NKANGALA DISTRICT MUNICIPALITY

AIR QUALITY MANAGEMENT PLAN
DRAFT V2

30 April 2015

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ABBREVIATIONS

$\mu g/m^3$	micrograms per cubic metre
µm	micrometres
ACGIH	American Conference of Government Industrial Hygienists
AEI	Atmospheric Emissions Inventory
AEL	Atmospheric Emission Licence
AGL	Above ground level
ALRI	Acute lower respiratory infection
APPA	Atmospheric Pollution Prevention Act, No. 45 of 1965
APPA	Atmospheric Pollution Prevention Act
AQA	National Environmental Management Air Quality Act
AQM	Air Quality Management
AQMP	Air Quality Management Plan
AQMP	Air Quality Management Plan
AQO	Air Quality Officer
AQUA	Aqua (EOS PM-1) is a multi-national NASA scientific research satellite in orbit around the Earth, studying the precipitation, evaporation, and cycling of water. It is the second major component of the Earth Observing System (EOS) following on Terra (launched 1999)
ATSDR	American Toxic Substances and Disease Registry
BNM	Base Njengo Magogo
BTEX	Benzene, toluene, ethylbenzene and xylene
BVOCs	Biogenic Volatile Organic Compounds
C_6H_6	Benzene
CBD	Central Business District
CO	Carbon monoxide
CO	Carbon monoxide
CO_2	Carbon dioxide
COPD	Chronic obstructive pulmonary disease
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism (formerly)
DM	District Municipality
DoH	Department of Health
DoT	Department of Transport
EF	Emission Factor
EHP	Environmental Health Practitioner
EIP	Environmental Implementation Plan
EMP	Environmental Management Plan
EMS	Environmental Management System
EPA	Environmental Protection Agency
FoE	Frequency of Exccedence
FRIDGE	Fund for Research into Industrial Development Growth and Equity

g/kg	grams per kilogram
GDACE	Gauteng Department of Agriculture, Conservation and Environment
H2S	Hydrogen sulphide
Hg	Mercury
IAPs	Interested and Affected Parties
IDP	Integrated Development Plan
IQ	Intelligence quotient
KPI	Key Performance Indicator
LED	Local Economic Development
LFA	Logical Framework Approach
LM	Local municipality
LPG	Liquid Petroleum Gas
MDEDET	Mpumalanga Department of Agriculture and Land Affairs
MEC	Member of Executive Council
mg/Nm^3	milligrams per normal cubic metre
MHS	Municipal Health Services
MODIS	Moderate-resolution Imaging Spectroradiometer is a scientific instrument launched into Earth orbit by NASA in 1999 on board the Terra Satellite, and in 2002 on board the Aqua (EOS PM) Satellite MRL minimum risk level
MoU	Memorandum of Understanding
MRAD	Minor restricted activity days
MW	MegaWatt
NASA	US National Aeronautical and Space Administration
NEMAQA	National Environment Management Air Quality Act, No. 39 of 2004
NMHC	Non-methane hydrocarbons
NO	Nitrous oxide
NO_2	Nitrogen dioxide
NOX	Nitrogen oxides (NO and NO2)
NOx	Oxides of nitrogen
O_3	Ozone
ORTIA	OR Tambo International Airport
PAH	Polycyclic aromatic hydrocarbons
Pb	Lead
PCB	Polychlorinated biphenyls
PM	Particulate matter
PM	Particulate matter
PM10	Particulate matter of aerodynamic diameter less than 10 micrometres
PM2.5	Particulate matter of aerodynamic diameter less than 2.5 micrometres
ppb	parts per billion
ppm	parts per million
RAD	Restricted activity days
SADHS	South African Demographic and Health Survey
SANRAL	South African National Roads Agency

SAPIA	South African Petroleum Industry Association
SAWS	South African Weather Service
SLA	Service Level Agreement
SO2	Sulphur dioxide
SO_2	Sulphur dioxide
SOER	State of Environment Report
STP	Standard temperature and pressure, which is 25°C and 1 kilopascal
t/a	Tons per annum
TERRA	Terra (EOS AM-1) is a multi-national NASA scientific research satellite in a sun-synchronous orbit around the Earth. It is the flagship of the Earth Observing System (EOS).
TSP	Total suspended particulates
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compounds
VTAPA	Vaal Triangle Airshed Priority Area
WHO	World Health Organisation

1 INTRODUCTION

The Nkangala District Municipality (NDM) is situated in the Mpumalanga province. The NDM is made up of the following local municipalities: Victor Khanye, Dr J.S. Moroka, eMalahleni, eMakhazeni, Steve Tshwete, and Thembisile Hani. The NDM is home to significant industrial, electricity generation, mining and manufacturing activity.

1.1 BACKGROUND TO THE AIR QUALITY MANAGEMENT PLAN

The overarching constitutional right to an environment that is not harmful to health or well-being is captured in the objectives of the National Environmental Management: Air Quality Act (No. 39 of 2004) (hereinafter "the NEM:AQA"). Importantly, the promulgation of the NEM:AQA marked a turning point in the approach to air pollution control and governance in South Africa, introducing the philosophy of effects based Air Quality Management (AQM), in line with international policy developments and the environmental right, i.e. Section 24 of the Constitution (Act No. 108 of 1996).

Section 15(2) of the NEM:AQA requires each municipality to include an Air Quality Management Plans (AQMPs) in its integrated development plan contemplated in Chapter 5 of the Municipal Systems Act (No. 32 of 2000)

1.2 PURPOSE OF THE AIR QUALITY MANAGEMENT PLAN

The Nkangala District Municipality AQMP has been developed to comply with the requirements of the NEM:AQA, and in particular to provide guidance on Air Quality Management (AQM) in the municipality in order to achieve the objectives of the Act, namely:

a) to protect the environment by providing reasonable measures for:
   (i) the protection and enhancement of the quality of air in the Republic;
   (ii) the prevention of air pollution and ecological degradation; and
   (iii) securing ecologically sustainable development while promoting justifiable economic and social development; and
b) generally to give effect to section 24 (b) of the Constitution in order to enhance the quality of ambient air for the sake of securing an environment that is not harmful to the health and well-being of people.

This AQMP seeks to identify and reduce the negative impacts of emissions to atmosphere on human health and the environment and ultimately to assist the NDM in bringing air quality in the District Municipality into sustainable compliance with National air quality standards within agreed timeframes.

2 GENERAL DESCRIPTION OF THE NKANGALA DISTRICT MUNICIPALITY

The purpose of this chapter is describe those aspects of the NDM have a bearing on air quality and air quality management.

The Nkangala District Municipality (NDM) is one of three district municipalities in the Mpumalanga province. The NDM consists of the following local municipalities:

- Victor Khanye
- Dr J.S. Moroka
- eMalahleni
- eMakhazeni
- Steve Tshwete
- Thembisile Hani

The NDM is home to significant industrial, electricity generation, mining and manufacturing activity (Nkangala District Municipality, 2009). The NDM spans a significant area of the South African Highveld. The area encompassed by the NDM includes significant economic resources and activity, notably influenced by:

- The presence of significant coal resources of the Karoo super group.
- Proximity of significant metal ore mining from the Bushveld Igneous Complex.
- Other mineral deposits including refractory (flint) and small deposits of gold, tin, copper, lead, manganese, uranium, nickel, cobalt and silver [Gaffney's 2009].
- Agricultural activity.

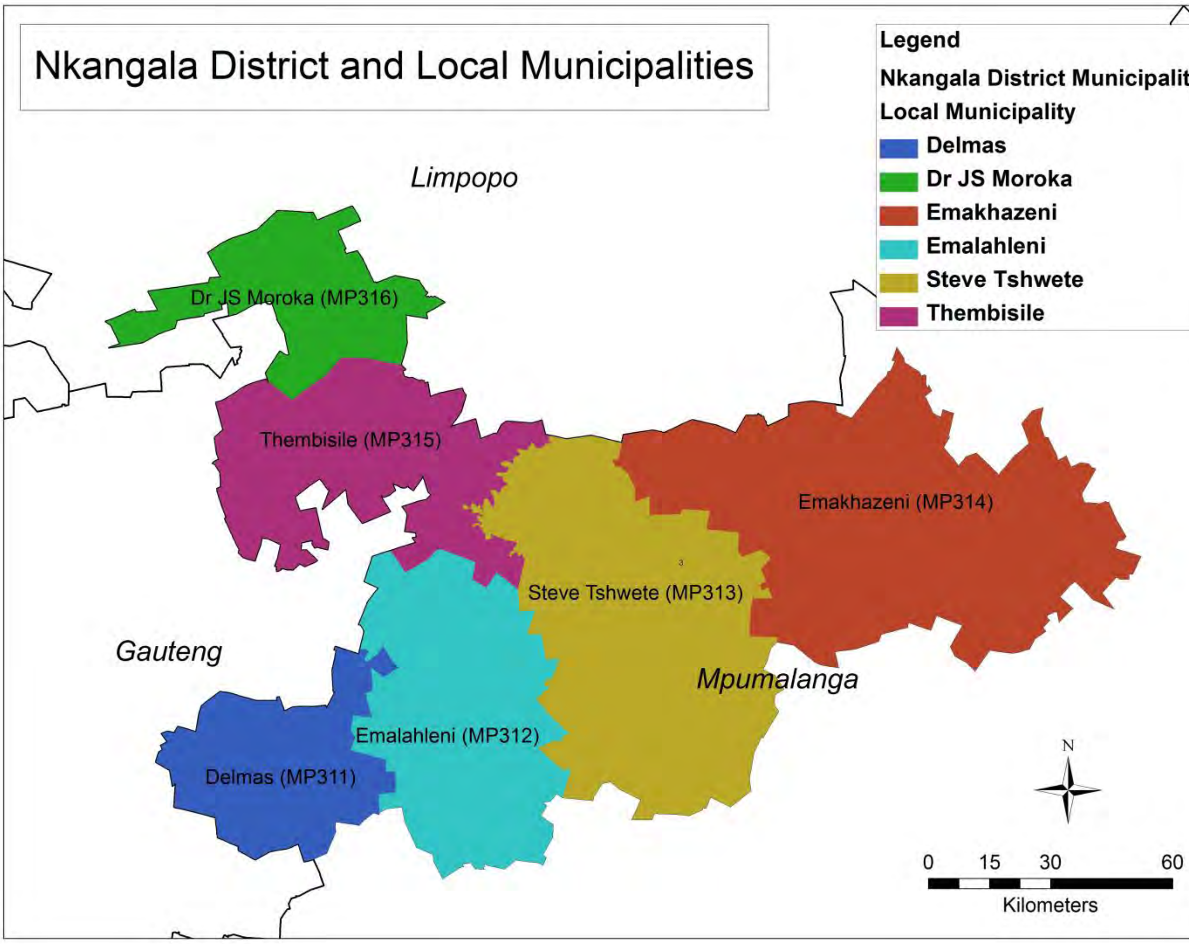


Figure 2-1: Nkangala District and Local municipalities within Mpumalanga Province

Geographical dimensions for all local municipalities within NDM are summarised below (Table 2-1).

Table 2-1: Geographical dimensions of Local Municipalities within Nkangala District Municipality

Local Municipality Name	Local Municipality Code	Area (km2)	Perimeter (km)
Victor Khanye	MP311	1567	237
eMalahleni	MP312	2678	308
Steve Tshwete	MP313	3979	396
eMakhazeni	MP314	4743	470
Thembisile Hani	MP315	2384	451
Dr J S Moroka	MP316	1416	265

Notably three of the NDM's local municipalities (Steve Tshwete, eMalahleni, and Victor Khanye) lie within the Highveld Priority Area as illustrated in Figure 2-2. The Highveld area in South Africa is associated with poor air quality. Elevated concentrations of criteria pollutants occur due to the high density of source emitters including both industrial and non-industrial source operations. As a result, the Highveld Priority Area (HPA) was declared a priority area by the Minister on 23 November 2007 under NEMAQA. HPA designation has been introduced as part of Air Quality Management in South Africa to direct resources into areas of poor air quality.

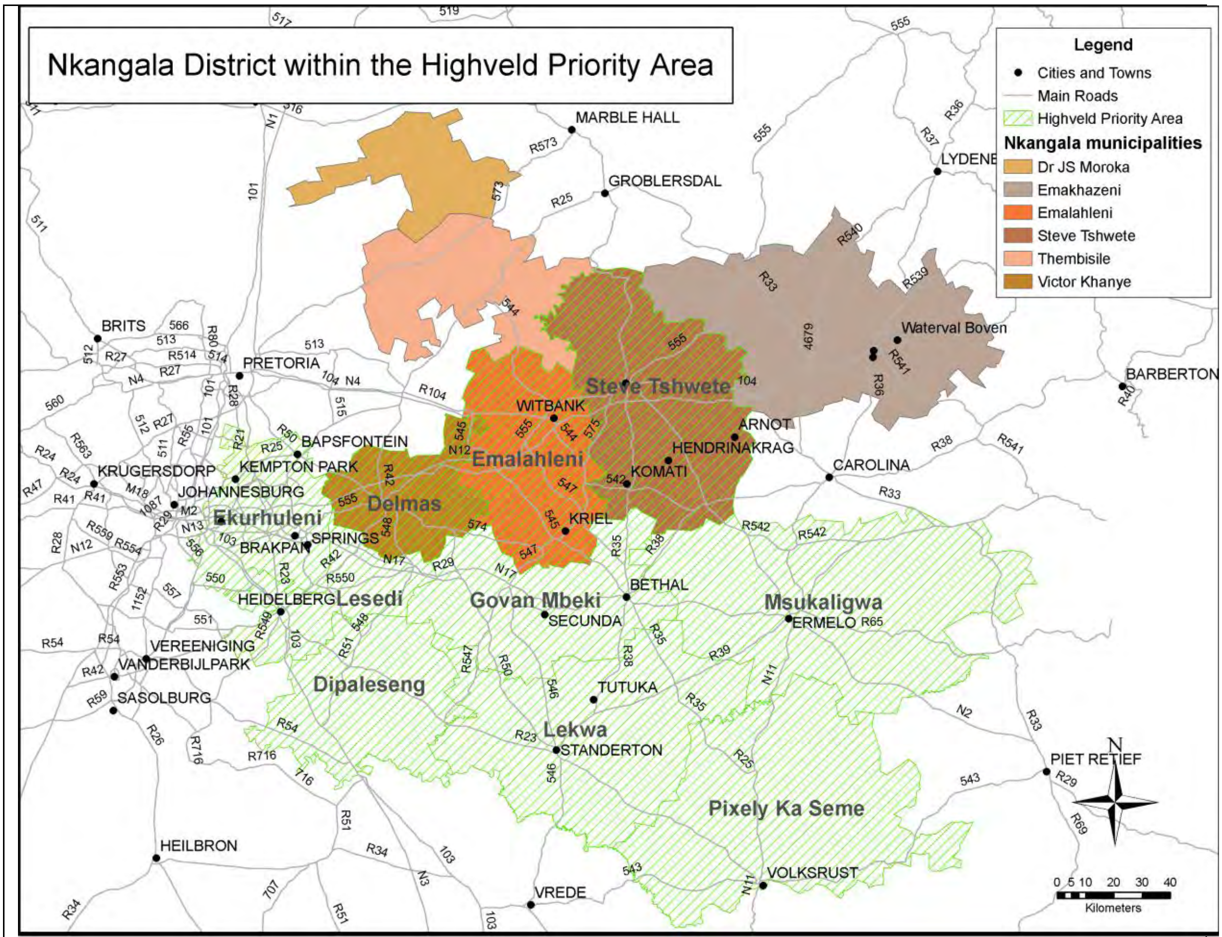


Figure 2-2: Nkangala District Municipality (NDM) and the Highveld Priority Area

2.1 TOPOGRAPHY AND LAND USE

The Nkangala District Municipality forms part of South Africa's elevated inland plateau. The topography of the NDM is relatively flat or gently undulating. It slopes gently from elevations of about 2300 m in the northeast, to 1500 m in the central parts and to a little more than 800 m in the south (**Figure 2-3**).

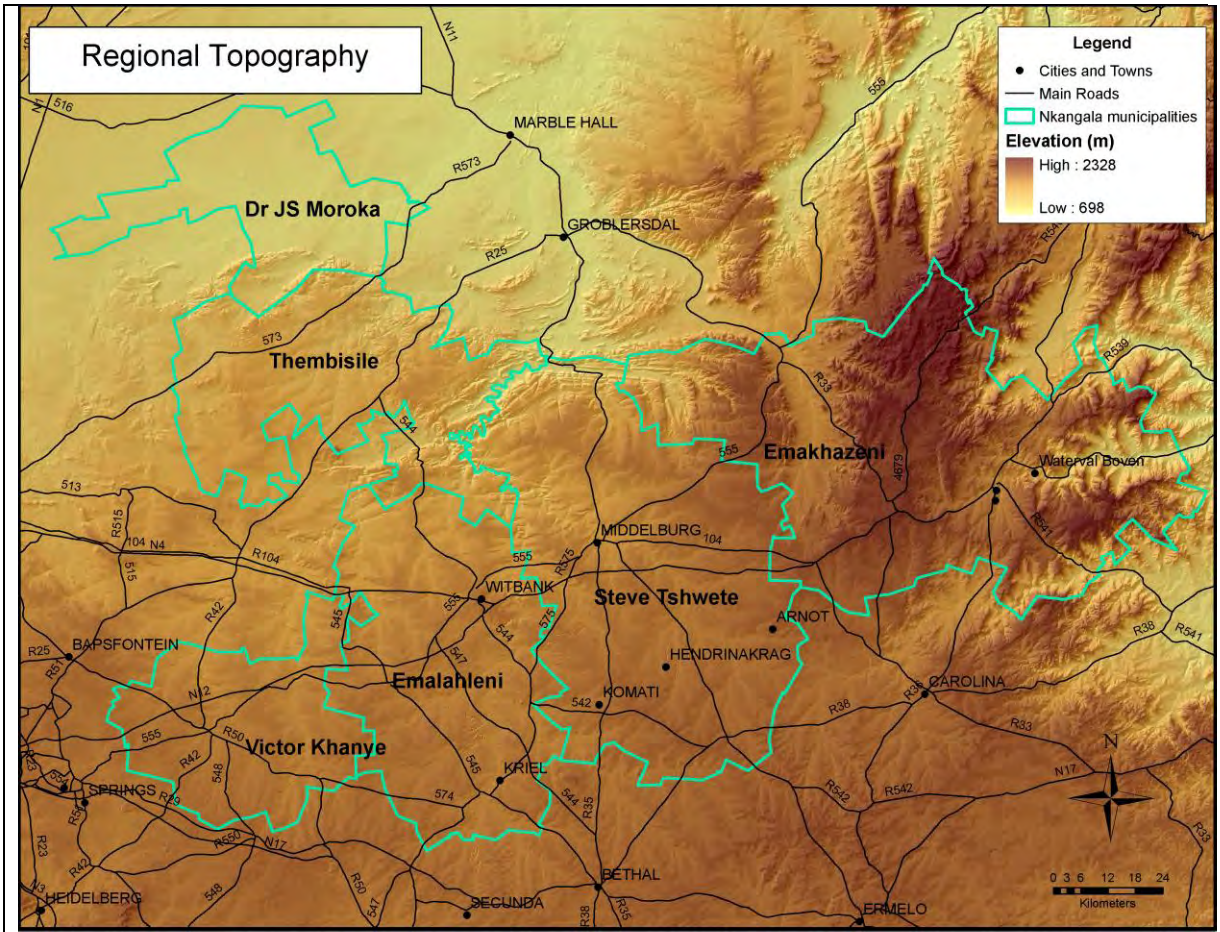


Figure 2-3: Schematic of the topography of the NDM

The NDM is covered by natural land with cultivation occurring throughout the area (**Error! Reference source not found.**), constituting 54.1 % and 29.8 % respectively of the total land cover. Urban and built-up areas occur within the central, south-western and northern portion and constitute 3.3 % of the total land cover.

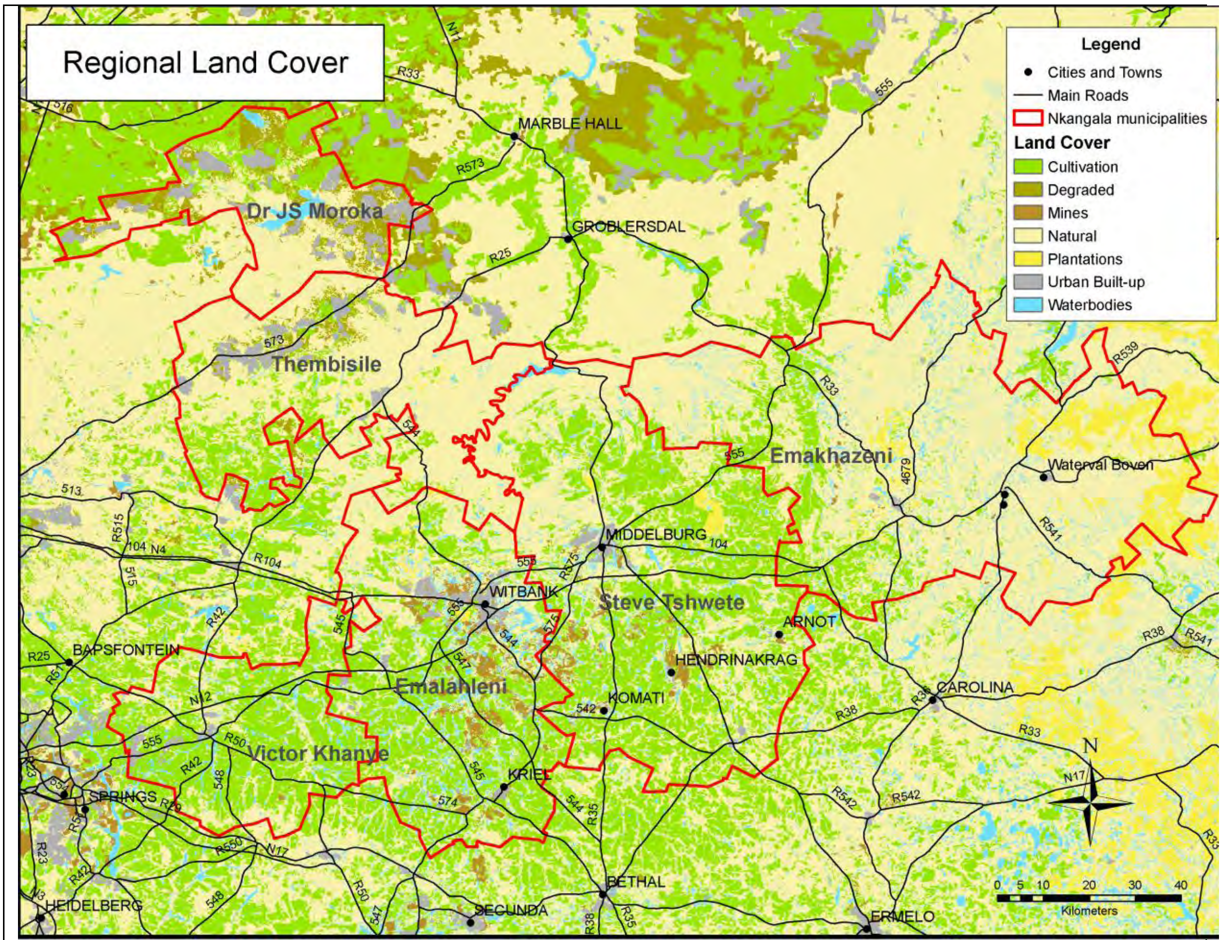


Figure 2-4: Land use distribution of the NDM

2.2 POPULATION DISTRIBUTION

The total population of the NDM is an estimated 1 181 816 individuals according to Census 2011 data (StatsSA, 2011). KwaGuqa hosts the largest population of individuals (10.5%), with the remainder of the town of eMalahleni hosting 7.3%, Mhluzi hosting 6%, Middelburg hosting 5.6%, Tweefontein hosting 5.3% and the balance (65 %) distributed across the remainder of the municipalities (Figure 2-5).

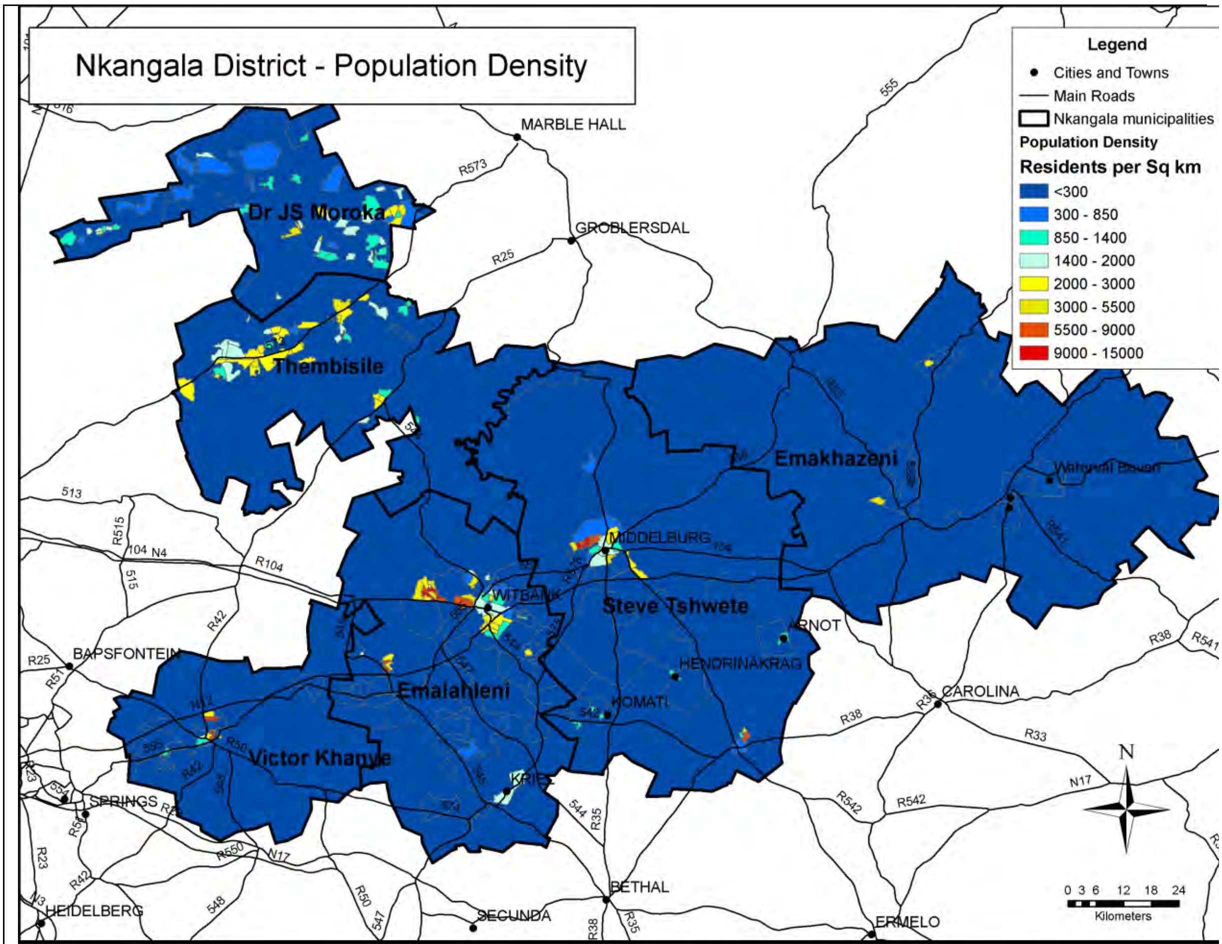


Figure 2-5: Population distribution across the NDM

2.3 DISPERSION POTENTIAL

1.1.1 CLIMATOLOGY AND METEOROLOGY

The climate and macro-scale air pollution dispersion potential of the region is largely influenced by atmospheric conditions associated with the semi-permanent anticyclonic continental high-pressure cell located over the interior. Light variable winds occur throughout the year over the region because of the anticyclone subsidence associated with the continental high pressure.

The tropical easterlies, and the occurrence of easterly waves and lows, affect the region throughout the year resulting in airflow with a north easterly to north westerly component, but their influence is generally weaker during winter months. During summer months, the anticyclonic belt weakens and shifts southwards, allowing the tropical easterly flow to resume its influence over the region. This latitudinal shift governs the climatology of the area by influencing the amount of solar radiation received, which influences heat transfer to the atmosphere from the earth's surface and as a result effects convection, turbulence and mixing height of the boundary layer.

In summer unstable conditions result in mixing of air and rapid dispersion of pollutants in the atmosphere. Westerly waves and lows are largely responsible for the southerly wind component, which occurs over the interior. The winter months are characterized by atmospheric stability caused by a persistent high-pressure system. This high-pressure system results in subsidence, causing clear skies and pronounced temperature inversions or stable layers at night. The passing of cold fronts may break these inversions periodically.

The temperature inversion layers and stable layers keep the air pollutants trapped in the lower atmosphere, causing increasingly poor air quality. These stable layers, which occur because of the anticyclone subsidence, suppress the diffusion and vertical dispersion of pollutants by reducing the depth of the mixing layer. Such stable layers play an important role in controlling the long-range transport and recirculation of pollution. The lowest elevated stable layers occur at approximately the 700 NLM level (3 km above sea level) (Cosijn, 1995). Conditions in the winter months are highly unfavourable for the dispersion of atmospheric pollutants (Preston-Whyte and Tyson, 1988).

2.3.1.1 Rainfall and temperature

Rainfall occurs predominantly in summer and autumn while the least amount of rain falls in the months of winter and spring. Summer temperatures are typically warmer, resulting in convection, with water vapour evaporation, and condensation completing the atmospheric water cycle processes. Precipitation in the form of showers and thundershowers are the products of condensation of atmospheric water vapour.

The following graphs illustrate the average rainfall versus temperature experienced at Middelburg (**Figure 2-6**) and Witbank (**Figure 2-7**).

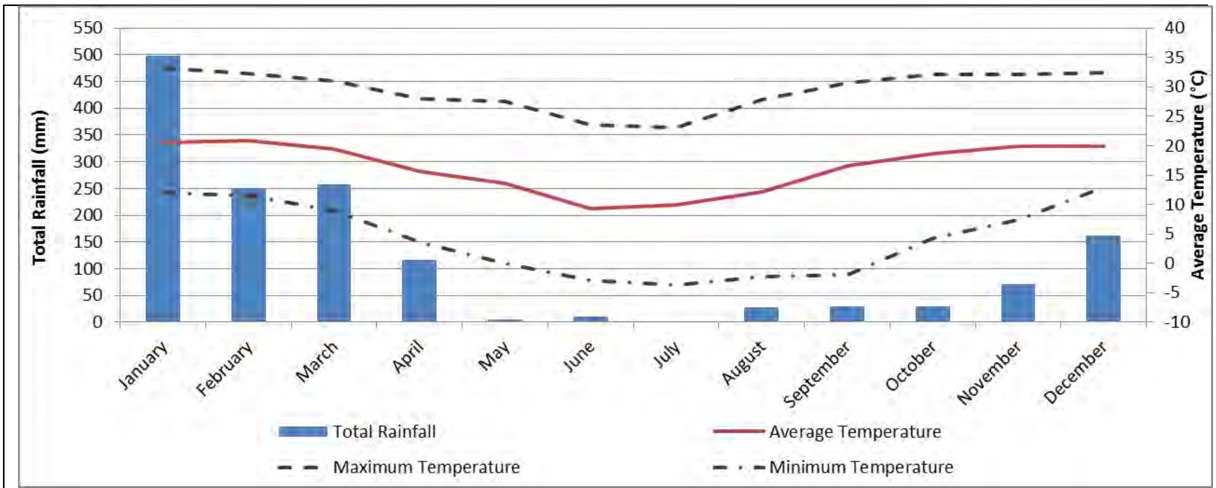


Figure 2-6: Rainfall vs Temperature observed data for Middelburg Meteorological Station for 2011 - 2013

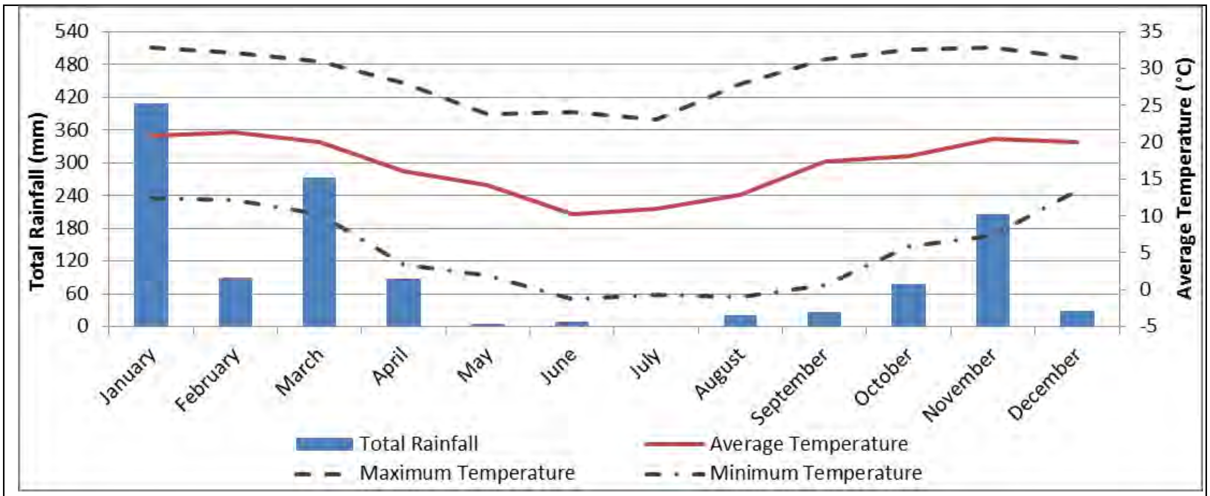


Figure 2-7: Rainfall vs Temperature observed data for Witbank Meteorological Station for 2011 - 2013

2.3.1.2 Surface and near-surface winds

Wind speed and wind direction are monitored by the South African Weather Services (SAWS) who maintain a network of stations. The reliable meteorological stations are located at Hendrina, Komati, Middelburg, Witbank, Elandsfontein and Phola (**Figure 2-8**).

Observed wind direction and wind speed at these stations are shown as wind roses in **Figure 2-9** and **Figure 2-10**. The length of the colour-coded line is proportional to the frequency of occurrence of wind blowing from that direction. Wind speed classes are also colour coded and the length of each class/category is proportional to the frequency of occurrence of wind speed.

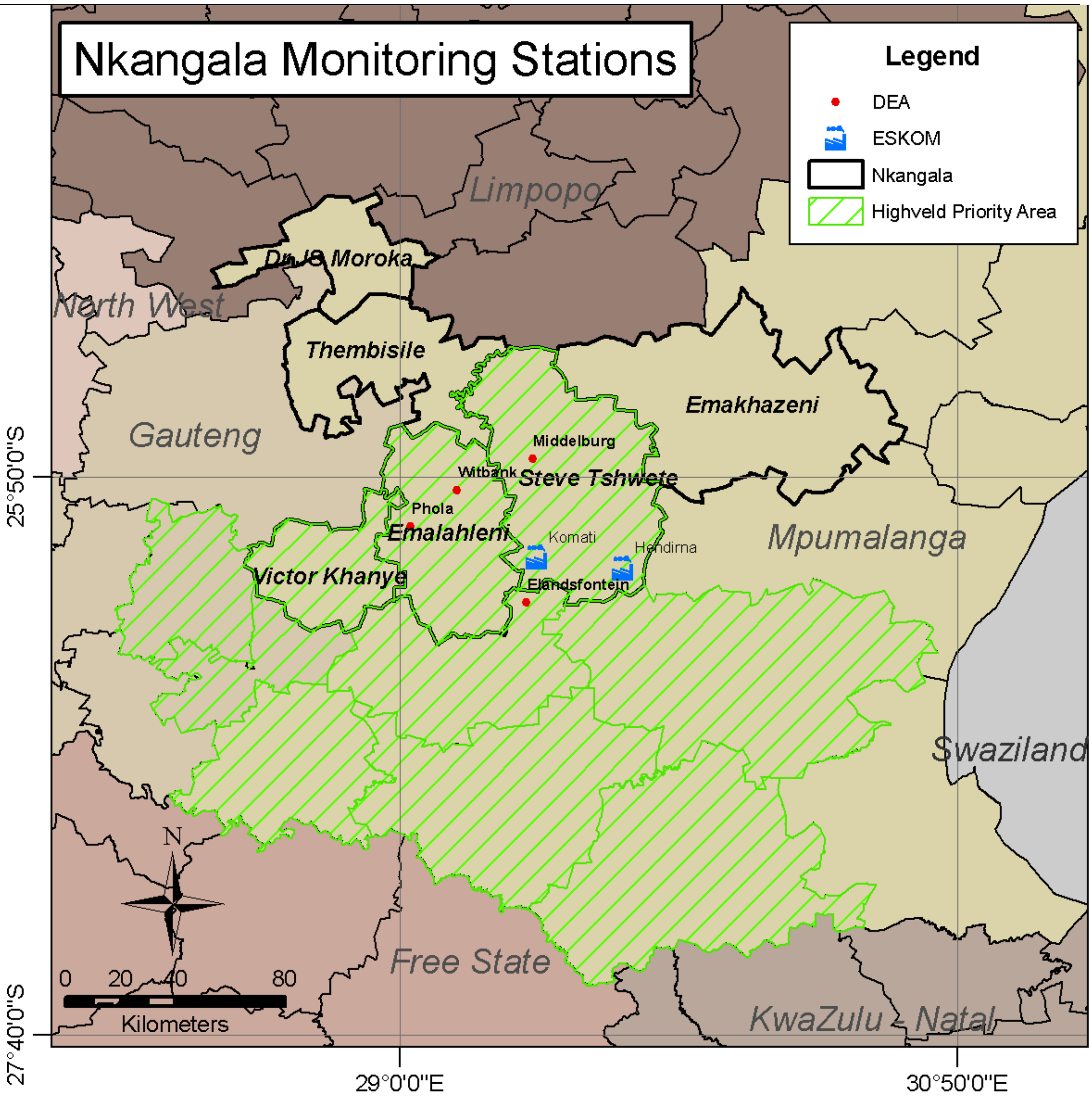


Figure 2-8: Location of meteorological stations in the NDM

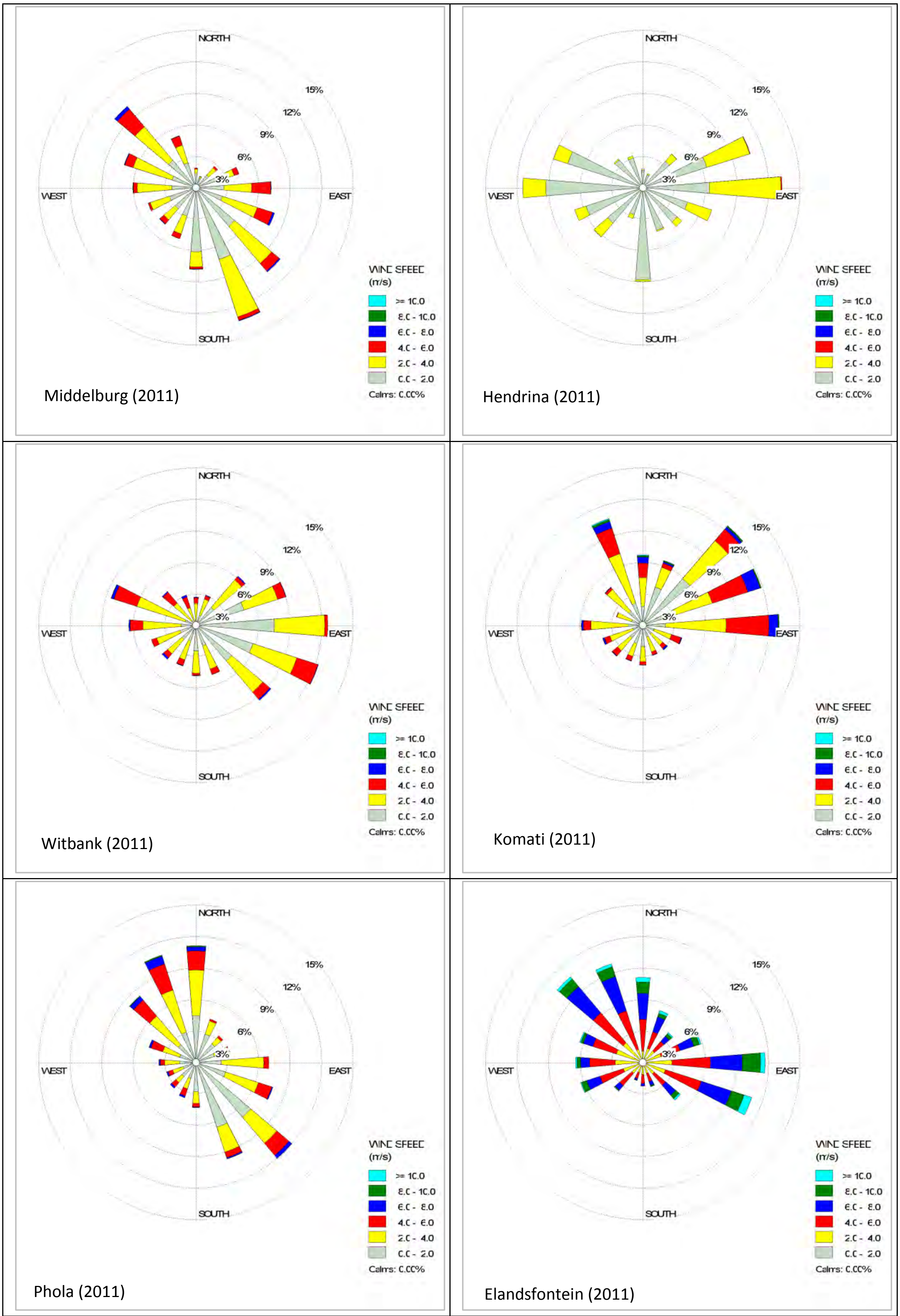


Figure 2-9: Annual wind roses at the monitoring stations in the NDM for the year 2011

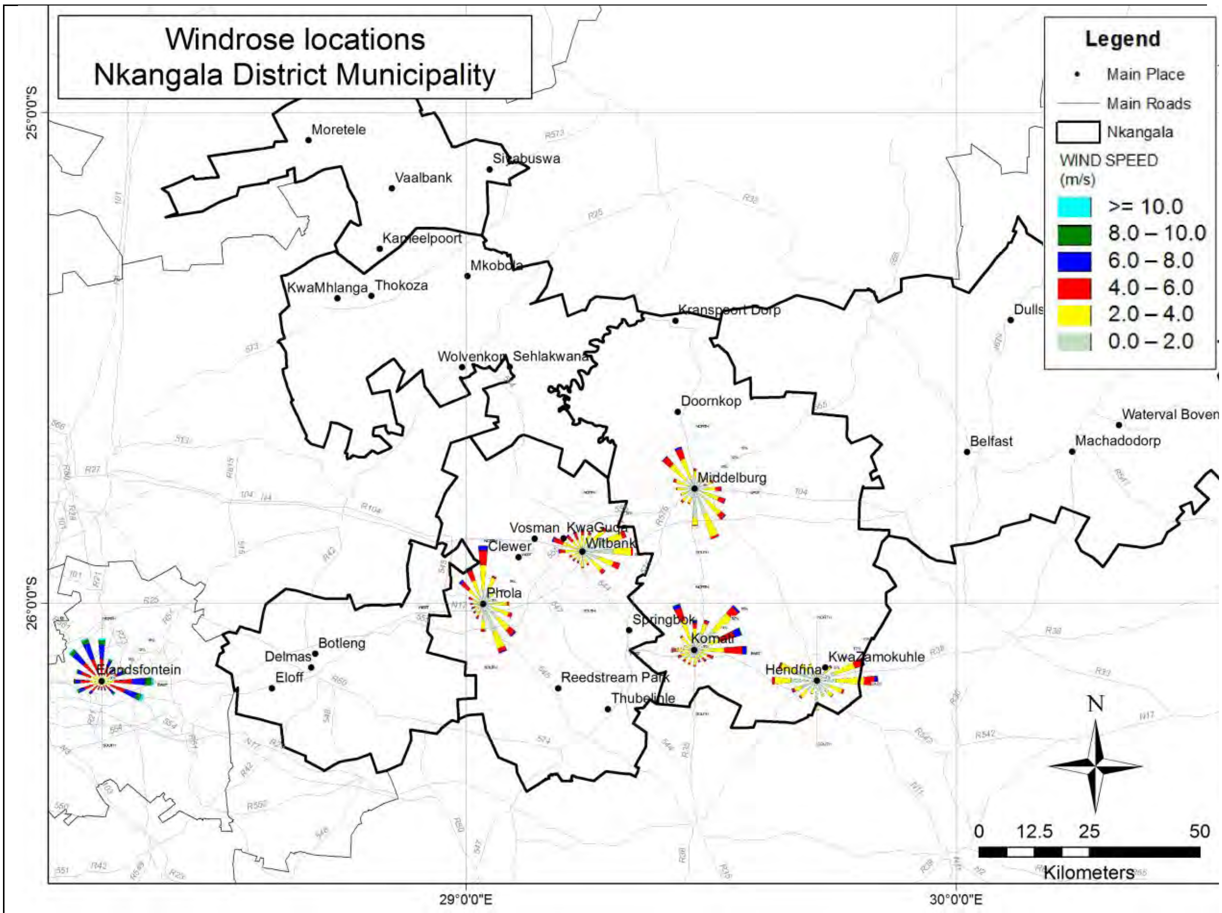


Figure 2-10: Annual wind roses at the monitoring stations in the NDM for the year 2011

2.3.2 DISPERION POTENTIAL

Investigation of the dispersion potential of the Highveld region identified the formation of a low-level wind maximum at night, known as a low-level jet (LLJ), under highly stable conditions and ranging in speed from 5 $m.s^{-1}$ to 15.5 $m.s^{-1}$ (von Gogh *et al*, 1982; Held, 1985; Jury and Tosen, 1987; Tosen and Jury, 1988). The south-north and east-west cross-sectional extent of the LLJ observed on 26 and 27 June 1986 in the vertical and horizontal is illustrated in **Figure 2-11**. Held *et al* (1990) suggest that the northern edge of the LLJ coincides with the topographical ridge just north of Middelburg and that it extends beyond the Vaal River basin to the south and to the escarpment in the east. Held and Hong (1989) showed the occurrence of a LLJ over the north-eastern Free State, implying that the regional-scale LLJ extends beyond the western edge of the Highveld region.

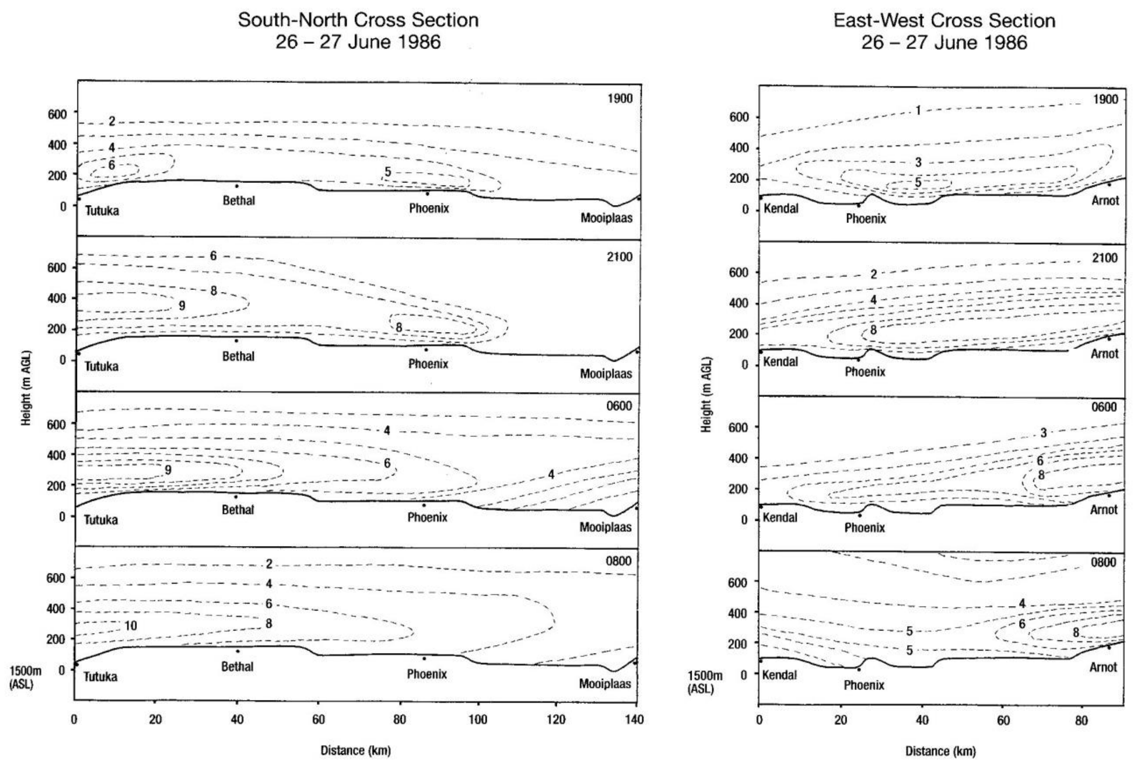


Figure 2-11: The south-north and east-west cross-sectional extent of the LLJ observed on 26 and 27 June 1986 in the horizontal and vertical with wind speeds in m/s (Held et al, 1990)

2.3.3 ATMOSPHERIC STABILITY

The high frequency of anticyclonic circulation and associated subsidence in the upper air reaches a maximum in winter. The subsidence is conducive to the formation of elevated temperature inversions throughout the year with a frequency of 60% and winter base height of about 1300 and 2600 m above ground level (AGL) in summer (van Gogh *et al*, 1986).

Stable and clear conditions are ideal for the formation of surface temperature inversions at night. Tyson *et al* (1976) showed the winter inversions in the Highveld region to vary in strength from 5 ^{0}C to 7 ^{0}C and in depth from 300 to 500 m AGL. Later, Pretorius *et al* (1986) and Tosen and Pearse (1987) showed the inversion to occur between 80 and 90% of winter nights, varying in strength from 3 ^{0}C to 11 ^{0}C and from 100 m to 400 m in depth. Inversions of more than 10 ^{0}C occur on more than 25% of winter nights. In summer, the surface inversions are weaker and seldom exceed 2 ^{0}C in strength (Pretorius *et al*, 1986). The maximum midday mixing depths vary between 1000 m and 2000 m AGL in winter and may exceed 2500 m in summer (Diab, 1975; Tosen and Pearse, 1987).

The presence of subsidence induced semi-permanent absolutely-stable layers at approximately 800 Highveld (about 350 m AGL) and 500 Highveld (about 3500 m AGL) were shown to extend over the southern African sub-continent (Cosijn and Tyson, 1996; Freiman and Tyson, 2000). These stable layers (Garstang *et al*, 1995) control the vertical transport of aerosols between the surface and the tropopause. Aerosols typically accumulate below the base of the respective layers and in turn, the layers promote transport of the aerosols at their respective levels. Garstang *et al* (1996) and

Tyson *et al* (1996) showed trajectories to pass through different height levels, but become trapped between absolutely-stable layers.

2.3.3.1 Atmospheric transport in and out of the Highveld Region

Considerable research effort has focused on the meteorological circulation responsible for the accumulation and recirculation of pollutants in the Highveld region. Scheifinger (1993) developed a synoptic classification describing the relationship between air mass movement and surface sulphate concentrations. Westerly ventilation of the Highveld region occurs mostly during winter with the passage of westerly waves across or south of the subcontinent. The westerly airflow over the Highveld region is warm, dry and relatively free of pollutants as it originates from a source-free area (Scheifinger, 1993). The easterly ventilation originates with a strongly ridging (or budding) anticyclone up the east coast, resulting in an onshore flow and easterly winds over the Highveld. Held *et al* (1994) showed the ridging anticyclone to result in a recirculation path that loops to the north in winter (**Figure 2-12**) and to the east and south in summer due to the seasonal north-south shift of the anticyclonic high-pressure belt.

Freiman and Piketh (2003) examined large-scale recirculation of air into and out of the Highveld region and the frequency of transport from the Highveld region that crosses into countries bordering South Africa. Four major transport pathways exist to the Highveld region in the lower troposphere. The most frequently occurring transport mode is from the Atlantic Ocean, occurring 43% of times. Transport from the Indian Ocean (26%) together with transport from the African continent (25%), account for half of the transport to the Highveld region. Regional-scale advection exclusively over southern Africa accounts for less than 10% of the transport. Air from the south and central Atlantic reaching the Highveld region is likely to be free of industrial pollutants, while African transport may carry pollutants from central and southern Africa, particularly industrial pollutants from the Zambian copper-belt, from biomass burning in winter, and Aeolian dust.

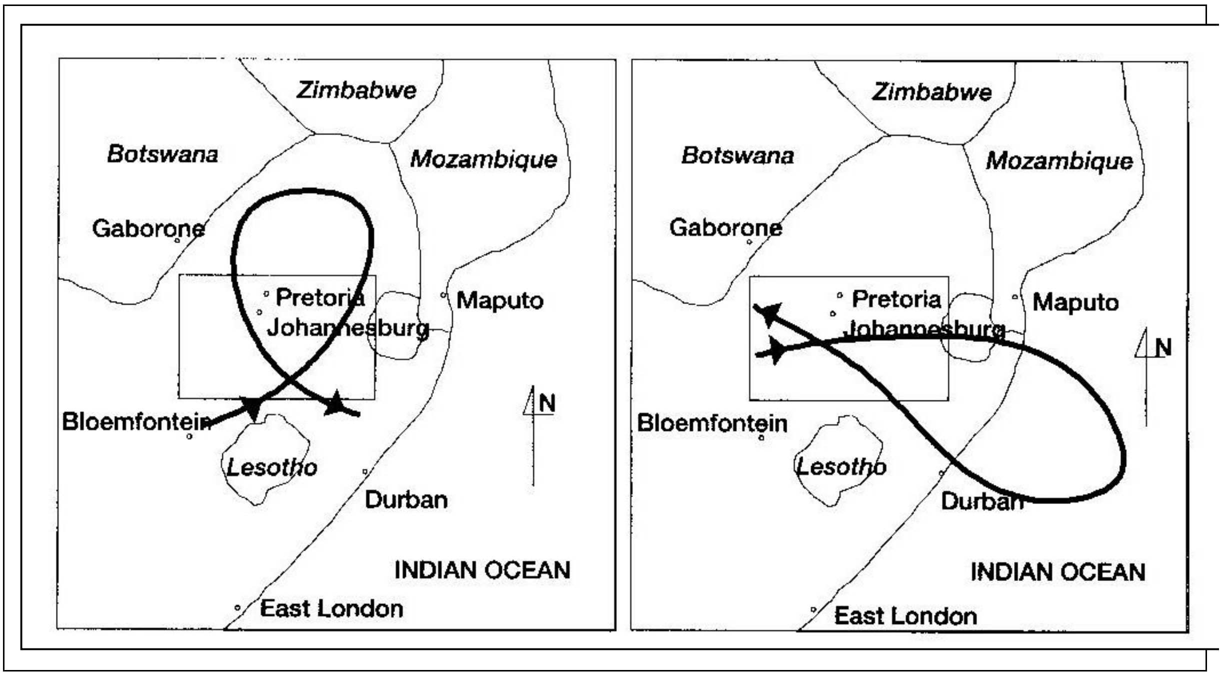


Figure 2-12: Characteristic wind paths during strong anticyclonic ridging in from May to June (left) and August to April (right) after Held et al (1994)

Significant seasonal variation exists in the transport of air to the Highveld region as shown in Table 2-2. Noteworthy is the high percentage of Indian Ocean transport (51%) in summer and by contrast, the high percentage of Atlantic transport (51%) in winter. The sub-continental scale recirculation does not vary much with season.

Table 2-2: Seasonal variation of transport types advecting air to the Highveld region at 850 to 700 Highveld, expressed as a percentage (Freiman and Piketh, 2003)

SEASON	FLOW			
	Atlantic Ocean	Indian Ocean	African Continent	Recirculation
Summer	34	54	7	5
Autumn	46	16	27	11
Winter	51	10	33	6
Spring	39	26	30	5

Freiman and Piketh (2003) identified two main transport modes out of the Highveld region, direct and re-circulated transport (Table 2-3). In the direct transport mode (45%), material is transported out of the Highveld region with little decay in a westerly (to the Indian Ocean), easterly (to the Atlantic Ocean), northerly (to the south Indian Ocean, or southerly (equatorial Africa) transport mode. The second mode is re-circulated transportation where material re-circulates over the subcontinent towards the point of its origin, on a regional or sub-continental scale (33%). The overall re-circulating time ranges from 2 to 9 days, depending on the scale of the re-circulation.

Table 2-3: Variation of transport types advecting air from the Highveld region at 850 to 700 Highveld, expressed as a percentage, enclosing approximately 95% of trajectories studied (Freiman and Piketh, 2003)

	Direct Transport				Re-circulated Transport
	Atlantic Ocean	Central Indian Ocean	South Indian Ocean	African Continent	
Summer	21	27	9	7	30
Winter	7	49	3	9	36

Approximately 41% of all air transported from the Highveld region affects countries bordering South Africa through either direct or re-circulated transport (Freiman and Piketh, 2003). Transport to Mozambique occurs more than 35% of the time, and more than 30% of the time to Botswana. Transport to Swaziland, Namibia and Zimbabwe is between 15% and 23% with less to other southern African countries (**Figure 2-13**).

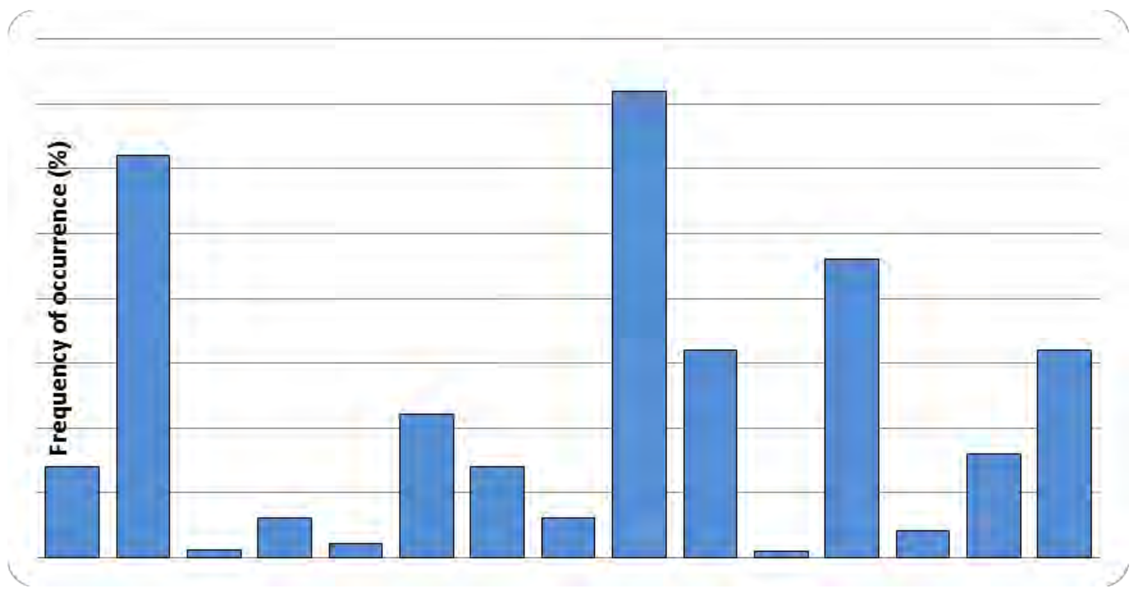


Figure 2-13: Percentage frequency with which the borders of each country are crossed by trajectories originating from the Highveld region for 1990-1994 (Freiman and Piketh, 2003)

2.3.3.2 Meteorology and air quality

The predominant anticyclonic circulation over the Highveld, particularly in winter, results in light winds, clear skies and the development of surface temperature inversions at night that persist well into the morning. The mechanisms to disperse pollutants that are released at or near ground level into this stable atmosphere are typically weak. Pollutants tend therefore to accumulate near their source or to travel under the light near-surface drainage winds. Relatively high ambient concentrations may occur especially at night and in the morning when the surface inversions are strongest. This meteorology is particularly relevant to low-level industrial stacks, domestic fuel burning, motor vehicles and burning coalmines and discard coal dumps.

During the day, surface warming induces the break-up of the surface inversion and promotes convection, which enhances the dispersion the night-time pollution build-up. Convection, on the other hand, may bring emissions from taller stacks down to ground level, so-called fumigation, that result in episodes of high ambient pollutant concentrations.

Immediately above the surface inversion, the LLJ, a strong nocturnal wind system, provides an effective mechanism to transport pollutants from taller stacks away from their source. The LLJ occurs over the much of the Highveld at night and is stronger and more persistent in winter.

Westerly flow into the Highveld is associated with the introduction of clean, mostly maritime, air. Hence, ambient air quality improves with the passage of wintertime westerly waves over the Highveld and ambient pollutant concentrations decrease. Convective summer showers and thundershowers wash pollutants out of the atmosphere on a relatively local scale, while widespread convective rain activity can reduce ambient pollutant concentrations on a larger scale.

Pollutants released in the Highveld do not only affect the Highveld. Easterly airflow associated with a ridging Indian Ocean Anticyclone results in recirculation over the subcontinent. Pollutants emitted in the Highveld are recirculated at different spatial and temporal scales depending on the strength of the ridging anticyclone. The recirculation may be limited to the Highveld for a few days only or for a number of days resulting in increases in ambient pollutant concentrations. Recirculation on larger spatial scales may transport pollutants emitted in the Highveld well beyond its boundaries and into neighbouring municipalities and even across international borders.

3 AMBIENT AIR QUALITY

3.1 INTRODUCTION

The state of ambient air quality in the NDM is described using ambient monitoring data, dispersion modelling and the findings of research projects on the Highveld. The monitoring stations provide data at specific sites and while their spatial representativeness is limited, they are accredited and the ambient concentrations are considered accurate. By contrast, the modelled ambient concentrations cover the full extent of the NDM, they are estimates, and their representativeness is determined by the model parameterisation, but mostly by the accuracy and completeness of the respective meteorological and emission input data. An overview of ambient air quality monitoring on the NDM and the dispersion modelling are presented.

Three of the local municipalities in the NDM fall within the Highveld Priority Area (Victor Khanye, eMalahleni and Steve Tshwete). The HPA is associated with poor air quality, and elevated concentrations of criteria pollutants. The poor air quality results from a combination of emissions from different industrial sectors, residential fuel burning, motor vehicle emissions, mining, and biomass burning amongst other emissions sources, as well as cross-boundary transport of pollutants into the NDM adding to the base loading.

3.2 AMBIENT AIR QUALITY STANDARDS

National ambient air quality standards were developed for South Africa by the DEA and published in 2009 and 2012 (Table 3-1). Seven criteria pollutants are regulated. Transitional compliance periods with higher limit values have been included for PM_{10} and benzene.

The standards include a limit value, averaging period, permissible frequency of exceedance and date at which compliance is required. The permissible frequency of exceedance refers to the number of times a limit value can be exceeded without being recorded as being non-compliant with the ambient standard, e.g. the SO_2 24-hour limit value of 125 µg/m^3 can be exceeded four times in a calendar year while maintaining compliance with the standard. Further detail on pollutants and ambient standards are provided in Appendix 1.

