DR RUTH S MOMPATI DISTRICT MUNICIPALITY

AIR QUALITY MANAGEMENT PLAN

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1. INTRODUCTION

The Dr Ruth S. Mompati District Municipality (herein referred to as Dr RSM DM), formerly known as the Bophirima District Municipality, is located in the North West Province in South Africa. The Dr RSM DM borders Botswana, the Northern Cape and the Free State Province. The Dr RSM DM is one of four District Municipalities in the North West Province and consists of the Naledi, Greater Taung, Kagisano-Molopo, Mamusa, and Lekwa-Teemane Local Municipalities. Community services, agriculture and trade are the main economic activities in the Dr RSM DM (Dr.RSM, 2016).

Air quality in South Africa is governed under the National Environmental Management Air Quality Act (herein referred to as NEM:AQA), Act 39 of 2004 (NEM:AQA, 2004) and related legislation such as the National Ambient Air Quality Standards (NAAQS) (NEM:AQA, 2009). The NEM:AQA (Section 15(2)) requires Municipalities to introduce Air Quality Management Plans (AQMP) that seeks to improve air quality, identifies and addresses emissions that have a negative effect on human health. Municipalities are required to include an AQMP as part of their Integrated Development Plans (IDP).

The main objective of this project is to develop an Air Quality Management Plan for the Dr RSM DM, as per the requirements of the NEM:AQA 2004.

The main aims of the Dr RSM DM AQMP are

- to ensure sustainable implementation of air quality standards throughout the five Local Municipalities within the Dr RSM DM;
- to comply with the Bill of Rights as enshrined in the Constitution of South Africa (RSA, 1996) of every citizen having the right to live in an environment that is free of pollution;
- to recommend the methodology and processes for the monitoring of pollution parameters consistent with national, provincial and local norms and standards;
- to evaluate the existing air quality monitoring system in the Municipality and make recommendations for an effective air quality monitoring programme;
- to review the protocol for data collection, processing, quality control and assurance;
- to review the protocol for interpretation and archiving of reports;

- to establish an emission inventory of the study area by identifying sources, quantifying pollution and capturing these in geographic information systems (GIS);
- to initiate an air pollution dispersion modeling system; and
- to ensure the provision of sustainable air quality management support and services to all stakeholders within the Dr RSM DM.

In order to meet these aims, the immediate objectives are

- to conduct a Status Quo Assessment to determine pollution sources, ambient concentrations and the potential for human health effects within the Dr RSM DM;
- to conduct a Feasibility Study to outline the strategies to address the current air quality situation and provide recommendations for air quality monitoring;
- to compile an AQMP for the Dr RSM DM.

An AQMP has been compiled for the North West Province (NW-READ, 2015) to promote air quality practices within the Province. This AQMP provides the framework for the development of an AQMP in the Dr RSM DM.

1.1. Geographic Overview

The Dr RSM DM covers an area of approximately 43 700 km^2 and is the largest district in the North West Province (Municipalities, 2012). The Dr RSM DM is bordered by Botswana to the north, the Free State Province to the south and Northern Cape Province to the west. The Vaal River forms the southern border of the Dr RSM DM. The Naledi, Greater Taung, Kagisano-Molopo, Mamusa, and Lekwa-Teemane Local Municipalities fall within the Dr RSM DM (Figure 1).

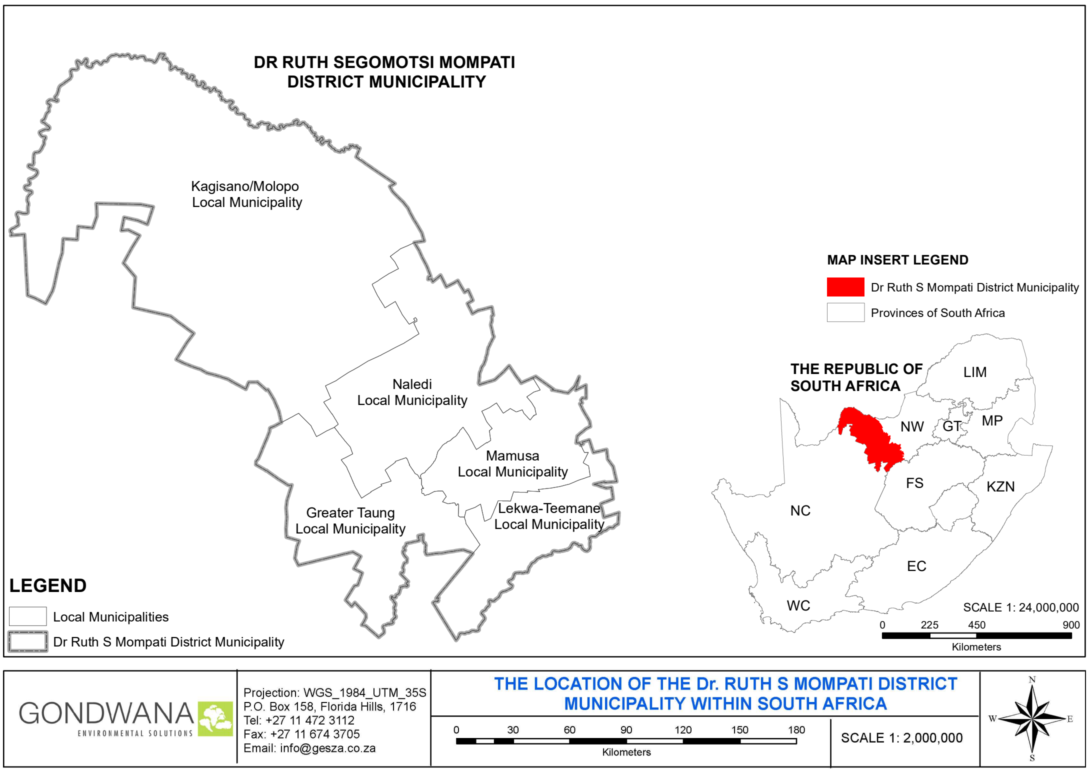


Figure 1: Local Municipalities of the Dr Ruth S Mompati District Municipality

Based on the 2011 Census, the Dr RSM DM has a total population of approximately 463 815 (Table 1 and Figure 2). The Greater Taung Local Municipality accounts for the largest part (38%) of the population in the Dr RSM DM, with a population of 177 642. Kagisano-Molopo Local Municipality comprises 23% of the population within the Dr RSM DM, Naledi Local Municipality 14%, Mamusa Local Municipality 13% and Lekwa-Teemane Local Municipality 11%.

Table 1: Population per Local Municipality in the Dr Ruth S Mompati District Municipality

Local Municipality	Census 2011
Naledi Local Municipality	66 781
Taung Local Municipality	177 642
Lekwa Teemane Local Municipality	53 248
Mamusa Local Municipality	60 355
Kagisano-Molopo Local Municipality	105 789
Total	463 815

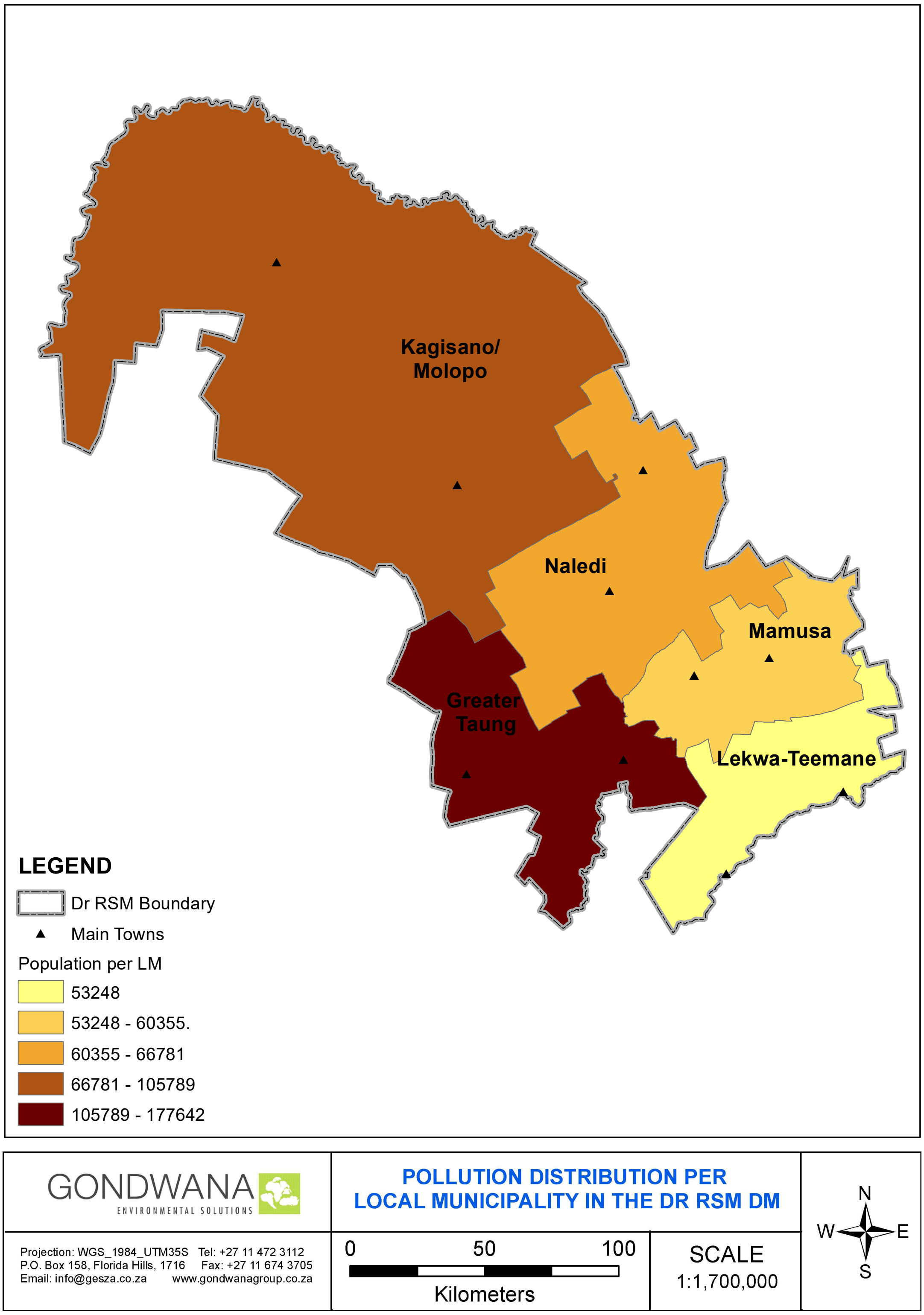


Figure 2: Population distribution of the Dr Ruth S Mompati District Municipality

1.2. National Air Quality Management Plans

The NEM:AQA 2004 aims to provide reasonable measures to prevent air pollution and give effect to Section 24 of the Constitution (RSA, 1996). The NEM:AQA 2004 states that local authorities are required to develop AQMP's which should be in their Integrated Development Plans (NEM:AQA, 2004) . Section 15(2) of the Air Quality Act requires each municipality to include an AQMP in its Integrated Development Plan (IDP) as required in terms of Chapter 5 of the Municipal Systems Act (Department of Environmental Affairs.

The AQMP developed for the Dr RSM DM is in line with the AQMPs developed locally. The guidelines outlined in the 2007 National Framework for Air Quality Management in the Republic of South Africa (NFAQM) (DEAT, 2007) the 2012 reviewed National Framework for Air Quality Management in the Republic of South Africa and the Air Quality Management Plan Guideline Documents provided by the Department of Environmental Affairs will also be followed.

2. POLICY AND REGULATORY REQUIREMENTS

2.1. National Environmental Management: Air Quality Act 39 of 2004

The NEM:AQA has shifted the approach of air quality management from source-based control to receptor-based control. The main objectives of the Act are to

- give effect to everyone's right to an environment that is not harmful to their health and well-being, and
- protect the environment by providing reasonable legislative and other measures that (i) prevent pollution and ecological degradation, (ii) promote conservation and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

The Act makes provision for the setting and formulation of national ambient air quality standards for *'substances or mixtures of substances which present a threat to health, well-being or the environment'* (NEM:AQA, 2004). More stringent standards can be established at the provincial and local levels. The control and management of emissions in the AQA relates to the listing of activities that are sources of emissions and the issuing of emission licenses.

Listed Activities are defined as "*activities which result in atmospheric emissions, which have or may have a significant detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage."* The South African Listed Activities were initially promulgated in 2009 and further amended in 2013 (NEM:AQA, 2013b). Any activity that falls within this list is required to have an Atmospheric Emissions License (Mansell et al.) to operate. The issuing of emission licenses for Listed Activities is the responsibility of the metropolitan and district municipalities. In addition, the minister may declare any substance contributing to air pollution as a priority pollutant. Any industries or industrial sectors that emit these priority pollutants will be required to implement a Pollution Prevention Plan. Municipalities are required to *'designate an air quality officer to be responsible for coordinating matters pertaining to air quality management in the Municipality'*. The appointed Air Quality Officer will be responsible for the issuing of AELs.

The NEM:AQA introduces the compulsory monitoring of ambient air quality. The national framework legislates protocols, standards and methodologies for monitoring (DEAT, 2007). The Act also requires relevant national departments, provinces and municipalities to introduce Air Quality Management Plans (AQMPs) that set out what will be done to achieve the prescribed air quality standards. Metropolitan, district and local municipalities are required to include an AQMP as part of their Integrated Development Plan.

A summary of the functions and responsibilities of National, Provincial and Local Government, as informed by the NEM:AQA and the NFAQM are provided hereafter (Table 2).

Table 2: Air quality responsibilities and functions of National, Provincial and Local Government

National Government	Provincial Government	Local Government
Establish and review National Framework	None	None
Identify national priority pollutants	Identify provincial priority pollutants	Identify priority pollutants (in terms of its by-laws)
Establish national air quality standards	Establish provincial air quality standards	Establish local air quality standards (more stringent)
Establish national emission standards	Establish provincial emission standards	Establish local emission standards
Appoint National Air Quality Officer	Appoint Provincial Air Quality Officer	Appoint Air Quality Officer
Prepare a National AQMP as a component of their EIP	Prepare a Provincial AQMP as a component of their EIP	Develop an AQMP as part of their IDP
Execute overarching auditing function to ensure that adequate air quality monitoring occurs	Ambient air quality monitoring	Ambient air quality monitoring
Declare national priority areas	Declare provincial priority areas	None
Prepare national priority areas AQMP	Prepare provincial priority areas AQMP	None
Prepare an annual report regarding the implementation of the AQMP	Prepare an annual report regarding the implementation of the AQMP	Prepare an annual report regarding the implementation of the AQMP

Prescribe regulations for implementing and enforcing the priority area AQMP	Prescribe regulations for implementing and enforcing the priority area AQMP	None
List activities	List activities	None
None	Perform emission licensing-authority functions	Perform emission licensing-authority functions
Declare controlled emitters	Declare controlled emitters	None
Declare and set requirements for controlled fuels	Declare and set requirements for controlled fuels	None
Set requirements for pollution prevention plans	Establish a programme of public recognition of significant achievement in air pollution prevention	None
Prescribe measures for the control of dust, noise and odours	Prescribe measures for the control of dust, noise and odours	None
Investigate and regulate transboundary pollution	None	None
Investigate potential international agreement contraventions	None	None

2.2. Legislation for Local Government

The Local Government: Municipal Systems Act, Act No. 32 of 2000 (LG:MSA, 2000), together with the Municipal Structures Act, Act No. 117 of 1998 (LG:MSA, 1998), establishes local government as an autonomous sphere of government with specific powers and functions as defined by the Constitution. Section 155 of the Constitution provides for the establishment of Category A, B and C municipalities which each has different levels of municipal executive and legislative authorities. According to Section 156(1) of the Constitution, a municipality has the executive authority in respect of, and has the right to, administer the local government matters (listed in Part B of Schedule 4 and Part B of Schedule 5) that deal with air pollution. Section 156(2) makes provision for a municipality to make and administer by-laws for the effective administration of any matters which it has the right to administer as long as it does not conflict with national or provincial legislation. The Municipal Systems Act as read with the Municipal Financial Management Act (LG:MFMA, 2003) requires municipalities to budget for and provide proper atmospheric environmental services. In terms of the National Health Act, Act 61 of 2003 (NHA, 2004), municipalities are required to appoint a health officer who is required to investigate any state of affairs that may lead to a contravention of Section 24(a) of the Constitution. Section 24(a) states that each person has the right to an environment that is not harmful to their health or well-being.

The Promotion of Access to Information Act, Act 2 of 2000 (PAIA, 2000), in conjunction with Section 32 of the Constitution, entitles everyone to the right of access to any information held by government and private individuals that is required for the exercise or protection of any rights. The relevance of the right to information is that government, industry and private individuals can be compelled, through court proceedings if required, to make information available regarding the state of the atmosphere and pollution. The Promotion of Administrative Justice Act, Act 3 of 2000 (PAJA, 2000), which was introduced by the State to give effect to Section 33 of the Constitution, provides everyone with the right to administrative action that is lawful, reasonable and procedurally fair and the right to be given written reasons when rights have been adversely affected by administrative action.

2.3. Local Air Quality By-Laws

Section 156(2) of the Constitution of the Republic of South Africa makes provision for a Local Municipality to make and administer by-laws for the effective administration of the matters which it has the right to administer as long as such by-laws do not conflict with National or Provincial legislation.

The Dr RSM DM has not established any air quality management by-laws. The Department of Environmental Affairs (DEA) has developed a generic air pollution control by-law for Municipalities (NEMA, 2010) which deals with most of the air quality management challenges expected in South Africa. The aim of the generic air quality management by-law is to assist municipalities in the development of their own air quality management by-law within their jurisdictions. Furthermore, use of the generic by-laws as a template will help ensure uniformity across the country when dealing with air quality management challenges. .

2.4. Ambient Air Quality Guidelines and Standards

Guidelines provide a basis for protecting public health from adverse effects of air pollution and for eliminating, or reducing to a minimum, those contaminants of air that are known or likely to be hazardous to human health and well-being (US-EPA, n.d.; WHO, 2000, 2005). Once the guidelines are adopted as standards, they become legally enforceable. Air quality guidelines and standards can prescribe various averaging periods, including an instantaneous peak, a 1-hour average, a 24-hour average, a 1-month average and an annual average.

The DEA, previously referred to as the Department of Environmental Affairs and Tourism (DEAT), issued NAAQS for several criteria pollutants, including, benzene (C_6H_6), carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), particulate matter with an aerodynamic diameter of less than 10 µm (PM_{10}), ozone (O_3) and sulphur dioxide (SO_2). In 2012, particulate matter with an aerodynamic diameter of less than 2.5 µm ($PM_{2.5}$) was promulgated as a priority pollutant (NEM:AQA, 2012) (Table 3).

Table 3: National Ambient Air Quality Standards for Criteria Pollutants (NEM:AQA, 2009, 2012)

Pollutant	Averaging Period	Concentration ($\mu g/m^3$)	Concentration (ppb)
SO_2	10-minute running average	500	191
	1-hr average	350	134
	24-hr average	125	48
	Annual average	50	19
NO_2	1-hr average	200	106
	Annual average	140	21
CO	1-hr average	30	26
	8-hourly running average	10	8.7
O_3	8-hourly running average	120	61
PM_{10}	24-hr average	120	-
	Annual average	50	-
$PM_{2.5}$	24-hr average	65	-
	Annual average	25	-
Pb	Annual average	0.5	-
C_6H_6	Annual average	10	3.2

The NEM:AQA does not make provision for the setting of legally binding local air quality standards by local authorities. However, it is accepted that local authorities may establish more stringent ambient air quality guidelines than the NAAQS.

2.5. Dustfall Standards

The Department of Environmental Affairs (DEA) gazetted National Dust Control Regulations (hereinafter referred to as NDCR) on 1 November 2013 (NEMA:AQA, 2013). These regulations provide the standard for acceptable dustfall rates for residential and non-residential areas based on the ASTM D1739, 1970 version of the standard. The maximum permissible dustfall rate over a 30-day averaging period in residential areas is 600 mg/m^2/day, and in non-residential areas 1 200 mg/m^2/day. For both residential and non-residential areas, these values may be exceeded twice a year, but not more than twice or in sequential months (Table 4).

Table 4: Acceptable dustfall rates (NEMA:AQA, 2013)

Restriction Areas	Dust Fall Rate (D) (mg/m^2/day), 30-day average)	Permitted Frequency of Exceeding Dust Fall Rate
Residential Areas	D < 600	Two within a year, not sequential months.
Non-Residential Areas	600 < D < 1,200	Two within a year, not sequential months.

Measures to control dust, as detailed in the NDCR (NEMA:AQA, 2013), state that

> *"6 (1) Any person who has exceeded the dustfall standard set out in regulation 3 must, within three months after submission of the dustfall monitoring report, develop and submit a dust management plan to the air quality officer for approval"*.

Additional requirements enforceable by the NDCR are detailed in the Regulations and it is the responsibility of the facility or dust generating activity to ensure that the conditions of the NDCR are complied with.

3. CRITERIA POLUTANTS AND ASSOCIATED HEALTH AND ENVIRONMENTAL IMPACTS

Deteriorating urban air quality has implications for human health, climate and visibility. An overview of the criteria pollutants and associated human health and environmental impacts is discussed in the section below. Criteria Pollutants include particulate matter, Sulphur dioxide, nitrogen dioxide, ozone, carbon monoxide and benzene which is a volatile organic compound

3.1. Human Health Impacts

3.1.1. Particulate Matter

Particles can be classified by their aerodynamic properties into coarse particles, PM_{10} (particulate matter with an aerodynamic diameter of less than 10 µm) and fine particles, $PM_{2.5}$ (particulate matter with an aerodynamic diameter of less than 2.5 µm). The fine particles contain the secondarily formed aerosols such as sulphates and nitrates, combustion particles and recondensed organic and metal vapours. The coarse particles contain earth crust materials and fugitive dust from roads and industries.

In terms of health impacts, particulate air pollution is associated with effects on the respiratory system (WHO, 2005). Particle size is important for health because it controls where in the respiratory system a given particle deposits. Fine particles have been found to be more damaging to human health than coarse particles. This is because larger particles are less respirable than smaller particles, in that they do not penetrate as deeply into the lungs as smaller particles (Pope and Dockery, 2006). Larger particles are deposited into the extrathoracic part of the respiratory tract while smaller particles are deposited into the smaller airways leading to the respiratory bronchioles (WHO, 2005).

Short-term exposure

Recent studies suggest that short-term exposure to particulate matter leads to adverse health effects, even at low concentrations of exposure (below 100 µg/m^3). Morbidity effects associated with short-term exposure to particulates include increases in symptoms of the lower respiratory tract, increases in medication use and small reductions in lung function (Scapellato and Lotti, 2007).

Long-term exposure

Long-term exposure to low concentrations (~10 μg/m^3) of particulates is associated with mortality and other chronic effects such as increased rates of bronchitis and reduced lung function (WHO, 2005). Those most at risk include the elderly, individuals with pre-existing heart or lung disease, asthmatics and children.

3.1.2. Sulphur dioxide

SO_2 originates from the combustion of sulphur-containing fuels and is a major air pollutant in many parts of the world. Health effects associated with exposure to SO_2 are also related to the respiratory system. Being soluble, SO_2 is readily absorbed in the mucous membranes of the nose and upper respiratory tract (Witschi and Last, 2001).

Short-term exposure

Most information on the acute effects of SO_2 is derived from short-term exposure in controlled chamber experiments. These experiments have demonstrated a wide range of sensitivity amongst individuals. Acute exposure of SO_2 concentrations can lead to severe bronchoconstriction in some individuals, while others remain completely unaffected. Response to SO_2 inhalation is rapid, with the maximum effect experienced within a few minutes. Continued exposure does not increase the response. Effects of SO_2 exposure are short-lived with lung function returning to normal within a few minutes to hours (WHO, 2005).

Exposure over 24 hours

The effects of exposure to SO_2, averaged over a 24 hour period, are derived from epidemiological studies in which the effects of SO_2, particulates and other associated pollutants are assessed. Studies of the health impact of emissions from the inefficient burning of coal in domestic appliances have shown that, when SO_2 concentrations exceed 250 μg/m^3, in the presence of particulate matter (as sulphates), an exacerbation of symptoms is observed in selected sensitive patients. More recent studies of health impacts in ambient air polluted by industrial and vehicular activities have demonstrated, at low levels, effects on mortality (total, cardiovascular and respiratory) and increases in hospital admissions. In these studies, no obvious SO_2 threshold level was identified (WHO, 2005).

Long-term exposure

Long-term exposure to SO_2 has been found to be associated with an exacerbation of respiratory symptoms and a small reduction in lung function in some children. In adults, respiratory symptoms such as wheezing and coughing are increased.

3.1.3. Nitrogen dioxide

Nitric oxide (NO) is a primary pollutant, emitted from the combustion of stationary sources (heating, power generation) and from motor vehicles. Nitrogen dioxide (NO_2) is formed through the oxidation of nitric oxide. Oxidation of NO by O_3 occurs rapidly, even at low levels of reactants present in the atmosphere. As a result, this reaction is regarded as the most important route for nitrogen dioxide production in the atmosphere.

Nitrogen dioxide is an important gas, not only because of its health effects, but because it (a) absorbs visible solar radiation and contributes to visibility impairment; (b) could have a potential role in global climate change if concentrations were to increase significantly; (c) is a chief regulator of the oxidizing capacity of the free troposphere by controlling the build-up and fate of radical species, including hydroxyl radicals; and (d) plays a critical role in determining ozone concentrations.

Short-term exposure

At concentrations greater than 1 880 µg/m^3 (1 000 ppb), changes in the pulmonary function of an adult is observed. Normal healthy people exposed at rest or with light exercise for less than 2 hours to concentrations above 4 700 µg/m^3 (2 500 ppb), experience pronounced decreases in pulmonary function. Asthmatics are potentially the most sensitive subjects although various studies of the health effects on asthmatics have been inconclusive. The lowest concentration causing effects on pulmonary function was reported from two laboratories that exposed mild asthmatics for 30 – 110 minutes to 565 µg/m^3 (301 ppb) during intermittent exercise (WHO, 2005).

Long-term exposure

Epidemiological studies have been undertaken on the indoor use of gas cooking appliances and health effects. Studies on adults and children under 2 years of age found no association between the use of gas cooking appliances and respiratory effects. Children aged 5 – 12 years have a 20% increased risk of respiratory symptoms and disease for each increase of 28 µg/m^3 (15 ppb) NO_2 concentration, where the weekly average concentrations are in the range of 15 – 128 µg/m^3 (8 – 68 ppb) (WHO, 2005).

Outdoor studies consistently indicate that children with long-term ambient NO_2 exposure exhibit increased respiratory symptoms that are of a longer duration. However, no evidence is provided for the association of long-term exposures with health effects in adults (WHO, 2005).

3.1.4. Ozone

Ozone in the atmosphere is a secondary pollutant formed through a complex series of photochemical reactions between NO_2 and VOCs in the presence of sunlight. Sources of these precursor pollutants include motor vehicles and industries. Atmospheric background concentrations are derived from both natural and anthropogenic sources. Natural concentrations of O_3 vary with altitude and seasonal variations (i.e. summer conditions favor O_3 formation due to increased insolation). Diurnal patterns of O_3 vary according to location, depending on the balance of factors affecting its formation, transport and destruction. From the minimal levels recorded in the early morning, concentrations increase as a result of photochemical processes and peak in the afternoon. During the night, O_3 is scavenged by nitric oxide. Seasonal variations in O_3 concentrations also occur and are caused by changes in meteorological conditions and insolation. Quarterly mean (arithmetic average of daily values for a calendar quarter) O_3 concentrations are typically highest in summer (WHO, 2005).

Ozone is a powerful oxidant and can react with a wide range of cellular components and biological materials. Health effects and the extent of the damage associated with O_3 exposure is dependent on O_3 concentrations, exposure duration, exposure pattern and ventilation (WHO, 2005).

Short-term exposure

Short-term effects include respiratory symptoms, pulmonary function changes, increased airway responsiveness and inflammation. Field studies in vulnerable persons (children, adolescents, young adults, elderly and asthmatics) have indicated that pulmonary function decrements can occur as a result of short-term exposure to O_3 concentrations in the range 120 – 240 µg/m^3 (61 – 122 ppb) and higher. Ozone exposure has also been reported to be associated with increased hospital admissions for respiratory complaints and exacerbation of asthma (WHO, 2005).

Long-term exposure

There is limited information linking long-term O_3 exposure to chronic health effects, however, there are suggestions that cumulative O_3 exposures may be linked with increasing asthma severity and the possibility of increased risk of becoming asthmatic (Katsouyanni, 2003).

Evidence provided by studies of health effects related to chronic ambient O_3 exposure is consistent in indicating chronic effects on the lung. Some studies have shown that long-term exposure to concentrations of O_3 in the range 240 – 500 µg/m^3 (122 – 255 ppb) causes morphological changes in the region of the lung resulting in a reduction in lung function (WHO, 2005).

3.1.5. Carbon monoxide

Carbon monoxide (CO) is one of the most common and widely distributed air pollutants. CO is a tasteless, odourless and colourless gas which has a low solubility in water. In the human body, after reaching the lungs, it diffuses rapidly across the alveolar and capillary membranes and binds reversibly with the haem proteins. Approximately 80 - 90% of CO binds to haemoglobin to form carboxyhaemoglobin (COHb) which is a specific biomarker of exposure in blood. The affinity of haemoglobin for CO is 200 – 250 times that for oxygen. This causes a reduction in the oxygen-carrying capacity of the blood which leads to hypoxia as the body is starved of oxygen.

Anthropogenic emissions of CO originate from the incomplete combustion of carbonaceous materials. The largest proportion of these emissions is produced from exhausts of internal combustion engines, in particular petrol vehicles. Other sources include industrial processes, coal power plants and waste incinerators. Ambient CO concentrations in urban areas depend on the density of vehicles and are influenced by topography and weather conditions. In the streets, CO concentrations vary according to the distance from the traffic. In general, the concentration is highest at the leeward side of the 'street canyon' with a sharp decline in concentration from pavement to rooftop level (Schwela, 2000).

Short and Long-term exposure

The adverse health effects of CO vary depending on the concentration and time of exposure. Clinical symptoms range from headaches, nausea and vomiting, muscular weakness, and shortness of breath at low concentrations (10 ppm) to loss of consciousness and death after prolonged exposure or after acute exposure to high CO concentrations (>500 ppm). Poisoning may cause both reversible, short-lasting neurological deficits and severe, often delayed, neurological damage. Neurobehavioural effects include impaired co-ordination, tracking, driving ability, vigilance and cognitive ability at COHb levels as low as 1.5 - 8.2% (WHO, 2005).

High risk patients with regards to CO exposure include persons with cardiovascular diseases (especially ischaemic heart disease), pregnant mothers, fetuses and newborn infants. Epidemiological and clinical studies indicate that CO from smoking and environmental or occupational exposures may contribute to cardiovascular mortality (WHO, 2005).

3.1.6. Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are organic chemicals that easily vaporize at room temperature and are colourless. VOCs are released from vehicle exhaust gases either as unburned fuels or as combustion products, and are also emitted by the evaporation of solvents and motor fuels. Short-term exposure to VOCs can cause eye and respiratory tract irritation and damage, headaches, dizziness, visual disorders, fatigue, loss of coordination, allergic skin reactions, nausea, memory impairment, damage to the bone marrow and even death. Long-term exposure to high levels of VOCs has been linked to an increase in the occurrence of leukaemia. VOCs can also cause damage to the liver, kidneys and central nervous system.

3.1.6.1. Benzene

Benzene (C_6H_6) in air exists predominantly in the vapour phase, with residence times varying between a few hours and a few days, depending on the environment, climate and the concentration of other pollutants. The only benzene reaction which is important in the lower atmosphere, is the reaction with hydroxyl radicals. The products of this reaction are phenols and aldehydes, which react quickly and are removed from the air by rain.

Benzene is a natural component of crude oil, and petrol contains 1 – 5% by volume. Benzene is produced in large quantities from petroleum sources and is used in the chemical synthesis of ethyl benzene, phenol, cyclohexane and other substituted aromatic hydrocarbons. Benzene is emitted from industrial sources as well as from combustion sources such as motor engines, wood combustion and stationary fossil fuel combustion. The major sources are exhaust emissions; evaporation losses from motor vehicles; and evaporation losses during the handling, distribution and storage of petrol.

