality guidelines and standards issued for various countries and organisations for sulphur dioxide are given in Table 6.

The WHO air quality guidelines (AQGs) published in 2000 for sulphur dioxide have recently been revised (WHO, 2005). Although the 10-minute AQG of 500 µg/m³ has remained unchanged, the previously published daily guideline has been significantly reduced from 125 µg/m³ to 20 µg/m³. The previous daily guideline was based on epidemiological studies. WHO (2005) makes reference to more recent evidence which suggests the occurrence of health risks at lower concentrations. Although WHO (2005) acknowledges the considerable uncertainty as to whether sulphur dioxide is the pollutant responsible for the observed adverse effects (may be due to ultra-fine particles or other correlated substances), it took the decision to publish a stringent daily guideline in line with the precautionary principle. The WHO (2005) stipulates an annual guideline is not needed for the protection of human health, since compliance with the 24-hour level will assure sufficiently lower levels for the annual average. Given that the 24-hour WHO AQG of 20 µg/m³ is anticipated to be difficult for some countries to achieve in the short term, the WHO (2005) recommends a stepped approach using interim goals as shown in Table 7.

Table 6: Ambient air quality guidelines and standards for sulphur dioxide for various countries and organisations.

Authority	Maximum 10-minute Average (µg/m³)	Maximum 1-hourly Average (µg/m³)	Maximum 24-hour Average (µg/m³)	Annual Average Concentration (µg/m³)
SA standards (Air Quality Act)	500(a)	-	125(a)	50
RSA SANS limits (SANS:1929,2004)	500(b)	-	125(b)	50
Proposed SA standards (Government Gazette No. 28899, 9 June 2006)	500(a)	350(a)	125(a)	50
Australian standards	-	524(c)	209 (c)	52
European Community (EC)	-	350(d)	125(e)	20(f)
World Bank (General Environmental Guidelines)	-	-	125(g)	50(g)
World Bank (Thermal Power Guidelines)			150(h)	80(h)
United Kingdom	266(i)	350(j)	125(k)	20(l)
United States EPA	-	-	365(m)	80
World Health Organisation (2000)	500(n)		125(n)	50(n) 10-30(o)
World Health Organisation (2005)	500(p)		20(p)	(p)

Notes:
(a) No permissible frequencies of exceedance specified
(b) Limit value. Permissible frequencies of exceedance, margin of tolerance and date by which limit value should be complied with not yet set.
(c) Australian ambient air quality standards. (http://www.deh.gov.au/atmosphere/airquality/standards.html). Not to be exceeded more than 1 day per year. Compliance by 2008.
(d) EC First Daughter Directive, 1999/30/EC (http://europa.eu.int/comm/environment/air/ambient.htm). Limit to protect health, to be complied with by 1 January 2005 (not to be exceeded more than 24 times per calendar year).
(e) EC First Daughter Directive, 1999/30/EC (http://europa.eu.int/comm/environment/air/ambient.htm). Limit to protect health, to be complied with by 1 January 2005 (not to be exceeded more than 3 times per calendar year).
(f) EC First Daughter Directive, 1999/30/EC (http://europa.eu.int/comm/environment/air/ambient.htm). Limited value to protect ecosystems. Applicable two years from entry into force of the Air Quality Framework Directive 96/62/EC.
(g) World Bank, 1998. Pollution Prevention and Abatement Handbook. (www.worldbank.org). Ambient air conditions at property boundary.
(h) World Bank, 1998. Pollution Prevention and Abatement Handbook. (www.worldbank.org). Ambient air quality in Thermal Power Plants.
(i) UK Air Quality Objective for 15-minute averaging period (www.airquality.co.uk/archive/standards/php). Not to be exceeded more than 35 times per year. Compliance by 31 December 2005.
(j) UK Air Quality Objective (www.airquality.co.uk/archive/standards/php). Not to be exceeded more than 24 times per year. Compliance by 31 December 2004.
(k) UK Air Quality Objective (www.airquality.co.uk/archive/standards/php). Not to be exceeded more than 3 times per year. Compliance by 31 December 2004.
(l) UK Air Quality Objective (www.airquality.co.uk/archive/standards/php). Compliance by 31 December 2000.
(m) US National Ambient Air Quality Standards (www.epa.gov/air/criteria.html). Not to be exceeded more than once per year.
(n) WHO Guidelines for the protection of human health (WHO, 2000).
(o) Represents the critical level of ecotoxic effects (issued by WHO for Europe); a range is given to account for different sensitivities of vegetation types (WHO, 2000).
(p) WHO Air Quality Guidelines, Global Update, 2005 – Report on a Working Group Meeting, Bonn, Germany, 18-20 October 2005. Documents new WHO guidelines primarily for the protection of human health. The 10-minute guideline of 500 µg/m³ published in 2000 remains unchanged but the daily guideline is significantly reduced from 125 µg/m³ to 20 µg/m³ (in line with the precautionary principle). An annual guideline is given at not being needed, since “compliance with the 24-hour level will assure lower levels for the annual average”.

Table 7: WHO air quality guidelines and interim guidelines for SO_2 (WHO, 2005).

	24-hour Average Sulphur Dioxide (µg/m³)	**10-minute Average Sulphur Dioxide (µg/m³)**
WHO interim target-1 (IT-1) (2000 AQF level)	125	
WHO interim target-2 (IT-2)	50(a)	
WHO Air Quality Guideline (AQG)	**20**	**500**

(a) Intermediate goal based on controlling either (i) motor vehicle (ii) industrial emissions and/or (iii) power production; this would be a reasonable and feasible goal to be achieved within a few years for some developing countries and lead to significant health improvements that would justify further improvements (such as aiming for the guideline).

Oxides of Nitrogen

NO_x, primarily in the form of NO, is one of the primary pollutants emitted during combustion. NO_2 is formed through oxidation of these oxides once released in the air. NO_2 is an irritating gas that is absorbed into the mucous membrane of the respiratory tract. The most adverse health effect occurs at the junction of the conducting airway and the gas exchange region of the lungs. The upper airways are less affected because NO_2 is not very soluble in aqueous surfaces. Exposure to NO_2 is linked with increased susceptibility to respiratory infection, increased airway resistance in asthmatics and decreased pulmonary function.

The standards and guidelines of most countries and organisations are given exclusively for NO_2 concentrations. South Africa's NO_2 standards are compared to various widely referenced foreign standards and guidelines in Table 8. In addition, South Africa also publishes standards for oxides of nitrogen (NO_x).

Table 8: Ambient air quality guidelines and standards for nitrogen dioxide for various countries and organisations.