Table 3-1: National ambient air quality standards in µg/m^3, with the permitted number of exceedances in brackets and compliance dates (DEAT, 2009 and 2012)

Pollutant	Averaging Period	Standards		Allowable Frequency of Exceedance	Compliance Date
		µg/m^3	ppb		
Sulphur Dioxide (SO_2)	10-min average	500	191	526	Immediate
	1-hr average	350	134	88	Immediate
	24-hr average	125	48	4	Immediate
	Annual average	50	19	0	Immediate
Nitrogen Dioxide (NO_2)	1-hr average	200	106	88	Immediate
	Annual average	40	21	0	Immediate

Carbon Monoxide (CO)	1-hr average	30,000	26,000	88	Immediate
	8-hourly running average	10,000	8700	11	Immediate
Ozone (O_3)	8-hourly running average	120	61	11	Immediate
Particulate Matter (PM_{10})	24-hr average	75	-	4	1 January 2016 to 31 December 2029
	Annual average	40	-	0	1 January 2016 to 31 December 2029
Lead (Pb)	Annual average	0.5	-	0	Immediate
Benzene (C_6H_6)	Annual average	10	3.2	0	Immediate
Particulate Matter ($PM_{2.5}$)	24-hour average	65	-	4	Immediate
	24-hour average	40	-	4	1 January 2016 to 31 December 2029
	24-hour average	25	-	4	1 January 2030
	Annual average	25	-	0	Immediate
	Annual average	20	-	0	1 January 2016 to 31 December 2029
	Annual average	15	-	0	1 January 2030
Note: ppb – part per billion µg/m^3 – micrograms per cubic metre					

3.3 AMBIENT AIR QUALITY MONITORING

Ambient air quality monitoring data for the 3-year period 2011-2013 was provided by the DEA and Eskom. The relative location of the monitoring sites within the NDM is presented in **Figure 3-1**. No ambient monitoring is undertaken in the Dr JS Moroka, Thembisile Hani, eMakhazeni and Victor Khanye Local Municipalities. Priority pollutants were the parameters of interest in the monitoring record, viz. NO_2, PM_{10}, and SO_2. Pollutants monitored at each site are summarised in Table 3-2. Information is also provided regarding the emission sectors that influence measurements at specific sites.

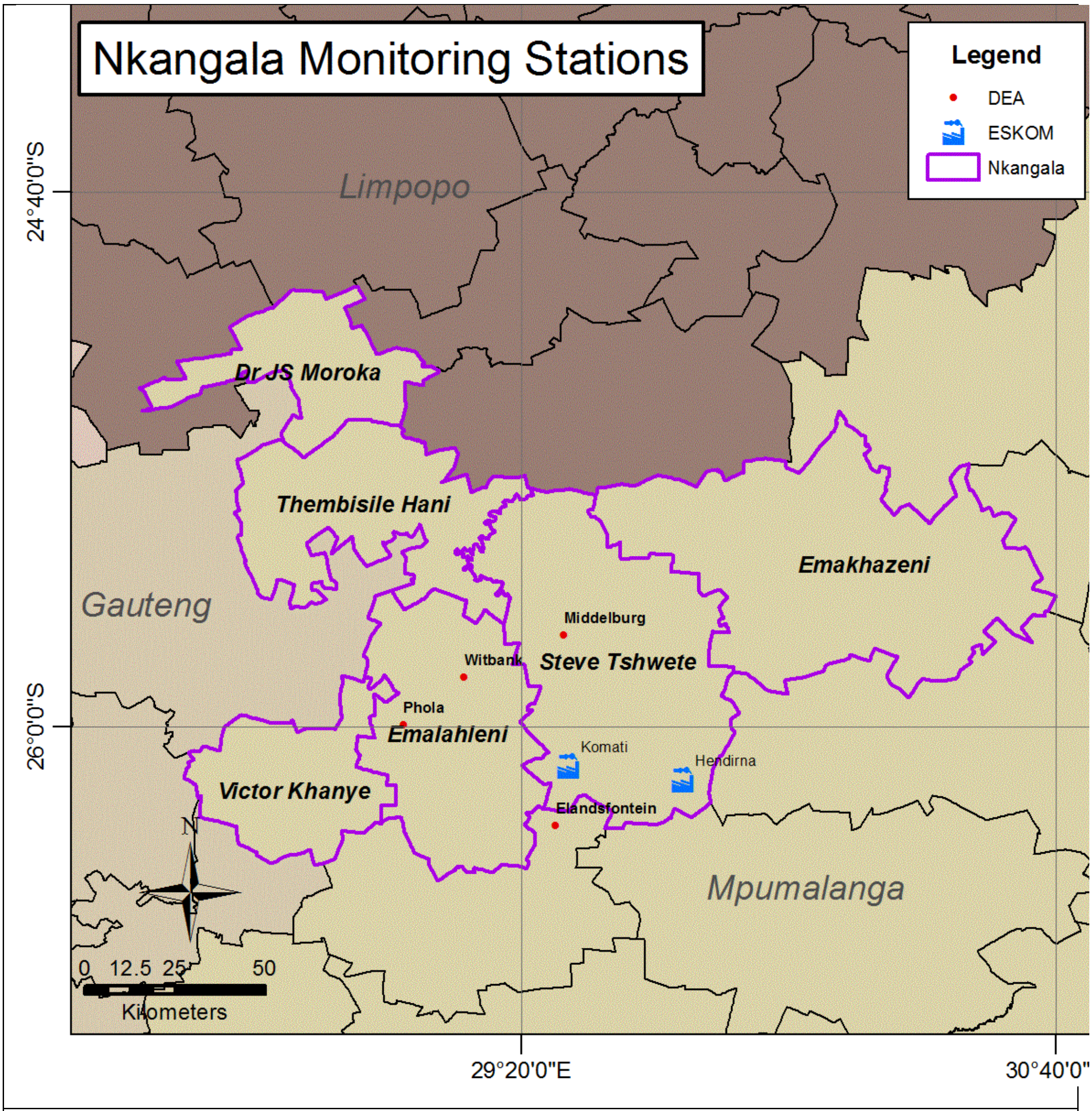


Figure 3-1: Location of ambient air quality monitoring sites in the NDM

Table 3-2: Monitoring sites with available data within the NDM

		$PM_{2.5}$	PM_{10}	SO_2	NO_X
eMalahleni	Phola	✗	✓	✓	✓
	Witbank	✓	✓	✓	✓
Steve Tshwete	Elandsfontein	✓	✓	✓	✓
	Middelburg	✓	✓	✓	✓
	Hendrina	✓	✓	✓	✓
	Komati	✗	✓	✓	✓

The current state of the ambient air quality was analysed using monitoring data from DEA and Eskom monitoring sites for the years 2011 through to 2013. The current state of air quality exceeds the NAAQ for PM_{10} for all six monitoring stations. While SO_2 emission concentrations were exceeded at Witbank, and NO_X concentrations limits were exceeded for Elandsfontein (Table 3-3 and Table 3-4).

Table 3-3: Hourly Exceedances at NDM sites based on monitoring data

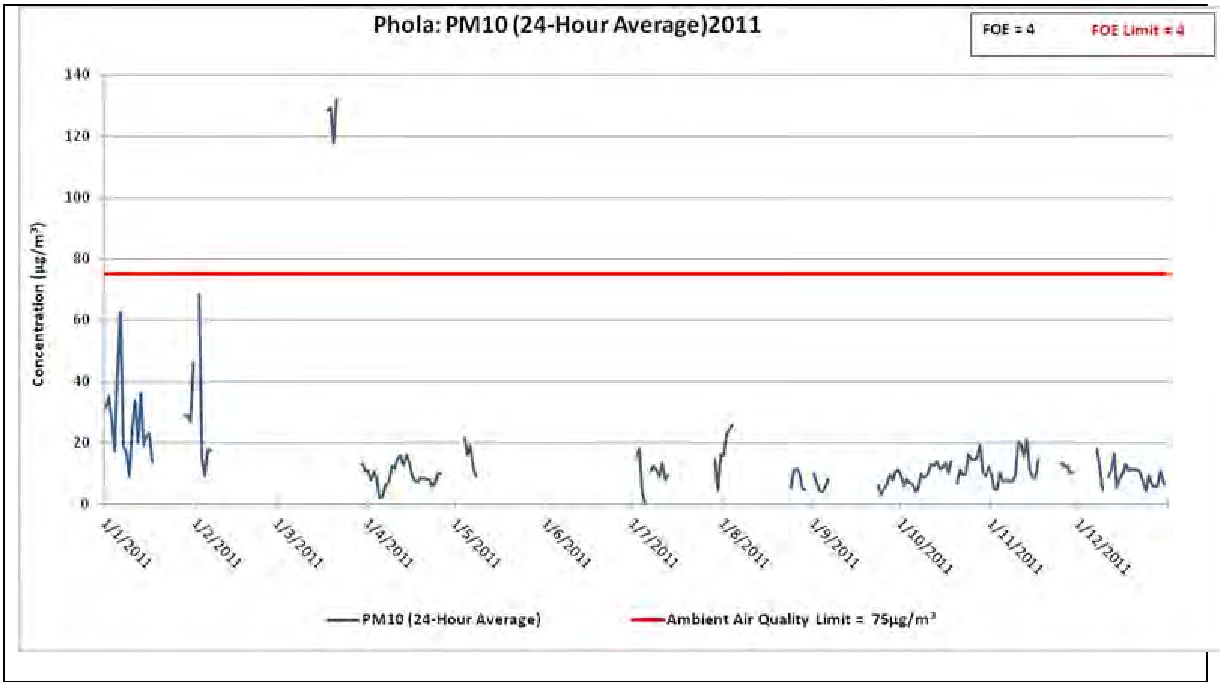
		SO_2			NO_2		
		2011	2012	2013	2011	2012	2013
eMalahleni LM	Phola	15	12	11	61	33	130
	Witbank	134	6	1	78	24	32
Steve Tshwete LM	Elandsfontein	18	4	-	220	3	-
	Middelburg	3	0	0	3	0	1
	Hendrina	0	2	11	15	17	20
	Komati	21	28	13	9	20	14
The allowable FOE for the hourly NAAQ is 88.							

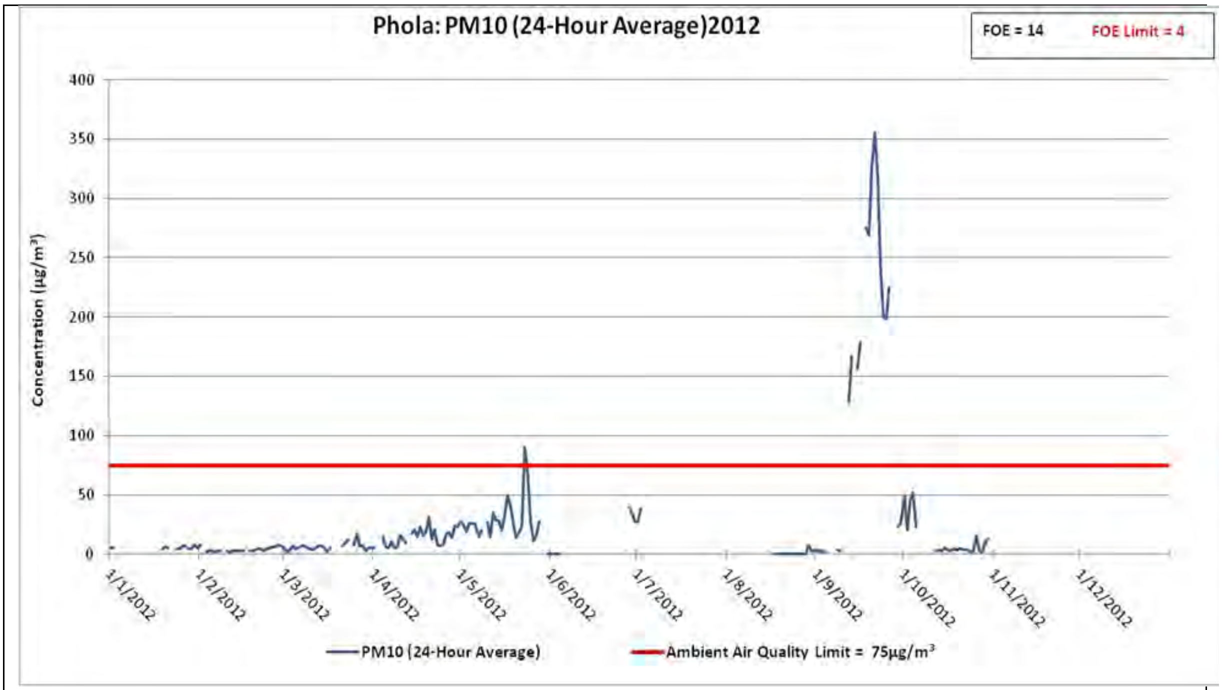
Table 3-4: Daily (24h average) Exceedances at NDM sites based on monitoring data

		PM_{10}			SO_2		
	Station	2011	2012	2013	2011	2012	2013
eMalahleni LM	Phola	4	14	122	0	1	1
	Witbank	56	50	69	31	0	1
Steve Tshwete LM	Elandsfontein	5	0	-	0	0	-
	Middelburg	68	85	53	0	0	0
	Hendrina	57	63	6	0	0	1
	Komati	96	96	16	1	4	1
The allowable FOE for the daily (24h average) NAAQ is 4.							

3.3.1.1 Phola Ambient Data

The Phola monitoring data for PM_{10} ambient concentrations was sporadic, however of the data available there were exceedances in all three years (2011 – 2013). The ambient concentrations for 2013 held the most complete year, and subsequently showed the most exceedances, 122 exceedances of the NEMAQA limit (Figure 3-2). The PM_{10} 24-hour NEMAQA limit allows for 4 exceedances of the 75µg/m^3 limit, therefore the Phola ambient concentrations far exceed this allowance. The 2012 PM_{10} ambient concentrations also exceed the NEMAQA limits, 14 times and the 2011 PM_{10} ambient concentrations exceed the limits 4 times. Compared with the PM_{10} ambient data, the SO_2 data was a more complete set for all three years, and therefore can be considered an accurate representation of the ambient SO2 levels (Figure 3-3). The 2011 SO_2 1-hour average concentrations exceed the 350µg/m^3 limit 15 times, which falls below the 88 allowable exceedances. The 2012 and 2013 SO_2 1-hour average concentrations show similar levels, with 12 and 11 exceedances respectively. The SO_2 24-hour average ambient concentrations only show one exceedance each for 2012 and 2013 (Figure 3-4), whilst the NOx 1-hour average ambient concentrations show significant exceedances, and exceedances of the allowable FOE limit (Figure 3-5). Notably, there were 130 exceedances of the 200 µg/m^3 limit for 2013, which exceeds the allowable 88 exceedances.





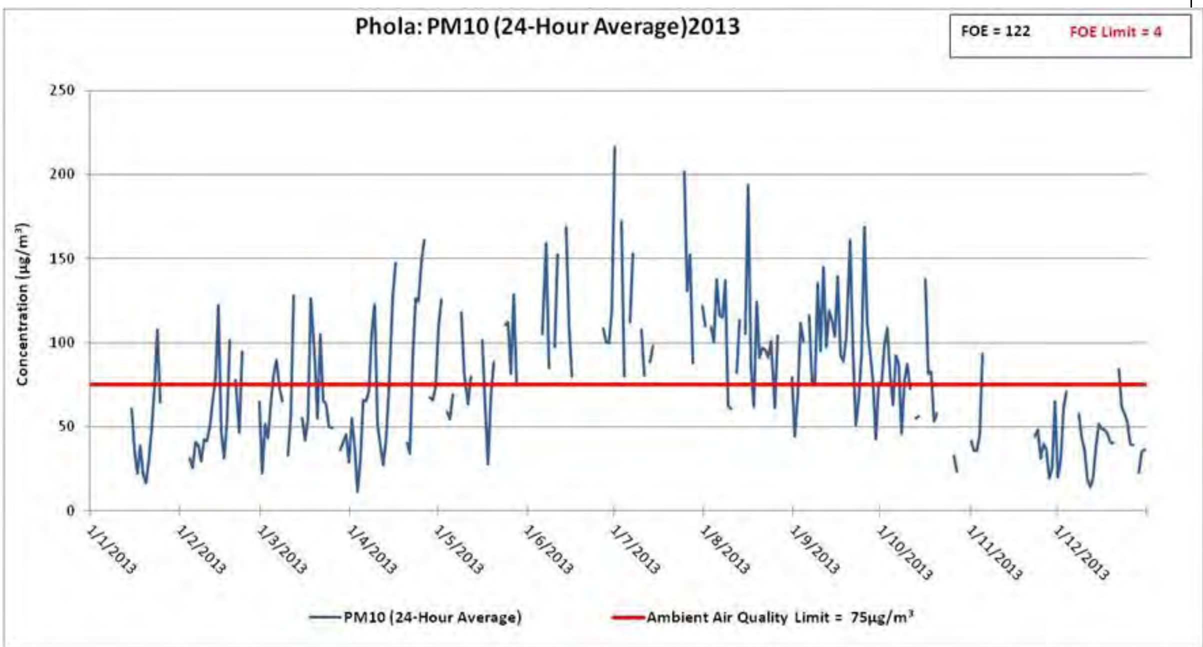
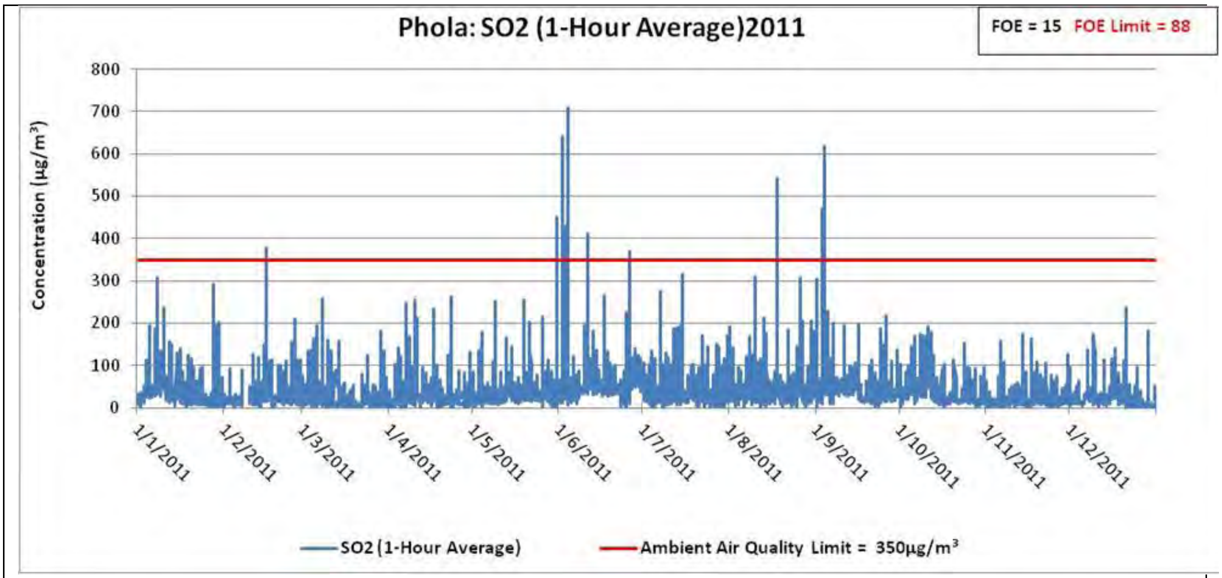
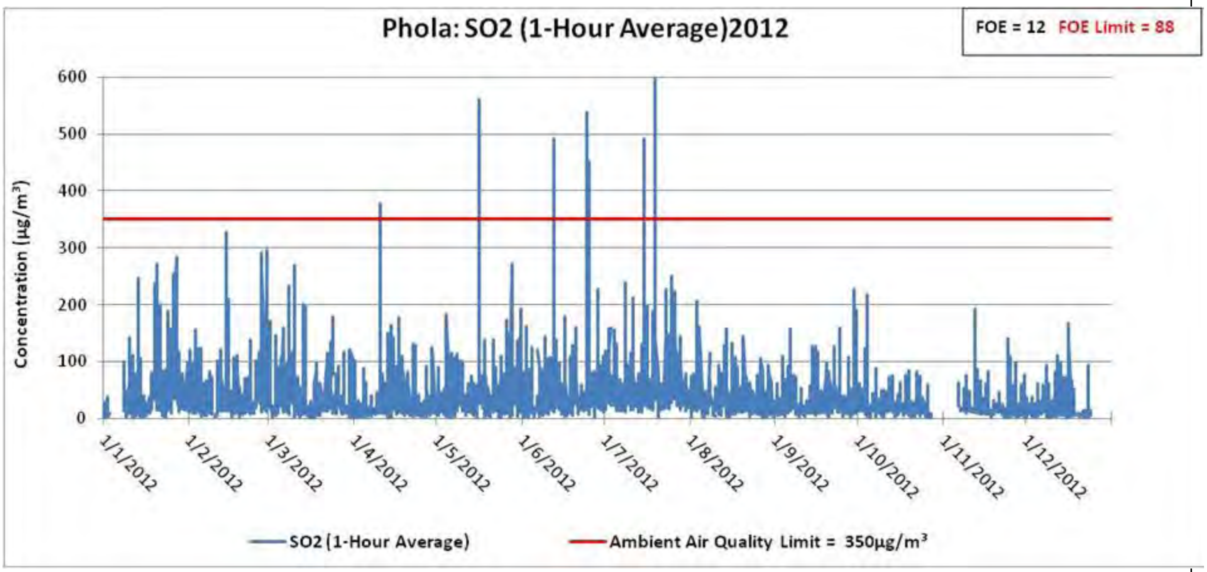


Figure 3-2: PM_{10} 24-hour average ambient data from the Phola Monitoring station for 2011 - 2013


Phola: SO2 (1-Hour Average)2011
FOE = 15 FOE Limit = 88
Concentration (µg/m³)
800
700
600
500
400
300
200
100
0
1/1/2011
1/2/2011
1/3/2011
1/4/2011
1/5/2011
1/6/2011
1/7/2011
1/8/2011
1/9/2011
1/10/2011
1/11/2011
1/12/2011
SO2 (1-Hour Average)
Ambient Air Quality Limit = 350µg/m³


Phola: SO2 (1-Hour Average)2012
FOE = 12 FOE Limit = 88
Concentration (µg/m³)
600
500
400
300
200
100
0
1/1/2012
1/2/2012
1/3/2012
1/4/2012
1/5/2012
1/6/2012
1/7/2012
1/8/2012
1/9/2012
1/10/2012
1/11/2012
1/12/2012
SO2 (1-Hour Average)
Ambient Air Quality Limit = 350µg/m³

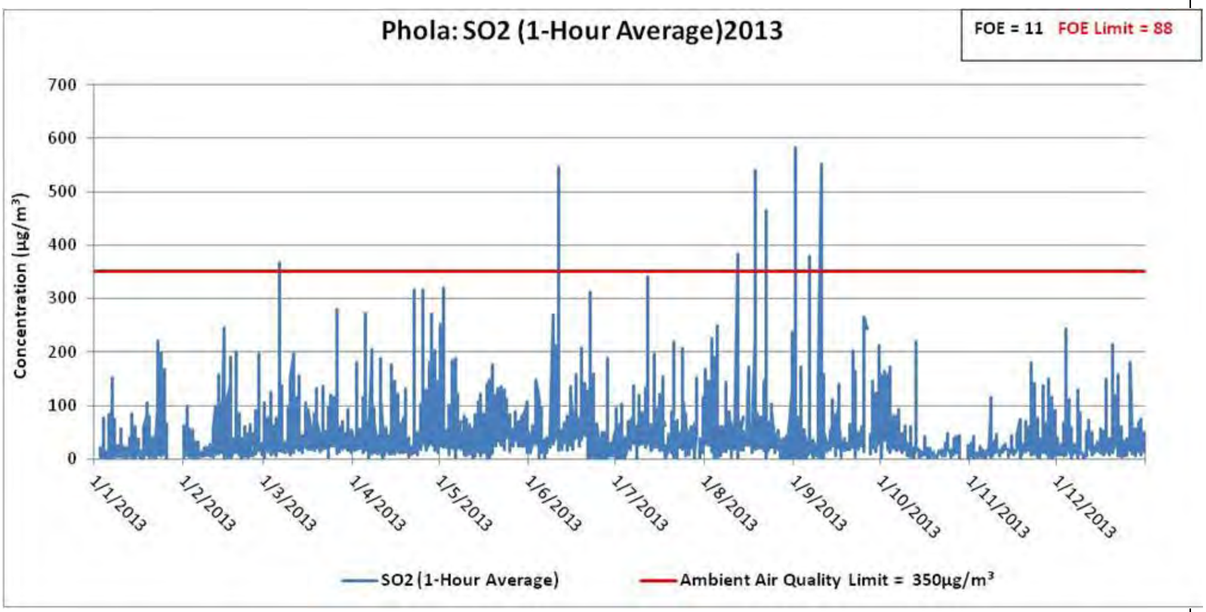
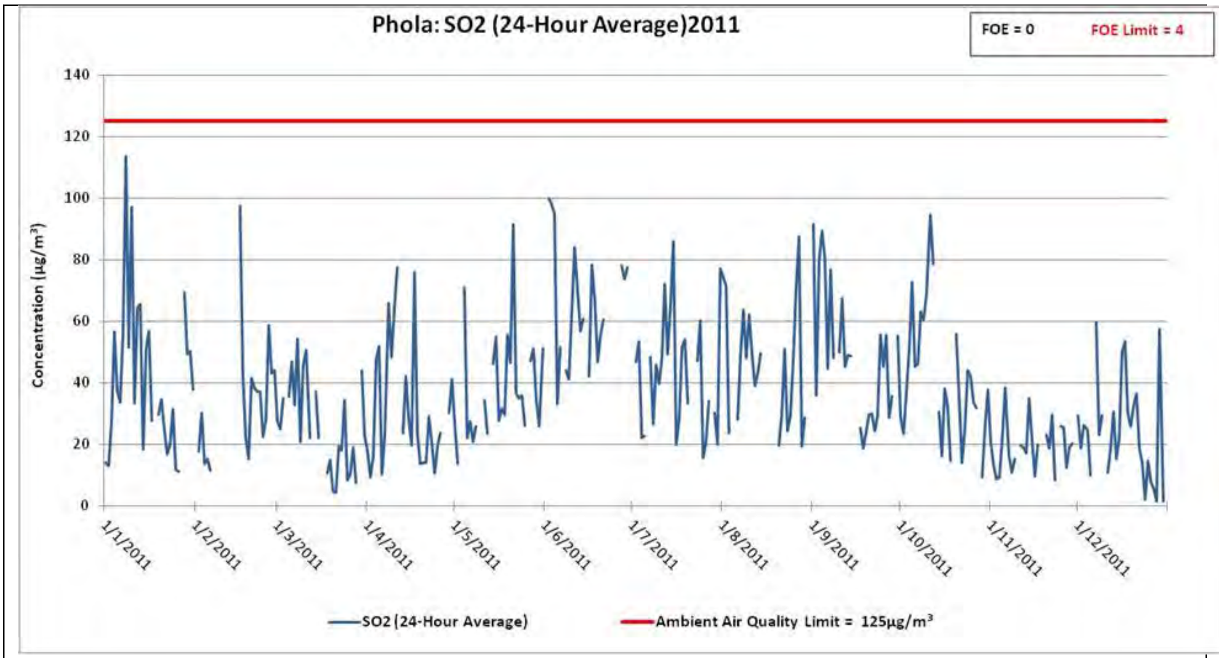
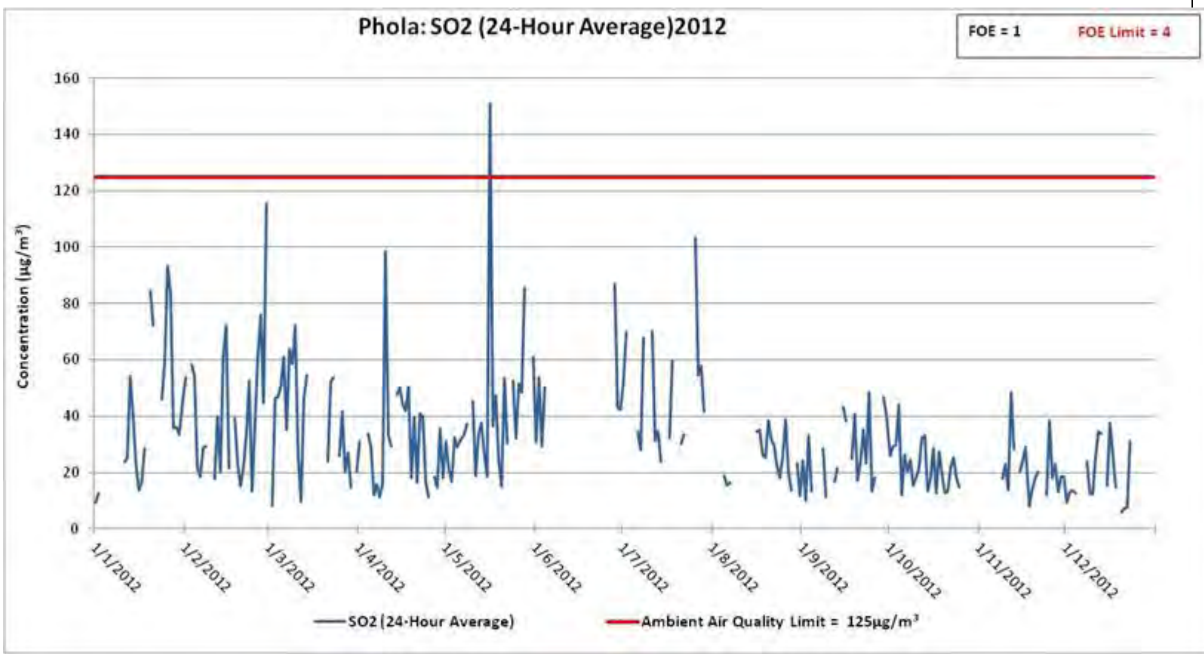

Phola: SO2 (1-Hour Average)2013
FOE = 11 FOE Limit = 88
Concentration (µg/m³)
700
600
500
400
300
200
100
0
1/1/2013
1/2/2013
1/3/2013
1/4/2013
1/5/2013
1/6/2013
1/7/2013
1/8/2013
1/9/2013
1/10/2013
1/11/2013
1/12/2013
SO2 (1-Hour Average)
Ambient Air Quality Limit = 350µg/m³

Figure 3-3: SO_2 1-hour average ambient data from the Phola Monitoring station for 2011 - 2013





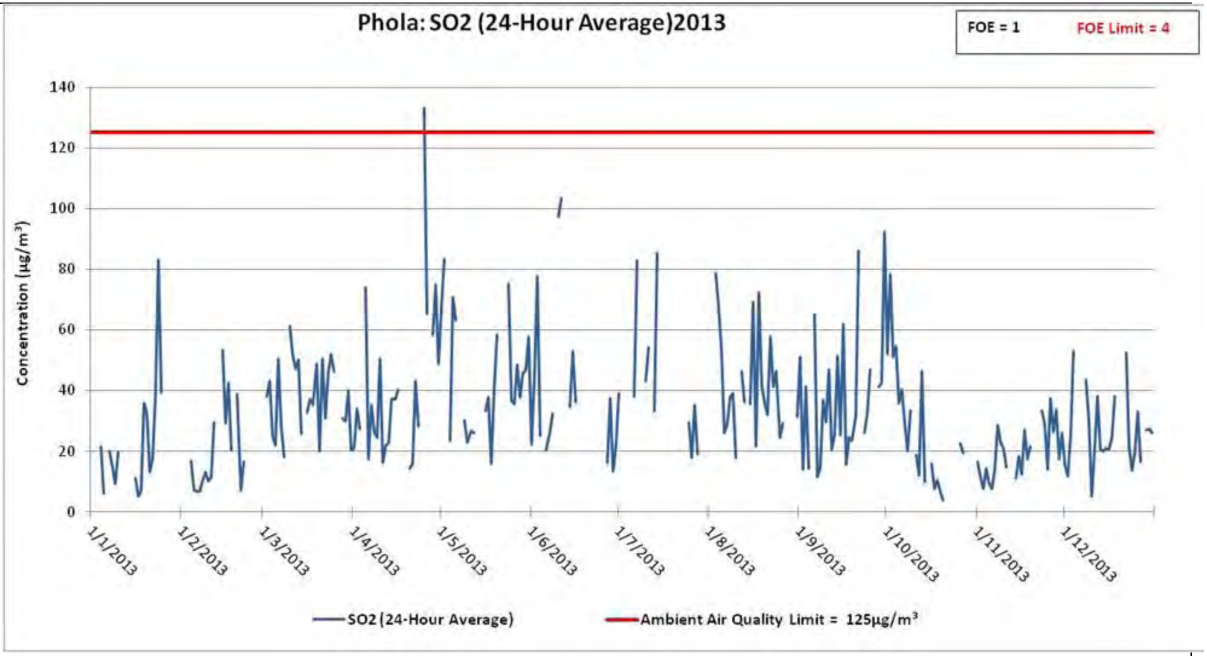
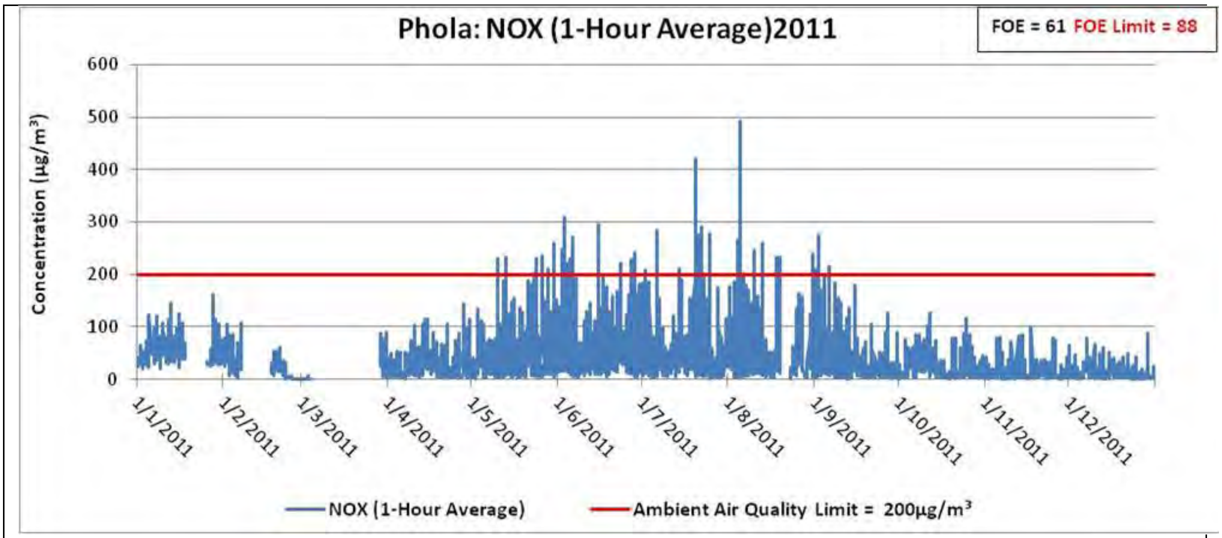


Figure 3-4: SO_2 24-hour average ambient data from the Phola Monitoring station for 2011 – 2013



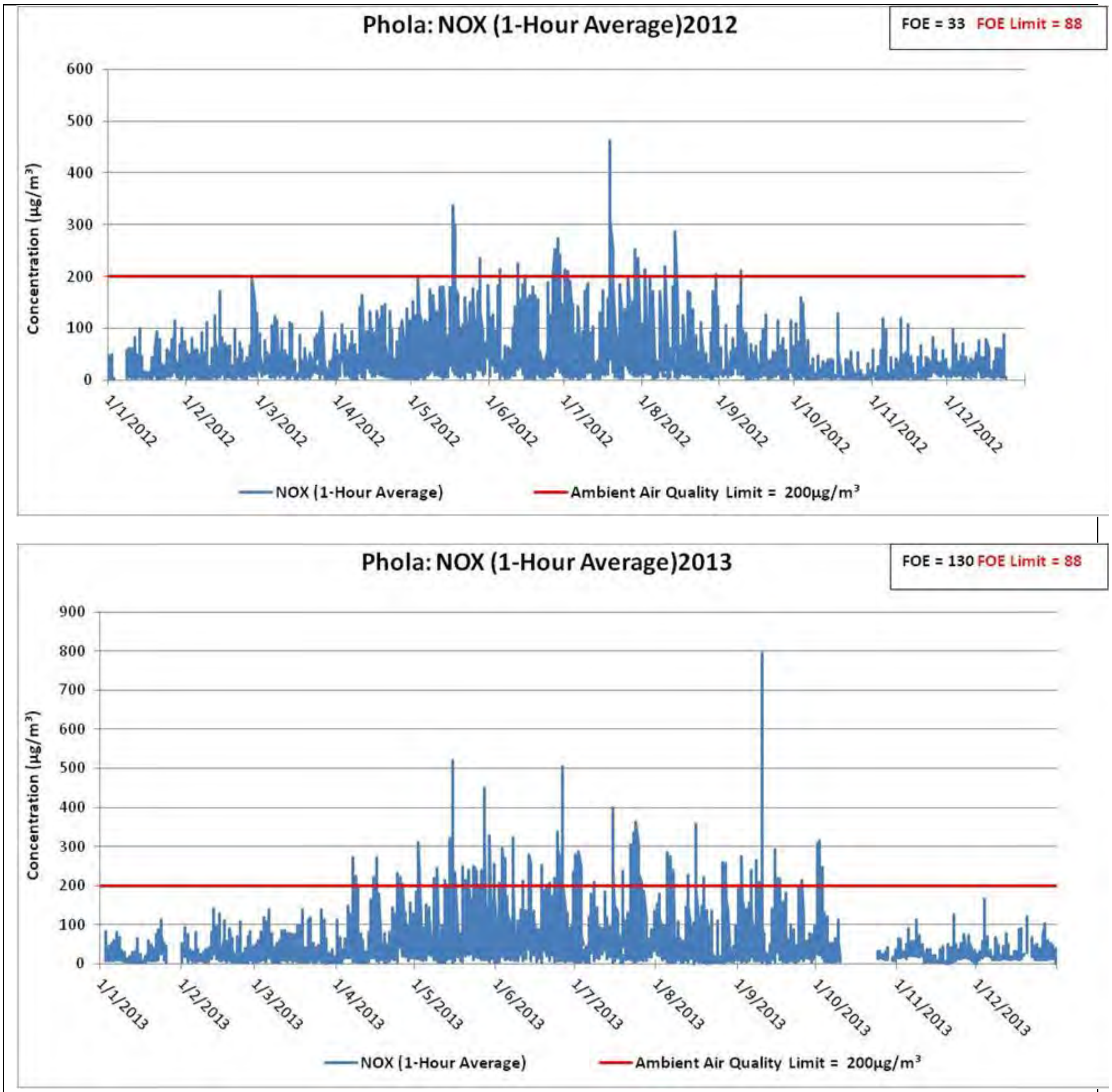
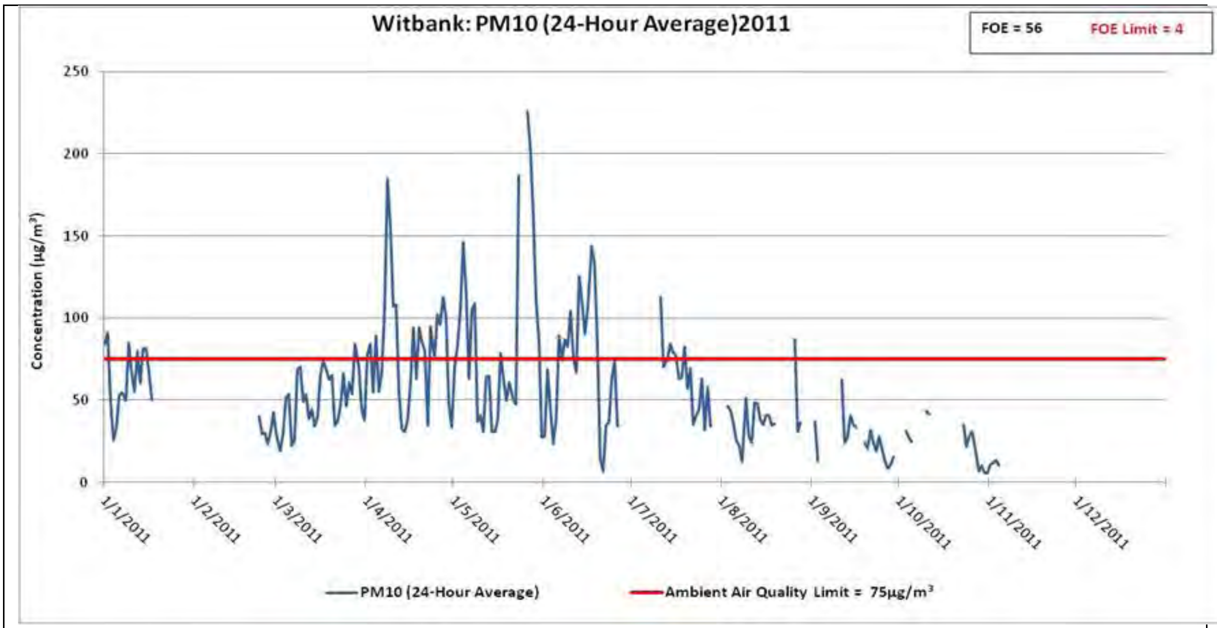
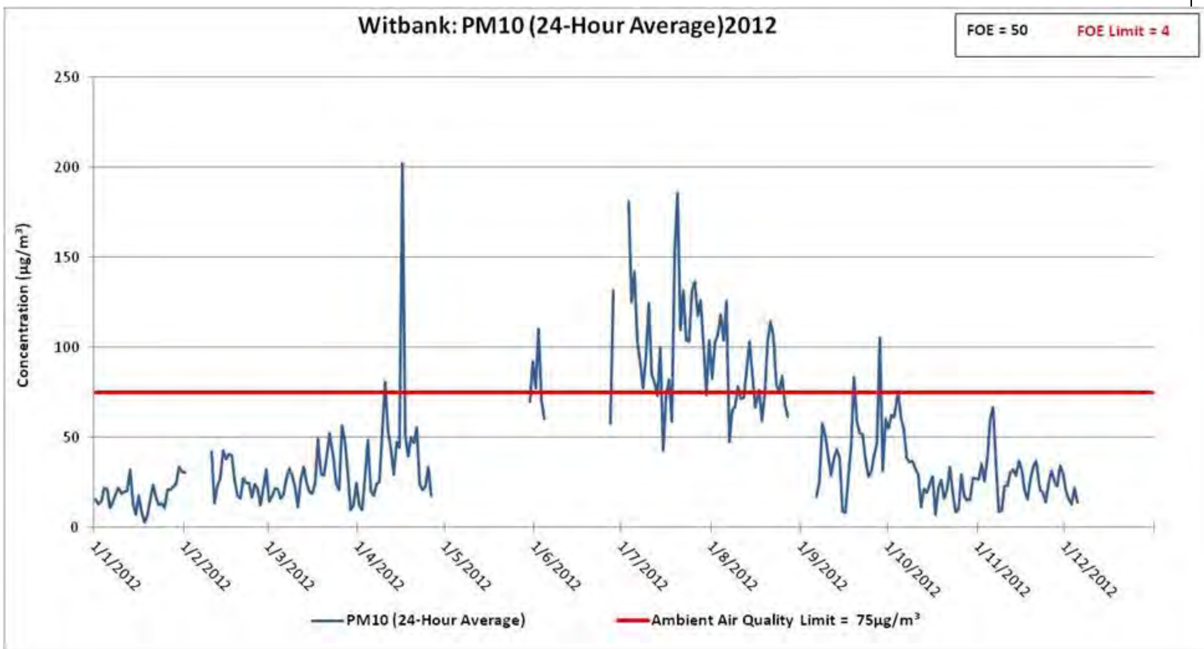


Figure 3-5: NOx 1-hour average ambient data from the Phola Monitoring station for 2011 – 2013

3.3.1.2 Witbank Ambient Data

The ambient PM_{10} 24-hour concentrations show a number of exceedances for all three years, specifically 56, 50 and 69 exceedances respectively (Figure 3-6). These exceedances all exceed the allowable number of FOEs, notably 4 exceedances a year. The ambient SO_2 1-hour concentrations for 2011 had a large number of exceedances (134), more than the allowable exceedances (88) (Figure 3-7). Whilst, the 2012 and 2013 SO_2 1-hour concentrations, only had 6 and 1 exceedance, respectively. The SO_2 24-hour average concentrations showed a similar pattern, whereby 2011 exceeded the allowable exceedance limit, whilst 2012 and 2013 had little to no exceedances (Figure 3-8). The NOx 1-hour ambient concentrations all fell below the allowable number of exceedances of the limit (88) (Figure 3-9).


Witbank: PM10 (24-Hour Average)2011
FOE = 56
FOE Limit = 4
Concentration (µg/m³)
250
200
150
100
50
0
1/1/2011
1/2/2011
1/3/2011
1/4/2011
1/5/2011
1/6/2011
1/7/2011
1/8/2011
1/9/2011
1/10/2011
1/11/2011
1/12/2011
PM10 (24-Hour Average)
Ambient Air Quality Limit = 75µg/m³


Witbank: PM10 (24-Hour Average)2012
FOE = 50
FOE Limit = 4
Concentration (µg/m³)
250
200
150
100
50
0
1/1/2012
1/2/2012
1/3/2012
1/4/2012
1/5/2012
1/6/2012
1/7/2012
1/8/2012
1/9/2012
1/10/2012
1/11/2012
1/12/2012
PM10 (24-Hour Average)
Ambient Air Quality Limit = 75µg/m³

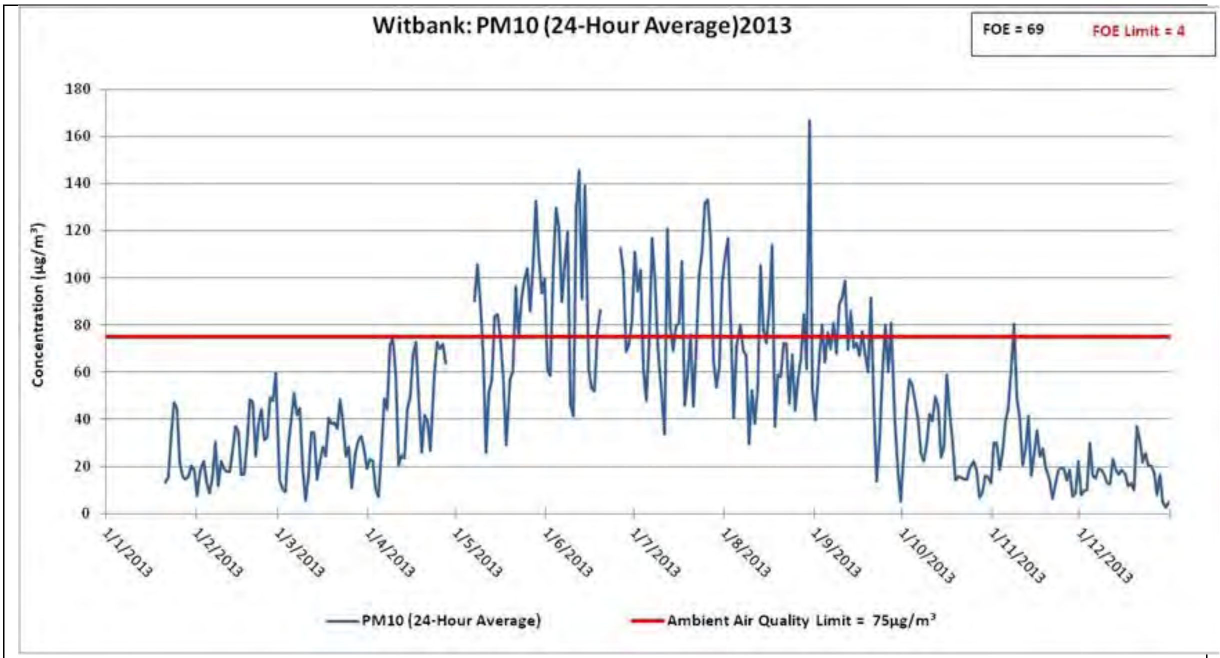
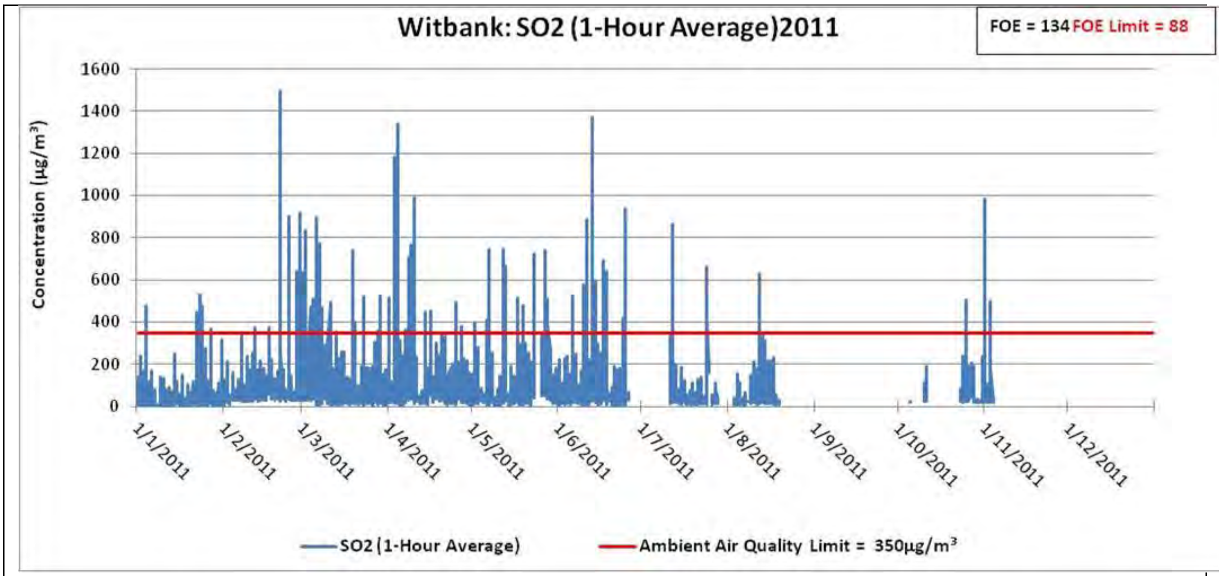


Figure 3-6: PM10 24-hour average ambient data from the Witbank Monitoring station for 2011 – 2013



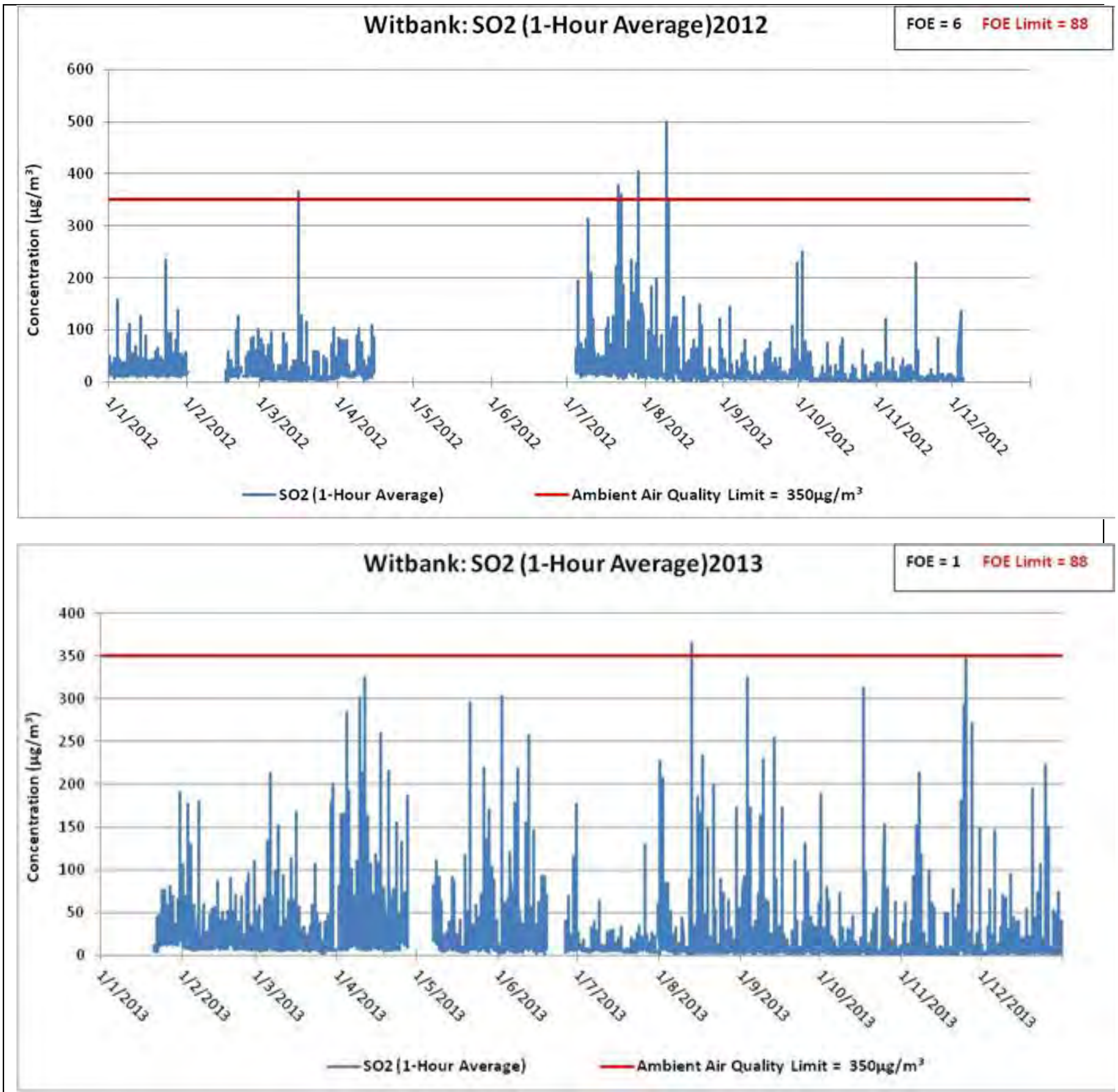
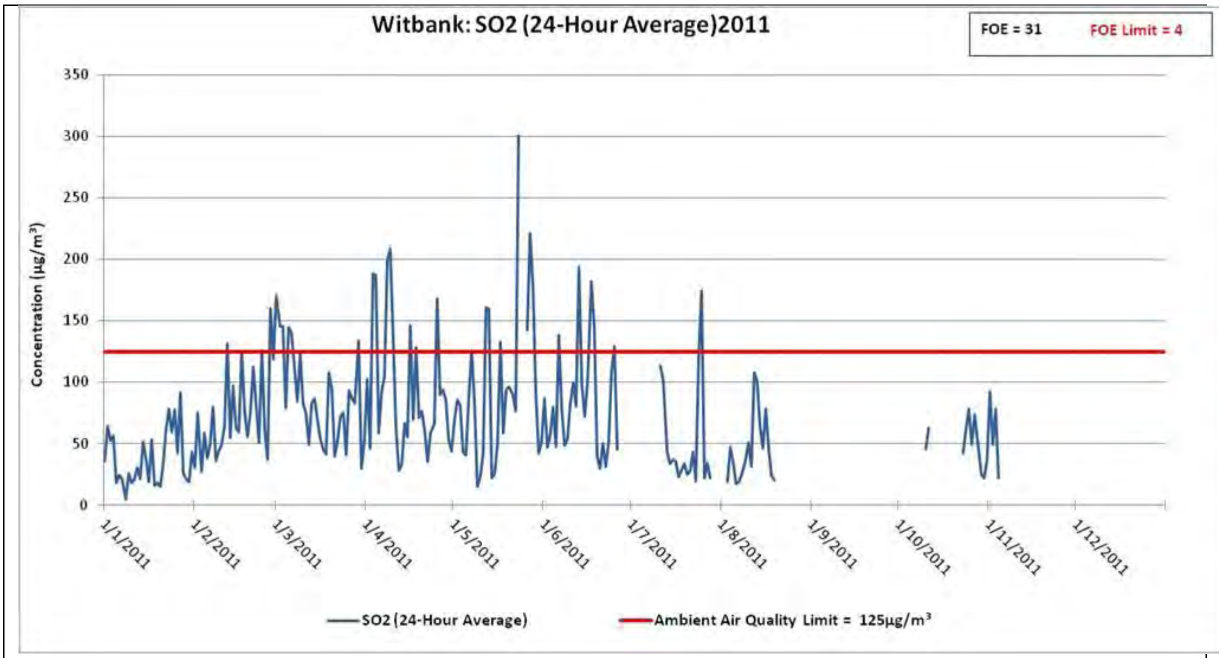
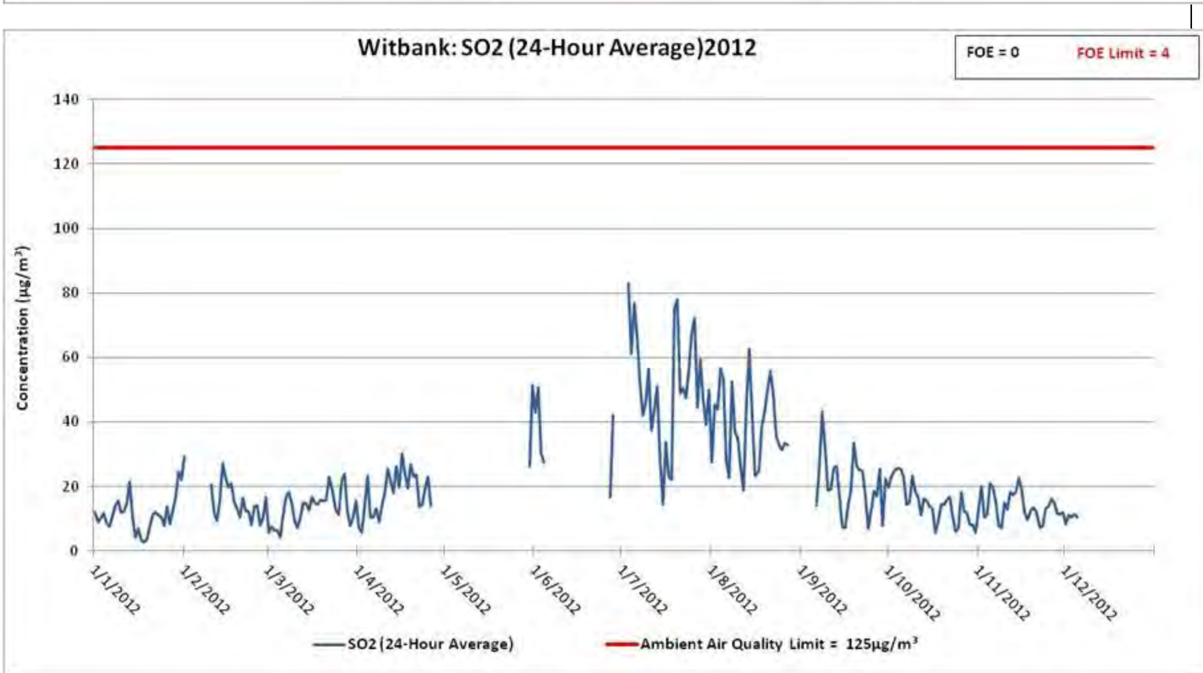


Figure 3-7: SO2 1-hour average ambient data from the Witbank Monitoring station for 2011 – 2013


Witbank: SO2 (24-Hour Average)2011
FOE = 31
FOE Limit = 4
Concentration (µg/m³)
350
300
250
200
150
100
50
0
1/1/2011
1/2/2011
1/3/2011
1/4/2011
1/5/2011
1/6/2011
1/7/2011
1/8/2011
1/9/2011
1/10/2011
1/11/2011
1/12/2011
SO2 (24-Hour Average)
Ambient Air Quality Limit = 125µg/m³


Witbank: SO2 (24-Hour Average)2012
FOE = 0
FOE Limit = 4
Concentration (µg/m³)
140
120
100
80
60
40
20
0
1/1/2012
1/2/2012
1/3/2012
1/4/2012
1/5/2012
1/6/2012
1/7/2012
1/8/2012
1/9/2012
1/10/2012
1/11/2012
1/12/2012
SO2 (24-Hour Average)
Ambient Air Quality Limit = 125µg/m³

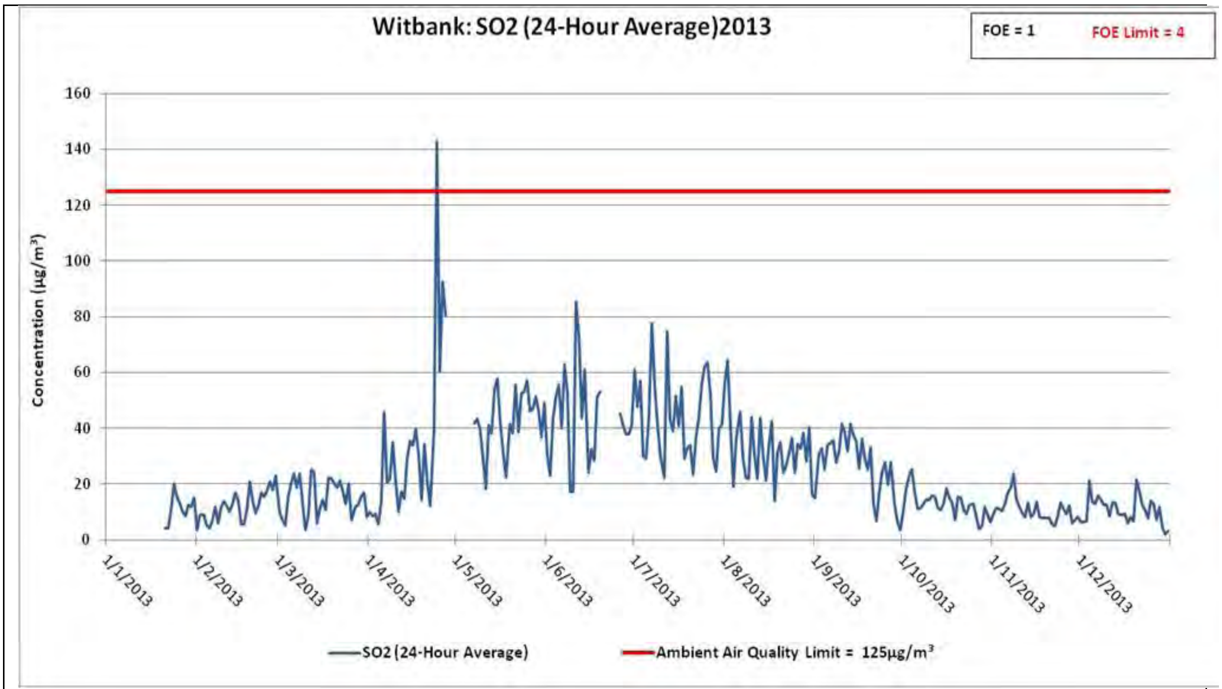
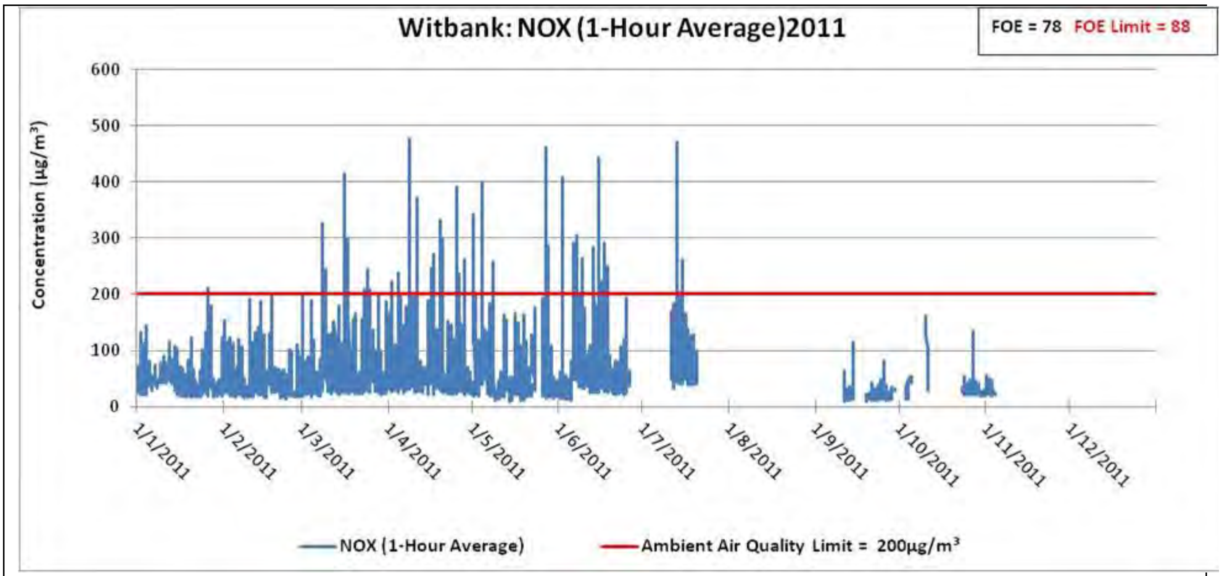


Figure 3-8: SO2 24-hour average ambient data from the Witbank Monitoring station for 2011 – 2013



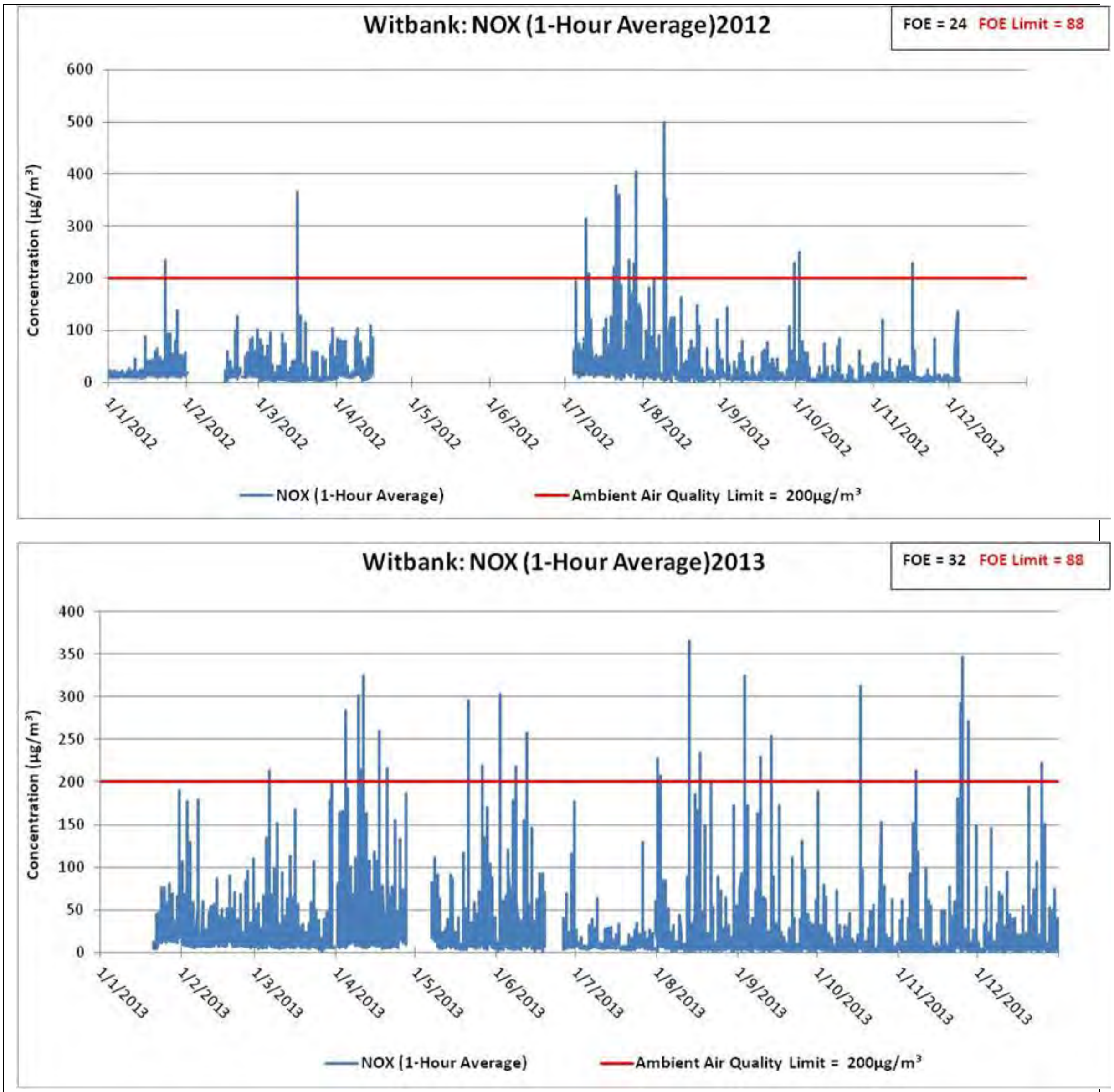
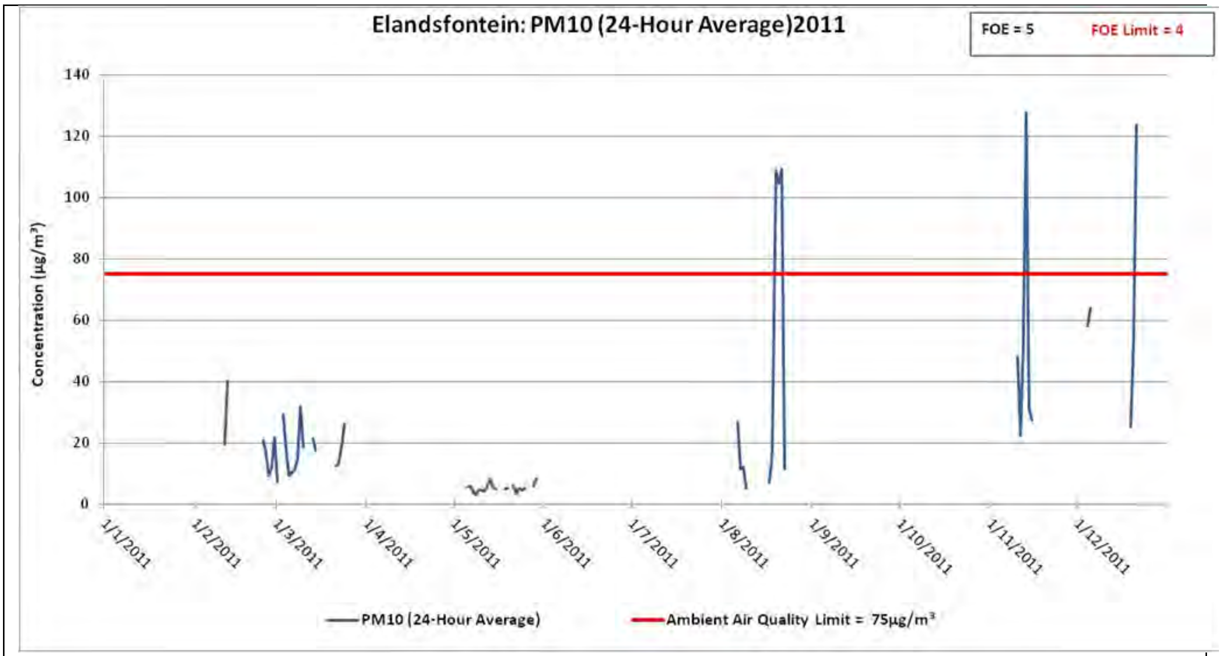


Figure 3-9: NOx 1-hour average ambient data from the Witbank Monitoring station for 2011 – 2013

3.3.1.3 Elandsfontein Ambient Data

The data provided from the Elandsfontein monitoring station showed large gaps in data, as evident in the PM10 graphs (Figure 3-10). Therefore any conclusions take from this data must be done so with care. The PM10 24-hour ambient data showed 5 and 0 FOEs for 2011 and 2012 respectively (Figure 3-10). The NEMAQA limit allows for only 4 exceedances a year, therefore PM10 for 2011 exceeds the FOE Limit as well. The SO_2 1-hour ambient data from Elandsfontein showed 18 and 4 exceedances of the NEMAQA limits for 2011 and 2012 respectively (Figure 3-11). The SO_2 24-hour ambient data for Elandsfontein showed no exceedances for both 2011 and 2012 (Figure 3-12). The NOx 1-hour ambient data showed a large number of exceedances of the NEMAQA limits, notably 220 exceedances for the 2011 NOx ambient concentration and only 3 exceedances for 2012 ambient data (Figure 3-13).