Information on health effects from short-term exposure to benzene is fairly limited. The most significant adverse effects from prolonged exposure to benzene are haematotoxicity, genotoxicity and carcinogenicity. Chronic benzene exposure can result in bone marrow depression expressed as leukopenia, anaemia and/or thrombocytopenia, leading to pancytopenia and aplastic anaemia. Based on this evidence, benzene is recognized to be a human and animal carcinogen. An increased mortality from leukemia has been demonstrated in occupationally exposed workers (WHO, 2005).

3.1.6.2. Toluene

Toluene is produced from the catalytic conversion of petroleum and aromatization of aliphatic hydrocarbons and as a by-product of the coke oven industry. The bulk of production is in the form of a benzene-toluene-xylene mixture that is used in the back blending of petrol to enhance octane ratings. Toluene is used as a solvent, carrier or thinner in the paint, rubber, printing, cosmetic, adhesives and resin industries; as a starting material for the synthesis of other chemicals; and as a constituent of fuels (WHO, 2005).

Toluene is believed to be the most prevalent hydrocarbon in the atmosphere. Reactions with hydroxyl radicals are the main mechanisms by which toluene is removed from the atmosphere. The lifetime of toluene can range from a few days in summer to a few months in winter (WHO, 2005).

The short-term and long-term effects of toluene on the central nervous system are of great concern. Toluene may also cause developmental decrements and congenital abnormalities in humans. The potential effects of toluene exposure on reproduction and hormonal balances in women are also of concern. Men occupationally exposed to toluene at 5 – 25 ppm have also been shown to exhibit hormonal imbalances. Limited information suggests an association between occupational toluene exposure (at an average concentration 88 ppm) and spontaneous abortions. Toluene has minimal effects on the liver and kidney, except in cases of toluene abuse. Studies have not indicated that toluene is carcinogenic (WHO, 2005).

3.2. Environmental Impacts

Trace gases and aerosols impact climate through their effect on the radiative balance of the earth. Trace gases, such as greenhouse gases, absorb and emit infrared radiation which raises the temperature of the earth's surface causing the enhanced greenhouse effect. Aerosol particles have a direct effect by scattering and absorbing solar radiation and an indirect effect by acting as cloud condensation nuclei. Atmospheric aerosol particles range from dust and smoke to mists, smogs and haze (IPCC, 2001). Smog and haze are common in regions where certain geographic features, such as mountains, and weather conditions, such as temperature inversions, contribute to the trapping of air pollutants (Kumar and Mohan, 2002). Smog and haze also contribute to visibility degradation through the absorption and scattering of radiation by gases and particulates (Elsom, 1996). This smog or 'brown haze' can be observed during the winter months (April to September) when strong temperature inversions and calm conditions promote the stagnation of pollutants.

Other environmental impacts associated with air pollution include loss of biodiversity, damage to sensitive environments and acid rain. Acid rain is a general term referring to a combination of wet and dry deposition from the atmosphere containing elevated amounts of sulphuric and nitric acid. Acid rain occurs when SO_2 and NO_x are emitted into the atmosphere, undergo chemical transformation and are absorbed by water droplets in clouds. The droplets then fall to earth as rain, snow, mist, dust, hail or sleet. This increases the acidity of soil and affects the chemical balance of dams and rivers. Acid rain can also cause damage to buildings and infrastructure.

4. METEOROLOGICAL OVERVIEW AND AMBIENT AIR QUALITY

An overview of the macroscale and mesoscale atmospheric circulations influencing airflow and the subsequent dispersion and dilution of pollutants is discussed. The local meteorological conditions in the Municipality are evaluated using surface meteorological data from weather stations operated by the South African Weather Service.

4.1. Macroscale Air Circulations

The mean circulation of the atmosphere over southern Africa is anticyclonic throughout the year due to the dominance of three semi-permanent, subtropical high-pressure cells over the subcontinent. Seasonal changes in the intensity and position of the high-pressure cells, together with the influence of the easterlies in the north and westerlies in the south, controls the climate of southern Africa.

Anticyclones centered over the subcontinent are associated with subsidence of air which produces clear, dry, stable conditions. The frequency of occurrence of anticyclones reaches a maximum over the interior plateau in June and July (79%) with a minimum during December (11%). Subsidence associated with anticyclones is conducive to the formation of absolutely stable layers in the troposphere that prevent the vertical transport of pollution. Over the interior plateau, three stable layers occur at 700 hPa, 500 hPa, and 300 hPa respectively, with another layer occurring at 800 hPa between the plateau and the coast. On days when these stable layers occur, dense haze layers are evident (Tyson et al., 1996). Absolutely stable layers at the surface, in the form of surface inversions, develop due to cooling during the night. Surface inversions prevent the vertical distribution of pollutants in the atmosphere which can reduce visibility during the early morning. During the day, heating causes the stable boundary layer to be replaced by a mixing layer which may erode away the surface inversion (Tyson et al., 1988). Pollutants trapped below the surface inversion are then able to rise and disperse.

Over southern Africa, semi-stationary easterly waves form in deep easterly currents in the vicinity of an easterly jet. The waves are barotropic (axes not displaced with height) and the perturbations take the form of open waves or closed lows which are evident near the surface. Surface convergence and upper air divergence to the east of the wave trough produces strong uplift, instability and the potential for precipitation. Ahead of and to the west of the wave trough, surface divergence and upper air convergence occurs, ensuring clear, dry conditions. Easterly lows are deeper systems than easterly waves, with surface convergence continuing upwards through the 500 hPa level.. Such phenomena are associated with copious rains if airflow has a northerly component. Tropical disturbances are mainly a summer phenomenon and peak during the summer months of December and February.

Westerly waves are baroclinic, Rossby waves and are tilted westward with height. Westerly waves are associated with surface convergence and upper-level divergence which produce gentle uplift of air. Subsidence and stable conditions occur ahead of the trough with cloud and precipitation to the rear of the trough. Other disturbances in the westerlies include cut-off lows, southerly meridional flow, ridging anticyclones, west-coast troughs and cold fronts. Cold fronts occur together with westerly waves, depressions or cut-off lows. Cold fronts occur most frequently in winter and bring cool weather due to airflow from the south and south-west. Ahead of the front, northerly airflow is associated with divergence and subsidence that brings stable, clear conditions. Behind the front, southerly airflow, associated with low-level convergence causes cool conditions and rain (Tyson and Preston-Whyte, 2000). With the passage of a cold front, wind direction changes from north-west to west and south-west.

4.2. Mesoscale Air Circulations

Air transport near the surface can either be induced by horizontal spatial discontinuities in temperature, pressure and density fields or by topographically induced local winds such as those on slopes and in valleys. Such mesoscale circulations have implications for the transport and recirculation of pollutants in an airshed.

On slopes, differential heating and cooling of the air produces local baroclinic fields (Figure 3). During the day, the absorption of radiation by the slopes warms the air near the surface, initiating low-level, up-slope anabatic flow with an upper-level return flow to complete the closed circulation. During the night, the mechanism and the circulation are reversed as surface cooling produces down-slope katabatic flow and its return flow. The formation of frost hollows and the accumulation of fog and pollutants are associated with down-slope flow (Atkinson, 1981).

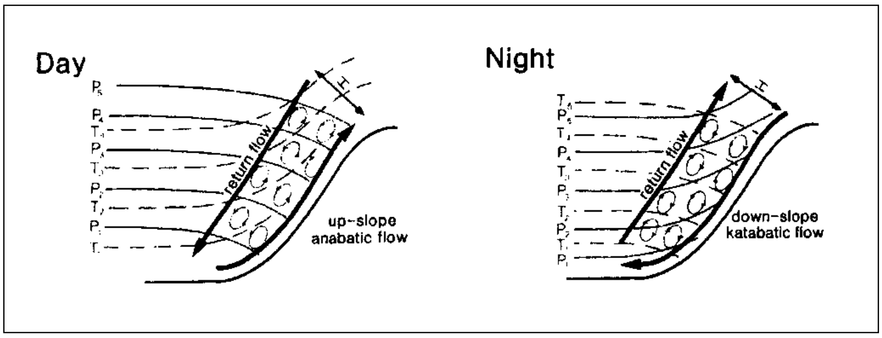


Figure 3: Diurnal variation of local winds on slopes (after Tyson and Preston-Whyte, 2000)

Within valleys, local airflow is dependent on the geometry (depth and orientation) of valleys and the time of day or night (Tyson and Preston-Whyte, 2000). In valleys whose slopes are equally heated (east-west valleys), early morning circulations are up-slope and down-slope in the evening (Figure 4).

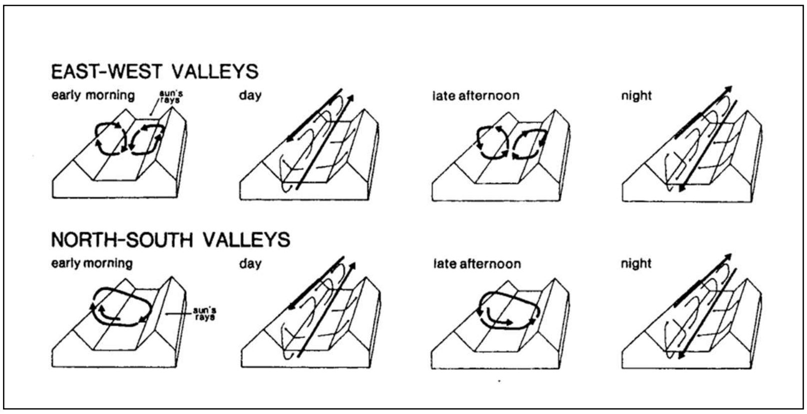


Figure 4: Diurnal variation of local winds in valleys (after Tyson and Preston-Whyte, 2000)

During the day, up-valley valley winds occur with an upper-level anti-valley wind to complete the closed circulation. During the night, down-valley mountain winds occur with the return upper-level anti-mountain wind. In valleys at right angles to the rising and setting sun (north-south valleys), the flow patterns are similar except that a unicellular circulation is set up at sunrise and sunset. These wind fields control the transport and dispersion of low-level pollutants within valleys (Tyson et al., 1988). Nocturnal mountain winds can transport pollution long distances down valleys under stable conditions while daytime valley winds can effectively disperse and dilute pollution trapped within the valley. Valley winds dominate and are strongest in summer when heating is greatest while mountain winds dominate and are strongest in winter when cooling is strongest (Tyson and Preston-Whyte, 2000).

4.3. Wind Field

Characterization of the wind field in Dr RSM DM was undertaken using surface meteorological data from available weather stations in the Dr RSM DM. Surface meteorological data was obtained from the South African Weather Service (SAWS) stations in Vryburg, Bloemhof and Tosca (Table 5 and Figure 5).

Table 5: Meteorological stations operated by the South African Weather Services in the Dr Ruth S Mompati District

Station Name/Town	Vryburg	Bloemhof	Tosca
Latitude (°S)	26°57'14"S	27°39'04"S	25°52'41"S
Longitude (°E)	24°39'07"E	25°37'16"E	23°57'58"E
Status	Active		
Monitoring Period	2013 to 2015		
Parameters Measured	Wind speed, Wind direction, Temperature, Humidity, Pressure, Rainfall		
Averaging Period	1 Hour intervals		

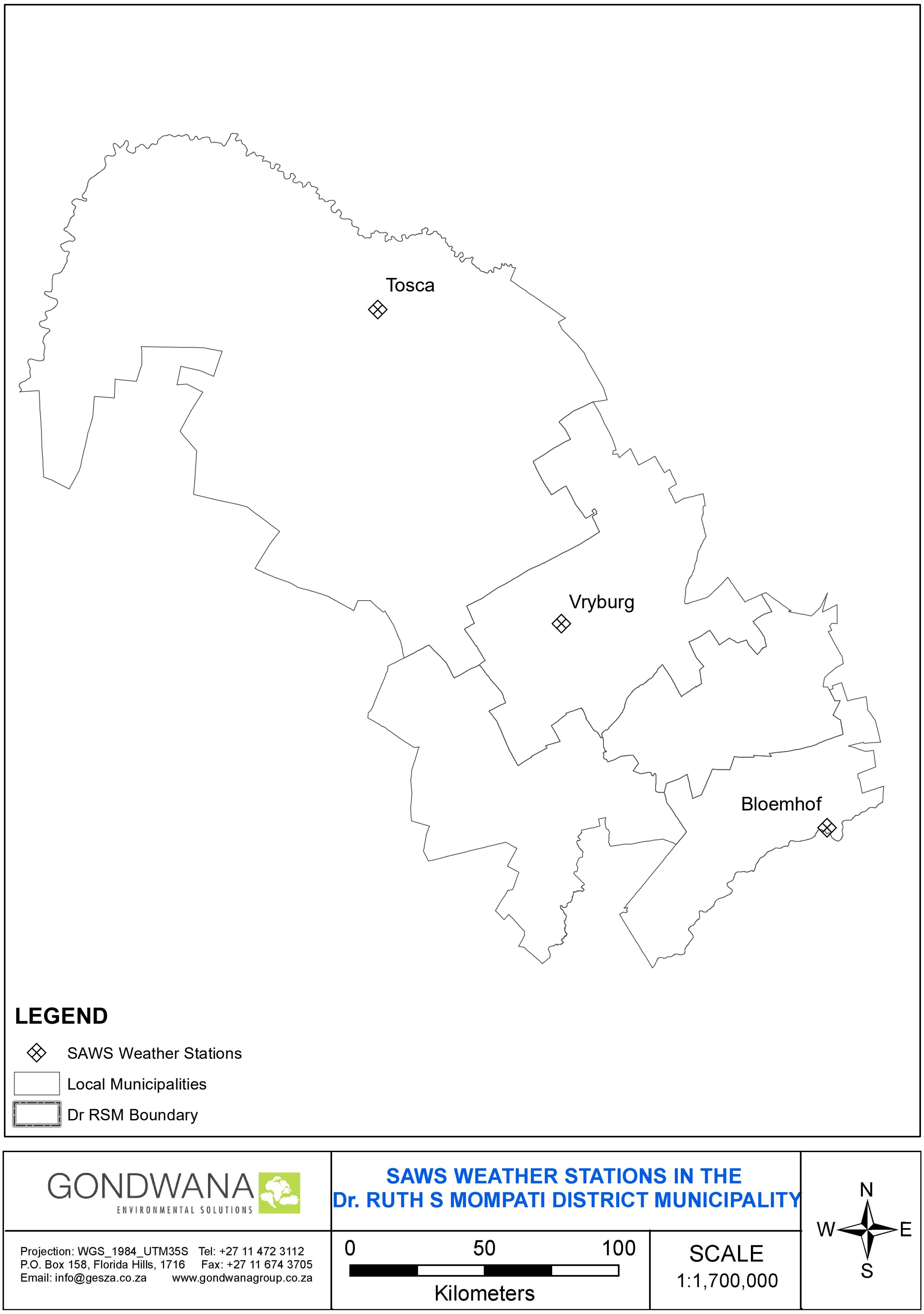


Figure 5: Location of SAWS weather stations in the Dr RSM DM.

Wind roses (Figure 6 to Figure 10) summarize the occurrence of winds at a location, representing their strength, direction and frequency. Each dotted circle represents a 10% frequency of occurrence during the monitoring period. Wind speed classes are represented as calm (> 1.0 m/s; white), light breeze (1 – 2 m/s; grey), gentle breeze (2 – 3 m/s; blue), moderate breeze (3 – 4 m/s; light green), fresh breeze (4 – 5 m/s; light blue), strong breeze (5 – 8 m/s, gold), near gale (8 – 11 m/s; orange), and gale winds (> 11 m/s; red).

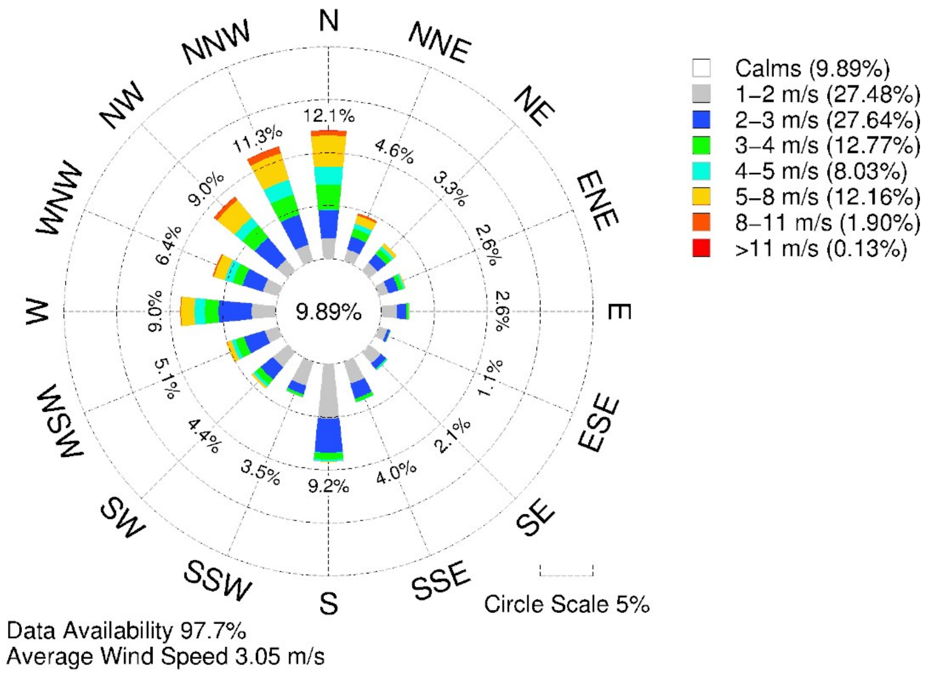


Figure 6: Wind rose of the recorded average hourly wind statistics at the South African Weather Service weather station located at Vryburg for the years 2013 – 2015

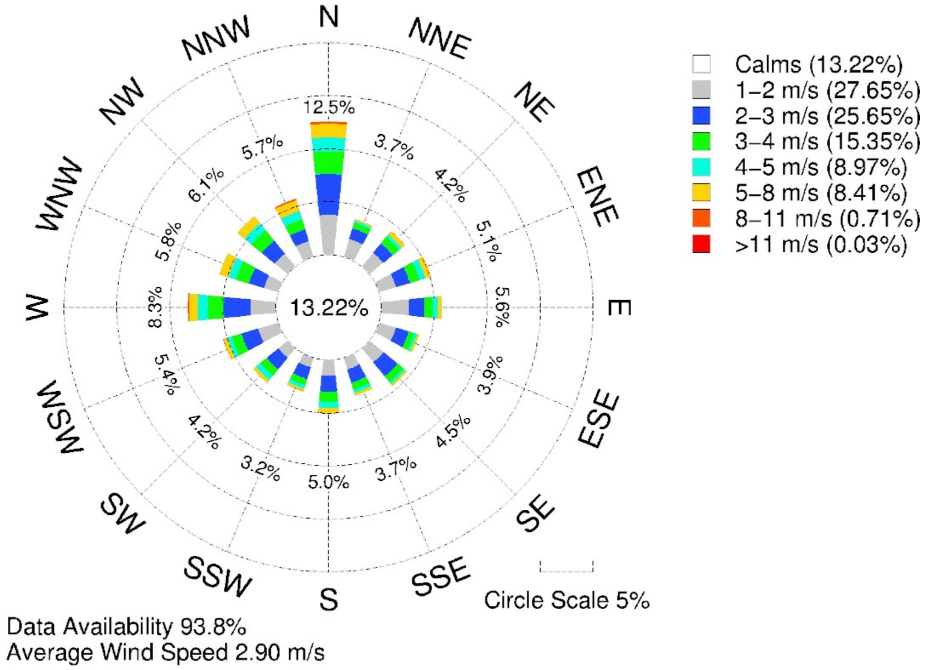


Figure 7: Wind rose of the recorded average hourly wind statistics at the South African Weather Service weather station located at Bloemhof for the years 2013 – 2015

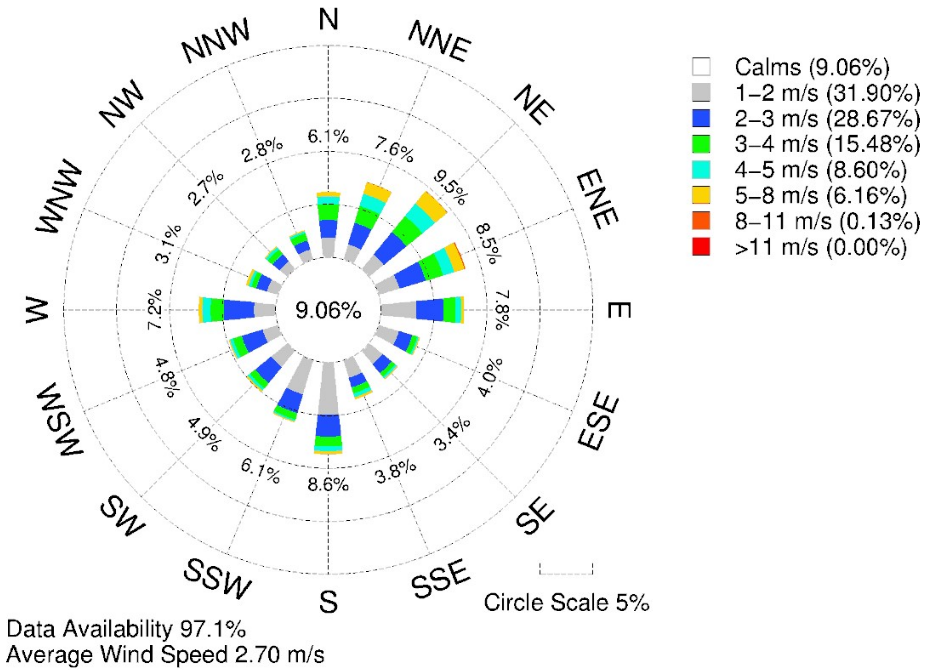


Figure 8: Wind rose of the recorded average hourly wind statistics at the South African Weather Service weather station located at Tosca for the years 2013 – 2015

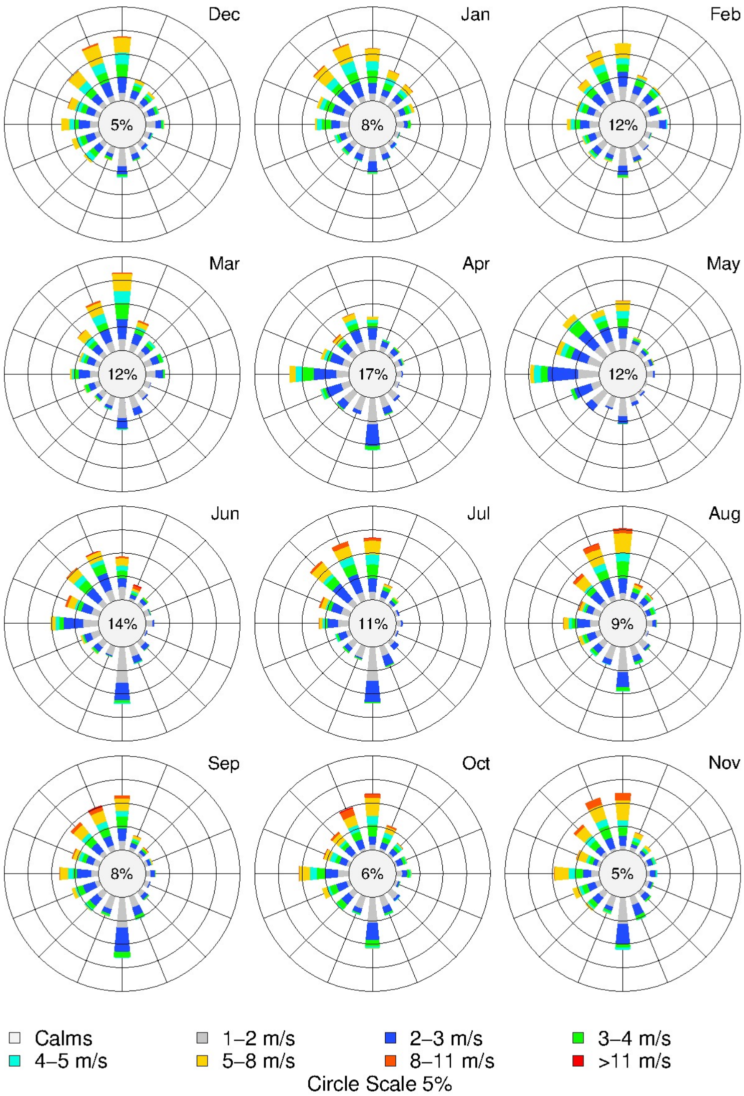


Figure 9: Monthly variation of surface winds for Vryburg for the period 2013 – 2015

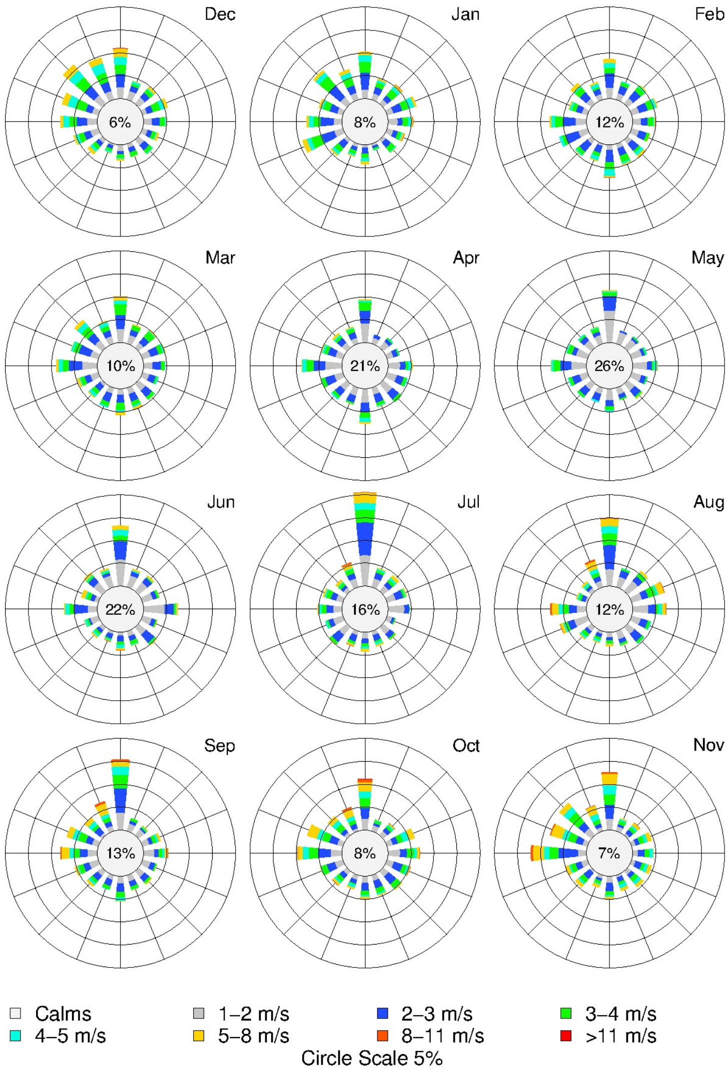


Figure 10: Monthly variation of surface winds for Bloemhof for the period 2013 – 2015

4.4. Temperature

The Dr RSM DM is situated in the western region of the North West Province and therefore its climate can be described as being predominantly temperate (DACE, 2002). The seasonal average temperatures for the Dr RSM DM were calculated using hourly data from the SAWS Meteorological data (Table 6).

Table 6: Dr RSM DM seasonal temperature averages

Seasonal Average (˚C)	Summer (Dec - Feb)	Autumn (Mar – May)	Winter (Jun – Aug)	Spring (Sept – Nov)
Vryburg	25.4	18.0	11.6	21.3
Bloemhof	25.2	17.8	11.0	20.8
Tosca	26.6	19.0	13.0	22.7

4.5. Precipitation

Rainfall data has been obtained from SAWS for the period of 2013 to 2015. There are three stations located within the Dr RSM DM, namely Vryburg, Bloemhof and Tosca stations. The annual averages over the three years for each of these stations are 391.5 mm, 250.3 mm, 366.1mm for Vryburg, Bloemhof and Tosca respectively. The rainfall data suggests that the Dr RSM DM receives most of its rainfall in the summer months, specifically late summer (Figure 11 to Figure 13). This is indicative of the summer rainfall distribution experienced in the northern parts of the country.

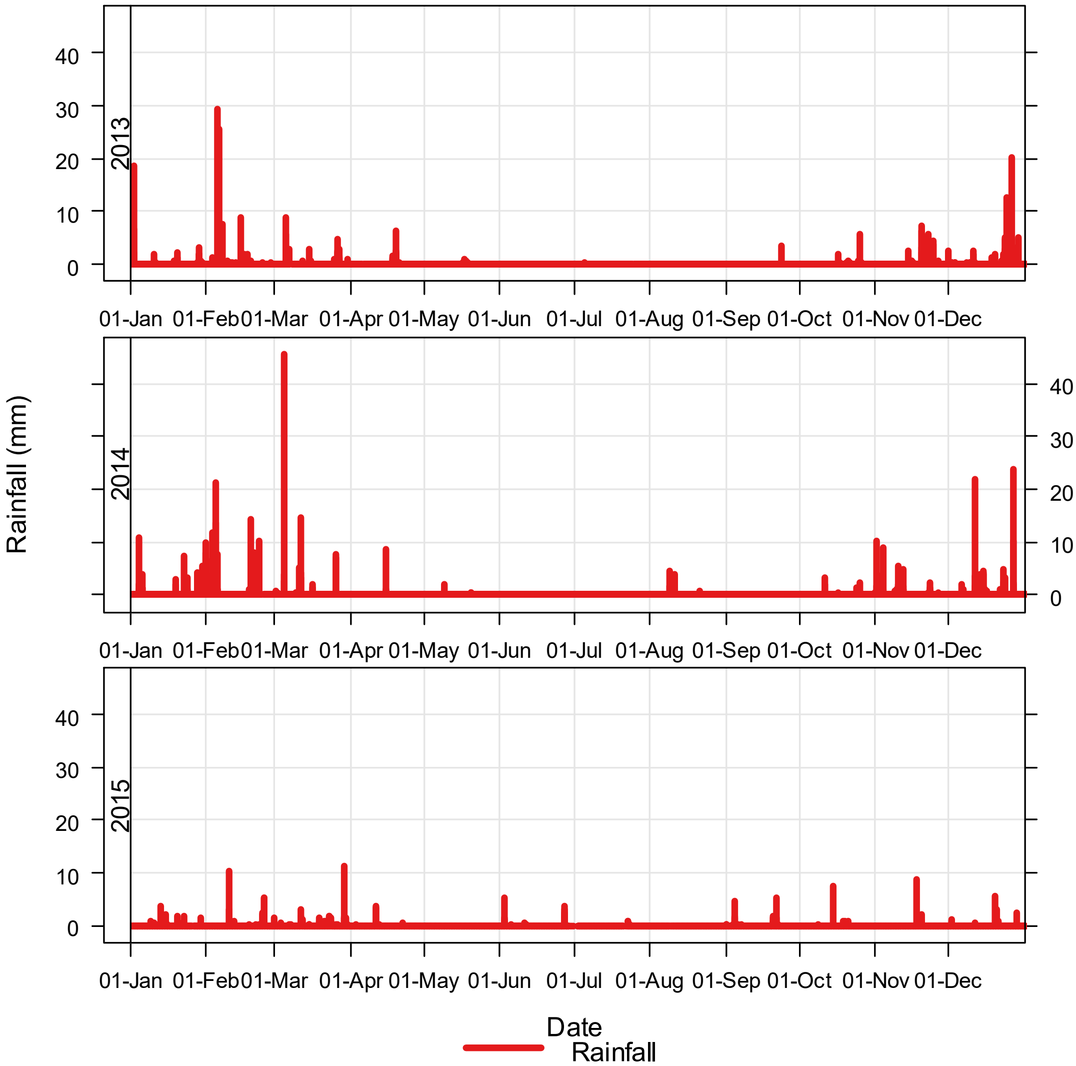


Figure 11: Rainfall figures from the South African Weather Service Station in Vryburg for the period 2013 – 2015.