Authority	Instantaneous Peak (µg/m³)	Maximum 1-hourly Average (µg/m³)	Maximum 24-hour Average (µg/m³)	Maximum 1-month Average (µg/m³)	Annual Average Concentration (µg/m³)
SA standards (Air Quality Act)[(3)]	940(a)	376(a)	188(a)	150(a)	94
RSA SANS limits (SANS:1929,2004)	-	200(b)	-	-	40(b)
Australian standards		226(c)			56
European Community (EC)	-	200(d)	-	-	40(e)
World Bank (General Environmental Guidelines)	-	-	150 (as NO_x)(f)	-	-
World Bank (Thermal Power Guidelines)			150(g)		100(g)
United Kingdom	-	200(h)	-	-	40(i) 30(j)
United States EPA	-	-	-	-	100(k)
World Health Organisation (2000, 2005)	-	200(l)		-	40(l)

Notes:
(a) No permissible frequencies of exceedance specified
(b) Limit value. Permissible frequencies of exceedance, margin of tolerance and date by which limit value should be complied with not yet set.
(c) Australian ambient air quality standards. (http://www.deh.gov.au/atmosphere/airquality/standards.html). Not to be exceeded more than 1 day per year. Compliance by 2008.
(d) EC First Daughter Directive, 1999/30/EC (http://europa.eu.int/comm/environment/air/ambient.htm). Not to be exceeded more than 18 times per year. This limit is to be complied with by 1 January 2010.
(e) EC First Daughter Directive, 1999/30/EC (http://europa.eu.int/comm/environment/air/ambient.htm). Annual limit value for the protection of human health, to be complied with by 1 January 2010.
(f) World Bank, 1998. Pollution Prevention and Abatement Handbook. (www.worldbank.org). Ambient air conditions at property boundary.
(g) World Bank, 1998. Pollution Prevention and Abatement Handbook. (www.worldbank.org). Ambient air quality in Thermal Power Plants.
(h) UK Air Quality Provisional Objective for NO_2 (www.airquality.co.uk/archive/standards/php). Not to be exceeded more than 18 times per year. Compliance by 31 December 2005.
(i) UK Air Quality Provisional Objective for NO_2 (www.airquality.co.uk/archive/standards/php). Compliance by 31 December 2005.
(j) UK Air Quality Objective for NOx for protection of vegetation (www.airquality.co.uk/archive/standards/php). Compliance by 31 December 2000.
(k) US National Ambient Air Quality Standards (www.epa.gov/air/criteria.html).
(l) WHO Guidelines for the protection of human health (WHO, 2000). AQGs remain unchanged according to WHO (2005).

Carbon Monoxide

Carbon monoxide absorbed through the lungs reduces the blood's capacity to transport available oxygen to the tissues. Approximately 80-90 % of the absorbed CO binds with haemoglobin to form carboxyhaemoglobin (COHb), which lowers the oxygen level in blood. Since more blood is needed to supply the same amount of oxygen, the heart needs to work harder. These are the main causes of tissue hypoxia produced by CO at low exposure levels. At higher concentrations, the rest of the

[3] On 9 June 2006 the Department of Environmental Affairs and Tourism gazetted new air quality standards for public comment (90 day comment period given). The proposed NO_2 standards are given as 200 µg/m³ for highest daily and 40 µg/m³ for annual averages (in line with the SANS limits) (Government Gazette No. 28899, 9 June 2006).

absorbed CO binds with other heme proteins such as myoglobin and with cytochrome oxidase and cytochrome P-450. CO uptake impairs perception and thinking, slows reflexes, and may cause drowsiness, angina, unconsciousness, or death. The ambient air quality guidelines and other standards issued for various countries and organisations for carbon monoxide are given in Table 9.

Table 9: Ambient air quality guidelines and standards for carbon monoxide for various countries and organisations.

Authority	Maximum 1-hourly Average ($\mu g/m^3$)	Maximum 8-hour Average ($\mu g/m^3$)
SA Guideline(a)	40 000(a)	10 000(a)
SA SANS limits (SANS:1929,2004)	30 000(b)	10 000(b)
Australian standards	-	10 000 (c)
European Community (EC)	-	10 000(d)
World Bank	-	-
United Kingdom	-	10 000(e)
United States EPA	40 000(f)	10 000(f)
World Health Organisation	30 000(g)	10 000(g)

Notes:
(a) Issued in 1990s by CAPCO. No air quality standards for CO were included in the National Environmental Management: Air Quality Act.
(b) Limit value. Permissible frequencies of exceedance, margin of tolerance and date by which limit value should be complied with not yet set.
(c) Australian ambient air quality standards. (http://www.deh.gov.au/atmosphere/airquality/standards.html). Not to be exceeded more than 1 day per year. Compliance by 2008.
(d) EC Second Daughter Directive, 2000/69/EC (http://europa.eu.int/comm/environment/air/ambient.htm). Annual limit value to be complied with by 1 January 2005.
(e) UK Air Quality Objective (www.airquality.co.uk/archive/standards/php). Maximum daily running 8-hourly mean. Compliance by 31 December 2003.
(f) US National Ambient Air Quality Standards (www.epa.gov/air/criteria.html). Not to be exceeded more than one per year.
(g) WHO Guidelines for the protection of human health (WHO, 2000).

Ozone

Ozone is one of the most toxic pollutants regulated under ambient air quality guidelines and standards. Exposure to sufficient quantities can cause severe damage to lung tissues and impair defences against bacteria and viruses. Lung function changes are concentration dependent, increasing with increasing depth of breathing. Chronic exposures to ozone may result in premature ageing of the lungs. Health effects associated with ozone exposures include increased incidence and severity of asthma attacks and increased pulmonary resistance. High exposure levels are associated with impaired carbon monoxide diffusion capacity, headaches and possible acute bronchiolitis. Air quality guidelines and standards for ozone are given in Table 10.

WHO (2005) publishes interim targets in addition to the AQG it stipulates for ozone (see Table 11). In addition to the target value for the protection of human health the EC published a target value for the protection of vegetation for ozone. This target value is given as 18,000 µg/m³.h averaged over five years (given as AOT40, calculated from 1 hour values from May to July). AOT40 means the sum of the difference between hourly concentrations greater than 80 µg/m³ and 80 µg/m³ over a given period using only the 1-hour values measured between 08h00 and 20h00 Central European Time each day.

Table 10: Ambient air quality guidelines and standards for ozone for various countries and organisations.