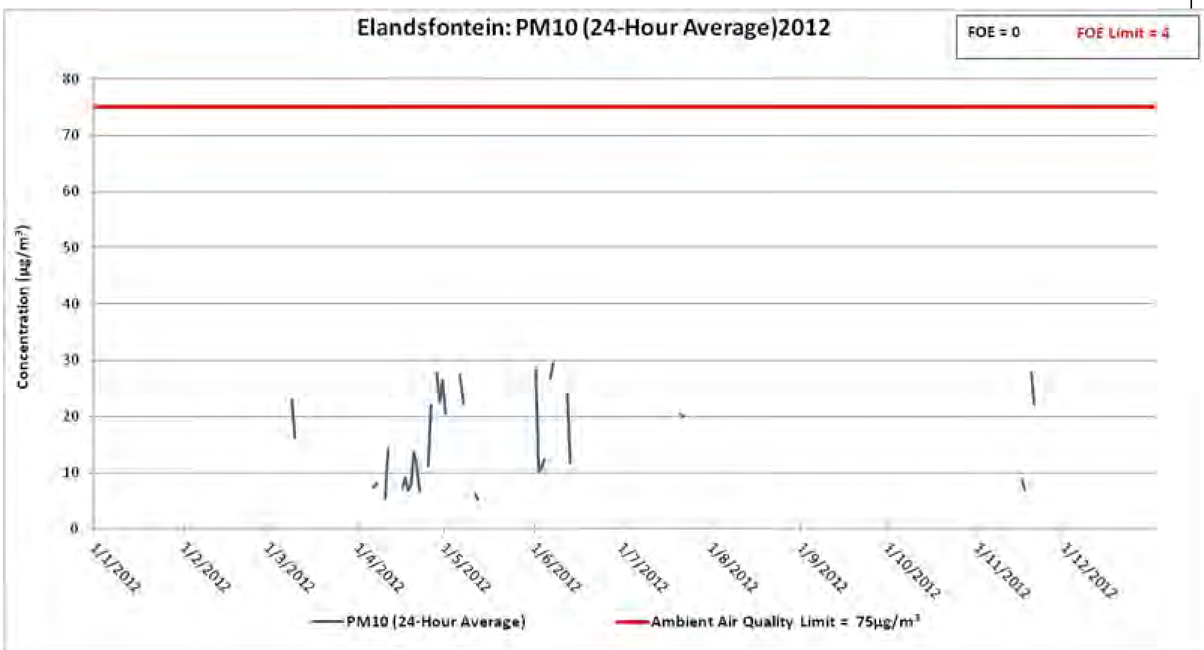
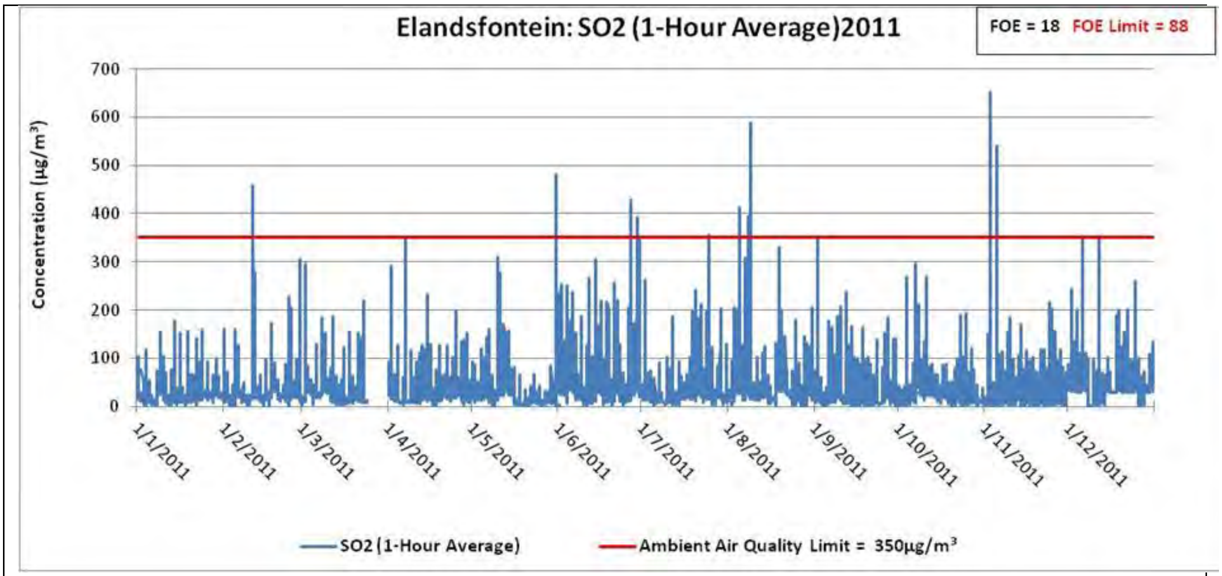


Figure 3-10: PM10 24-hour average ambient data from the Elandsfontein Monitoring station for 2011 and 2012, no data available for 2013



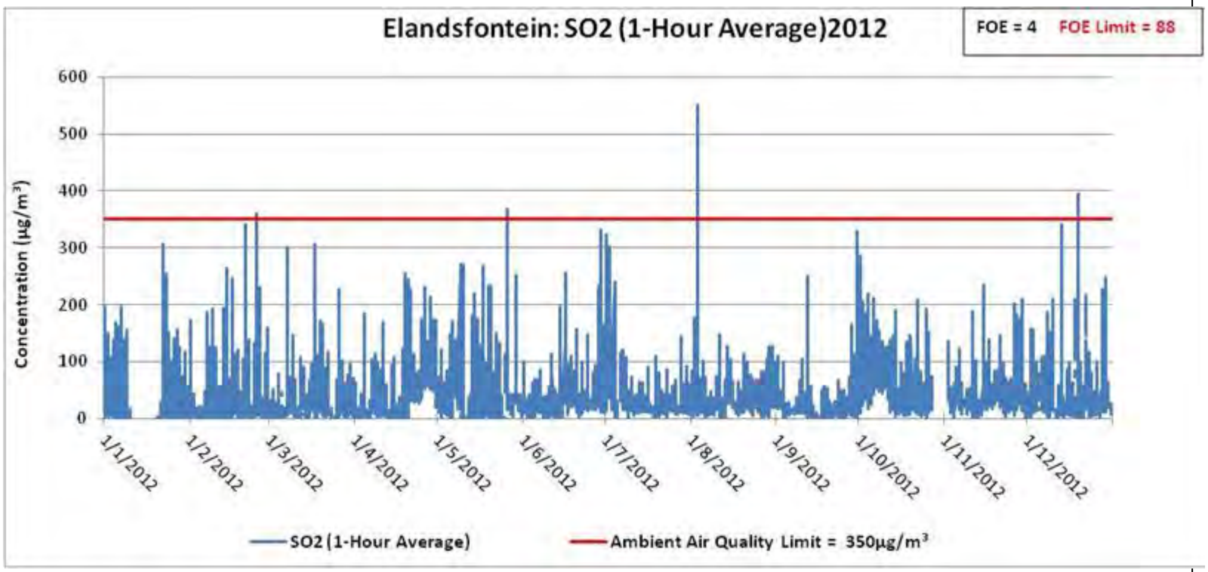
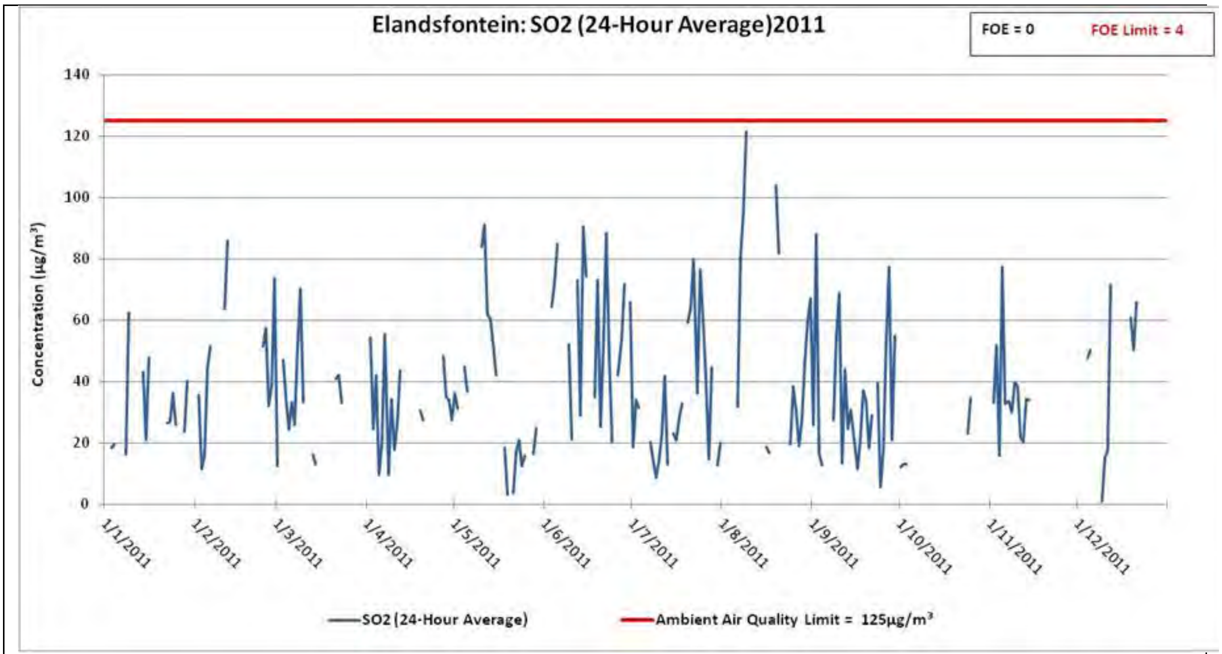


Figure 3-11: SO_2 1-hour Ambient data from the Elandsfontein Monitoring station for 2011 and 2012, no data available for 2013



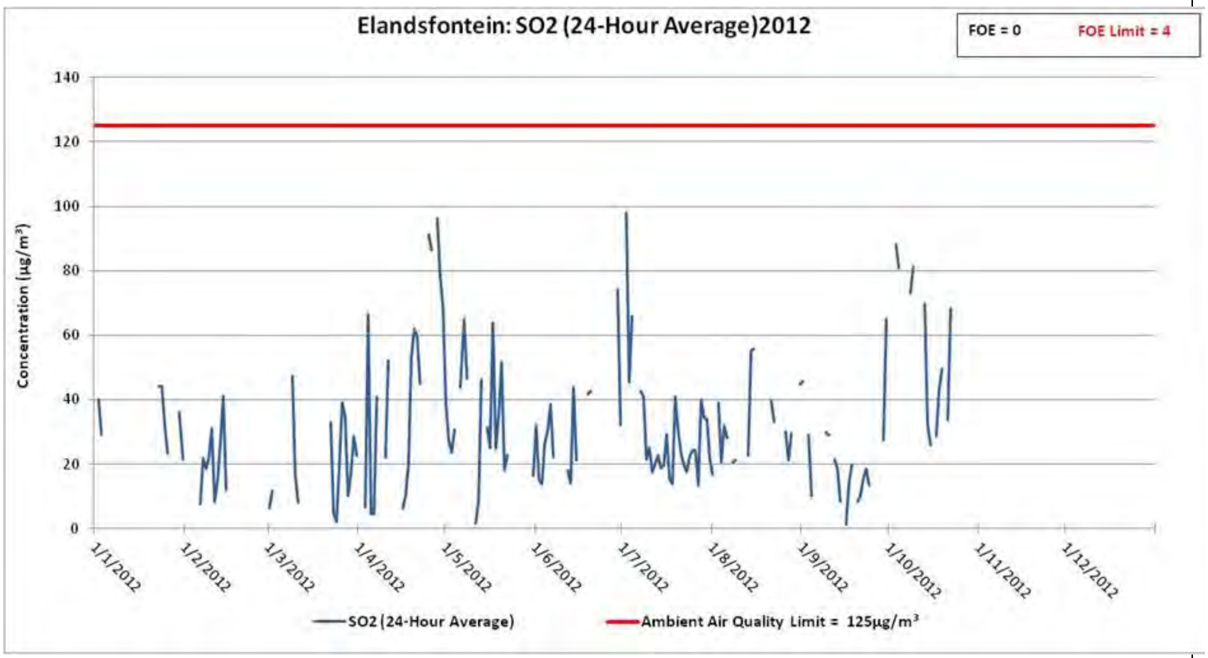
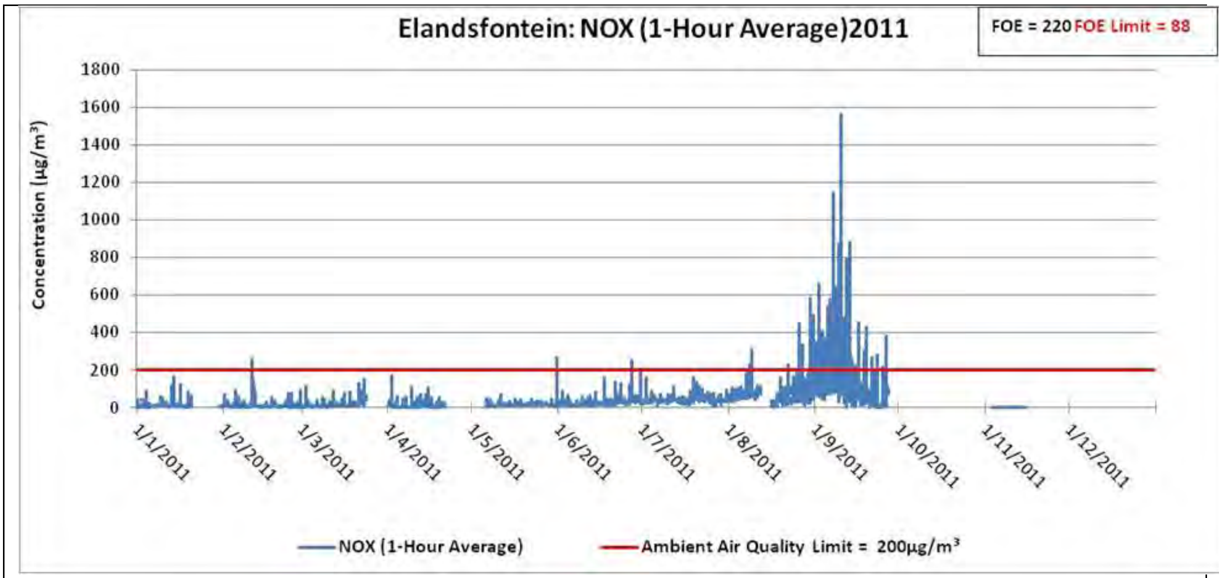


Figure 3-12: SO2 24-hour Ambient data from the Elandsfontein Monitoring station for 2011 and 2012, no data available for 2013



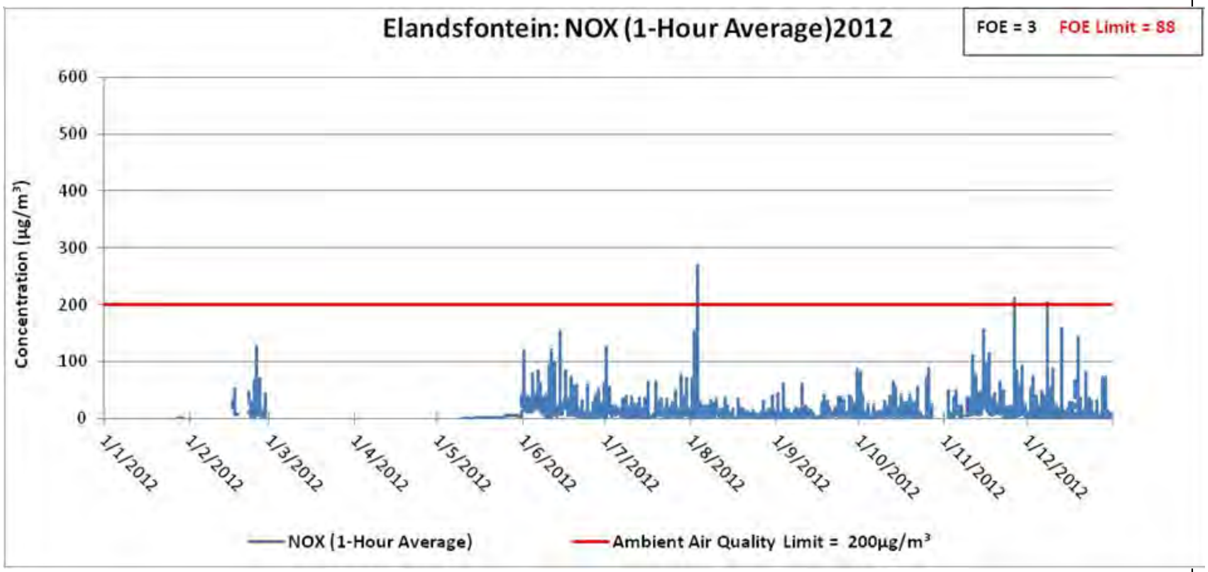
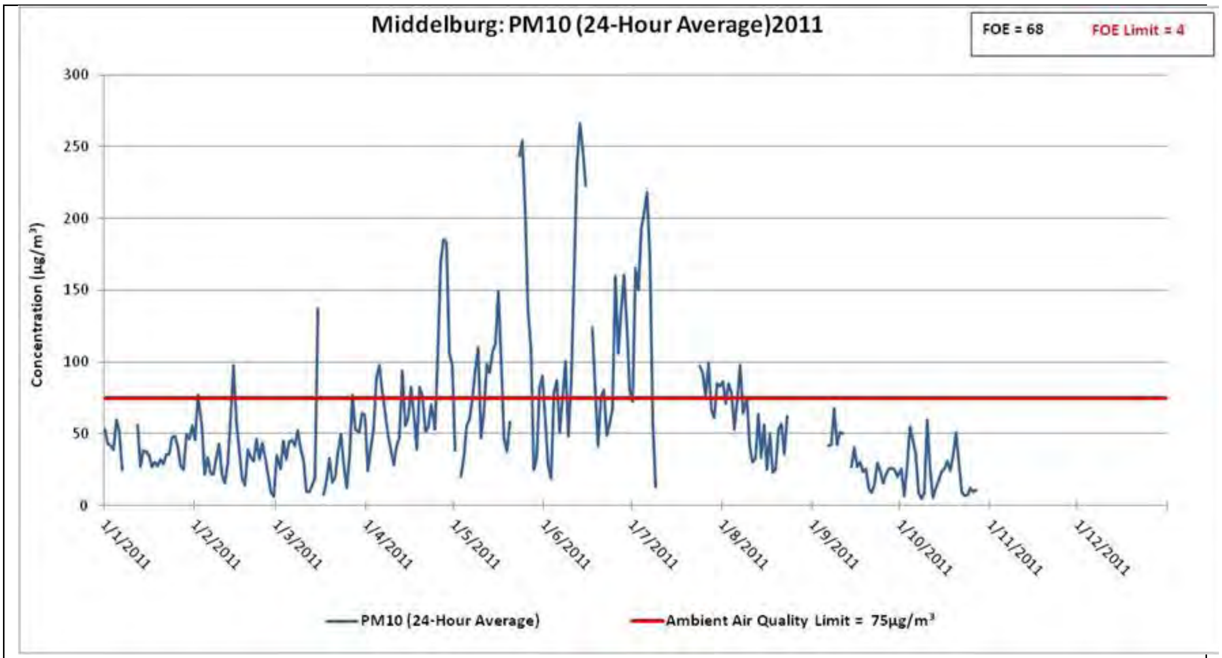
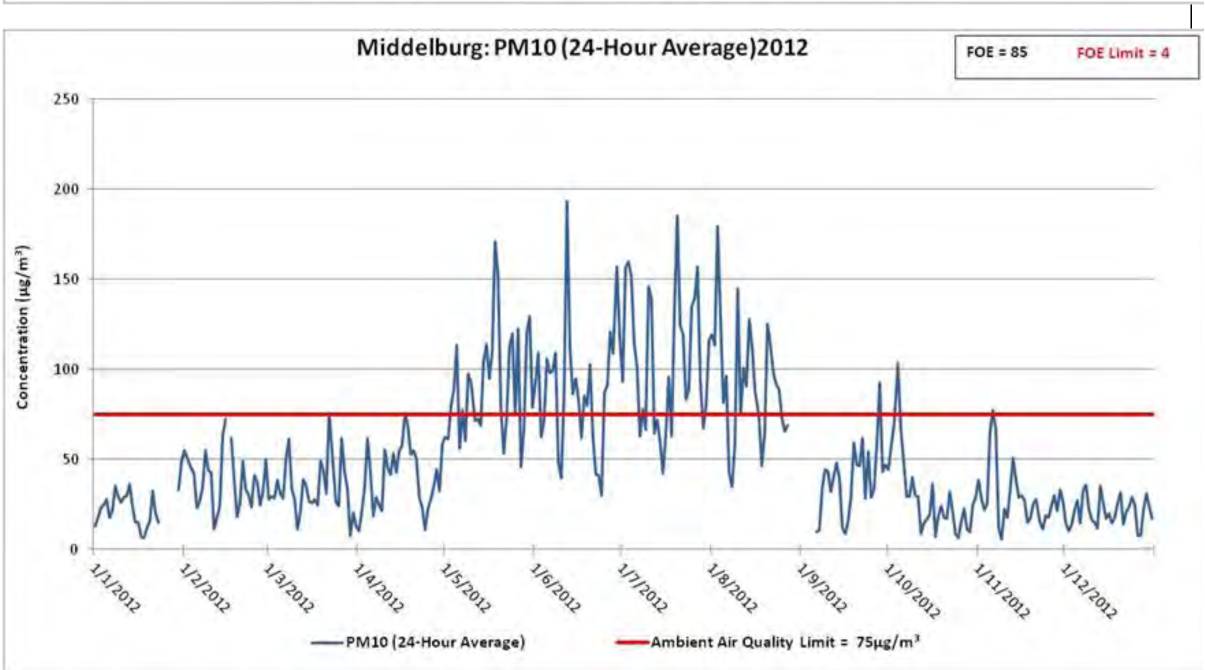


Figure 3-13: NOx 1-hour Ambient data from the Elandsfontein Monitoring station for 2011 and 2012, no data available for 2013

3.3.1.4 Middelburg

The Middelburg PM_{10} 24-hour ambient concentrations for all three years exceeded the limit, and also exceeded the allowable number of exceedances (4) (Figure 3-14). The SO_2 1-hour ambient concentrations only had three exceedances of the limit for 2011, whilst 2012 and 2013 had no exceedances (Figure 3-15). The SO_2 24-hour average concentrations had no exceedances for the NEMAQA limit (Figure 3-16). The NOx ambient concentrations had three exceedances for 2011 and one exceedance for 2013 (Figure 3-17).


Middelburg: PM10 (24-Hour Average)2011
FOE = 68
FOE Limit = 4
Concentration (µg/m³)
300
250
200
150
100
50
0
1/1/2011
1/2/2011
1/3/2011
1/4/2011
1/5/2011
1/6/2011
1/7/2011
1/8/2011
1/9/2011
1/10/2011
1/11/2011
1/12/2011
PM10 (24-Hour Average)
Ambient Air Quality Limit = 75µg/m³


Middelburg: PM10 (24-Hour Average)2012
FOE = 85
FOE Limit = 4
Concentration (µg/m³)
250
200
150
100
50
0
1/1/2012
1/2/2012
1/3/2012
1/4/2012
1/5/2012
1/6/2012
1/7/2012
1/8/2012
1/9/2012
1/10/2012
1/11/2012
1/12/2012
PM10 (24-Hour Average)
Ambient Air Quality Limit = 75µg/m³

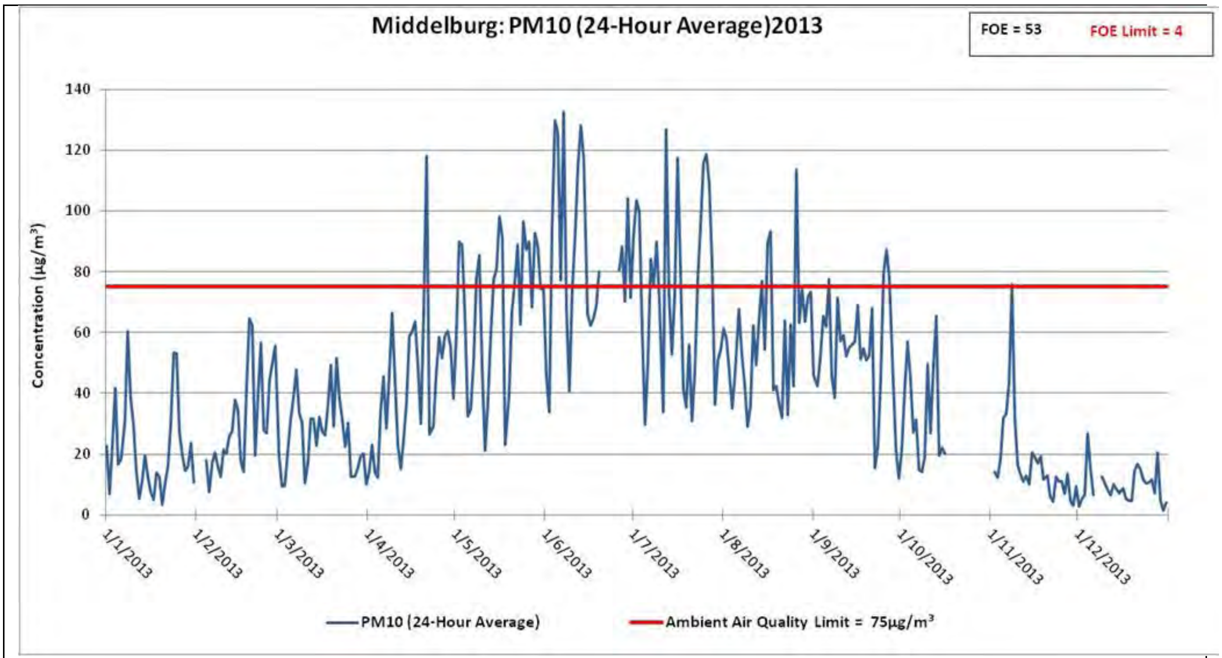
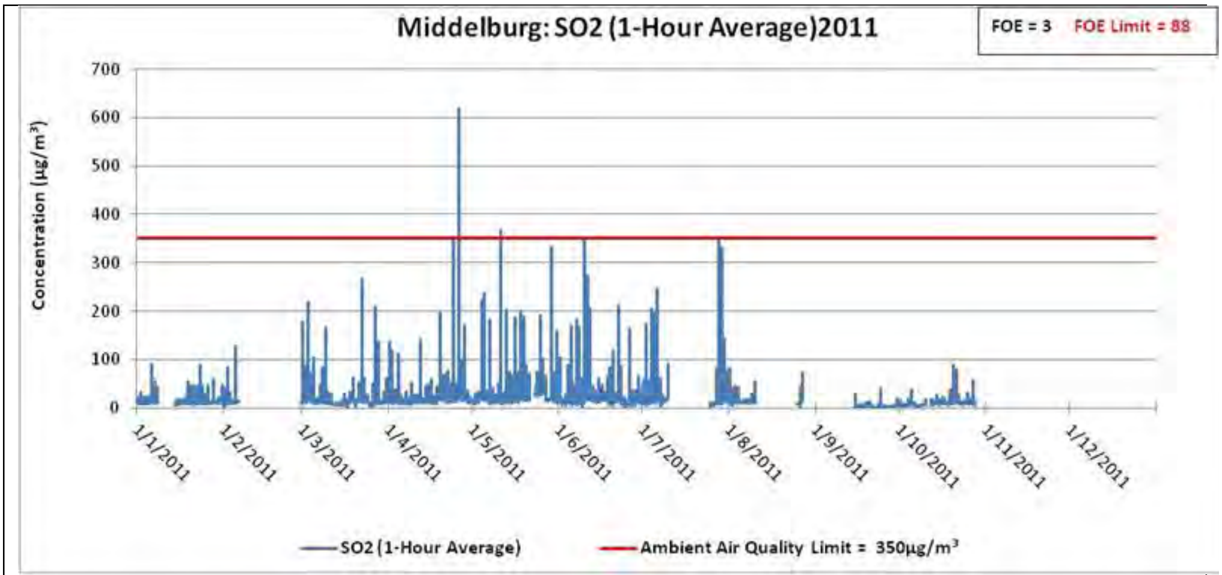


Figure 3-14: PM_{10} 24-hour Ambient data from the Middelburg Monitoring station for 2011 - 2013



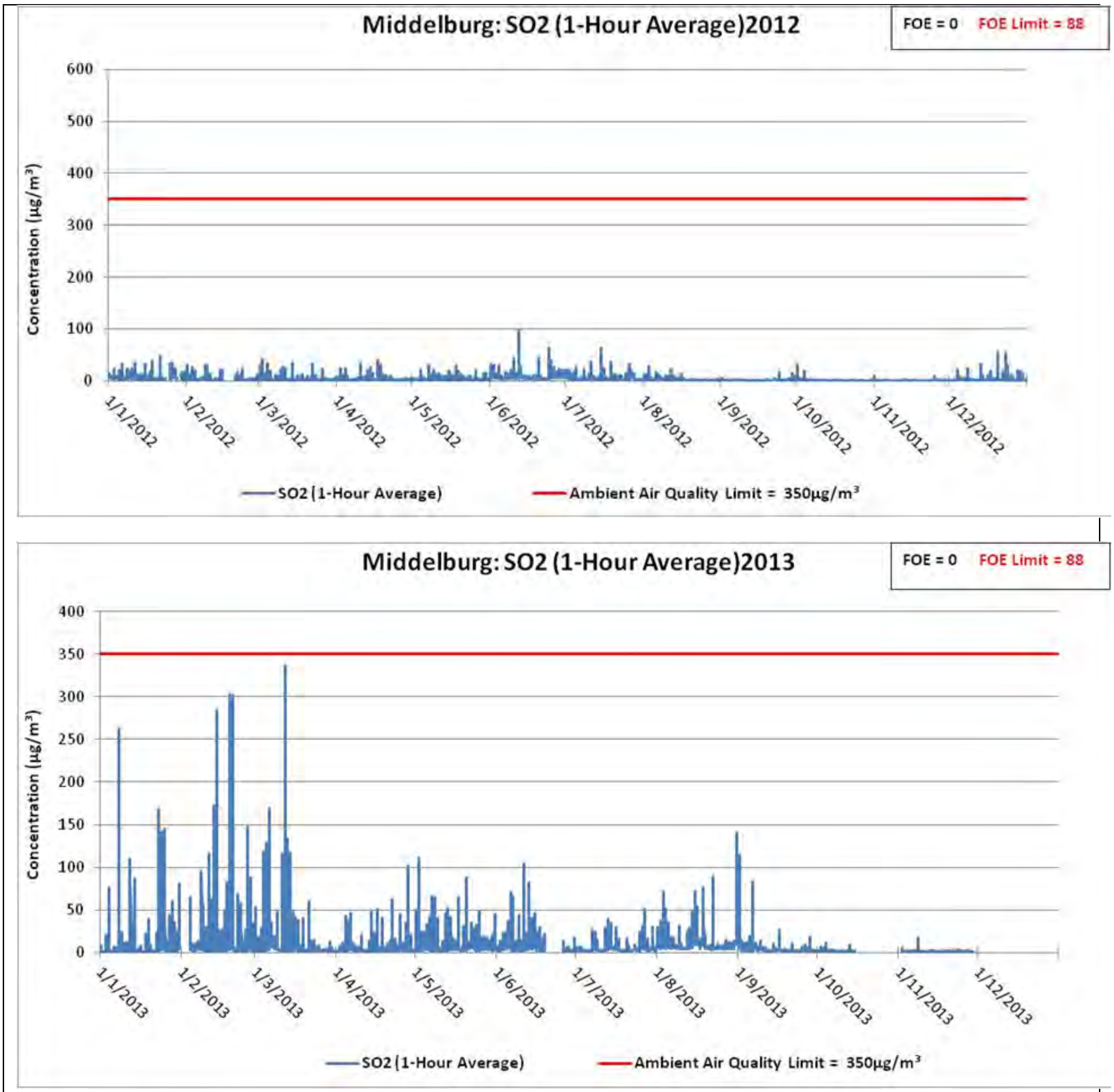
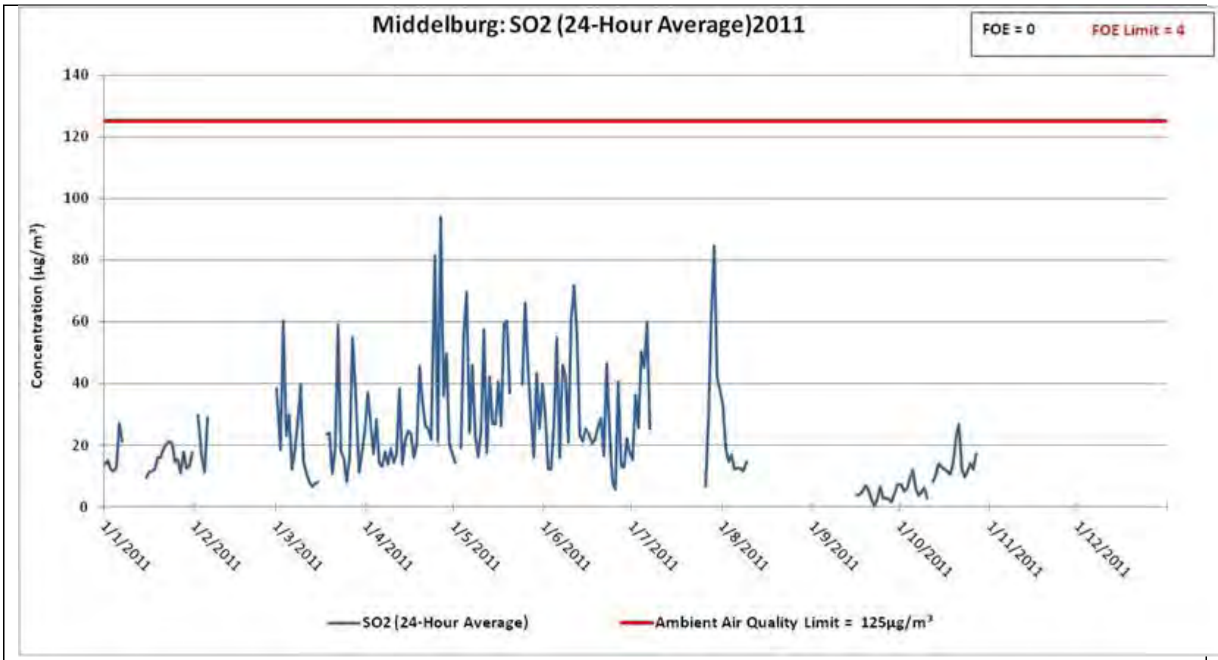
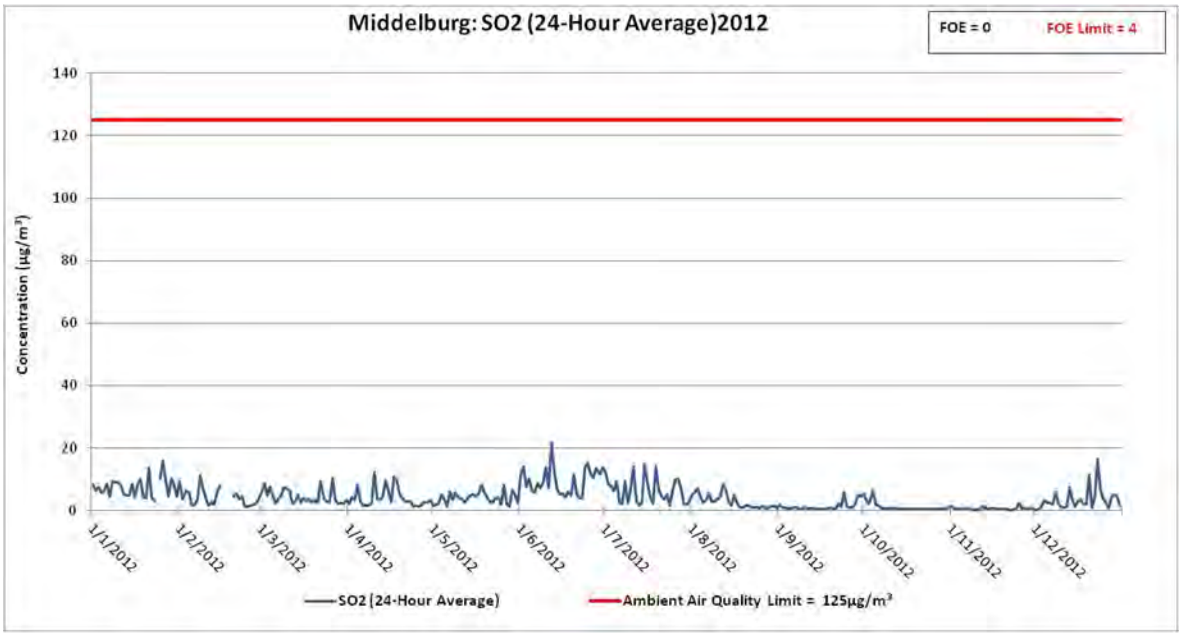


Figure 3-15: SO_2 1-hour Ambient data from the Middelburg Monitoring station for 2011 - 2013


Middelburg: SO2 (24-Hour Average)2011
FOE = 0
FOE Limit = 4
Concentration (µg/m³)
140
120
100
80
60
40
20
0
1/1/2011
1/2/2011
1/3/2011
1/4/2011
1/5/2011
1/6/2011
1/7/2011
1/8/2011
1/9/2011
1/10/2011
1/11/2011
1/12/2011
SO2 (24-Hour Average)
Ambient Air Quality Limit = 125µg/m³


Middelburg: SO2 (24-Hour Average)2012
FOE = 0
FOE Limit = 4
Concentration (µg/m³)
140
120
100
80
60
40
20
0
1/1/2012
1/2/2012
1/3/2012
1/4/2012
1/5/2012
1/6/2012
1/7/2012
1/8/2012
1/9/2012
1/10/2012
1/11/2012
1/12/2012
SO2 (24-Hour Average)
Ambient Air Quality Limit = 125µg/m³

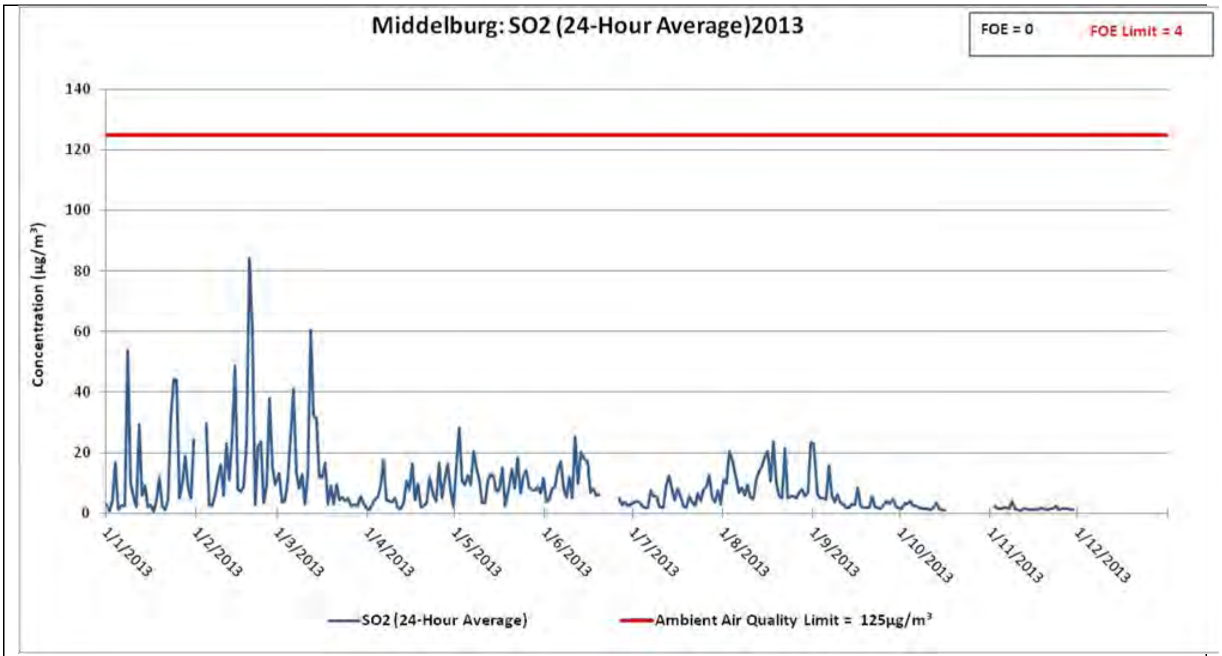
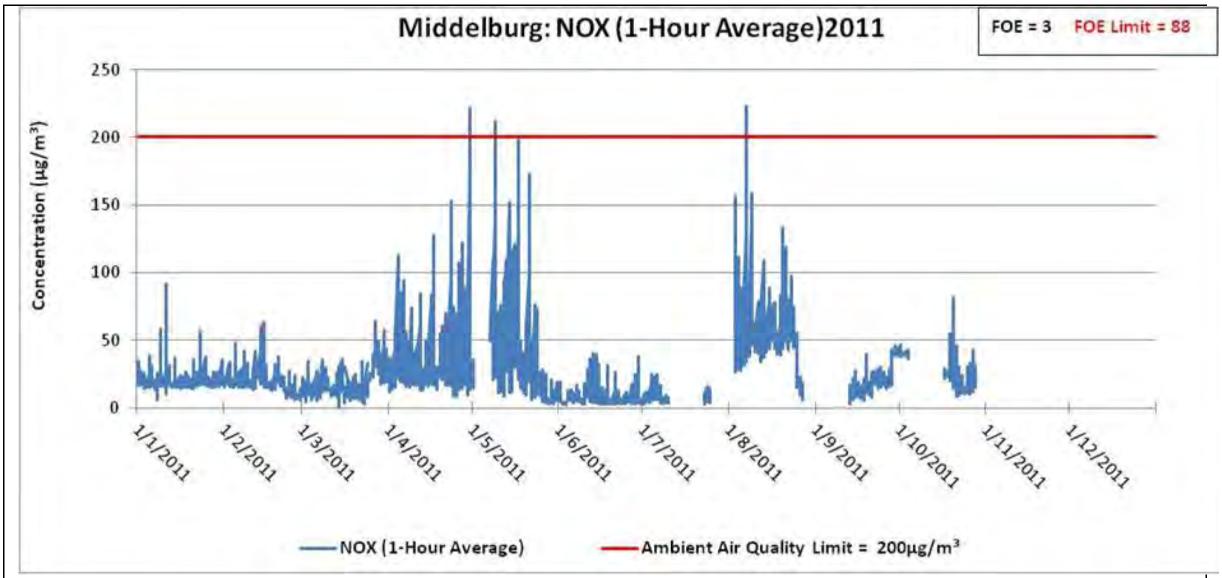


Figure 3-16: SO_2 24-hour Ambient data from the Middelburg Monitoring station for 2011 - 2013



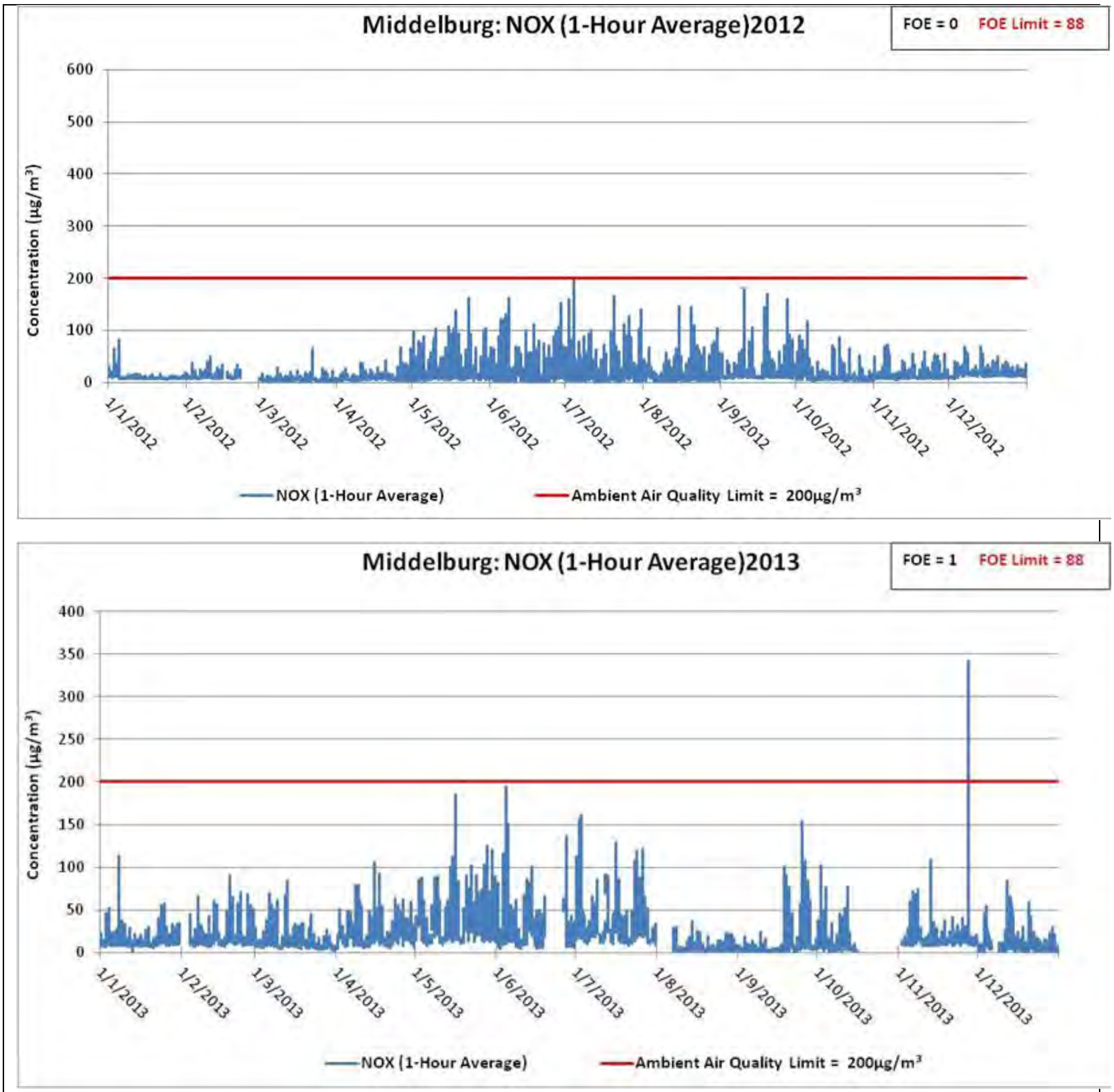
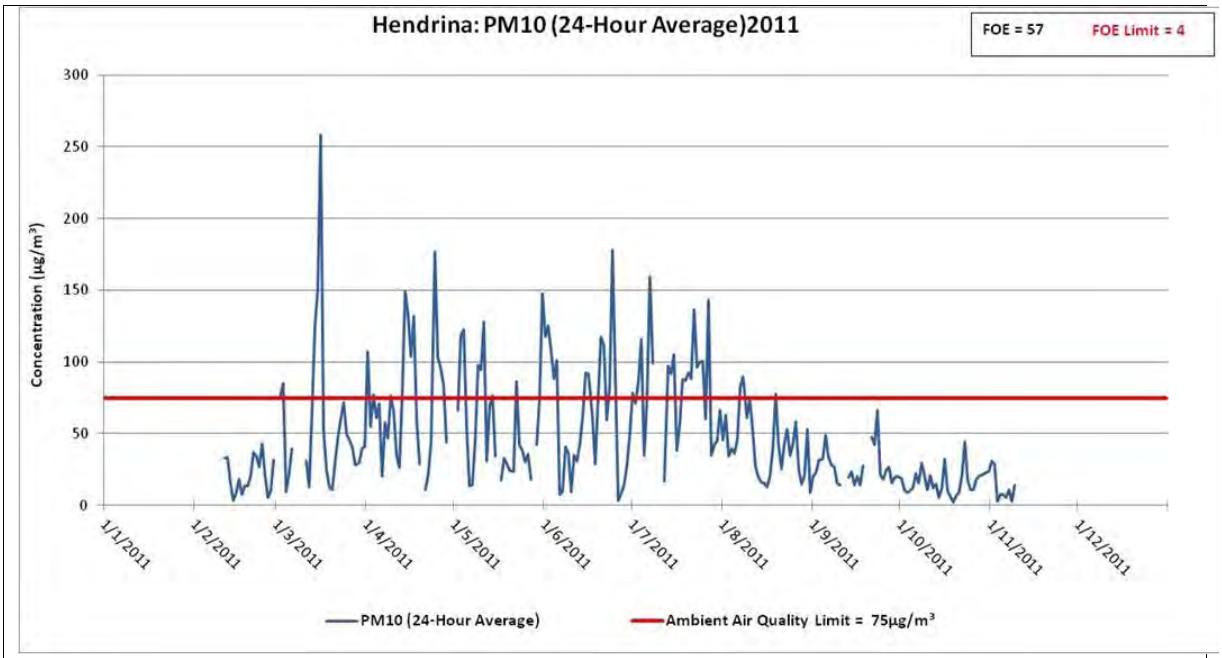
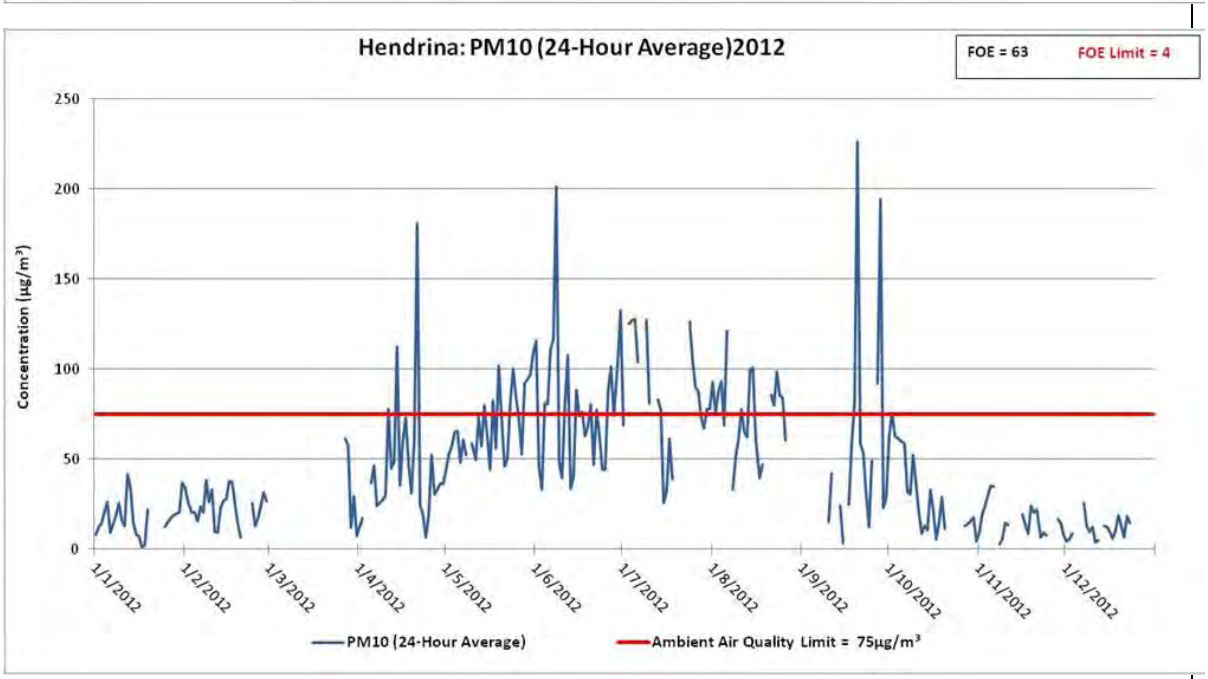


Figure 3-17: NOx 24-hour Ambient data from the Middelburg Monitoring station for 2011 - 2013

3.3.1.5 Hendrina

The PM10 24-hour ambient concentrations for the Hendrina monitoring station had a high number of exceedances for 2011 and 2012, 57 and 63 exceedances each, whilst 2013 only had six exceedances (Figure 3-18). These all fall above the allowable number of exceedances per year (4). The SO2 1-hour ambient concentrations had no exceedances in 2011, whilst 2012 and 2013 had a low number of exceedances, two and 11 respectively (Figure 3-19). The SO2 24-hour ambient concentrations only had one exceedance for 2013 (Figure 3-20). The NOx ambient concentrations had 15 and 17 exceedances for 2011 and 2012, while 2013 had 20 exceedances. These all fall below the allowable number of exceedance per year (88) (Figure 3-21).