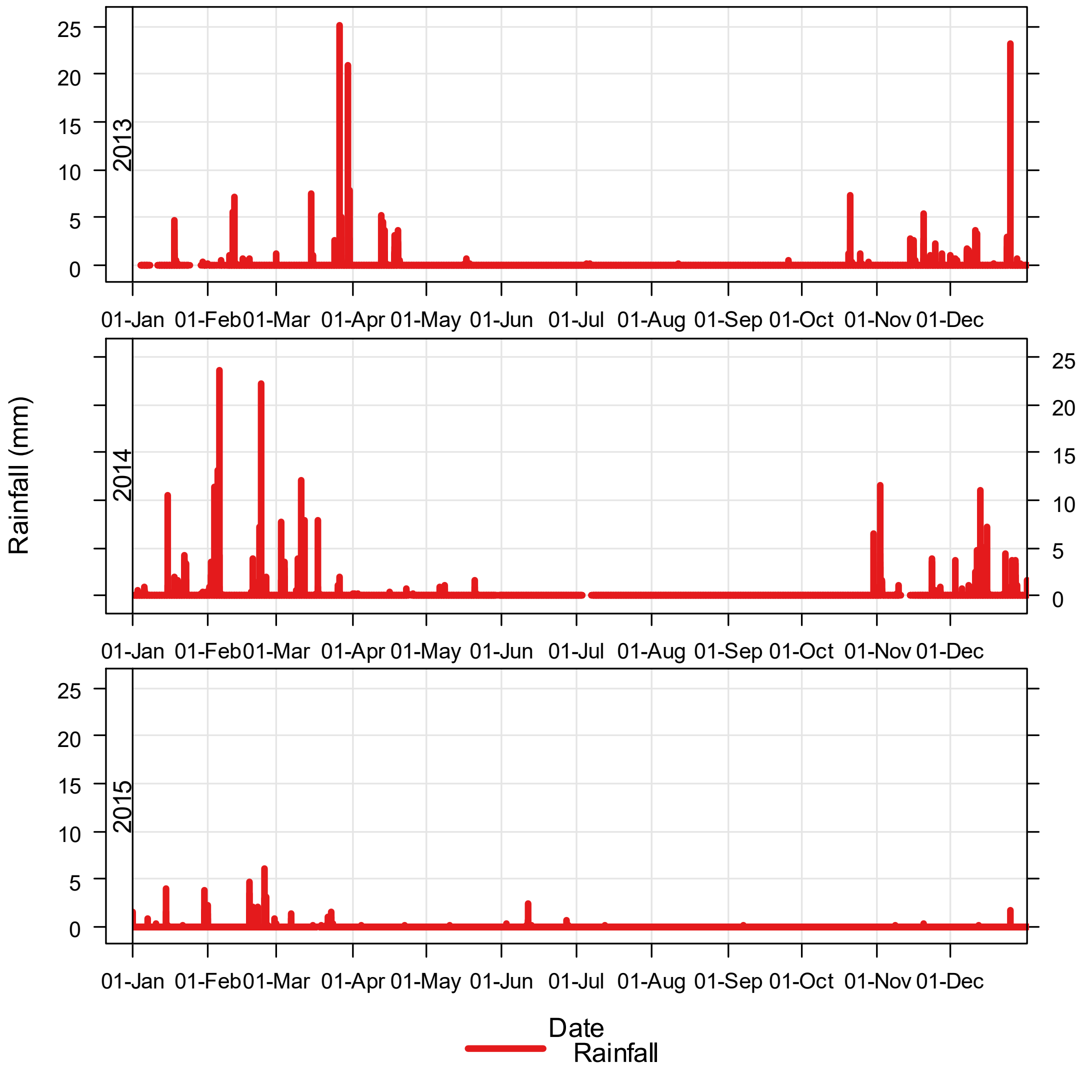


Figure 12: Rainfall figures from the South African Weather Service Station in Bloemhof for the period 2013 – 2015.

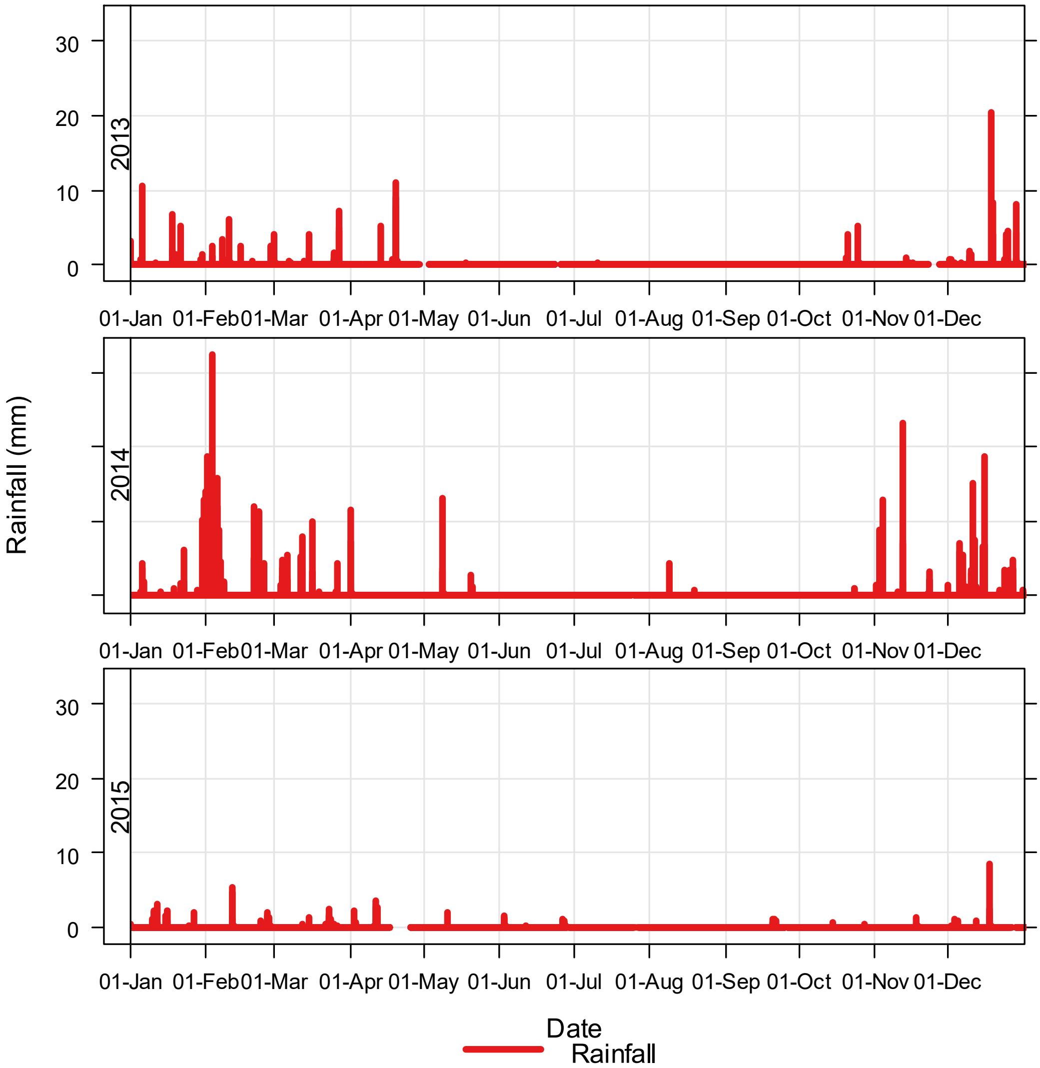


Figure 13: Rainfall figures from the South African Weather Service Station in Tosca for the period 2013 – 2015.

5. STATUS QUO OF THE AMBIENT AIR QUALITY

This section of the Dr. RSM DM AQMP describes the current ambient air quality, some background to emission sources, and the baseline emissions inventory for the data that is available in the Dr. RSM DM. The predicted air quality from dispersion modelling and risk assessment is presented towards the end of this section.

An assessment of the current ambient air quality in the DR. RSM DM is undertaken through analysing emission data, and through dispersion modelling using an emissions inventory. The challenge here is that data was difficult to obtain and no ambient air quality monitoring stations exist in the district.

5.1 Background to Emission Sources

This section contains background information to the different sectors identified in the Dr. RSM DM that contributes to the pollutant emissions, these sectors include: Agricultural activities; Biomass burning (veld fires); Domestic fuel burning; Denuded land; Mining; Landfills; Vehicle tailpipe emissions; Waste treatment and disposal; and some Industrial operations.

5.1.1 Listed Activities and Boilers

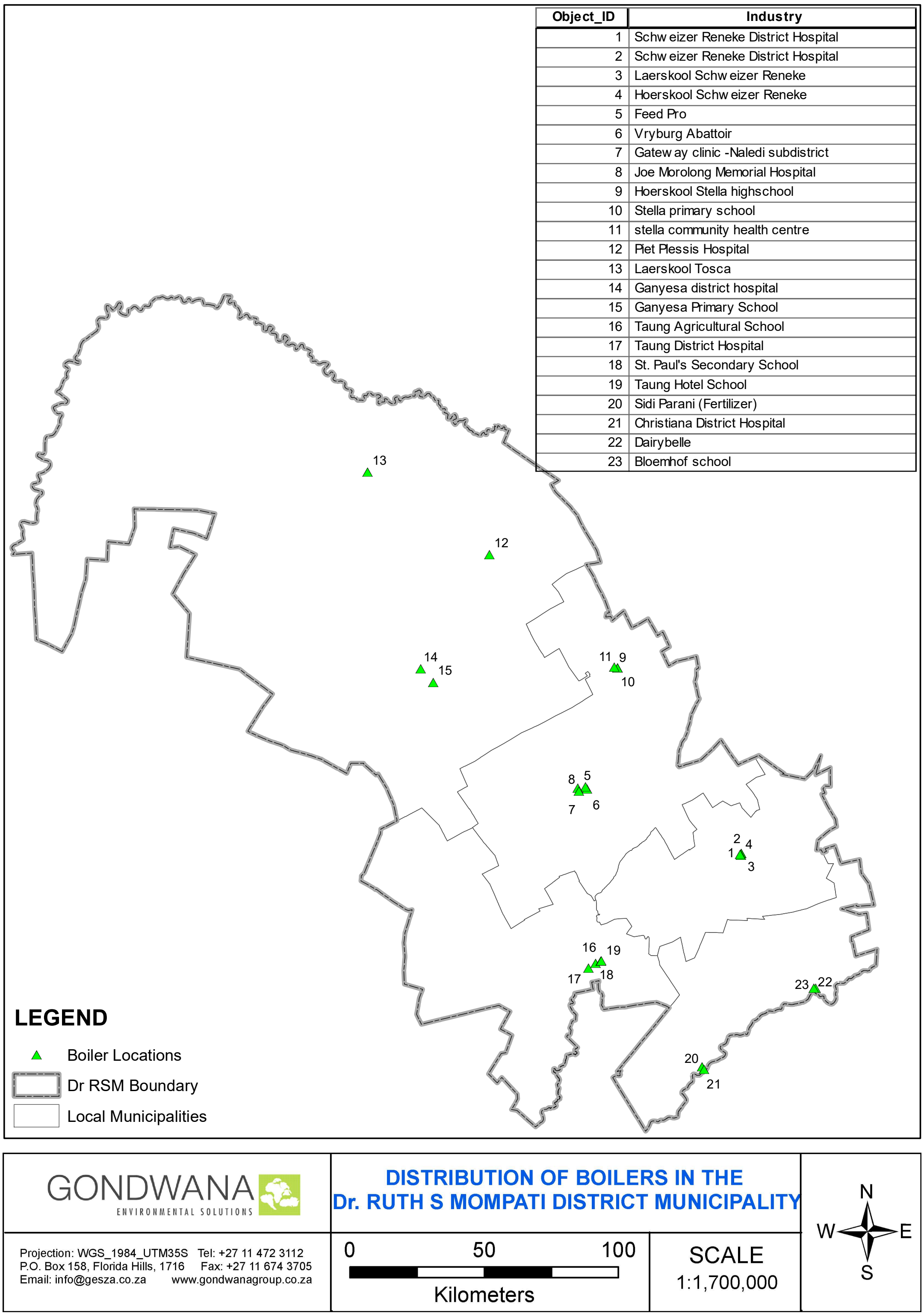
Large and small industries have the potential to emit pollutants, depending on their processes. South African legislation controls a large variety of industries through their classification as Listed Activities (NEM:AQA, 2013b). In addition, where industries are not legislated as Listed Activities, they may be legislated under the Small Boiler regulations (NEM:AQA, 2013a). Small boilers were declared controlled emitters in 2013. Those industries that are not regulated under either of these laws are excluded from this study as their emission potential is considered negligible in comparison to the Listed Activities and Boilers. As such, only the Listed Activities and Small Boiler industries are discussed hereafter.

a) Listed Activities

Listed Activities were initially described in the Atmospheric Pollution Prevention Act, Act 45 of 1965 (APPA, 1965) as Scheduled Processes, based on the enterprises' process type. In 2004, Scheduled Processes were integrated into the NEM:AQA, 2004 (NEM:AQA, 2004) as Listed Activities that have or may have negative impacts on the environment, which includes health, social, economic, ecological and cultural environments. The Listed Activities are updated periodically, with the latest Listed Activities published in 2013 (NEM:AQA, 2013b) and the latest amendment published in 2015 (NEM:AQA, 2015). Few Listed Activities, like clay brick manufacturers and storing of petroleum industries, were identified in the Dr Ruth S Mompati District Municipality.

b) Small Boilers

Small boilers (boilers) are used not only by industries, but also by schools, hotels, restaurants, municipal offices, hospitals and a variety of commercial enterprises throughout the Dr Ruth S Mompati District Municipality (Figure 14).



Object_ID	Industry
1	Schweizer Reneke District Hospital
2	Schweizer Reneke District Hospital
3	Laerskool Schweizer Reneke
4	Hoerskool Schweizer Reneke
5	Feed Pro
6	Vryburg Abattoir
7	Gateway clinic -Naledi subdistrict
8	Joe Morolong Memorial Hospital
9	Hoerskool Stella highschool
10	Stella primary school
11	stella community health centre
12	Piet Plessis Hospital
13	Laerskool Tosca
14	Ganyesa district hospital
15	Ganyesa Primary School
16	Taung Agricultural School
17	Taung District Hospital
18	St. Paul's Secondary School
19	Taung Hotel School
20	Sidi Parani (Fertilizer)
21	Christiana District Hospital
22	Dairybelle
23	Bloemhof school

Figure 14: Distribution of some of the identified boilers in the Dr Ruth S Mompati District Municipality

5.1.2 Vehicles

In developing countries, such as South Africa, increased road networks increase welfare benefits but at the same time have a negative environmental impact compounded with increased atmospheric pollution (Santos et al., 2010). Vehicles have the potential to contribute significant amounts of pollutants into the atmosphere, not only in localised areas, but throughout the surrounding airsheds. The health impact from transport emissions is often located away from the source of contamination due to the effect of dispersion, nonetheless, vehicle emissions are considered a significant source of urban pollution (Stone and Bennett, 2001).

Greenhouse gases (GHG) are among the highest pollutants emitted from vehicles. Developing countries are considered to have the fastest growing source of GHG emissions due to the rapid expansion of road networks in these countries. The South African transport sector contributes up to 9% of South Africa's total GHG emissions with the road transport sector contributing up to 88% of these emissions (Thambiran and Diab, 2011). The increase in atmospheric emissions results in increased negative health impacts from the release of hydrocarbons, nitrogen oxides (NO_x), carbon monoxide (CO), carbon dioxide (CO_2) and particulate matter (PM) (Silva et al., 2006).

Vehicle emissions in South Africa have been identified as a growing concern, with increased emissions resulting from the increase in the number of vehicles, the age of the vehicles and the lack of emission control devices in a significant portion of South African vehicles (Burger et al., 2009). Vehicle emission concentrations vary according to the vehicle's size, age, engine, fuel specification and speed travelled, with the newer vehicles having significantly reduced emissions compared with vehicles manufactured in the 1980s (Burger et al., 2009).

Increasing economic development has led to an increase in motorists on the road and an increased demand for fuel. The main vehicle types consist of cars, light delivery vehicles and sport utility vehicles, which constitute the least efficient, most polluting mode of passenger transport in urban areas (Goyns, 2009). The large demand for vehicles in South Africa is due to the dispersed nature of land use in the country, requiring commuters to travel large distances between residences and places of work (Goyns, 2009).

The main transport routes of the road network in the Dr RSM DM operate as corridors which include: linking Kimberley and Johannesburg through Bloemhof and Christiana via the N12; linking Pretoria and Upington through Vryburg via the N14; and linking Kimberley and Gaborone through Vryburg via the N18; (Figure 15).

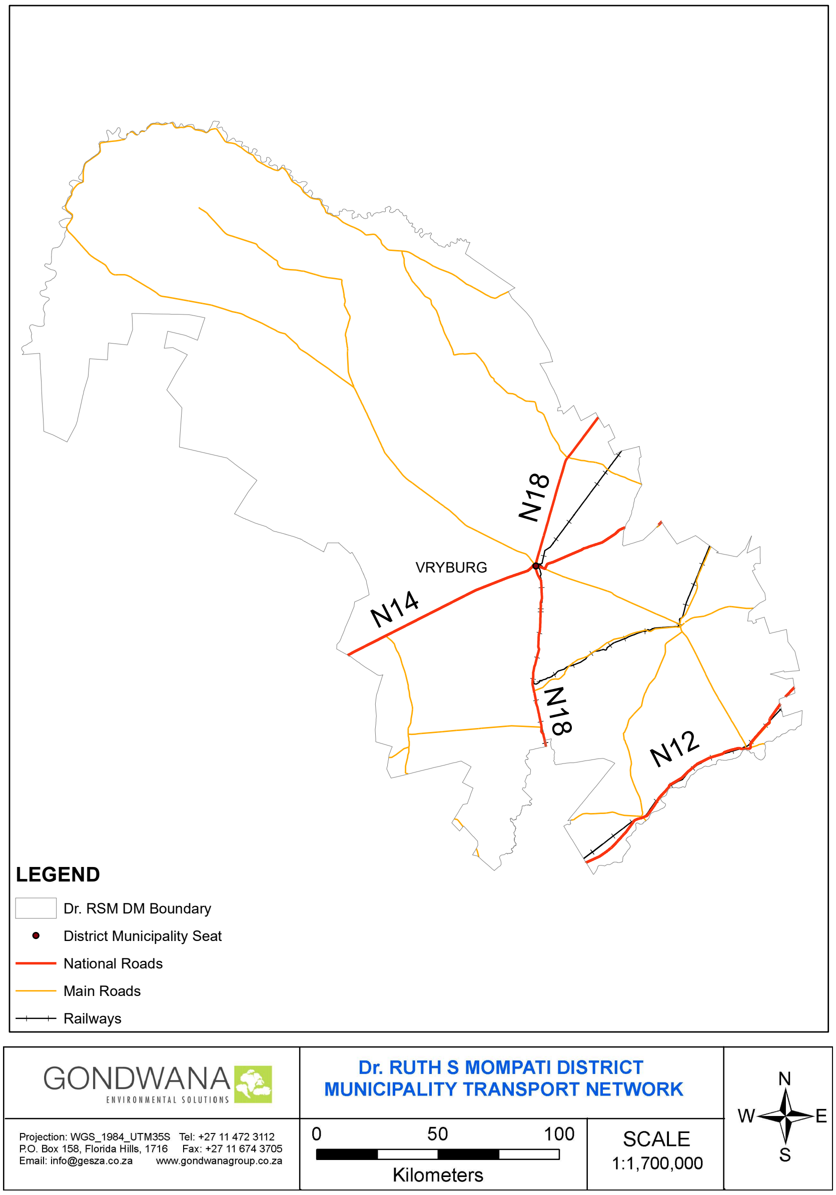


Figure 15: The Dr RSM DM transport network

5.1.3 Domestic Fuel Burning

Domestic fuel usage is mostly found in the densely populated, low-income and informal settlements. Fuel such as wood, paraffin and coal are widely used for cooking and heating, especially in the colder months. Domestic fuel burning is a source of atmospheric emissions and it contributes to PM, SO_2 and CO emissions. Human health impacts related to household coal and wood burning remains the most serious and pressing national air pollution problem (DEA, 2008).

Coal burning emits a large amount of gaseous and particulate matter pollutants including SO_2, PM, PM_{10}, heavy metals and inorganic ash, CO, benzo(a)pyrene and polycyclic aromatic hydrocarbons (PAH), which are recognised as carcinogens. Pollutants resulting from the combustion of wood include PM_{10}, NO_2, CO, PAH, particulate benzo(a)pyrene and formaldehyde. Particulate emissions from wood burning within South Africa have been found to contain about 50% elemental carbon and about 50% condensed hydrocarbons (DEA, 2008).

Even though many people living in dense, low-income communities know and acknowledge that the burning of coal or wood may have a negative impact on their health and well-being, they continue to burn these fuels. The reason for this is simply that they cannot afford to use alternative energy sources to satisfy their needs (DEA, 2008).

5.1.4 Biomass Burning

The entire Dr RSM DM is classed as high veldfire risk (CSIR 2010). The vegetation types throughout the district (Figure 16), combined with the climatic conditions, result in the potential for a high number of veld fires to occur (Figure 17). Each open fire, be it a veld fire or burning of garden refuse, adds CO, NO_x, SO_2, non-methane volatile organic compounds (NMVOCs), PM, ammonia (NH_3) and GHG to the atmosphere.

Air pollution in the Dr RSM DM is exacerbated in the winter months when the incidences of veld fires (together with the increased use of domestic fuel burning for heating) coincides with an inversion layer (warmer air trapped under a layer of colder air) that prevents the vertical dispersion of pollutants from escaping into the upper atmosphere.

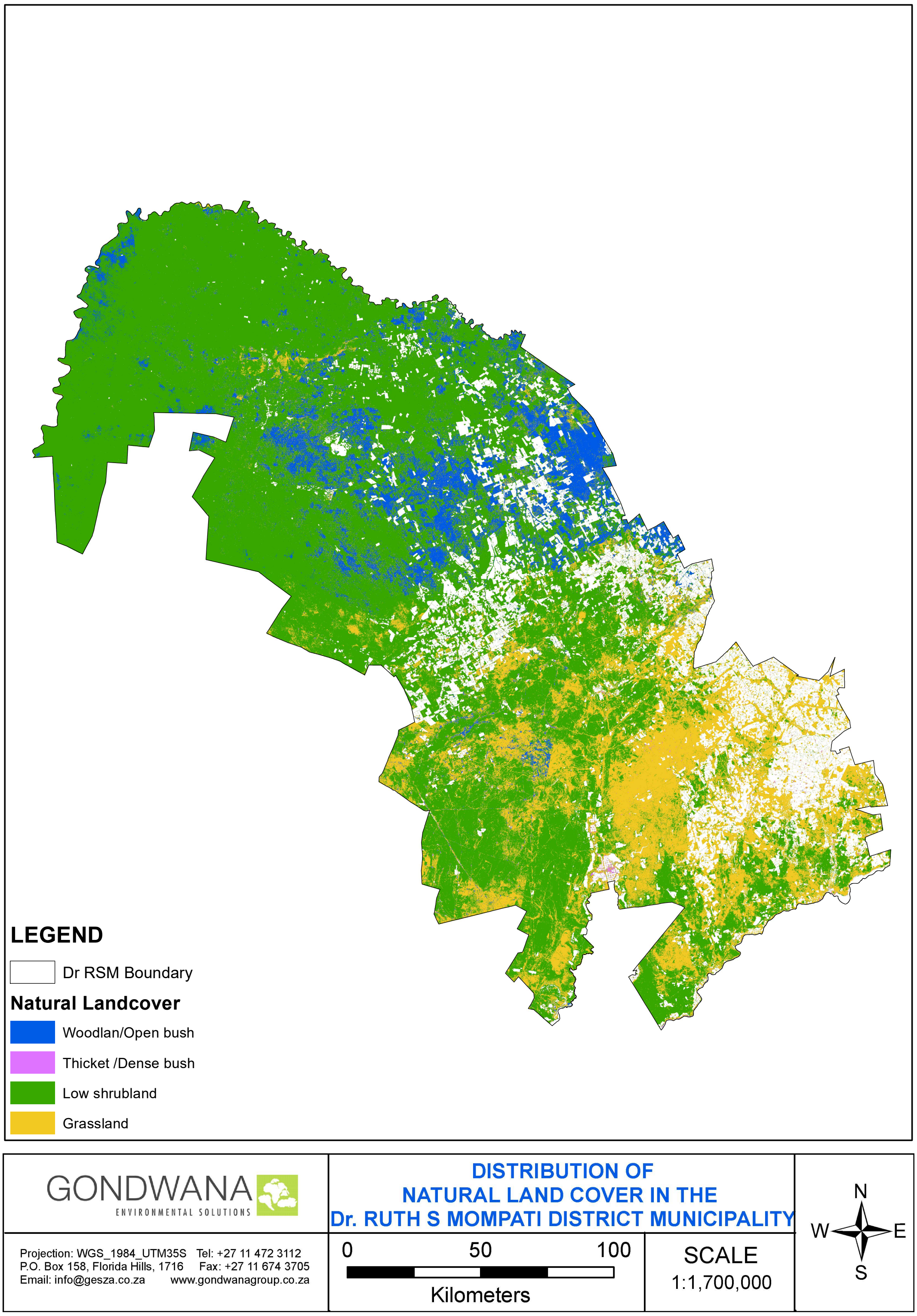


Figure 16: Distribution of natural land cover in the Dr Ruth S Mompati District Municipality (DEA 2015)

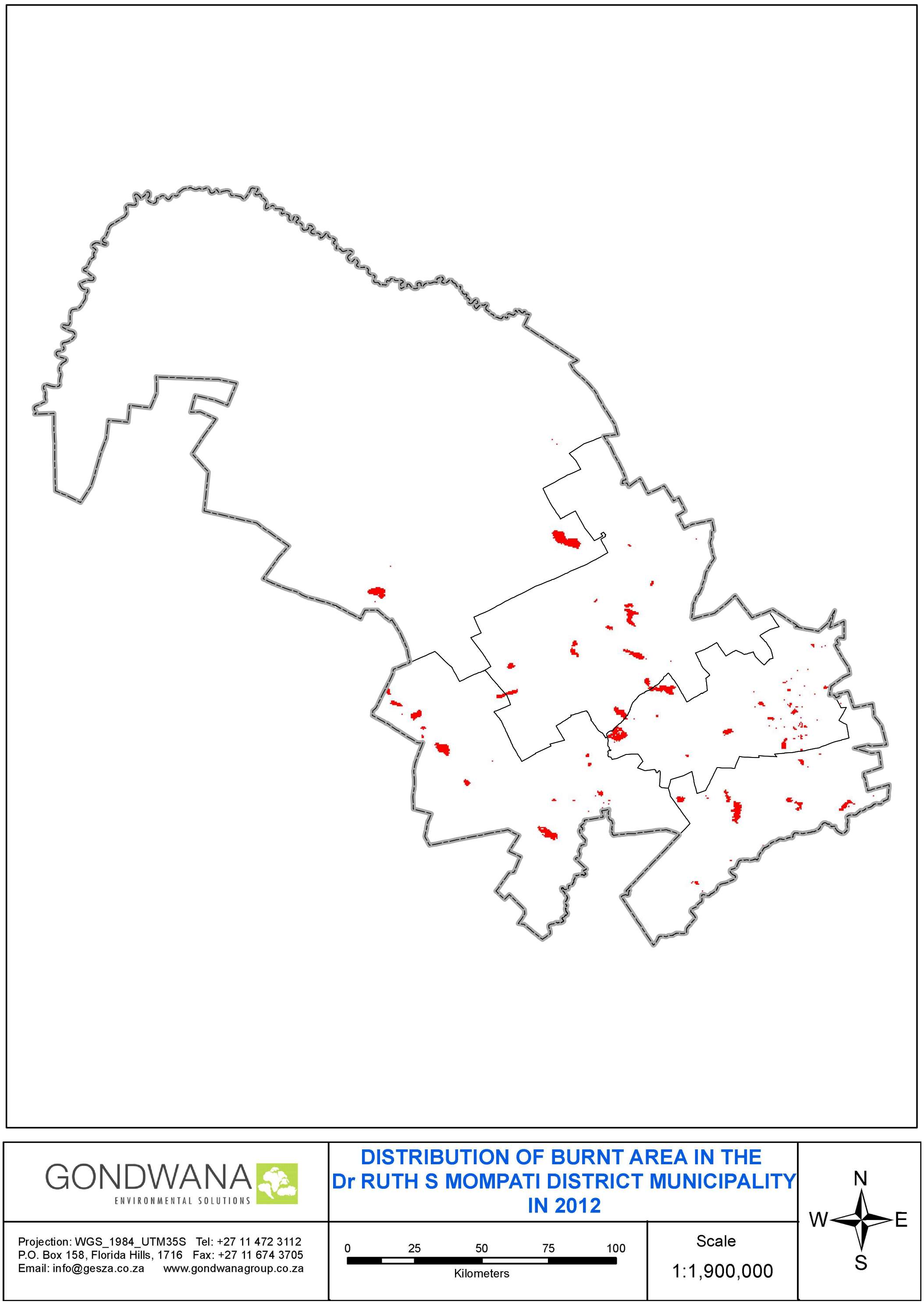


Figure 17: Distribution of burnt areas in the Dr Ruth S Mompati District Municipality (MODIS, 2012)

5.1.5 Agricultural Activities

Agricultural activities are a large economic sector within the Dr RSM DM and the North West Province. Some of the largest cattle herds in the world are found near Vryburg. North West is also South Africa's major producer of white maize, with sunflowers being another important crop (GCIS 2014) (Figure 18). Agricultural activities can be sub-divided into two groups – crop farming and livestock farming.

a) Crop Farming

There are four main sources of emissions from crop farming and agricultural soils, with each source responsible for a particular emission (denoted in brackets):

1. Fertiliser application (NH_3);
2. Soil microbial processes (NO);
3. Crop processes (NH_3 and NMVOCs); and
4. Soil cultivation and crop harvesting (PM).

NH_3 emissions can cause acidification and eutrophication of natural ecosystems (EMEP/EEA, 2013). NH_3 may also form secondary PM. NO and NMVOCs play a role in the formation of O_3 which, near the surface of the Earth, can have an adverse effect on human health and plant growth. PM emissions also have an adverse impact on human health (EMEP/EEA, 2013).

Emissions of gaseous NH_3 and NO from crop farming and agricultural soils are generally closely related to the amount of nitrogen fertiliser applied. A fraction of N contained in the fertilizers is emitted into the atmosphere as NH_3 and NO. The emissions of NH_3 are influenced by the types and amounts of fertilizers, methods and timing of fertilizer application, types of soils to which fertilizers are applied, and climate factors. In the absence of detailed information related to these influencing factors, the emissions of NO can be calculated as a fraction of the total amount of N fertilizers applied (SCMDEIEA, 2011).

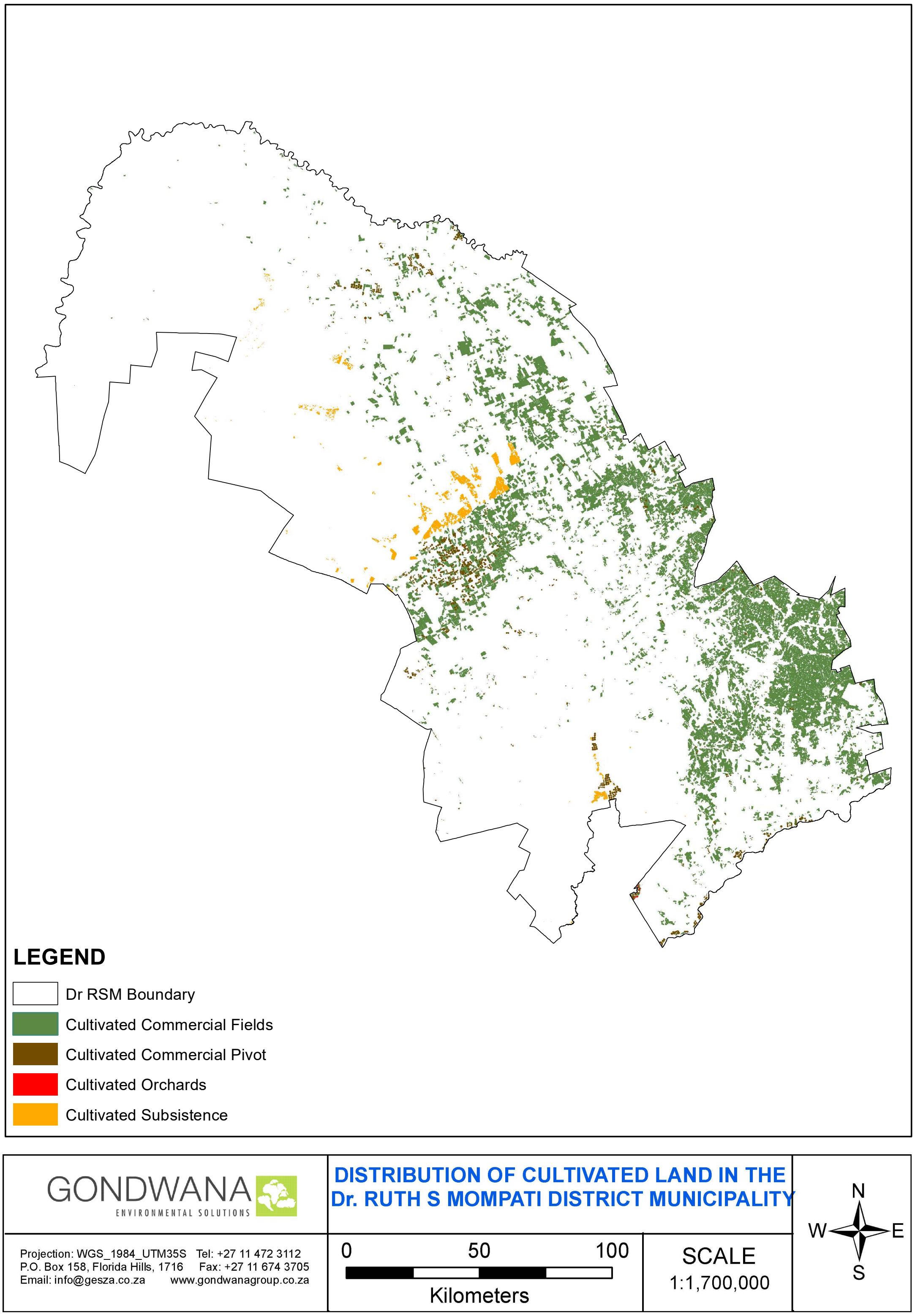


Figure 18: Distribution of agricultural activities in the Dr Ruth S Mompati District (DEA 2015)

Crop farming and agricultural soils are currently estimated to emit < 1% of total NMVOC emissions (EMEP/EEA, 2013); therefore, NMVOC emissions are not calculated in this study.