Authority	Instantaneous Peak (µg/m³)	Maximum 1-hourly Average (µg/m³)	Maximum 8-hour Average (µg/m³)
SA Standard (Air Quality Act)[4]	472 (0.25 ppm)	226 (0.12 ppm)	
RSA SANS target values (SANS:1929,2004)		200(a)	120(a)(b)
Australian standards(c)		189 (0.1 ppm) 1-hour 151 (0.08 ppm) 4 hour	
World Health Organisation (2005)			100(d)
United Kingdom			100(e)
European Community (EC)(f)			100(g)

Notes:
(a) SANS 1929:2004 target values. Permissible frequencies of exceedance, margin of tolerance and date by which limit value should be complied with not yet set.
(b) 8-hourly running average calculated on hourly averages; designed to protect human health.
(c) Australian ambient air quality standards. (http://www.deh.gov.au/atmosphere/airquality/standards.html). Goal to be achieved by 2008, with a maximum allowable exceedance of 1 day per year.
(d) WHO (2005), value set for daily maximum 8-hour mean.
(e) UK Air Quality Objective (www.airquality.co.uk/archive/standards/php). Maximum daily running 8-hourly mean. Compliance by 31 December 2005. Not to be exceeded more than 10 times per year.
(f) EC Directive, 2002/3/EC (http://europa.eu.int/comm/environment/air/ambient.htm). Target value for the protection of human health.
(g) Maximum daily 8-hour mean, not to be exceeded on more than 25 days per calendar year averaged over three years. Compliance with target values will be assessed as of this value. 2010 will be the first year the data for which is used in calculating compliance over the following three or five years as appropriate.

[4] On 9 June 2006 the Department of Environmental Affairs and Tourism gazetted new air quality standards for public comment (90 day comment period given). The proposed standards are the same as those issued by the SANS (Government Gazette No. 28899, 9 June 2006).

Table 11: WHO (2005) air quality guidelines and interim guidelines for ozone.

	Daily Maximum 8-hour Mean (µg/m³)	Effects at Selected Ozone Level
High level	240	Significant health effects, substantial proportion of vulnerable population affected.
WHO interim target-1 (IT-1)	160	Important health effects, an intermediate target for populations with ozone concentrations above this level. Does not provide adequate protection of public health. Rationale: (i) Lower level of 6.6-hour chamber exposures of health exercising young adults, which show physiological and inflammatory lung effects. (ii) Ambient level at various summer camp studies showing effects on health of children. (iii) Estimated 3-5% increase in daily mortality* (based on findings of daily time-series studies).
WHO Air Quality Guideline (AQG)	**100**	This concentration will provide adequate protection of public health, though some health effects may occur below this level. Rationale: (i) Estimated 1-3% increase in daily mortality*(based on findings of daily time-series studies); (ii) Extrapolation from chamber and field studies based on the likelihood that real-life exposure tends to be repetitive and chamber studies do not study highly sensitive or clinically compromised subjects, or children, (iii) likelihood that ambient ozone is a marker for related oxidants.

*Deaths attributable to ozone concentrations above estimated baseline of 70 µg/m³. Based on range of 0.3 to 0.5% increase in daily mortality for 10 µg/m³ 8-hour ozone.

Benzene

Benzene has also been classified as a known human carcinogen, having been linked to increases in the incidence of leukaemia in humans. Acute neurological symptoms of inhalation exposure to benzene include drowsiness, dizziness, headaches, convulsions, and death in humans. Exposure to vapour may irritate the skin, eyes and upper respiratory tract. Chronic exposures cause disorders in the blood in humans, and specifically affect bone marrow. Aplastic anaemia, excessive bleeding and damages to the immune system due to changes in blood levels of antibodies and loss of white blood cells, may occur.

The air quality limit for benzene published in SANS 1929: 2004 is given as 5 µg/m³ for an annual averaging period. This is in line with the EC limit value for benzene which is also given as 5 µg/m³, to be met by 1 January 2010. The margin of tolerance for the EC limit is given as 5 µg/m³ (i.e. actual current threshold of 10 µg/m³). The margin is reduced by 1 µg/m³ on 1 January 2006 and by a further 1 µg/m³ every 12 months thereafter to ensure that the value of 5 µg/m³ is reached by 2010.

Dust Deposition

Dust deposition has to date been evaluated according to the following criteria:

SLIGHT	-	less than 250 mg/m^2/day
MODERATE	-	250 to 500 mg/m^2/day
HEAVY	-	500 to 1200 mg/m^2/day
VERY HEAVY	-	more than 1200 mg/m^2/day

The 1200 mg/m^2/day threshold level has typically been used in practice as an action level, with exceedances of this dustfall rate indicating the need for investigating the specific causes of high dustfall and for taking remedial steps. "Slight" dustfall is barely visible to the naked eye. "Heavy" dustfall indicates a fine layer of dust on a surface; with "very heavy" dustfall being easily visible should a surface not be cleaned for a few days. Dustfall levels of > 2000 mg/m^2/day constitute a layer of dust thick enough to allow a person to "write" words in the dust with their fingers.

A perceived weakness of the above-mentioned dustfall guidelines is that they are purely descriptive, without specific guidance for action or remediation not being made explicit in the guidelines. SANS 1929:2004 stipulates that dustfall rates be evaluated against a four-band scale, as presented in Table 12. Target, action and alert thresholds for ambient dust deposition are given in Table 13.

Table 12: Bands of dustfall rates proposed for adoption (SANS 1929:2004).

BAND NUMBER	BAND DESCRIPTION LABEL	DUST-FALL RATE (D) (mg m^{-2} day^{-1}, 30-day average)	COMMENT
1	RESIDENTIAL	D < 600	Permissible for residential and light commercial
2	INDUSTRIAL	600 < D < 1200	Permissible for heavy commercial and industrial
3	ACTION	1200 < D < 2400	Requires investigation and remediation if two sequential months lie in this band, or more than three occur in a year.
4	ALERT	2400 < D	Immediate action and remediation required following the first exceedance. Incident report to be submitted to relevant authority.

Table 13: Target, action and alert thresholds for ambient dustfall (SANS 1929: 2004).

LEVEL	DUST-FALL RATE (D) (mg m^{-2} day^{-1}, 30-day average)	AVERAGING PERIOD	PERMITTED FREQUENCY OF EXCEEDANCES
TARGET	300	Annual	
ACTION RESIDENTIAL	600	30 days	Three within any year, no two sequential months.
ACTION INDUSTRIAL	1200	30 days	Three within any year, not sequential months.
ALERT THRESHOLD	2400	30 days	None. First exceedance requires remediation and compulsory report to authorities.

According to the proposed dustfall limits an enterprise may submit a request to the authorities to operate within the Band 3 ACTION band for a limited period, providing that this is essential in terms of the practical operation of the enterprise (for example the final removal of a tailings deposit) and provided that the best available control technology is applied for the duration. No margin of tolerance will be granted for operations that result in dustfall rates in the Band 4 ALERT.