Hendrina: PM10 (24-Hour Average)2011
FOE = 57
FOE Limit = 4
300
250
200
150
100
50
0
Concentration (µg/m³)
1/1/2011
1/2/2011
1/3/2011
1/4/2011
1/5/2011
1/6/2011
1/7/2011
1/8/2011
1/9/2011
1/10/2011
1/11/2011
1/12/2011
PM10 (24-Hour Average)
Ambient Air Quality Limit = 75µg/m³


Hendrina: PM10 (24-Hour Average)2012
FOE = 63
FOE Limit = 4
250
200
150
100
50
0
Concentration (µg/m³)
1/1/2012
1/2/2012
1/3/2012
1/4/2012
1/5/2012
1/6/2012
1/7/2012
1/8/2012
1/9/2012
1/10/2012
1/11/2012
1/12/2012
PM10 (24-Hour Average)
Ambient Air Quality Limit = 75µg/m³

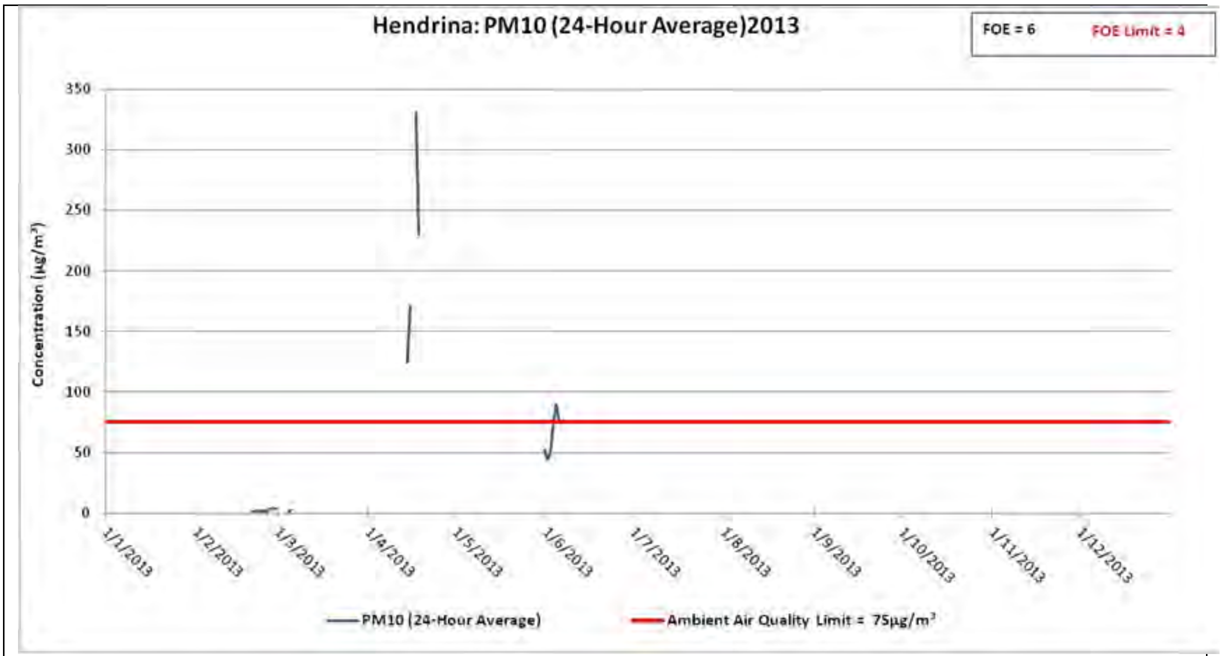
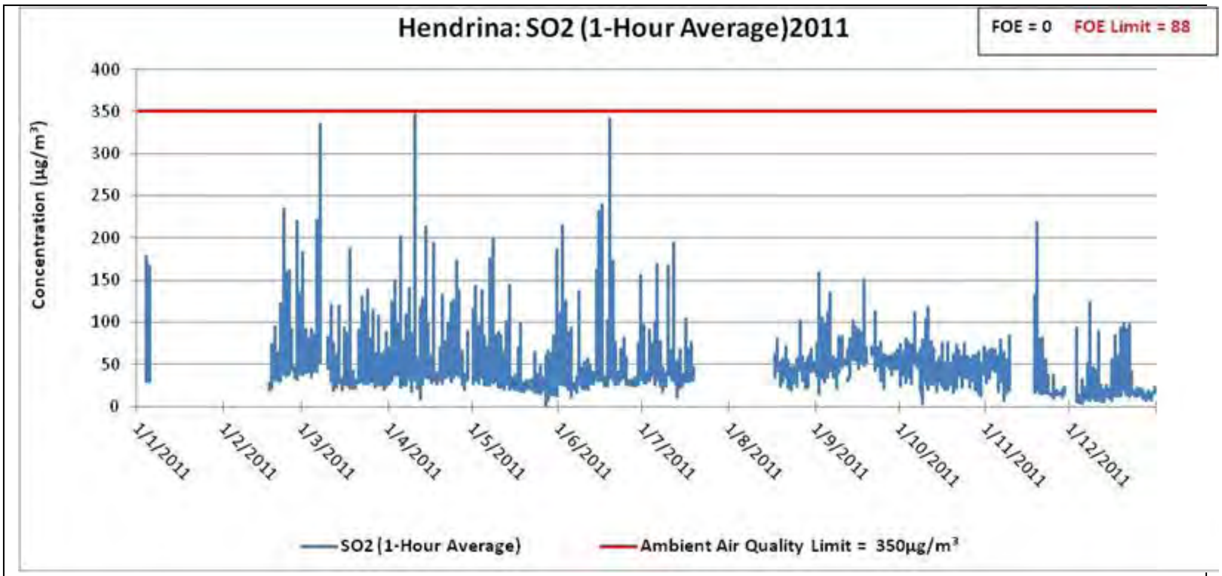
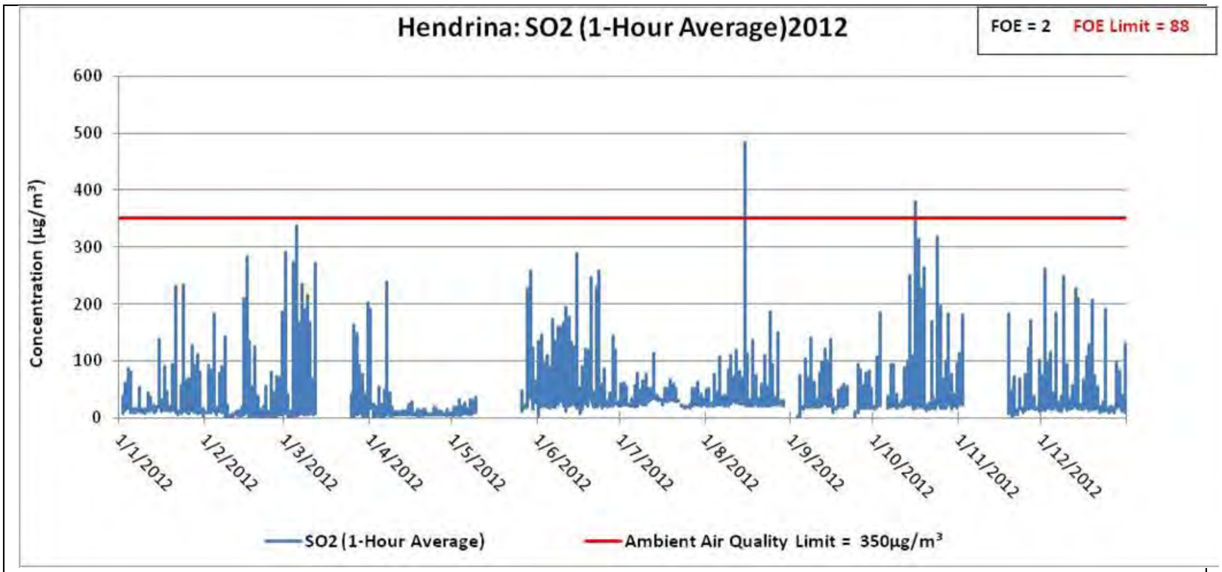


Figure 3-18: PM10 24-hour Ambient data from the Hendrina Monitoring station for 2011 - 2013





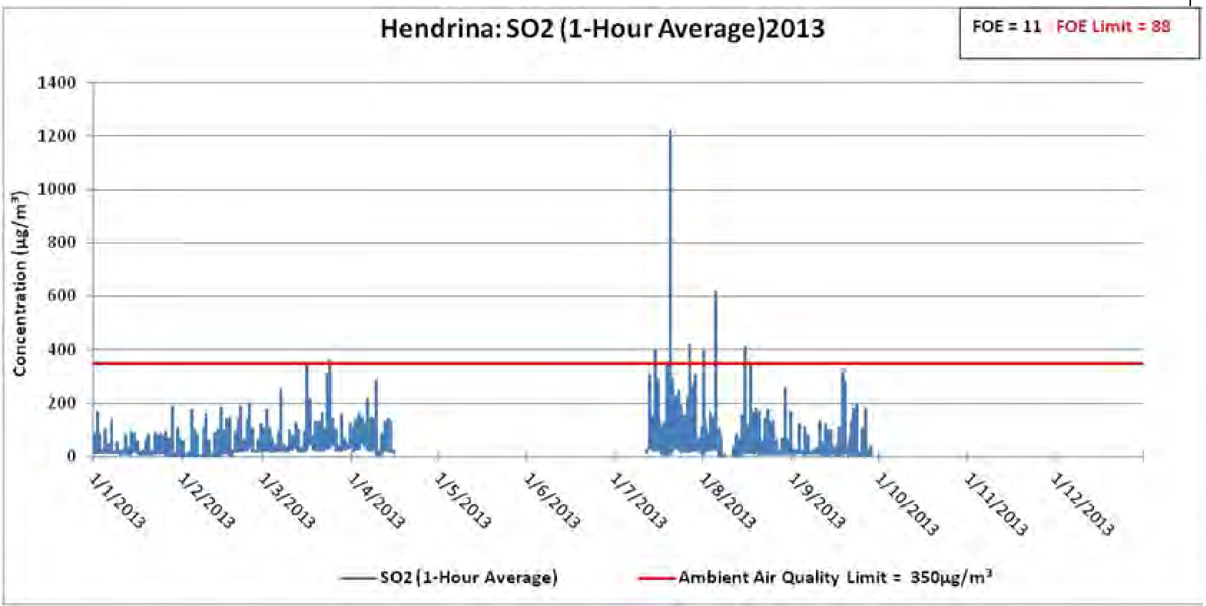
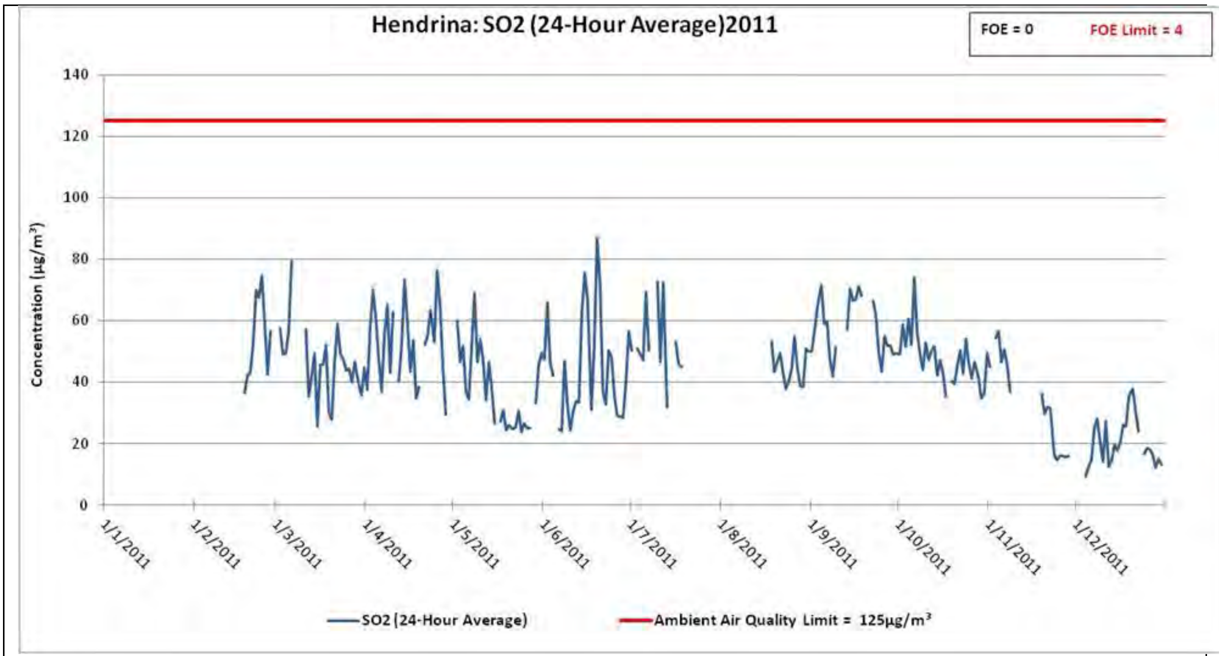
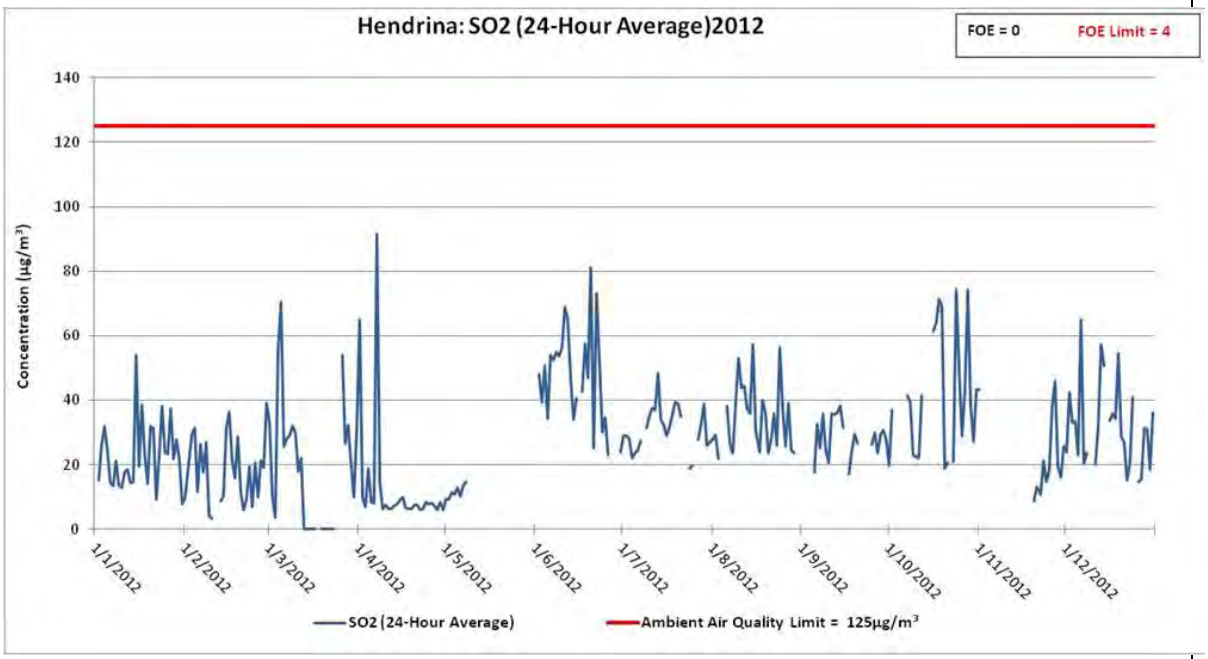


Figure 3-19: SO_2 1-hour Ambient data from the Hendrina Monitoring station for 2011 - 2013


Hendrina: SO2 (24-Hour Average)2011
FOE = 0
FOE Limit = 4
Concentration (µg/m³)
140
120
100
80
60
40
20
0
1/1/2011
1/2/2011
1/3/2011
1/4/2011
1/5/2011
1/6/2011
1/7/2011
1/8/2011
1/9/2011
1/10/2011
1/11/2011
1/12/2011
SO2 (24-Hour Average)
Ambient Air Quality Limit = 125µg/m³


Hendrina: SO2 (24-Hour Average)2012
FOE = 0
FOE Limit = 4
Concentration (µg/m³)
140
120
100
80
60
40
20
0
1/1/2012
1/2/2012
1/3/2012
1/4/2012
1/5/2012
1/6/2012
1/7/2012
1/8/2012
1/9/2012
1/10/2012
1/11/2012
1/12/2012
SO2 (24-Hour Average)
Ambient Air Quality Limit = 125µg/m³

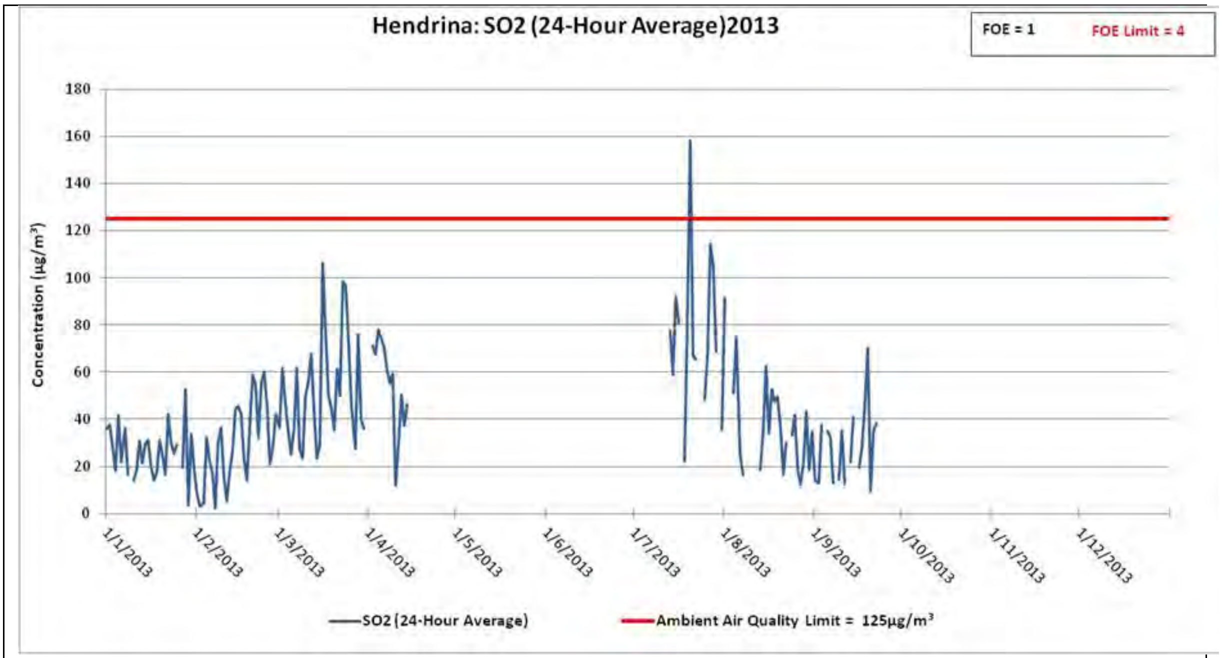
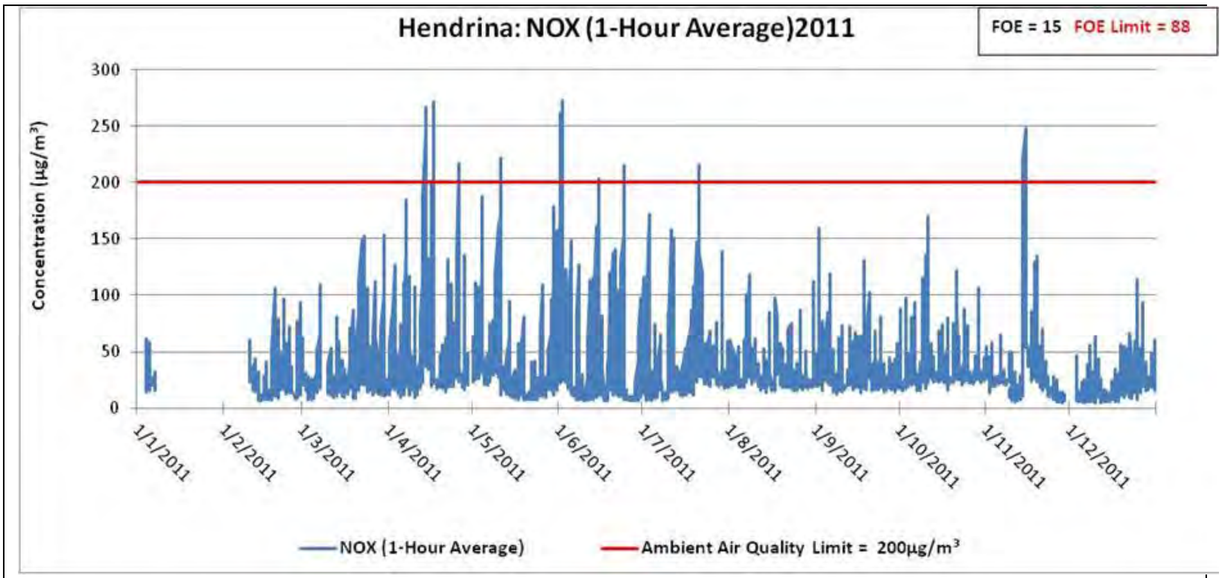
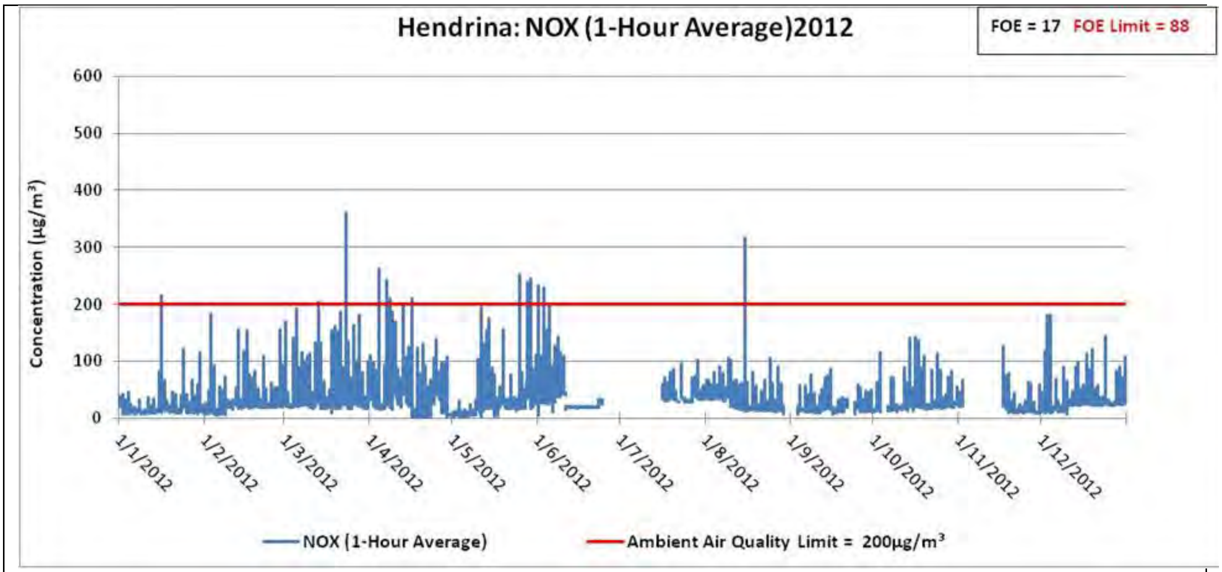


Figure 3-20: SO_2 24-hour Ambient data from the Hendrina Monitoring station for 2011 - 2013





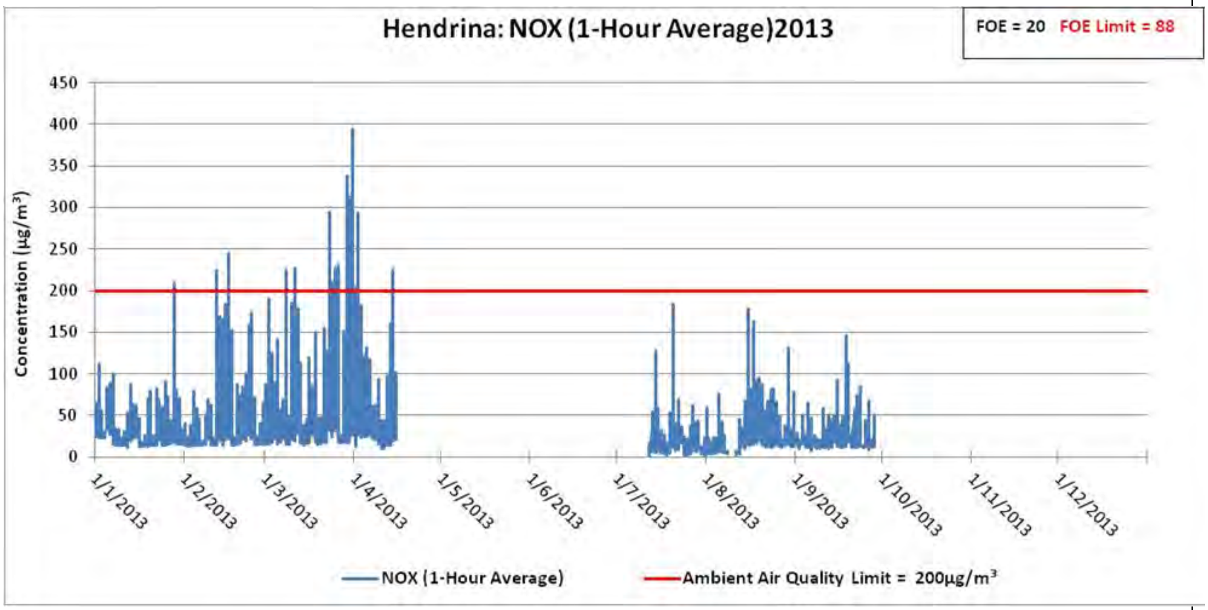
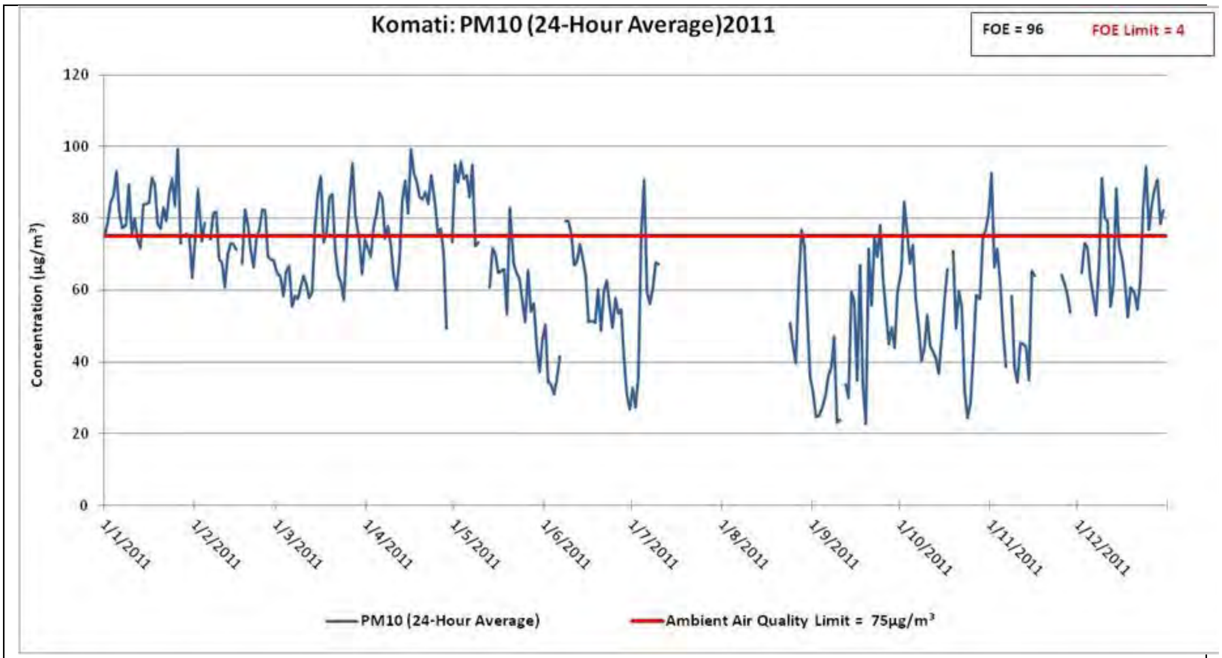
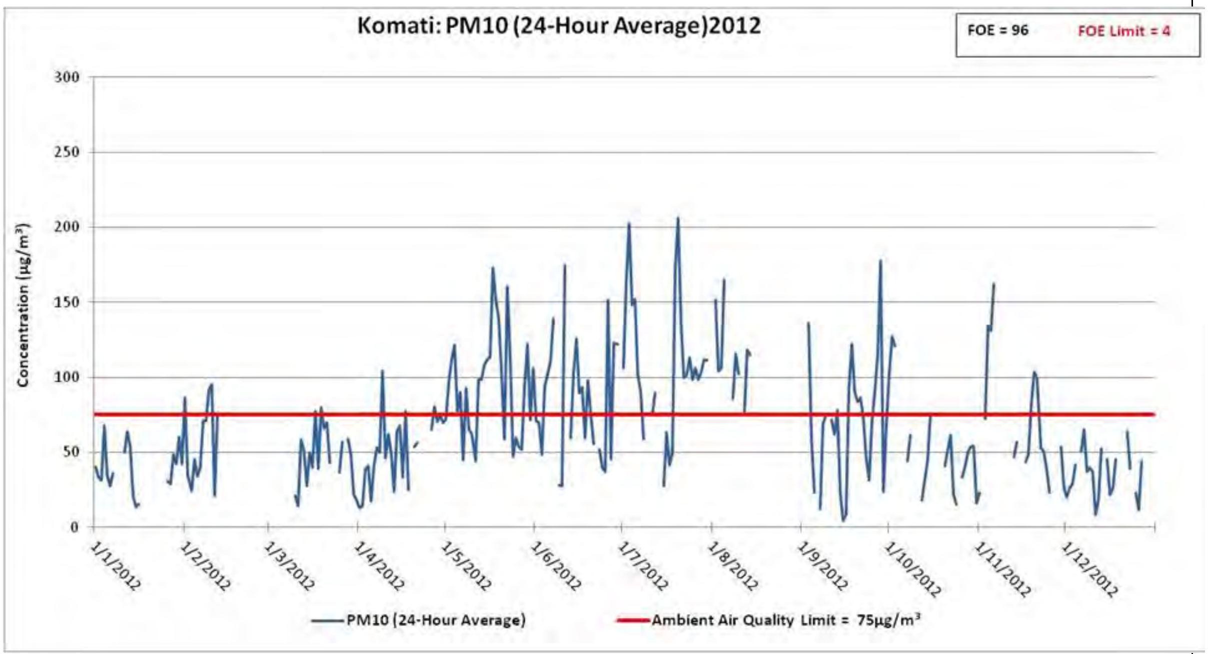


Figure 3-21: NOx 1-hour Ambient data from the Hendrina Monitoring station for 2011 - 2013

3.3.1.6 Komati

The PM10 ambient concentrations for all three years fell above the allowable number of exceedances per year, 4 exceedances allowed. 2011 and 2012 each had 96 exceedances whilst 2013 had 16 (Figure 3-22). The SO2 ambient concentrations all fell below the allowable number of exceedances, 88 (Figure 3-23). The 24-hour SO2 ambient concentrations for Komati monitoring station all fell on or below the allowable number of exceedances, 4. 2011 and 2013 each had one exceedance whilst 2012 had 4 exceedances (Figure 3-24). The NOx ambient concentrations for 2011 had 9 exceedances of the NEMAQA limit, with 2012 and 2013 having 20 and 14 respectively (Figure 3-25).


Komati: PM10 (24-Hour Average)2011
FOE = 96
FOE Limit = 4
Concentration (µg/m³)
120
100
80
60
40
20
0
1/1/2011
1/2/2011
1/3/2011
1/4/2011
1/5/2011
1/6/2011
1/7/2011
1/8/2011
1/9/2011
1/10/2011
1/11/2011
1/12/2011
PM10 (24-Hour Average)
Ambient Air Quality Limit = 75µg/m³


Komati: PM10 (24-Hour Average)2012
FOE = 96
FOE Limit = 4
Concentration (µg/m³)
300
250
200
150
100
50
0
1/1/2012
1/2/2012
1/3/2012
1/4/2012
1/5/2012
1/6/2012
1/7/2012
1/8/2012
1/9/2012
1/10/2012
1/11/2012
1/12/2012
PM10 (24-Hour Average)
Ambient Air Quality Limit = 75µg/m³

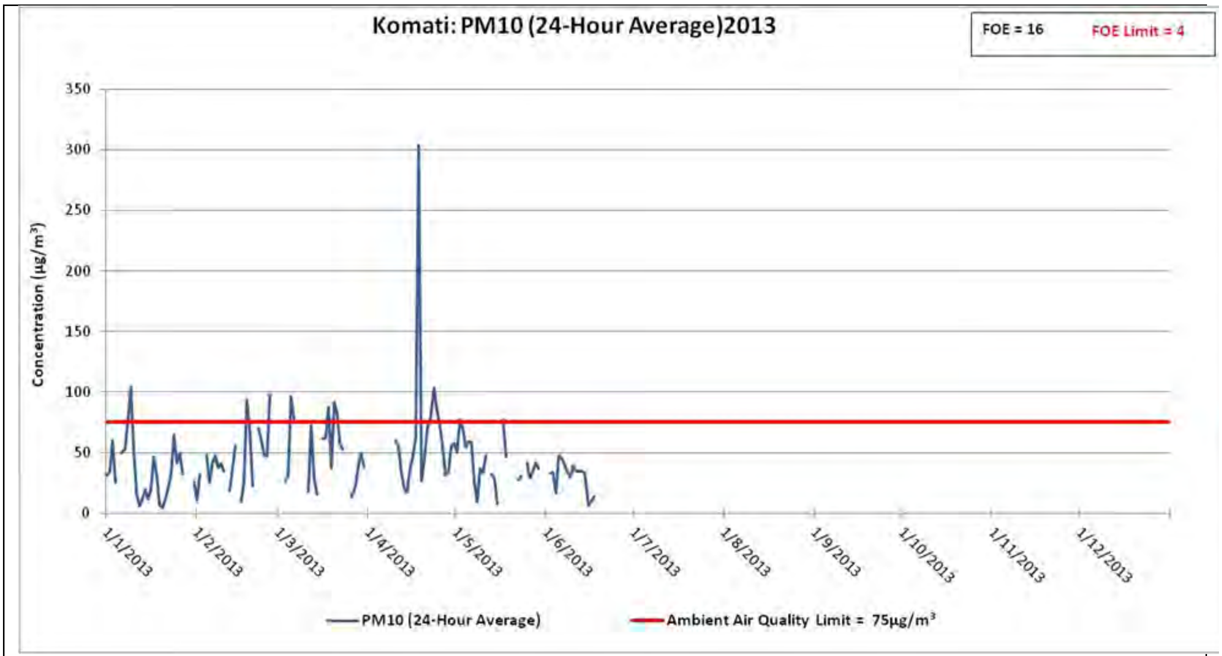
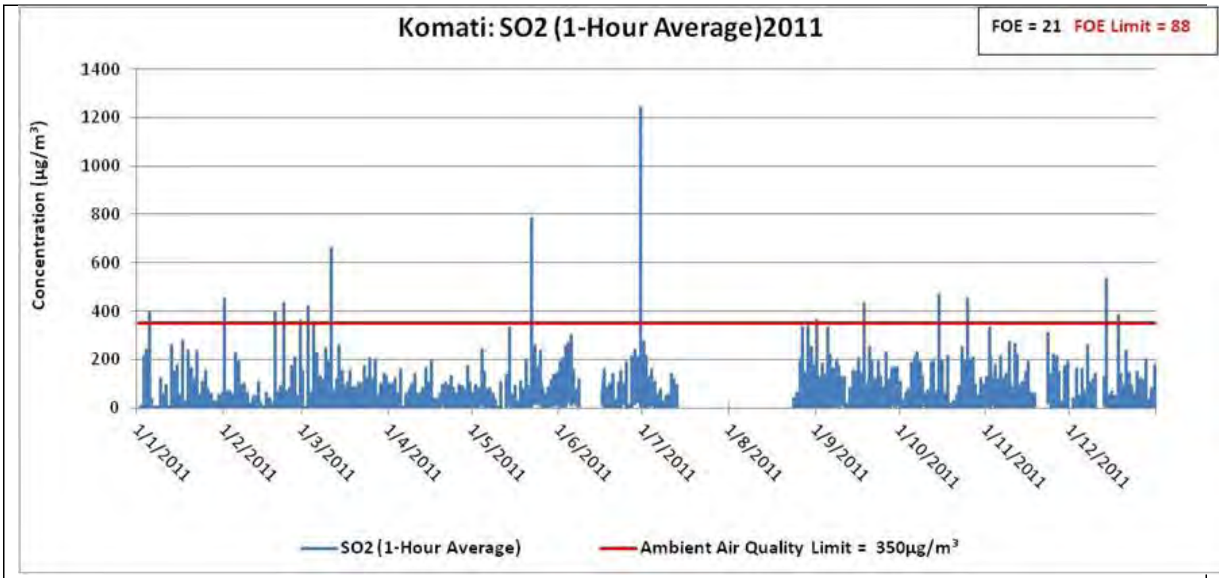


Figure 3-22: PM10 24-hour Ambient data from the Komati Monitoring station for 2011 - 2013



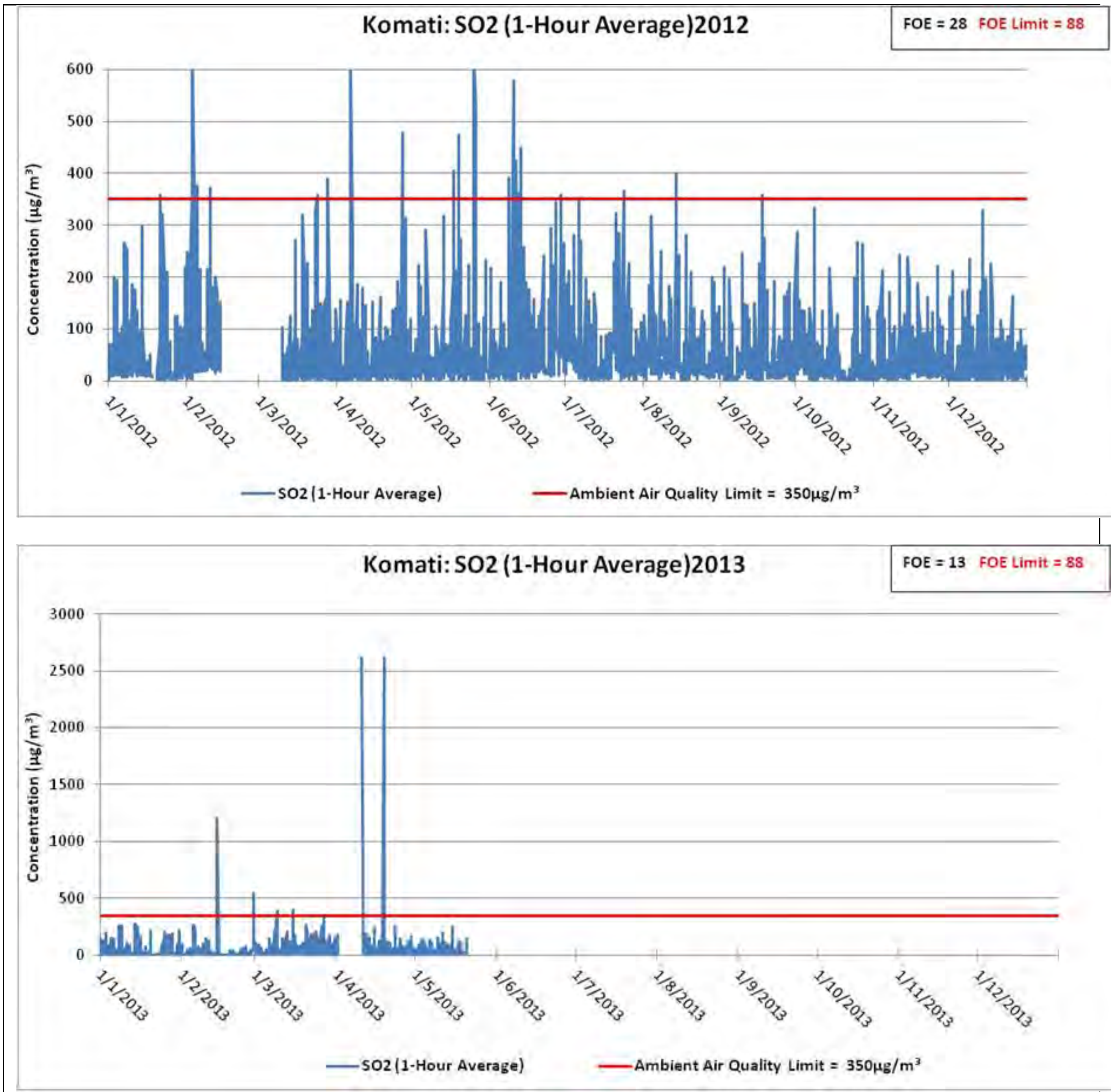
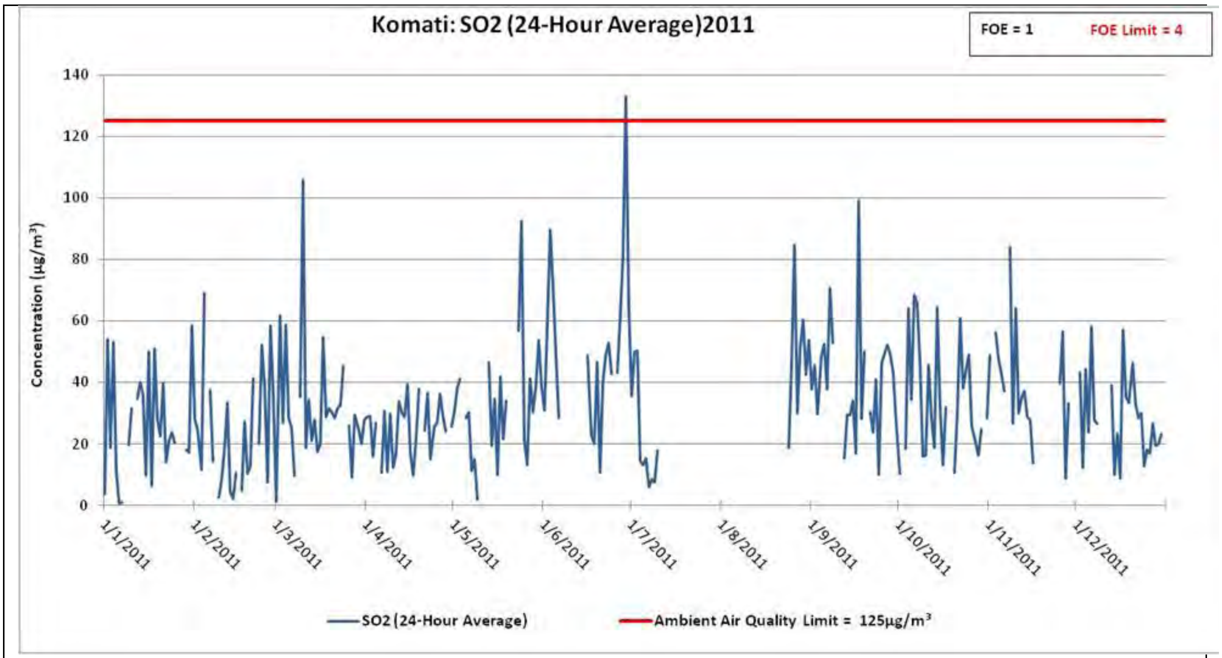
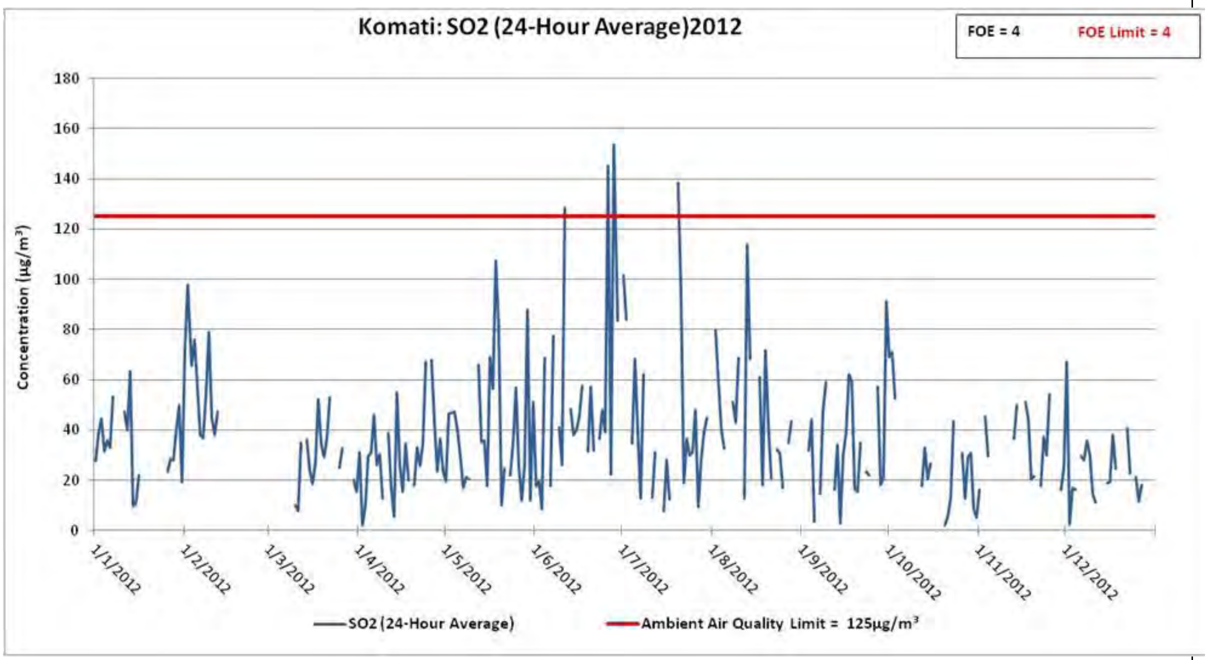


Figure 3-23: SO_2 1-hour Ambient data from the Komati Monitoring station for 2011 - 2013


Komati: SO2 (24-Hour Average)2011
FOE = 1
FOE Limit = 4
Concentration (µg/m³)
140
120
100
80
60
40
20
0
1/1/2011
1/2/2011
1/3/2011
1/4/2011
1/5/2011
1/6/2011
1/7/2011
1/8/2011
1/9/2011
1/10/2011
1/11/2011
1/12/2011
SO2 (24-Hour Average)
Ambient Air Quality Limit = 125µg/m³


Komati: SO2 (24-Hour Average)2012
FOE = 4
FOE Limit = 4
Concentration (µg/m³)
180
160
140
120
100
80
60
40
20
0
1/1/2012
1/2/2012
1/3/2012
1/4/2012
1/5/2012
1/6/2012
1/7/2012
1/8/2012
1/9/2012
1/10/2012
1/11/2012
1/12/2012
SO2 (24-Hour Average)
Ambient Air Quality Limit = 125µg/m³

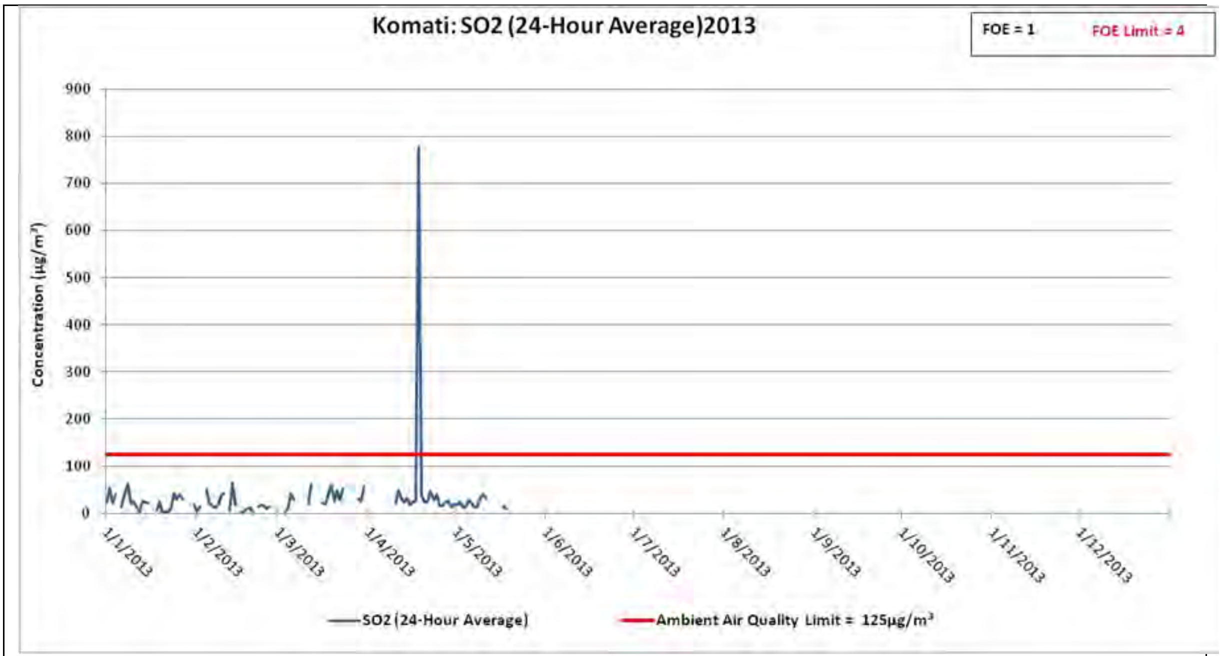
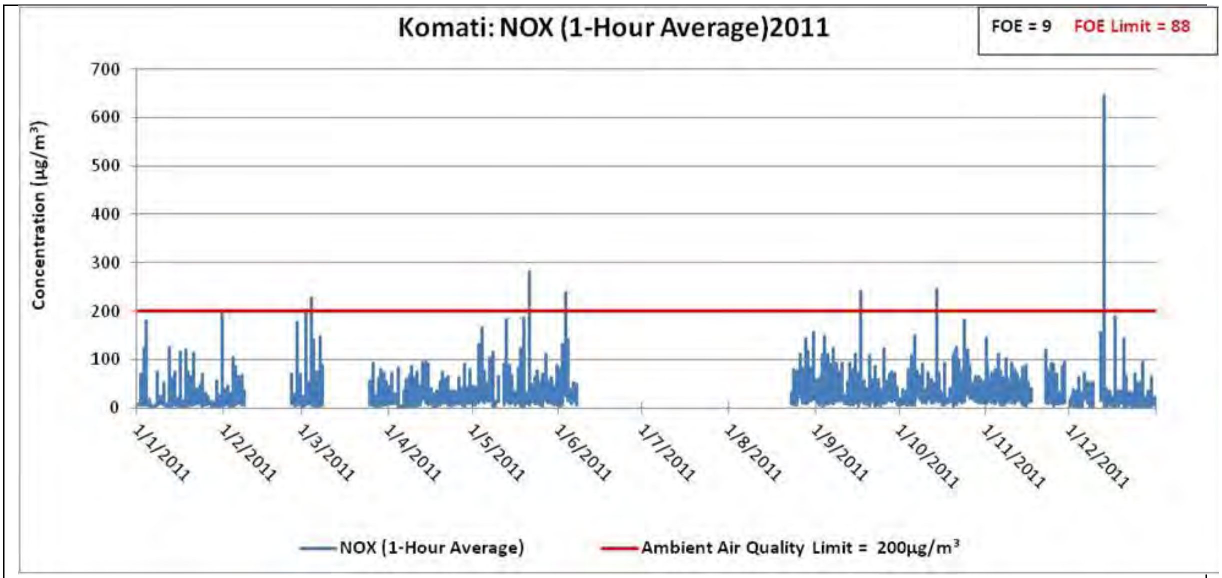


Figure 3-24: SO_2 24-hour Ambient data from the Komati Monitoring station for 2011 - 2013



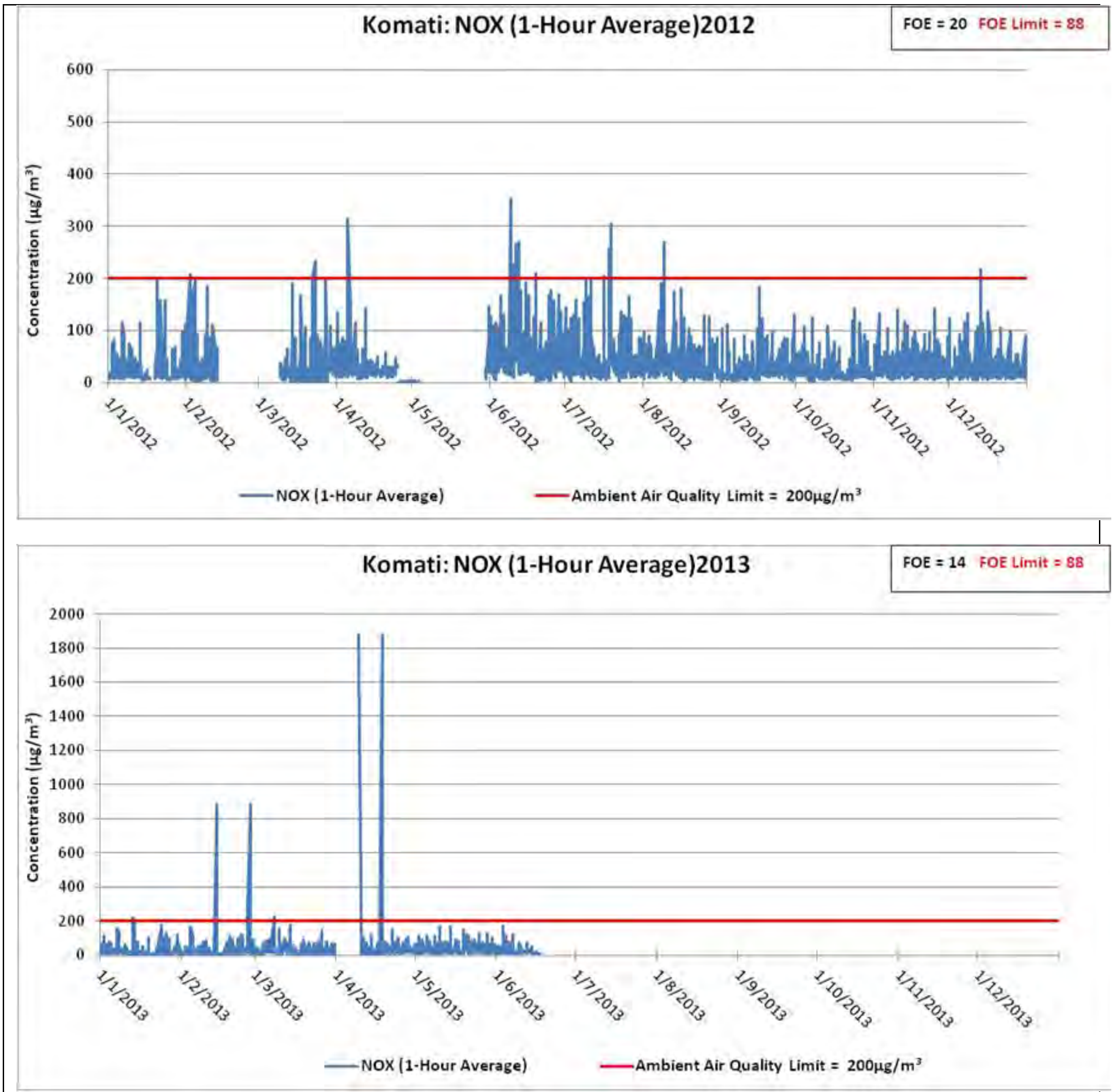


Figure 3-25: NOx 24-hour Ambient data from the Komati Monitoring station for 2011 - 2013

3.4 DISPERSION MODELLING

Dispersion modelling was undertaken using the CALPUFF suite of models to estimate ambient concentrations of SO_2, NO_x and PM_{10} in the NDM for the 3-year period 2011 to 2013. The objective of the dispersion modelling is to identify areas in the NDM where ambient air quality standards are exceeded or may be exceeded. Three-years of monitored and modelled meteorological data were pre-processed as input to the CALPUFF dispersion model. A spatially resolved emission inventory was used to estimate the relative contribution of emission from different sectors. The following sectors were modelled independently:

- Industrial Point Sources
- Residential fuel burning

Industrial point source emissions were assumed to be constant over time. The maximum allowable emissions per the sites' AELs were employed, with the exception of instances where the actual emissions were availed. Notably sources which have applied for postponement of compliance with the Minimum Emission Standards were modelled at the rates indicated in the Atmospheric Impact Reports submitted to the National Air Quality Officer.

Residential fuel burning emissions were modelled with temporal profiles to account for the diurnal and seasonal variations that characterise these sources.

Dispersion modelling was not conducted for other source categories either due to it being impractical to accurately reproduce their variability using dispersion modelling or due to them being low level non-buoyant sources with limited dispersion range. In the case of biomass burning the deficiency of data in respect of the time of occurrence of the fires and their temporal progression prevents accurate modelling thereof.

Dispersion modelling for The Nkangala District Municipality was run at two resolutions, specifically at a 2km resolution for long range cumulative assessment and 300m resolution to zoom in to the areas of focus. The 300m resolution is of particular significance for household fuel burning emissions as these typically have a limited geographical spread but a significant impact in areas of high population density. For the 300m resolution modelling, seven modelling domains were created:

- Delmas
- Doornkop
- Kwazamokuhle
- Thokoza
- Vaalbank
- Vosman
- Watervalboven

These domains are illustrated in Figure 3-26.

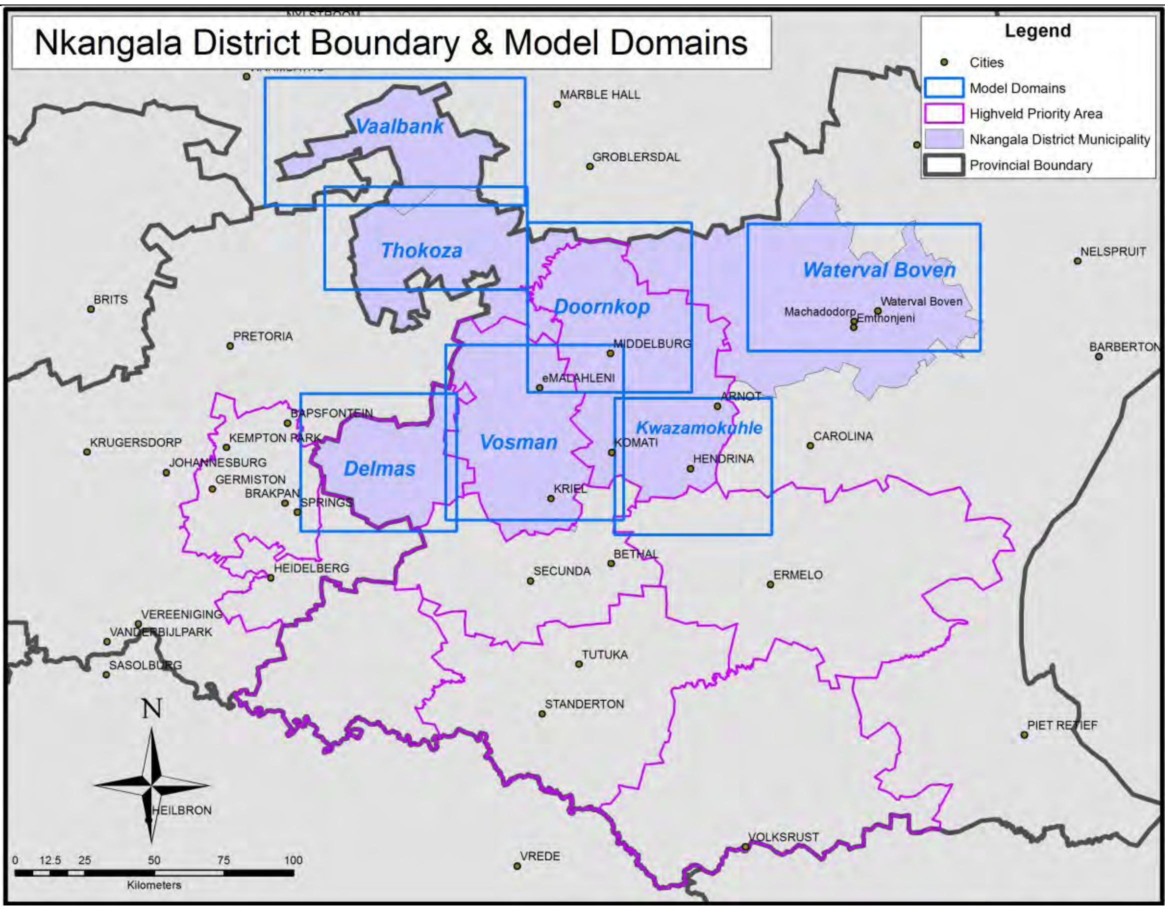


Figure 3-26: Location of the 7 model domains for the NDM

3.4.1 COMPARISON OF MODEL ESTIMATES AND MONITORING DATA

The index of agreement (IOA) is a measure of how well the model predicted variations about the observed mean. It provides a more consistent measure of model performance than the correlation coefficient and an IOA with a value greater than about 0.5 considered to be good (Hurley, 2000). Willmott (1981) was used to provide the IOA calculation methodology.

The performance of model output is evaluated by comparing CALPUFF results, for industrial sources, with observed data from the NDM. The CALPUFF results were compared for the six monitoring stations within the NDM, namely;

- Phola
- Elandsfontein
- Middelburg
- Komati
- Witbank
- Hendrina

A score of zero for IOA indicates little to no agreement between the observed and modelled data. A score below 0.5 for the IOA indicates that there are inconsistencies between the observed and modelled data, whilst a value of 1 indicates a uniform and complete agreement between the two sets of data. The IOA for the pollutants from the CALPUFF results and monitoring stations are provided in Table 3-5.

Table 3-5: IOA Statistics for Monitoring Stations within NDM for 2012

Site	SO_2 1-hr	NOx 1-hr	PM_{10} 1-hr
Elandsfontein	0.41	0.14	0.44
Middelburg	0.43	0.43	0.43
Komati	0.39	0.25	0.41
Witbank	0.34	0.40	0.41
Hendrina	0.48	0.40	0.37

For the 1-hour SO_2 predictions, CALPUFF performed best at Hendrina, Middelburg and Elandsfontein; otherwise the IOA is relatively low. The generally low IOA is attributed mostly to variation in emissions that are not parameterised in the model, but will be captured by the monitoring stations. This is illustrated in Figure 3-27.

The IOA remained in the same interval for the 1-hour NO_x predictions, with an IOA of > 0.4 at four of the six monitoring stations. Middelburg, Hendrina and Witbank CALPUFF results performed the best of the six stations. Whilst, for the IOA for the PM_{10} 1-hour predictions showed similar results, having four of the six stations with an IOA >0.4. Elandsfontein and Middelburg CALPUFF station results performed the best.

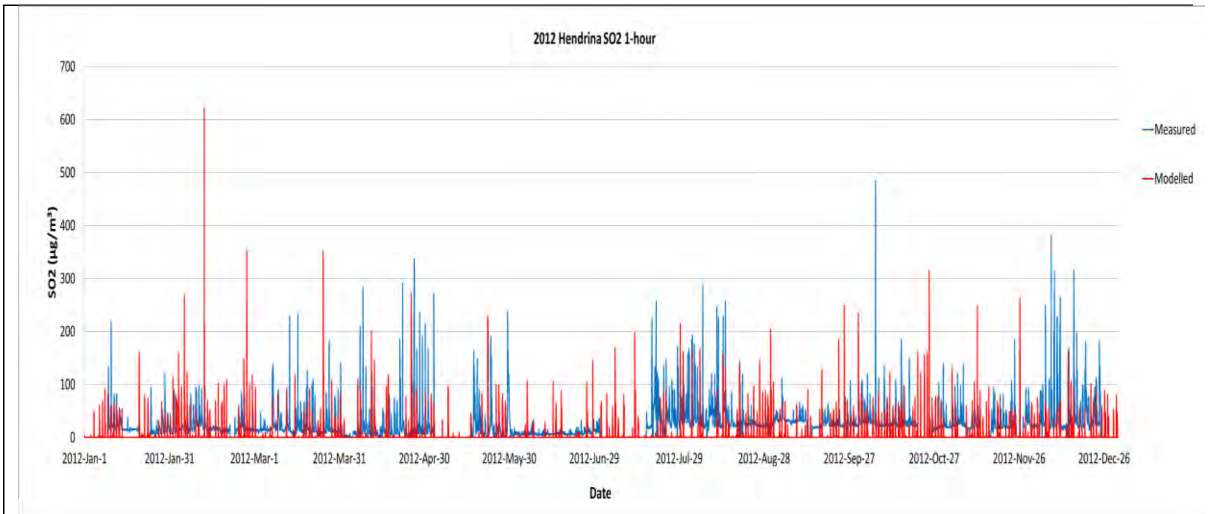


Figure 3-27: Hendrina Monitoring Station CALPUFF results vs measured SO2 hourly averages for 2012

4 AIR QUALITY HOT SPOTS

Where the NAAQS are not met there are potentially significant impacts on human health and the environment. Through review of ambient monitoring data and dispersion modelling output, various areas have been identified where the NAAQS are not met. In particular the risks to human health may be significant where these areas intersect with populated regions.