Windblown dust emissions from agricultural land can be influenced by non-climatic factors (Mansell et al., 2003) as follows:

- Long-term effects of irrigation (i.e., soil "clodiness");
- Short-term effects of irrigation (i.e., surface soil wetness);
- Crop canopy cover;
- Post-harvest vegetative cover (i.e., residue);
- Post-harvest replanting (i.e., multi-cropping);
- Bare soil (i.e., barren areas within an agricultural field that do not develop crop canopy for various reasons, etc.); and
- Field borders (i.e., bare areas surrounding and adjacent to agricultural fields).

This level of information, however, is not available for agricultural activities in the Dr RSM DM. Furthermore, PM emissions from soil cultivation and crop harvesting together account for > 80% of total PM_{10} emissions from tillage land.

The source strength of soil cultivation and crop harvesting depends on crop, soil type, cultivation method and weather conditions before and during working. Because of the absence of information on soil type and cultivation method, Tier 1 emission factors, based on crop type only, were used in this study.

b) Livestock Farming

There are four main sources of emissions from livestock farming with each source responsible for a particular emission (denoted in brackets):

- Livestock housing (PM);
- Livestock manure management (NH_3, methane (CH_4) and nitrous oxide (N_2O));
- Land spreading of manure (NO_x and NH_3); and
- Land spreading of urea (NH_3 and CO_2).

Information on manure and urea management is not available for the Dr RSM DM; therefore, only PM emissions have been calculated.

5.1.6 Denuded Land

A source of PM pollution is windblown dust from denuded land. For the purposes of this report, denuded land is defined as erosion donga, bare non-vegetated and degraded land-cover classifications as obtained from National Land-Cover Data Set (DEA 2015). Based on these classifications denuded land comprises approximately 0.06% of the total area of the Dr RSM DM (Figure 19).

5.1.7 Mining

The Dr RSM DM mining sector is spread out throughout the south-eastern part of the district. There are no active mining activities taking place in the Kagisano-Molopo Local Municipality which lies in the north-western part of the District Municipality (Figure 20 and Appendix A). While mines produce an impact on the atmosphere in a variety of ways, the focus in this section of the report is on windblown dust from mine tailings. Other sources of emissions are incorporated in point source and vehicle emissions.

Figure 19: Distribution of denuded land in the Dr Ruth S Mompati District Municipality (DEA 2015)

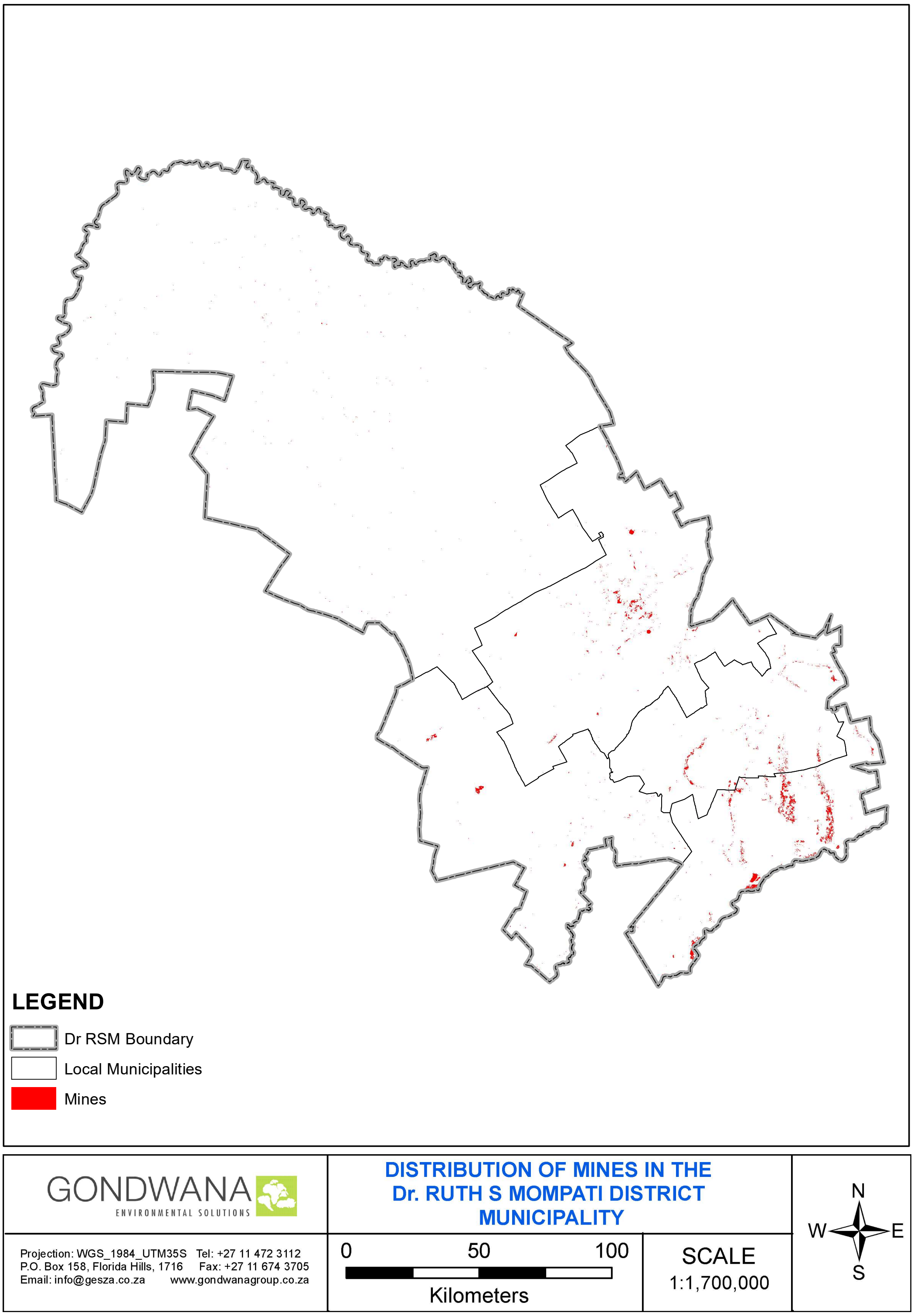


Figure 20: Distribution of mining activities in the Dr Ruth S Mompati District Municipality (DEA 2015)

5.1.8 Landfills

The disposal of waste at landfill sites has a potentially negative impact on the environment in a number of ways, including emissions to the atmosphere. These emissions can cause a nuisance, odour and health impact. While landfills emit GHGs, the primary criteria pollutants emitted are PM and C_6H_6. Landfills are found near most towns and cities (Figure 21). Although there may be many informal landfills, only licensed landfills have been quantified in this project.

5.1.9 Waste Water Treatment Works

According to the National Department of Water Affairs and Forestry (DWAF, 2011) there are 4 wastewater collection and treatment systems in the Dr RSM DM. WWTW are located near urban areas and, therefore, are not distributed evenly throughout the district (Figure 22).

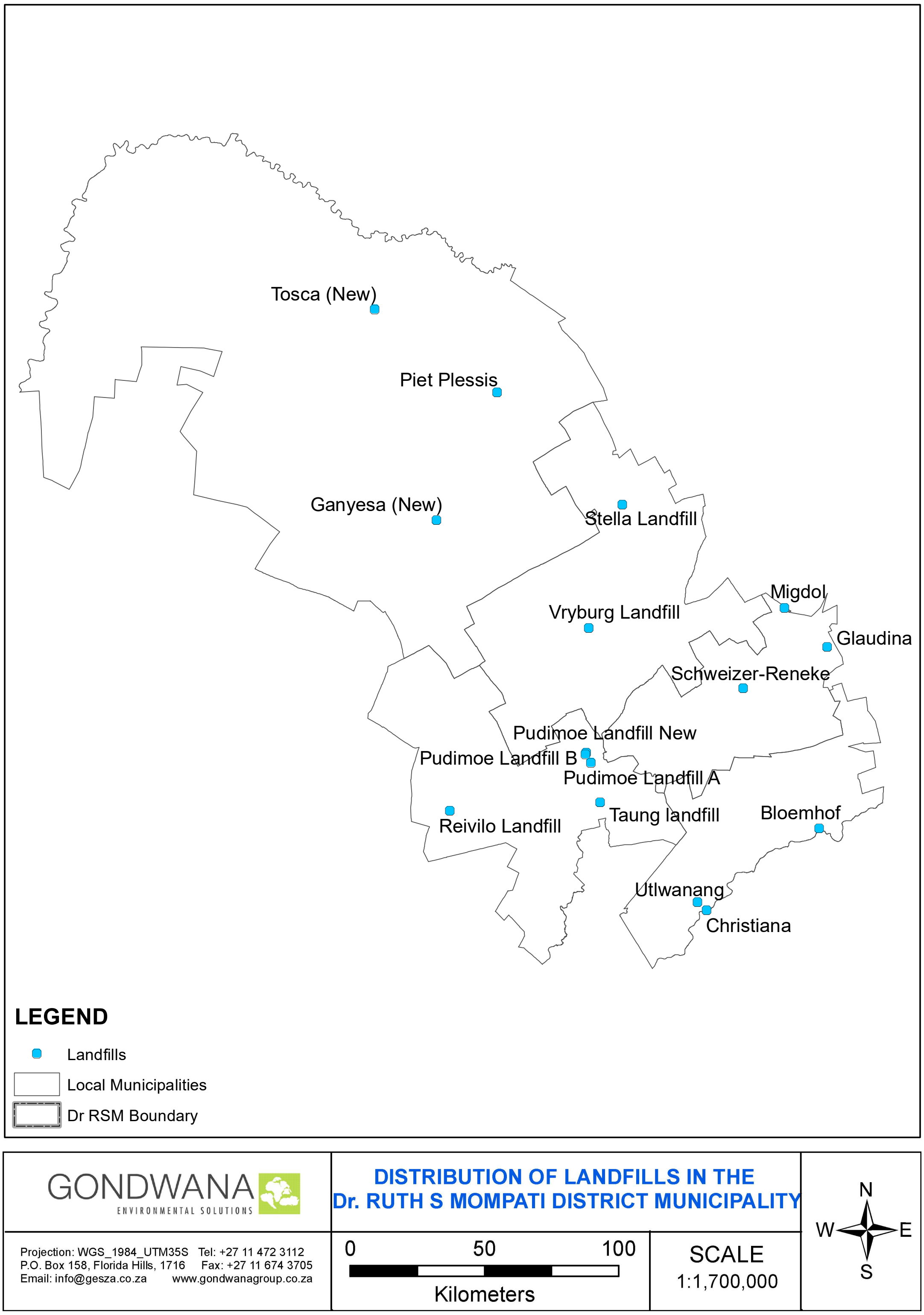


Figure 21: Distribution of Landfill Sites in the Dr Ruth S Mompati District Municipality

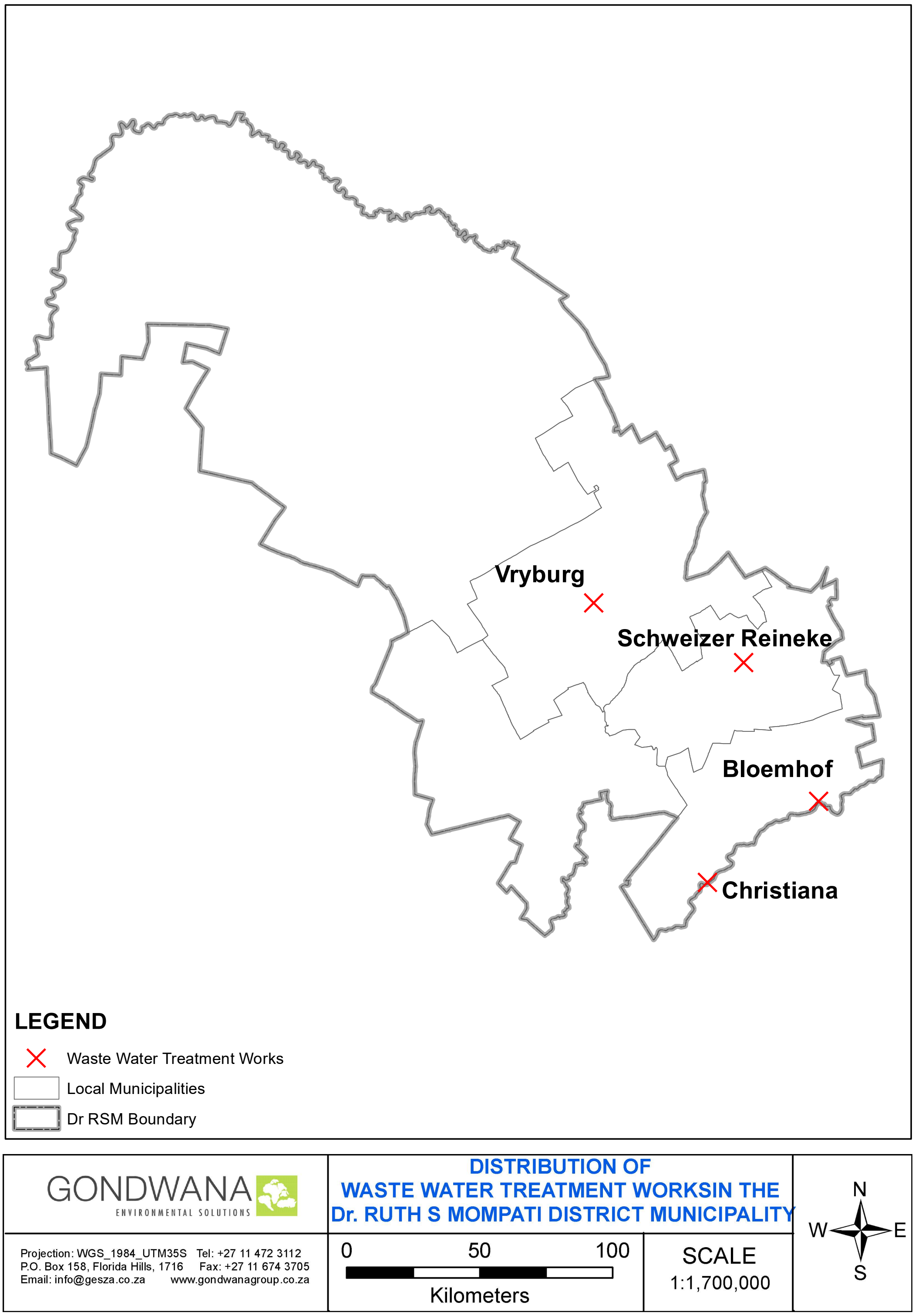


Figure 22: Distribution of Waste Water Treatment Works in the Dr Ruth S Mompati District Municipality

5.1.10 Other Emission Sources

Sources of emissions to the atmosphere are widely varied and it is not possible to cover them all in this project. Some examples of sources that have not been quantified include:

- Aircraft;
- Illegal waste burning; and
- Emissions from unpaved roads by vehicle entrainment.

5.2 Methods

Quantification of emissions by monitoring is almost non-existent in the Dr RSM DM. Emissions are thus estimated by calculation. The emissions inventory calculations have been structured to determine emissions at district and provincial levels where applicable. The overarching method to determine emissions from various sources is as follows:

Equation 1: Generalised Emissions Rate Calculation

Emission Rate = [Emission Factor] x [Activity Rate]

Where:

- Emission Rates have units of [*Mass of Pollutant / Time*];
- Emission Factors have units of [*Mass of Pollutant / Activity*] where activity can be expressed in a variety of ways, e.g. mass of product, mass of raw material, area covered, volume of material processed, etc.; and
- Activity Rates have units of [*Activity / Time*].

Emission Factors (Négyesi et al.) are obtained from the literature such as the United States Environmental Protection Agency, AP42 documents (US-EPA, 1995) and the Australian National Pollutant Inventory (NPI) Emission Estimation Technique Manuals (NPI, 2011, 2012). Activity rates are obtained from literature, information received directly from the sources themselves, or estimated by comparison to similar sources in the literature.

5.2.1 Listed Activities and Boilers

a) Listed Activities

Enterprises involved in listed activities were identified primarily by means of database information received from the authorities which is based on Atmospheric Emissions Licence (Mansell et al.) applications of relevant stakeholders.

b) Boilers

Enterprises using boilers were also identified primarily by means of database information received from the authorities and a district surveillance trip. However, specific fuel consumption data for individual boilers in the Dr RSM DM was not available for all boilers at the time of finalising this report. As such, various assumptions had to be made. Because stoker firing systems account for the vast majority of coal-fired watertube boilers for industrial, commercial, and institutional applications (US-EPA 1995), all boilers were assumed to be overfeed stoker coal-fired boilers (An overfeed stoker uses a moving grate assembly in which coal is fed from a hopper onto a continuous grate which conveys the fuel into the furnace). Emissions were calculated on a per annum basis using emission factors (Table 7) and the following equations:

Table 7: Emission Factors for Overfeed Stoker Coal-fired Boilers (US-EPA, 1995)

Emission Factor - Pollutant [lb/ton]			
SO_2	**PM_{10}**	**NO_x**	**CO**
38S	6	7.5	6

S = weight percent sulphur in fuel

Equation 2: SO_2 Emission Calculation

SO_2 [kg/year] = [[Emission factor x fuel sulphur content] x annual fuel usage] x 0.5

Where the SO_2 emission factor is multiplied by the weight percent sulphur in the feed coal, which was assumed to be 2% for South African coal (Kalenga, 2011), therefore S = 2. (The factor 0.5 is the conversion factor from pounds/ton to kilograms/Megagram).

Equation 3: NO_x, CO and PM_{10} Emission Calculation

Pollutant [kg /year] = [Emission factor x fuel usage] x 0.5

The fuel usage for boilers, for which the specific annual fuel consumption rate was not known, was assumed to be 4,800 ton/year. This activity rate is the average for coal fired boilers obtained from the City of Tshwane Emission Inventory (GES, 2012).

5.2.2 Vehicles

The total contribution of air emissions resulting from traffic in the Dr RSM DM were quantified using total fuel sales statistics. This method is inherently biased to localised areas, and interpolation for the entire region is simplistic; however, it does provide an indication of fuel-related emissions for the region. The main assumption of this emission calculation is that all fuel sold in the Dr RSM DM is combusted in the Dr RSM DM airshed. Cognisance must be taken of the fact that the southern road network of the Dr RSM DM is used as a corridor between various locations.

Annual fuel sales for towns within the Dr RSM DM were obtained from the Department of Energy (DoE) fuel sales for 2013 (DoE, 2013). Fuel statistics from the DoE were provided in litres for petrol and diesel. Fuel sales were converted from litres to tons based on the density of petrol and diesel, using the SI Metric conversion rates as published in 2007 (SIMetric, 2007). The density of petrol was taken as 737.22 kg/m^3 at 15.56°C (60°F) while diesel was taken at a density of 950[1] kg/m^3 at 15°C (59°F). The equation used was as follows:

Equation 4: Fuel Sales Conversion to tons/year

*Total Fuel [tons/year] = [total fuel in kilolitres per year*fuel type density]/1000*

Emission factors (Table 8) were applied to the total fuel (tons per year) to determine the total emissions per pollutant, for petrol and diesel during 2012 for the criteria pollutants only.

Whilst emission factors are provided for Lead Replacement Petrol (LRP) and Unleaded Petrol (ULP), the DoE statistics do not separate this information. As such, a conservative

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[1] The density of diesel ranges between 820 and 950 kg/m^3; the upper limit of 950 kg/m^3 was used to determine the worst case scenario.

assumption was made to only use the ULP emission rates, as the majority of vehicles on the Dr RSM DM roads would be vehicles using ULP fuel.

Table 8: Fuel Emission Factors (Ntziachristos and Samaras, 2000; Wong, 1999)

Fuel Emission Factor [kg/tons]			
Pollutant	Fuel Type		
	LRP	ULP	Diesel
NO_X	1.99	2.15	11.68
CO	16.13	10.7	3.54
SO_2	0.05	0.04	1.54
Benzene	0.03	0.02	-
Lead	0.02	-	0.64

5.2.3 Domestic Fuel Burning

Domestic fuel usage for cooking, heating and lighting comprises a wide range of sources, including; animal dung, candles, coal, electricity, gas, paraffin, solar power and wood in the Dr RSM DM. To quantify emissions from these various fuel sources, the total number of households utilizing each source was determined. Population data per local municipality from the StatsSA Census 2011 was used (StatsSA, 2012). The census data indicates that the total number of households using domestic fuel burning in the Dr RSM DM was 125,271 in 2011.

The 2011 census data provides the number of households that utilized each fuel type for cooking, heating and lighting. The three dominant fuels which have quantifiable emissions were paraffin, wood and coal. All other fuels used, except electricity, are consumed in small quantities, thus making their impact relatively insignificant.

Average household quantities of paraffin and wood used as domestic fuel were derived from a study conducted by Van Nierop (1995) and average household quantities of coal were derived from Scorgie *et al.* (2005). Both studies were conducted in the Vaal Triangle. Paraffin usage was calculated at 173,33 litres per annum per household and wood at 0,22 tons per annum per household (van Nierop, 1995). Coal usage was calculated at 1,19 tons per annum per household (Scorgie et al., 2005). These values were used as a best estimate for this study to calculate the total amount of fuel used for each fuel type in the Dr RSM DM due to lack of alternative, site specific data.

Total annual household fuel usage for paraffin, wood and coal was multiplied by the number of households using each type of fuel to determine the total value per resource used. This was multiplied by an emission factor (Table 9) to establish total criteria pollutant emissions per fuel type per year (Equation 5).

Equation 5: Domestic Fuel Burning Emissions

Emission (kg / year) = (number of households x quantity of fuel) x pollutant emission factor

Table 9: Emission Factors from Domestic Fuel Burning (Thomas, 2008)

Fuel Type	Domestic Fuel Burning Emission Factors [g/kg]		
	SO_2	NO	PM_{10}
Paraffin	0.1	1.5	0.2
Wood	0.2	1.3	17.3
Coal	11.6	4	12

5.2.4 Biomass Burning

Open veld fires are typically dynamic fires, in which a moving fire front passes through a fuel bed. The emission factors of the various smoke constituents are determined by the composition of the fuel and by the physical and chemical processes during combustion (Andreae and Merlet, 2001). This makes it difficult to predict the type and extent of pollution emissions from veld fires. Furthermore, the timing, location and movement of the fire front are unpredictable. Since information to take these factors into account is not available, the calculations of the emissions undertaken in this report are taken as a Tier 1 approximation.

Biomass burning emissions are influenced by the type of vegetation and the season in which the biomass burns. Hectares of land burned per month in the Dr RSM DM in 2012 were calculated from MODIS images (MODIS 2012). Emission factors for savannah and grasslands (Table 10) for biomass burning were used (Andreae and Merlet, 2001) for criteria pollutants only.

Table 10: Emission Factors of the Air Pollutants and GHGs from Field Burning in Savannah and Grassland (Andreae and Merlet, 2001)

Air pollutant / GHG	Emission Factor [kg of pollutant / tons of Dry weight]
CO	65
NO_x as NO	3.9
SO_2	0.35
$PM_{2.5}$	5.4

The general equation used to estimate emissions from veld fires is:

Equation 6: Biomass burning emissions

$$L_{fire} = A \times M_B \times C_f \times G_{ef} \times 10^{-3}$$

Where:

- L_{fire}: emissions from veldfires (for each pollutant, tons per year);
- A: area burnt [ha];
- M_B: mass of fuel actually combusted [tons ha^{-1}]. This includes biomass, underground litter and dead wood;
- C_f: combustion factor (dimensionless); and
- G_{ef}: emission factor [g/kg dry matter burnt].

The default biomass density (BMD) for temperate grasslands of 450 g/m^2 dry weight (DW) (EMEP/EEA, 2013) was used for mid and late dry season burns for the mass of fuel combusted. This value is more or less in keeping with 4.1 tons of dry matter per hectare given for mid or late dry season burns in savannah grasslands (IPCC, 2006). For early dry season burns, the value of 2.1 tons of dry matter per hectare, given for early dry season burns in all savannah grasslands, was used (IPCC, 2006). Fires occurring from November to April were considered to be ‘early dry season’ burns, and fires occurring from May to October were considered to be ‘mid and late dry season’ burns. By this definition 96% of all veld fires in the Dr RSM DM occur during the mid and late dry season. The combustion factor (C_f) gives the proportion of pre-fire fuel biomass consumed. The mean value of 0.74 (IPCC, 2006) was used for all burns.

5.2.5 *Agricultural Activities*

Emissions emanating from agricultural activities are categorised into (a) crop farming and agricultural soil emissions and (b) emissions from livestock farming. Both categories are discussed separately hereafter.

a) Crop Farming

Emissions from unfertilised crops, with the exception of legumes, are usually considered to be negligible and all fertilized crops are treated the same. The Tier 1 approach for NH_3 and NO emissions from crop farming and agricultural soils uses the general equation.

Equation 7: NH_3 and NO emissions from agricultural practices

$$E_{pollutant} = AR_{fertiliser\_applied} \cdot EF_{pollutant}$$

Where:

- $E_{pollutant}$ = amount of pollutant emitted [kg a^{-1}];
- $AR_{fertiliser\_applied}$ = amount of N applied [kg a^{-1}]; and
- $EF_{pollutant}$ = EF of pollutant [kg kg^{-1}].

Data provided by National Crop Statistics Consortium was used to separate out areas for specific crops (DAFF, 2016). Fertilizer use was then calculated using Nitrogen Fertilizer use rates per crop type (Table 11). Crops such as grain sorghum and other summer cereals; barley and other winter cereals; teff and other fodder crops; and seeds were categorised as 'other pastures'. The emission factors used were derived from the EMEP/EEA (Table 12).

Table 11: Proportions of Crops Fertilized and Average Rates of Nitrogen Fertilizer Use in South Africa (FAO, 2005; FSSA, 2004)

Description	Percent fertilized [%]	N Fertilizer Use Rate [kg/ha of the fertilized area]
Wheat	100	30
Sunflower	85	15
Soybeans	40	7
Lucerne	90	15
Other Pastures	30	50
Subtropical fruits/nuts	100	180

Groundnuts		0
Citrus	100	80
Deciduous Fruit	100	110
Vegetables	100	170
Potatoes	100	170

Table 12: Pollutant Emission Factors from Fertilizer Application (EMEP/EEA, 2013)

Air pollutant	**NO**	**NH_3**	**PM_{10}**	**$PM_{2.5}$**
Units	**kg kg^{-1} fertilizer-N applied**		**kg/ha**	
Emission Factor	0,026	0,081	1,56	0,06

The Tier 1 approach for NMVOC and PM emissions from crop farming and agricultural soils uses the general equation:

Equation 8: NMVOC and PM Emissions from Agricultural Practices

$$E_{pollutant} = AR_{area} \cdot EF_{pollutant}$$

Where:

- $E_{pollutant}$ = amount of pollutant emitted [kg a^{-1}];
- AR_{area} = area covered by crop [ha]; and
- $EF_{pollutant}$ = EF of pollutant [kg ha^{-1} a^{-1}].

It was decided to use emission factors for Greece (Table 13) rather than the general emission factors for Europe or Great Britain for example, as we expect the climate of Greece to be closer to that of South Africa, and the crop types are similar to those planted in the North West Province. For vegetables, no emission factor was provided for Greece; therefore, the emission factor for Great Britain was used.

It should be noted that PM_{10} emissions from soil cultivation and harvesting originate at the sites where the tractors and other machinery operate and are thought to consist of a mixture of organic fragments from the crop and soil mineral and organic matter. Total dust emissions contain only small proportions of PM_{10} and $PM_{2.5}$ (EMEP/EEA, 2013). It is important to note, therefore, that the PM emissions calculated here are intended to reflect the amounts found immediately adjacent to the field operations. A substantial proportion of this emission will normally be deposited within a short distance of the location at which it is generated.

Table 13: Emission Factors for PM for Greece and Great Britain (IIASA, 2000)

Crop types	Greece				Great Britain	
	PM_{10} [kg/ha/a]			$PM_{2.5}$ [kg/ha/a]	PM_{10} [kg/ha/a]	$PM_{2.5}$ [kg/ha/a]
	Land Preparation	Harvest	Total			Total
Barley	4,15	1,95	6,1	1,35	6,945	1,136
Maize (Irrigated)	5,25	1,88	7,13	1,58	.	.
Maize (Non-irrigated)	.	.	.	.	2,82	0,22
Other Cereals	4,15	1,23	5,38	1,19	6,945	1,136
Pastures	0	0	0	0	0	0
Potatoes	25,56	1,91	27,46	6,1	2,87	0,231
Rye	4,15	1,23	5,38	1,19	.	.
Soya	8,63	1,88	10,51	2,33	.	.
Stonefruits	0,08	0,09	0,17	0,04	.	.
Sugarbeets	25,56	1,88	27,44	6,09	2,82	0,22
Vegetables	.	.	.	.	2,82	0,22
Vineyards	1,68	0,19	1,87	0,42	.	.
Wheat	4,15	2,25	6,4	1,42	9,48	1,698
Oilseed	.	.	.	.	6,945	1,136

b) *Livestock Farming*

Emissions from livestock are calculated as follows:

Equation 9: Emissions from livestock

$$E_{pollutant\_animal} = AAP_{animal} \cdot EF_{pollutant\_animal}$$

Where:

- $E_{pollutant\_animal}$ = amount of pollutant emitted [kg a^{-1}];
- AAP_{animal} = annual average population; and
- $EF_{pollutant\_animal}$ = EF of pollutant [kg a^{-1}].

The National Crop Statistics Consortium (DAFF, 2016) provided the number of animals in the different livestock categories (Table 14 and Table 15) and emission factors for Greece and Great Britain, where applicable, were used (Table 16).

Table 14: Number of Livestock Found in Dr Ruth S Mompati District Municipality (DAFF, 2016)

Livestock	Cattle	Sheep	Goats
Number	428 554,00	119 671,00	74 336,00

Table 15: Number of Livestock Found per Local Municipality (DAFF, 2016)

Magisterial Area	Cattle	Sheep	Goats
Lekwa-Teemane (Bloemhof)	28 386,00	9 056,00	2 060,00
Lekwa-Teemane (Christiana)	27 540,00	9 056,00	4 218,00
Mamusa (Schweizer-Reineke)	57 382,00	31 802,00	5 436,00
Naledi (Vryburg)	315 246,00	69 757,00	62 622,00

Table 16: Emission factors for PM for Greece (IIASA, 2000)

Animal types	Greece		Great Britain	
	PM_{10} [kg/head]	$PM_{2.5}$ [kg/head]	PM_{10} [kg/head]	$PM_{2.5}$ [kg/head]
Beef	0,236	0,053	0,216	0,048
Cows	0,217	0,048	0,216	0,048
Horses	0	0	0	0
Laying Hens	0,047	0,011	0,047	0,011
Other Poultry	0,047	0,011	0,047	0,011

Pigs	0,438	0,078	0,423	0,075
Sheep/goats*	0	0	0	0

*Note that there is no emission factor for sheep and goats.