4. AIR QUALITY LEGISLATION

4.1. National Environmental Management: Air Quality Act No. 39 of 2004 (AQA)

The National Environmental Management: Air Quality Act 39 of 2004 (AQA) has shifted the approach towards air quality management from source-based control to receptor-based control. The basis of this approach will be control of all major sources, including mining, industrial, vehicles and domestic sources in terms of ambient air concentrations and will be the responsibility of Local Government where possible.

The Act makes provision for '*measures of the control of dust in specified places or areas, either in general or by specified machinery or in specified instances*'. More stringent standards can be established at the provincial and local levels. The control and management of emissions in 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 to have a significant* *detrimental effect on the environment, including human health'* and will be identified by the Minister of the Department of Environmental Affairs and Tourism (DEAT).

Minimum Requirements for the Waste Disposal by Landfill: Section 20 of the Environment Conservation Act, 1989 (Act 73 of 1989) stipulates that no person may dispose of waste unless under the authority of a permit issued by the Minister of Environmental Affairs and Tourism. Waste disposal sites are regulated by the Department of Environmental Affairs and Tourism (DEAT) by means of the *Minimum Requirements for the Waste Disposal by Landfill* (DWAF, 1998, Second Series). These guidelines initially drafted and administered by DWAF and now in their 3rd revision and administered by DEAT, deal with waste disposal by landfill, handling, classification and disposal of hazardous waste, and water monitoring at waste management facilities.

Eskom requires authorization from the National Department of Environmental Affairs and Tourism (DEAT) for the undertaking of the proposed project. In order to obtain authorization for this project, comprehensive, independent environmental studies must be undertaken in accordance with the EIA Regulations.

Depending on the landfill classification and size landfill requirements may include:

- Various types of landfill lining and capping systems
- Operational controls, e.g. daily cover of work surface with cover material
- Gas monitoring and management systems
- Restrictions on ambient methane concentrations.

Typical problems associated with landfill operations in South Africa which are associated with atmospheric emission potentials include: fires, inadequate daily cover practices and acceptance of hazardous waste types by general landfill operations. DEAT and the Gauteng Department of Agriculture, Conservation and Environment (GDACE) have started to initiate coordinated programmes to address such non-compliance issues. The evaluation checklist used by both DEAT and GDACE personnel for site inspection purposes are both based on the Minimum Requirements. It is also notable that the DEAT is currently in the process of revising the Minimum Requirements (Third Revision) document and that the revision is expected to deal more holistically with the management of atmospheric emissions and impacts of landfill operations.

National Waste Management Strategies and Action Plans (NWMS) (DEAT, 1999): This sets out numerous strategies and plans on how to manage and especially minimise or prevent waste. The first three components selected for implementation are health care waste, recycling and a waste information system. It also advocates a tiered approach to waste management with waste prevention, treatment and recycling being prioritised, has important implications for local landfill operations.

The Policy on Pollution Prevention, Waste Minimisation, Impact Management and Remediation: This policy outlines government's thinking in relation to pollution and waste management and encompasses all domestic and industrial sectors. *The White Paper on Integrated Pollution and Waste Management* (DME, 2000) advocates a shift from the focus on waste disposal and impact control (i.e. end-of-pipe) to integrated waste management and prevention as well as minimisation.

The Polokwane Declaration on Waste Management states that the government, business and civil society need to join in common efforts toward the accomplishment of the goal for reduction of waste generation and disposal by 50% and 25% respectively by 2012, and develop a plan for "zero waste" by 2022.

Buffer and Management Zone Projections

Buffer zones, or set back distances, represent separations between the registered landfill site boundary and any adjacent residential areas or sensitive developments. Such buffer zones are established to ensure that a landfill operation does not have an adverse impact on *quality of life and/or public health*. The establishment and maintenance of buffer zones is enforceable in terms of the Health Act, 1977 (Act 63 of 1977), which makes provision for measures necessary to prevent any nuisance, unhygienic or offensive condition that is harmful to health (DWAF, 1998a).

Although the width of the buffer zone is prescribed for communal and small landfills, such zones need to be independently defined for all other landfills based on the classification of the landfill and on site-specific factors which may influence the landfill's impact on the environment (DWAF, 1998a). The extent of gaseous emission is largely dependent on the composition of the waste accepted at the landfill and the waste treatment and management methods applied. The amount of vehicle activity at the site, and the control efficiency of fugitive dust abatement measures implemented determine the particulate emission rate. The atmospheric dispersion of gaseous and particulate emissions is a function of the macro- meso- and micro-scale ventilation potentials characterising the site.

It is recommended by the Department of Water Affairs and Forestry (1998a) that scientific investigations, which could include air dispersion modelling and health risk assessments, be undertaken to determine the width of buffer zones for large and hazardous waste landfills. Buffer zone widths are ultimately approved by the relevant government departments, on the basis of the investigations undertaken and following consultation with interested and affected parties (I&AP). In regards to the definition of a buffer zone for waste disposal site it is recommended that a distinction be made between:

5. BASELINE AIR QUALITY ASSESSMENT

5.1. Meteorological Overview

Limpopo Province experiences a wide range of both natural and anthropogenic sources of air pollution ranging from veld fires to industrial processes, agriculture, mining activities, power generation, paper and pulp processing, vehicle use and domestic use of fossil fuels. Different pollutants are associated with each of the above activities, ranging from volatile organic compounds and heavy metals to dusts and odours.

Ambient air quality in this region of South Africa is strongly influenced by regional atmospheric movements, together with local climatic and meteorological conditions. The most important of these atmospheric movement routes are the direct transport towards the Indian Ocean and the recirculation over the sub-continent (Scholes, 2002). It is these climatic conditions and circulation movements that are responsible for the distribution and dispersion of air pollutants within Limpopo and between neighbouring provinces and countries bordering South Africa.

Wind roses represent wind frequencies for the 16 cardinal wind directions. Wind frequencies are indicated by the length of the shaft when compared to the circles drawn to represent the frequency of occurrence. Wind speed classes are assigned to illustrate the frequencies of high and low wind for each wind vector. The frequency of calm periods, defined as periods for which wind speeds are below 1 m/s, is indicated at the bottom of the legend.

Annual, seasonal and diurnal wind roses generated based on measured data from the Lephalale Agriculture Research Council station are illustrated in Figure 2, 3 and Figure 4 respectively.