4.1 HIGHVELD PRIORITY AREA AQMP HOT SPOTS

According to the HPA AQMP, most of the HPA experiences relatively good air quality, but there were nine extensive areas identified where ambient air quality standards for SO_2, NO_2, PM_{10} and O_3 are exceeded. These "hot spots" are illustrated in Figure 20 by the number of modelled exceedances of the 24-hour SO_2 and PM_{10} standards and the 1-hour NO_2 standard, and are confirmed by ambient monitoring data (Figure 4-1 and Figure 4-2). The nine hot spot areas are:

- Inside the NDM
    - eMalahleni
    - Kriel
    - Steve Tshwete
    - Delmas
- Outside the NDM
    - Balfour
    - Ermelo
    - Secunda
    - Ekurhuleni
    - Lekwa

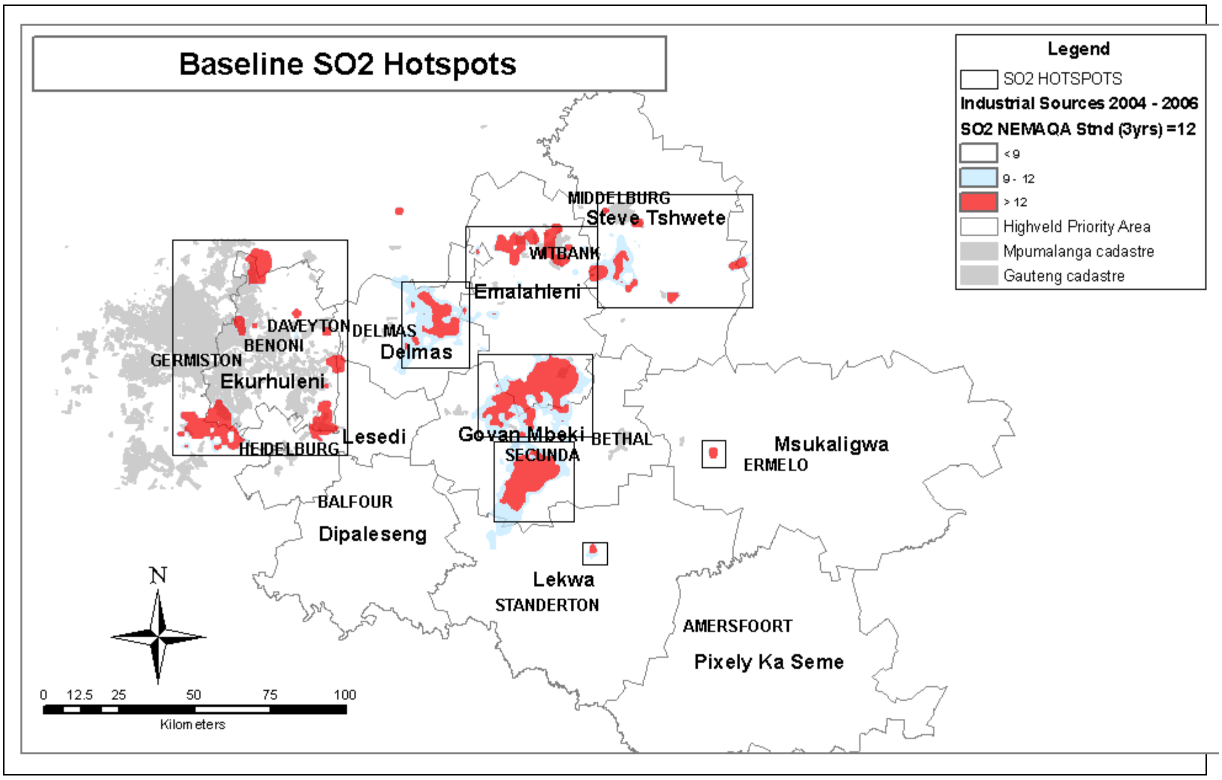


Figure 4-1: Modelled frequency of exceedance of 24-hour ambient SO2 standards in the HPA, indicating the modelled air quality Hot Spot areas

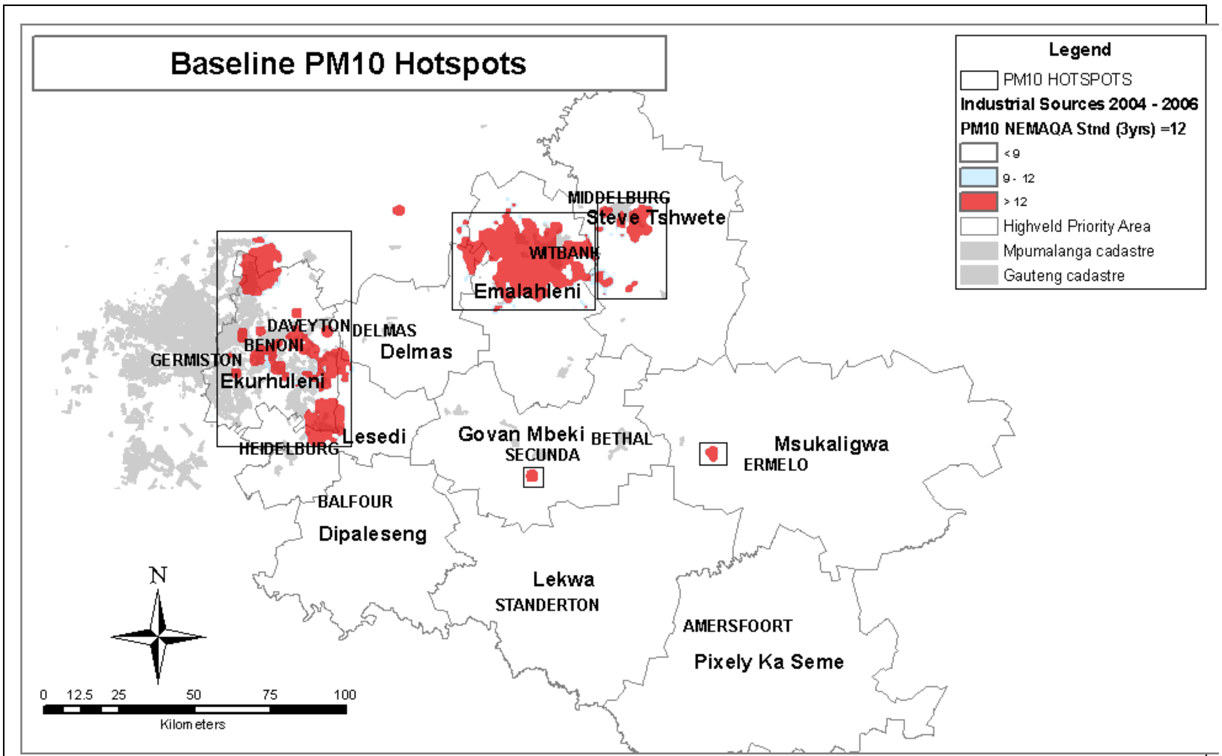


Figure 4-2: Modelled frequency of exceedance of 24-hour ambient PM10 standards in the HPA, indicating the modelled air quality Hot Spot areas

4.2 NDM HOTSPOTS

The air quality hotspots of the NDM are summarised in Table 4-1 with an indication of the pollutants of concern.

Table 4-1: NDM Hotspots

Hot Spot	PM	SO2	NO2
eMalahleni	✓	✓	✓
Middelburg[1]	✓	✓	✓
Komati	✓	✓	✓
Hendrina	✓	✓	✓
Kriel			✓
Hotspot identification is based on measured ambient data and results of dispersion modelling.			

[1] Notably SO_2 from metallurgical operations may be overestimated in the absence of measured emissions data due to the effect wet scrubbers.

The hotspots are depicted in Figure 4-3 to Figure 4-5.

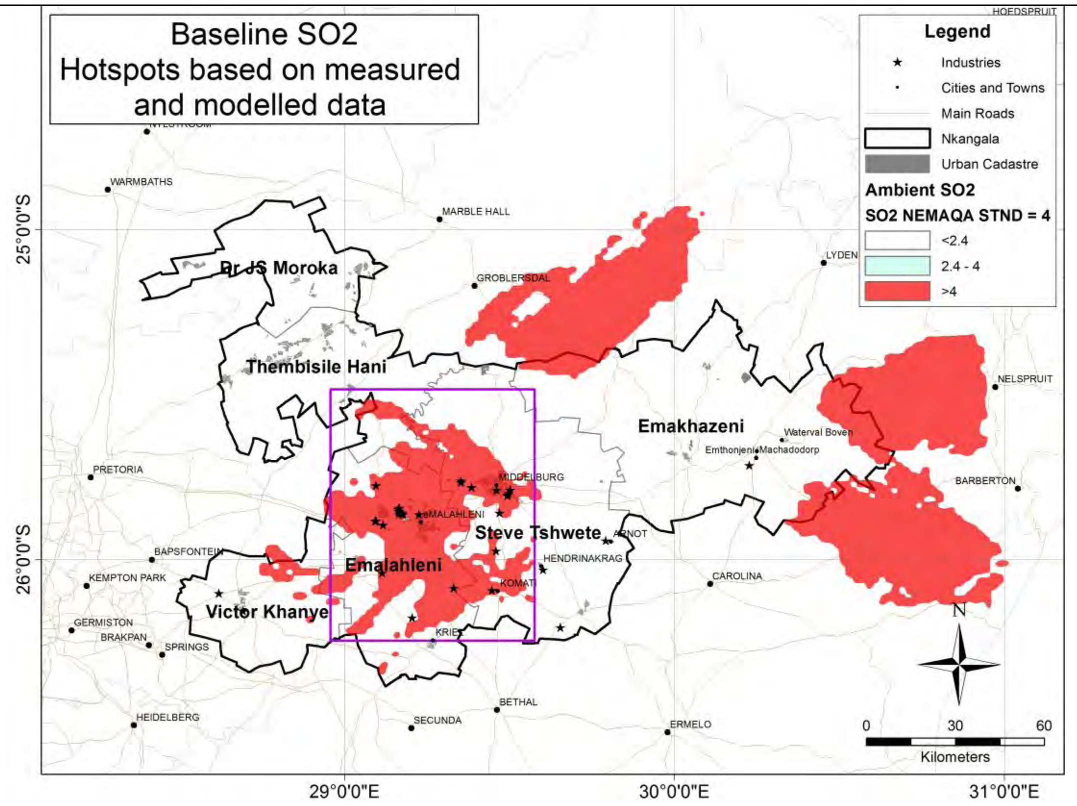


Figure 4-3: SO2 Hotspot

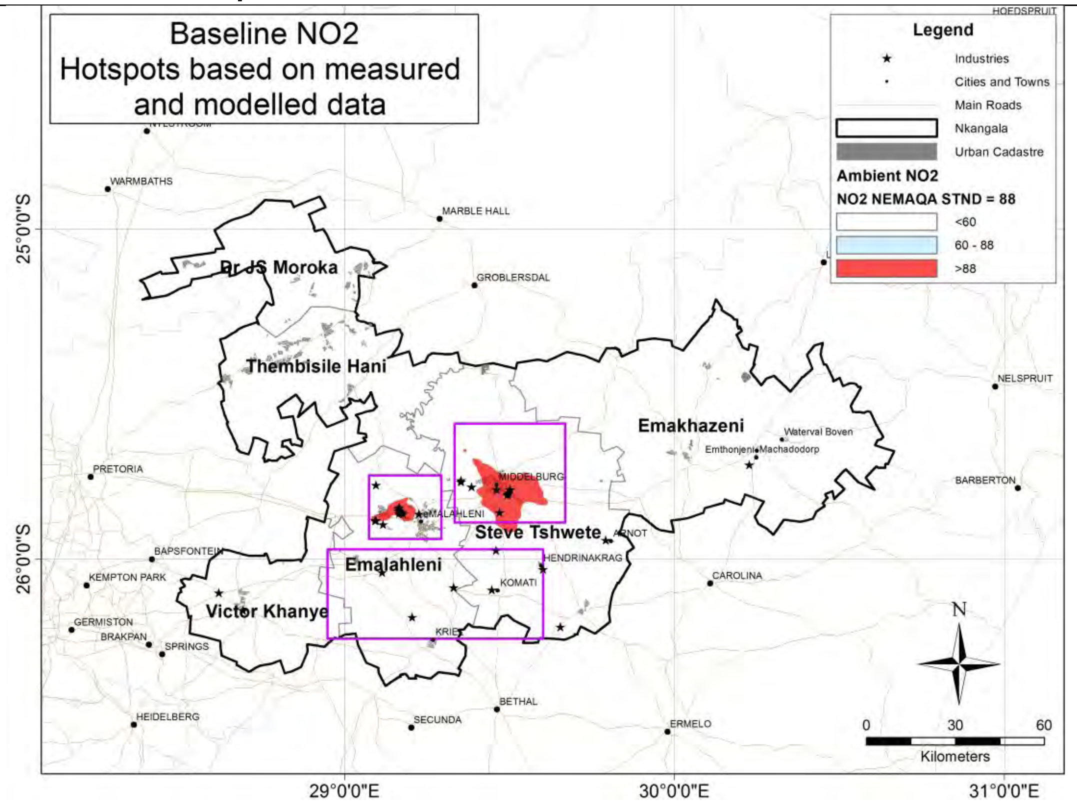


Figure 4-4: NO2 Hotspot

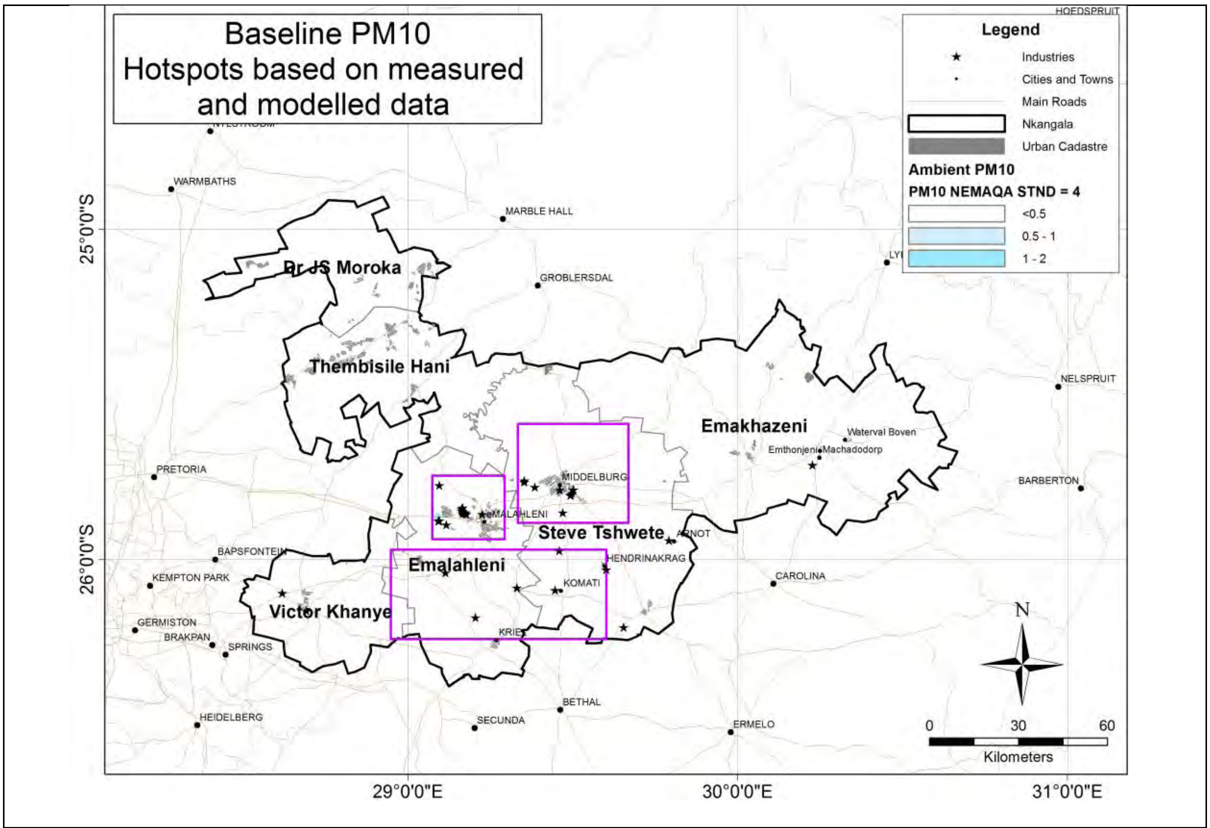


Figure 4-5: PM Hotspot

The hotspots identified for the NDM are notably different to those indicated in the HPA AQMP. It must be noted that the emissions inventory employed for dispersion modelling during the HPA AQMP development was derived prior to the issuing of AELs and thus significant assumptions were necessary in respect of large industrial emissions sources. These gaps in information are to a significant extent resolved by the use of data availed through the Atmospheric Emission Licencing process.

The PM10 dispersion modelling output is significantly lower around the towns of eMalahleni and Middelburg, this is attributed to significantly reduced emissions (and emissions estimates) from brick manufacturing and ferroalloys producers.

5 AIR POLLUTION AND HEALTH IN THE NDM

Human exposure to poor air quality is linked to adverse health effects, ranging from acute symptoms, such as nose and throat irritation, to chronic and debilitating illness and disease. The World Health Organization (WHO) states that chronic respiratory diseases, (i.e. asthma, chronic obstructive pulmonary disorder, and pneumonia), are among the leading causes of mortality and morbidity, and while not all of these adverse health effects are caused by air pollution, they are all exacerbated by the presence of poor air quality (Wright et al 2011).

Atmospheric emissions from numerous sources in the NDM impact on ambient air quality and thus impact on human health and environment. High-density low-income residential areas in particular are affected due domestic fuel burning, and often the proximity of residential areas to significant industrial source emissions amongst others.

This baseline study which informs this AQMP does not undertake an in depth health impact assessment in NDM, however various studies have been undertaken covering the HPA from which information has been gleaned. Although these do not encompass the entire NDM and do cover areas outside of the NDM as well, they provide significant insight into heath risk related to air quality in the NDM.

5.1 SUSCEPTIBILITY OF LOW INCOME COMMUNITIES

Low income communities may be at relatively higher risk to air pollutant related exposure due to several factors, which include exposure to fumes from combustion of fuels for domestic purposes (heating, cooking etc.), in addition to exposure to background pollutant concentrations from other anthropogenic and non-anthropogenic sources. This may be expected to be exacerbated by nutrition challenges and limited availability of health management resources.

Health risk assessments specific to these communities is required in order to quantify the harmful effects of exposure to air pollution in these areas.

5.2 HEALTH RISK REVIEW ACCORDING TO THE HPA BASELINE ASSESSMENT

Health risk estimates that are directly relevant to the NDM were derived in 2002 for major areas, viz. Mpumalanga Highveld (Scorgie et al, 2004). The contributions from the various source activities in the country are also estimated (Scorgie et al, 2004).

5.2.1 SOURCE CONTRIBUTIONS

Source sector contributions to the health risk estimates were estimated for the Mpumalanga Highveld. Power generation activities were estimated to be the primary driver for hospital admissions in Mpumalanga, with a 51% contribution, followed by the Sasol Secunda complex at 17%. Domestic coal burning also made a significant contribution (12%). Similarly, contributions were recorded for mortality outcomes as well. Domestic wood burning was the overwhelming contribution to leukaemia cases in the Mpumalanga Highveld, with vehicle emissions contributing very marginally. Point sources within the NDM with significant individual contributions are Highveld Steel and Vanadium and Sasol Secunda.

5.2.2 EXPOSURE ESTIMATES

Some inference can be made on health risk and exposure of populations in the NDM based on the location of emission exceedances relative to human populations. eMalahleni, and Steve Tshwete are areas with large populations possibly at risk from the ambient concentrations of SO_2 and PM_{10}.

Table 5-1: Health impacts from combustion emissions in 2002 (Scorgie et al, 2004)

Health endpoint		Mpumalanga
Respiratory hospital admissions (due to PM_{10}, SO_2 and NO_2 exposures)		8,685.3
Cardiovascular hospital admissions (due to PM_{10} exposures)		34.5
Premature mortality (due to PM_{10} and SO_2 exposures)		16.8
Chronic bronchitis (due to PM_{10} exposures)		6,440.1
Restricted activity days (RAD, due to PM_{10} exposures)		31,542.8
Minor restricted activity days (MRAD, due to SO_2 exposures)		32,135,642.1
Leukaemia cases (due to 1.3 butadiene and benzene exposures)		6.4
Nasal carcinoma cases (due to formaldehyde exposures)		0.3
Number of children exposed to > 2µg/m3 & hence to potential for IQ point reductions (lead exposure)		0

5.2.3 MORTALITY

Norman et al (2007a) estimated mortality arising from outdoor air pollution in major urban centres using PM_{10} and $PM_{2.5}$ concentrations. Mortality outcomes calculated for South African urban areas estimated that air pollution caused 3.7% of total mortality from cardiopulmonary disease in adults aged 30 years and older, 5.1% of mortality attributable to cancers of the trachea, bronchus, and lung in adults, and 1.1% of mortality from acute respiratory infections in children under 5 years of age (Norman et al, 2007a). Further detail is included in Table 5-2.

Table 5-2: Burden of disease relating to mortality outcomes from outdoor air pollution (Norman et al, 2007a)

Related health outcomes	Attributable deaths (in individuals)	Attributable years of life lost (in years)
Lung cancer (adults 30+years)	350	3604
Cardiopulmonary disease (adults 30+years)	4222	36423
Asthma	237	2644
Acute respiratory infections (children 0-4 years)	65	2193
Lower respiratory infections	64	2144
Upper respiratory infections	1	45
Total	4637	42219
% of total burden	0.9	0.4

The largest contribution to the attributable-burden was from cardiopulmonary disease, indicating the significance of air pollution impacts on the cardiovascular system including hypertension, heart disease, stroke, asthma and other respiratory diseases. In addition, the annual averages of PM concentrations determined in the study broadly demonstrate excessive risk levels for individuals residing in urban areas as health-based standards were exceeded. This relationship highlights the importance of health-based standards in air quality management and continual monitoring of pollutant concentrations.

5.2.4 CHRONIC LUNG DISEASE

Chronic lung disease includes largely chronic obstructive pulmonary disease (COPD) and asthma, with increasing prevalence in developing countries. These conditions place significant demands on health services and medication costs, with COPD listed as the fifth most common cause of death worldwide in 2001 (SADHS, 2003). In South Africa, respiratory disease, excluding tuberculosis, was ranked as the seventh most important cause of disability-adjusted life years in 2000, with asthma ranked as the 13th highest cause of death, and 18th highest cause of years of life lost in 2001 (SADHS, 2003). Asthma prevalence and mortality was also more closely linked in South Africa, indicating the need for better control and management of the disease.

The findings from the SADHS regarding COPD and asthma were based on self-reported symptoms and were presented with data for 1998 and 2003 for comparison purposes (Table 5-3). Asthmatic symptoms, as reported, showed a greater overall prevalence in women, although a contradictory change in prevalence was reported across genders from 1998 to 2003. An average prevalence showed that overall asthmatic conditions remained unchanged in South Africa. A decrease in chronic bronchitis symptoms was also noted, with further notes made on the influence of education and tobacco smoking. Abnormal peak flow was more prevalent in the 2003 survey, with some technical error recorded. Higher prevalence of abnormal peak flow was noted for women and for non-urban residents as well. Special note was made of the life-long impact of tuberculosis, as well as the need for a life-course consideration in the delivery of health services, where consistent care and medical and other needs are provided for from childhood to adulthood.

Table 5-3: Adult health indicators from SADHS 1998 and 2003 (SADHS, 2003)

Respiratory condition (% of adults 15+ years)	1998		2003	
	Men	Women	Men	Women
Symptoms of asthma	6.7	8.6	7.2	8.1
Symptoms associated with chronic bronchitis	2.3	2.8	2.3	2.0
Abnormal peak flow	4.0	4.1	7.9	10.9

5.2.5 INDOOR AIR POLLUTION AND HEALTH

Exposure to indoor air pollution was associated with a number of health outcomes, including COPD, lung cancer, nasopharyngeal cancer, tuberculosis, cataracts, asthma, birth defects, and acute lower respiratory infections (ALRI) among children younger than 5 years (Norman et al, 2007b). ALRIs were the leading cause of death of children under 5 years worldwide, and similarly, fourth highest in South African children.

The total ALRI burden on children under 5 years was 24% in 2000, attributable to indoor air pollution from household fuel use (Norman et al, 2007b). Similarly for COPD, the female population experienced more than double the male attributable burden. Lung cancer burden was relatively minor from indoor air pollution as a result of household fuel use. Indoor air pollution from household fuel use was responsible for 2 489 deaths, or 0.5% of the total health burden on the individual, and resulted in the loss of 60 934 disability adjusted life years, or 0.4% of the total burden (Norman et al, 2007b). Details on burdens of disease and health outcomes are provided in (Table 5-4).

The study also observed high mortality rates in African male and female populations, with the Coloured population showing far lower rates, with a minimal mortality rate in Indian and White populations. African females were at higher risk than males. In the study, mortality and life years lost were almost exclusively experienced in the African population. The ALRI burden contributed the greatest to the total burden of disease, indicating the significant impact on young children from indoor air pollution.

Table 5-4: Burden of disease relating to health outcomes from indoor air pollution (Norman et al, 2007b)

Outcome	Population attributable fraction (%)	Deaths (in individuals)	Disability adjusted life years (in years)
Acute lower respiratory infections (children 0-4 years)	23.7	1428	48 579
Chronic obstructive pulmonary disease (adults 30+ years)	23.2	1024	11 877
Lung cancer (adults 30+ years)	2.4	37	479
Total (% of total burden)		2 489 (0.5)	60 934 (0.4)

5.3 HEALTH RISK ANALYSIS RELATING TO ESKOM OPERATIONS

An air pollution compliance assessment and health risk analysis of cumulative operations of current, return to service and proposed Eskom power stations located within the Mpumalanga and Gauteng provinces was undertaken by Scorgie et al in 2006 (Report No.: APP/06/ESKOM-05 Rev 1.0).

The main conclusion reached is that current baseline Eskom Power Station emissions are associated with significant non-compliance with relevant ambient sulphur dioxide limits even in the absence of contributions by "other sources". Ambient PM10 and NO_2 concentrations due exclusively to current baseline Eskom Power Station emissions are potentially within acceptable ranges, with the need for reduction being dependent on the potential which exists due to cumulative concentrations resulting from "other sources".

With respect to future baseline Eskom Power Station emissions the main conclusion reached is that these stations are associated with significant non-compliance with relevant ambient sulphur dioxide limits even in the absence of contributions by "other sources". The magnitude, frequency and spatial extent of such non-compliance are predicted to increase significantly when compared to current baseline emissions. Increased frequencies of exceedance over the Vaal Triangle and Witbank areas are predicted to occur as a result of the increase in future emissions from existing Eskom Power Stations. Ambient PM10 and NO2 concentrations due exclusively to future baseline Eskom Power Station emissions are potentially within acceptable ranges.

Although the assessment covers an area larger than the NDM specifically, the findings thereof are of significance given that there are seven cola fired Eskom power stations at full operation in the NDM and an eighth large power station in process of ramping up. The study noted that current emissions from Eskom and other sources quantified during the study were predicted to result in 550 deaths/year and approximately 117

200 respiratory hospital admissions per year. The main findings with regard to pollutant and source contributions to such risks were as follows:

- Contribution of pollutants - Exposures to PM10 were estimated to be responsible for 69% of the total non-accidental mortality and 90% of the respiratory hospital admissions. Sulphur dioxide was predicted to be responsible for 28% of the total non-accidental mortality and 5% of the respiratory hospital admissions. Nitrogen dioxide was found to be the least significant of the three pollutants considered in terms of total morbidity and mortality, accounting for only 3% of the total non-accidental mortality estimated and 4% of the respiratory hospital admissions.
- Household fuel burning was predicted to result in the most significant health risks, accounting for 50% of the total non-accidental mortality cases (287 deaths/year) and 50% of the respiratory hospital admissions (~58 000 cases/year) predicted.
- Industrial sources, including non-Eskom power generation, represented the next most significant source – responsible for 34% of the mortalities and 35% of the morbidities.
- Current Eskom Power Stations were cumulatively calculated to be responsible for 17 non-accidental mortalities per year and 661 respiratory hospital admissions, representing 3.0% and 0.6% of the total non-accidental mortalities and respiratory hospital admissions projected across all sources.
- Vehicle exhaust emissions are estimated to contribute 9% of the estimated mortalities and 11% of estimated respiratory hospital admissions.
- Power Stations contributing most significantly to risks related to Eskom's current operations were identified as being Kendal (~61%), Matla (~20%), Lethabo (8%) and Kriel (~7%). Together these four power stations contributed over 95% of the non-accidental mortality cases and respiratory hospital admissions predicted to occur as a result of Eskom Power Stations. Sulphur dioxide emissions from Eskom Power Stations were predicted to be largely responsible for the health risks predicted, accounting for all of the calculated mortality cases and respiratory hospital admissions due to power station emissions.

5.4 OTHER STUDIES

According to a baseline assessment of child respiratory health in the HPA (Albers 2011). Study results show a relatively low asthma prevalence of 7.1%, however, a prevalence of 11.4% for wheezing was found. A prevalence of coughing was found to be 10%; more respondents from Witbank (4.7%) reported having a cough for more than three months, as compared to Middelburg (1.3%). This is important as coughing is often a symptom of asthma in children. These results indicate that there is possibly a respiratory health problem in the area; the exact causes have not yet net been determined. Other factors such as social characteristics and the prevailing medical system may have an influence on these results, for example it appears that the prevalence of asthma may be under reported. These results are understood to be in respect of prevalence of respiratory health outcomes in children between the ages of 9 and 11 years in the area.

The second objective of the study was to show associations between risk factors and child respiratory health. This was done using bivariate and multivariate analyses on identified risk factors and health outcomes. The majority of the indoor risk factors included in the questionnaire were statistically significant with a number of the health outcomes, either in bivariate or multivariate analysis. Of note, is the continued reoccurrence of the fossil fuels used in the house, smoking and having mould inside the house were also frequently demonstrated as being significant. Some of the following associations were found during multivariate analysis; the use of a fireplace for space heating was associated with having chest wheeze; having phlegm on the chest; pneumonia; and allergies. The use of gas or paraffin for space heating was associated with having sinusitis. Using an asbestos heater was associated with pneumonia. Smoking in the house was found to be associated with asthma, sinusitis, earache, pneumonia and bronchitis. Mould also repeatedly came up as being strongly associated with health outcomes such as bronchitis and pneumonia. Hay fever was found to be associated with the type of fuel used for cooking and owning pets was associated with having pneumonia.

The third objective was to describe the air quality in the two towns and compare it to the South African National Air Quality Standards and the WHO guidelines. According to the study, for Witbank, the pollutants of most concern were noted to be SO2 and the PM. For Middelburg, the pollutants of most concern were the PMs. The higher levels of SO2 seen in Witbank and can most likely be attributed to the town's closer proximity to the nearby power stations.

The second part of the third objective was to examine measured child respiratory health in relation to the air quality. The respiratory related health outcomes for both towns appeared similar; there was limited evidence from the data to support worse health in Witbank. However, using the prevalence reported for both towns it would appear that Witbank had a greater degree of lower respiratory disease (bronchitis, pneumonia and asthma), while Middelburg had a greater degree of upper respiratory diseases (otitis media, hay fever and sinus). It was concluded that the reasons behind this observation could not be known with certainty; however, differing ambient situations and differing indoor pollutant profiles may have a role to play.

The study concludes that the overall air quality of the area was found to be poor and there were respiratory health effects reportedly being experienced by the children in the area. However, the contribution of ambient air pollution levels to these health effects is unknown, since the study aim was not to prove causation. This study showed that here were a number of indoor risk factors for the examined health outcomes; however, this does not exclude outdoor risk factors that were not assessed in this study.

The study showed that there are respiratory health effects being experienced and there are harmful concentrations of pollutants in the ambient air. It also found a number of risk factors for child respiratory health. The direct relationship between child respiratory health and ambient air quality in the area is an important next step. Future studies should endeavour to quantify this in order to protect child health and create an environment that is not harmful to their well-being.

Notably, this study also set out to determine potential indoor risk factors for child respiratory health. Two primary risk factors were identified: indoor fossil fuel burning; and indoor smoking.

6 AIR QUALITY MANAGEMENT CAPACITY IN THE NDM

The NEM:AQA gives each municipality a number of exclusive air quality management responsibilities. The NDM must:

- Implement an atmospheric emission licensing system, and carry out the responsibility for performing the functions of the licensing authority as set out in Chapter 5 of the NEM:AQA.
- Designate an Air Quality Officer (AQO) from its administration.
- Develop an AQMP for inclusion in its Integrated Development Plan (IDP)
- Prepare an annual report including progress regarding the implementation of the AQMP and compliance with the plan.

The municipality may also:

- Establish municipal standards for emissions from point, non-point and mobile sources if a municipality, in terms of its by-laws, identifies a substance or mixture of substances in ambient air which through ambient concentrations, bioaccumulation, deposition or any other way, presents a threat to health or well-being or the environment, or which the municipality reasonably believes presents such a threat.
- Require the appointment of an Emission Control Officer in a given company (Section 48 of NEM:AQA), thereby extending the powers of the authority by ensuring that the Emission Control Officer is responsible for the company applying the correct measures to minimise emissions.

Table 6-1 below provides a summary of primary air quality management functions of municipalities taking into account both specific requirements under AQA and the governance cycle.

Table 6-1: Summary of the municipal air quality management functions

FUNCTION	NEM:AQA
To monitor ambient air quality and point, non-point and mobile source emissions.	S.8(a)
The development of air quality management plans as a component of integrated development plans as required by the Municipal Systems Act.	S.15(2)
The setting of municipal standards for emissions from point, non-point or mobile sources in the municipality in respect of identified substances or mixtures of substances in ambient air which, through ambient concentrations, bioaccumulation, deposition or in any other way, present a threat to health, well-being or the environment in the municipality.	S.11(1)

Table 6-1: Summary of the municipal air quality management functions	
FUNCTION	NEM:AQA
To monitor ambient air quality and point, non-point and mobile source emissions.	S.8(a)
Implement the AQA atmospheric emission licensing system referred and for this purpose perform the functions of licensing authority as set out in Chapter 5 and other provisions of the AQA. (Districts and Metros only).	Chapter 5
Monitoring potential illegal listed activities. (Districts and Metros only).	S.51(1)(a)
Monitoring compliance with emission standards in respect of the manufacture, sale or use any appliance or conducting of an activity declared as a controlled emitter.	S.51(1)(a)
Monitoring compliance in respect to reasonable steps to prevent the emission of any offensive odour caused by any activity.	S.51(1)(a)
Monitoring compliance with directives to submit an atmospheric impact report.	S.51(1)(c)
Monitoring compliance with notification requirements in respect of mines that are likely to cease mining operations within a period of five years.	S.51(1)(d)
Monitoring compliance with conditions or requirements of an atmospheric emission license. (Districts and Metros only)	S.51(1)(e)
Monitoring any information provided to an air quality officer to ensure that it does not contain false or misleading information.	S.51(1)(g)

In ensuring that the constitutional mandates of municipalities are carried out effectively, the Municipal Systems Act, 2000 (No. 32 of 2000) provides mechanisms and procedures through which municipalities can provide services. The application of the AQA at municipal level must be carried in line with the provisions of the Municipal Systems Act, 2000 (No. 32 of 2000).

Over and above the functions listed above, municipalities are also responsible for providing input to all other aspects of Air Quality Management as outlined in Chapter 4 of the National Framework for Air Quality Management.

6.1 EXISTING CAPACITY IN THE NDM

In reference to Table 6-1, the NDM has a significant deficiency of resources required to fulfil its mandates in terms of NEM:AQA. Table 6-2 provides a summary of human resources allocated and positions vacant in respect of these mandates.

Table 6-2: Summary of NDM mandates versus resources

FUNCTION	Human Resources Allocation	Vacancies
Implement the AQA atmospheric emission licensing system	3	2
Monitoring potential illegal listed activities.		
Monitoring compliance with AEL.		
Monitoring veracity of information provided to an AQO.		
Monitor ambient air quality and source emissions.	0	-
Development of AQMP.	0	-
The setting of municipal emissions standards.	0	-
Monitoring compliance with emission standards.	0	-
Monitoring compliance in respect of offensive odour.	0	-
Monitoring compliance with directives to submit AIRs.	0	-
Monitoring compliance with notification requirements in respect of mines closure.	0	-

In 2012, the NDM undertook an assessment to determine the resources required in respect of establishing an atmospheric emission licencing function, as per S78 of the Local Government: Municipal Systems Act, No. 32 of 2000. The assessment concluded that the municipality requires 3 positions of responsibility to effectively execute atmospheric emission licencing as illustrated in Figure 6-1. One of the positions has been filled, with 2 currently vacant. This results in significant constraints in respect of licencing activities for which the NDM is responsible.

The report further indicates those responsibilities which fall within the roles of the atmospheric emission licence authority, and it is clear that various air quality management roles mandated in terms of the NEM:AQA are yet to be resourced.

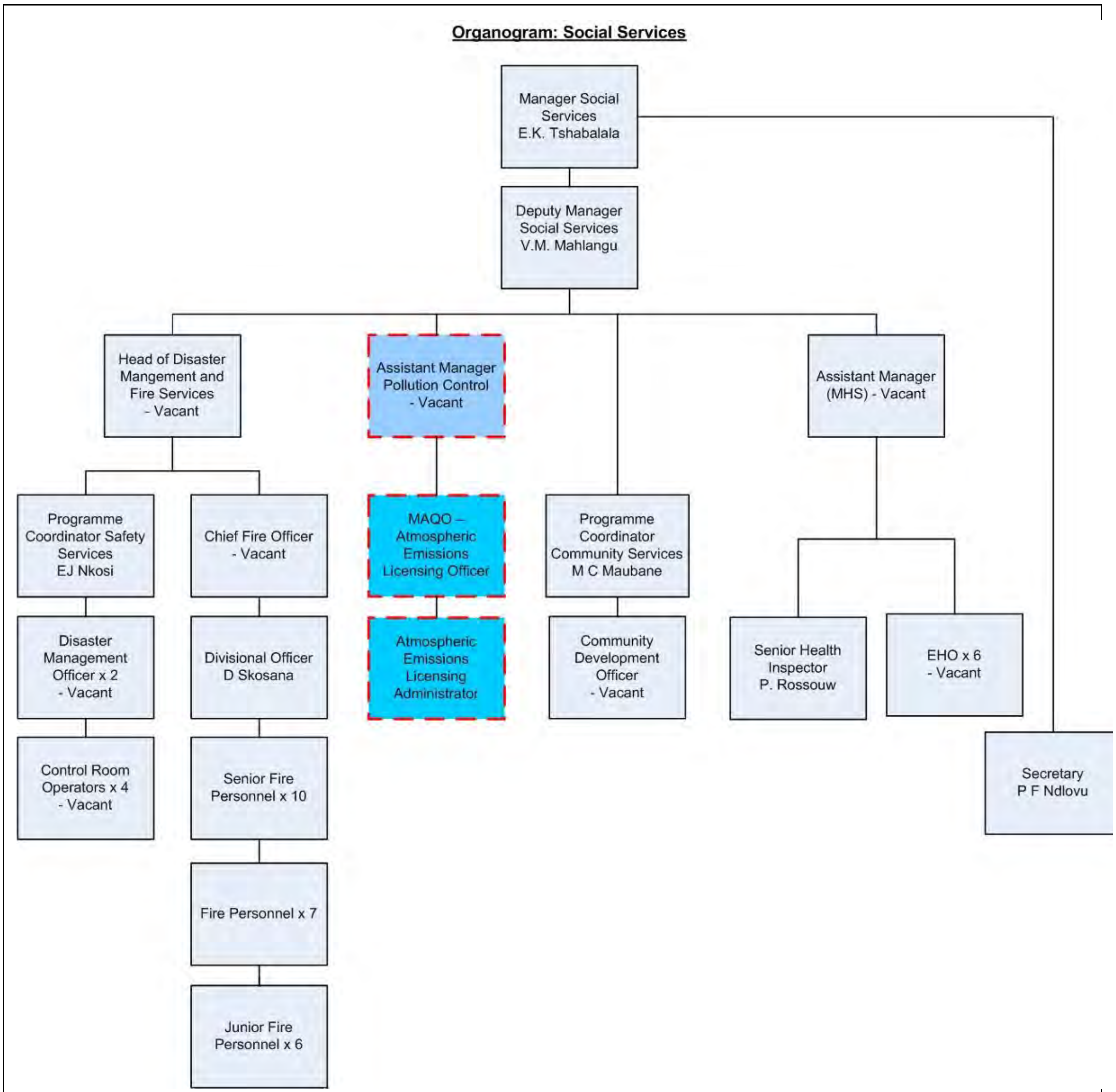


Figure 6-1: Organogram of the NDM Social Service Department Excerpted from Atmospheric Emission Licensing Section 78 Assessment Report And Implementation Plan - February 2012

The Department of Environmental Affairs undertook a Status Quo Report for Assessment of the Requirements for Municipalities and Provinces to Fully Undertake Air Quality Functions in 2014.

The status quo report concludes that it is evident that there are prevailing challenges across the municipal and provincial spheres of government with respect to the full implementation of the NEM:AQA. The report has demonstrated that the effecting of Air Quality functions is significantly impacted by three factors; human resource constraints, insufficient or no budget allocation and inadequate technical resources. The other significant challenge is the prevailing perceptions of politicians and executives on Air Quality Management due to limited awareness, leading to exclusion of Air Quality in Integrated Development Plans (IDPs), Budgets and Provincial planning processes.

The report has further provided recommendations and interventions that could transform the air quality functions performance within authorities to leverage the ability to fully effect the air quality functions as required by the AQA and the National Framework. The outcomes of this report will be considered in developing the business cases. Recommendations for intervention include:

- Air Quality to be a Key Performance Indicator for Municipal Manager/Mayor
- Air Quality should form part of Municipal Manager/Mayor's scorecard and that of DDGs at provincial departments
- Make Air Quality and Auditable function within authorities (municipalities and provincial)
- Capacitating Councillors and Politicians on importance of Air Quality and legislative requirements on Air Quality
- Allocation of budgets to fund organizational structure
- Review, evaluate and standardization, where possible, remuneration of Air Quality Officials
- Defining standard Air Quality organizational Structures and job descriptions
- Defining Air Quality Management Business Process across authorities
- Recruitment of a blend of Environmental health practitioners, engineers and scientists for licensing functions and compliance monitoring
- Lobby enabling structures such as SALGA to instil change
- Authorities to strongly consider a blend of skills (i.e. Technicians for Air Quality Monitoring Stations, Engineers for Licensing, Scientist for Modelling etc.) when recruiting staff to be able to fully implement the requirements and functions of Air Quality
- Recruitment of experienced scientist and engineers for AEL processing
- Training of AEL staff to enhance capacity
- Capacity building on Air Dispersion Modelling for all relevant Air Quality officials
- Authorities and National Department should have, as part of conditions in terms of reference, skill transfer as a service provider key performance indicator
- Air Quality Budget should from adequate provisions for both OPEX and CAPEX

- Use of panel of consultants and the use of long term contracts for procurements of critical services or goods (i.e. appointment of panel of services providers over 3-5 years), this is common practice nowadays in most authorities

7 SITUATION ASSESSMENT

7.1 EMISSION SOURCES

7.1.1 INTRODUCTION

Of those emissions quantified, the total annual emissions of fine particulate matter (PM_{10}) in the NDM are estimated at 111 981.09 tons per annum, of which approximately 90% is attributed to Industrial sector (Table 7-1), whilst 99% of the NO_x and >99% of the SO_2 emissions are from the industrial sector.

The emission inventory for industrial sources was relatively complete, as well as specific methodologies used for determining residential fuel burning, coal mining, biomass burning and burning coal mine and smouldering coal dump emissions. Source categories where emissions could not be determined were landfills, traffic, incinerators, waste water treatment works, tyre burning, biogenic sources, odour and agricultural dust. The issues relating to these emissions will be taken forward into the development of the AQMP.

Table 7-1: Total emission of PM, NOx and SO2 from the different source types on the NDM (in tonnes per annum), and the percentage contribution for each source category

Source category	PM10		NOx		SO2		PM2.5	
	t/a	%	t/a	%	t/a	%	t/a	%
Industrial	156 509	55%	1 185 345	99%	2 876 102	>99%	10 229	22%
Household Fuel Burning	2 467	1%	808	<1%	1 613	<1%	637	1%
Waste burning	75	<1%	28	<1%	5	<1%	67	<1%
Mining Haul Roads	113 246	40%	0	0%	0	0%	27 394	59%
Biomass Burning	8 861	3%	4 159	<1%	507	<1%	7 873	17%
Agricultural Dust*	-	-	-	-	-	-	-	-
Wind Blown Dust*	-	-	-	-	-	-	-	-
Traffic	842	<1%	9498	1%	431	<1%	-	-
TOTAL NLM	281 999	100%	1 199 838	100%	2 878 658	100%	46 201	100%

*These sources have not yet been calculated due to insufficient data

Each source category is discussed in detail in the following sections.

7.1.2 INDUSTRIAL SECTORS

Industrial sources contributors were grouped into the following categories:

- Mineral Processing Storage and Handling
- Combustion Installations
- Carbonisation and Coal Gasification
- Metallurgical Industry

- Hazardous and General Waste

Table 7-2: Number of listed facilities per local municipality and type of activity

Type of Activity	No. of Listed Companies
eMalahleni	**21**
1.Combustion installations	7
3.Carbonization and coal gasification	3
4.Metallurgical Industry	6
5.Mineral processing storage and handling	4
8.Disposal of hazardous and general waste	1
Steve Tshwete	**16**
1.Combustion installations	2
3.Carbonization and coal gasification	1
4.Metallurgical Industry	4
5.Mineral processing storage and handling	5
8.Disposal of hazardous and general waste	4
Victor Khanye	**1**
5.Mineral processing storage and handling	1
eMakhazeni*	**1**
4.Metallurgical Industry	1

* The listed activity in eMakhazeni (Assmang Machadodorp ferroalloy smelter) is in the process of shutting down expected shutdown date 30 April 2015. http://www.miningmx.com/page/news/ferrous_metals/1650045-Assmang-hooks-ferroalloys-smelter#.VRJvnPmUf3Q .

N.B There are no recorded listed activities in the Dr JS Moroka and Thembisile Hani Municipalities

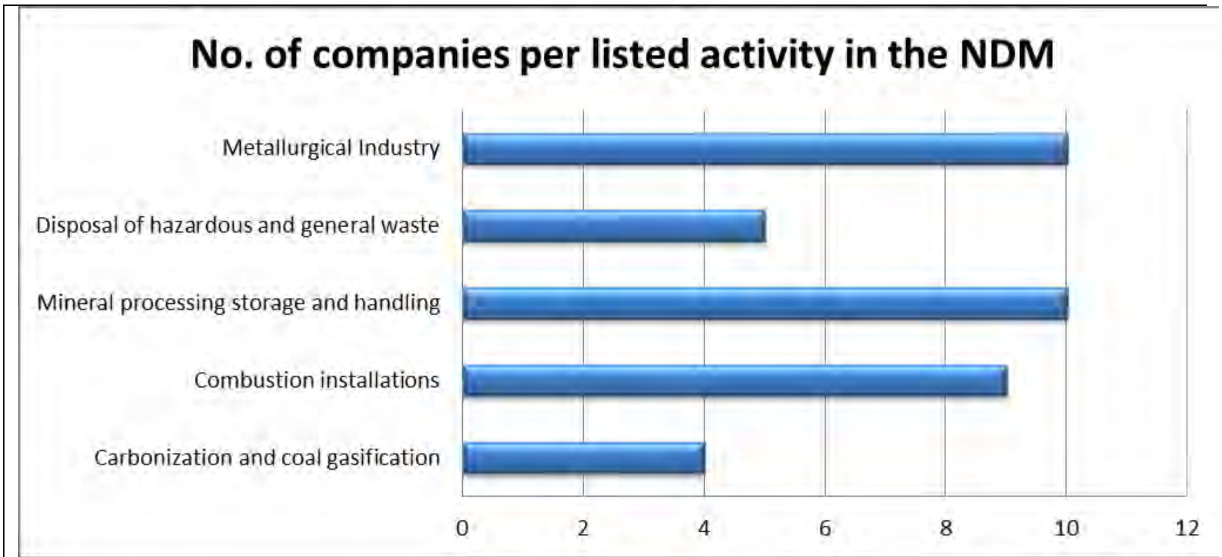


Figure 7-1: Breakdown of Industry Sources, based on Listed Activity within the NDM

The Power Generation sector is the highest contributor to Industrial PM10 emissions in the NDM (87%); this is followed by the Metallurgical industry (7%) and the Mineral processing storage and handling that accounts for almost 6%. It must be noted that applications for postponement of compliance timeframes stipulated in GN 893:2013 were submitted for several facilities in the NDM, namely:

- Eskom Arnot Station
- Eskom Duvha Station
- Eskom Hendrina Station
- Eskom Kendal Station
- Eskom Kriel Station
- Eskom Komati Station
- Eskom Matla Station
- Evraz Highveld Steel and Vanadium

Although postponement decisions had been issued by the National Air Quality Officer for the Eskom applications, the NDM had not received communication of a decision in respect of Evraz at the time of drafting this document.

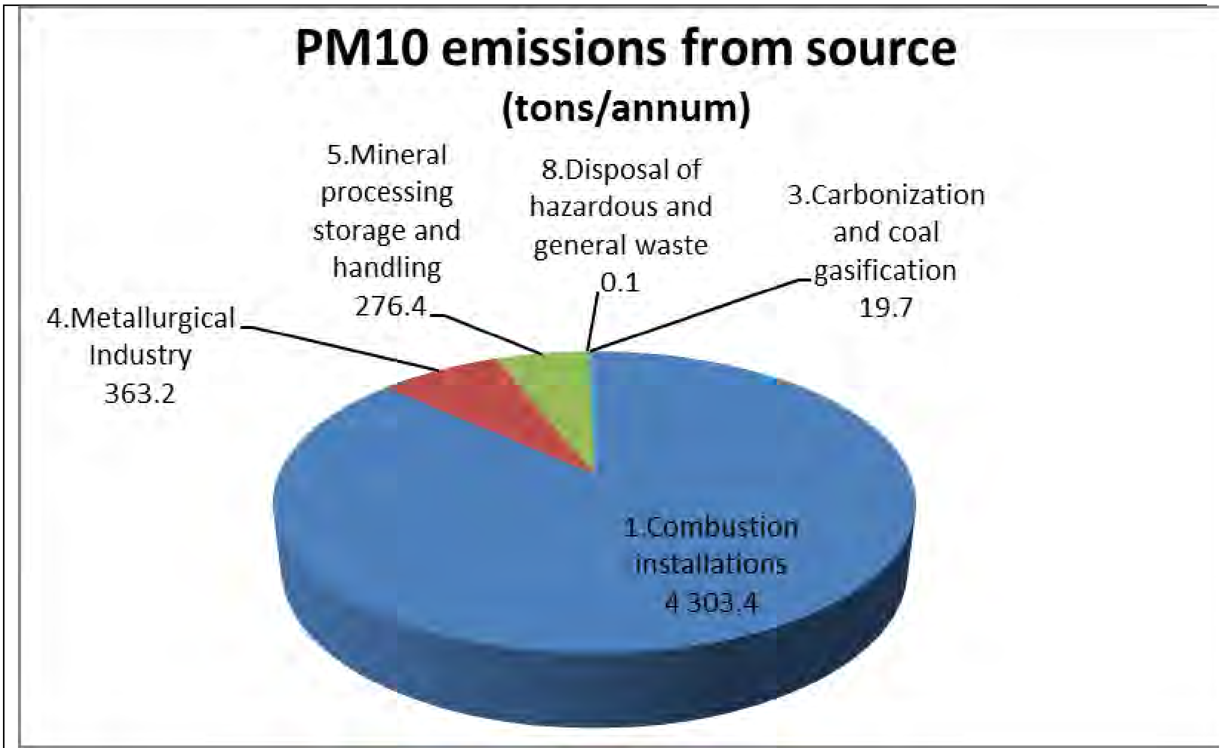
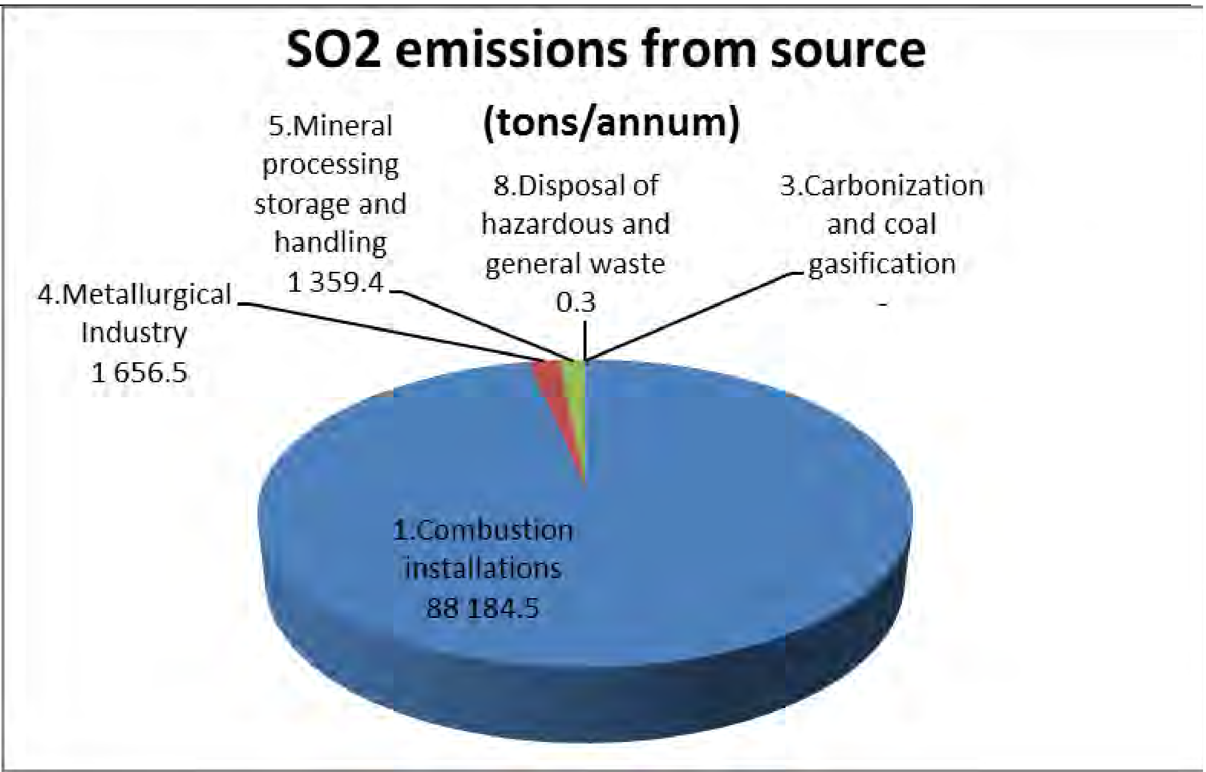


Figure 7-2: PM10 emission per industrial sector, for the NDM

The main industrial contributor to SO_2 emissions is Power Generation, responsible for 97% of industrial SO_2 emitted; followed by the metallurgical industry with 2% and Mineral processing, storage and handling is third with 1%. NO_x emissions are primarily a result of combustion relating to Power Generation, metallurgical industry and Mineral processing storage and handling with contributions 91%, 6% and 3% respectively.



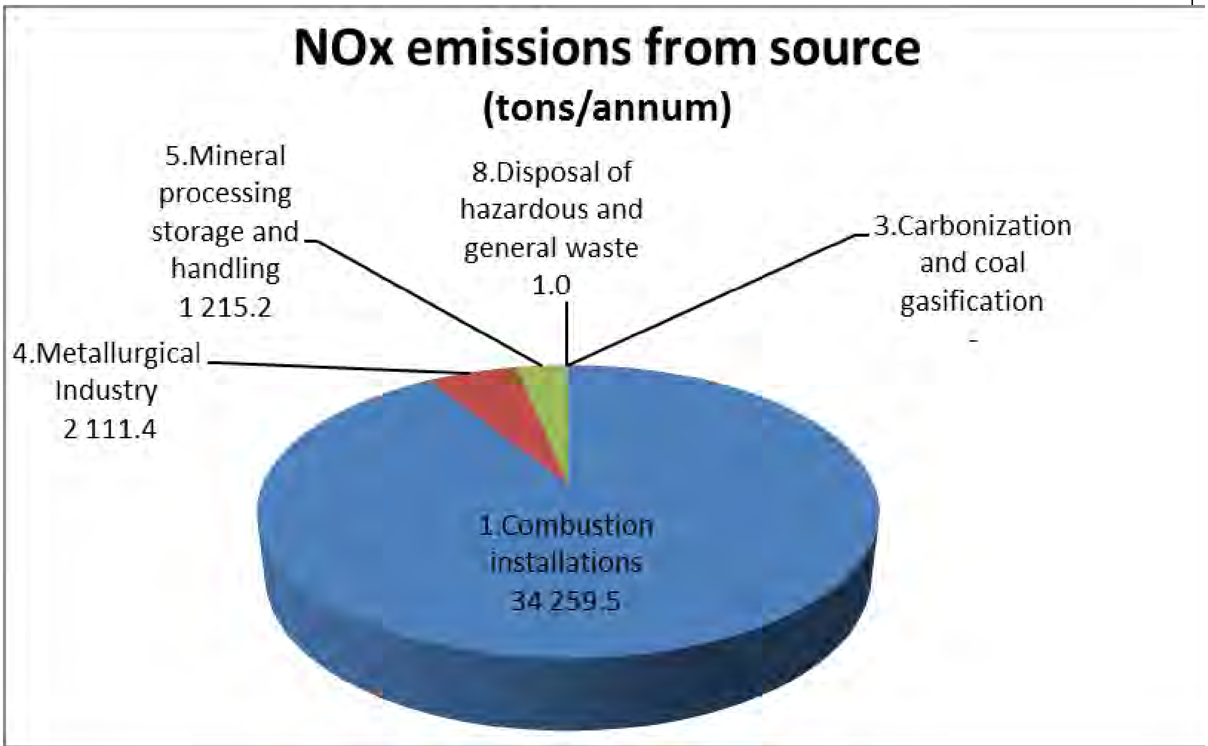


Figure 7-3: SO2 and NOx emission per industrial sector, for the NDM

Most emissions of CO are produced from the Metallurgical Industry (98%) with a smaller fraction emanating from the disposal of hazardous and general waste (2%). However, disposal of hazardous and general waste is the main source of VOC emissions in the NDM.

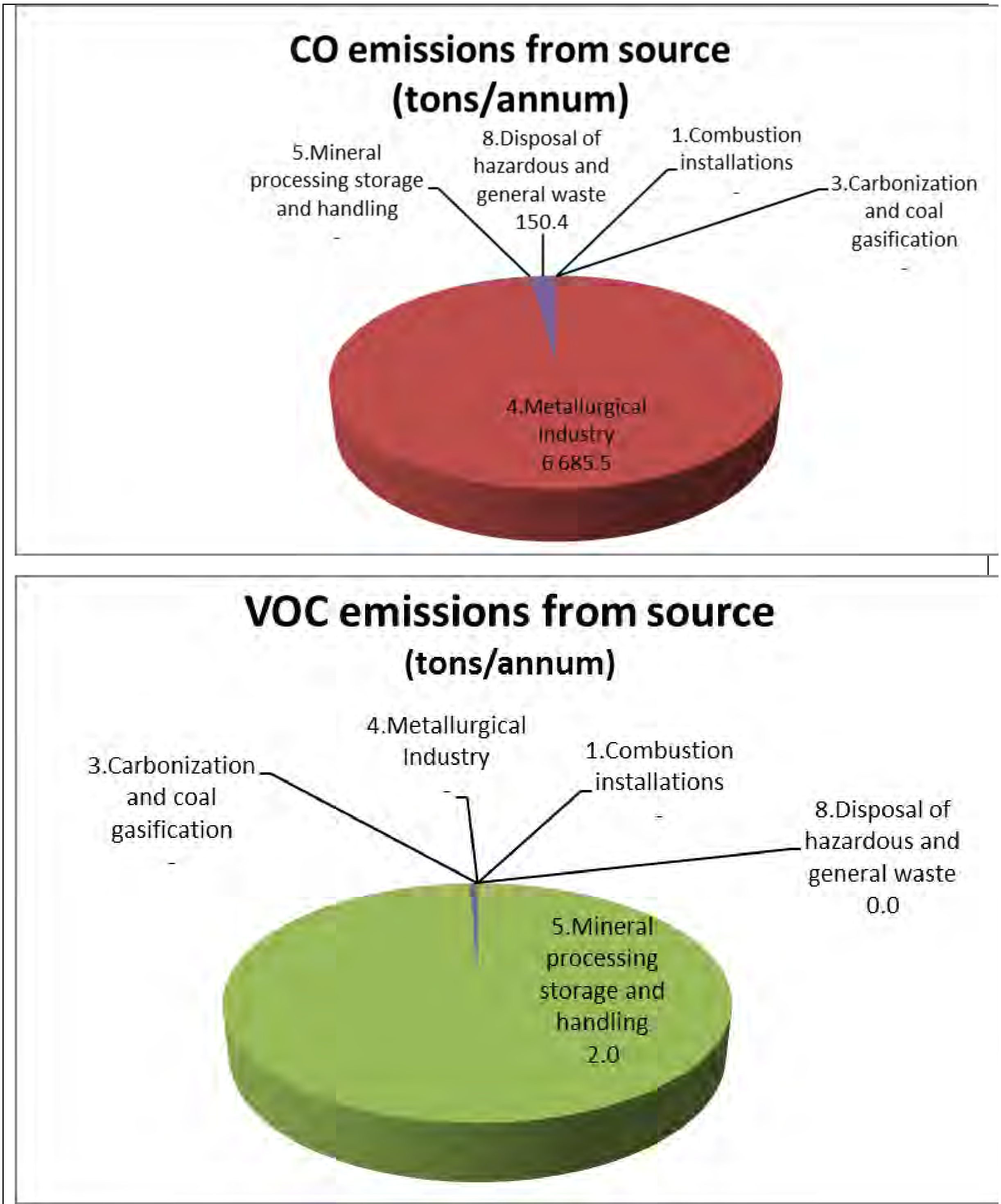


Figure 7-4: CO and VOC emission per industrial sector, for the NDM

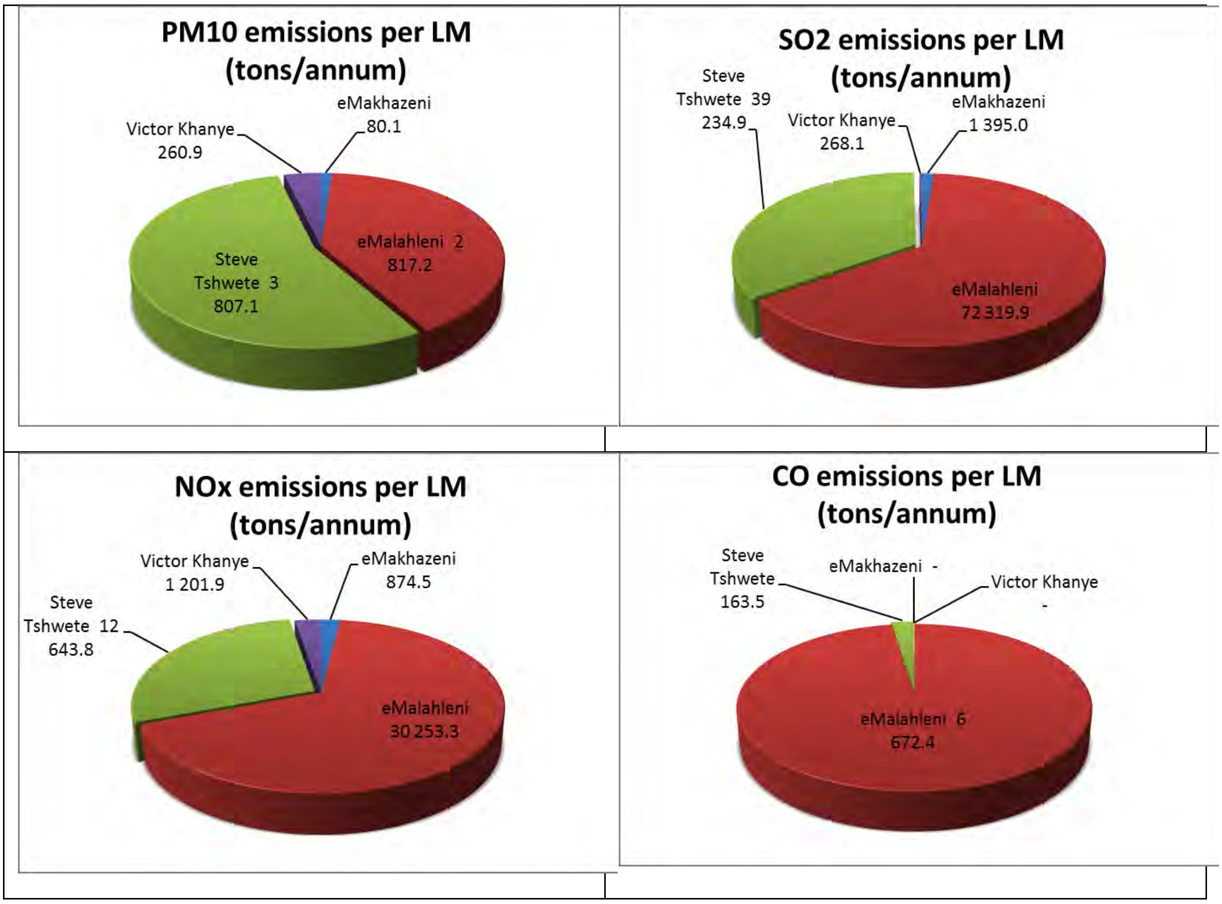
The requirements for applications for atmospheric emissions licensing have significantly improved the comprehensiveness and accuracy of emissions data available from listed sources. The monitoring requirements issued as conditions to the AELs and subsequent submission of emissions monitoring data will further improve the emissions inventory.

Further to this, the implementation of model by-laws is expected to improve the comprehensiveness and accuracy of emissions data available from smaller industrial sources, as well as notably small boilers being declared as controlled activities sources.

The emissions per local municipality (refer to Table 7-3) indicate that the Steve Tshwete local municipality was responsible for the majority of PM10 (71%), SO2 (75%) and NOx (71%) within the Nkangala District Municipality (Figure 7-5).