5.2.6 Denuded Land

Windblown dust emissions from denuded land is fraught with complexities, from the definition of denuded land, to the quantification of the emission (Maricopa, 2011):

> *"there are many factors that control the production of windblown dust beyond wind speed velocities and disturbance levels that cannot be directly accounted for in this dust scheme (e.g., soil texture, soil moisture, topography, land use, etc.). Data for these factors can be limited, non-existent or unreliable. It is also unknown what degree of importance each of these factors have when they combine in the processes that contribute to the production of windblown dust."*

The extent of denuded land was obtained from land-cover data obtained from the National Land Cover Dataset (DEA, 2015a). Denuded land was extracted from the base dataset, converted to shapefiles and the area (km^2) calculated. Denuded land was categorised as erosion dongas, bare non-vegetated land and degraded land. The total area, based on this classification of denuded land, in the Dr RSM DM is approximately 26km^2, which is approximately 0,05% of the total land area.

Given the lack of detailed information required to perform a complex modelling estimation of emissions from denuded land, the approach taken in this study was to estimate the PM_{10} and $PM_{2.5}$ emissions of denuded land using a worked example from the literature (Maricopa, 2011). The emission factor for denuded land was thus calculated as follows:

Equation 10: Denuded Land Emission Factor

Emission Factor = Average Emission Rate / Area

Where:

- Emission Factor = The estimated emission factor for Denuded Land [ton/km^2/year];

- Average Emission Rate = The average emission rate for Vacant Land for the 2008 Maricopa County study [ton/year] (Maricopa, 2011); and
- Area = The total Vacant Land identified in the Maricopa County study [km^2].

The estimated emission factors for denuded land are calculated to be:

- EF_{PM10} = 0.360 ton/km^2/yr; and
- $EF_{PM2.5}$ = 0.054 ton/km^2/yr.

These emissions factors were used to calculate the estimated emission rate for denuded land using the denuded land area obtained from the land cover data set.

5.2.7 Mining

Only the windblown particulate emissions from mine tailings are dealt with in this section. Other emissions from mining activities (e.g. vehicle transportation) are assumed to be incorporated into other sections of the report.

Windblown emissions from tailings are a function of, amongst others, particle size distribution, moisture and meteorological conditions. Taking into account these complexities, the Australian National Pollutant Inventory report (NPI, 2012) obtained a characteristic emission factor for PM emissions from mine tailings (emission factor for PM_{10} Australia = 0,2 kg/ha/hr). For the purposed of this report, it is assumed that the emissions from mine tailings in South Africa are the same. Thus the emission factor for PM_{10} for mine tailings used is: EF(PM_{10}) = 1 752 kg/ha/yr.

The area covered by mine tailings in the local municipalities in the Dr RSM DM was extracted from the National Land Cover Data Set, enabling the calculation of the particulate matter emission rate for the district.

5.2.8 Landfills

Emissions from landfills are a function of the type and volume of waste in the landfill, and the length of time the waste has been in the landfill. There are 16 landfills in the District (excluding transfer stations, landfills licenced for closure (assumed to be rehabilitated) and private sites (e.g. mines)).

Sufficient data, e.g. the size of each landfill, was not available. For the purposes of this project, the emissions from each landfill were therefore assumed to be the same as the emissions (Table 17) modelled for a typical South African landfill (Burger et.al. 2012).

Table 17: Emission Rates for a Typical South African Landfill

Pollutant	ton/year
Benzene	0,660
PM_{10}	0,244

5.2.9 Waste Water Treatment Plants

The Dr RSM DM has 4 WWTW treating approximately 19 Mega-litres/day (DWAF, 2011). The WWTW with their associated capacity is described in the Department of Water Affairs report on the Green Drop status of the works.

Emissions from WWTW depend on the type of waste water entering the facility. However, the Australian NPI (2011) has determined a characteristic emission of VOCs from WWTW that was used as the emission factor for calculating emissions from the WWTW in the Dr RSM DM.

5.3 Emission Inventory Results

Results of emission calculations for the different sources are presented in this section.

5.3.1 Listed Activities and Boilers

a) Listed Activities

No emission data has been received for listed activities that were identified for the Dr RSM DM.

b) Boilers

Boilers were identified as potential stakeholders in this study that were not part of any listed activity. Where possible, reported fuel consumption per boiler was used to calculate emissions. For the remainder, the fuel usage was assumed to be 4 800 ton/year. This activity rate is the average for coal fired boilers obtained from the City of Tshwane Emission Inventory (GES 2012). The calculated total emissions from boilers for the Dr RSM DM for SO_2, NO_x, CO and PM_{10} are presented in Table 18.

Table 18: Total Emissions from Boilers for the Dr RSM DM

	Total Number of Boilers	Boiler Emissions (tons/annum)			
		SO_2	NO_X	CO	PM_{10}
Mamusa Local Municipality	4	729,6	72	57,6	57,6
Naledi Local Municipality	7	1 276,8	126	100,8	100,8
Kagisano-Molopo Local Municipality	4	729,6	72	57,6	57,6
Greater Taung Local Municipality	4	729,6	72	57,6	57,6
Lekwa-Teemane Local Municipality	4	729,6	72	57,6	57,6
Dr RSM District Municipality	**23**	**4 195,2**	**414**	**331,2**	**331,2**

Of the criteria pollutants, SO_2 has the highest contribution by mass to the emission load from boilers (Figure 23).

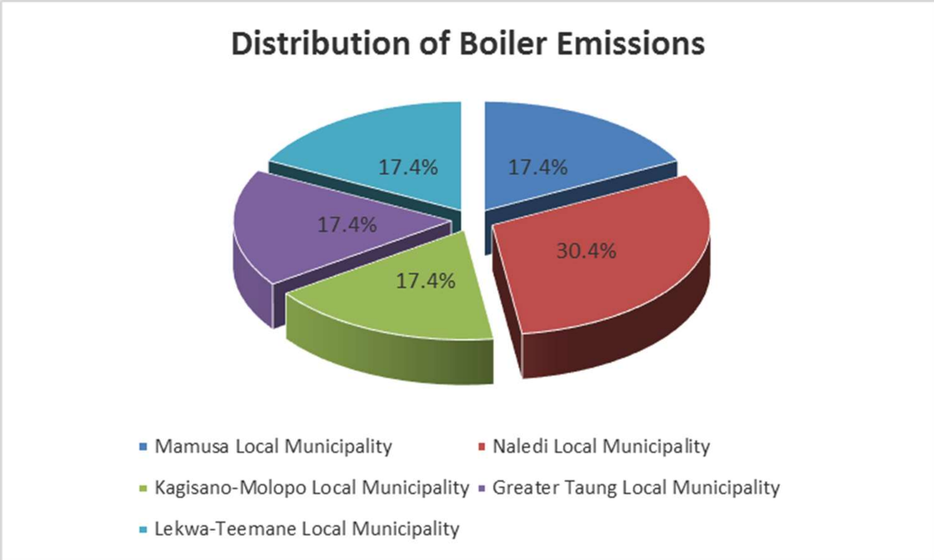

Figure 23: Proportional Representation of Criteria Pollutants from Boiler Emissions in the Dr Ruth S Mompati District Municipality

5.3.2 Vehicles

Fuel sales and subsequently emissions from fuel were calculated per town and local municipality and then for the district municipality as a whole. A total of 8 towns within the Dr RSM DM had fuel sales statistics recorded for 2013 amounting to over 100 000 tons of fuel sold during 2013 (Table 19).

Table 19: Fuel sales in the Dr Ruth S Mompati DM during 2013

Municipality	Total Fuel Sales [tons/year]
Greater Taung Local Municipality	8 803
Kagisano-Molopo Local Municipality	23 610
Lekwa Teemane Local Municipality	23 011
Mamusa Local Municipality	11 042
Naledi Local Municipality	61 049
Dr Ruth Segomotsi Mompati District Municipality Total	127 515

The highest fuel sales are found in Naledi Local Municipality followed by Kagisano-Molopo and Lekwa-Teemane Local Municipalities (Figure 24).

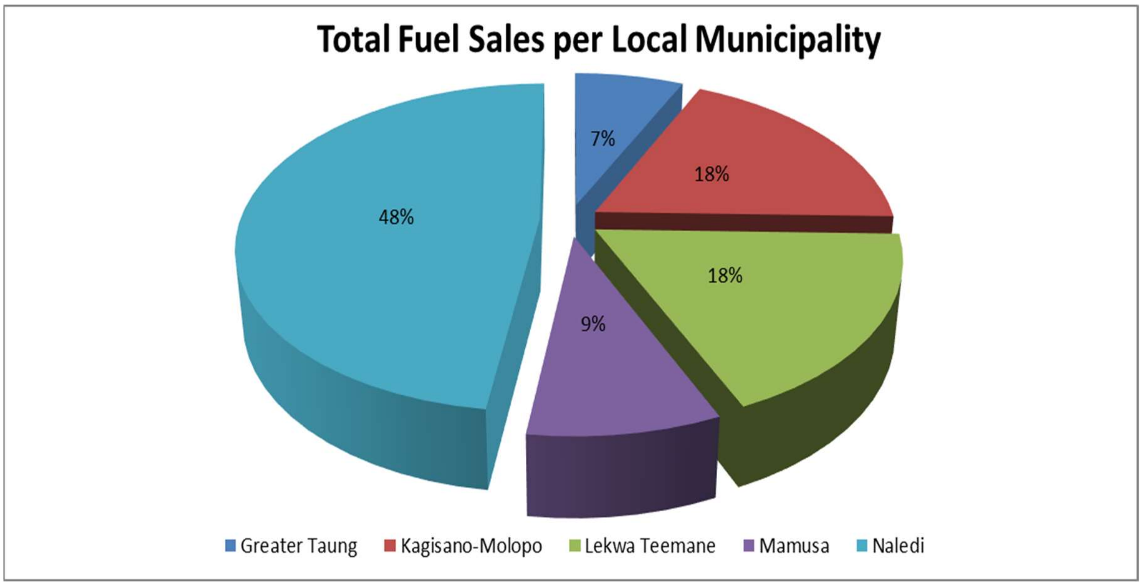

Figure 24: Distribution of Fuel Sales at Local Municipality Level in the Dr RSM DM

Diesel accounted for 52% of total fuel sales while petrol accounted for the remaining 48% of fuel sales for vehicles in the Dr RSM DM during 2013 (Figure 25). NOx constitutes 55% of the criteria pollutant emissions from fuel (Figure 26) with over 1000 tons emitted per year over the Dr RSM DM (Table 20).

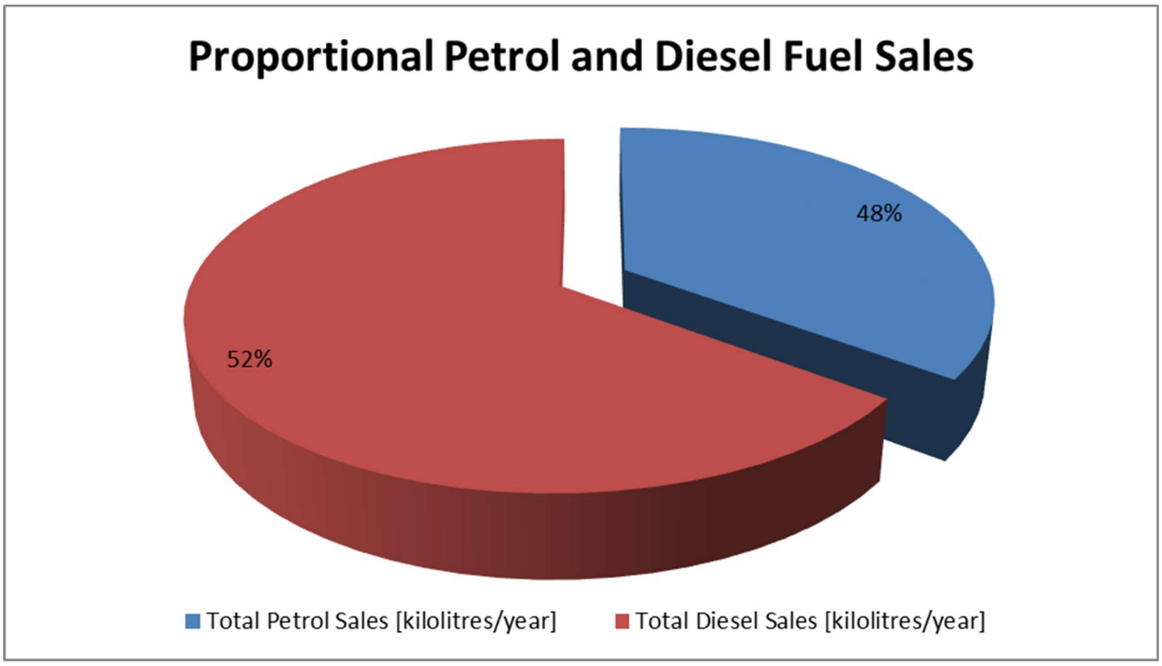

Figure 25: Proportion of diesel and petrol fuel sales in the Dr RSM DM (2013)

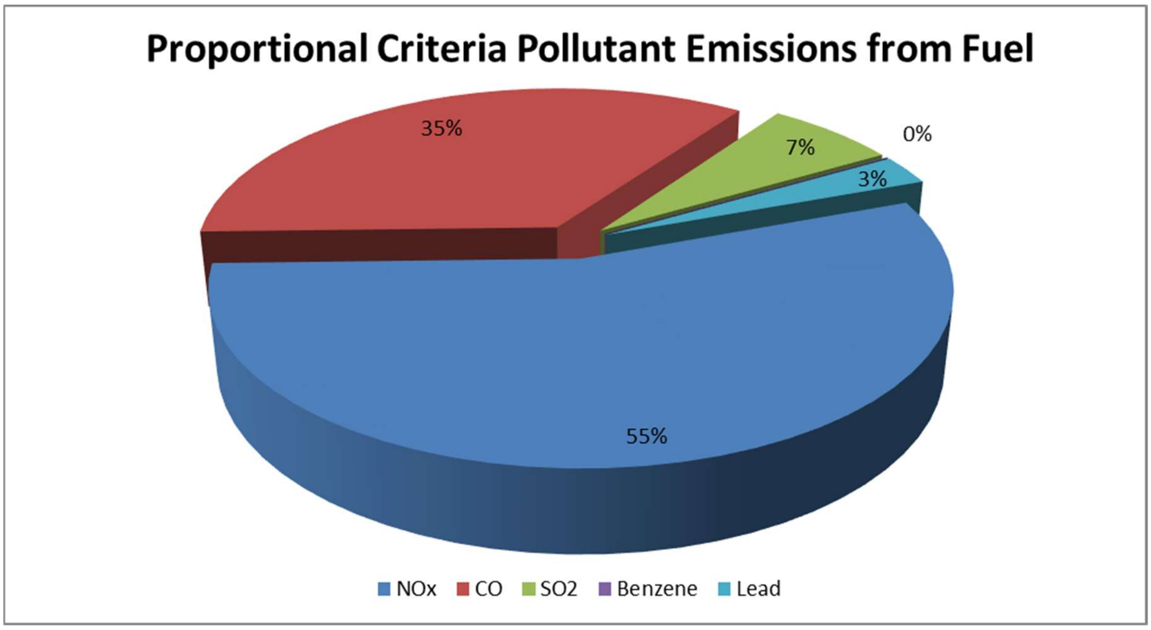

Figure 26: Criteria Pollutant Emissions from Fuel in the Dr RSM DM

Table 20: Emissions of Criteria Pollutants from Vehicle Fuel Combustion

Local Municipality	Town	Total Fuel Emissions [tons/year]				
		NO_x	CO	SO_2	Benzene	Lead
Greater Taung LM	Taung	63,57	60,65	7,38	0,08	3,00
Kagisano-Molopo LM	Ganyesa	1,44	2,13	0,15	0,00	0,06
Kagisano-Molopo LM	Molopo	169,02	160,57	19,64	0,22	7,98
Lekwa Teemane LM	Bloemhof	169,68	77,36	21,74	0,05	8,99
Lekwa Teemane LM	Christiana	48,08	42,42	5,67	0,06	2,31
Mamusa LM	Schweizer-Reneke	96,79	63,27	11,94	0,07	4,91
Naledi LM	Vryburg (NE)	7,95	4,03	1,01	0,00	0,42
Naledi LM	Vryburg (S)	573,86	310,69	72,35	0,27	29,84
Dr Ruth S Mompati DM		**1 130,39**	**721,12**	**139,87**	**0,75**	**57,50**

5.3.3 *Domestic Fuel Burning*

On average, 73% of households in the Dr RSM DM use electricity for cooking (Table 21), and 46% use electricity for heating (Table 22).

Table 21: Households in the Dr RSM DM using Electricity for Cooking

Municipality	Number of Households	Total Households Using Electricity for Cooking	% Households Using Electricity for Cooking
Naledi Local Municipality	18 572	11 973	64
Mamusa Local Municipality	14 625	10 912	75
Greater Taung Local Municipality	48 613	35 240	72
Lekwa-Teemane Local Municipality	14 930	12 106	81
Kagisano/Molopo Local Municipality	28 531	14 797	52
Dr Ruth S Mompati DM	**96 740**	**70 231**	**73**

Table 22: Households in the Dr RSM DM using Electricity for Heating

Municipality	Number of Households	Total Households Using Electricity for Heating	% Households Using Electricity for Heating
Naledi Local Municipality	18 572	9 411	51
Mamusa Local Municipality	14 625	9 404	64
Greater Taung Local Municipality	48 613	19 587	40
Lekwa-Teemane Local Municipality	14 930	8 234	55
Kagisano/Molopo Local Municipality	28 531	10 924	38
Dr Ruth Segomotsi Mompati DM	**125 271**	**57 560**	**46**

Fuel emissions from domestic burning (for cooking and for heating) of paraffin, wood and coal were calculated, firstly at local municipal level and then at district municipal level (Table 22 to Table 28).

Electricity is the most used domestic fuel for both cooking and heating in all Local Municipalities in the Dr RSM DM except for Kagisano-Molopo LM where wood is the most used energy source for heating. After electricity, wood is the preferred fuel used for cooking in households in the Dr RSM DM. However, on Local Municipal Level, Paraffin is preferred for cooking purposes in Naledi, Mamusa and Lekwa-Teemane for cooking purposes.

For heating purposes, other than electricity, wood is the most used fuel in the Dr RSM DM, and wood remains the preferred heating source at local municipal level. Coal is the least used fuel for domestic burning.

Table 23: Emissions from Domestic Burning of Paraffin for Cooking

Municipality	Number of Households	Total Households Using Paraffin for Cooking	Total Paraffin Usage [kg/year]	Total Paraffin Emissions [kg/year]		
				SO_2	NO	PM_{10}
Naledi Local Municipality	18 572	2 609	369 530	37	554	74
Mamusa Local Municipality	14 625	1 683	238 374	24	358	48
Greater Taung Local Municipality	48 613	2 279	322 790	32	484	65
Lekwa-Teemane Local Municipality	14 930	1 473	208 631	21	313	42
Kagisano/Molopo Local Municipality	28 531	1 089	154 242	15	231	31
Dr Ruth Segomotsi Mompati DM	**96 740**	**8 044**	**1 139 325**	**114**	**1 709**	**228**

Table 24: Emissions from Domestic Burning of Wood for Cooking

Municipality	Number of Households	Total Households Using Wood for Cooking	Total Wood Usage [kg/year]	Total Wood Emissions [kg/year]		
				SO_2	NO	PM_{10}
Naledi Local Municipality	18 572	1 912	420 640	84	547	7 277
Mamusa Local Municipality	14 625	1 466	322 520	65	419	5 580
Greater Taung Local Municipality	48 613	9 578	2 107 160	421	2 739	36 454
Lekwa-Teemane Local Municipality	14 930	754	165 880	33	216	2 870
Kagisano/Molopo Local Municipality	28 531	11 436	2 515 920	503	3 271	43 525
Dr Ruth Segomotsi Mompati DM	**96 740**	**13 710**	**3 016 200**	**603**	**3 921**	**52 180**

Table 25: Emissions from Domestic Burning of Coal for Cooking

Municipality	Number of Households	Total Households Using Coal for Cooking	Total Coal Usage [kg/year]	Total Coal Emissions [kg/year]		
				SO_2	NO	PM_{10}
Naledi Local Municipality	18 572	29	34 510	400	138	414
Mamusa Local Municipality	14 625	18	21 420	248	86	257
Greater Taung Local Municipality	48 613	85	101 150	1 173	405	1 214
Lekwa-Teemane Local Municipality	14 930	14	16 660	193	67	200
Kagisano/Molopo Local Municipality	28 531	22	26 180	304	105	314
Dr Ruth Segomotsi Mompati DM	**96 740**	**146**	**173 740**	**2 015**	**695**	**2 085**

Table 26: Emissions from Domestic Burning of Paraffin for Heating

Municipality	Number of Households	Total Households Using Paraffin for Heating	Total Paraffin Usage [kg/year]	Total Paraffin Emissions [kg/year]		
				SO_2	NO	PM_{10}
Naledi Local Municipality	18 572	2 147	304 094	30	456	61
Mamusa Local Municipality	14 625	977	138 379	14	208	28
Greater Taung Local Municipality	48 613	926	131 156	13	197	26
Lekwa-Teemane Local Municipality	14 930	437	61 895	6	93	12
Kagisano/Molopo Local Municipality	28 531	447	63 312	6	95	13
Dr Ruth Segomotsi Mompati DM	**125 271**	**4 934**	**698 835**	**70**	**1 048**	**140**

Table 27: Emissions from Domestic Burning of Wood for Heating

Municipality	Number of Households	Total Households Using Wood for Heating	Total Wood Usage [kg/year]	Total Wood Emissions [kg/year]		
				SO_2	NO	PM10
Naledi Local Municipality	18 572	2 965	652 300	130	848	11 285
Mamusa Local Municipality	14 625	2 414	531 080	106	690	9 188
Greater Taung Local Municipality	48 613	21 516	4 733 520	947	6 154	81 890
Lekwa-Teemane Local Municipality	14 930	2 848	626 560	125	815	10 839
Kagisano/Molopo Local Municipality	28 531	14 443	3 177 460	635	4 131	54 970
Dr Ruth Segomotsi Mompati DM	**125 271**	**44 186**	**9 720 920**	**1 944**	**12 637**	**168 172**

Table 28: Emissions from Domestic Burning of Coal for Heating

Municipality	Number of Households	Total Households Using Coal for Heating	Total Coal Usage [kg/year]	Total Coal Emissions [kg/year]		
				SO_2	NO	PM_{10}
Naledi Local Municipality	18 572	76	90 440	1 049	362	1 085
Mamusa Local Municipality	14 625	27	32 130	373	129	386
Greater Taung Local Municipality	48 613	222	264 180	3 064	1 057	3 170
Lekwa-Teemane Local Municipality	14 930	69	82 110	952	328	985
Kagisano/Molopo Local Municipality	28 531	62	73 780	856	295	885
Dr Ruth Segomotsi Mompati DM	**125 271**	**456**	**542 640**	**6 295**	**2 171**	**6 512**

Although coal burning is the biggest polluter by mass in terms of both SO_2 and PM_{10}, it is the least preferred fuel for domestic burning in the Dr RSM DM for both cooking and heating. NO is the main criteria pollutant by mass emitted from burning paraffin for domestic fuel use, while PM_{10} is the largest criteria pollutant emitted from burning wood. In total, by mass emitted, PM_{10} is the largest criteria pollutant emitted from domestic fuel burning in the Dr RSM DM (Figure 27).

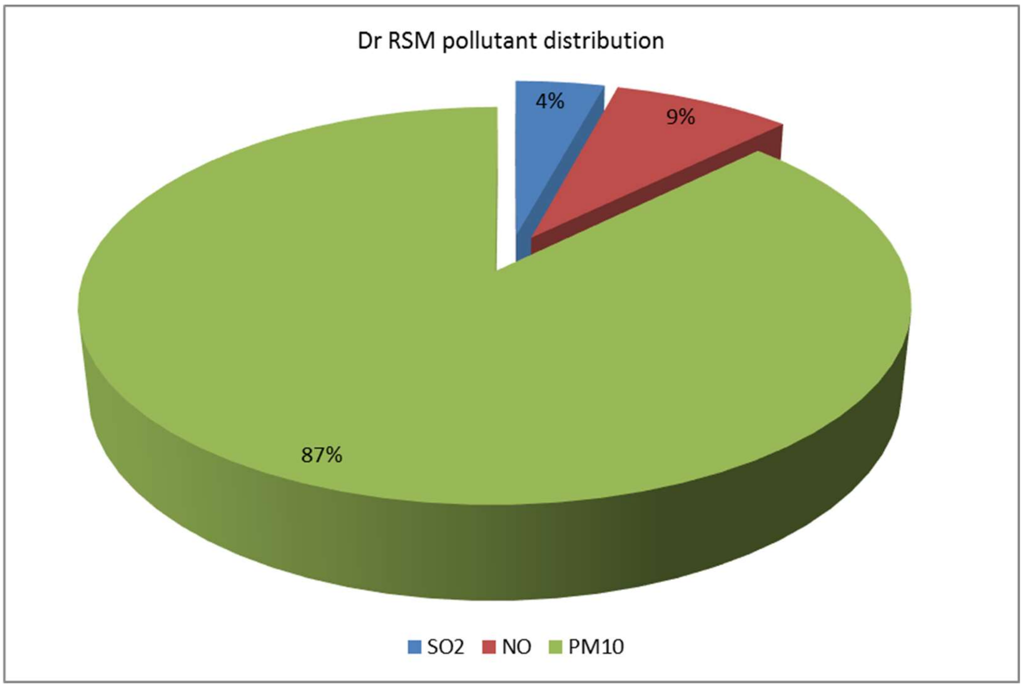

Figure 27: Total Domestic Fuel Burning Emissions in the Dr Ruth S Mompati DM

5.3.4 Biomass Burning

The biomass emissions from the area burnt in 2012 (Figure 17) is the smallest emission in the Dr RSM DM. The total area of the Dr RSM DM is 4 370 000 ha, and the total area of biomass burning for 2012 was 0.000035 ha. This is less than 0.0001% of the total area of the district

In the early dry season, the Mamusa LM has the highest biomass burning area, contributing to 68% (0.000024 ha) of the area burnt, and in the mid / late dry season, Naledi Lm contributed the highest area with 23 % and the Geater Taung LM the second highest with 22% of the area (0.000142 ha combined).

5.3.5 Agricultural Activities

a) Crop Farming

Emissions from agricultural activities (excluding livestock processes) occur from fertilizer application, soil cultivation, harvesting, cleaning and drying for all crop types. Crops identified in the Dr RSM DM include maize, oil seeds (including sunflower seeds), wheat, groundnuts, soybeans, pasture and other arable processes. Emissions were calculated for the land preparation and harvesting of these crops.

A total of ~14 million kilograms of nitrogen fertilizer is applied for agricultural activities per annum. The application of fertilizer equates to over 1 million kilograms of PM_{10} emissions per annum (Table 29). Additional emissions from fertilizer application include NO, NH_3 and $PM_{2.5}$.

Table 29: Emission from Fertilizer Application

Total Emissions from Agriculture Fertilizer Application				
Pollutant	**NO**	**NH_3**	**PM_{10}**	**$PM_{2.5}$**
Emissions [kg/year]	385 252,08	1 200 208,42	1 073 433,92	41 285,92

PM_{10} and NH_3 are the dominant emissions resulting from agricultural processes of land preparation and harvesting, with land preparation accounting for the majority of PM_{10} emissions for almost all crops types (Table 30).

Table 30: PM10 Emissions from Agricultural Processes

Total PM_{10} Emissions from Agriculture Processes [kg/year]		
Crop	**Land Preparation**	**Harvesting**
Wheat	13 819,27	7 492,37
Maize	653 567,06	234 039,25
Soya	29 322,69	6 387,79
Oil Seeds	321 083,89	-

Maize contributes the highest PM_{10} (70%) and $PM_{2.5}$ (75%) emissions from agricultural processes, which include land preparation and harvesting in the Dr RSM DM (Table 31, Figure 28 and Figure 29).

Table 31: Total PM Emissions from Agricultural Crops

Total PM emissions from crops [kg/year]		
Crop	**Total PM_{10}**	**Total $PM_{2.5}$**
Wheat	21 311,64	4 728,52
Maize	887 606,31	196 692,56
Soya	35 710,48	7 916,79
Oil Seeds	321 083,89	52 519,99

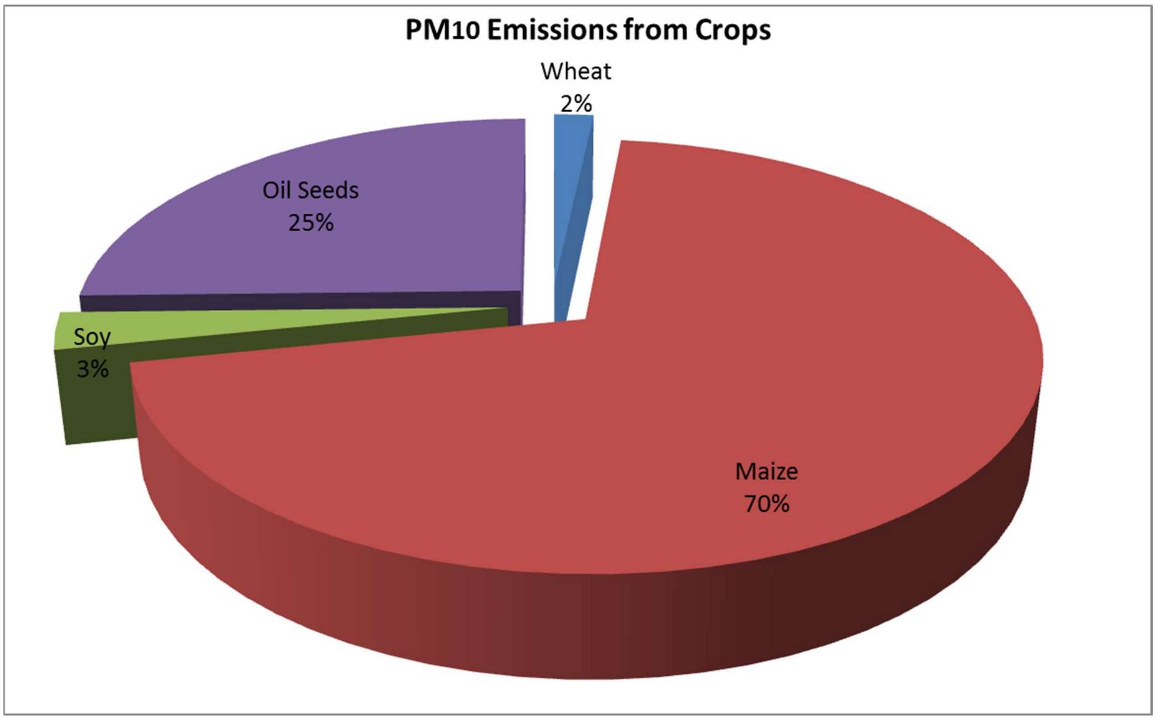

Figure 28: PM10 Emissions from Crop Farming

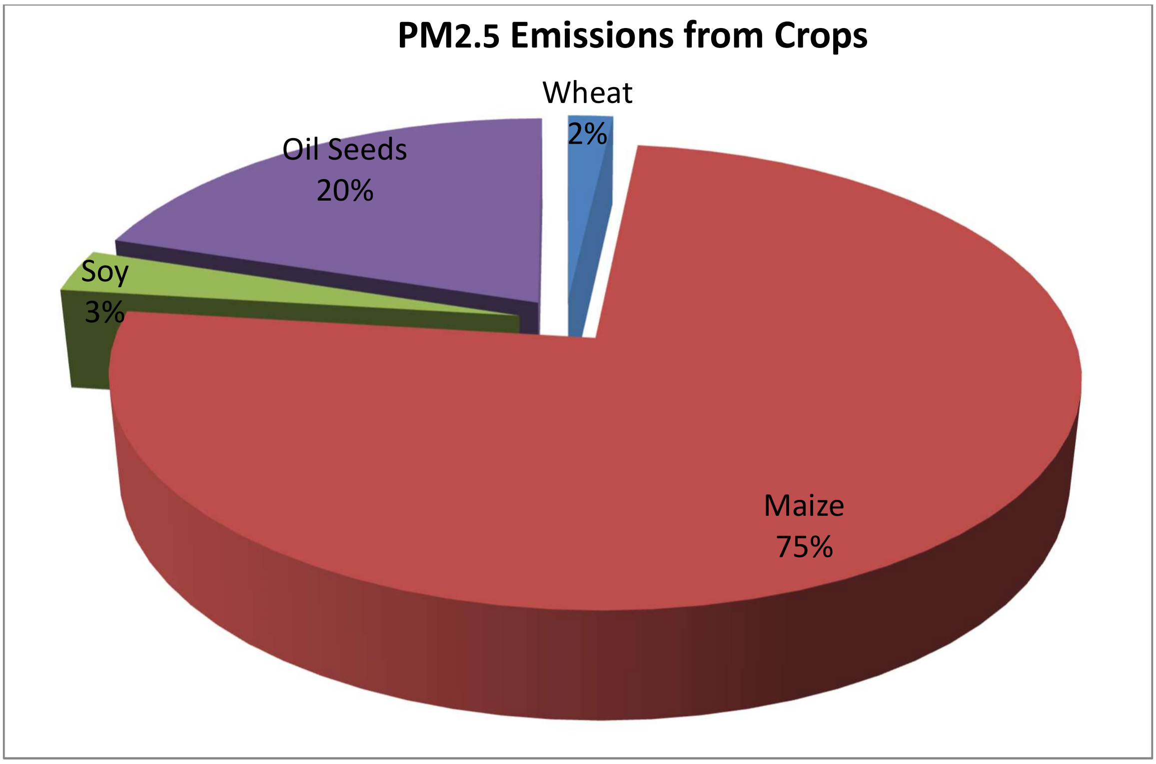

Figure 29: PM2.5 Emissions from Crop Farming

Maize also accounts for the largest area planted in the district, with Mamusa Local Municipality having the most hectares planted with maize followed by Naledi Local Municipality (Figure 30).