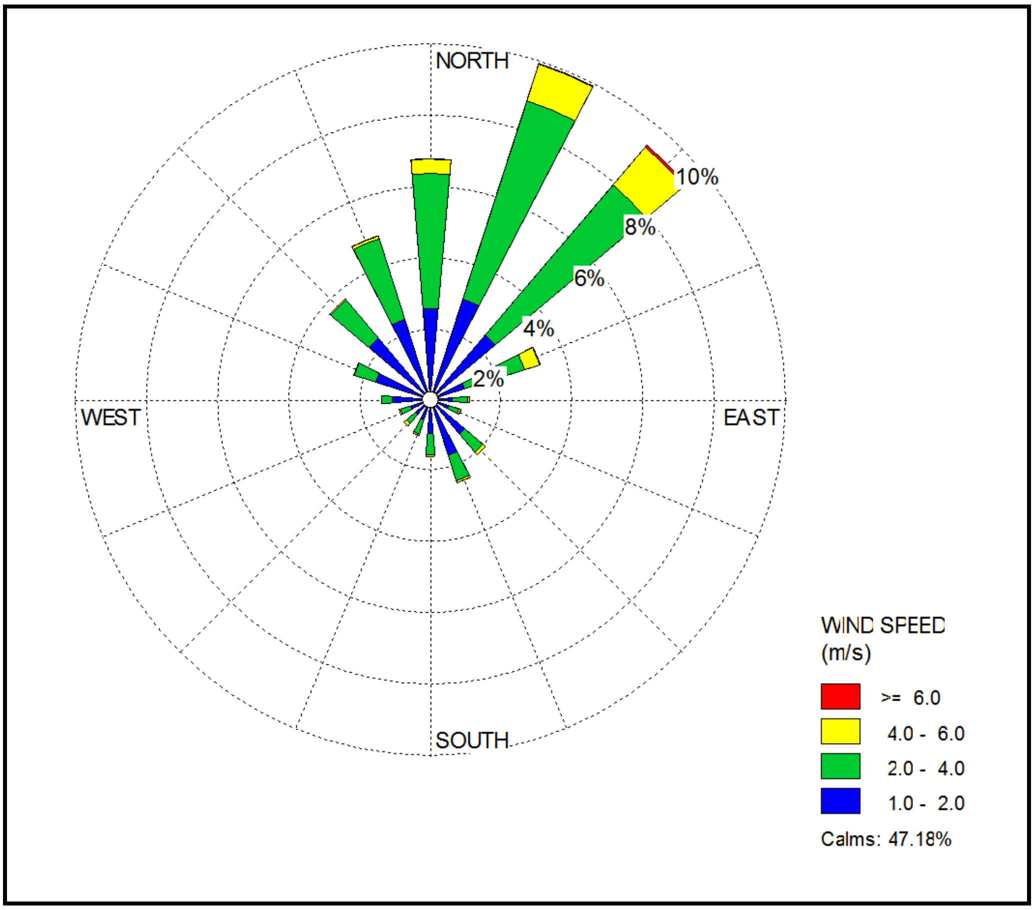

Figure 2: **Annual average wind rose for the Lephalale Agricultural Research Council Station for the period 2006 to 2008.**

The wind regime of the study area largely reflects the synoptic scale circulation. The flow field is dominated by north-easterly winds, as may be expected due to the continental high pressure, which persists over the region, in combination with the tropical easterly systems which influence the flow field during much of the year. Winds are infrequently experienced from the westerly and south-easterly sector for all two years of data analysed. The wind speeds are generally low throughout the period (2 - 4 m/s).

The predominant wind direction at Lephalale is north-north-east (10 %) with a lesser wind component from the north-east (9.5%) and north (6.5%) (Figure 2). Wind speeds are generally slow to moderate with no wind speeds exceeding 6 m/s being recorded. Wind speeds of less than 1 m/s, which are designated as calm, occur 47.18 % of the time.