Table 7-3: Industrial emissions per Local Municipality within the NDM

	PM_{10} (g/s)		SO_2 (g/s)		CO (g/s)		NO_x (g/s)		VOCs (g/s)	
eMakhazeni	80.1	1%	1 395	1%	-	0%	875	2%	-	0%
eMalahleni	2817	40%	72 319	64%	6 672	98%	30 253	67%	2.7	77%
Steve Tshwete	3807	55%	39 234	35%	164	2%	12 644	28%	0.8	23%
Victor Khanye	260	4%	268	>0%	-	0%	1 202	3%	-	0%
Grand Total	**6 965**	**100%**	**113 217**	**100%**	**6 836**	**100%**	**44 974**	**100%**	**3.4**	**100%**



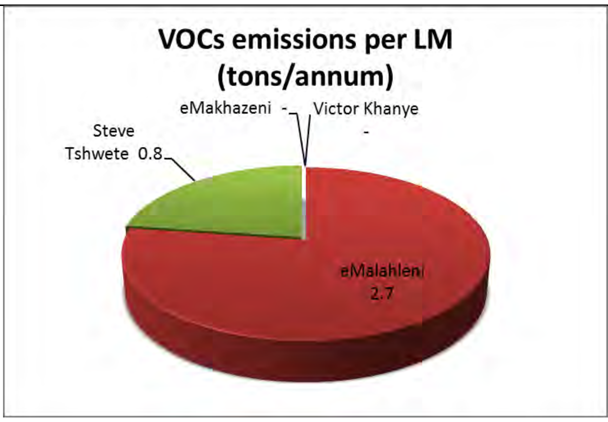


Figure 7-5: Emission ratios per Local Municipality for the pollutants of concern for the NDM (in tons per annum)

7.1.3 DOMESTIC FUEL BURNING

Domestic use of fuels such as coal, wood and paraffin for cooking and space heating purposes, particularly within informal, low-income and densely populated settlements, is a significant source of air pollutant emissions, especially during winter. Significant to note regarding emissions from residential fires are the release close to ground level and the relatively low temperature of the fires. The low-level release implies that the pollutants are released into the stable surface inversion layer, where dispersion is inhibited and pollutants tend to accumulate close to the source. High ambient concentrations may result near the source under these conditions. The relatively low fire temperature implies that the combustion process is incomplete.

Domestic coal burning contributes to particulate (PM2.5 and PM10) emissions. SO2 and CO emissions are also released in high quantities as a result of coal burning, particularly when low-grade, high sulphur coal is burned. Domestic burning of wood (in addition to veldt fire burning) results in the release of fine-scale particulate emissions (PM2.5) as well as NO2, CO and formaldehyde. Domestic coal and wood combustion within informal settlements and rural areas has been identified through various studies to be, potentially, one of the greatest sources of airborne particulates and gaseous emissions to be inhaled in high concentration (i.e. before dispersion and fallout processes can ameliorate impact). In addition, this fuel combustion adds to greenhouse gas emissions.

Although many households are electrified, informal households use predominantly a contribution of this fuel mix (coal, wood, paraffin and LPG with animal dung and other waste materials used to a smaller extent) primarily due its availability and affordability, although factors such as cultural traditions also play a role in the continuing use of other fuels. Population density and growth also play a significant part, amongst a variety of additional factors. The preliminary household fuel combustion model results for 2011 for the NDM are depicted below.

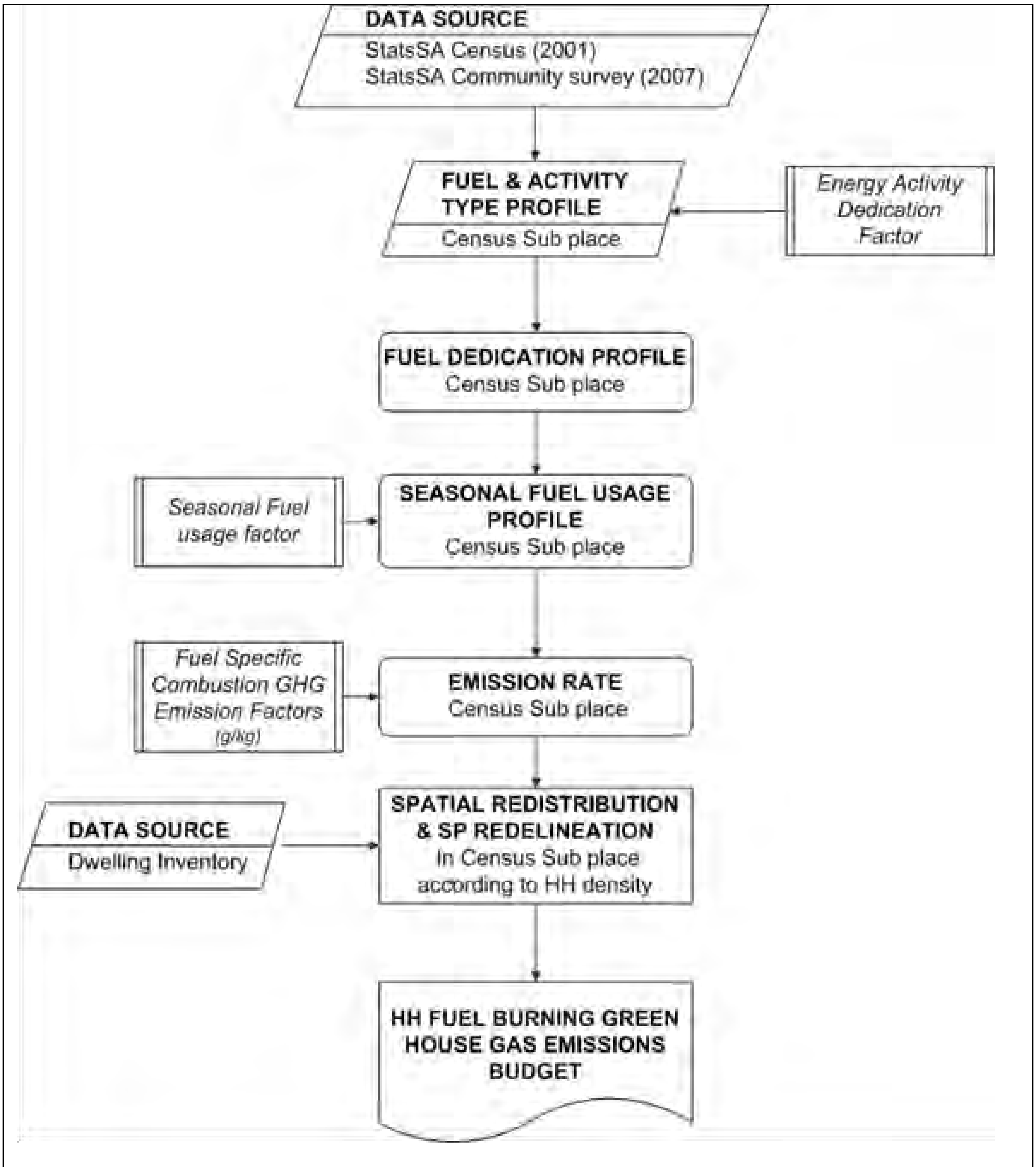


Figure 7-6: Household emissions inventorisation and parameterisation process

A GIS-based emissions quantification model was developed to be able to spatially resolve emissions for dispersion modelling. The emissions quantification model used the following inputs:

- Population statistics sourced from StatsSA Census 2011,
- Energy use patterns sourced from StatsSA Census 2011 and corrected using surveys undertaken by the Nova Institute (personal communication Pauw, 2009)
- Fuel usage factors for coal, wood and paraffin (personal communication Pauw, 2009, Madunsi & Shackleton, 2007, and Afrane Okese, 1998).

- Emission factors (Table 7-4) were sourced/ derived as follows
- For wood combustion for $PM_{2.5}$, PM_{10} and NO_x from the US EPA (1995);
- For coal combustion an emission factor for TSP reported by the CSIR (2004) is fractionated proportionally to $PM_{2.5}$ and PM_{10} fractions using the US EPA (1995), SO_2 is applied as reported by CSIR (2004);
- The SO_2 emission factor for paraffin was derived from the S mass balance for Engen illuminating paraffin.

The Basa Njengo Magogo fire lighting method results in a significant reduction in particulate emissions (CSIR, 2004), however the assumption was made that is not widely used during the 2004 to 2006 period evaluated for the baseline assessment.

Table 7-4: Emissions factors for household combustion of fuels (US-EPA AP42, CSIR 2001)

Fuel	$PM_{2.5}$	PM_{10}	SO_2	NO_X
Coal (g/kg)	12.01	12.91	9.91	4.55
Wood (g/kg)	16.089	17.3	0.2	1.3
Paraffin (g/l)	0.0012	0.1596	0.3991	1.5

Population statistics from the Census 2011 are used in the calculation of emissions (Table 7-5). The spatial distribution of PM_{10} emissions from domestic fuel burning and the relative volumes are illustrated in **Figure 7-11**.

Table 7-5: NDM Census 2011 GIS-based analysis of total annual emissions (in tons) due to household fuel combustion

Local municipality	PM_{10}	SO_2	CO	NO_X
Dr JS Moroka	913.64	69.93	7152.14	292.18
eMakhazeni	243.56	126.78	2806.59	78.95
eMalahleni	437.89	514.43	7388.32	147.09
Steve Tshwete	279.22	307.61	4558.56	92.72
Thembisile	448.76	379.13	6349.18	148.54
Victor Khanye	143.68	214.88	2816.40	48.22
TOTAL of NDM	**2466.75**	**1612.76**	**31071.20**	**807.69**

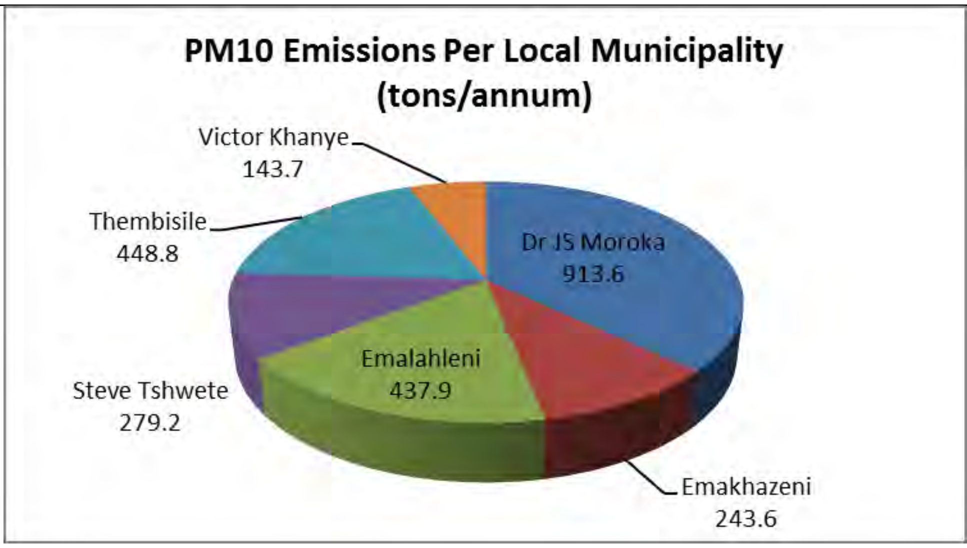


Figure 7-7: PM10 Emissions per Local Municipality for Domestic Fuel Burning in the NDM

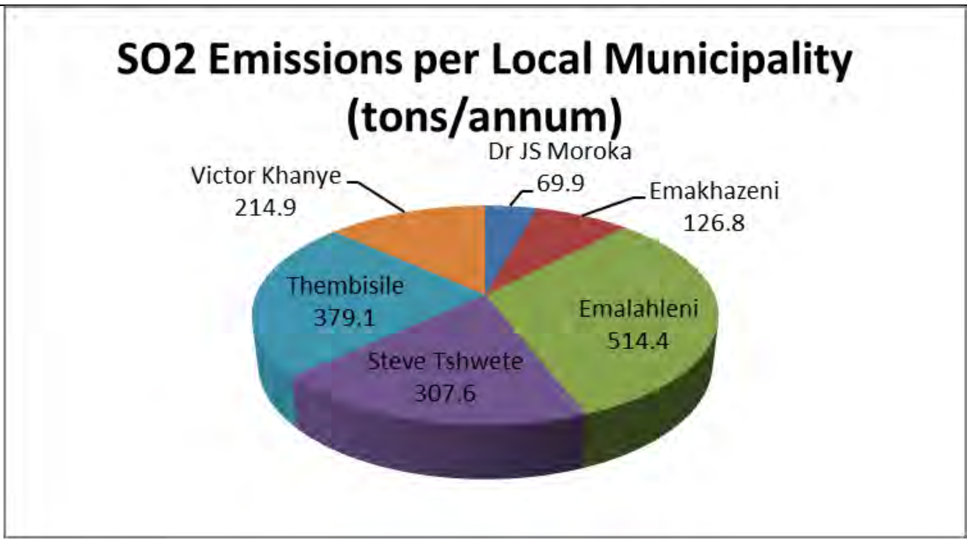


Figure 7-8: SO2 Emissions per Local Municipality for Domestic Fuel Burning in the NDM

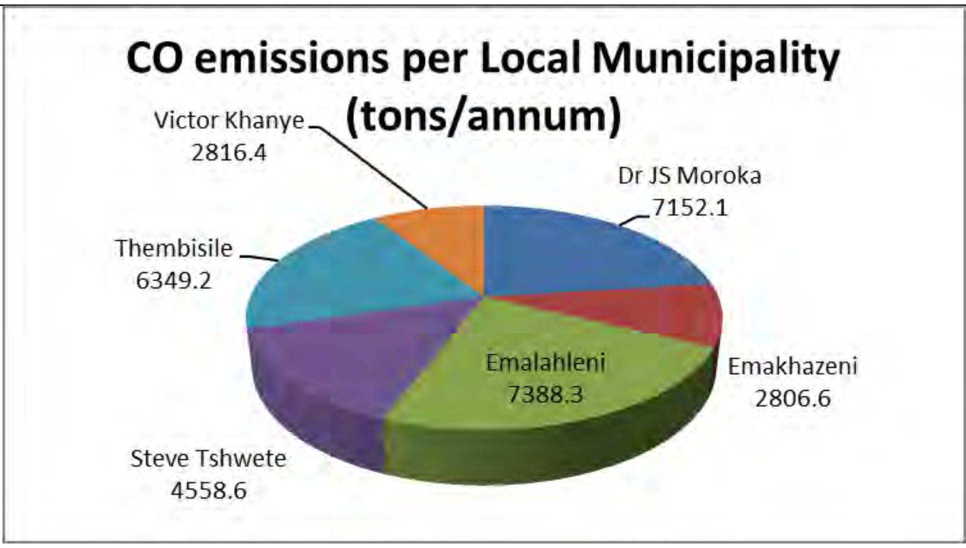


Figure 7-9: CO Emissions per Local Municipality for Domestic Fuel Burning in the NDM

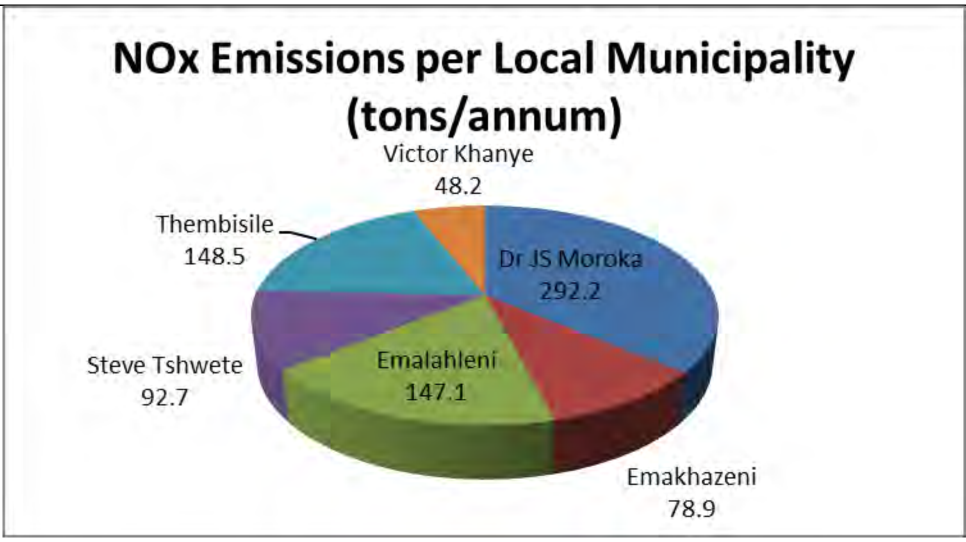


Figure 7-10: NOx Emissions per Local Municipality for Domestic Fuel Burning in the NDM

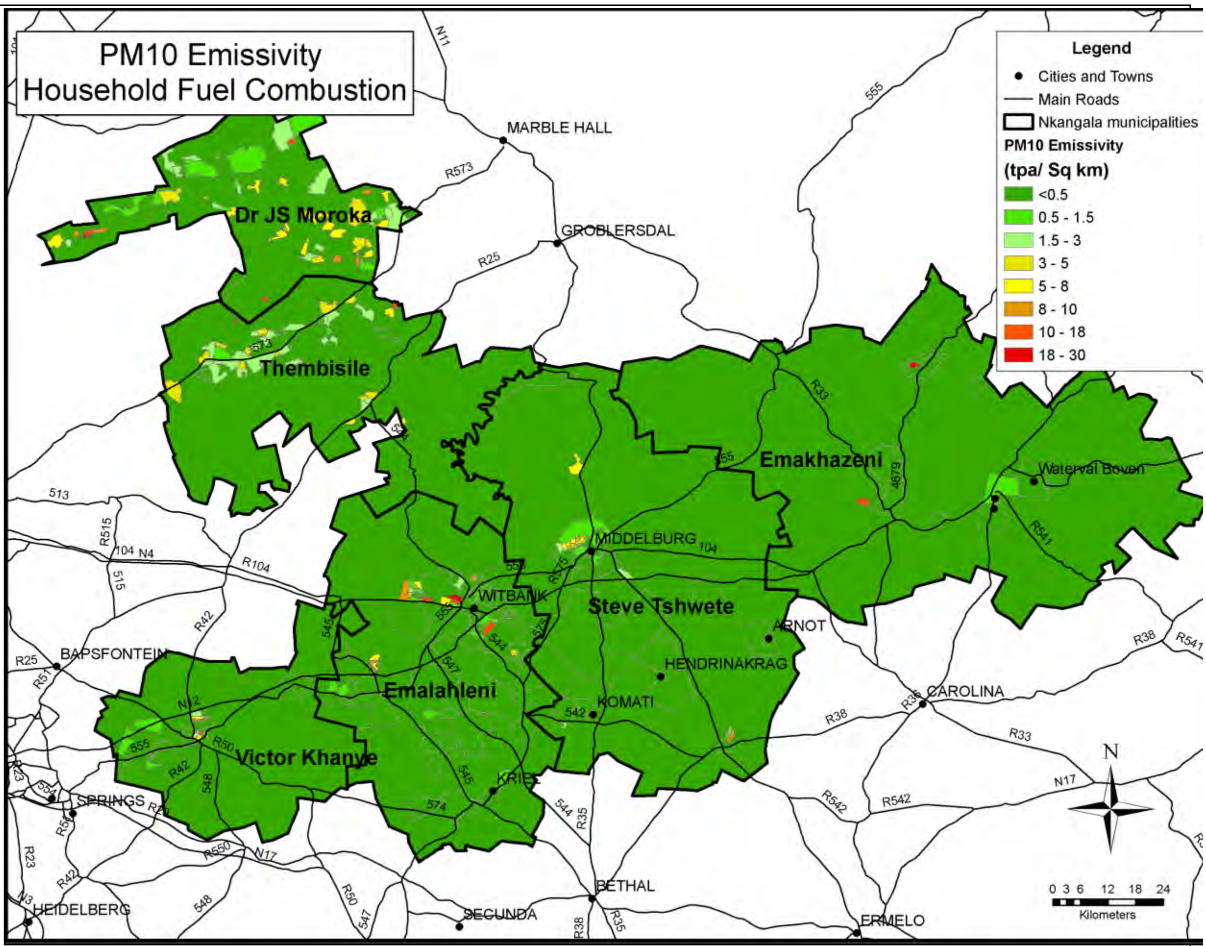


Figure 7-11: Annual PM10 emissions from domestic fuel use on the NDM for an average month

Significant notes regarding emissions from residential fires are the release close to ground level and the relatively low temperature of the fires. The low-level release implies that the pollutants are released into the stable surface inversion layer, where dispersion is inhibited and pollutants tend to accumulate close to the source. High ambient concentrations may result near the source under these conditions. The relatively low fire temperature implies that the combustion process is incomplete. The vast majority of particulate emissions from incomplete combustion are condensed organic products with a diameters equal to or less than 10 µm, .e.g. PM_{10} (US EPA AP-42). The high levels of organic compounds and CO emissions also result from incomplete combustion of the wood. Organic compounds include carcinogenic compounds such as dioxins, formaldehyde and PAH which have known negative impacts on human health.

In light of the wood usage rates in the NDM (StatsSA, 2001), the higher household wood fuel usage factors, as well as the increased emission factors associated with wood (as opposed to coal), the conclusions drawn from emissions estimates derived in this study ranks wood combustion as the single largest source of household particulate emissions. Wood emissions rank first, being followed by coal with a slightly smaller contribution, and the implication is therefore that wood combustion is also a very significant contributor to the health impact associated with household air pollution. Although wood use is more prevalent in rural areas, it is noteworthy that large volumes are consumed in urban areas (StatsSA, 2001). The emissions derived in this study therefore highlight domestic wood use as a significant contributor to the health impact of air pollution on the NDM, followed by coal.

7.1.4 WASTE TREATMENT AND WASTE DISPOSAL

7.1.4.1 Landfill

Disposing of general municipal waste to landfill is common practice in the NDM. Currently, there are 10 municipal landfill sites in operation (Table 7-6). A significant number of private operators are found in the area, catering to the needs of the various mining, manufacturing and power generation industries.

Atmospheric emissions from general waste landfills, or landfill gas, are composed of a mixture of many different gases. By volume, landfill gas typically contains 45% to 60% methane and 40% to 60% CO_2. It also includes small amounts of nitrogen, oxygen, ammonia, sulphides, hydrogen, CO, and non-methane organic compounds (NMOCs) such as trichloroethylene, benzene, and vinyl chloride (Duffy, 2007). Hazardous waste includes solvents, industrial wastes, and construction wastes such as asbestos.

Unpermitted landfill operations are commonplace in Nkangala (Nkangala DM, 2008). Accurate information on the number of landfill operations in the NDM could not be sourced for the area as a whole; however the South African Waste Information Centre (SAWIC) kept some records for the waste disposed during 2013 is presented in Table 7-6 below.

7.1.4.2 Incinerators

The incineration of waste is a Listed Activity in terms of the AQA (Category 8) that is facilities where general and hazardous waste including health care waste, crematoria, veterinary waste, used oil or sludge from the treatment of used oil are incinerated. The minimum emission standards are applicable only to facilities with a capacity of 10 kg of waste processed per hour or larger capacity. Pollutants released from waste incineration include SO_2, heavy metals, acid gases, dioxins and furans, which pose negative impacts on air quality and human health risk. Particulate emissions from incinerators may also contain heavy metals such as chromium and cadmium, which are suspected human carcinogens. Emissions from licensed incinerators are be included within the Industrial-Listed activities report.

7.1.4.3 Waste water treatment works

The range of air emissions originating from wastewater treatment processes is highly dependent on the composition of the incoming effluent streams. The typical hazardous air pollutants emitted from wastewater treatment plants are benzene, toluene, xylenes, methylene chloride, ethyl benzene, chloroform, tetrachloroethylene and naphthalene (US EPA, 1995). Wastewater treatment plants are also associated with the emission of odorous compounds, the most common of which is H_2S. This pollutant is formed through the anaerobic bacterial reduction of sulphates and sulphur-containing organic compounds. The potential for emissions of VOCs during wastewater treatment is a cause for concern. Pollutants measured at local waste water treatment works have included H_2S, mercaptans, ammonia, formaldehyde, acetone, toluene, ethyl benzene, xylenes, perchloroethylene, butyric acid, propionic acid, valeric acid and acetic acid. Species which represent the most important odorants include H_2S, mercaptans, NH_4, and the various fatty acids (butyric, propionic, valeric and acetic).

Five waste water treatment works are operating on a municipal basis in the NDM. These also service water-borne sanitation and waste water treatment works. In addition, the rural and under-developed areas of Mpumalanga are formally serviced by a system of french drains, septic tanks and other sanitation means. However information regarding location, technology, and operational capacity was not provided, therefore such emissions cannot be quantified and are not included in the present emissions inventory.

7.1.4.4 Open Waste

In areas where there are insufficient municipal service delivery mechanisms, the habitual burning of waste from households includes:

- Packaging, papers and plastics
- Food and garden waste, and
- Other combustible household waste.

In addition to this there is intermitted and uncontrolled burning of waste on many waste disposal sites.

Emissions from these sources are dependent on the chemical constitution of the material, the amount of material burnt, and the combustion conditions. Pollutants include the criteria pollutants as well as various volatile and semi-volatile organics. The quantification of these emissions is related to:

- Availability and proximity of municipal landfills
- Household income distribution
- Availability of municipal service delivery
- Household waste generation and disposal profiles in accordance with the above
- Emission factors for quantification in cognisance of the above.

Table 7-6: Waste disposed recorded in the Nkangala Municipality during 2013 (tons/year) (Compiled from SAWIC)				
	Facilities	**General**	**Hazardous**	**Total**
eMakhazeni	1	0	890 032.9	890 032.9
Hazardous: Slag: Ferrous metal slag		-	890 032.9	890 032.9
eMalahleni	5	0*	1 773 059.3	1 773 059.3
Hazardous: Mineral waste: Other		-	11 795.0	11 795.0
Hazardous: Slag: Ferrous metal slag		-	951 022.4	951 022.4
Hazardous: Slag: Other		-	810 241.9	810 241.9
Waste Recovery or Recycling		30 768.5	-	-
Waste Treatment (Physical treatment)		6 767.9	-	-
Nkangala District Municipality	1	0	8 585 428.8	8 585 428.8
Hazardous: Mineral waste: Other		-	8 585 428.8	8 585 428.8
Steve Tshwete	3	105 853.0*	72 610.0	178 463.0
General: Commercial and industrial waste		26 198.2	-	26 198.2
General: Constr. and demolition waste		18 254.0	-	18 254.0
General: Municipal waste		48 155.0	-	48 155.0
General: Organic waste		12 643.0	-	12 643.0
General: Other		602.8	-	602.8
Hazardous: Slag: Ferrous metal slag		-	43 502.0	43 502.0
Hazardous: Slag: Other		-	29 108.0	29 108.0
Waste Recovery or Recycling		6 264.1	5 835.1	12 099.2
Waste Treatment (Physical treatment)		-	1 075.0	1 075.0
Hazardous Waste Exporter		1 256.6	-	1 256.6

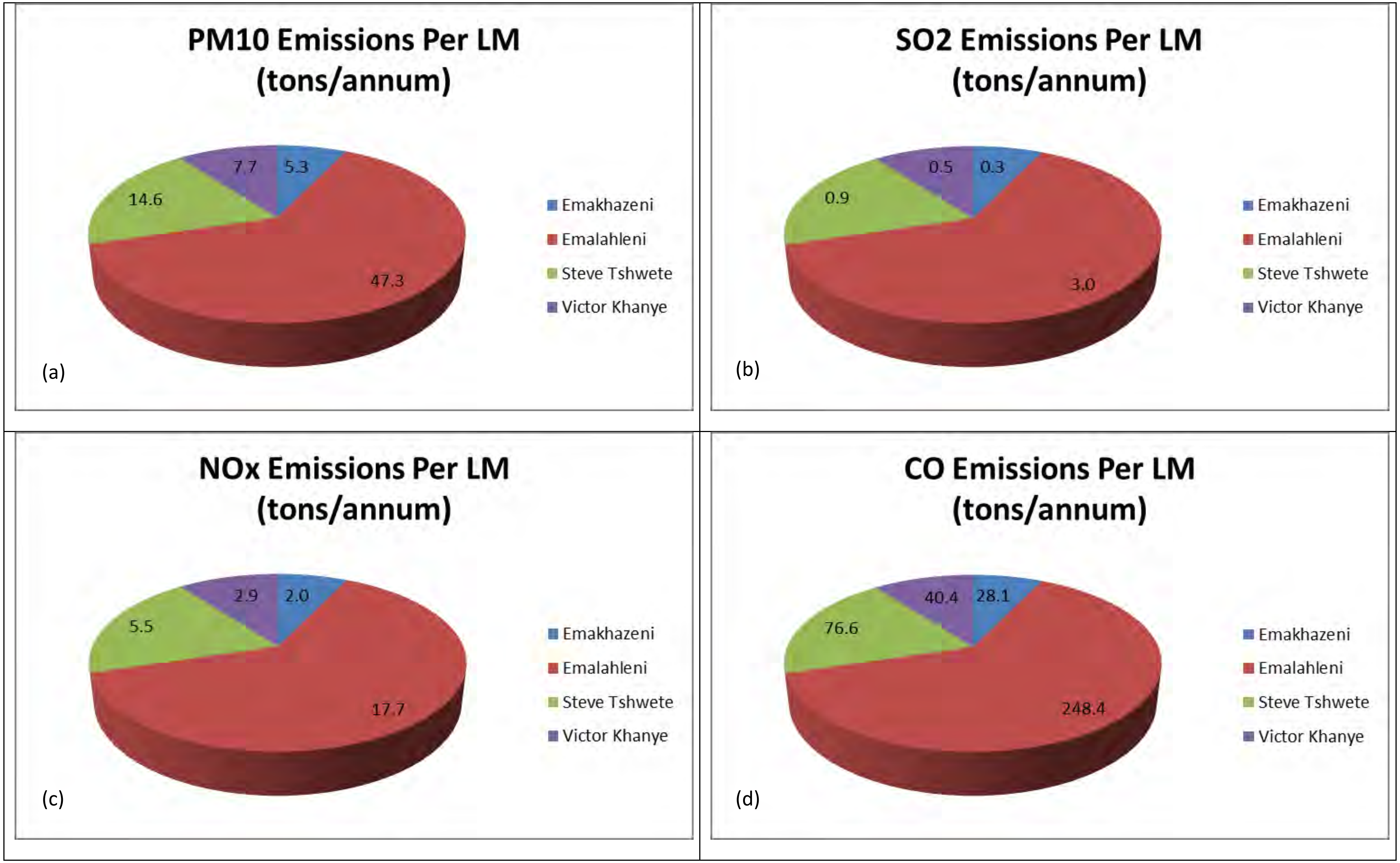
*Does not include recover/recycled waste, treated or exported

Table 7-7: Disposal of waste received at the Nkangala Municipality during 2013 (tons/year) (Compiled from SAWIC)

Place	General waste	Hazardous waste	Total waste	Disposal of waste to land[1]		Disposal of waste to landfill[2]		Storage/disposal of waste in surface impoundments[3]	
eMakhazeni	0	890 032.90	890 032.90	890 032.90	100%		0%		0%
eMalahleni	0*	1 773 059.30	1 773 059.30	751 925.90	42%	1 009 338.40	57%	11 795.00	1%
Nkangala DM	0	8 585 428.80	8 585 428.80				0%	8 585 428.80	100%
Steve Tshwete	105 853.0*	72 610.00	178 463.00	1 498.20	1%	176 964.80	99%		0%

*Does not include recover/recycled waste, treated or exported

1. Disposal of waste to land (e.g. specially engineered landfill)
2. Disposal of waste to landfill (e.g. non-engineered landfill)
3. Storage/disposal of waste in surface impoundments (e.g. placement of liquid or sludge discards into pits, ponds, lagoons etc.)


PM10 Emissions Per LM (tons/annum)
7.7
5.3
14.6
47.3
Emakhazeni
Emalahleni
Steve Tshwete
Victor Khanye
(a)
SO2 Emissions Per LM (tons/annum)
0.5
0.3
0.9
3.0
Emakhazeni
Emalahleni
Steve Tshwete
Victor Khanye
(b)
NOx Emissions Per LM (tons/annum)
2.9
2.0
5.5
17.7
Emakhazeni
Emalahleni
Steve Tshwete
Victor Khanye
(c)
CO Emissions Per LM (tons/annum)
40.4
28.1
76.6
248.4
Emakhazeni
Emalahleni
Steve Tshwete
Victor Khanye
(d)

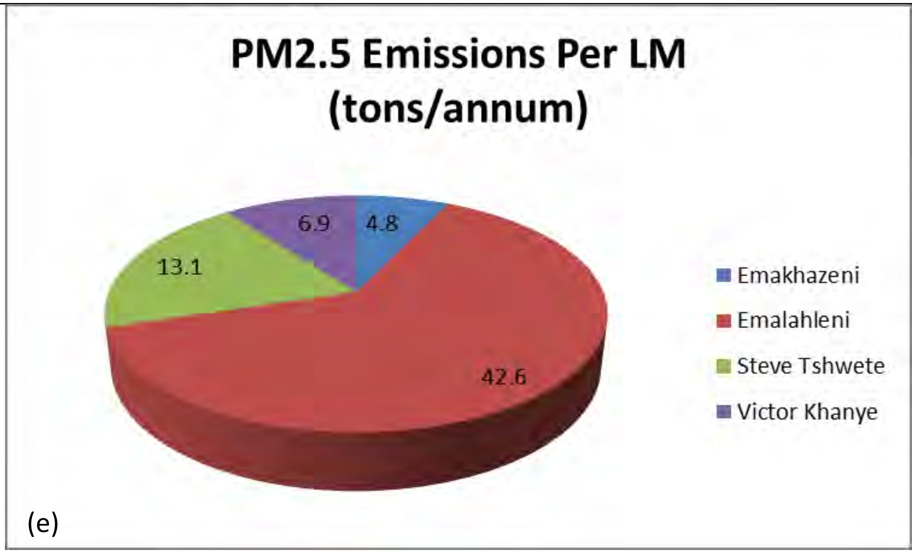


Figure 7-12: Waste burning PM10 (a), SO2 (b), NOx (c), CO (d) and PM2.5 (e) emissions for the Nkangala District Municipality

7.1.4.5 Informal Open Waste

In the absence of municipal services, residential generators of waste are forced to find means of disposal other than through the formal landfills. In essence this entails waste disposal through:

- Informal burning of waste
- Burying of waste
- Discarding of waste

A household's income has a direct and pertinent effect on the waste volumes and composition generated by households. Using income and service delivery data from Census 2011 data it is possible to identify and quantify waste generation profiles for census sub-places. It must be noted that the composition of waste generated varies and the methods of disposal vary between rural and urban populations. Accordingly these populations are addressed separately. Although the spatial distribution of sources can be identified using GIS data, the specific locations and temporal habits related to waste burning have not been addressed in detail, and thus although emissions may be estimated the inventory cannot be formulated in a model ready fashion.

Present day domestic waste streams contain significant amounts of plastic of various types, specifically PVC, as well as other component streams (including electronics) which may emit or aid the formation of toxic gaseous compounds and particulates to the atmosphere when burned. Although household waste has historically been burned, modern waste streams and redundant consumer items, including plastics and WEEE waste, emit significantly more emissions and often of compounds that have higher health hazards than waste of times gone by. Emissions from these activities may be grouped as follows (DEAT, 2010):

- Gaseous criteria pollutants (SO_2, NO_x, CO);
- Acid gases (such as HCl, HBr, HF);
- Particulate criteria pollutants (PM10 and PM2.5);
- Heavy metals (such as Cr, Hg, Pb and Cd) (DEAT, 2009b); and
- Dioxins and furans (such as polychlorinated dibenzo-p-dioxins and dibenzo furans).

Open burning is generally recognised as an environmentally unacceptable practice (UNEP, 2004) that liberates polychlorinated dibenzodioxins and dibenzofurans (also sometimes collectively called dioxins - persistent chemicals listed in Annex C of the Stockholm Convention), over and above numerous other hazardous products of incomplete combustion [e.g. particulate matter, benzene, polycyclic aromatic hydrocarbons (PAHs) and carbon monoxide].

The methodology for emissions estimation from un-serviced waste combustion is summarised in Figure 7-13.

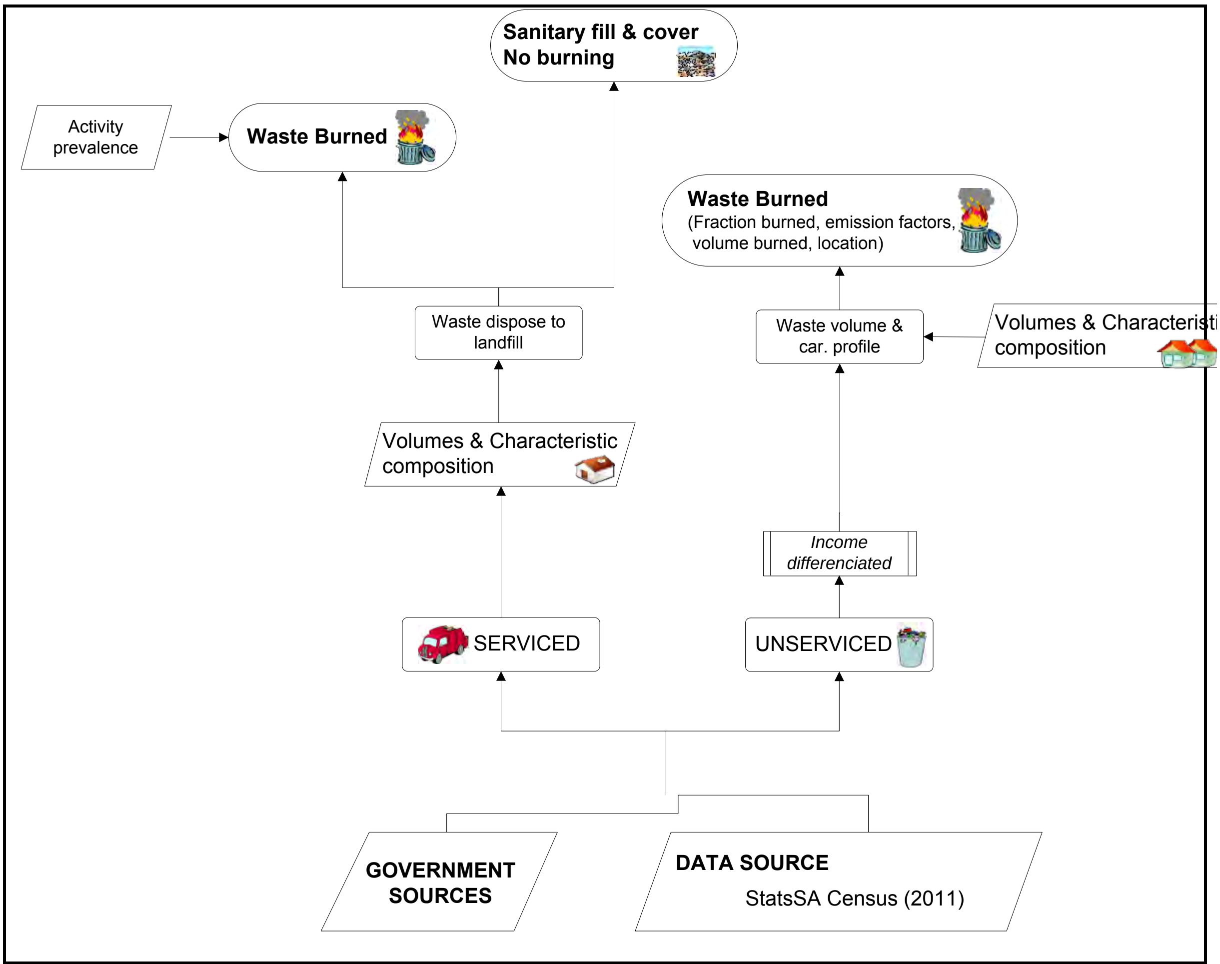


Figure 7-13: Emissions Quantification Methodology for Waste Burning

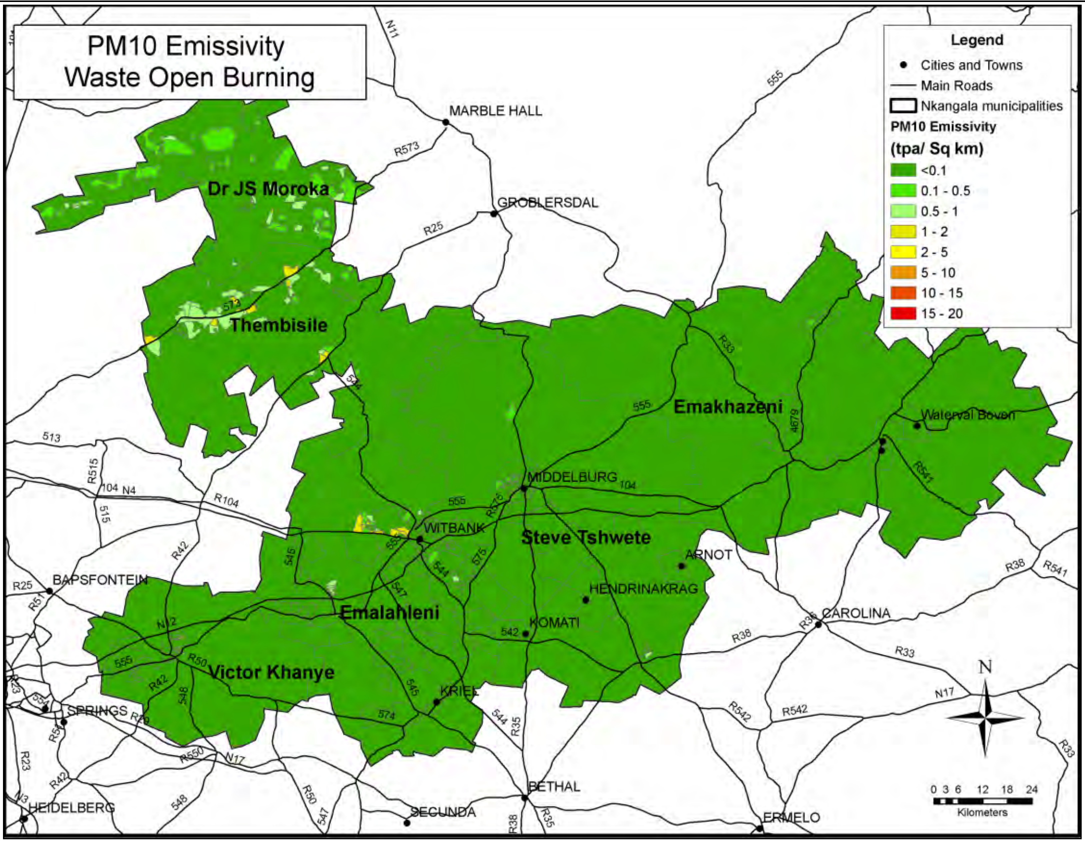


Figure 7-14: PM10 Emissions shown per census sub-place per tonnes per annum for burning of wastes within the NDM

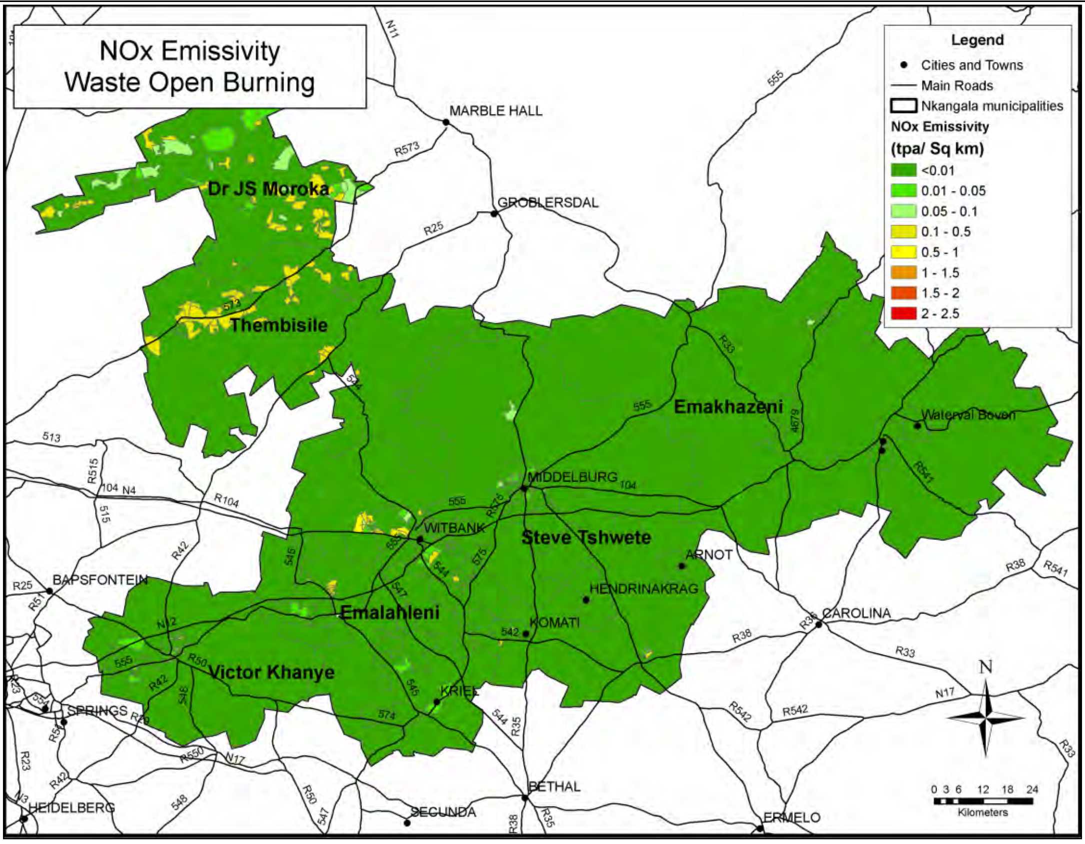


Figure 7-15: NOx Emissions shown per census sub-place per tonnes per annum for burning of wastes within the NDM

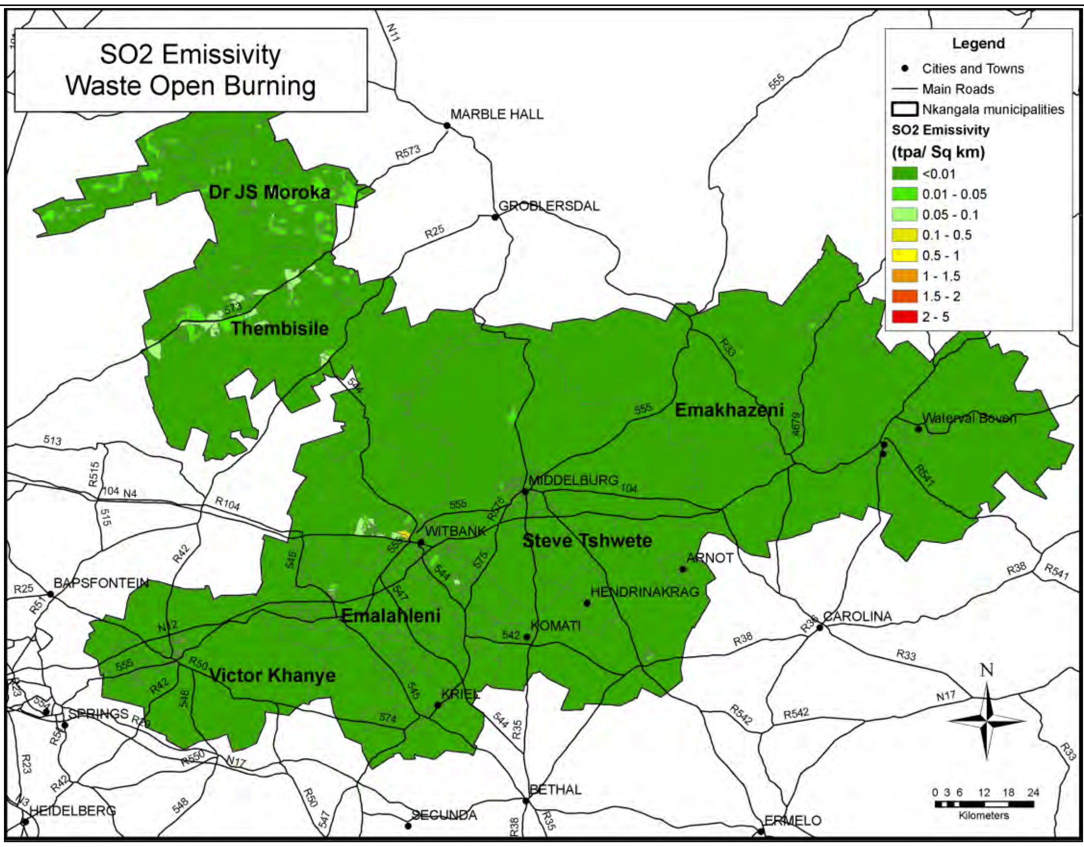


Figure 7-16: SO_2 Emissions shown per census sub-place per tonnes per annum for burning of wastes within the NDM

7.1.5 OPENCAST COAL MINING

The NDM hosts a number of coal mining operations extracting this resource through opencast and underground mining methods. Such operational mines have various activities that result in the entrainment/suspension of particulate matter, including but not limited to:

- The use of vehicles on unpaved and paved roads for transporting ore, personnel, waste rock etc;
- Blasting;
- Overburden stripping;
- Ore and overburden handling;
- Crushing and screening of ore; and
- Wind entrainment from stockpiles.

According to Thompson and Visser (2001) "Dust, created through the mechanical disintegration of particulate matter, is a problem common to most surface mining operations". The broader environmental effects of dust have been reviewed by Amponsah-Dacosta (1997) who established an emission inventory for a South African coal strip mining operation. The emission inventory was based on a characterisation of open dust sources over a specific interval of time, to produce a dispersion model to enable predictions to be made concerning ambient pollution levels and the identification of major control areas. The analysis, conducted according to US EPA42 guidelines, found that 93.3% of the total emissions from the mine were attributable to dust generated from the mine haul road (the next highest source is attributable to top soil handling as illustrated in Figure 7-17).

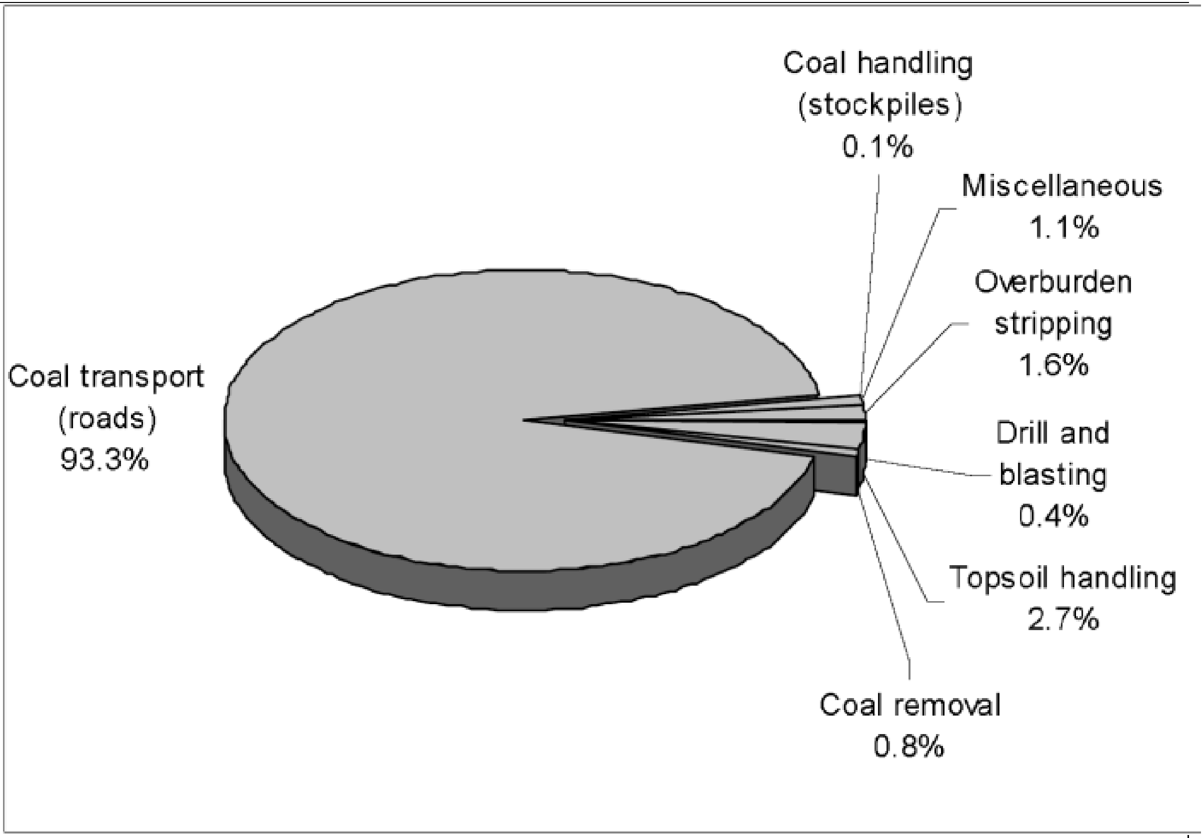


Figure 7-17: Percentage contributions to total dust emissions from typical South African strip mine (Visser & Thompson, 2001)

Although a high tonnage operation, the road network on the mine was similar to other such operations and it was concluded that emissions from the road network would be typical of most opencast coal mines, when calculated on a percentage of total emissions basis. The quantification of particulate emissions from coal mining was accordingly focussed on the quantification of particulate emissions associated with major haul roads at open cast coal mining facilities. The estimations were undertaken using the US EPA's AP42 emissions factors for estimation of dust entrainment from vehicles on unpaved roads.

$$E = k\left(\frac{s}{12}\right)^{a} \cdot \left(\frac{W}{3}\right)^{b} \cdot 281.9$$

Where:

E = emission factor for particulates per vehicle kilometre travelled (g/VKT)

K = k, a, and b are empirical constants

S = silt content of road surface material (%);

W = mean vehicle weight (tonnes)

In the absence of more current information, the mining emissions inventory is based on historical mining production data which could be accessed in the public domain, circa 2006.

Table 7-8: PM10 and PM2.5 Emission from Mining Roads per Local Municipality

Local Municipality	PM10 (tons/annum)	PM10 (%)	PM2.5 (tons/annum)	PM2.5 (%)
eMakhazeni	393.31	<1%	95.14	<1%
eMalahleni	46 006.72	41%	11 129.03	41%
Steve Tshwete	65 424.59	58%	15 826.21	58%
Victor Khanye	1 421.10	1%	343.76	1%
Total	**113 245.72**	**100%**	**27 394.14**	**100%**

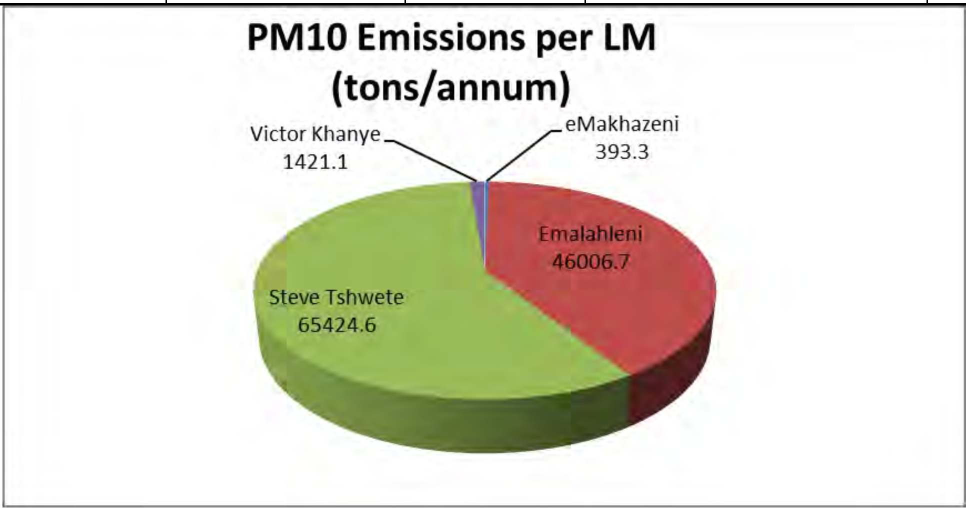


Figure 7-18 : PM10 Emissions from open cast coal mine haul roads

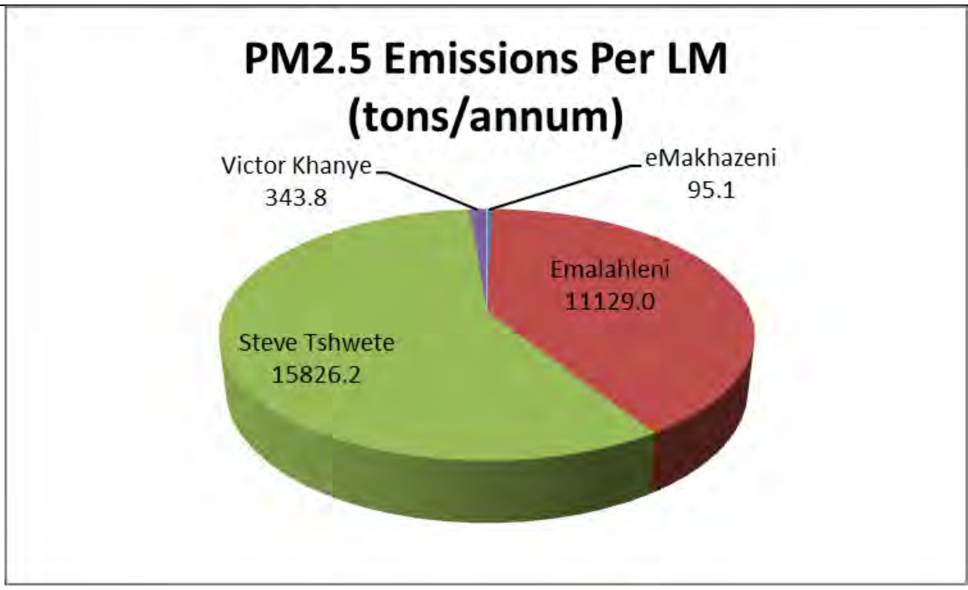


Figure 7-19: PM2.5 Emissions from open cast coal mine haul roads

7.1.6 BIOMASS BURNING

Biomass burning includes the burning of evergreen and deciduous forests, woodlands, grasslands, and agricultural lands. Biomass burning is a key Earth system process, a major element of the terrestrial carbon cycle and a globally significant source of atmospheric trace gases and aerosols (Hao *et al*, 1990; Andreae and Merlet, 2001). Varying in size, location and timing, fires significantly modify land surface properties, influence atmospheric chemistry and air quality, and perturb the radiation budget (IPCC, 2001).

Africa is the single largest continental source of biomass burning emissions (Roberts *et al* 2008). Fire is prevalent throughout southern Africa. It is typically characterised by a prolonged winter dry season, preceded by summer periods with relatively fast rates of plant growth, leading to fuel accumulation that create conditions conducive to frequent fires. In southern Africa, most fires occur in the dry season, particularly July to September, when herbaceous vegetation is either dead (annual grasslands) or dormant, and when deciduous trees have shed their leaves, thereby contributing to an accumulation of dry and fine fuels that are easily combustible (Archibald *et al*, 2009).

Biomass burning results in the oxidation of organic plant material and is typified by being, to a significant extent, an incomplete combustion process (Cachier, 1992), with CO, CH_4 and NO_2 gases being emitted. Other pollutants associated with biomass burning are CO_2, non-methane hydrocarbons (NMHC), formaldehyde, NO_x (NO + NO_2), N_2O, SO_2 and particulates (TSP and PM_{10}). Emissions from biomass burning include a wide range of gaseous compounds and particles that contribute significantly to the tropospheric budgets on local, regional, and even global scales. The emission of CO, CH_4 and VOC affect the oxidation capacity of the troposphere by reacting with OH radicals, and emissions of nitric oxide and VOC lead to the formation of ozone and other photo oxidants. The fraction of the landscape that burns across the region varies because of the influence of weather conditions, the presence of ignition sources, and the amount, type, and arrangement of the available fuel (Archibald *et al*, 2009). The majority of fires on the NDM are thought to be anthropogenic and include veld fires, burning of grazing land and crop-residue.

The emission of criteria pollutants from biomass fires is calculated by the general formula:

Emission **=** (Area burned) **x** (Fuel Load) **x** (Completeness of combustion) **x** EF

Any method for determination of emissions of criteria pollutants thus has to estimate the Area burned, the Fuel load and the Completeness of combustion and couple the resultant mass of fuel burned with an emission factor relating to the specific fuel type.

Biomass burning is accompanied by a wide variety of characteristic spectral signatures that can be detected by earth observation satellites. These include thermal radiation from actively burning fires, and the spectral reflectance and albedo changes induced by newly burned surfaces when compared to reference and surroundings. As such, it is ideal for monitoring using remote sensing techniques on earth observation satellites.