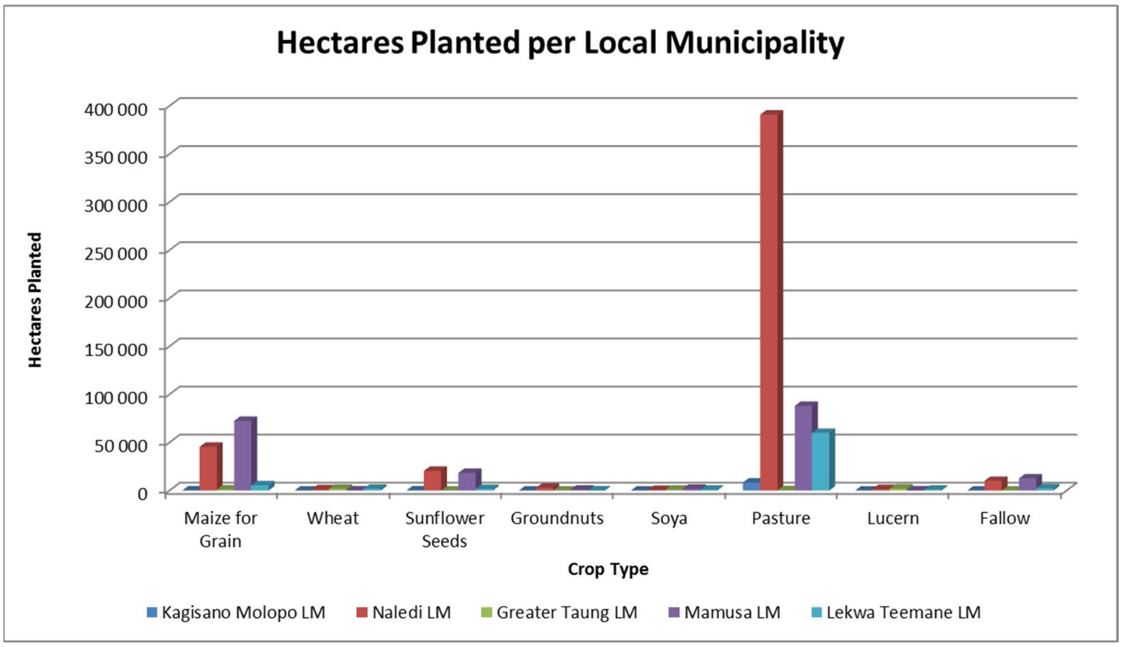

Figure 30: Hectares of Maize, Wheat, Sunflowers and Groundnuts Planted per Local Municipality.

b) Livestock Farming

Because there are no emission rates for sheep and goats, cattle farming accounts for 100% of the total livestock $PM_{2.5}$ and PM_{10} emissions in the Dr RSM DM (Table 32).

Table 32: Total Emissions from Livestock

Total Emissions from Livestock [kg/year]		
Animal types	**PM_{10}**	**$PM_{2.5}$**
Cattle	97 067,48	428 554,00
Sheep/goats	-	-
TOTAL	97 067,48	428 554,00

Most of the cattle are found in the Naledi Local Municipality, followed by Mamusa and Lekwa-Teemane Local Municipalities (Figure 31).

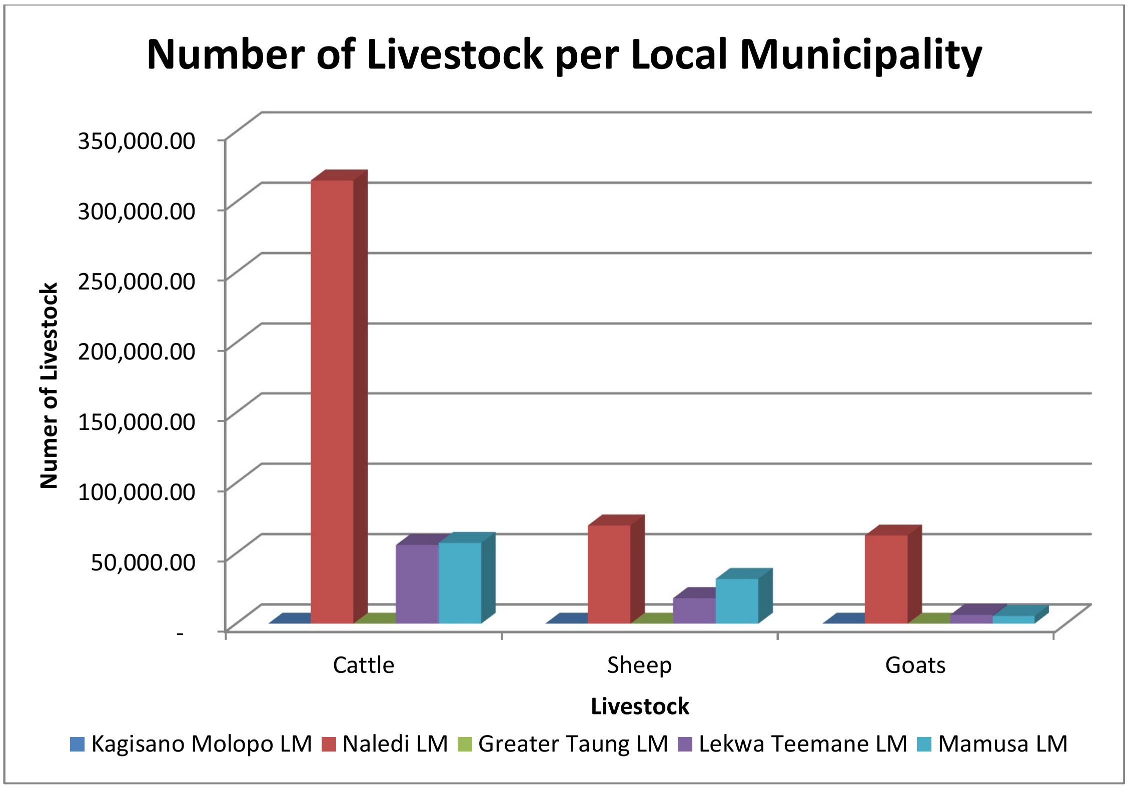

Figure 31: Number of Cattle, Sheep and Goats per Local Municipality.

5.3.6 Denuded Land

Denuded land occurs throughout the Dr RSM DM with the largest area occurring in the Greater Taung Local Municipality (Table 33).

Table 33: Denuded Land Particulate Emissions at the Local Municipality Level

District Municipality	Total Area of Degraded Land [km^2]	Estimated PM_{10} Emission [ton/year]	Estimated $PM_{2.5}$ Emission [ton/year]	Percentage Contributions
Naledi Local Municipality	2	0,67	0,10	7%
Mamusa Local Municipality	1	0,49	0,07	5%
Greater Taung Local Municipality	10	3,46	0,52	38%
Lekwa Teemane Local Municipality	8	2,97	0,44	32%
Kagisano Molopo Local Municipality	4	1,62	0,24	18%
Dr Ruth S Mompati District Municipality	**26**	**9,20**	**1,38**	**100%**

The $PM_{2.5}$ emissions are significantly lower than the PM_{10} emissions, possibly due to the fact that the smaller particles have been removed more easily in the beginning leaving only coarser material available to be entrained by wind action. For the Maricopa County study (2011), $PM_{2.5}$ emissions were assumed to be 15% of the PM_{10} emissions.

The distribution of emissions from denuded land is proportional to the area of denuded land in each Local Municipality (Figure 32).

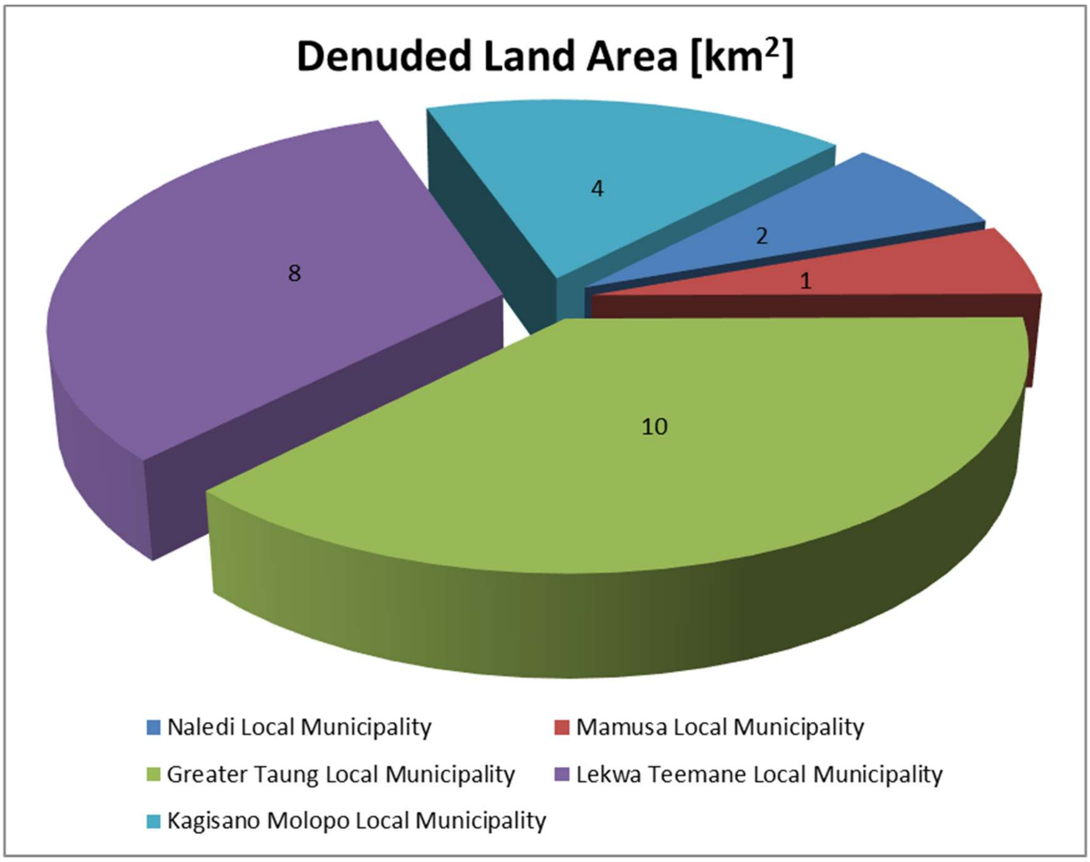

Figure 32: Distribution of Emissions from Denuded Land by Local Municipality

5.3.7 Mining

Mining activities, but specifically tailings, contribute towards emissions. The Dr RSM SM has some mining areas, with mine tailings covering approximately 13 000 hectares (Table 34). The largest areas covered by mine tailings occur in the Lekwa-Teemane and the Naledi Local Municipalities.

Table 34: Particulate Emissions from Mine Tailings in the Local Municipalities of the Dr Ruth S Mompati DM

Local Municipality	Total Area of Tailings (ha)	Estimated PM_{10} Emission [kg/year]
Naledi Local Municipality	2 556	4 477 844
Mamusa Local Municipality	1 986	3 480 155
Greater Taung Local Municipality	881	1 543 388
Lekwa-Teemane Local Municipality	7 113	12 461 119
Kagisano/Molopo Local Municipality	501	876 937
Dr Ruth S Mompati DM	**13 036**	**22 839 443**

5.3.8 Landfills

Within the Dr RSM DM, the Taung Local Municipality has the most landfill sites while the Naledi Local Municipality has the least (Table 35, Figure 33). Although the Taung LM has the largest population, the Naledi Local Municipality does not have the smallest population. Information on the size of landfills was not available for all the landfills, which is why an average size was assumed. However, the difference between population size and number of landfill sites indicates that the landfills in the Naledi and Kagisano-Molopo local municipalities are probably larger than the average landfill size. Although this means that the District Municipality distribution of landfill emissions is flawed, a sense of landfill emissions relative to the total for all sectors is gained (Figure 36) (NW READ, 2015).

Table 35: Number of Landfills, with their Emissions Rates, in the Dr RSM DM per Local Municipality

Municipality	Number of Landfills	Calculated Emissions [kg/year]	
		Benzene	PM_{10}
Naledi Local Municipality	2	1 320	487
Taung Local Municipality	5	3 300	1 218
Lekwa Teemane Local Municipality	3	1 980	731
Mamusa Local Municipality	3	1 980	731
Kagisano-Molopo Local Municipality	3	1 980	731
Dr RSM DM Total	**16**	**10 560**	**3 897**

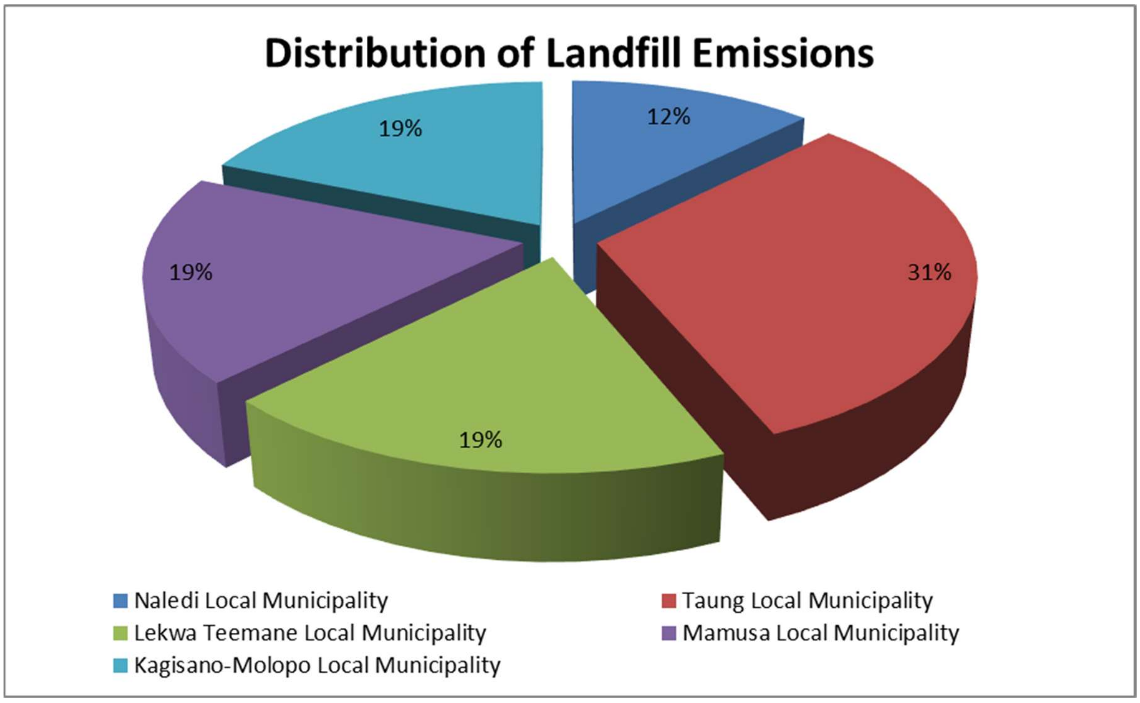

Figure 33: Distribution of Landfill Emissions by Local Municipality

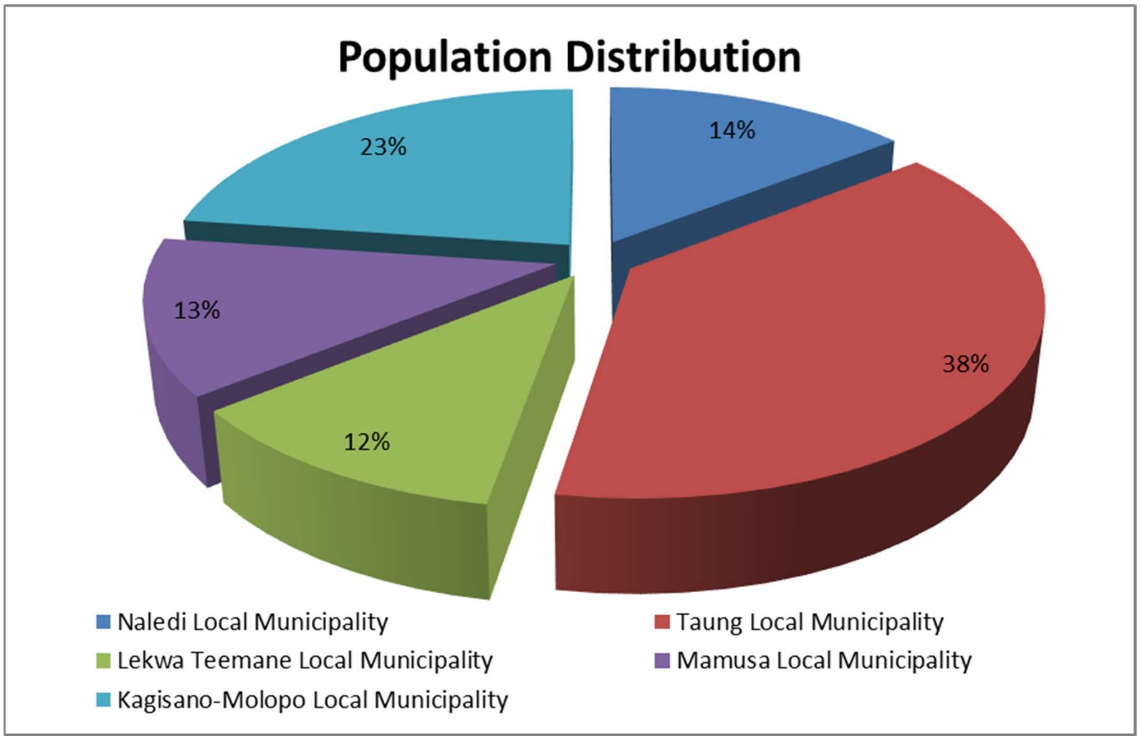

Figure 34: Population Distribution of Dr Ruth S Mompati District Municipality by Local Municipality

5.3.9 Waste Water Treatment Works

The total volume of waste water treated at WWTW in the Dr RSM DM is ~7 million cubic meters per year and VOC emissions from WWTW equate to about 7.3 tons per year in total (Table 36). The Naledi Local Municipality is responsible for the most VOC emissions from this source per year.

Table 36: VOC emissions per District Municipality from the Waste Water Treatment Works

Local Municipality	Number of Plants	Total Volume Treated (m^3/yr)	Estimated VOC Emission [ton/year]
Naledi LM	1	2 763 075	3,0
Mamusa LM	1	2 106 188	2,3
Lekwa Teemane LM	2	1 999 075	2,1
Dr Ruth Segomotsi. Mompati DM Total	**4**	**6 868 338**	**7,3**

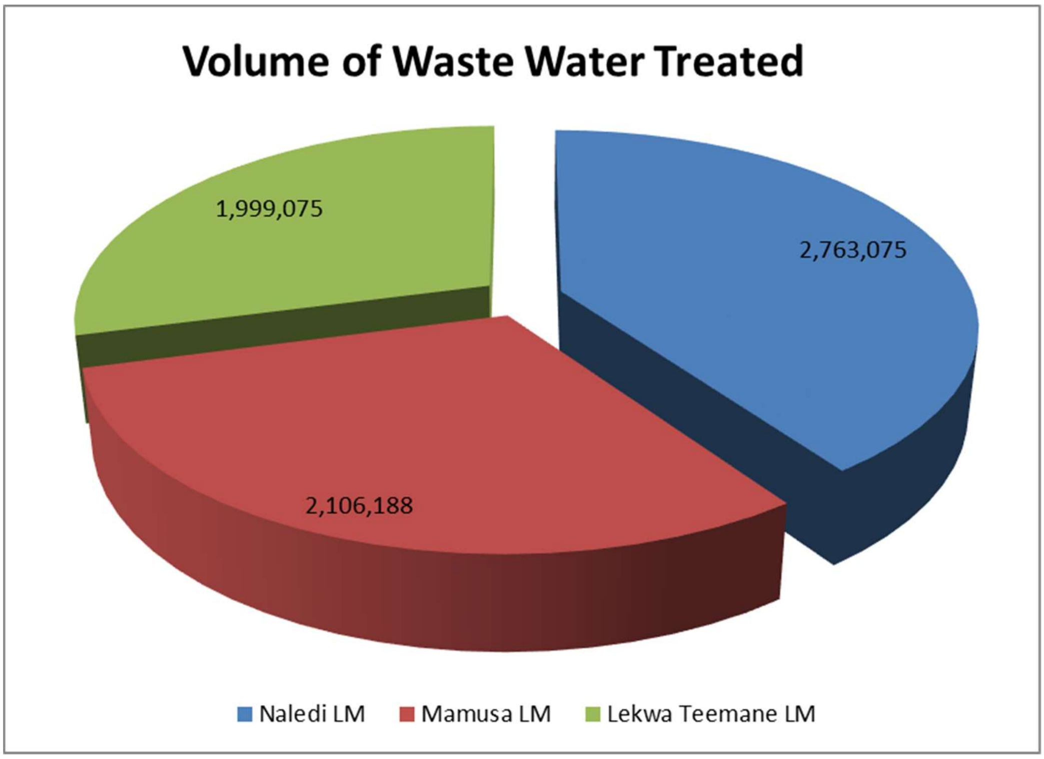

Figure 35: Volume of Waste Water Treated (m3/year) in the Dr RSM DM Local Municipalities

5.3.10 Total Emissions in the Dr Ruth S Mompati District Municipality

A summary of the emissions from all the sources in the Dr RSM DM is presented (Table 37). The Mining sector generates 70% of the criteria pollutant emissions in the District (Figure 36) with the dominant emissions from these sources being PM_{10} (22 839 tons/year). Mining contributes the highest PM_{10} emissions compared to any other sector included in this report. The majority of emission sources, except vehicles (dust entrainment from vehicles was not considered in this report) and WWTW, as analysed in this report, have PM_{10} emissions. Agricultural activities and biomass burning contribute ~ 41 tons per year of $PM_{2.5}$ emissions. It is likely that tailings contribute a significant amount of $PM_{2.5}$ emissions; however, these emissions were not quantified in this study. Boilers and vehicles emit the highest amount of SO_2, NO_x and CO. Lead is only emitted by vehicles in this study.

Table 37: Summary of Pollutant Emissions from all Sources for the Dr Ruth S Mompati District Municipality

	Pollutant (ton/annum)							
Sector	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NO_x**	**CO**	**Benzene**	**Lead**	**Total**
Boilers	331		4 195	414	331			**5272**
Vehicles			140	1 130	721	1	58	**2 050**
Domestic Fuel Burning	229		11	22				**263**
Biomass Burning		0	0	0	0			**0**
Agriculture	1 073	41		385				**1 500**
Livestock	97	429						**526**
Denuded Land	9	1						**11**
Mining (tailings)	22 839							**22 839**
Landfills	4					11		**14**
WWTW (VOCs)						7		**7**
TOTAL	**24 584**	**471**	**4 346**	**1 952**	**1 052**	**19**	**58**	**32 481**

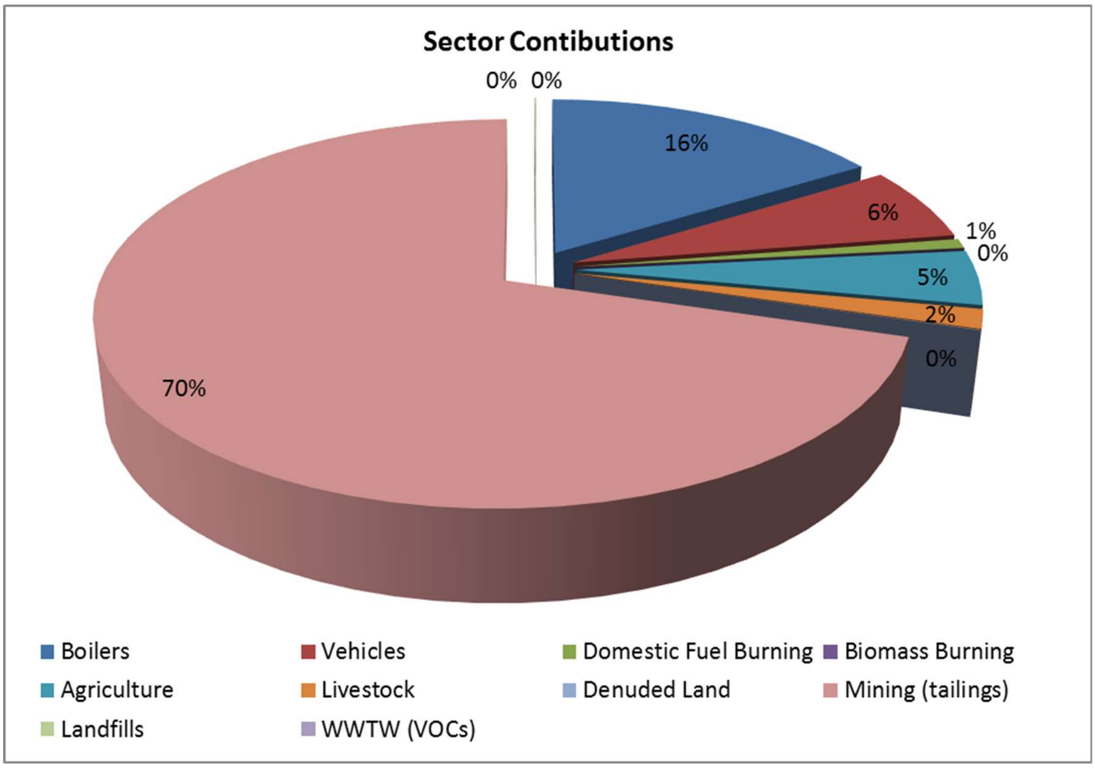

Figure 36: Contribution of Sectors to Total Emissions in the Dr RSM DM

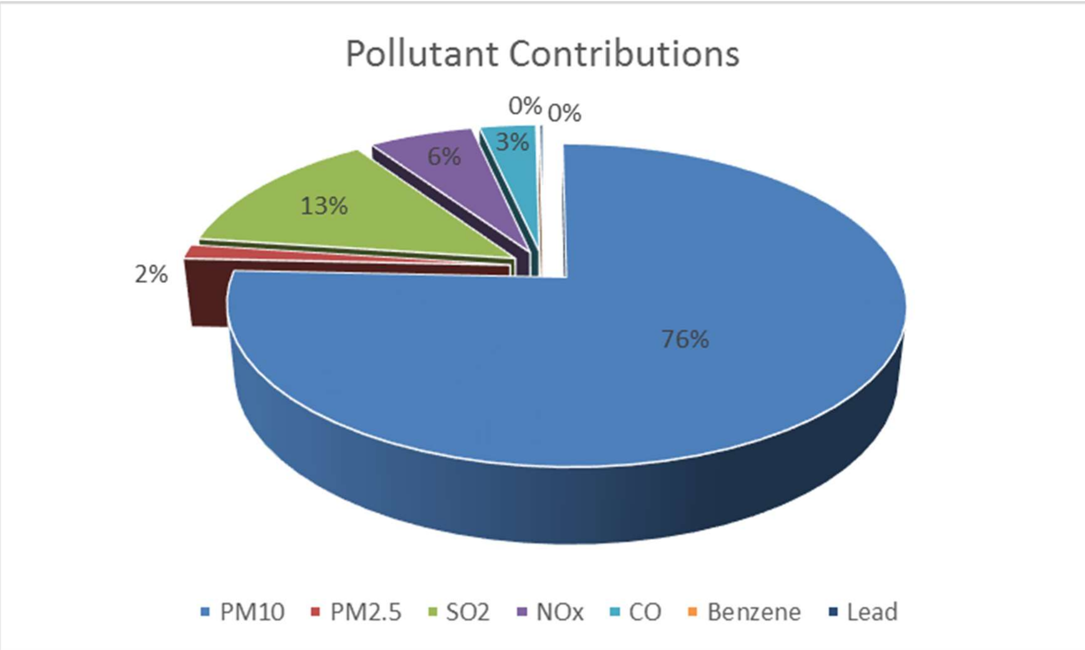

Figure 37: Pollutant Distribution in the Dr RSM DM

5.3.11 Geospatial Representation of Air Pollution

A spatial assessment of air pollution risk is necessary for effective air quality management. Dispersion modelling is typically used to identify areas where the ambient concentration of particular compounds exceeds the national ambient air quality standard. However, emission rates are the biggest uncertainty in dispersion modelling assessments. Although huge progress has been made towards better inventories of emissions to air in South Africa, we are a long way from having all the necessary information from all the important sources. This leads to assessments that overemphasize sources which we know a lot about, and under represents sources that are difficult to quantify. This is particularly true for domestic burning. Another problem with dispersion models is the inability to accurately assess intra-urban exposure from large area sources that emit at low temperatures, close to the ground, like residential solid fuel burning (Jerrett, 2005). This assessment made use of a proximity-based geospatial model that uses nearness to a particular pollution source as a proxy for exposure similar to Wright and Diab, 2009 (Wright, 2009).

The geospatial model represents each source category as a weighted layer. Sources that had sufficient information available were modelled. The sum off all the different layers' results in an assessment of how many sources impacts on that particular conurbation. This exposure map is then combined with population demographics in order to assess risk.

a) Sources with High Uncertainty in their Emissions

Domestic fuel burning (Residential solid fuel burning) is one of the emissions with the greatest impact. Even if the total emissions are much lower than industrial emissions, particulate matter associated with domestic fuel burning is emitted close to ground level in areas with the highest population density (Piketh, 2014). Even a small number of domestic fuel burning households can have a detrimental impact on the ambient air quality of the whole suburb. The only data available to estimate the number of domestic fuel burning households is the census data. However, this has been shown to not be a very accurate reflection of the total domestic fuel burning households (Pauw, 2006). The 2011 census data (Christopher, 2014) was therefore used to identify areas where domestic fuel burning might be a concern.

Biomass burning emissions is another source with large uncertainties. Although satellite based fire products are readily available, uncertainties in the land cover as well as the variability of the associated atmospheric emissions makes biomass burning very difficult to model explicitly.

Mine tailings are a significant source of particulate matter under certain meteorological conditions. The variability of surface properties, chemistry, age and control efforts between different tailings is large. Without a detailed assessment to characterise every tailings, as well as how it responds to different wind regimes, the uncertainties are too large to model.

Traffic emissions along the national corridors have a potential to be an important local source. However, the fleet composition, age, routes and speeds are not known.

There are many uncertainties about true extent of air quality in Dr RSM DM. Very little data is available and emissions are extrapolated from areas that might have some variation. Domestic solid fuel use dominates the potential impacts using the assumptions made regarding emissions in the area. The priority for the Dr RSM DM should be to confirm the high ambient levels of PM in dense, low-income areas of municipalities.

b) Geospatial Modelling of Different Source Groups

The different source groups were modelled as spatial layers. The PM_{10} and SO_2 layers are obtained from dispersion modelling estimates for the industrial sources. Tailings and other industrial fugitive emissions are represented by the 2014 national land cover dataset. A 1km buffer is placed around all industrial and mining land-cover classes. Traffic pollution exposure is modelled with a 300m buffer around all major roads, railways and commercial centres. Domestic fuel burning (residential fuel) areas are identified as small area layers in the 2011 census that had 15% informal housing, use at least 15% solid fuels for either cooking or heating, and have a population density higher than 500 people per square kilometre.

c) Probability of Air Pollution Exposure

The probability of air pollution exposure is shown in Figure 38. Huhudi has the largest area where a very high probability of exposure is modelled. This means that people living in this area are being exposed to multiple air pollution sources. Ganyesa and Taung also has significant areas with a very high probability.