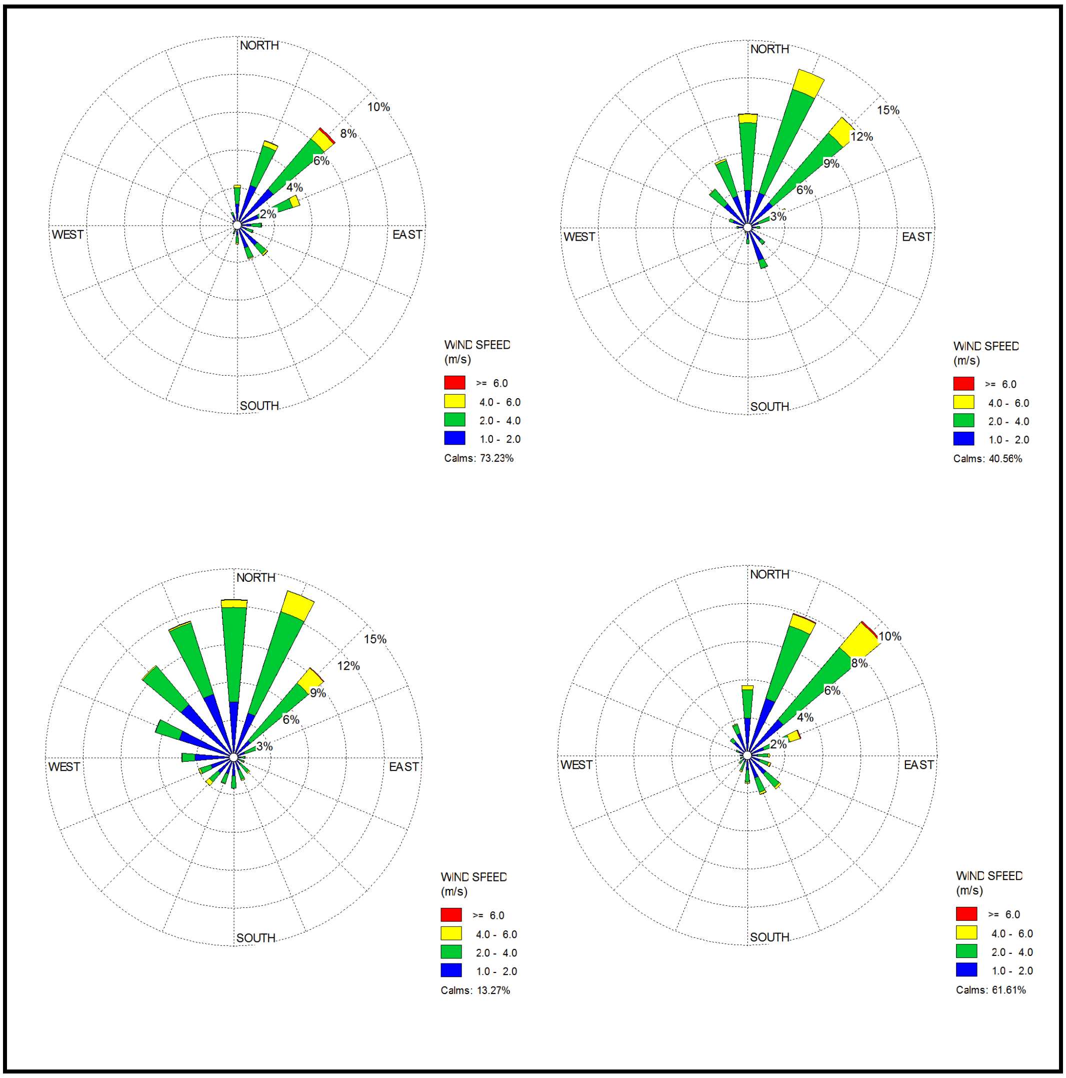

Figure 3: **Diurnal variation of winds at Lephalale between 00:00 – 06:00 (top left), 06:00 – 12:00 (top right), 12:00 – 18:00 (bottom left) and 18:00 – 24:00 (bottom right).**

A significant diurnal variation in wind direction is observed at Lephalale (Figure 3). Between 00:00 – 06:00, winds are predominantly from the north-east (7.5 %) with an additional component from the north-north-east (4.8 %). Between 06:00 – 12:00 winds are predominantly from the north-north-east (13 %), with additional components from the north-east (11.8 %) and north (9%). Winds remain from the north-north-east (14%) during the afternoon (12:00 – 18:00), with additional components from north (12.1 %) and north-north-west (11.6 %). During the evening (18:00 – 24:00), winds blow from the north-east (9%) and north-north-east (7.9 %). An increase in calm conditions is observed during the night (61.61%).

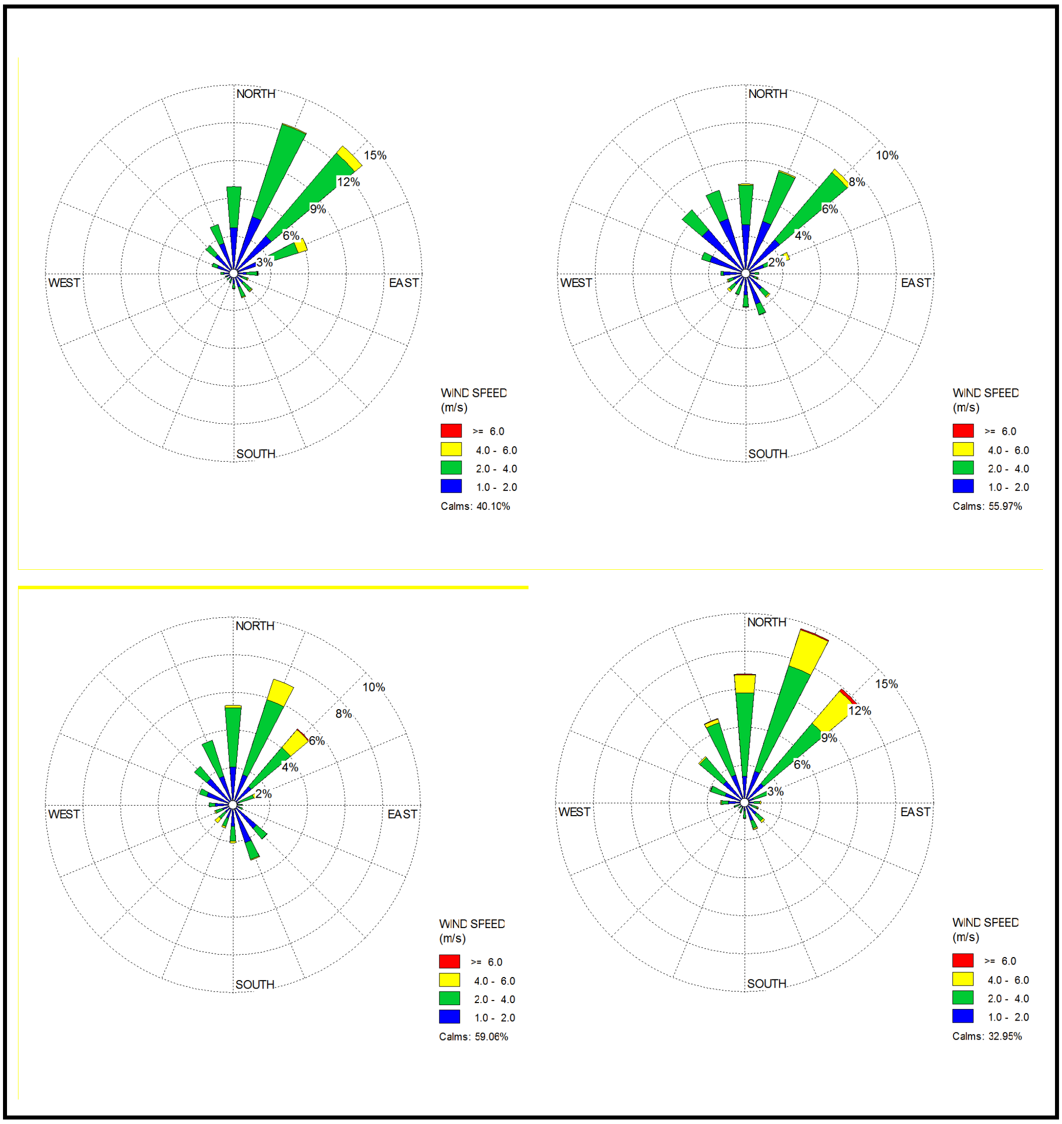

Figure 4: **Seasonal variation of winds in summer (DJF) (top left), autumn (MAM) (top right), winter (JJA) (bottom left) and spring (SON) (bottom right).**

A significant seasonal variation in wind direction is observed at Lephalale (Figure 3). During summer (DJF), winds are predominantly from the north-east (13 %) with an additional component from the north-north-east (12.2 %). Autumn (MAM) is also characterised by winds that are predominantly from the north-east (7 %), with additional components from the north (4.3 %), north-north-west (4.3%) and north-west (4.3%). Winds blow from the north-north-east (7.5%) during the winter season (JJA) with additional components from north (5.5 %) and north-east (5.8 %). During the Spring (SON) a similar pattern is observed with winds remaining from the north-north-east (14.8%), north-east (12 %) and north (10%) with a component from the north-north-west (7%). An increase in calm conditions is observed during the winter season (59.06%).