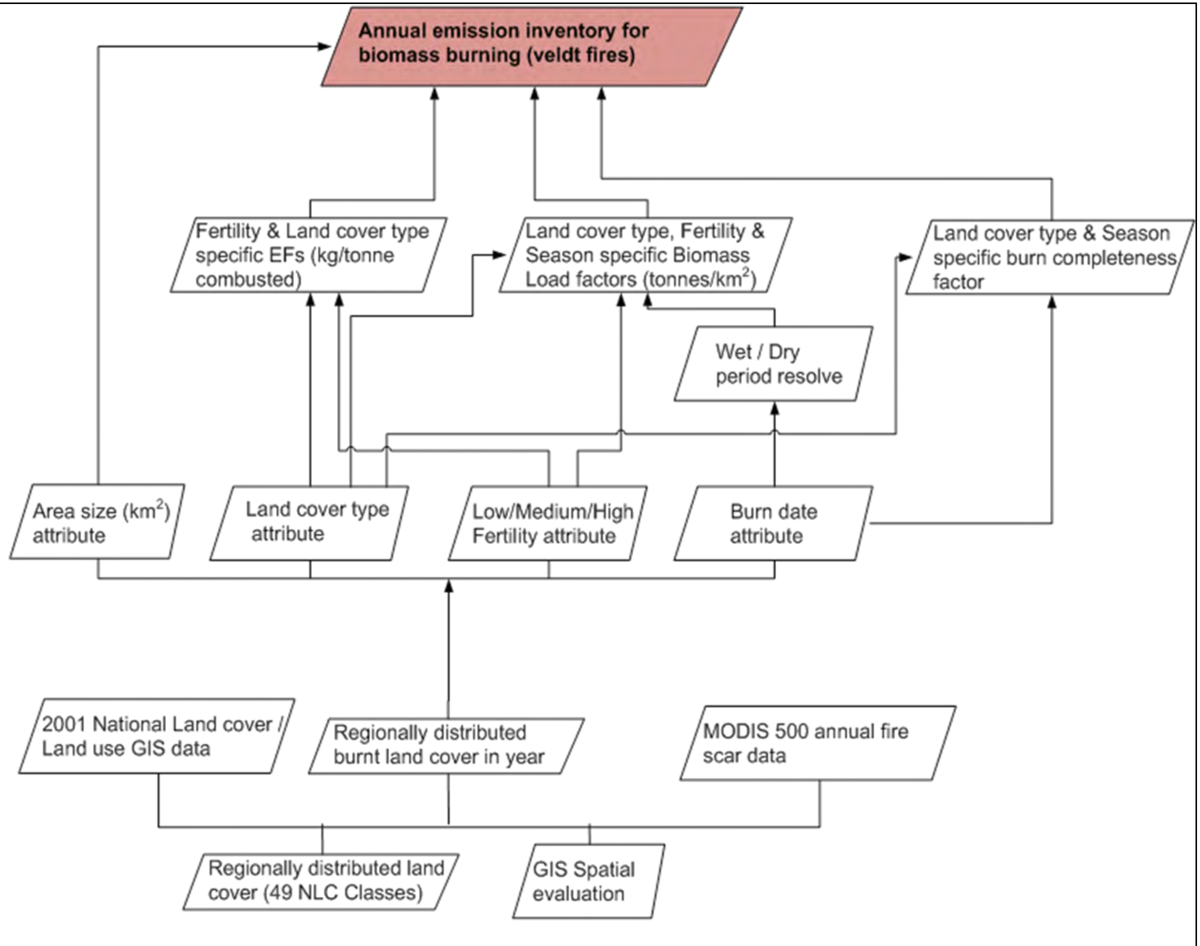
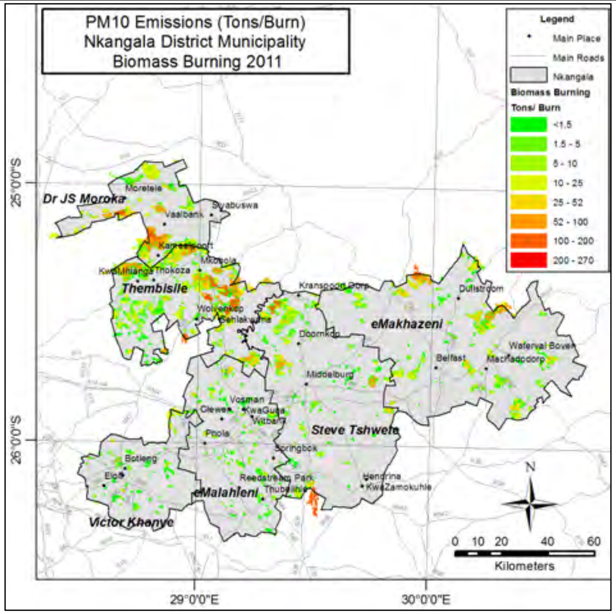
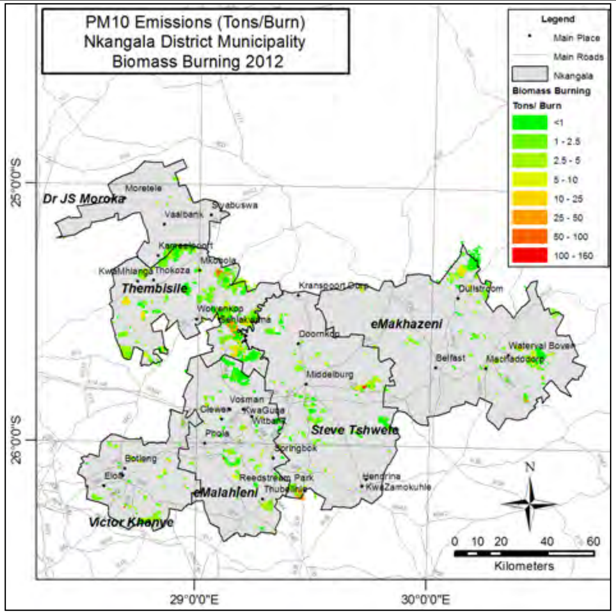


Figure 7-20: Biomass emissions inventorisation and parameterisation process


PM10 Emissions (Tons/Burn)
Nkangala District Municipality
Biomass Burning 2011
Legend
Main Place
Main Roads
Nkangala
Biomass Burning
Tons/ Burn
<1.5
1.5 - 5
5 - 10
10 - 25
25 - 52
52 - 100
100 - 200
200 - 270
Dr JS Moroka
Thembisile
eMakhazeni
Steve Tshwete
eMalahleni
Victor Khanye
0 10 20 40 60
Kilometers
25°0'0"S
26°0'0"S
29°0'0"E
30°0'0"E


PM10 Emissions (Tons/Burn)
Nkangala District Municipality
Biomass Burning 2012
Legend
Main Place
Main Roads
Nkangala
Biomass Burning
Tons/ Burn
<1
1 - 2.5
2.5 - 5
5 - 10
10 - 25
25 - 50
50 - 100
100 - 160
Dr JS Moroka
Thembisile
eMakhazeni
Steve Tshwete
eMalahleni
Victor Khanye
0 10 20 40 60
Kilometers
25°0'0"S
26°0'0"S
29°0'0"E
30°0'0"E

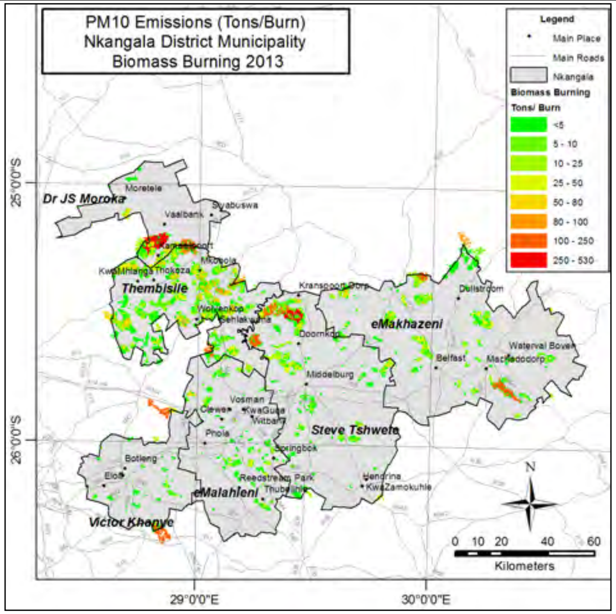


Figure 7-21: PM10 emissions from Biomass Burning within the NDM for 2011 - 2013

The emissions from biomass burning for the NDM between 2011 and 2013 indicated the most emissions coming from the Steve Tshwete local Municipality. With 47% of the total PM_{10} emissions (**Figure 7-22**), 47% of total SO_2 (**Figure 7-23**), 41% of total NO_x (Figure 7-24) and 47% of total CO (**Figure 7-25**) emitted from biomass burning.

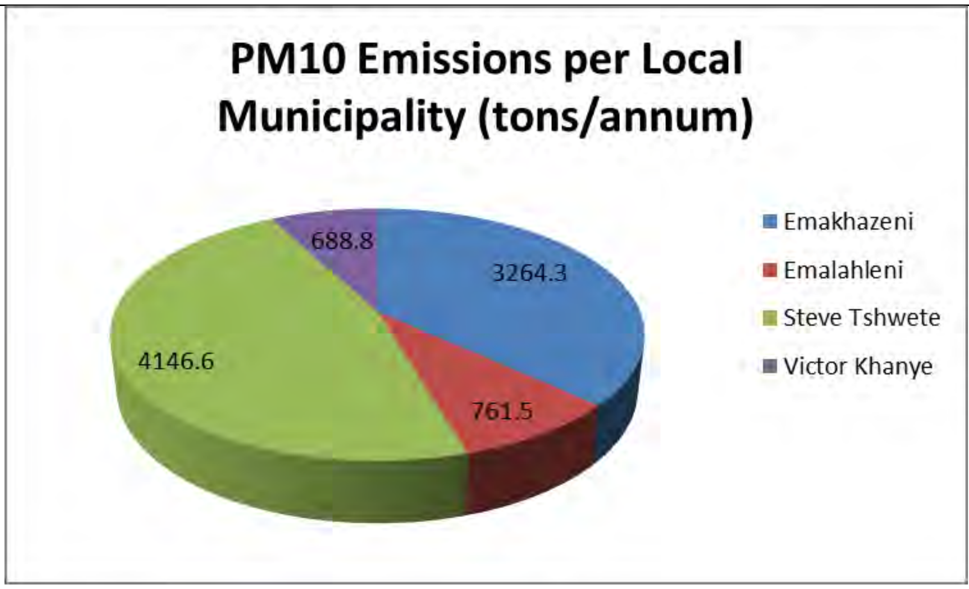


Figure 7-22: PM10 Emissions per local municipality for the NDM

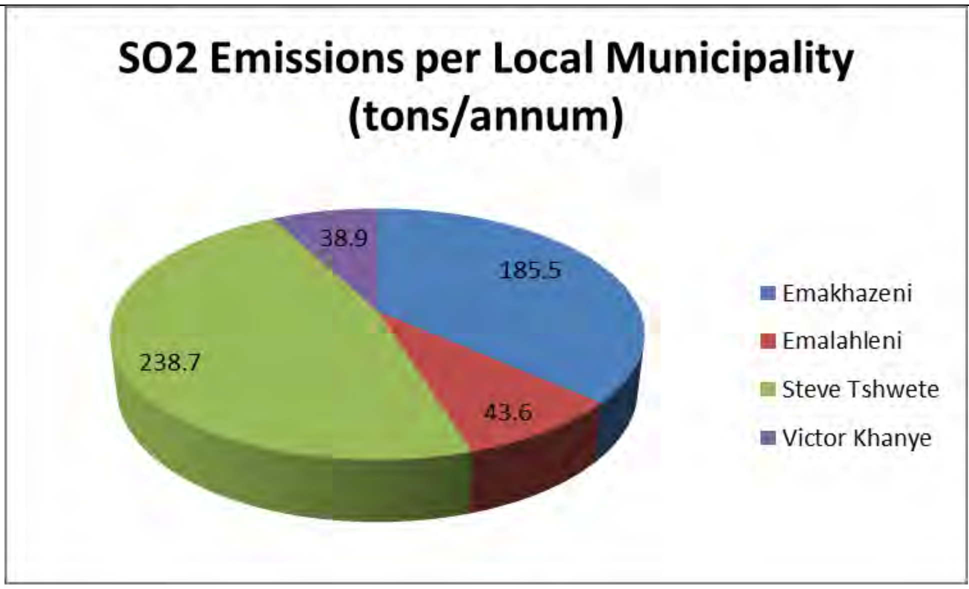


Figure 7-23: SO2 Emissions per local municipality for the NDM

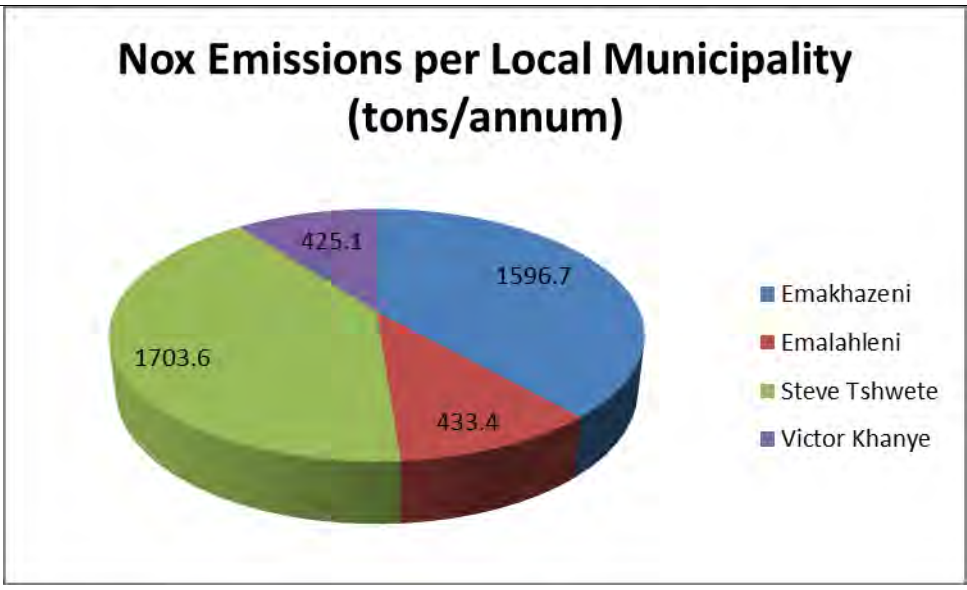


Figure 7-24: NOx Emissions per local municipality for the NDM

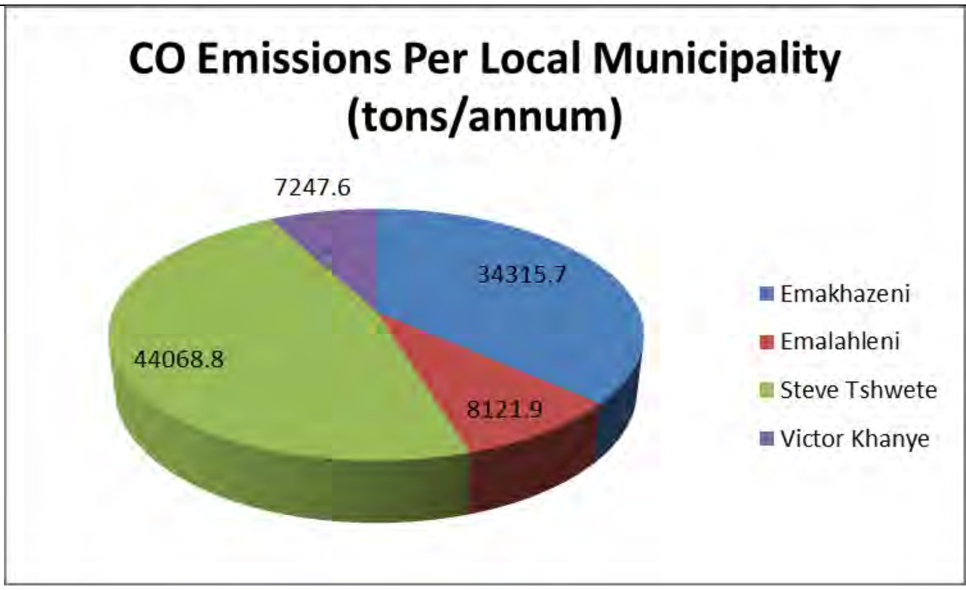


Figure 7-25: CO Emissions per local municipality for the NDM

7.2 VEHICLE EMISSIONS

Although there are various forms of transport operated in the NDM, road going motorised vehicles are by far expected to be the most significant source of transport related emissions. Emissions from vehicles arise from various sources, namely:

- Exhaust fumes comprising gases and PM from fuel combustion
- Fugitive fumes due to evaporation of fuel from the fuel tank.
- PM from attrition associated with the braking system, tyre wear etc.
- PM entrained from road surfaces.
- Fugitive PM may also arise from trucks carrying uncovered loads from PM can become entrained.

The following key pollutants are emitted from motor vehicles:

- Nitrogen oxides (NO_x)
- Carbon monoxide (CO)
- Particulate matter (PM_{10}, $PM_{2.5}$)
- Sulphur dioxide (SO_2)
- Hydrocarbons (e.g. benzene - C_6H_6)

The quantity of pollutants emitted is typically estimated based on vehicle type, fuel used, traffic characteristics (speed, time spent idling etc.), and vehicle age amongst other variables. Emissions on a wide scale can also be estimated using fuel use data. The DEA undertook a national motor vehicles emissions inventory (DEA 2012), which uses a combination of these methods. The data is reported down to municipal level. This data was used directly to account for vehicle emissions in the NDM, and is summarised in Table 7-9 and further illustrated in the pie charts which follow.

Table 7-9: Vehicle Emissions in the NDM

Municipality	Emission Rate (ton/year)							
	NO_x	**SO_2**	**CO**	**PM_{10}**	**NMVOC**	**Benzene**	**Lead**	**CO_2**
Dr JS Moroka	438	6.1	3 148	17.1	434	0.56	0.00059	86 646
eMakhazeni	5 320	261.7	14 608	453.4	2 106	2.42	0.01029	1 150 893
eMalahleni	760	35.9	2 234	117.6	323	0.37	0.00143	161 221
Steve Tshwete	2 847	125.3	9 233	247.7	1 325	1.54	0.00528	604 239
Thembisile	78	2.3	411	5.4	57	0.07	0.00012	16 010
Thembisile	55	0	495	0.5	68	0.09	0.00006	10 619
TOTAL	**9 498**	**431.3**	**30 129**	**841.7**	**4 313**	**5.05**	**0.01777**	**2 029 628**

Notably the report that the South African Petroleum Industries Association (SAPIA) was initially contacted to source the data. This is now the responsibility of the Department of Energy (DoE). Fuels sales data for the years 2007, 2008 and 2009 was readily obtained from the DoE as this data currently resides in the public domain. However, the preferred data set for the year 2011 could only be released by the DoE with special permission by application from the Deputy Director General (DDG) of the Department of Environmental Affairs. The 2011 fuel sales data was still outstanding at the time emission estimation calculations commenced, so the next best option was to use 2009 data.

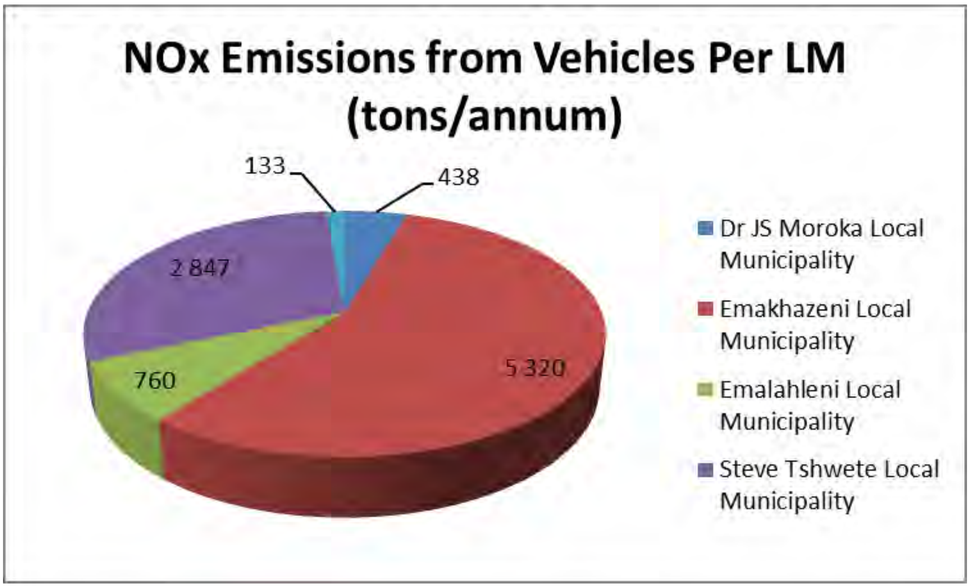


Figure 7-26: NOx Emissions from Vehicles within NDM

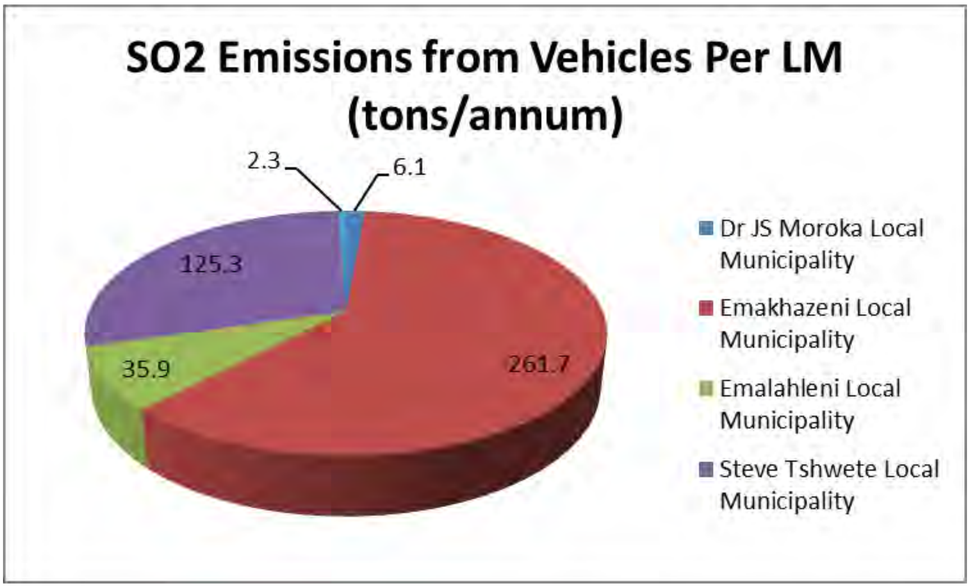


Figure 7-27: SO_2 Emissions from Vehicles within NDM

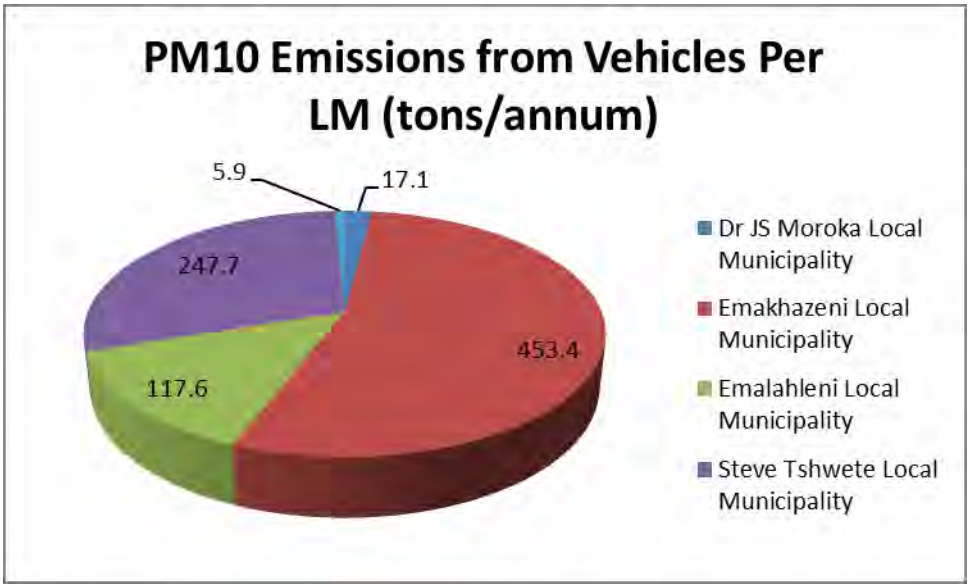


Figure 7-28: PM10 Emissions from Vehicles within NDM

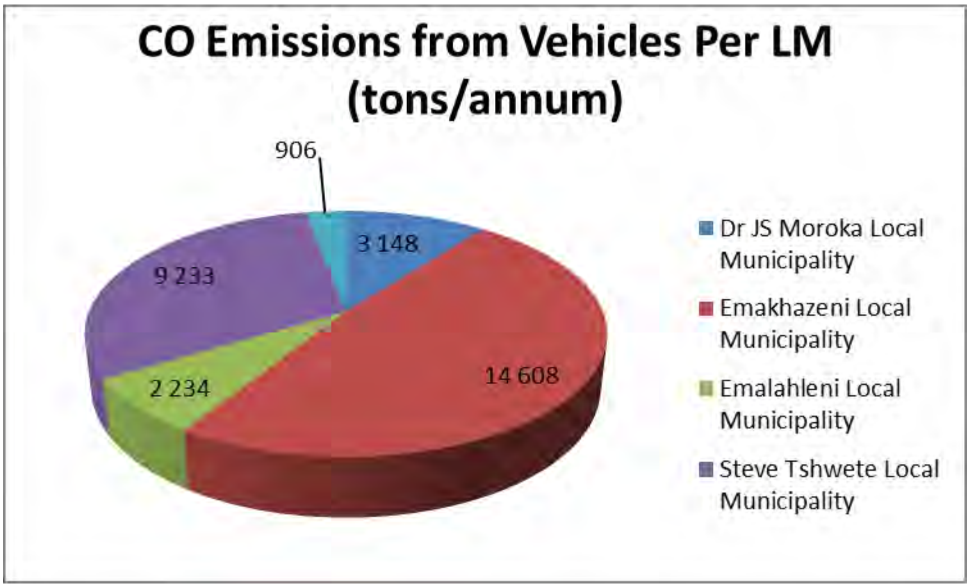


Figure 7-29: CO Emissions from Vehicles within NDM

8 AIR QUALITY PROBLEM DESCRIPTION

8.1 MEASURED AND MODELLED AMBIENT POLLUTANT CONCENTRATIONS

Where the NAAQS are not met there are potentially significant impacts on human health and the environment. Through review of ambient monitoring data and dispersion modelling output, various areas have been identified where the NAAQS are not met. In particular the risks to human health may be significant where these areas intersect with populated regions.

The air quality hotspots of the NDM are summarised in Table 4-1 with an indication of the pollutants of concern.

Table 8-1: NDM Hotspots

Hot Spot	PM	SO2	NO2
eMalahleni	✓	✓	✓
Middelburg[1]	✓	✓	✓
Komati	✓	✓	✓
Hendrina	✓	✓	✓
Kriel			✓
Hotspot identification is based on measured ambient data and results of dispersion modelling.			

Notably dispersion modelling shows that the impact of SO_2 emissions from power stations, if they are assumed to emit at the rates applied for in their postponement applications would affect the entirety of the Victor Khanye, Steve Tshwete, and eMalahleni and Victor Khanye local municipalities as well significant portions of the JS Moroka and Thembisile Hani local municipalities, however these results are likely an over-estimation of the impact given that reported annual average emissions are significantly less than the maxima applied for. The hotspots are therefore based on scenario 1 emission rates.

The hotspots are depicted in Figure 8-1 to Figure 8-3. SO_2 and NO_2 are largely associated with industrial sources. Ambient PM10 is derived from numerous sources, most of which have not been dispersion modelled and whose contributions are therefore difficult to apportion.

[1] Notably SO_2 from metallurgical operations may be overestimated in the absence of measured emissions data due to the effect wet scrubbers.

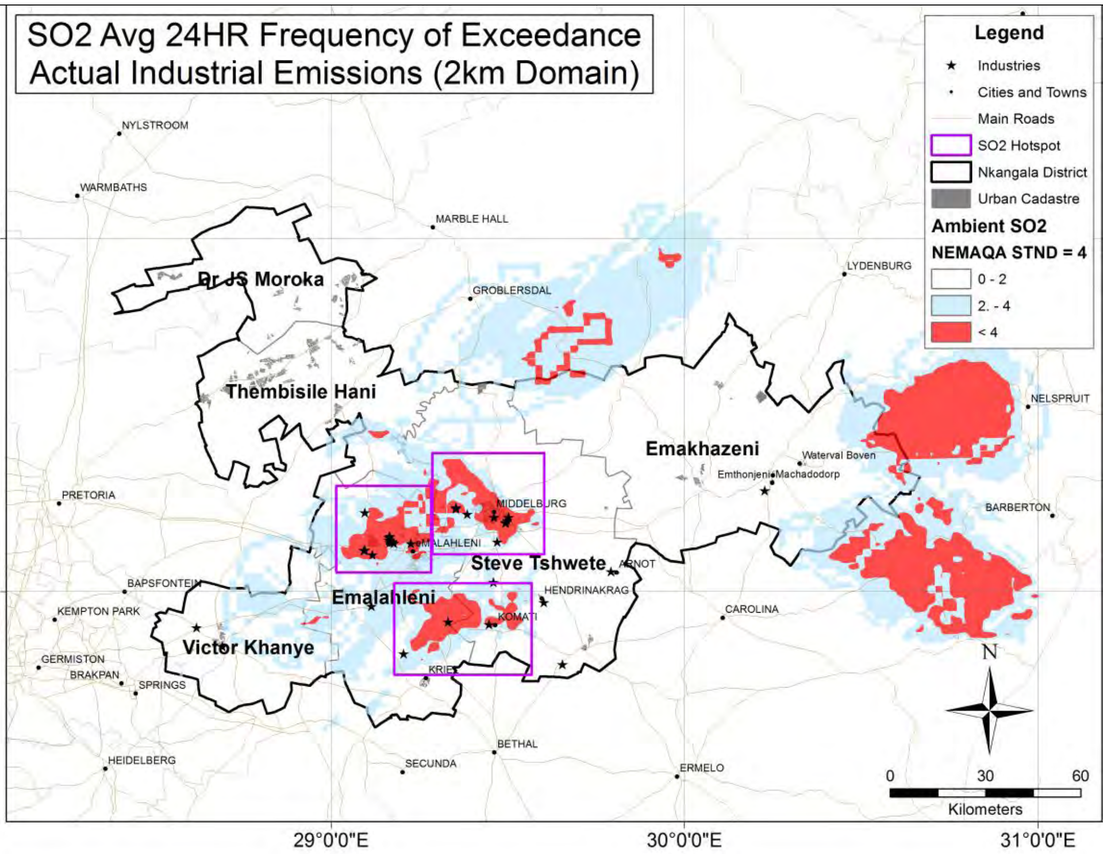


Figure 8-1: SO2 Hotspots

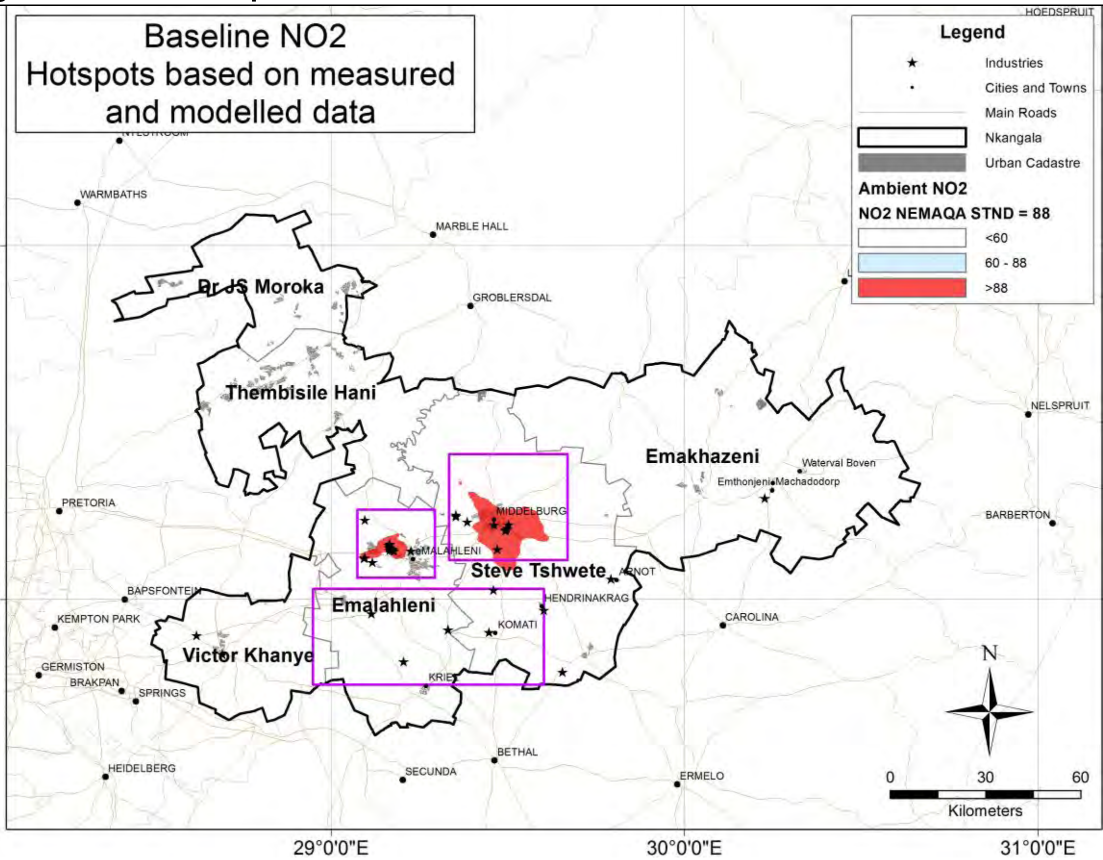


Figure 8-2: NO2 Hotspots

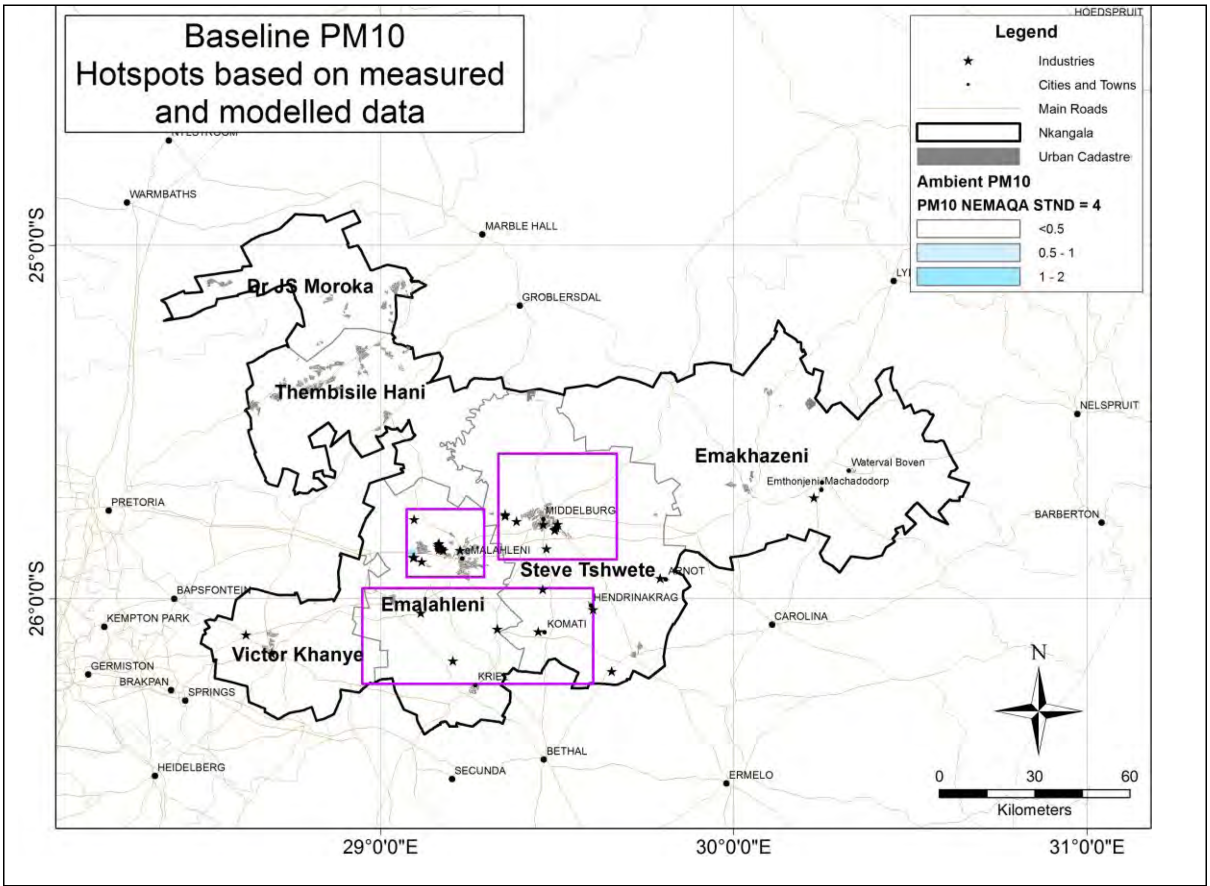


Figure 8-3: PM Hotspots

8.2 HOUSEHOLD FUEL COMBUSTION

High density low income areas where significant volumes of wood and coal are combusted for domestic purposes (heating, cooking etc.) are also of significant concern due to exposure of these populations to emissions therefrom. Receptors are in proximity to the sources and this is further exacerbated by the low release height of these emissions which results in constrained dispersion during stable low level atmospheric conditions, as is typical on the highveld during winter. These stable conditions coincide with the highest coal and wood usage rates due to low ambient temperatures. Proximity to significant industrial sources may further impact on receptor exposure depending on distance and direction from these sources, as well as intervening topography.

Due to the constrained dispersion of domestic fuel burning sources the area of impact is typically does not extend far beyond the settlements themselves as illustrated in Figure 8-4. Consequently these areas of high ambient pollutant concentration are not conspicuous in the hotspots depicted in Figure 8-1 to Figure 8-3.

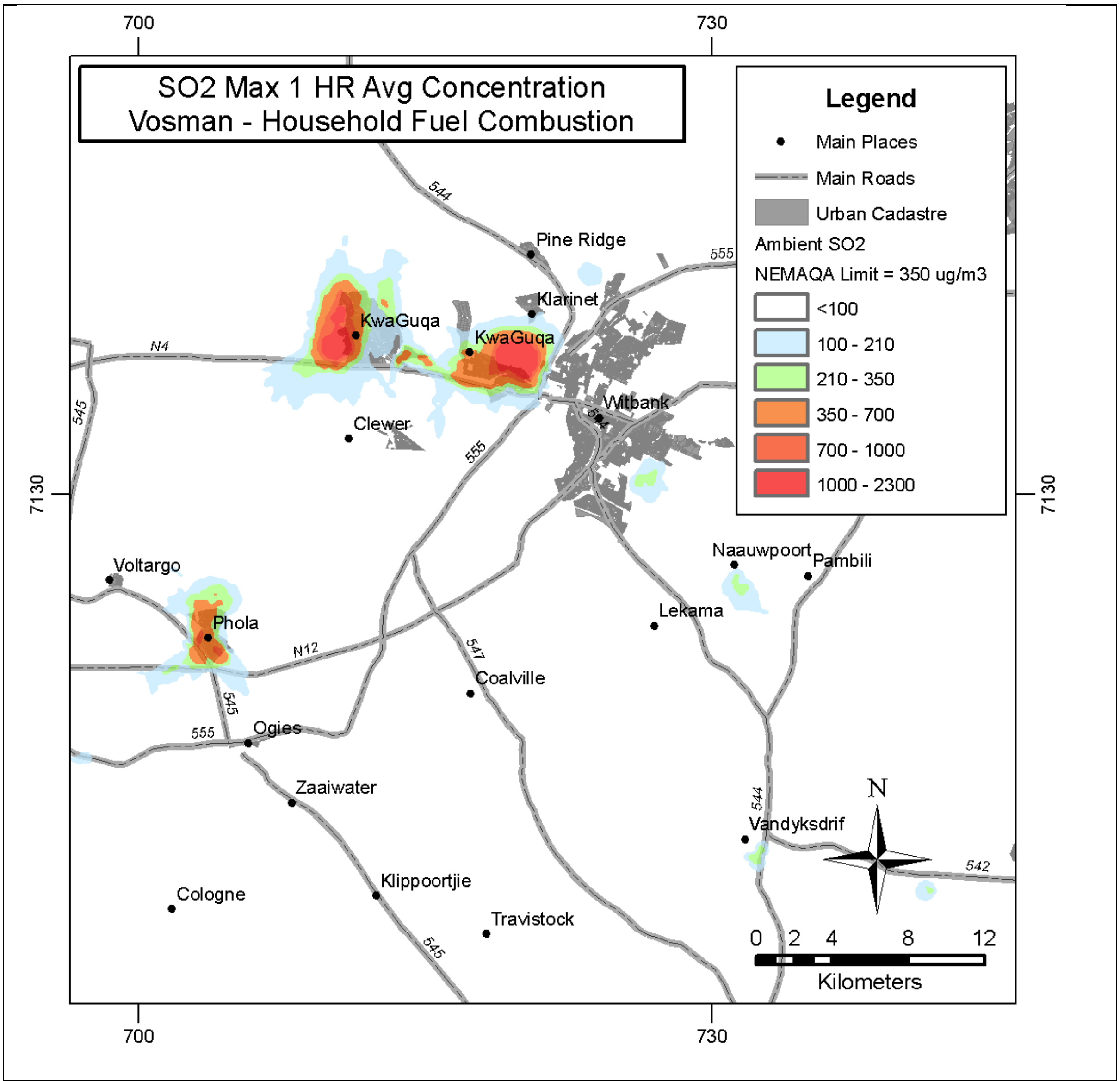


Figure 8-4: Household Fuel Combustion Impact

8.3 AIR QUALITY MANAGEMENT CAPACITY

The NDM has a significant deficiency of resources required to fulfil its mandates in terms of NEM:AQA. Table 8-2 provides a summary of human resources allocated and positions vacant in respect of these mandates.

Table 8-2: Summary of NDM mandates versus resources

FUNCTION	Human Resources Allocation	Vacancies
Implement the AQA atmospheric emission licensing system referred and for this purpose perform the functions of licensing authority as set out in Chapter 5 and other provisions of the NEM:AQA.	3	2
Monitoring potential illegal listed activities.		
Monitoring compliance with conditions or requirements of an atmospheric emission license.		
Monitoring any information provided to an air quality officer to ensure that it does not contain false or misleading information.		
Monitor ambient air quality and source emissions.	0	-
The development of air quality management plans as a component of integrated development plans as required by the Municipal Systems Act.	0	-
The setting of municipal standards for emissions from point, non-point or mobile sources in the municipality in respect of identified substances or mixtures of substances in ambient air which, through ambient concentrations, bioaccumulation, deposition or in any other way, present a threat to health, well-being or the environment in the municipality.	0	-
Monitoring compliance with emission standards in respect of the manufacture, sale or use any appliance or conducting of an activity declared as a controlled emitter.	0	
Monitoring compliance in respect to reasonable steps to prevent the emission of any offensive odour caused by any activity.	0	
Monitoring compliance with directives to submit an atmospheric impact report.	0	
Monitoring compliance with notification requirements in respect of mines that are likely to cease mining operations within a period of five years.	0	

A review was undertaken of the current structures within the Social Development Section with respect to air quality management roles and requirements of the municipality, in comparison to the municipality's mandates, and in cognisance of, amongst others:

- The number of listed emitters in the NDM
- The potential number of controlled emitters
- The geographical spread of the NDM
- Monitoring and enforcement requirements
- Current workload

It is clear that the existing human resource allocations are insufficient for fulfilling the mandate. Adequate human resources to fulfil the municipality's mandates are illustrated in Figure 8-5 and were derived based on a review NDM S78 assessment for the Atmospheric Emission Licencing function as well Sedibeng District Municipality's S78 assessment Delivery of an Effective Air Quality Management Services. Notably the need for enforcement capacity through designation of Environmental Management Inspectors is a key requirement across the sub-functions. The provision legal expertise in respect of environmental, administrative, and enforcement legislation is also key to the success of air quality management service provision.

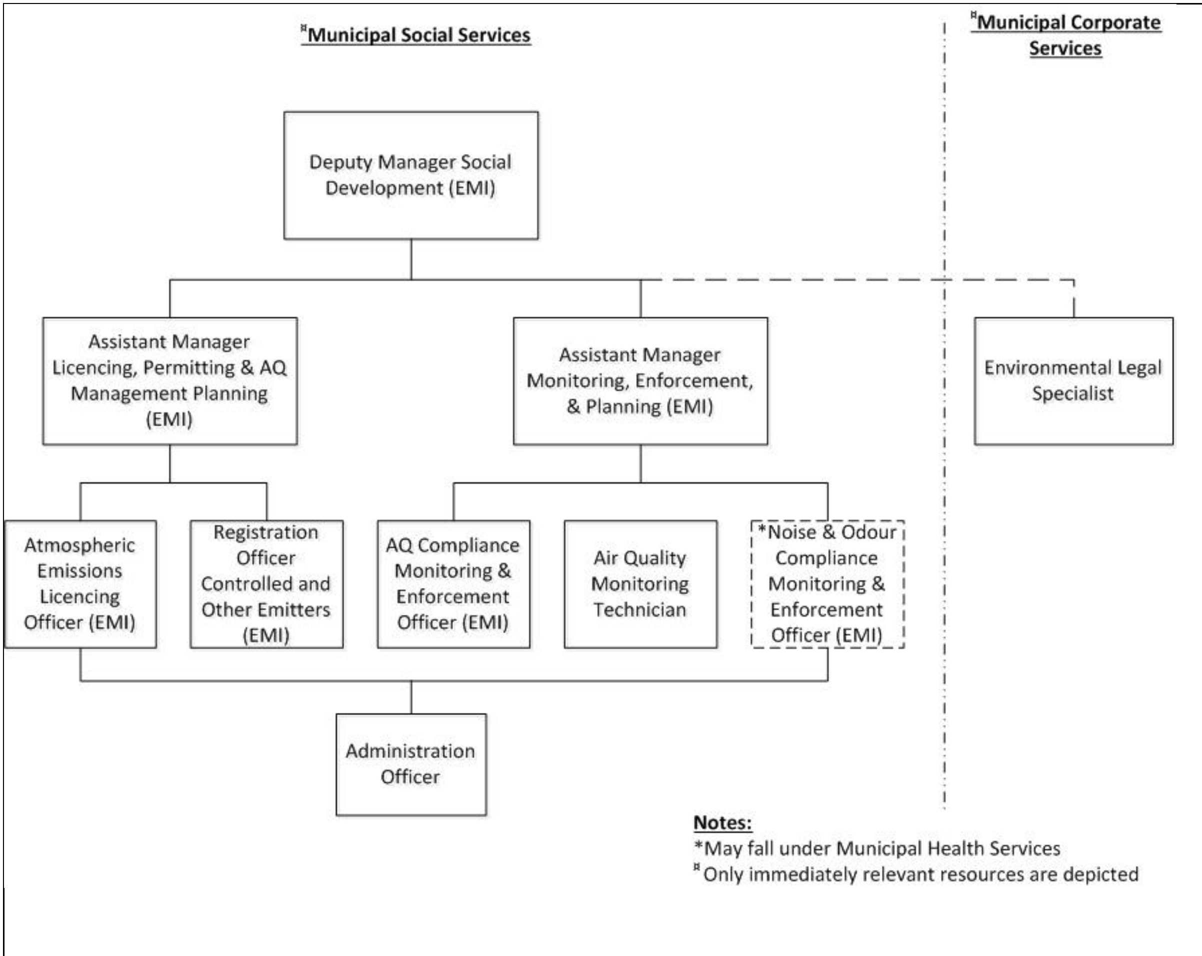


Figure 8-5: Proposed Structure for Effective Air Quality Management Service Delivery in the NDM

8.4 EMISSIONS MANAGEMENT PROBLEMS

Table 8-3: Summary of Abatement Technology Problems

	Challenges	Developments/Plans
Industrial sources	• Management of fugitive and non-point sources • PM, SO_2 and NO_2 emission management and control, primarily cost related.	• Several applications for postponement of compliance with the MES (GN 893:2013) granted, with requirement for emissions off-setting plans. • AELs issued with requirements for fugitive emissions planning; enforcement required.
Mining	• Control of PM from unpaved haul roads	• Various means of abatement available, enforcement action required.

Domestic fuel burning	• Poor uptake of technology due to economic circumstances • Pace of settlement growth	• Emissions off-setting plans may provide improvements. This may provide a model more for more effective emissions reduction. • Electrification roll-out underway • Housing projects in progress (Reconstruction and Development Programme (RDP))
Motor vehicle emissions	• Ageing vehicle fleet • Increasing vehicle population • Lack of structured efficient public transports systems	• Vehicle emission standards continue to improve • Drive towards cleaner fuels and low emission vehicles is increasing • Vapour recovery units can address re-fuelling emissions

9 TECHNOLOGY REVIEW

9.1 TYPICAL ABATEMENT TECHNOLOGY IN USE IN THE NDM

There are numerous sources of emission to atmosphere in the NDM. Each of these sources has unique characteristics, however the sources can, and have, been broadly grouped in terms of the similarity of the processes undertaken. Similar sources generally tend to have similar, although not identical, emissions. Likewise, there are numerous methods available and in use for the prevention and abatement of atmospheric emissions. A brief description of commonly used abatement technologies is provided here.

1.1.1 PARTICULATE ABATEMENT

Point emission sources are in many cases fitted with emissions extraction and abatement equipment. Based on information availed in AELs, Particulate abatement for sources in the NDM is achieved mainly by:

- Electrostatic Precipitators (ESPs)
- Fabric Filters
- Wet Scrubbers
- Cyclone Separators

1.1.2 ELECTROSTATIC PRECIPITATION

ESPs operate on principles of electrostatic attraction. The dust-laden gases pass through a chamber where the individual particles of dust are ionised as a result of a high voltage negative direct current (DC) field. The charged dust particles are removed from the gas stream onto the collecting electrodes. After being dislodged by intermittent blows on the electrodes - called rapping - the dust particles drop into dust hoppers situated below the electrodes.

The efficient operation of a precipitator depends largely on the resistivity of the ash. The resistivity in turn depends on the chemistry of the ash. High sulphur coals will tend to produce ash with lower resistivity and thus higher ESP efficiency and vice versa. The use of low sulphur coal can thus reduce ESP efficiency but this can be counteracted with flue gas conditioning (FGC). At present, the injection of sulphur tri-oxide (SO_3) is used to improve the surface conductivity of ash fed through ESPs. The sulphur injection rate should generally be low in comparison to the inherent sulphur from the coal.

ESPs are generally highly effective at removing particulate matter, including very small particulates. They are able to operate at high temperatures and handle high gas volumes with low operating costs. The main disadvantages of ESPs are the initial capital costs, the dependence on particulate resistivity, and the inability to handle explosive gases.

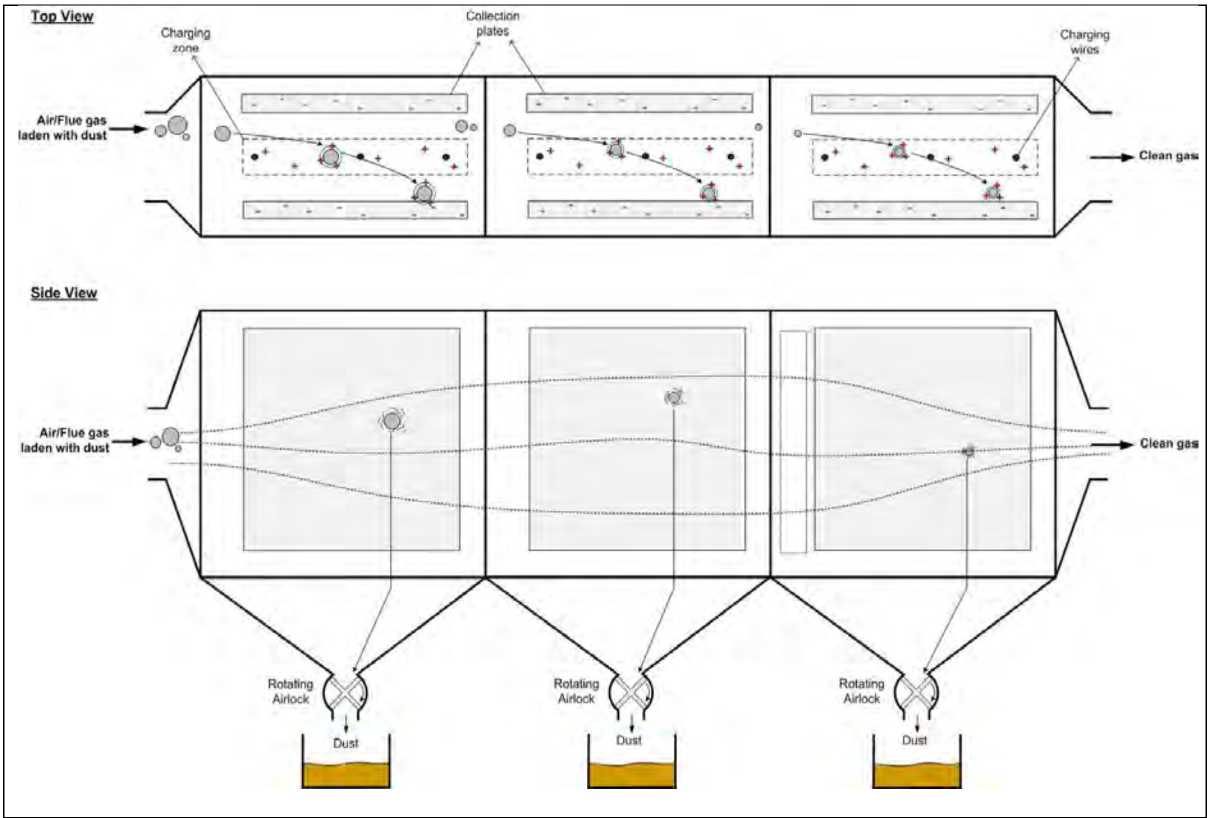


Figure 9-1: Conventional Electrostatic Precipitator

1.1.3 FABRIC FILTERS

Fabric filters are a well-known and widely applied method for separating dry particulates from gas flow. The gas passes through a set of filter bags in parallel leaving particulates retained on the fabric, this layer of 'dust' then further improves the filtration efficiency for small particulates. The bags are periodically cleaned (usually by pulses of compressed air) in order to drop the filter cake off the bag for collection in hoppers at the bottom of the filter.

Fabric filters are generally highly effective at removing particulate matter, including very small particulates. They can operate on a wide variety of dust types. The main disadvantages are susceptibility to corrosive gases, fire, moist gas streams and the temperature limitations of the bags.

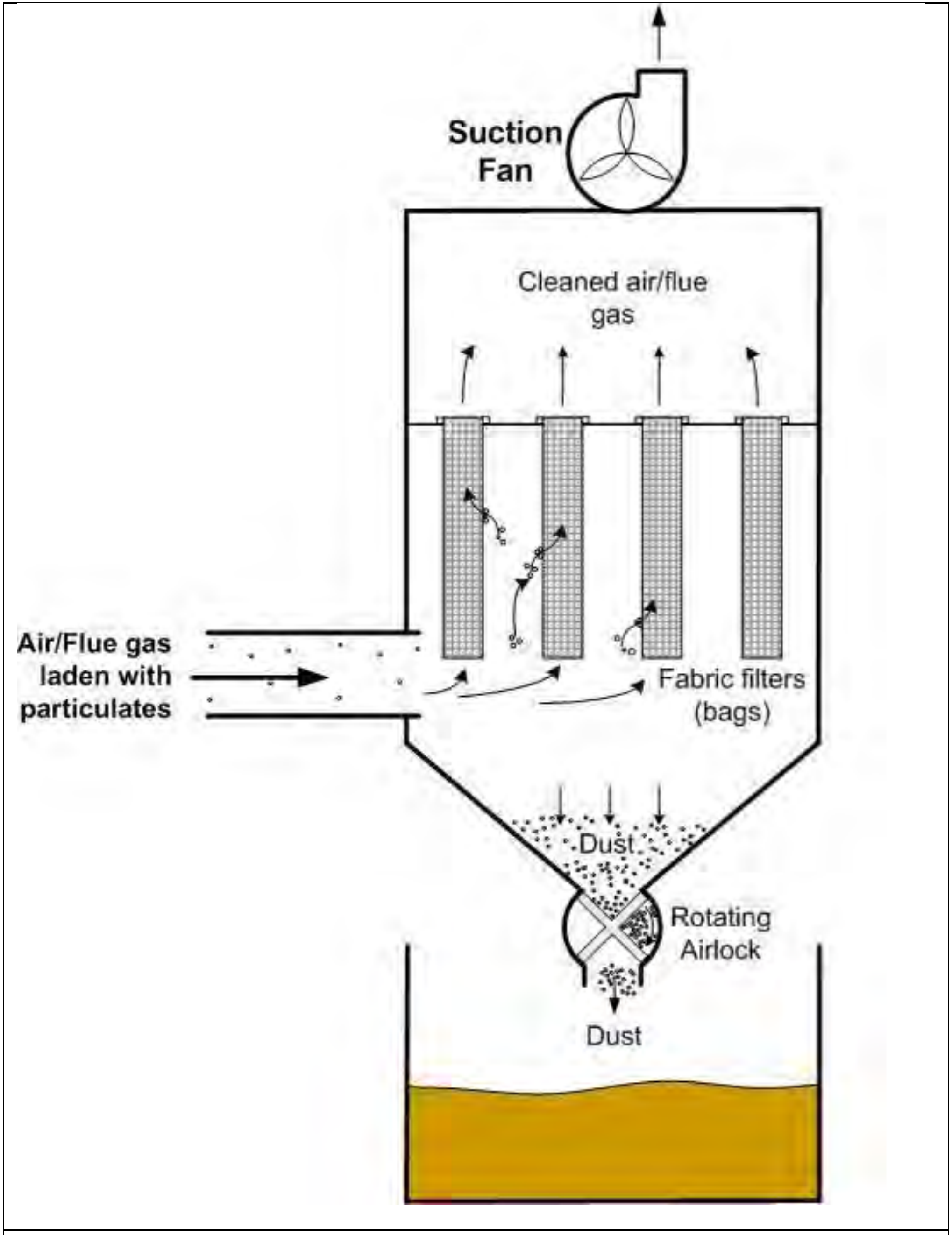


Figure 9-2: Fabric filter Plant

1.1.4 SCRUBBERS

Scrubbers come in various forms and combinations of devices used for wet and dry abatement. Particulate scrubbers are generally wet collection devices. There are numerous forms of scrubbers; however the main method of removal of particulates is through the entrapment of particulates in droplets (usually water droplets) and subsequent removal from the gas stream.

Scrubbers may have high efficiencies for a range of particle sizes and are generally suitable for moist, corrosive, and explosive gas streams. They have the disadvantage of producing effluent and being more maintenance intensive than fabric filters and ESPs.

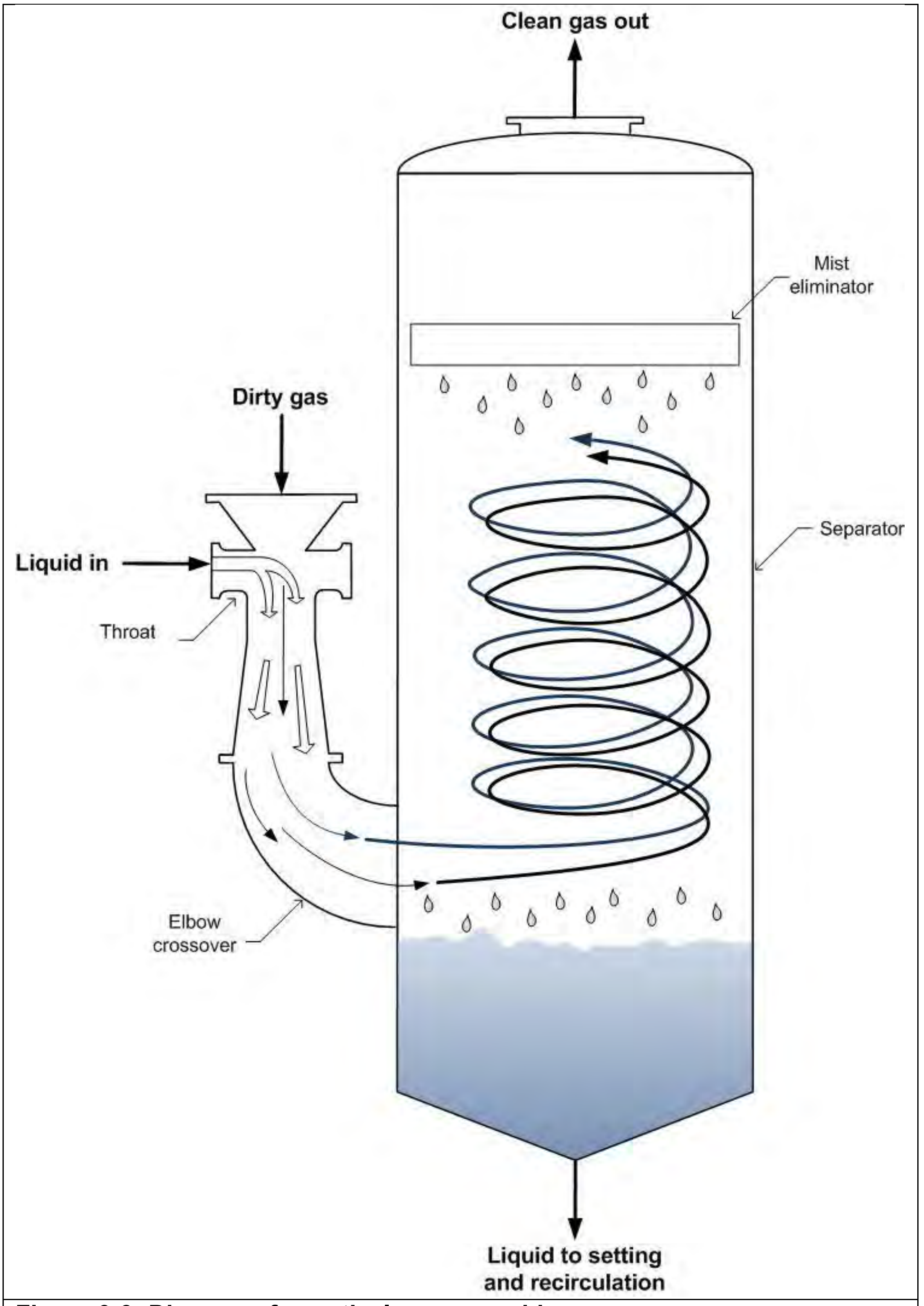


Figure 9-3: Diagram of a vertical spray scrubber

1.1.4.1 Cyclone separators

Cyclone separators (commonly referred to as cyclones) remove particulates from laden gas streams using centrifugal forces. Typically, a particulate-laden gas enters tangentially near the top of the cyclone as depicted in Figure 9-4. The gas flow is forced into a downward spiral due to the cyclone's shape and the tangential entry.

The centrifugal inertia of the particulates forces them to move outward and collide with the outer wall of the cyclone. The particulates then slide down to the bottom of the cyclone. The gas stream reverses near the bottom and spirals up in an inner spiral, which exits as a cleaned gas through a narrow tube at the top of the cyclone.

Cyclones are typically used as initial particulate removal equipment. They are generally inadequate for meeting particulate emissions limits but provide a cost effective, relatively maintenance-free means of effectively reducing particulate load in the gas stream, thus reducing the burden on downstream abatement equipment such as fabric filters and ESPs. The larger and denser the particulates in the gas stream, the more effective the cyclones. Collection efficiency decreases with decreasing particulate density and size.

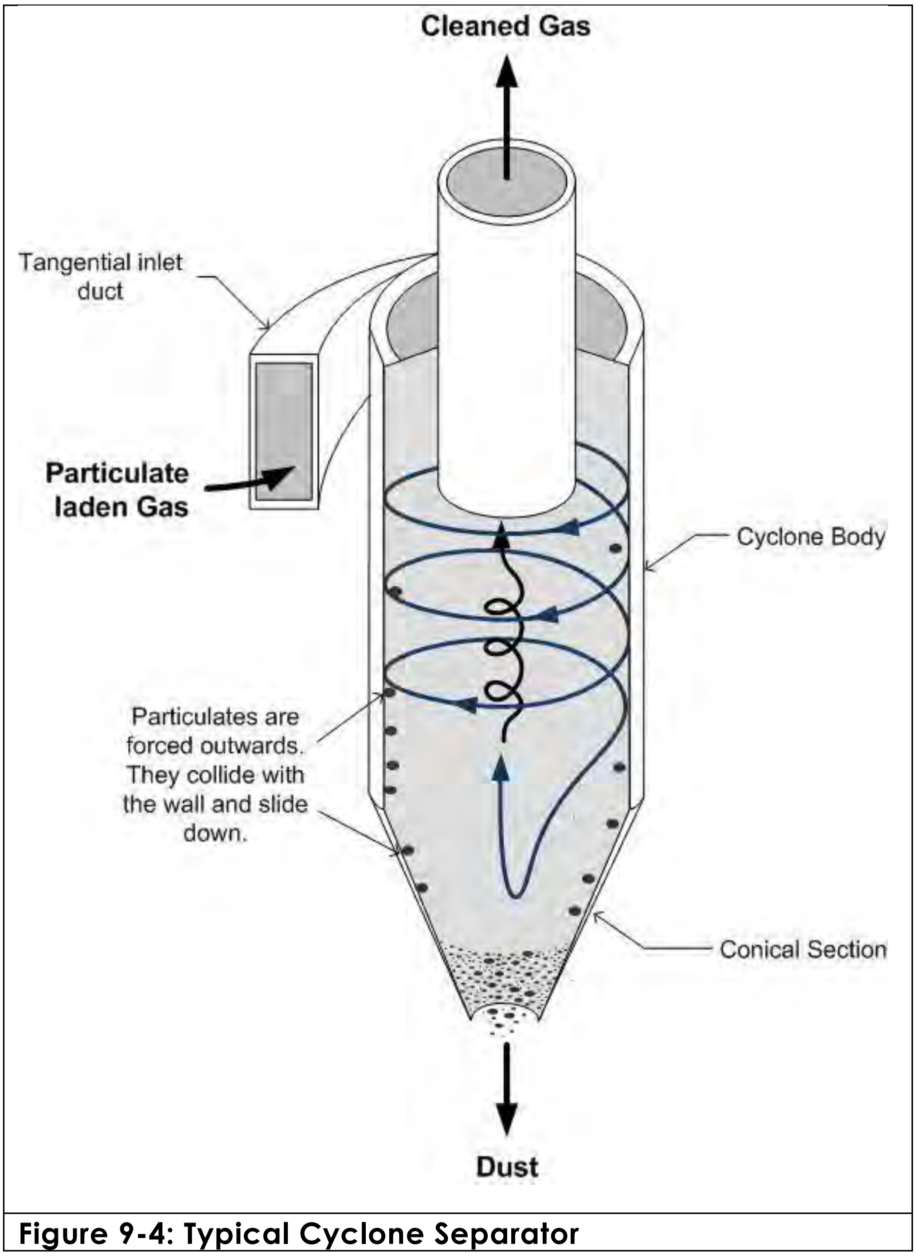


Figure 9-4: Typical Cyclone Separator

1.1.5 SO_2 PREVENTION AND ABATEMENT

SO_2 emissions are generally associated with the combustion of coal, although other sources of SO_2 exist depending on the raw materials employed in certain processes. The rate of generation of SO_2 is dependant primarily on the sulphur content of the source. Sulphur content in coal depends on the source of the coal used. South Africa's coal reserves are mainly bituminous with a relatively high ash content (about 45%) and low sulphur content (about 1%) (DEAT 2004). Coal is the most prolific source of fossil energy in South Africa and is particularly abundant on the South African Highveld. It is thus a prime source of energy for industrial processes as well as for domestic thermal requirements.