Although the relative size of the areas with a high or very probability of air pollution exposure is small, most of these areas have a high population density. This likely affects up to 40% of people living in Kagisano-Molopo and Lekwa-Teemane and around 30% in the Dr RSM DM as a whole (Figure 38). Priority settlements to investigate include: Huhudi, Ganyesa, Taung, Utlwanang, Morokweng B (Table 38)

Table 38: Small area layers and number of people of areas with a high probability of air pollution exposure

Place name	Number of People exposed
Huhudi	22083
Ganyesa	17880
Taung	14754
Utlwanang	14169
Morokweng B	12720
Colridge	12024
Tlakgameng	9921
Boitumelong	8544
Vryburg	8448
Mokgareng	7521
Ipelegeng Ext 3	7239
Dry Harts	7197
Ipelegeng Ext 2	6393
Tsokonyane	5442
Mamusa [Schweizer-Reneke] NU	5085
Lower Majeakgoro	5073
Ipelegeng Ext 1	5004
Magogong	4974
Molatswanene	4806

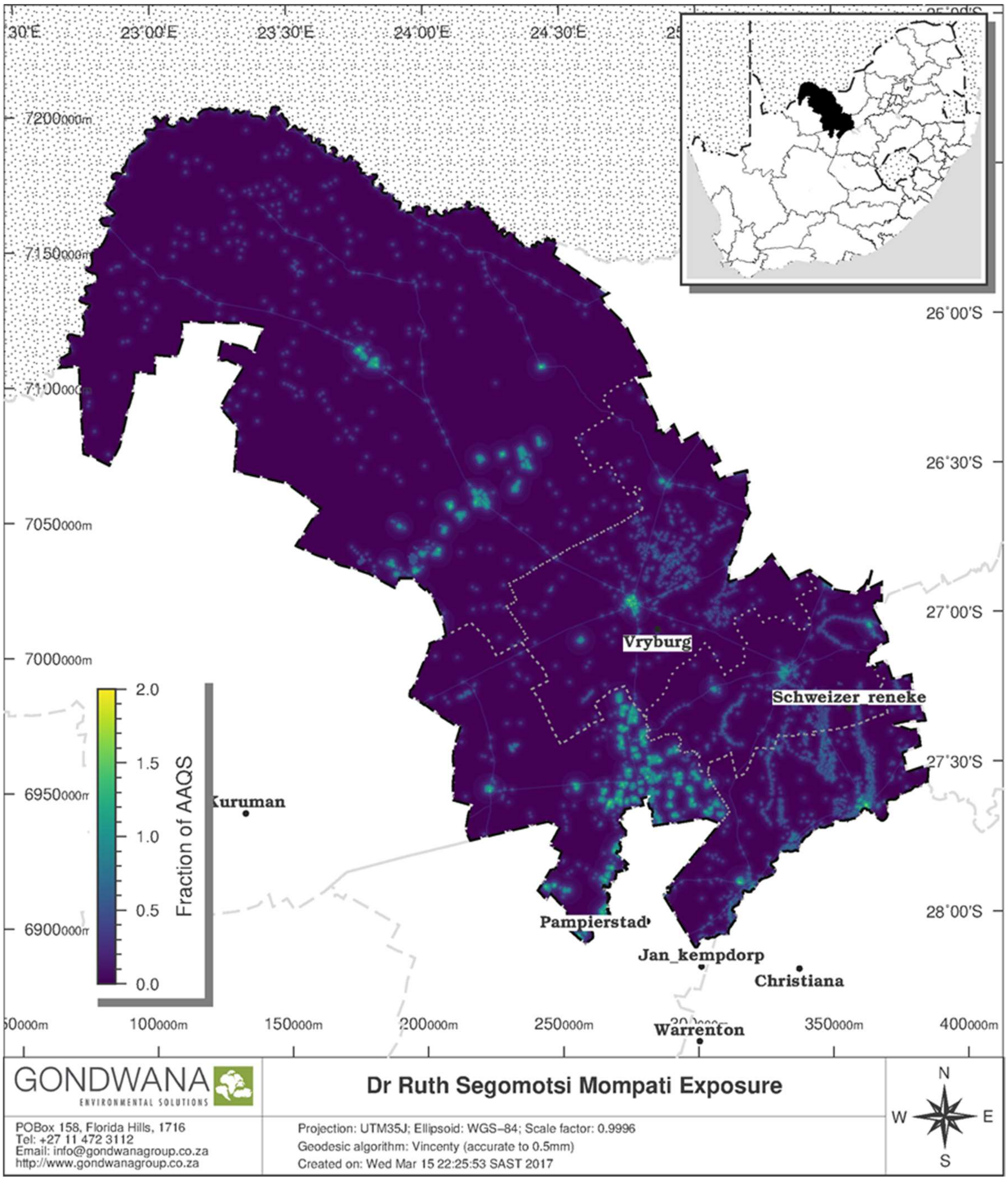

Figure 38: Spatial distribution of air quality exposure in the Dr RSM DM

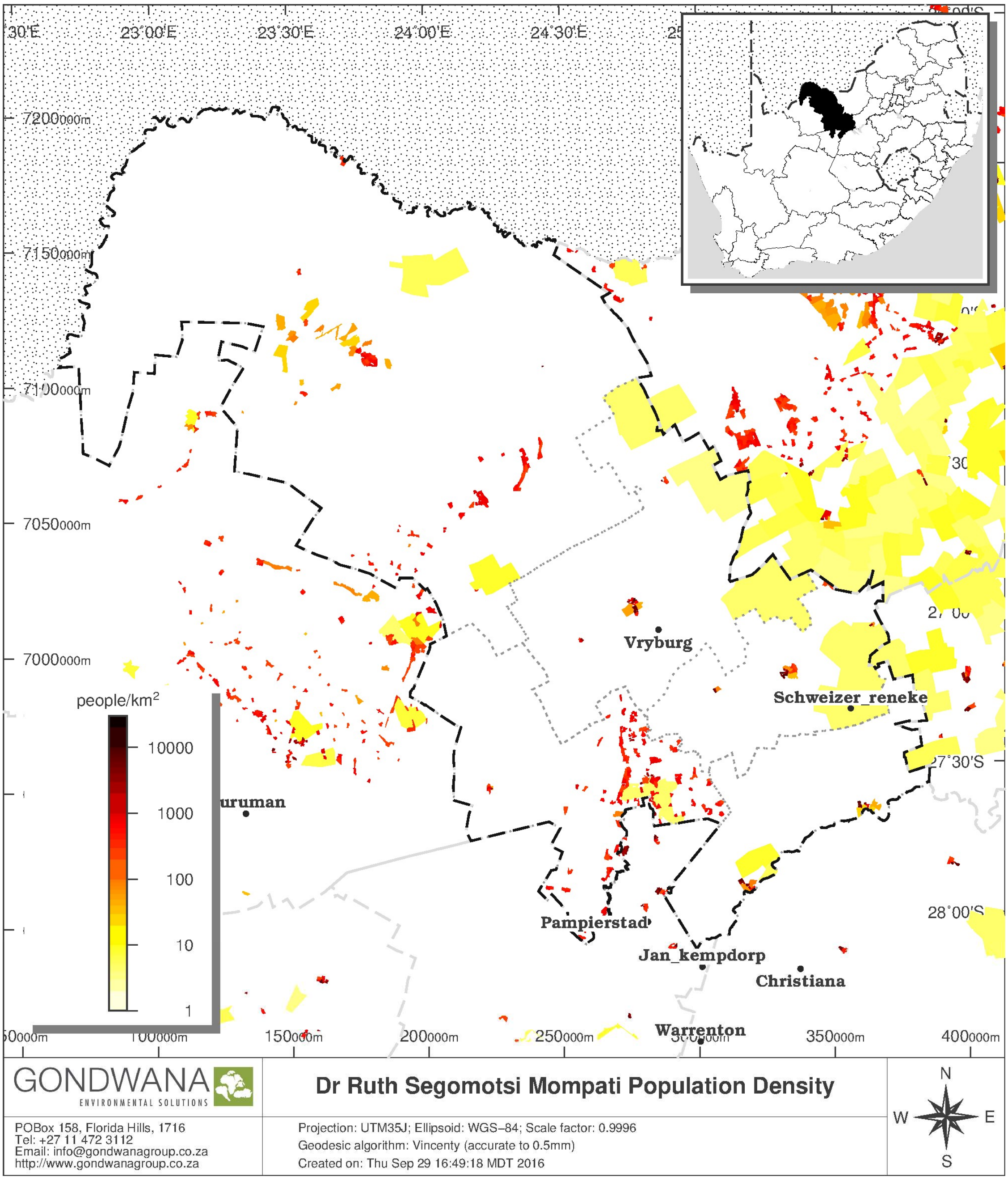

Figure 39: Population density spatially represented within the Dr RSM DM

5.4 Discussion

The quantification of emissions to the atmosphere in the Dr RSM DM was accomplished for the different source types. Emissions inventory calculations were structured to allow for emission totals to be broken down to local municipality levels where applicable.

While many sources were quantified, almost in all instances, information to do detailed quantification was missing. This was the biggest challenge of establishing the status quo in terms of ambient air quality in the Dr RSM DM. It also meant that many assumptions had to be made to complete the calculations.

The Dr RSM DM AQMP emissions inventory added detail to what was already seen in the NW provincial AQMP. Some data gaps, like industries, from the provincial AQMP has been filled but continuous sourcing of relevant information (land use, industry information, and so forth) is required to enable the emission inventory to be updated and improved. Increasing the monitoring of source emissions and ambient air quality can increase the accuracy of future emission inventories. Owners of both Listed Activities and boilers should be encouraged to be more active in knowing what their emissions are.

6. AIR QUALITY PRACTICES AND INITIATIVES WITHIN PROVINCIAL AND LOCAL GOVERNMENT

6.1. Government Structure and Functions

The capacity for air quality management and control within the Dr RSM DM is assessed within the various spheres of Government. The current capacity at District and Local levels is evaluated in terms of available personnel, functions and resources.

6.1.1. Provincial Level

Within the North-West Province, the Department of Rural, Environment and Agricultural Development (NW-READ) is responsible for air quality related functions. Air quality is primarily a function of the Environmental Management Sub-Directorate (Figure 40).

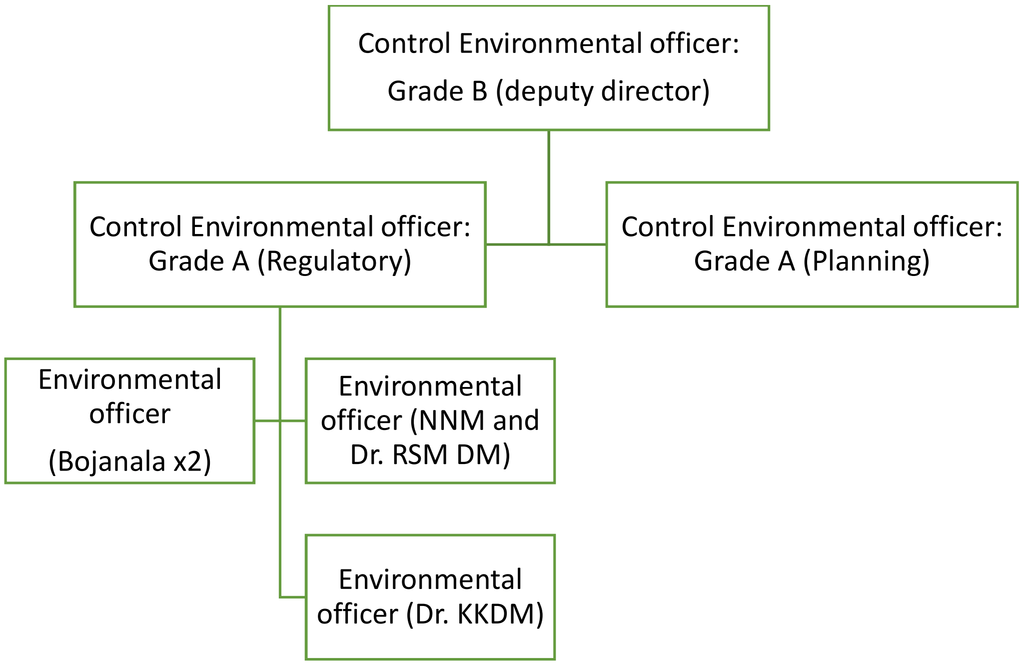

Figure 40: Organizational structure for the READ Department

6.1.2. District Level

Within the Dr RSM DM, the Environmental Health Services (EHS) department is responsible for air quality management. There are currently no Air Quality Officers, only EH practitioners that undertake the air quality duties of the district (Figure 41).

6.1.3. Local Level

There are no Environmental Management or Air Quality Management units at local level, and, therefore, there are no dedicated Air Quality Officers within the Local Municipalities.

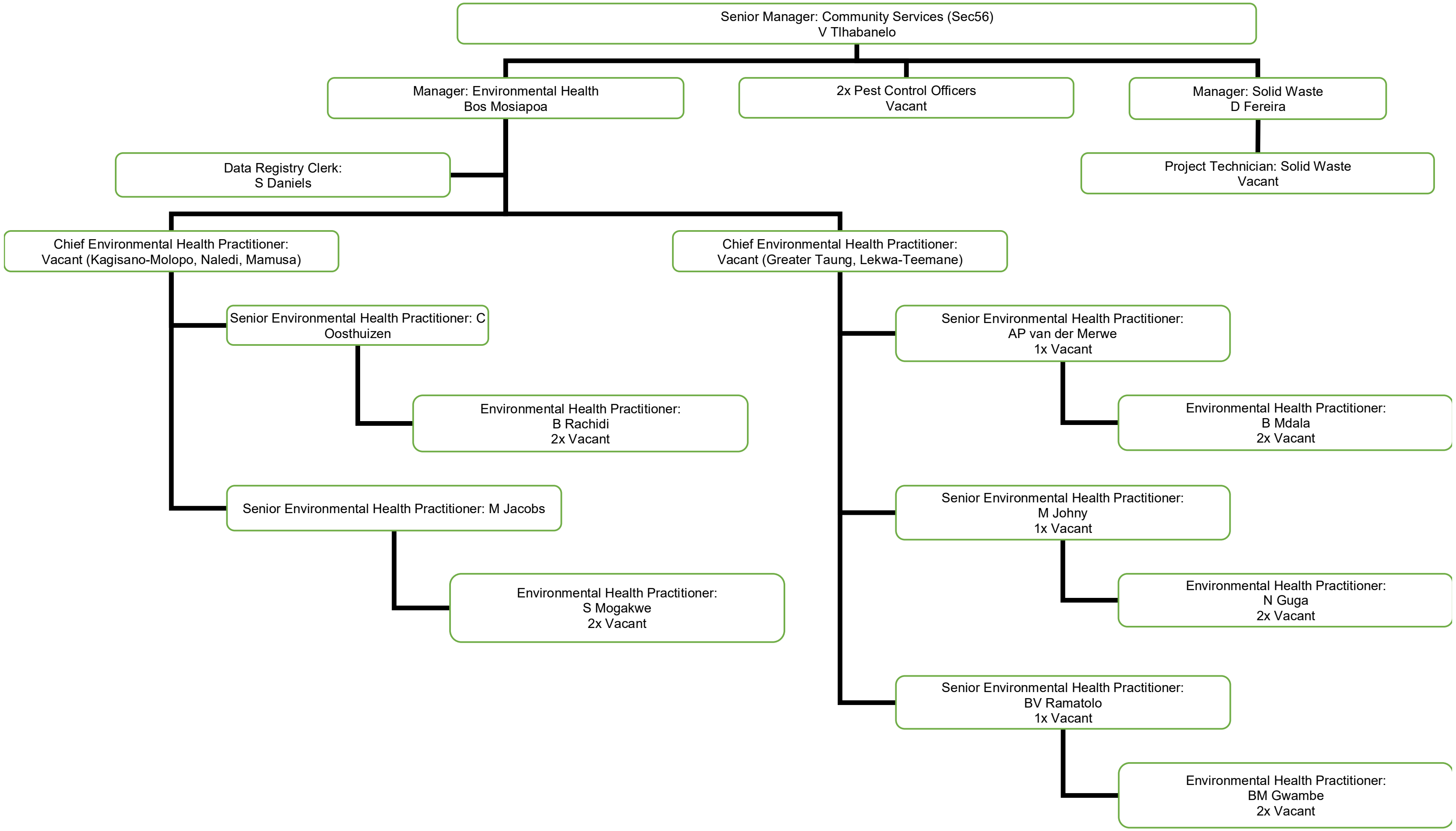

Figure 41: Dr RSM DM Community Services – Environmental Health Organogram

6.2. Air Quality Management Tools

6.2.1. Complaints Response Database

Air pollution complaints received from the public need to be recorded in a database, investigated and addressed within each level of Government. Pollution complaints need to be logged into a centralised electronic pollution complaints database at the READ Department to ensure the effective co-ordination and management of complaints received. Complaints reported to the National Department of Environmental Affairs (DEA) is referred back to the Dr RSM DM.

Prior to such a system being implemented at Provincial level, it is recommended that the Dr RSM DM maintain a complete complaints system, keeping records of responses, letters, notices and feedback to the complainant. Currently there is no database being kept for the Dr RSM DM. Complaints should be broken down into complaint type such as smoke, odours, dust etc. and be dealt with accordingly. In terms of compliance and enforcement, verbal warnings are generally issued and, in more serious offences, written notices are served.

6.2.2. Emissions Inventory Database

For effective air quality management and control, an accurate, electronic emissions inventory of point, non-point and mobile sources must be established. The emissions inventory should include information on source parameters (source location, stack height, stack diameter, exit gas velocity, exit temperature) and associated pollutant emission rates. An emissions inventory serves the function of

- providing spatially resolved source strength data on each pollutant for dispersion modelling,
- predicting environmental impacts,
- helping in urban and regional planning,
- supporting the design of regional monitoring networks,
- contributing a basis for evaluating trends, and
- assisting in the formulation of air quality management policies.

There is no existing emissions inventory database for the Dr RSM DM. A preliminary emissions inventory database has been established as part of the Baseline Assessment (Section 5). This information will need to be verified and updated by the North West Province, Dr RSM DM and the Local Municipalities.

It is not necessary for the Dr RSM DM to purchase emissions inventory software; use can be made of available software such as Microsoft Excel or Microsoft Access to capture the emissions inventory information supplied by industries. The Dr RSM DM will need to ensure that their current emissions inventory database is regularly updated and that it is incorporated into the South African Air Quality Information System.

As part of the South African Air Quality Information System phase two, all source and emissions data recorded within each Municipality and Province should be incorporated into a National Atmospheric Emissions Inventory System (NAEIS), allowing for easy access and manipulation of data from any sphere of Government. Since NAEIS has been established, Atmospheric Emissions License holders have to submit annual emissions inventory reports for the compilation of a National emission inventory profile (NEM:AQA, 2013).

6.2.3. Dispersion Modelling Software

Limited software and knowledge exists within each sphere of Government to support dispersion modelling. Dispersion modelling software is not available at either the Local, or District level. When required, dispersion modelling is undertaken by external consultants. The use of such modelling software is critical to the understanding of the temporal and spatial distribution of pollutants in the atmosphere.

Atmospheric dispersion modelling forms an integral component of air quality management and planning. Air quality models are used to establish a relationship between emissions and air quality. Dispersion models require the input of data which includes

- meteorological conditions such as wind speed and direction, the amount of atmospheric turbulence, ambient air temperature and the height to the bottom of any inversion layers in the upper atmosphere,
- emission parameters such as source location and height, stack diameter, exit gas temperature and exit velocity,
- terrain elevations at the source and surrounding regions, and
- the location, height and width of any obstructions (such as buildings).

Dispersion modelling is typically used to determine compliance with ambient air quality guidelines or standards and assist in health and environmental risk assessments. It also provides information for the positioning of ambient monitoring networks and helps to assess source contributions to ambient air quality concentrations.

The Department of Environmental Affairs (DEA) has developed Air Dispersion Modelling Regulations and technical guidance under paragraph (p) of section 53 of the AQA to ensure that that dispersion modelling practices throughout South Africa are standardised.

6.2.4. Data Monitoring and Reporting Practices

Currently there is no continuous ambient air quality monitoring in the Dr RSM DM. Once established, the co-ordinated transfer of data from the monitoring stations to a centralised database is critical to ensure the effective and efficient management and verification of the monitoring data. As part of the South African Air Quality Information System (SAAQIS), a centralised database has been developed at the South African Weather Services to which all ambient monitoring data is transferred. This database is useful for ensuring that industries report their emissions and for the authorities to monitor compliance.

An ambient air quality management system consists of various hardware, software and communication systems as well as activities related to the ongoing maintenance and calibration of the system. Continuous ambient air quality monitoring requires, among other things, a set of trace gas analysers housed in a secure shelter, meteorological equipment and a data communication and acquisition system, as well as various other mechanical, civil and electrical structures such as an inlet manifold, fencing, a concrete plinth, an air conditioner, an Uninterrupted Power Supply (UPS) and safety devices such as a lightning conductor. As part of a monitoring network design (macro- and micro-siting) it is important to consider:

- the proximity of residential areas,
- the location of industries, major roads, sources of domestic fuel burning emissions etc.,
- the dominant wind direction,
- dispersion modelling results,
- topography,

- the location of existing monitoring stations,
- sensitive environments,
- sensitive populations, and
- trans-boundary transport of air pollution from neighbouring sources.

a) Continuous Ambient Air Quality Monitoring

Continuous ambient air quality monitoring ensures that the environment is being properly protected and helps Local Government manage the impact of atmospheric emissions on the environment. This type of monitoring provides continuous, accurate data on pollution concentrations at a specific location. However, limitations of this type of monitoring are associated with spatial coverage, technical skills required for maintenance and calibration as well as the ongoing financial implications. Ambient air monitoring stations (Figure 42) are not operated in the Dr RSM DM. Other monitoring practices would be more practical in a district with, relatively speaking, such little air quality issues.

Figure 42: Examples of continuous ambient air quality monitoring stations

At the 11th Annual Air Quality Lekgotla, held on 3-5 October 2016 in Mbombela, the DEA presented the proposed monitoring categories as part of the draft National Ambient Air Quality Monitoring Strategy. The Dr RSM DM will be categorized as level two when the strategy is published. Level two requires municipalities to install continuous monitoring that must be informed by a screening process. If the screening process indicates that continuous monitoring may be required, the monitoring will have to include PM, SO_2, and

O_3. Other specific pollutants may be considered, but there is no requirement to include all the parameters.

b) Passive Diffusive Monitoring

Passive monitoring is an inexpensive method of monitoring over a large area and requires little human intervention. Passive badges can measure a range of pollutants including SO_2, NO_2, O_3, hydrogen sulphide (H_2S), hydrochloric acid, VOCs, and various aldehydes among others. Passive diffusive sampling calculates an average reading over a time period as opposed to real-time data acquisition that continuous monitoring can provide. Passive badges (Figure 43) have to be sent away to an accredited laboratory for analysis further extending the lag time in getting results (2 – 3 weeks). Passive sampling conforms to international methodologies and standards and can be used to validate dispersion modelling results.

However, there are limitations associated with passive monitoring. These include questionable concentrations, given that passive badge monitoring is based on diffusion of pollutants, making comparison with ambient air quality guidelines/standards difficult. Extreme meteorological conditions such as high humidity and temperatures influence diffusion rates, and hence, affect concentrations.

Figure 43: Passive badge sampling equipment

c) Proposed Air Quality Monitoring for the Dr RSM DM

No further monitoring is required until National Ambient Air Quality Standards are being exceeded. The Dr RSM DM should support the provincial Air Quality Monitoring Initiatives as described in the NW AQMP (NW-READ, 2015):

- Conducting passive air quality monitoring to establish pollution volumes per type of pollution in areas with no active air quality monitoring station,
- Publishing data/reports on the NW READ server and SAAQIS, and
- Drawing up agreements with privately owned stations (if any present in the district) to receive data.

Asbestos has been a problem in some of the northern areas of the Dr RSM DM in the past. It is recommended that an Asbestos monitoring program should be established in those areas. This would ensure that the ambient air concentrations of Asbestos in the area are not harmful to human health and confirm that the rehabilitation programmes were successful.

6.3. Vision, Mission and Objectives

The vision, mission, goals and objectives developed for the Dr RSM DM reflect the vision, mission and general approach for air quality management at the National, Provincial and Local levels. The National Framework for Air Quality Management (NEM:AQA, 2013) was referenced during this process to ensure the District is in line with National requirements.

6.3.1. Vision

Attainment and maintenance of good air quality for the benefit of all inhabitants and natural environmental ecosystems within the Dr RSM DM.

6.3.2. Mission

- To ensure the maintenance of good air quality through proactive and effective management principles that take into account the need for sustainable development into the future.
- To work in partnership with communities and stakeholders to ensure that the air is healthy to breathe and is not detrimental to the well-being of persons in the Dr RSM DM.

- To ensure that future developments (transportation, housing etc.) minimise air quality impacts.
- To reduce the potential for damage to sensitive natural environmental systems from air pollution both in the short and long term.
- To facilitate intergovernmental communication at the Local, Provincial and National levels to ensure effective air quality management and control in the Dr RSM DM.

6.3.3. Commitment

- Integrating air quality considerations into the town planning mechanisms especially when considering housing, transportation and spatial planning developments.
- Raising awareness around air quality issues, thereby promoting community well-being and empowerment.

6.3.4. Strategic Goals and Objectives

- Implementing the Air Quality Management Plan within the Dr RSM DM.
- Assigning clear responsibilities and functions for air quality management.
- Air quality training of current and future air quality personnel at the Local level.
- Obtaining the necessary resources and funding for air quality management.
- Maintaining good air quality within the boundaries, with specific emphasis on Particulates, Asbestos and SO_2 concentrations.
- Compliance monitoring and enforcement of air quality legislation, policies and regulations.
- Assessing the contribution of various activities / sources to ambient air quality and establishing measures to control emissions from these sources.

6.4. Human Resources

As per Schedule 4, Part B, Section 156 of the Constitution, air pollution is an exclusive function of Local Municipalities (NEM:AQA, 2013). Air quality functions are, therefore, primarily the responsibility of the Local Government, with support to be provided from Provincial and National Government. Within the Dr RSM DM, support is provided to Local Municipalities by the District Municipality and North West Province.

For the Dr RSM DM AQMP to be effective, co-operative governance and political buy-in across all spheres of government will be required, as well as the capacity to enforce compliance with new legislation. It is recognised that air quality management and control is primarily a function of District Municipalities with emission licensing functions undertaken by the NW READ Department. In order to increase capacity in Local Government, authorities need to invest both time and capital. For Municipalities to fulfil their regulatory role in terms of air quality, dedicated Air Quality Officers and personnel need to be appointed. All newly appointed Air Quality Officers should be sent to undergo relevant training.

Municipalities are also required to undertake monitoring, data analysis and reporting on ambient air quality as per their mandate as air quality authorities. Training on calibration and maintenance of analysers in the ambient monitoring stations will be required, as well as training on data acquisition and analysis. For this task, technical personnel will need to be appointed. Alternatively, this function needs to be outsourced.

According to legislation (NEM:AQA, 2004) , Municipalities are required to appoint an Air Quality Officer. Currently, no dedicated Air Quality Officers have been appointed within the Local Municipalities, with air quality functions forming part of other EHPs responsibilities. The Dr RSM DM currently has ten Environmental Health Practitioners who were assigned to air quality along with their other environmental and pollution control duties.

6.4.1. Local Municipalities

It is not recommended that a fulltime air quality officer be appointed in each of the Local Municipalities but it should form part of an EHPs (or equivalent) duties, as long as support is continually provided by the Dr RSM DM and the Province. Various capacity building strategies should be initiated to equip staff within the Dr RSM DM and within each Local Municipality with the necessary skills. The Dr RSM DM should collaborate with Industry and other Municipalities which are actively involved in air quality matters. Inter-governmental co-operation and co-ordination will support information sharing and dissemination. Each Local Municipality should support the Dr RSM DM air quality management initiatives.

6.4.2. Summary

A summary of the air quality responsibilities of the Dr RSM DM as per the National requirements are given in Table 39.

Table 39: Air quality responsibilities of the Local Municipalities as per the National Requirements (NEM:AQA, 2004)

Air Quality Functions	National Requirements	Current Resources	Required Resources
Identify priority pollutants	Municipalities may, in terms of a by-law, identify substances or mixtures of substances which represent a threat to health, well-being or the environment in the Municipality. As per the generic air pollution control by-law, a Municipality must compile a list of substances (using set criteria) which must be submitted to Standards South Africa to develop local emission standards.	Seven National criteria pollutants have been identified (SO_2, NO_2, O_3, CO, Pb, PM_{10}, $PM_{2.5}$ and C_6H_6). No clear capacity exists for the identification and prioritisation of pollutants in the LM.	Measures are currently not required for identification of any additional priority pollutants in the District.
Establish local emission standards	Municipalities may, in terms of a by-law, establish local standards from point, non-point and mobile sources. If National or Provincial standards have been established, a Municipality may not alter such standards except by establishing stricter standards. As per the generic air pollution control by-law, a Municipality must formally request Standards South Africa to develop local emission standards. Standards South Africa will develop (using a set methodology) local emission standards. Once developed, the local emission standards will be published.	National emission standards were established as part of the Listed Activities and Minimum Emissions Standards legislation. Insufficient capacity exists for the drafting of local emission standards.	More stringent local emission standards are currently not required for pollution sources in the District.
Establish local air quality	No provision is made for the setting of	National Air Quality Standards	The National Air Quality Standards should

standards.	standards by local authorities. However, Local Government may establish more stringent local air quality guidelines for the purpose of air quality management.	have been established by DEAT. Local air quality guidelines have not been established for the District.	be adopted for the District. More stringent local air quality guidelines are not required.
Appoint Air Quality Officers.	Each Municipality must designate an Air Quality Officer from its administration to be responsible for air quality management. Duties and functions of an Air Quality Officer have been prescribed in the generic air pollution control by-law.	No dedicated Air Quality Officers have been appointed within the Local Municipalities. Air quality functions currently form part of other EHPs' responsibilities and are not separate, dedicated positions.	A dedicated Air Quality Officer should be appointed in each Local Municipality, where required. Air Quality Officers should attend air quality courses including monitoring, modelling and management courses.
Develop and implement an Air Quality Management Plan.	Each Municipality must include an Air Quality Management Plan in its Integrated Development Plan. An annual report must be submitted on the implementation of its Air Quality Management Plan.	Limited capacity is available to develop and implement an Air Quality Management Plan.	An AQMP Implementation Task Team should be established in the District comprising representatives from industry, Government, NGOs, CBOs and other institutions. The Implementation Task Team should meet on a quarterly basis during the implementation phase.
Ambient air quality monitoring.	The National Framework has established national norms and standards for Municipalities to monitor ambient air quality.	No continuous ambient air quality monitoring is being undertaken in the District.	Local Municipalities should provide support when monitoring by the Province, Industry and Academia is conducted.

7. EMISISON REDUCTION AND MANAGEMENT INTERVENTIONS

Emission reduction measures are proposed for sources identified in the Dr RSM DM. Where possible, timeframes were assigned to each intervention. Generic timeframes ranging from short term (1 – 2 years), medium term (3 – 5 years) and long term (5 – 10 years) were assigned.

Where possible, emissions from industrial activities as well as other contributing sectors were quantified as part of the Baseline Assessment (Section 5). For those industries that did not provide their emissions information, Dr RSM DM should formally request this information from each of the industries in the district. In addition, smaller companies and industries that were not included in this plan should be identified and quantified.

7.1. Mining Operations

Mining activities within the Dr RSM DM include approximately 129 mines and/or mining operations. Fugitive emissions from mining and processing activities could be monitored to better quantify and manage emission from mining operations.

7.1.1. Proposed Interventions

Possible management intervention:

- Develop a list of active mines and mining operations in the Dr RSM DM, with associated emissions inventories.

Possible Emission reduction interventions that can be employed by mining companies within the Dr RSM DM include

- dust suppression with water tankers to spray the roads,
- dust suppression on the tailings dam walls and traversed tailings once the walls have been raised,
- extraction fans with air filters to reduce dust and emissions at the Analytical Laboratories,
- scrubber plants outside the Analytical Laboratories to reduce emissions,
- planned vehicle maintenance programmes to reduce CO_x emissions, and
- development of a monitoring system for emissions released during blasting and other activities.