Atmospheric Stability and Mixing Depth

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. This layer is directly affected by the earth's surface, either through the retardation of flow due to the frictional drag of the Earth's surface, or as result of the heat and moisture exchanges that take place at the surface. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated absolutely stable layer. Radiative flux divergence during the night usually results in the establishment of ground-based inversions and the erosion of the mixing layer. Nighttimes are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds, hence less dilution potential.

The mixed layer ranges in depth from a few metres (i.e. stable or neutral layers) during night times to the base of the lowest-level elevated inversion during unstable, daytime conditions. Elevated inversions may occur for a variety of reasons and on some occasions as many as five may occur in the first 1000 m above the surface. The lowest-level elevated inversion is located at a mean height above ground of 1550 m during winter months with a 78 % frequency of occurrence. By contrast, the mean summer subsidence inversion occurs at 2600 m with a 40% frequency.

Atmospheric stability is frequently categorised into one of six stability classes. These are briefly described in Table 14.

Table 14: Atmospheric Stability Classes

A	Very Unstable	calm wind, clear skies, hot daytime conditions
B	Moderately Unstable	clear skies, daytime conditions
C	Unstable	moderate wind, slightly overcast daytime conditions
D	Neutral	high winds or cloudy days and nights
E	Stable	moderate wind, slightly overcast night-time conditions
F	Very Stable	low winds, clear skies, cold night-time conditions

The atmospheric boundary layer is normally unstable during the day as a result of the turbulence due to the sun's heating effect on the Earth's surface. The thickness of this mixing layer depends predominantly on the extent of surface heating, growing gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. The extent of thermal turbulence is enhanced on clear warm days with light winds. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

For elevated releases, the highest ground level concentrations would occur during unstable, daytime conditions. In contrast, the highest concentrations for ground level non-wind dependent releases would occur during weak wind speeds and stable (night-time) atmospheric conditions.

5.2. Existing Sources of Atmospheric Emissions in Lephalale Area

A comprehensive emissions inventory has not been completed for the region to date. The establishment of such an inventory is not within the scope of the current study. Instead, source types present in the area and the pollutants associated with such source types are noted with the aim of identifying pollutants that may be of importance in terms of cumulative impact potentials.

Existing sources of atmospheric emission which occur in the vicinity of the identified landfill sites include:

- Existing Matimba Power Station and its associated ash dump,
- Construction of Medupi power station
- Grootegeluk coal mining operations,
- Potential veld fires,
- Sewage works (Farm Nelsonskop),
- Wind blown dust from open areas and agricultural activities,
- Household fuel combustion,
- Vehicle exhaust releases and road dust entrainment along paved and unpaved roads in the area.
- Burning of the municipal waste dump
- Cross-boundary pollution from biomass burning, and industrial and power generation activities

The pollutants listed above are released directly by sources and are therefore termed 'primary pollutants'. 'Secondary pollutants' which form in the atmosphere as a result of chemical transformations and reactions between various compounds include: NO_2, various photochemical oxidants (e.g. ozone), hydrocarbon compounds, sulphuric acid, sulphates, nitric acid and nitrate aerosols.

Ambient air pollutant concentrations within the Lephalale region occur not only due to local source but also as a result of emissions from various remote sources. Regionally- transported air masses comprising well mixed concentrations of 'aged' (secondary) pollutants are known to represent a significant component of ambient fine particulate concentrations within the South African interior. Such air masses contain pollutants released from various remote sources including elevated releases from distant industrial operations and power generation facilities and large scale biomass burning in neighbouring countries. Typical pollutants which circulate within such regionally-transported polluted air masses include nitrates, ammonium nitrate and sulphates.

The quantification of background particulate concentration, which is of particular importance given the nature of the proposed development, is complicated due to the large number of sources of this pollutant. Sources of particulates also include a significant proportion of fugitive emissions from diffuse sources (e.g. vehicle-entrained dust from roadways, wind-blown dust from stockpiles and open areas, dust generated by materials handling) which are more difficult to quantify than are emissions from a point source.

5.3. Potential Sources of Atmospheric Emissions

Vehicle-Entrained Dust from Unpaved Roads

Vehicle-entrained dust emissions from unpaved roads represent a potentially important source of fugitive dust. Such sources have been found to account for the greatest portion of fugitive dust emissions from many local waste disposal operations. The force of the wheels of vehicles travelling on unpaved roadways causes the pulverisation of surface material. Particles are lifted and dropped from the rotating 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. The quantity of dust emissions from unpaved roads varies linearly with the volume of traffic.

Wind Erosion of Open Areas

Dust emissions due to the erosion of open storage piles and exposed areas occur when the threshold wind speed is exceeded (Cowherd *et al.*, 1988; EPA, 1995). 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 (Cowherd *et al.*, 1988).

Material Handling Operations

The quantity of dust being generated from material transfer operations, i.e. dumping of waste on landfill surface, depends on various climatic parameters, such as wind speed and precipitation, in addition to non-climatic parameters such as the nature and volume of the material handled. Fine particulates are most readily disaggregated and released to the atmosphere during the material transfer process, as a result of exposure to strong winds. High moisture contents decrease the potential for dust emission, since moisture promotes the aggregation and cementation of fines to the surfaces of larger particulates.

5.4. Site Selection

The proposed site screening exercise narrowed the geographical alternatives to the Farm Grootvallei 515 LQ (Figure 1). This farm is adjacent to the Medupi Power Station which is currently under construction. In addition to this, a site has similarly been identified within Matimba Power Station i.e. the Farm Grootestryd.

The site scoring criterion is based on the following conditions:

- The location of site in relation to residential areas or areas inhabited by people and animals;
- The location of the site in relation to wind direction to determine the direction of predicted dust fallout and odour;
- The location of site in relation to other activities that generate dust or any other form of air pollution;

- The distance from the location of the site to the Power Stations to determine the pollution footprint of vehicle tail-pipe emissions.

Site 1, Site 2 and Site 4 have been allocated a medium health risk due to the sites being located in areas that are not adjacent to residential areas. All of these sites are located to the north of the vacant Nooitgedacht farm which implies any dust fallout from the landfill will blow towards this farm because the wind is predominantly blowing from the east-north-east direction. The reason the sites were allocated the medium score is because of their distance from the power stations, and the implications this has for increased particulate emissions from the trucks (vehicle-tail-pipe emissions) that will transport the waste to the site. According to information gathered during the site visit, the trucks will be travelling to the site once a day. This has minimal implications for particulate emissions on a daily basis; however the entire lifespan of the landfill has been taken into account. This means that the potential cumulative impacts of the particulate emissions from the trucks have to be considered over the 50 years.