SO_2 emissions are most effectively prevented through limiting sulphur input. SO_2 is a soluble acidic gas and there are various means of removing or reducing SO_2 from gas emission streams. The most commonly used means of reducing emissions is by absorption in scrubber water or by dissolution and neutralisation in alkaline scrubber water. SO_2 may also be removed through dry scrubbing, or lime dosing.

1.1.6 NO_2 PREVENTION AND ABATEMENT

There are two main sources of oxides of nitrogen (NO_x):

- Thermal NO_x
- Fuel NO_x

Thermal NO_x is produced by the reaction of oxygen with nitrogen at high temperatures and typically originates from high temperature combustion processes. The rate of thermal NO_x formation depends on the temperature and residence time during which the reagents are exposed to high temperatures, in particular residence time in flames where temperatures can be as much as 2000°C. Thermal NO_x can thus be reduced by reducing flame temperatures and reducing oxygen availability in high temperature zones. This requires specially designed combustion equipment that employs numerous methods to reduce flame temperature, oxygen availability and residence time, including, but not limited to:

- Off-stoichiometric combustion;
- Low NO_x burners;
- Flue gas recirculation;
- Gas re-burning; or
- Water injection (or steam injection).

Fuel NO_x depends on the nitrogen content of the fuel/raw materials used. The rate of NO_x generation is governed largely by the availability of oxygen during combustion, and is less temperature-dependent than thermal NO_x formation.

NO_x emission levels can also be reduced through flue gas treatment (FGT), the primary means of which are wet absorption, dry sorption, catalytic and non-catalytic conversion.

1.1.7 POWER GENERATION SECTOR

Power generation in the NDM consists in the main of coal fired power stations. Typically these activities consist of the follow processes:

- Receiving, handling and subsequent storage of coal in silos.
- Milling of coal to particle size suitable for the boilers used.

- Combustion in boilers to produce steam which is subsequently used to drive turbines that in turn drive generators to produce electricity.
- Ash from boilers is quenched or dampened and disposed to ash dams.

The facilities use bag filters or ESPs for particulate abatement. In some instances sulphur trioxide is injected in the flue gas to improve ESP efficiency. There are no acid gas (SO_2 and NO_2) abatement facilities installed.

1.1.8 METALLURGICAL INDUSTRY

South Africa has significant metallurgical ore resources, and is a significant global contributor in many sectors of the ferroalloy industry, and related industrial chemicals sectors. The "primary metallurgical group", in this study, encompasses pyrometallurgical processes in the NDM, in the main:

- Iron and steel producers and;
- Ferrosilicon producers

In all cases, production involves the application of pyrometallurgical processes for the winning of primary, intermediate and/or final products from ore. The primary energy sources for these processes are:

- Coal;
- Natural gas; and/or
- Electricity.

In many instances, coal also provides the fundamental reagent (carbon) required for reduction of raw materials to yield ferroalloys.

Emissions associated with these operations typically include the three primary atmospheric pollutants covered in the NDM AQMP (i.e. PM, NO_2, and SO_2), however the full suite of pollutants depends on the nature of the processes undertaken as well as the nature of the raw materials and products. Pollutants of potential significance may include:

- Carbon monoxide (CO);
- Oxides of nitrogen from high temperature processes and flares
- Particulates containing heavy metals in various states of oxidation depending on the source; and/or
- Organic and inorganic volatile and semi-volatile emissions.

Key emission sources include:

- Arc furnaces; and/or
- Blast oxygen furnaces.

Other sources of potential significance include:

- Material stockpiles;
- Vehicle entrainment on unpaved roads; and
- Slag and other bulk waste heaps.

Fugitive emissions from operational procedures such as oxygen lancing and tapping may also be significant.

1.1.8.1 Particulate abatement

Key emission sources are in most, if not all, cases fitted with emissions extraction and abatement equipment. Particulate abatement is achieved mainly by:

- Electrostatic precipitators (ESPs);
- Fabric filters;
- Wet scrubbers; and/or
- Cyclone separators.

9.1.1.1.1 Cyclone separators

Cyclone separators are mostly used as pre-cursors to the other three systems. In some cases, only cyclones are used for cleaning gas streams laden with relatively large particles.

9.1.1.1.2 ESPs and fabric filters

ESP and fabric filters are used in instances where flue gases are not explosive. ESPs have the advantage of being able to operate at higher temperatures, however bag filters are advantageous at appropriate temperatures in that they are not dependent on the resistivity of the particulates they capture.

9.1.1.1.3 Wet scrubbers

Operations such as closed electrode arc furnaces produce significant amounts CO. CO is highly flammable and can be explosive. Generally, wet scrubbers are used for particulate removal in these instances. The clean gas is then flared.

1.1.8.2 Fugitive emissions

Fugitive emissions are often not captured or efforts to capture these emissions are not very effective. Dust entrainment from unpaved roads is in some cases reduced by application of water or chemical palliatives.

9.1.1.1.4 SO_2 prevention and abatement

SO_2 abatement is achieved as a secondary benefit of the use of wet scrubbers for closed furnace and other off-gases. In some cases, the use of low sulphur coal may reduce SO_2 emissions.

9.1.1.1.5 NO_2 prevention and abatement

Conversion of open furnaces to closed and semi-closed furnaces at some facilities is expected to reduce the availability excess oxygen required for formation of both thermal and fuel NO_x. However, thermal NO_x is subsequently generated in clean gas flares.

9.1.2 MINERAL PROCESSING STORAGE AND HANDLING

In this category, the main subcategories applicable to the NDM are the storage and handling of ore and coal, drying, brick production, and cement production.

9.1.2.1 Brick Manufacturing

The brick manufacturing process has six general phases, namely:

- Mining and storage of raw materials,

- Preparing raw materials by sizing and screening,
- Forming the brick,
- Drying,
- Firing and cooling in a furnace, and
- De-hacking and storing finished products (The Brick Industry Association, 2006).

The firing process is the most significant source of atmospheric pollutant emissions. Significant quantities of fossil fuels are burned to generate heat for brick curing. A combination of fuels may be used, including coal, natural gas, sawdust, and used oil.

The licenced kilns in the NDM are tunnel kilns and transverse arc kilns.

The wide-scale use of coal leads to significant SO_2 emissions, however no SO_2 abatement is in use. Both thermal and fuel NO_x may be generated, however the low temperatures and lack of excess oxygen imply that NO_x generation is low.

9.1.2.2 Cement Production

The cement production process involves the following phases:

- **Quarrying raw materials** – A naturally occurring secondary limestone deposit, located close to a plant is quarried to provide calcium carbonate ($CaCO_3$), the main raw material for cement manufacture. The nature of the deposit of the limestone is such that the quarry is not very deep, but it covers a very large area. It is necessary to remove this material in the quarry by drilling and blasting.
- **Crushing –** The raw materials are hauled into trucks and transported to a primary crusher unless the crusher is movable and located in the vicinity of the mine.
- **Calcination** – The raw materials then homogenized and fed to the kiln. The high temperatures in the kiln firstly dissociate calcium carbonate to calcium oxide, expelling carbon dioxide gas, followed by a reaction of calcium oxide with other substances to form calcium silicates and calcium aluminates. The reaction product mix leaves the kilns as a grey to black nodular material, clinker. It is then cooled in coolers, and conveyed to clinker silos for storage.
- **Cement Production** – Gypsum, fly ash and other additives are mixed with the clinker material. This mix is then progressively milled to produce a fine powdery mixture, referred to as cement.

Licenced cement manufacturing operations in the NDM consist of crushing, drying, milling and blending plants, serviced by bag filters where particulate abatement is in place.

9.1.3 INORGANIC CHEMICAL INDUSTRY

The inorganic industry involves the synthesis of inorganic and organometallic compounds for various uses. In the NDM, there exists a calcium carbide producer in this category. The expected emissions from the entire operation include among others PM, NO_2, SO_2, CO and CO_2.

Calcium carbide (CaC_2) is manufactured by heating a lime and carbon mixture to 2000 to 2100°C (3632 to 3812°F) in an electric arc furnace. At those temperatures, the lime is reduced by carbon to calcium carbide and carbon monoxide (CO), according to the following reaction:

$CaO + 3C \rightarrow CaC_2 + CO$

Lime for the reaction is usually made by calcining limestone in a kiln at the plant site. The sources of carbon for the reaction are petroleum coke, metallurgical coke, and anthracite coal.

Some of the abatement equipment used in this industry includes:

- Flares
- Scrubbers
- Cyclones
- Electrostatic precipitators/Bag filters

1.1.9 OPENCAST COAL MINING

Open cast mining is widely employed for the economical extraction of coal deposits close to surface in the NDM. The key atmospheric pollutant emitted from these operations is PM. There are various sources of PM emissions including, but not limited to, the following:

- The use of vehicles on unpaved and paved roads
- Mark out blast holes and drilling
- Blasting;
- Overburden Stripping;
- Ore and overburden handling;
- Crushing and screening of ore; and
- Wind entrainment from stockpiles.

It has been noted previously that the primary contributor to PM is from unpaved mine haul roads. When a vehicle travels on an unpaved road the force of the wheels on the road surface causes pulverisation of the 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 (US EPA, 1995).

The rate of PM entrainment is largely dependent on the characteristics of the wearing course material, the mass and number of vehicles travelling and, to an extent, the speed at which these vehicles travel on the roads. Mines apply various means of reducing haul road-related PM emissions through the application of palliative measures. These include:

- Application of chemical palliatives;
- Applying low vehicle speed limit;
- Regular light watering of the road.
- Providing a tightly-bound wearing course material;
- Armouring the surface (placing a thin layer of higher quality wearing course on the existing material or turning this into the top 50mm of material);
- Good maintenance practices; and/or

The degree to which these methods are applied varies across mines. Under typical summer conditions, for a water-based spray suppression system with a large rear-dump truck running on a well-built and maintained haul road, re-watering is required at approximately 30-minute intervals to maintain a dust defect that at no time exceeds a score of two. Under winter conditions, the re-application interval extends to approximately 50 minutes (Thompson & Visser 2001). This approach therefore requires dedicated resources and management but can be effective if undertaken correctly and is considered a relatively cheap option.

The palliation achieved using chemical palliatives can significantly reduce dust emissions from mine haul roads. All palliatives (with infrequent watering) share one common failing as compared with frequent water-spray systems. This is the inability to prevent material spillage from being entrained. In mines where spillage cannot be effectively controlled, watering or removal of spillage by sweepers/vacuum in combination with a dust palliative may prove to be more effective for dust control.

Poor wearing course materials generally cannot be improved to deliver adequate performance solely through the addition of a dust palliative, and this may be a significant factor in inhibiting dust suppression in some cases.

1.4 SUMMARY

There are numerous emission sources each with unique emission characteristics in the NDM. However, there are similarities in the physical and chemical processes that generate these pollutants, and in the prevention and abatement technologies that may be applied.

In general it is noted that:

- Significant emphasis is employed in controlling particulate emissions from point sources, and a variety of abatement means are applied.
- The management of fugitive sources of particulate emissions is less vigorously applied and in many cases, non-point emissions are uncontrolled.
- Prevention and/or control measures for SO_2 and NO_2 emissions are not commonly employed. Although various practicable technologies and means exist for preventing and/or controlling these pollutant emissions.
- Regulation of Scheduled Processes has, in the past, placed a more significant focus on particulate emissions and this is also a contributing factor to the lack of SO_2 and NO_2 emissions management.

10 AQMP OVERALL OBJECTIVE AND GOALS

It must be noted that 3 of the local municipalities in the NDM are part of the HPA. Consequently the objectives and goals of this AQMP must be aligned where appropriate with those of the HPA AQMP.

The overall objective for the NDM AQMP is stated as:

Objective: Ambient air quality in the NDM complies with all national ambient air quality standards

The achievement of the overall objective must be supports by more focused scope specific goals as presented in the ensuing sub sections.

10.1 LOCAL GOVERNMENT CAPACITY GOALS

Government Capacity Goals are aimed at addressing providing adequate human and financial resources in the NDM, and its local municipalities, looking at the necessary structures, systems, skills, strategies and funding requirements. The goals have been defined as follows:

- Local Government Capacity Goal 1: By 2017 all government spheres that have an air quality management function have undertaken organisational capacity review and developed structures to allow it to effectively maintain, monitor and enforce compliance with ambient air quality standards and minimum emission standards.
- Local Government Capacity Goal 2: By 2018 all government structures have provided adequate budgets and human resources to implement the AQMP and to efficiently and effectively maintain, monitor and enforce compliance with ambient air quality standards.
- Local Government Capacity Goal 3: By 2018 a measurable increase in awareness and knowledge of air quality exists such that air quality and related health issues are incorporated in IDPs.

To achieve these goals, it is necessary to focus on institutional capacity, arrangements, resource availability, cooperation and collaboration and is further linked to access to information, resources, improving governance and authorities' capacity, and promoting air quality issues amongst stakeholders

10.1.1 INDUSTRIAL EMISSION REDUCTION GOALS

Industrial Emission Reduction Goals have the aim of achieving equitable industrial emissions reductions so as to achieve compliance with ambient air quality standards and dust fallout limit values. Emission quantification and reduction goals are proposed for Iron and Steel/ Ferroalloy, Power Generation and Small Industry sectors.

- Industrial Emission Reduction Goal 1: All listed activities are required to meet the stipulations issued in terms of the NEM:AQA, namely the Minimum Emission Standards, the emissions standards for controlled emitters, and any emissions standards as may be set in future.
- Industrial Emission Reduction Goal 2: By 2018 Ferroalloy sector has reduced emissions to the extent that contributions from the sector do not cause

exceedance of ambient standards at source fence line and by 2020 further reductions of all sources, including the Iron and Steel / Ferroalloy sector, is such that aggregate emissions do not cause exceedance of National Ambient Air Quality Standards.

- Industrial Emission Reduction Goal 3: By 2017 controlled emitter contribution to total emissions have been quantified and impact to air quality determined; by 2018 emissions from Clay Brick sector has reduced emissions to the extent that contributions from the sector do not cause exceedance of the National Ambient Air Quality Standards.
- Industrial Emission Reduction Goal 4: By 2018 Power generation sector contribution to PM2.5 and PM10 through secondary particle formation have been quantified and impact to air quality determined; by 31 March 2016 an quantified offset plan with enforceable and time bound objectives and action plans have been submitted to the NDM Air Quality Officer and the National Air Quality Office; by 2020 emissions have been cut and/or offset to the extent that contributions from the sector do not cause exceedance of national ambient standards over residential settlements.
- Industrial Emission Reduction Goal 5: By 2018 Emissions from Clay Brick sector have been quantified and impact to air quality determined; by 2020 emissions from Clay Brick sector have reduced and/or offset emissions to the extent that contributions from the sector do not cause exceedance of ambient standards at the fence line; by 2020 further reductions of all sources, including the Clay Brick sector, is such that aggregate emissions do not cause exceedance of national ambient standards.

To achieve these goals a combination of improved emissions measurement and quantification, emissions reduction through improved abatement efficiency, operational control and emission offsetting is required.

10.1.2 DOMESTIC FUEL BURNING EMISSION REDUCTION GOALS

Household Fuel Combustion Emission Reduction Goals have the aim of achieving improved quantification of emissions, an improved understanding of air quality impacts and reduction of domestic fuel burning emissions so as to achieve compliance with national ambient air quality standards.

- Household Fuel Combustion Emission Reduction Goal 1: By 2018 fuel usage by households have been quantified, local emission factors determined and impact to air quality assessed; by 2020 emissions from the household sector has been reduced to the extent that contributions from the sector do not cause exceedance of national ambient air quality standards.
- Household Fuel Combustion Emission Reduction Goal 2: By 2018 Health risk assessments have been undertaken in respect of exposure to air pollutants in priority settlements and the cost to the South African economy as a result of exposure to household fuel combustion emissions as well as biomass burning, industrial, transport and power generation emissions are quantified.
- Household Fuel Combustion Emission Reduction Goal 3: By 2018 an evaluation is undertaken of household emission reduction options including but not limited to the rollout of new stoves, retrofit of houses with energy efficiency measures,

energy efficient RDP houses, fitment of ceilings, LPG rollout and subsidy and a household emission reduction action plan is developed; by 2018 a household emission reduction plan is rolled out by government and assisted by industry through offsetting; by 2020 emissions have been reduced to the extent that there are no exceedances of national ambient air quality standards.

Effective interventions, research, awareness raising and education are major aspects in achieving the goal. The role of economic development, technological improvements in combustion equipment and emissions offsetting are also critical.

10.1.3 MINING EMISSION REDUCTION GOALS

Mining Emission Reduction Goals have the aim of achieving the improved quantification of emissions from mining sources and reduction of emissions so as to achieve compliance with national ambient air quality standards and dust fallout limit values.

- Mining Emission Reduction Goal 1: By 2018 emissions from open cast and underground mining operations as well as underground fires and burning of discard coal have been quantified and impact to air quality assessed; by 2020 emissions from Mining sector have been reduced to the extent that contributions from the sector do not cause exceedance of ambient standards at source fence line.

10.1.4 TRANSPORT EMISSION REDUCTION GOALS

This goal focuses on the implementation of the National Vehicle Emission Strategy, as it will provide direction on emission reduction, technological improvement, and enforcement of vehicle emission limits. These goals are subject to the National Vehicle Emission Strategy.

- Transport Emission Reduction Goal 1: By 2017 all local authorities undertake vehicle emissions testing.
- Transport Emission Reduction Goal 2: By 2018 all local authorities will have developed public transport plans and integrate into IDPs
- Transport Emission Reduction Goal 3: By 2020, all vehicles comply with the requirements of the National Vehicle Emission Strategy.

Emission testing is recognised as a major driver for current reductions in vehicle emissions, which can be instituted by local authorities.

10.1.5 VELD BURNING EMISSION REDUCTION GOALS

Veld Burning Emission Reduction Goals have the aim of achieving improved quantification of emissions from veld burning, improved understanding of air quality impacts and a reduction of veld burning emissions so as to achieve compliance with national ambient air quality standards.

- Veld Burning Emission Reduction Goal 1: By 2018 veld burning emissions have been quantified spatially and temporally to allow impact to air quality assessed by dispersion and atmospheric transformation modelling (specifically emission of ozone precursors and secondary PM2.5 formation).

- Veld Burning Emission Reduction Goal 2: By 2018 Health risk assessments have been undertaken of exposure to air pollutants in priority settlements and the cost to the South African economy as a result exposure to veld burning (as well as household fuel burning, industrial, transport and power generation) made known.
- Veld Burning Emission Reduction Goal 3: By 2018 an evaluation is undertaken of veld burning emission reduction options and a veld burning emission reduction action plan is developed; by 2020 veld burning emission reduction action plan is rolled out by the NDM and assisted by industry through offsetting.

10.1.6 WASTE BURNING EMISSION REDUCTION GOALS

Waste Burning Emission Reduction Goals have the aim of achieving improved quantification of emissions from waste burning, improved understanding of air quality impacts and a reduction of veld burning emissions so as to achieve compliance with national ambient air quality standards.

- Waste Burning Emission Reduction Goal 1: By 2018 waste burning emissions have been quantified spatially and temporally to allow impact to air quality assessed by dispersion and chemical modelling (specifically emission of dioxin, ozone precursors and secondary PM2.5 formation).
- Waste Burning Emission Reduction Goal 2: By 2018 Health risk assessments have been undertaken of exposure to air pollutants in priority settlements and the cost to the South African economy as a result exposure to waste burning (as well as household fuel burning, industrial, transport and power generation) made known.
- Waste Burning Emission Reduction Goal 3: By 2018 an evaluation is undertaken of waste burning emission reduction options and a waste burning emission reduction action plan is developed; by 2020 waste burning emission reduction action plan is rolled out by government and by 2022 all communities are served with refuse collection services.

10.1.7 AGRICULTURAL EMISSION REDUCTION GOALS

Agricultural Emission Reduction Goals have the aim of achieving improved quantification of emissions from agricultural activities and reduction of emissions so as to achieve compliance with national ambient air quality standards.

- Agricultural Emission Reduction Goal 1: By 2018 an evaluation is undertaken agricultural emission reduction options including no-till farming (also called zero tillage or direct planting) and action plan involving Department of Agriculture Forestry and Fisheries; by 2020 agricultural emission reduction action plan is rolled out by government.

10.1.8 COMMUNITY AWARENESS GOALS

Community awareness is important in respect of identifying air quality problems, identifying solutions, and supporting air quality management enforcement.

- Community Awareness Goal 1: By 2020, an increase in awareness and knowledge of air quality management issues.

11 AQMP IMPLEMENTATION PLAN

11.1 STAKEHOLDER ROLES AND RESPONSIBILITIES

The responsibilities of the authorities functioning in the NDM are listed in the NEM:AQA and are further elaborated upon in the National Framework.

The regulated roles and responsibilities of the NDM have been used an input into the implementation plan for the AQMP. Roles and responsibilities of other spheres of government are described in the NEM:AQA and National Framework for AQM. The roles and responsibilities of other stakeholders in the NDM are clearly outlined, and education and awareness roles are suggested, as well as the adoption of good environmental practices. Reference to industries in the implementation plan is broad and all encompassing, including listed and smaller non-listed activities, as well as municipal-, provincial- and state-operated entities.

Several platforms for inter-governmental, as well as other stakeholder, cooperation and collaboration exist in the NDM. Examples of these groups are listed in Table 11-1. These groups can constitute part of the membership of the AQMP Working Groups, assist in implementation of the AQMP, and communicate progress on implementation. The available mechanisms can be maximised to ensure the implementation of the AQMP.

Table 11-1: Air quality groups operating in the HPA

Name	Membership
Nkangala District Environmental Forum	MDEDET, district and local authorities
Highveld branch of National Association for Clean Air (NACA)	Industry and authorities in Mpumalanga
Mpumalanga Air Quality Officers' Forum	Provincial Air Quality Officer, Air Quality Officers from each local and district municipality, DEA
Highveld Environmental Justice Network (HEJN)	
HPA Multi-Stakeholder Reference Group	
Nkangala Environmental Crisis Association (NECA)	
Centre for Environmental Rights	

11.2 IMPLEMENTATION PLAN

It is important to note that there is a necessary alignment required with the HPA AQMP implementation. The implementation plan must be reviewed with stakeholders.

Timeframes: Short-term (1-2 years); Medium-term (3-5 years); Long-term (>5 years)

Responsibilities: P = Principal; I = Input; O = Oversight

11.2.1 LOCAL GOVERNMENT CAPACITY GOALS

- Local Government Capacity Goal 1: By 2017 all government spheres that have an air quality management function have undertaken organisational capacity review and developed structures to allow it to effectively maintain, monitor and enforce compliance with ambient air quality standards and minimum emission standards.
- Local Government Capacity Goal 2: By 2018 all government structures have provided adequate budgets and human resources to implement the AQMP and to efficiently and effectively maintain, monitor and enforce compliance with ambient air quality standards.
- Local Government Capacity Goal 3: By 2018 a measurable increase in awareness and knowledge of air quality exists such that air quality and related health issues are incorporated in IDPs.

Objectives	Activities	Timeframe	Responsibility	Indicator
1) Goals and objectives of NDM AQMP are implemented through respective business plans	Use NDM AQMP to inform business planning for air quality function	Short, On-going	P – NDM, Local municipalities	• Business plans include NDM AQMP goal and objectives • NDM AQMP incorporated within IDP/ EIPs • Council resolution passed adopting municipal AQMPs
	Draft municipal-level AQMP case study using NDM implementation plan	Short	P – I - NDM, Local municipalities	
	Adopt NDM AQMP as part of IDPs and EIPs	Short	P - NDM, Local municipalities	
	NDM AQMP goals become part of municipal manager and mayor's key performance indicators	Short, On-going	P – NDM	

Objectives	Activities	Timeframe	Responsibility	Indicator
2) Air quality function is assigned to the most section of local municipalities and provinces	Consultation between local, district and provincial authorities to identify the most appropriate sphere for AQM function on behalf of each municipality	Short	P – NDM, affected local municipalities	• AQM function allocation or delegation made for every municipality • Functional analysis conducted and assignment made
	Create database of AQM functional analyses conducted	Short	P – NDM I – Provincial environmental authorities, Local municipalities	
3) Institutional arrangements accommodate AQM function	Revise organograms to create air quality structure and designation of EMIs, where needed	Short	P – affected local municipalities	• AQO appointed • AQM responsibilities allocated to personnel • Staff appointed to fill AQM posts in organogram • AQM scarce skills retention policy developed
	Training and designation of EMIs to facilitate enforcement of NEM:AQA	Short, On-going	P – NDM, Local municipalities	
	Optimise air quality resource availability	Short	P – affected local municipalities	
	Fill AQM posts with appropriately skilled staff	Short	P – affected local municipalities	
	Develop/ revise retention policies to retain scarce AQM skills	Short	P – NDM, Local municipalities	

Objectives	Activities	Timeframe	Responsibility	Indicator
4) Skills and knowledge transfer	Formalise inter-governmental cooperation to ensure that skills and experience are transferred particularly from MDEDET to NDM	Short, On-going	P – NDM, MDEDET	• Cooperation mechanism established and regular meetings held
	Provide guidance and assistance in AQM to NDM and local authorities	Short, On-going	P – MDEDET, NDM , local municipalities	
5) Personnel are equipped to perform AQM function and use AQM tools effectively	Cooperatively develop training guideline document to identify skills training needs for AQM.	Short	P – NDM, I - Local municipalities	• Training guideline developed • Skills gap analysis conducted • Skills development plans implemented • Standard courses used for training • Consultation with tertiary and other training institutions to access AQM courses
	Conduct AQM skills gap analysis to identify areas of capacity development for assigned sections/departments.	Short	P – NDM, I - Local municipalities	
	Develop skills development plans to address identified gaps	Short	P – NDM, I - Local municipalities	
	Implement skills development plans	Short, On-going	P – NDM, I - Local municipalities	

Objectives	Activities	Timeframe	Responsibility	Indicator
	Engage with tertiary institutions and other training institutions to receive AQM training courses	Short, On-going	P – NDM, I - Local municipalities	• AQM research needs identified and communicated
	Coordinate officials' schedules to enable attendance of courses	Short, On-going	P – NDM, I - Local municipalities	
	Engage with NACA on sponsorship of AQM capacity development	Short	P – NDM	
	Determine areas of research needed in AQM and communicate to relevant research institutions and academia	Short	P – NDM	
6) Financial resources are available for air quality governance	Develop AQM implementation plan and budget to give effect to adopted NDM AQMP and include in IDP/ EIP	Short	P – NDM, Local municipalities	• AQM implementation plan and budget developed and included in IDP/ EIP • Consultation meetings held with D-COGTA and SALGA
	Engage with D-COGTA and SALGA to address specific financial and performance management needs of priority areas	Short	P – Local municipalities	

Objectives	Activities	Timeframe	Responsibility	Indicator
7) All NDM AQOs have extensive practical experience in air quality governance	Contribute to EIA decision-making and environmental authorisations through commenting on air quality impact assessments	Short, On-going	P – NDM,	• Air quality noted in EIA process • Industrial plant comply with AEL conditions • Emission reports received and processed regularly • Presentations made and discussion held on AQM activities
	Conduct regular inspections to monitor plant performance and compliance with AELs and NEMAQA	Short, On-going	P – NDM, Local municipalities I -	
	Carry out enforcement action on all non-compliant incidences	Short, On-going	P - NDM AQO I – Other non-NDM AQO local municipalities	

Objectives	Activities	Timeframe	Responsibility	Indicator
	Use established inter-governmental governance forum as an experience-sharing platform	Short, On-going	P – MDEDET, NDM, Local municipalities	
8) Development planning in the NDM recognises the objectives of the AQMP	Include air quality in environmental decision-making tools for land use planning	Short, On-going	P – NDM, Local municipalities	• Air quality criteria are included in planning decision-making and discussed in policy • IDP, SDFs and EMFs aligned with AQMP
	Align and integrate municipal AQMP and with other planning tools with the IDP/ SDFs/ EMFs in the NDM	Short, On-going	P – NDM, Local municipalities	
9) Use of air quality management tools such as ambient monitoring, emission inventories, dispersion modelling, etc. are optimised and expanded	Develop monitoring station purchase and operation guideline, including capacity development activities	Short	P – NDM I – MDEDET, DEA	• Improved data availability at stations • Publicly available data has undergone quality assurance and control and is up-to-date
	Conduct quality control and assurance on all data to assist compliance monitoring	Short, On-going	P – NDM, DEA, MDEDET	
	Upload monitoring data to SAAQIS routinely	Short, On-going	P – NDM,	
	Compile annual reports on monitored data, for technical and AQM purposes	Short, On-going	P – NDM,	

Objectives	Activities	Timeframe	Responsibility	Indicator
	Develop NDM emission database and update based on measured emissions reported	Short	P – NDM,	• Annual monitoring and emission reports are available • Annual reports are presented at Air Quality Governance Lekgotla • Updated NDM emission database is available based on measured data • Scenario modelling is carried out for NDM • All AQIAs for EIA, and all Atmospheric Impact Reports contain cumulative assessments.
	Maintain the database to ensure it remains current and representative	Short, On-going	P – NDM,	
	Compile annual reports on emissions data, for technical and AQM purposes	Short, On-going	P – NDM,	
	Use dispersion modelling to assist planning and decision making	Short, On-going	P – NDM,	
	Ensure that all Air Quality Impact Assessment and Atmospheric Impact Reports include cumulative impact assessment by availing the emissions inventory and require assessors to conduct cumulative impact assessment	Short, On-going	P – NDM, EAPs, Air Quality Specialists	

Objectives	Activities	Timeframe	Responsibility	Indicator
10) Progress on the implementation of the NDM AQMP is monitored	Establish a Standing Committee with governance stakeholders to assess and report on progress with the NDM AQMP implementation	Short, On-going	P – NDM, I – Local municipalities	• Standing Committee established and operational • Progress reports on AQMP implementation available
	Develop progress reports regularly	Short, On-going	P – NDM, Local municipalities	

11.2.2 INDUSTRIAL EMISSION REDUCTION GOALS

By 2020, industrial emissions are equitably reduced to achieve compliance with ambient air quality standards and dust fallout limit values

- Industrial Emission Reduction Goal 1: All listed activities are required to meet the stipulations issued in terms of the NEM:AQA, namely the Minimum Emission Standards, the emissions standards for controlled emitters, and any emissions standards as may be set in future.
- Industrial Emission Reduction Goal 2: By 2018 Ferroalloy sector has reduced emissions to the extent that contributions from the sector do not cause exceedance of ambient standards at source fence line and by 2020 further reductions of all sources, including the Iron and Steel / Ferroalloy sector, is such that aggregate emissions do not cause exceedance of National Ambient Air Quality Standards.
- Industrial Emission Reduction Goal 3: By 2017 controlled emitter contribution to total emissions have been quantified and impact to air quality determined;
- Industrial Emission Reduction Goal 4: By 2018 Power generation sector contribution to PM2.5 and PM10 through secondary particle formation have been quantified and impact to air quality determined; by 31 March 2016 a quantified offset plan with enforceable and time bound objectives and action plans have been submitted to the NDM Air Quality Officer and the National Air Quality Office; by 2020 emissions have been cut and/or offset to the extent that contributions from the sector do not cause exceedance of national ambient standards over any residential settlements.
- Industrial Emission Reduction Goal 5: By 2018 Emissions from Clay Brick sector have been quantified and impact to air quality determined; by 2020 emissions from Clay Brick sector have reduced and/or offset emissions to the extent that contributions from the sector do not cause exceedance of ambient standards at the fence line; by 2020 further reductions of all sources, including the Clay Brick sector, is such that aggregate emissions do not cause exceedance of national ambient standards.

Objectives	Activities	Timeframe	Responsibility	Indicator
1) Emissions are quantified from all sources	Establish and maintain a site emission inventory that includes all point and diffuse sources for all significant pollutants, and submit emissions monitoring results as per requirements of AELs and controlled emitter gazettes	Short, On-going	P - Industries O - NDM AQO	• Site emission inventories completed • Emission reports available
	Establish site emission inventory that includes all point and diffuse sources for all significant pollutants	Short, On-going	P - Mines O - NDM AQO	
	Submit emission inventory report as per emission reporting regulation	Short, On-going	P - Industries O - NDM AQO	
2) Gaseous and particulate emissions are reduced to meet Minimum Emission Standards	Develop emissions reduction plans and submit to the NDM AQO	Short	P – Industries O - NDM AQO	• AELs issued with emission reductions • Emission reduction measures implemented by industries • emissions off-sets plans developed and approved by NAQO in
	Develop emissions off-sets plans as per requirements of postponement decisions, taking into consideration quantified health risk assessments of the impacts of exposure to listed emitter's emissions and other significant sources such as domestic fuel combustion and any significant sources which may contribute appreciably to the health risk or the targeted receptors.	Short	P – Industries O – NAQO, NDM AQO	

Objectives	Activities	Timeframe	Responsibility	Indicator
	Develop and implement maintenance plan for each plant	Short	P – Industries	consultation with NDM AQO • Maintenance plans implemented • Reduced disruptions to plant operations • AELs issued with plans as committed to by emitters
	Schedule and conduct repairs to coincide with plant offline times	On-going	P – Industries	
	Incorporate equipment changes into maintenance schedule	On-going	P – Industries	
	Operate plants with minimum disruption e.g. back-up plan for energy consumption/ generation	Short, On-going	P – Industries	
	Ensure that plans are integrated into AELs	Short, On-going	P – NDM AQO	
3) Fugitive emissions are minimised	Develop fugitive emission management plan and ensure that plans are integrated into AELs	Short	P – Industries, Mines O – NDM AQO	• Fugitive emission management plan developed and implemented • Reduction in fugitive emissions
	Implement appropriate interventions	Short, On-going	P – Industries, Mines O – NDM AQO	
4) Emissions from dust - generating activities are reduced	Develop and implement dust reduction programmes in line with industry best practice, considering technology and management interventions	Short, On-going	P – Industries O – NDM AQO	• Dust reduction programme implemented

Objectives	Activities	Timeframe	Responsibility	Indicator
	Investigate feasibility of using alternative means for haulage e.g. conveyer, rail	Medium	P – Industries, Mines	• Fleet maintenance carried out • Alternate haulage and waste management investigated • NDM – vehicle emissions testing
	Plan and carry out regular fleet maintenance and ensure that vehicle emissions standards are met	Short, On-going	P – Industries	
	Investigate opportunities to market waste as raw material inputs to other industries e.g. discard coal	Medium	P – Industries	
5) Greenhouse gas emissions are reduced	Include greenhouse gas emissions in site emission inventory as per regulatory requirements	Short	P – Industries	• Site greenhouse gas emission inventories compiled • Energy efficiency plans implemented
	Develop and implement a site energy efficiency plan for inclusions in AEL	Short	P – Industries I – NDM, Local municipalities	
	Consider climate change implications in AQM decision-making	Short, On-going	P – Industries	
	Investigate opportunities for co-generation e.g. off-gas as an energy source	Short – Medium	P – Industries	
	Investigate feasibility of renewable energy	Short – Medium	P – Industries	

Objectives	Activities	Timeframe	Responsibility	Indicator
6) Incidences of spontaneous combustion are reduced	Communicate the need to determine abandoned mine ownership to facilitate rehabilitation and/or closure to DMR	Short	P – NDM	• Consultation with DMR on abandoned mines • Reduced incidences of spontaneous combustion
	Promote the need for compliance monitoring of abandoned mines.	Short	P – NDM and DMR	
	Communicate need for identification and prevention of spontaneous combustion at operating mines	Short	P – NDM and DMR	
7) Abatement technology is appropriate and operational	Install, update, and/or maintain appropriate air pollution abatement technology compliant with requirements of AEL and achieving Section 21 emission standards	Short – Long	P – Industries O - NDM	• Air pollution abatement technology installed • Equipment operated optimally • Minimum Emission Standards are met and confirmed with measured data
	Train operators and maintenance crews to ensure optimal operation of abatement equipment	On-going	P – Industries	
	Motivate for and undertake research to improve abatement technology and reduce retrofitting costs	Medium	P – Industries, Research institutions	
	Establish sector information sharing fora	Short	P – Industries	• Sector fora established

Objectives	Activities	Timeframe	Responsibility	Indicator
8) Industrial AQM decision making is robust and well-informed, with necessary information available	Compile best practice documents for the sectors	Short – Medium	P – I - NDM AQO	• Sector best practice guidelines available • Benchmarking promoted
	Conduct international benchmarking within the sectors	Medium	P – Industries O –	
	Make sector emission performance information available for company benchmarking	Medium	P – I – Industries	
	Make best practice information available on SAAQIS	Medium	P -	
9) Clean technologies and processes are implemented	Incorporate cleaner technology considerations into AEL	Short	P - NDM AQO I -	• AEL includes clean technology recommendations • Clean technology feasibility studies conducted • Clean technology options implemented
	Investigate feasibility of introducing clean technologies on plant-specific basis	Medium	P – Industries	
	Implement feasible technology options on plant-specific basis	Medium – Long	P – Industries	
	Investigate regulatory mechanisms to facilitate introduction of new technology	Medium	P – NDM,	
	Investigate feasibility of switching to clean fuels at times of poor dispersion	Medium	P – Industries	

Objectives	Activities	Timeframe	Responsibility	Indicator
	Investigate alternative design and process options to improve plume dispersion	Medium	P – Industries	
	Implement feasible alternative design and process options	Medium - Long	P – Industries	
10) Adequate resources are available for AQM in industry	Revise organograms to create air quality structure and designation, where needed, and designate Emission Control Officers as required by AEL.	Short	P – Industries	• AQM personnel designated • Emission Control Officer • Abatement and measurement financial planning complete
	All AELs must require the designation of an Emission Control Officer	Short	P – NDM AQO	
	Optimise environmental management resource availability to accommodate air quality function	Short	P – Industries	
	Fill AQM posts with appropriately skilled staff, where needed	Short	P – Industries	
	Input into financial planning to implement emission abatement and measurement requirements of AEL and Section 21 emission standards	Short	P – Industries	
	Investigate the possible use of offset programmes to reduce financial investments	Medium	P – Industries I – NDM AQO	

Objectives	Activities	Timeframe	Responsibility	Indicator
11) Ambient air quality standard and dust fallout limit value exceedances as a result of industrial emissions are assessed	Conduct ambient air quality monitoring in accordance with AEL requirements	Short, On-going	P – Industries O - NDM AQO	• Ambient air quality and dust fallout monitoring carried out • AELs require dustfall monitoring • Monitoring results reported • AIRs updated to include monitoring results
	AEL must require dust fallout monitoring and reporting at sites with significant fugitive dust generation	Short, On-going	P – NDM AQO	
	Conduct dust fallout monitoring in accordance with legislative requirements	Short, On-going	P – Industries O - NDM AQO	
	Report ambient monitoring results, to relevant AQO	Short, On-going	P – Industries O – NDM AQO	
	Update AIR submissions	Short, On-going	P – Industries O – NDM AQO	

11.2.3 DOMESTIC FUEL BURNING EMISSION REDUCTION GOALS

- Household Fuel Combustion Emission Reduction Goal 1: By 2018 fuel usage by households have been quantified, local emission factors determined and impact to air quality assessed; by 2020 emissions from the household sector has been reduced to the extent that contributions from the sector do not cause exceedance of national ambient air quality standards.
- Household Fuel Combustion Emission Reduction Goal 2: By 2018 Health risk assessments have been undertaken in respect of exposure to air pollutants in priority settlements and the cost to the South African economy as a result of exposure to household fuel combustion emissions as well as biomass burning, industrial, transport and power generation emissions are quantified.
- Household Fuel Combustion Emission Reduction Goal 3: By 2018 an evaluation is undertaken of household emission reduction options including but not limited to the rollout of new stoves, retrofit of houses with energy efficiency measures, energy efficient RDP houses, fitment of ceilings, LPG rollout and subsidy and a household emission reduction action plan is developed; by 2018 a household emission reduction plan is rolled out by government and assisted by industry through offsetting; by 2020 emissions have been reduced to the extent that there are no exceedances of national ambient air quality standards.

Objectives	Activities	Timeframe	Responsibility	Indicator
1) Investigate and develop a strategy for dense low income settlements in accordance with emissions offsets requirements from postponement applications	Promote the objectives of the strategy in dense low income settlements on the NDM	Medium, On-going	P – NDM, Eskom I – Local municipalities	• Planning of dense low income settlements considers the objectives of the strategy
2) Clean fuels and technology are used that are affordable and easily available	Coordinate BnM rollout in NDM PM_{10} "hot spot" settlements	Short, On-going	P – NDM, I – Local municipalities, DoE, Industries	• BnM demonstrations held across NDM

	Communicate the air quality benefits of subsidy provision for clean combustion technology (stoves) and clean fuels (anthracite coal, gas) to implementing stakeholders	Short, On-going	P – NDM, I - Local municipalities	• Mechanisms to provide clean energy are investigated
	Motivate for other regulatory and financial mechanisms to improve affordability of clean energy	Short, On-going	P – NDM I – Local municipalities	
	Communicate the benefit of accessing CDM funding for fuel switching projects in NDM	Short, On-going	P – I – NDM, Local municipalities	
3) Service delivery to low income residential areas is improved	Communicate the air quality benefits of improved service delivery to relevant departments, particularly: • Electrification • Housing provision • Road surfacing • Refuse removal • Greening	Short, On-going	P – NDM Air quality management planning officer	• Benefits of service provision are understood in relevant departments • Input is given • Electrification program is revised to address identified air

	Provide input to municipal IDPs in respect of service delivery plans for: • Electrification • Housing provision • Road surfacing • Refuse removal • Greening		P – NDM Air quality management planning officer	quality hot spots as priority
	Participate in development of prioritisation methodology for electricity provision	Short	P – NDM, Local municipalities	
	Engage Eskom to electrify areas of poor air quality in hot spots as a priority	Short, On-going	P – NDM Air quality management planning officer	
4) Adequate scientific, health and economic information is available on domestic fuel burning and air quality	Identify and communicate research needs to research institutions and organisations to motivate research on domestic fuel use, particularly emission reduction measures	Short, On-going	P – NDM, I – Local municipalities	• Research on domestic fuel burning and related topics conducted

	Develop linkage between NDM website and SAAQIS database of available information	Short, On-going	P – NDM, I - Local municipalities, Research institutions, Industries	• Research outcomes on domestic fuel burning and related topics available on SAAQIS • Plan and budget for health risk assessments in place
	Identify, plan and budget for health risk assessments related to atmospheric pollution exposure for hotspot areas.	Short, On-going	P – NDM, I - Local municipalities, Research institutions, Industries	
5) Low-income and informal households are energy efficient	Participate in the revision of low cost housing design principles	Short	P – DoH, NDM, Local municipalities	• Low cost housing design principles consider energy efficiency
	Communicate the air quality benefits of large-scale subsidised solar water heating and other energy efficient fittings	Short	P – NDM	
6) Social upliftment and development has air quality benefits	Promote air quality-related corporate social investment in low income communities in hot spot areas	Short, On-going	P – NDM, Local municipalities	• Corporate investment occurs in low income communities in hot spot areas

11.2.4 TRANSPORT EMISSION REDUCTION GOALS

- Transport Emission Reduction Goal 1: By 2017 all local authorities undertake vehicle emissions testing.
- Transport Emission Reduction Goal 2: By 2018 all local authorities will have developed public transport plans and integrate into IDPs
- Transport Emission Reduction Goal 3: By 2020, all vehicles comply with the requirements of the National Vehicle Emission Strategy.

Objectives	Activities	Timeframe	Responsibility	Indicator
1) Requirements for motor vehicle emission reduction	Implement requirements of the national vehicle emission strategy	Short - Medium	P – DoT, DoE	• National vehicle emission strategy implemented
2) Emission testing capacity is extended	Develop emission testing regulation	Short	P – NDM	• Emission testing regulated and implemented • Emission testing report compiled
	Acquire emission testing equipment	Short	P – NDM	
	Conduct training programme for testing personnel	Short	P – NDM and local municipalities I – NDM, local municipalities with testing function	
	Formulate a testing schedule and conduct regular tests	Short, On-going	P - relevant local municipalities	

	Compile report on emission testing activities and effectiveness	Short, On-going	P - relevant local municipalities	

11.2.5 BY 2020, INCREASE IN AWARENESS AND KNOWLEDGE OF AIR QUALITY MANAGEMENT ISSUES

Objectives	Activities	Timeframe	Responsibility	Indicator
1) Air quality information is easily accessible to all stakeholders	Simplify technical reports and management plans for public consumption	Short, On-going	P – NDM, Local municipalities	• Air quality information is available in hard copy and electronic formats • Air quality information is available in official languages • Simplified technical information is available
	Disseminate information in areas accessible to all stakeholders (e.g. community libraries in the NDM)	On-going	P – NDM, Local municipalities	
	Use media to share information on air quality	Short, On-going	P – NDM, Local municipalities	
	Use organisations' websites for distribution of information	Short, On-going	P – NDM, Local municipalities	
	Develop educational material on air quality impacts in relevant official languages aimed at individuals, communities and government officials	Short	P - NDM	
2) Air quality information is communicated to all stakeholders	Conduct educational campaigns within all NDM communities	Short, On-going	P – NDM, Local municipalities	• Educational campaigns conducted across NDM • Stakeholder fora established
	Conduct educational awareness programmes at schools which host monitoring stations	Short, On-going	P – NDM,	

	Establish a community forum/fora (NGOs, CBOs and FBOs) to address stakeholder education, awareness and capacity building	Short	P – NDM, Local municipalities	• Training and awareness-raising courses held for community leaders and councillors • Air quality criteria considered in development planning policy and initiatives • Use of fire danger index promoted • Reduction in incidents of burning (controlled and uncontrolled)
	Organise seminars, workshops and training courses for community leaders and councillors on air quality issues	Short	P – NDM, Local municipalities	
	Conduct air quality awareness raising activities accompanied by elected officials	Short	P – NDM, Local municipalities	
	Increase awareness of development planners to consider air quality criteria in planning decision-making	Short	P – NDM, Local municipalities	
	Conduct awareness-raising activities and educational programmes on correct use of fire and vegetation management	Short, On-going	P – DAFF, NDM, Local municipalities	
	Publicise the existing fire danger index as part of AQM	Short	P – NDM, Local municipalities	
	Promote the “Follow the smoke” campaign	Short	P – I - NDM, Local municipalities	

3) Research is considerate of stakeholders in the area of study	Consult communities, local leaders, community organisations etc as part of research process	Short, On-going	P – Research institutions	• Community knowledge is included in air quality studies
	Incorporate indigenous information/ knowledge into air quality studies	Short, On-going	P – NDM, Local municipalities, Research institutions	
4) Opportunities for public participation and involvement in air quality decision-making are readily available	Use stakeholder fora to provide communication platform to communities	Short, On-going	P – Local municipalities	• Community communication platform established • Community are able to access AQM officials in emergencies
	Publish contact details of relevant AQOs in communities	Short	P – Local municipalities	
	Investigate feasibility of establishing a toll free number for air quality incidents for the NDM	Short	P – NDM,	

11.2.6 VELD BURNING EMISSION REDUCTION GOALS

- Veld Burning Emission Reduction Goal 1: By 2018 veld burning emissions have been quantified spatially and temporally to allow impact to air quality assessed by dispersion and atmospheric transformation modelling (specifically emission of ozone precursors and secondary PM2.5 formation).
- Veld Burning Emission Reduction Goal 2: By 2018 Health risk assessments have been undertaken of exposure to air pollutants in priority settlements and the cost to the South African economy as a result exposure to veld burning (as well as household fuel burning, industrial, transport and power generation) made known.
- Veld Burning Emission Reduction Goal 3: By 2018 an evaluation is undertaken of veld burning emission reduction options and a veld burning emission reduction action plan is developed; by 2020 veld burning emission reduction action plan is rolled out by the NDM and assisted by industry through offsetting.

Objectives	Activities	Timeframe	Responsibility	Indicator
1) Emissions from biomass burning and agricultural activities on the NDM are quantified	Develop a spatially and temporally resolved emission inventory for biomass burning (natural and controlled)	Short	P – NDM I – DAFF	• Current emission estimate available for biomass burning and agriculture
	Maintain information on fires on NDM using AFIS and other resources	On-going	P – NDM	
	Model and determine the contribution of biomass burning to ambient pollutant load	Short	P – NDM	
	Undertake health risk assessment related to exposure to biomass burning atmospheric pollutants.	Short	P – NDM	

Objectives	Activities	Timeframe	Responsibility	Indicator
2) Management alternatives to burning are available	Promote grass cutting and baling in agricultural, protected and road reserve areas, to be used as a resource e.g. fodder, compost, smokeless fuel	Short, On-going	P – DAFF, DoT I – NDM,	• Reduction in burning in agricultural, protected and road reserve areas
	Motivate for research on veld management practices/ strategies for alternatives to burning and on the relationship between fire and environmental factors	Short	P – DAFF	
3) Legal requirements discourage vegetation burning	Optimise the use of existing regulatory tools to prevent agricultural burning in poor conditions	Short	P – DAFF	• Regulation restricting burning is promulgated
	Motivate for specific conditions for creating fire breaks in Veld and Forest Fires Act	Short – Medium	P – DAFF	
	Motivate for regulation of burning in sensitive ecosystems and surrounding areas	Medium	P – DAFF	
4) Dust entrainment, odour, and pesticide emissions are reduced	Cooperatively investigate the feasibility of the development and publication of weather forecasts for optimum ploughing time and spraying of pesticides	Short	P – SAWS, DAFF	Feasibility report prepared on agricultural forecast available

11.2.7 WASTE BURNING EMISSION REDUCTION GOALS

- Waste Burning Emission Reduction Goal 1: By 2018 waste burning emissions have been quantified spatially and temporally to allow impact to air quality assessed by dispersion and chemical modelling (specifically emission of dioxin, ozone precursors and secondary PM2.5 formation).
- Waste Burning Emission Reduction Goal 2: By 2018 Health risk assessments have been undertaken of exposure to air pollutants in priority settlements and the cost to the South African economy as a result exposure to waste burning (as well as household fuel burning, industrial, transport and power generation) made known.
- Waste Burning Emission Reduction Goal 3: By 2018 an evaluation is undertaken of waste burning emission reduction options and a waste burning emission reduction action plan is developed; by 2020 waste burning emission reduction action plan is rolled out by government and by 2022 all communities are served with refuse collection services.

Objectives	Activities	Timeframe	Responsibility	Indicator
1) Emissions from waste management activities on the NDM are quantified	Waste burning emissions quantified to allow impact to air quality assessed by dispersion, chemical modelling.	Short	P – NDM	• Emission estimates available for waste management facilities • Contribution to ambient air quality quantified
	Waste incineration emissions quantified based on reported measured emissions data in accordance with AELs to allow impact to air quality assessed by dispersion, chemical modelling.	Short	P – NDM	
	Health risk assessment to establish impact of exposure to atmospheric pollutants from waste burning.			

2) Management of waste processing sites considers air pollutant and greenhouse gas emission reductions	Develop emission reduction plan for all process and fugitive sources	On-going	P – Operating Entities O – NDM AQO	• Emission reduction plans developed and implemented • Emission reductions plans are in place and implemented. • Methane extraction feasibility assessment undertaken.
	Implement emission reduction and maintenance plan for all emission sources resulting from waste management activities	Short, On-going	P – Operating Entities O – NDM AQO	
	Investigate feasibility of methane extraction for energy generation	Short – Medium	P - Operating Entities	
	Promote the use of best available technology in waste management	Medium	P – NDM, Local municipalities	
3) Emissions from burning of waste are reduced	Input to IDPs for refuse removal service delivery	Short, On-going	P – NDM	• IDPs are aligned with AQMP goals. • Burning of waste/refuse included in by-laws
	Motivate for regular collection of waste from skips	Short	P – Local municipalities	
	Apply/ develop regulatory tools to control waste burning	Short – Medium	P - NDM, Local municipalities I –	
	Motivate for enforcement action on incidences of waste burning	Short – Medium	P - NDM, Local municipalities	

11.2.8 AGRICULTURAL EMISSION REDUCTION GOALS

- Agricultural Emission Reduction Goal 1: By 2018 an evaluation is undertaken agricultural emission reduction options including no-till farming (also called zero tillage or direct planting) and action plan involving Department of Agriculture Forestry and Fisheries; by 2020 agricultural emission reduction action plan is rolled out by government.

Objectives	Activities	Timeframe	Responsibility	Indicator
5) Emissions from biomass burning and agricultural activities on the VTAPA are quantified	Develop emission estimate for biomass burning (natural and controlled)	Short	P – NDM I – DAFF	• Current emission estimate available for biomass burning and agriculture
	Maintain information on fires on VTAPA using AFIS and other resources	On-going	P – NDM	
	Develop emission estimate for agriculture: • Pesticides • Odour-related pollutants • Dust	Short	P – NDM I – DAFF	
6) Management alternatives to burning are available	Promote grass cutting and baling in agricultural, protected and road reserve areas, to be used as a resource e.g. fodder, compost, smokeless fuel	Short, On-going	P – NDM, DAFF, DoT	• Reduction in burning in agricultural, protected and road reserve areas
	Motivate for research on veld management practices/ strategies for alternatives to burning and on the relationship between fire and environmental factors	Short	P – NDM, DAFF	
7) Legal requirements discourage vegetation burning	Optimise the use of existing regulatory tools to prevent agricultural burning in poor conditions	Short	P – NDM, DAFF	• Regulation restricting burning is promulgated

Objectives	Activities	Timeframe	Responsibility	Indicator
	Motivate for specific conditions for creating fire breaks in Veld and Forest Fires Act	Short – Medium	P – NDM, DAFF	
	Motivate for regulation of burning in sensitive ecosystems and surrounding areas	Medium	P – NDM, DAFF,	
8) Dust entrainment, odour, and pesticide emissions are reduced	Cooperatively investigate the feasibility of the development and publication of weather forecasts for optimum ploughing time and spraying of pesticides	Short	P – NDM, SAWS, DAFF	• Feasibility report prepared on agricultural forecast available

11.2.9 MINING EMISSION REDUCTION GOALS

- Mining Emission Reduction Goal 1: By 2018 emissions from open cast and underground mining operations as well as underground fires and burning of discard coal have been quantified and impact to air quality assessed; by 2020 emissions from Mining sector have been reduced to the extent that contributions from the sector do not cause exceedance of ambient standards at source fence line

Objectives	Activities	Timeframe	Responsibility	Indicator
1) Emissions are quantified from all sources	Establish and maintain a site emission inventory that includes all point and diffuse sources for all significant pollutants	Short, On-going	P - Mines	• Site emission inventories completed • Emission reports available
	Submit emission inventory report	Short, On-going	P - Mines O - NDM	

Objectives	Activities	Timeframe	Responsibility	Indicator
2) Fugitive emissions are minimised	Develop road transport and spontaneous combustion emission management plan	Short	P – Mines I - NDM	• emission management plan developed and implemented
3) Emissions from dust-generating activities are reduced	Develop and implement dust reduction programmes in line with industry best practice, considering technology and management interventions	Short, On-going	P – Mines O - NDM	• Dust reduction programme implemented • Fleet maintenance carried out • Alternate haulage and waste management investigated
	Investigate feasibility of using alternative means for haulage e.g. conveyer, rail	Medium	P – Mines	
	Plan and carry out regular fleet maintenance	Short, On-going	P – Mines	
4) Greenhouse gas emissions are reduced	Include greenhouse gas emissions in site emission inventory	Short	P – Mines	• Site greenhouse gas emission inventories compiled • Energy efficiency plans implemented
	Develop and implement a site energy efficiency plan	Short	P – Mines I - NDM	
	Consider climate change implications in AQM decision-making	Short, On-going	P – Mines	
	Investigate opportunities for co-generation e.g. off-gas as an energy source	Short – Medium	P – Mines	
	Investigate feasibility of renewable energy	Short – Medium	P – Mines	
5) Incidences of spontaneous combustion are reduced	Promote research needs regarding spontaneous combustion	Short	P – NDM I - Municipalities	• Research needs communicated

Objectives	Activities	Timeframe	Responsibility	Indicator
	Communicate the need to determine abandoned mine ownership to facilitate rehabilitation and/or closure	Short	P – NDM	• Consultation with DMR on abandoned mines • Reduced incidences of spontaneous combustion
	Promote the need for compliance monitoring of abandoned mines	Short	P – NDM	
	Implement and enforce discard dump management regulations	Short	P – NDM	
	Improve supply and demand forecasting to reduce coal stockpile size and limit coal stockpile retention time	Medium	P – Mines	
6) Abatement technology is appropriate and operational	Install and/or maintain appropriate air pollution abatement technology	Short – Long	P – Mines	• Air pollution abatement technology installed • Equipment operated optimally • Individual technology benchmarks completed
	Train operators to ensure optimal operation of abatement equipment	On-going	P – Mines	
	Promote individual benchmarking of abatement technology	Medium	P – NDM	
	Motivate for and undertake research to improve abatement technology	Medium	P – NDM, Mines, Research institutions	
7) Industrial AQM decision making is robust and well-informed, with necessary information available	Establish sector information sharing fora	Short	P – Mines	• Sector fora established • Sector best practice guidelines available
	Conduct international benchmarking within the sectors	Medium	P – Mines O – NDM	

Objectives	Activities	Timeframe	Responsibility	Indicator
	Make sector emission performance information available for emitter benchmarking	Medium	P – NDM I – Mines	• Benchmarking promoted
	Make best practice information available on SAAQIS	Medium	P – NDM	
8) Adequate resources are available for AQM in mining industry	Revise organograms to create air quality structure and designation, where needed	Short	P – Mines	• AQM personnel designated • Abatement and measurement financial planning complete
	Optimise environmental management resource availability to accommodate air quality function	Short	P – Mines	
	Fill AQM posts with appropriately skilled staff, where needed	Short	P – Mines	
	Input into financial planning to implement emission abatement and measurement requirements	Short	P – Mines	
	Investigate the possible use of offset programmes to reduce financial investments	Medium	P – Mines I - NDM	
9) Ambient air quality standard and dust fallout limit value exceedances as a result of industrial emissions are assessed	Conduct ambient air quality monitoring in communities located close to mines	Short, On-going	P – Mines I – NDM	• Ambient air quality and dust fallout monitoring carried out • Monitoring results reported and available on SAAQIS • AIRs updated to include monitoring results
	Conduct dust fallout monitoring in accordance with legislative requirements, and consider advances in monitoring technology	Short, On-going	P – Mines I – NDM	
	Report ambient monitoring results, to relevant AQO and publish on SAAQIS	Short, On-going	P – Mines O – NDM,	

Objectives	Activities	Timeframe	Responsibility	Indicator
	Update AIR submissions	Short, On-going	P – Mines O – NDM	
10) A line of communication exists between mines and communities	Conduct quarterly consultative community meetings facilitated by the NDM. Stakeholders to be given at least 14 days' notice of meetings. The notice must include an agenda for comment; and copies of all documents to be discussed/presented at the meeting must be made available to stakeholders by the most practical means. Minutes of the meetings to be circulated within 14 days of the meeting.	Short, On-going	P – Mines	• Quarterly meetings held between industry and communities • Stakeholders to be given at least 14 days' notice of meetings. • Minutes of the meetings circulated within 14 days of the meeting.

11.3 CO-BENEFITS FROM PROJECTS BY OTHER GOVERNANCE STAKEHOLDER

As part of the AQMP development, work by stakeholders not directly related to air quality but having co-benefits for improved air quality in the NDM has been included. The projects listed are under development, have been implemented, or are proposed following consultation, and possible collaboration.

Table 0-1: Collaborative working and support projects

Implementing agent	Project

Department of Health	• Implementation of the guideline on indoor air pollution • Cooperatively develop healthcare admission methodology to include air pollution exposure parameters • Input to health risks assessments • Input to domestic fuel burning reduction plans
Department of Transport	• Motivate for the inclusion of emission testing as part of roadworthiness certification
Department of Energy	• Revision of fuel specifications as part of National Vehicle Emissions Strategy
Department of Energy, Eskom	• Develop promotional material and tools to inform energy efficient and alternative energy choices • Electrification programme • Emissions off-setting programme
Department of Education	• Promote revision of school curriculum to include AQM • Distribute air quality educational material to educators in the NDM • Promote AQM as a career path at schools and tertiary institutions
Department of Justice	• Motivate for stricter enforcement action through prosecution and penalties for contraventions of NEM:AQA
Department of Agriculture Forestry and Fisheries	• Promote research on improving farming techniques and good agricultural practices e.g. minimum tillage, application of pesticides • Promote best practice for the conversion of animal waste to manure and fertiliser
Department of Water Affairs and Sanitation	• Compile best practice documents for the waste management sector
	• Develop promotional material on air quality benefits of household waste minimisation

12 MONITORING, EVALUATION AND REVIEW

12.1 MONITORING

Monitoring the progress of the implementation of the AQMP is a key factor in maintaining momentum for the rollout of interventions and provides a means to update key stakeholders. Working groups are the preferred mechanism for monitoring, as they are the primary means for initiation of implementation. The outcomes of the meetings will be taken forward into the annual evaluation exercise.

Table 12-1: Monitoring	
Responsibility	NDM, Working Groups
Method	Progress meeting/Level of completion of interventions
Timeframe	Bi-annually

12.2 EVALUATION

On-going evaluation is an essential element of AQMP implementation as it allows for a thorough assessment of the AQMP, including the shortcomings and strengths evident in implementation. Evaluation is an internal mechanism to measure the performance of the AQMP implementation. Annual evaluation of the AQMP will be conducted as a minimum timeframe and is ideally incorporated into the annual performance review mechanisms existing in the NDM authorities.

AQMP evaluation is to be undertaken internally on an on-going evaluation, which addresses implementation outcomes, as well as through performance review through integration with the municipal IDP.

12.3 REVIEW

AQMP review comprises internal and external review components, and addresses further developments in the science as well as management of air quality. The purpose of the NDM AQMP review will be to assess the contents of the plan, including institutional and strategic arrangements put in place for the plan implementation, assess progress on interventions implementation, re-look into the AQMP baseline assessment, and determine the current air quality status through analysis of current monitoring data and emission inventory. The plan review will further investigate current and future economic realities and provide recommendations to further strengthen intervention implementation.

With regards to the formal review of the AQMP and the implementation, a review period of every *five years* is recommended in the DEA Manual. The definition of the review period is subject to funding and political cycles, as well as implementation outcomes.

The process of five-yearly review is anticipated to be initiated through an internal review mechanism and incorporate the annual evaluation exercise, effectively assessing the five-year performance of the AQMP and examining the successes and failures of implementation. An evaluation of the current organisational and air quality setting is necessary to complete the evaluation portion of the review. Following the comprehensive evaluation, goals and objectives are amended as needed and activities updated. The internal revision is communicated to stakeholders through a limited public participation process, followed by a further iteration and publication.

Table 12-2: Evaluation and review of the AQMP	
Responsibility	NDM, Working Groups, MSRG
Method	Compilation of annual evaluations
Timeframe	5 year

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14 GLOSSARY OF TERMS

1. **Ambient air:** Outdoor air in the troposphere, excluding work places. According the National Environmental Management Act, (Act no.39 of 2004) **"ambient air"** excludes air regulated by the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).
2. **Averaging Period:** A period of time over which an average value is determined.
3. **Limit values:** a numerical value associated with a unit of measurement and averaging period that forms the basis of the standard.
4. **Frequency of exceedance:** A frequency (number/time) related to a limit value representing the tolerated exceedance of that limit value, i.e. if exceedances of limit value are within the tolerances, and then there is still compliance with the standard.
5. **Standard:** A standard may have many components that define it as a "standard". These components may include some or all of the following; Limit values, averaging periods, frequency of exceedances, and compliance dates.
6. **Interim Levels**: These levels represent the timeframes for compliance with the standards.
7. **Compliance date**: A date when compliance with the standard is required. This provides a transitional period that allows activities to be undertaken to ensure compliance date.
8. **Morbidity:** The incidence rate, or the prevalence of a disease or medical condition
9. **Mortality**: Mortality rate of a condition is the proportion of people dying during a given time interval
10. **Exposure:** An event that occurs when there is contact a human and a contaminant of a specific concentration in the environment for an interval of time (Ott, 1995)