Site 3 has been allocated the score of low health risk due to its location in close proximity to power line servitude and the Power stations. The servitude ensures that there will not be any people or animals impacted by the dust fallout from the landfill. In addition, the site is a shorter distance from the Power stations as compared to Site 1, 2 and 4 respectively which entails the trucks travelling a shorter distance to deliver the waste and consequently there will be less particulate emissions from the trucks (vehicle tail-pipe). In addition, due to the predominant wind direction blowing from the east-north-east, there are no anticipated dust fallout impacts on people or animals. Site 5 has a high health risk due to it being located north-east of the Medupi Power Station. Due to the predominant wind direction being east-north-east, this could impact on the people working and living on the construction site and village as all dust fallout and odour from the landfill will be blown in that direction.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Mitigation Measures

The pollution from the proposed landfill largely depends on the manner in which the facility is managed, specifically with regard to the effective design, implementation and ongoing review of landfill gas and fugitive dust mitigation and monitoring systems.

Compliance with DWAF Minimum Requirements

The landfill operator must ensure compliance with DWAF *Minimum Requirements*. The following aspects are of particular significance in terms of avoiding air quality impacts:

- Daily covering of working face with adequate cover material
- Prevent acceptance of hazardous wastes
- Site access control to avoid illegal dumping
- Minimise odours from stored leachate, e.g. through storing leachate in tanks, treating leachate or applying odour controls to the leachate pond
- Prevention of all on-site fires
- Avoid residential settlement within the agreed buffer zone
- Maintenance of as small a working face as practical
- Immediate covering of malodorous wastes, e.g. putrescible general wastes and use of odour suppressants in extreme cases
- Progressive rehabilitation though application of final cover or capping, topsoiling and vegetation of completed cells.

Field studies indicate that emissions, as estimated using LandGEM, are a factor of 2 orders lower for temporary cover areas and more than 4 order lower for final cover areas (Bogner *et al.*, 2003). *This implies that by applying a temporary cover to filled cells and retaining a limited working face the proposed landfill operators could reduce air pollution with the buffer zone then being based on the area of exceedance of the PM10 reference level.*

Fugitive Dust Mitigation

Control measures which should be adopted during the operational period to reduce the potential for fugitive dust emissions are presented in Table 15. Control techniques for fugitive dust sources generally involve watering, chemical stabilisation and the reduction of surface wind speed through the use of wind breaks and source enclosures.

Table 15: Dust control measures implementable during the operational phase.

Activity	Recommended Control Measure(s)
Material handling (soil, waste)	Mass transfer reduction Drop height reduction Wind speed reduction through sheltering Wet suppression
Vehicle entrainment from unpaved roads	Wet suppression or chemical stabilisation of unpaved roads Reduction of unnecessary traffic Strict speed control Avoid track-on onto neighbouring paved roads
Vehicle entrainment from the paved access road	Regular sweeping or vacuuming of the paved access road to restrict the silt loading on the roadway
	Avoidance of track on from unpaved roads (e.g. wheel wash bays)
	Avoidance of spillage of waste onto road surface through ensuring waste haul trucks maintain the necessary freeboard
Open areas – wind erosion	Reduction of extent of open areas through careful planning and progressive vegetation Reduction of frequency of disturbance Compaction and stabilisation (chemical or vegetative) of disturbed soil Introduction of wind-breaks

The following recommendations are based on the baseline information from the desktop study, the site visit and Gondwana Environmental Solutions experience. Site 3 is recommended as the site to be assessed in the EIA. This Site has a low health risk due to its location which will not have any health impacts. In addition, it is closer to the Power stations than Sites 1, 2 and 4 respectively and will therefore have a reduced pollution footprint from the trucks (vehicle tailpipe emissions) transporting the waste. It must be noted that these recommendations are based on the desktop study and a site visit and that there needs to be a further study conducted to quantify the pollutant concentrations in the area. This can be achieved through a detailed air quality impact assessment with dispersion modelling so that the impact of the emissions may be quantified prior to the construction phase.

7. REFERENCES

Bogner J, Scheutz C, Chanton J, Blake D, Morcet M, Aran C and Kjeldsen (2003). Field Measurement of Non-methane Organic Compound Emissions from Landfill Cover Soils, Proceedings Sardinia 2003 International Solid and Hazardous Waste Symposium, published by CISA, University of Cagliari, Sardinia.

Chestnut, L.G et al., 1991: Pulmonary Function and Ambient Particulate Matter: Epidemiological Evidence from NHANES I, *Archives of Environmental Health*, 46, 135 – 144.

Cowherd C., Muleski G. E. and Kinsey J. S. (1998). *Control of Open Fugitive Dust Sources, EPA-450/3-88-008,* United States Environmental Protection Agency, Research Triangle Park, North Carolina.

Department of Environmental Affairs and Tourism (1994). Guideline for Scheduled Processes, Unpublished document issued by the Department of Environmental Affairs and Tourism, Pretoria.

EPA (1995). *Compilation of Air Pollution Emission Factors (AP-42), 6th Edition, Volume 1, as contained in the AirCHIEF (AIR Clearinghouse for Inventories and Emission Factors) CD-ROM (compact disk read only memory),* US Environmental Protection Agency, Research Triangle Park, North Carolina.

Fenger, J., 2002: Urban air quality, In J. Austin, P. Brimblecombe and W. Sturges (eds), *Air pollution science for the 21st century*, Elsevier, Oxford.

Ferguson, J.H., Downs, W.H and Pfost, D.L., 1999: Fugitive dust: Non-point sources, MU Extension, University of Missouri-Columbia, <muextension.missouri.edu/xplor

Harrison, R.M. and R.E. van Grieken, 1998: *Atmospheric Aerosols*. John Wiley: Great Britain.

Manahan, S.E., 1991: *Environmental Chemistry*, Lewis Publishers Inc, United States of America.

Maroni, M., Seifert, B., Lindvall, T., 1995: *Indoor air quality – a comprehensive reference book*, Elsevier, Amsterdam.

Pope, C. A III and Dockery, D.W., 1992: Acute Health Effects of PM10 Pollution on Symptomatic and Non- Symptomatic Children, *American Review of Respiratory Disease,* 145, 1123–1128.

Scholes, R., 2002: SAFARI 2000 – Nitrogen and Sulphur Deposition in Southern Africa. Final report to DACST. CSIR Report No. ENV-P-C 2002-020.

World Health Organization, WHO Air Quality Guidelines for Europe, 2nd edition, WHO Regional Office for Europe, 2000, Copenhagen, Denmark (WHO Regional Publications, European Series, No 91).