7.2. Industries

Industries include Listed activities and Small Boilers, the scale of the intervention and the subsequent implementation strategy should be tailored to the size of the industry.

7.2.1. Proposed Interventions

Industries in the Dr RSM DM are mainly small to medium-sized industries and include brick making, cement production, and limestone distribution. The inventory compiled for the Dr RSM DM as part of the AQMP represents the first step towards identifying and quantifying industrial emissions. The Dr RSM DM and Local Municipalities will need to update this emissions inventory to include the other industries where no information was available.

At a minimum, the emissions inventory should include information on

- company name and contact details,
- type of fuel burning appliance (e.g. boiler, incinerator, furnace),
- make and model of fuel burning appliance,
- type of fuel,
- quantity of fuel used,
- stack parameters (height, diameter, gas exit temperature and gas exit velocity),
- sulphur and ash content of fuel (where applicable),
- periods of operation, and
- control equipment (e.g. grit collectors).

Table 40: Proposed emission reduction interventions for industries

Intervention	Responsible Party	Timeframe
Support NW READ in conducting compliance monitoring of AEL conditions.*	DM, NW READ, DEA	Ongoing
Discuss emission reduction measures with individual companies that operate within DM.*	DM, NW READ	Medium Term
Implement short term emission reduction measures.*	DM, NW READ	Medium Term
Mid-term review of reduction measures.*	DM, NW READ	Medium Term
Identify and register all controlled emitters.*	LM, DM, NW READ	Medium Term
Develop emission reduction plan/measures for controlled emitters.*	LM, DM, NW READ	Medium Term
Enforce air emissions reduction measures for controlled emitters.*	LM, DM, NW READ	Medium to Long Term
Identify non-listed sources of air pollution in the	LM, DM, NW READ	Medium Term

province.*		
Identify priority pollutants per LM.*	LM, DM, NW READ	Medium Term
Conduct compliance monitoring of non-listed activities (get reports from activities). *	LM, DM, NW READ	Medium Term
Develop emission reduction measures for identified activities.*	LM, DM, NW READ	Medium Term

* Adapted from the North West Air Quality Management Plan (NW-READ, 2015).

7.3. Domestic Fuel Burning

7.3.1. National Government Interventions

The DME published the Energy Efficiency Strategy of the Republic of South Africa in 2011. This strategy allows for the immediate implementation of no-cost and low-cost interventions, as well as higher-cost measures with a short payback period. This strategy aims to make energy affordable to everyone, and to minimise the effects of energy usage on human health and the environment. Measures to reduce energy demand include the introduction of standards for housing and household appliances, energy labelling of appliances, and awareness campaigns around the cost-benefits of energy efficiency within households. The approach is focused on energy efficiency in higher income areas as well as in state-subsidised housing which will incorporate energy efficiency measures (DoE, 2011).

The top-down ignition method, called ‘Basa Njengo Magogo’, which has proven to be successful, is considered a short- to medium-term solution to address domestic fuel burning (Figure 44). This method, meaning ‘make fire like grandmother’ is a top-down approach to fuel loading in mbawulas and stoves. In the classical bottom-up fire ignition approach, the order of preparing a fire is paper, wood then coal. In the ‘Basa Njengo Magogo’ method, the order of preparing a fire is coal, paper, wood and a few pieces of coal at the top (Le Roux, 2009). Smoke generated in the latter method is burnt as it rises through the hot zone, resulting in reduced smoke emissions. In 2004, the CSIR undertook controlled laboratory tests of the Basa Njengo Method to determine the reduction in particulate emissions. These tests demonstrated an 80% to 90% reduction in smoke emissions and a 20% reduction in fuel consumption (le Roux, 2009).

Figure 44: The 'Basa Njengo Magogo' fire-lighting Method (left) and classical fire lighting method (right)

7.3.2. Proposed Interventions

Emissions from domestic fuel burning need to be accurately determined to ensure that the contribution to the overall ambient air quality in the Dr RSM DM is accurately quantified. As part of the Status Quo Assessment (Section 5), a first step in the quantification of domestic fuel burning was undertaken. This initial domestic fuel burning emissions inventory needs to be updated as population statistics become available.

An awareness campaign should be initiated in the Dr RSM DM to educate people on the social and financial benefits of using alternative options. This awareness campaign (or strategy) should use all forms of media including television, radio, newspapers and flyers. The use of other forms of domestic energy such as low smoke fuels (such as char briquettes), gas (Liquid Petroleum Gas) and paraffin should also be encouraged (where available and accessible).

A viable option is considered to be the introduction of energy efficiency measures into low-cost housing. Such measures include solar water heaters, roofing insulation and energy efficient lighting to reduce financial costs and environmental impacts (Table 41).

Although electrification is often the preferred option, domestic fuels are often still used even after electrification due to factors such as affordability, accessibility and social preferences.

In 2013, Eskom initiated a pre-feasibility study for an offset project, whereby the stack emissions from Eskom's power plants would be offset by household emission reductions.

This intervention project can be implemented in areas where air quality is impacted both by Eskom and domestic fuel burning in households. Interventions will include

- fully retrofitting subsidy houses with thermal insulation in both the walls and ceilings,
- installing ceilings and ceiling insulation in houses that do not have ceilings,
- designing and constructing new subsidy houses which have a high thermal standard (shell insulation, ventilation, orientation, surface to volume ratio and solar heat absorption),
- replacing old stoves with new smokeless stoves,
- subsidising electricity and electric heaters, and
- providing subsidised Liquefied Petroleum Gas (LPG) and heating appliances (and possibly also cooking appliances) through a "stove-for-LPG" exchange programme.

It is proposed that a similar offsetting project should be considered within the Dr RSM DM in areas with high domestic fuel burning emissions.

Table 41: Proposed emission reduction interventions for domestic fuel burning

Intervention	Responsible Party	Timeframe
Review domestic fuel burning emissions inventory with updated population statistics as these become available.	DM	Medium Term
Conduct a count of all illegal settlements and establish an estimate of the number of residents within these settlements (support).*	LM	Medium to Long Term
Identify and prioritise the residential areas using fossil fuels that require installation of air quality monitoring equipment.*	LM, DM	Medium Term
Develop a domestic fuel burning strategy.*	LM, DM	Medium Term
Create awareness campaigns around the negative health impacts of domestic fuel burning.	DM, DEA	Short Term
Continue implementing the 'Basa Njengo Magogo' method in informal settlements.	DM, NW READ	Short Term
Encourage the distribution of alternative forms of domestic energy such as LPG, LSF, gas, methanol, etc.	DM	Medium Term
Implement electrification in informal	DM	Medium to Long

settlements.		Term
Ensure that all low-income formal houses have insulated ceilings.	DM	Short to Medium Term

* Adapted from the North West Air Quality Management Plan (NW-READ, 2015).

7.4. Transportation

7.4.1. National Government Interventions

In 2013 the Department of Transport (DoT) (DoT, 2013) published an Integrated Strategy for the Control of Motor Vehicle Emissions. The strategy specifically targeted motor vehicles emissions in South Africa, with 2009 as the base year. The focus of the strategy was vehicle emission reduction strategies and included the predicted effect on emissions as a consideration. The Strategy included action plans for the following activities:

- improving fuel quality,
- setting emission standards for new vehicles,
- setting emission standards for in-use vehicles,
- expanding the public transport system, and
- using compressed natural gas in buses and taxis.

The Air Quality Act makes provision for the Minister or Provincial MECs to declare vehicles or vehicles falling within a specified category as a ‘controlled emitter’. Emission standards, which include standards setting the permissible amount, volume, emission rate or concentration of a specified substance or a mixture of substances, need to be established for such emitters. Measurements of emissions from controlled emitters must also be carried out. The Act also makes provision for the declaration of a substance or a mixture of substances as a ‘controlled fuel’. Standards may be established for the use, manufacture, sale and composition of the controlled fuel. Alternatively, the manufacture, sale or use of the controlled fuel could be prohibited (NEM:AQA, 2013).

7.4.2. Proposed Interventions

Vehicle emissions within the Dr RSM DM are not considered to be a major source of atmospheric emissions. Vehicle numbers are significantly lower than those observed within other major cities such as Johannesburg and Cape Town.

Proposed emission reduction interventions to address emissions from the transportation sector are given in Table 42.

Table 42: Proposed emission reduction interventions for transportation

Intervention	Responsible Party	Timeframe
Review vehicle emissions database with updated traffic count data as these become available.*	DM	Short Term / Ongoing
Compile a detailed assessment of the vehicle fleet in the Municipality including information on vehicle numbers, type, age and fuel usage.	DM	Medium Term
Synchronise traffic lights.	DM	Ongoing
Create inventories for vehicular emissions.	LM, DM, NW READ	Medium Term

* Adapted from the North West Air Quality Management Plan (NW-READ, 2015).

7.5. Agriculture

7.5.1. Proposed Interventions

Agriculture is a dominant land use within many areas of the Dr RSM DM. Emissions from agricultural activities such as crop spraying, crop burning, harvesting and N-fertilizer application are potentially significant sources of air pollution in the Dr RSM DM. Information on the quantity of pesticides sold in the local municipalities should be obtained as a first step in quantifying the potential impact of crop spraying. Impacts associated with crop spraying can be minimised by ensuring that crops are sprayed during periods of favourable meteorological conditions, such as when wind speeds are low, to reduce spray drift.

Adjusting the methods for managing land and growing crops can result in the reduction of agricultural emissions. Fertilizing crops with the correct amount of Nitrogen can result in lower NO emissions.

Proposed emission reduction interventions for agricultural activities are given in Table 43.

Table 43: Proposed emission reduction interventions for agriculture.

Intervention	Responsible Party	Timeframe
Obtain information on the quantity of pesticides and fertilizers consumed in the LM. Develop relationship with pest control associations in the area	LM, DM, and Agri-NW	Ongoing
Adopt environmentally sound pest control techniques.*	Agri-NW, NW READ	Ongoing
Ensure that crop spraying takes place under favourable atmospheric conditions that reduce	LM, DM	Ongoing

spray drift, i.e. when wind speeds and temperatures are low.		
Allow agricultural burning only under favourable dispersion conditions which occur in the middle of the day.	LM, DM	Ongoing
Update agricultural inventories.*	LM, DM, NW READ	Medium Term

* Adapted from the North West Air Quality Management Plan (NW-READ, 2015).

7.6. Biomass Burning

7.6.1. Proposed Interventions

Emissions arising from biomass burning are difficult to accurately quantify due to the seasonal and irregular nature of this source.

Public awareness, specifically with farm owners, should be raised about the dangers associated with uncontrolled fires and the implications for air quality and human health. Possible forms of media include community forums, television, radio, newspapers and posters. Establishing relationships between systems operators (e.g. the CSIR, ARC, etc.) to help identify, manage, and quantify the emissions from biomass burning.

The emission reduction interventions for biomass burning are given in Table 44.

Table 44: Proposed emission reduction interventions for biomass burning

Intervention	Responsible Party	Timeframe
Identify and quantify emissions from biomass burning.	LM, DM	Short to Medium Term
Identify the role of fire services to assist in air pollution control.	LM, DM	Short Term
Each local Fire Department should maintain and update a database of the locations of veld fires and the extent of the areas burnt.	LM	Short to Medium Term (initiation) and ongoing
Establish a biomass burning advisory line which will help people to burn on days that are not hazardous to air quality or runaway fires. A complaints line should also be set up.	LM, DM	Medium Term
Update biomass burning inventories.	LM, DM, NW READ	Medium Term

* Adapted from the North West Air Quality Management Plan (NW-READ, 2015).

7.7. Waste Treatment and Disposal

7.7.1. Proposed Interventions

Emissions from waste treatment and disposal facilities (with the exception of incinerators) are an important contributor to air quality due to the pollutants released and the increase in these pollutants released if they are poorly maintained.

Landfill sites within the Dr RSM DM also need to be issued with permits to ensure that these landfills are effectively managed and controlled, and to reduce illegal dumping and waste burning. The responsibility of issuing landfill permits and of ensuring that landfills operate within their permits will be delegated to the province. Several Municipalities within South Africa, including the eThekwini Municipality in KZN, have initiated a waste-to-energy programme. Three projects at the La Mercy, Mariannhill and Bisasar landfill sites were initiated and are believed to be producing 7,5 MW of electricity (Gumbo, 2013).

Similar to the waste-to-energy programmes from landfills, waste water treatment works can be run off the electricity generated from the conversion of waste (methane) to energy. Control mechanisms can be placed in the plants whereby aerators are controlled by the levels of ammonia in the waste water (E Mare 2014, Pers. Comm., 14 April).

Again, awareness campaigns around the environmental benefits of recycling should be promoted. These campaigns should focus on schools with recycling bins and depots installed at each school in the region. Proper refuse collection in all areas within the Dr RSM DM will also minimise illegal waste dumping and domestic waste burning in informal settlements.

Other possible interventions include landfill gas monitoring and rehabilitation of closed landfill sites. The proposed interventions for waste treatment and disposal are provided in Table 45.

Table 45: Proposed emission reduction interventions for waste treatment and disposal

Intervention	Responsible Party	Timeframe
Ensure all operating incinerators are issued with permits and are operating within their permit requirements.	READ, DM, LM	Short Term
Maintain a current database of landfill sites, including those with permits and those without.	DM, READ, DEA	Short Term

Introduce awareness programmes and public education of waste minimization and recycling initiatives.	DM, LM	Medium Term
Reduce illegal dumping and the creation of informal landfills through efficient waste removal service delivery in residential areas.	READ, DM, LM	Medium Term
Undertake landfill gas monitoring and management schemes.	READ, DM, LM	Ongoing
Initiate a waste-to-energy project to reduce waste at landfill sites and produce energy.	LM	Long Term
Initiate waste to energy and aerator control mechanisms in WWTW.	LM	Long Term

8. RECOMMENDATIONS AND CONCLUSION

8.1. Pollutants, Sources and Impact Areas

The main pollutants identified to be of concern in the Dr RSM DM are PM_{10} and SO_2. The main sources influencing the air quality in the Dr RSM DM have been identified to be:

- Mining – mainly fugitive dust emissions from mining activities (tailings). Mining is the largest source of PM_{10} emissions in the Dr RSM DM.
- Industries – mainly emissions from fuel burning and fuel handling. Industrial sources emit the majority of the SO_2 emissions in the District, as well as contributing to PM_{10} concentrations.
- Domestic fuel burning – mainly coal, wood and paraffin burning in informal settlements.
- Agricultural activities – agricultural activities are considered to be an important source of ambient particulate concentrations with the second highest PM_{10} contribution in the Dr RSM DM.
- Biomass burning – data for the burning of biomass in the Dr RSM DM is limited, but is not considered to be an important contributor to ambient particulate concentrations.
- Other fugitive dust sources such as wind erosion of exposed areas – emissions have not been quantified as part of the AQMP.

Mining (tailings) was identified to be one of the main contributing sources to PM_{10} emissions (93%) in the Dr RSM DM with agricultural activities contributing approximately 4%. Vehicles, agriculture and industrial activities are the main contributing sources of NO_X emissions in the Dr RSM DM. Mining contributes 70% of the total emissions in the Dr RSM DM followed by industrial activities (16%) and vehicles (6%).

8.2. Capacity Building within Government

The current capacity for effective and co-ordinated air quality management of the Dr RSM DM is limited by the shortage of personnel, skills and tools. Air quality management is a relatively new function within the District as a whole. Where required, air quality support is provided to the Local Municipalities by the District Municipality and by the Province.

8.2.1. Human Resources

It is recommended that an Air Quality Officer be appointed in each of the Local Municipalities. However, given the resources and finances required for these appointments, it is recommended that the current support provided to the Local Municipalities by the Dr RSM DM and NW READ should be defined according to the specific air quality management needs. Sufficient training of officials should be conducted with regards to the air quality management needs.

8.2.2. Air Quality Management Tools

Air quality management tools are required in the Dr RSM DM to effectively fulfil their air quality management functions. Such tools include emissions inventory software (Microsoft Excel will be sufficient), dispersion modelling software and air quality monitoring hardware. The first step in compiling an emissions inventory for the Dr RSM DM has been achieved as part of this AQMP. The Dr RSM DM should complete and regularly update the emissions inventory. As and when dispersion modelling skills are available, a range of models are available either as freeware or for purchase.

The Dr RSM DM should not currently acquire new Ambient Air Quality Monitoring Stations. A screening process should first be undertaken, as per the draft National Ambient Air Quality Monitoring Strategy, to establish whether there is a need for new Ambient Air Quality Monitoring Stations in the District.

8.2.3. Knowledge and Information Management

The North West Air Quality Management Plan outlines actions for the different spheres of government within the province. The actions that should be implemented by the Dr RSM DM include (NW-READ, 2015):

- Develop and implement an air quality management plan (AQMP) and ensure that it is included in the IDP.
- Support the province in developing an awareness strategy to improve the understanding of air quality and its impacts in the District. This includes providing input on the communication mechanism, the level of information required and the language of communication.
- Implement this awareness strategy.
- Support the province in conducting training for air quality officers across the province/district.
- Support the province in identifying and recommending AQM courses to train officials.
- Expand the stakeholder database for non-industry emissions.
- Provide support to the province with regards to updating NAEIS annually.
- Continually update its emission inventory.

8.3. Summary of Emission Management Interventions

Emission reduction interventions have been recommended for air pollution sources in the Dr RSM DM. Interventions for the major sources are summarised in the sections below. The proposed interventions should be tailored by the Dr RSM DM for each specific source.

8.3.1. Mining

Recommended interventions for the mining industry:

- Comprehensive emissions inventories need to be developed / obtained for each mine in the Local Municipalities.
- All small mines and quarrying operations that were not included in the AQMP need to be identified and quantified where possible.
- The rehabilitation of old mine dumps and slimes dams should be encouraged.
- Ambient air quality monitoring, in particular dust fallout and PM_{10} monitoring, should be undertaken by the mines to determine ambient particulate levels.

8.3.2. Industries

Recommended interventions for industries:

- The electronic database of all small industries developed as part of this AQMP should be updated to account for the industries that did not respond to requests for information. Thereafter, it should be updated regularly by the Local Municipalities and the District Municipality in conjunction with the North West Province.

8.3.3. Domestic Fuel Burning

Recommended interventions in the *short to medium term* for domestic fuel burning:

- The domestic fuel burning emissions inventory should be reviewed with updated population statistics as these become available.
- An awareness raising programme through media campaigns and community forums should be developed to educate the public around the negative health impacts of domestic fuel burning.
- The District should encourage the distribution of alternative forms of energy such as low smoke fuels (by replacing coal with cheaper low smoke char briquettes) and liquid petroleum gas (LPG).
- Electrification in informal areas should be actively undertaken.
- Promotion of the ‘Basa Njengo Magogo’ method should be continued.

8.3.4. Transportation

Recommended interventions in the *short to medium term*:

- The vehicle emissions database should be reviewed with updated traffic count data as these become available.
- A detailed assessment of the vehicle fleet in the Dr RSM DM should be undertaken including information on vehicle numbers, type, age and fuel usage. Information has been obtained on the vehicle sales and fuel sales for the District.
- Traffic lights should be synchronized to promote traffic flow.
- Integrated public transport strategies for the main transport routes through the main towns should be considered. Similar interventions may be borrowed from successful projects such as Tshwane and Bojanala Municipalities.

8.3.5. Agriculture and Biomass Burning

Recommended interventions for agriculture:

- Local municipalities should obtain information on the quantity of pesticides and fertilizer consumed.
- Crop spraying should only take place under favourable atmospheric conditions to reduce spray drift.
- Agricultural burning should also only be allowed under favourable dispersion conditions to reduce the air quality impact.

Recommended interventions for biomass burning:

- Emissions from biomass burning need to be accurately quantified.
- The role of the fire services in air pollution control needs to be identified in the Local Municipalities.
- Each local Fire Department should maintain and update a database of the locations of veld fires and the extent of the areas burnt. This will assist with the quantification of biomass burning emissions.
- A biomass burning advisory line should be established by the Municipality to assist with agricultural burning.

8.3.6. Waste Treatment and Disposal

Recommended interventions for waste treatment and disposal:

- The Municipality should develop a detailed emissions inventory of all waste sources in the area including any incinerators, sewage and waste water treatment works and landfills.

- Any other operating incinerators should be licensed and operating within their license requirements.
- The Municipality should introduce awareness raising programmes around waste minimization and recycling initiatives.
- Service delivery of waste removal in residential areas should be efficient in order to reduce illegal dumping and burning.
- Recycling initiatives at illegal dumping sites have proven successful in some Local Municipalities. It is recommended that these initiatives be implemented in the Dr RSM DM.

8.4. Human Resource Recommendations

Currently, the management of the Air Quality in each Local Municipality of the Dr RSM DM can form part of the duties of an EHP, rather than appointing a dedicated Air Quality Officer on a full-time basis. However, the Dr RSM DM and NW READ should provide support to the EHPs until such time as a dedicated, full time AQO is required.

The EHP/AQO should advise the relevant department regarding the review of the AQMP, preferably every 5 years. In addition, the EHP/AQO should advise the relevant department if they have identified any changes that should be made in the AQMP, prior to the scheduled review of the document. The AQMP should be considered to be a living document that would require changes as they arise.

The DEA published a Business Case Report (e-tool) in 2015 (DEA, 2015b) that provides an assessment of functions and workloads that Air Quality Units / Divisions are required to undertake. It was developed to assist authorities in understanding capacity requirements for implementing the requirements of the NEM:AQA (DoE, 2013). The Business Case Report could be used as a reference source to identify the quality and number of human resources, the infrastructure and the financial resources required to effectively manage air quality at both Local and District Municipality levels.

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APPENDIX A:

List of operating mines and quarries in the Dr RSM DM (DMR, 2015)

Mine Code	Mine Name	Mine Owner	Postal Address	Telephone & Fax Number	Commodity	Magisterial District & Province	Area	Province	Operational Status & Type Of Mining	Farm Names
14823	Barend Frederik Du Plessis	Barend Frederik Du Plessis	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Welgedaan 292 Ho
15210	Bassfour 2782	Sarel Potgieter	Po Box 627 Christiana 2680	083 540 2589 (053) 441 3107	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Zoutpan 301 Ho; Witgatboom 317 Ho
14550	Bitflow Investments 20 (Pty) Ltd	Bitflow Investments 20 (Pty) Ltd	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Zevenfontein 240 Ho
14525	Central High Trading 58 - Mooifontein	Central High Trading 58	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Mooifontein 140 Ho
14852	Christiaan Stephanus Swan	Christiaan Stephanus Swan	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Bessieslaagte 328 Ho
13993	Coenraad Du Toit	Coenraad Du Toit	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Gezicht 265 Ho
14632	Daniel Johannes Jacobus Van Zyl	Daniel Johannes Jacobus Van Zyl	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Zwartlaagte 345 Ho
13984	Desitelf 18 T/A Gz Mining	Biccy Arnoldi	Po Box 618 Fountainbleau 2032	(011) 792 1006 (011) 792 1006	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Catharina 44 Hn
13990	Dj Fourie	Little Rock Trading 6 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Wildgooselodge 136 Ho
13871	Ds Snyders	Ds Snyders	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Olievenfontein 114 Ho

Mine Code	Mine Name	Mine Owner	Postal Address	Telephone & Fax Number	Commodity	Magisterial District & Province	Area	Province	Operational Status & Type Of Mining	Farm Names
14528	Dumela Diamonds	Dumela Diamonds	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Blesbok 143 Ho
14133	Gert Venter	Gert A Venter	Po Box 540 Bloemhof 2660	082 413 2289	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Klipfontein 344 Ho
14566	Global Gem Minng (Pty) Ltd	Global Gem Mining (Pty) Ltd	Po Box 1086 Schweizer Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Matlabanestad 299 Ho
15126	Glomix 109 Bk - Wildgooselodge	Little Rock Trading 6 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Wildgooselodge 136 Ho
13585	Hendrik George Rohlandt	Hendrik George Rohlandt	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Avondster 142 Ho
15198	Leopard Lilly Trading	Hs Badenhorst	Po Box 713 Bloemhof 2660	083 274 8541 (053) 433 1286	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Swartlaagte
14367	Lomlex	Viska Delwery	Po Box 1086 Schweizer Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Kareepan 336 Ho
13858	Long Island - Grootdoorns	Long Island Trading 400 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Grootdoorns 116 Ho Various
14138	Mr Cooperation (Pty) Ltd	Sonop Delwery	Po Box 21 Delportshoop 8377	(053) 562 0041 (053) 562 0046	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Kromellenboog 320 Ho
13740	Panfontein Delwery	Gpj Grobbelaar	Po Box 586 Welkom 9460	(057) 353 4413 (057) 353 2339	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Morgenroodt
13780	Papavangelo Trading 26 (Pty) Ltd	Sonop Delwery	Po Box 21 Delportshoop 8377	(053) 562 0041 (053) 562 0046	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Witgatboom 317

Mine Code	Mine Name	Mine Owner	Postal Address	Telephone & Fax Number	Commodity	Magisterial District & Province	Area	Province	Operational Status & Type Of Mining	Farm Names
14265	Pgl Boerdery - Schoonzight	Pgl Boerdery (Pty) Ltd	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Schoonzight 237 Ho
14113	Pharatlhatle Small Mining Cc	Pharatlhatlhe Small Mining Cc	Po Box 960 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Christiana Town And Townlands 325 Ho
14769	Praxos 604 Cc - Brussels	Praxos 604 Cc	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Brussels 736 Hn; Driepoort 664 Hn; Dwaarsrivier 741 Hn; Grootkloof 737 Hn; Jacobs Val 817 Hn; Kromkloof 738 Hn; Lisbon 739 Hn; Takwanen Native Reserve 662 Hn; Venters Dwaak 717 Hn; Willoughby 744 Hn
14317	Range View Trading 1010 (Pty) Ltd	Range View Trading 1010 (Pty) Ltd	Po Box 1086 Schweizer Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Vechtvallei 122 Ho
14273	Saaiman Diamond Mining Trust	Hp Saaiman	Po Box 124 Bloemhof 2660	083 254 3756 (053) 433 1856	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Swartlaagte 749 Ls
14318	Spring Green Trading 115 Cc	Spring Green Trading 115 Cc	Po Box 93 Schweizer Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Schoonzicht 237 Ho

Mine Code	Mine Name	Mine Owner	Postal Address	Telephone & Fax Number	Commodity	Magisterial District & Province	Area	Province	Operational Status & Type Of Mining	Farm Names
14750	Trustees Of The Heleen Zerwick Trust	Trustees Of The Heleen Zerwick Trust	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Honi-Soit-Quimal-Y-Pense 275 Ho 3; Kameelpan 276 Ho 7
14824	Trustees R & S Delwery Trust	Trustees R & S Delwery Trust	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Avondster 142 Ho; Olievenfontein 114 Ho
14348	Vaalbrass Foundry (Pty) Ltd	Sonop Delwery	Po Box 21 Delportshoop 8377	(053) 562 0041 (053) 562 0046	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Kareefontein
15185	Van Wyk Delwery Site 1	Jj Van Wyk	Po Box 552 Wolmaransstad 2630	(018) 596 2689 (018) 596 2689	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Kareepan 210 Ho Ext Of 1
15186	Van Wyk Delwery Site 2	Jj Van Wyk	Po Box 552 Wolmaransstad 2630	(018) 596 2689 (018) 596 2689	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Olievenfontein 114 Ho 5 7 8
14235	W & P Trust	W & P Trust	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Zevenfontein 240 Ho
15197	Wj Wessels - Kaalpan	Wj Wessels	Po Box 2122 Wilropark 1731	082 411 9949	Diamonds Alluvial	Christiana North-West	Christiana	North-West	Mine Opencast	Kaalpan 337 Ho
13322	Travryka Stene	Jh Stronkhorst (Edms) Bpk	Po Box 106 Christiana 2680	(053) 441 2054 (053) 441 2054	Shale Brickmaking	Christiana North-West	Christiana	North-West	Mine Opencast	Christiana Commonage Ptn 16
14069	Brittenmyn	Oos-Tvl Kalkverskaffers (Edms) Bpk	Po Box 948 Lichtenburg 2740	(018) 632 6046 (018) 632 3772	Limestone; Lime	Christiana North-West	Christiana	North-West	Mine Opencast	Kareepan 298 Hq; Kareepan 300 Hq; Kareepan 301 Hq
10673	Vaal River Salt Works Ltd	Vaal River Salt Works Ltd	Po Box 165 Bloemhof 2660	(053) 441 3911 (053) 441 3911	Salt	Christiana North-West	Christiana	North-West	Mine Opencast	Zoutpan 301 Ho

Mine Code	Mine Name	Mine Owner	Postal Address	Telephone & Fax Number	Commodity	Magisterial District & Province	Area	Province	Operational Status & Type Of Mining	Farm Names
14796	Vaalrivier Sandwerke - Goedehoop	Jh Appelgryn	Po Box 251 Christiana 2680	076 020 9965 (053) 441 3682	Aggregate; Sand Natural	Christiana North-West	Christiana	North-West	Mine Opencast	Goede Hoop 331 Ho
14955	Anix Trading 701 - Pleidooi	Anix Trading 701 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Pleidooi 92 Ho
14288	Anna Lock	Anna Lock	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Geluk 87 Ho; Maraetchesfontein 54 Ho; Panfontein 58 Ho
13918	Batavia Trading (Vryheid)	Batavia Trading	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Vryheid 154 Ho
14034	Batavia Trading 46 Cc - Ganspan	Batavia Trading 46 Cc	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Ganspan 194 Ho
14758	Bd Bouwer - Olievenfontein	Route 7 Trading 184 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Grootdoorns 116 Ho 4; Olievenfontein 114 Ho 2 & 9; Schoonzigt 237 Ho 4 & 14
14352	Bd Bouwer - Pienaarsfontein	Jodeo Four (Pty) Ltd	Po Box 93 Schweizer Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Pienaarsfontein 113 Ho

Mine Code	Mine Name	Mine Owner	Postal Address	Telephone & Fax Number	Commodity	Magisterial District & Province	Area	Province	Operational Status & Type Of Mining	Farm Names
14756	Belrex 592 - Maraetchesfontein	Belrex 592 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Biesielaagte 53 Ho 5 20 & 21; De Hoop 198 Ho 2 & 3; Diamanddoorns 169 Ho Ptns; Doornplaat 55 Ho 2 & 3; Makaauwkop 167 Ho 9 & 10; Maraetchesfontein 54 Ho 10 & 18
14822	Belrex 592 Cc - (Doornplaat)	Belrex 592 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Diamantdoorns 169 Ho; Doornplaat 55 Ho
15158	Bender Delwery	Three Diamonds Trading 429 (Pty) Ltd	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Vaalboschfontein 188 Ho
15146	Calandria 186 Cc	Kobus Kriek	Po Box 309 Schweizer-Reneke 2780	(053) 963 2900 (053) 963 2785	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Italie 381 Ho; Italie 123 Ho
13866	Central Node	Morning Dew Trading	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 086 719 7882	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Mahempannen 217 Ho
14155	Central Node (Pty) Ltd	Hilgardt Kairuz	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Ganspan 194 Ho
14135	Charles Muller Delwery	Ivory Sun Trading 2 (Pty) Ltd	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Bauchansville 61 Iq
14261	Circle Seven Trading 861 Cc	Circle Seven Trading 861 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Doornbult 393 Iq
14806	Corline 117 Cc	Trustees Fo The Ferdinant	Po Box 1086 Schweizer-Reneke	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke	Schweizer - Reneke	North-West	Mine	Pienaarsfontein 113 Ho

Mine Code	Mine Name	Mine Owner	Postal Address	Telephone & Fax Number	Commodity	Magisterial District & Province	Area	Province	Operational Status & Type Of Mining	Farm Names
		Pieterse Trust	2780			North-West			Opencast	
14871	Corne Van Der Merwe	Emanuel Mulder	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Mahempannen 217 Ho; Graspan 210 Ho
14506	Counter Point Trading 403cc - Leeuwbosch	Counter Point Trading 403 Cc	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Leeuwbosch 236 Ho
15060	Country Cloud Trading 174 Cc	Country Cloud Trading 174 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Hartklip 722 In; Eenzaamheid 717 In
14443	Dankie Oupa Delwery	Mattys Janse Van Vuuren	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Boschplaats 149 Ho; Vogelstruiskuil 400 Ho; Welverdient 151 Ho
14732	Develex 342 Cc - Mietjesdoorns	Develex 342 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Mietjesdoorns 187 Ho
14733	Develex 342 Cc - Weltevreden	Develex 342 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Weltevreden 176 Ho
15130	Ej Gagiano	Ej Gagiano	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Blyvooruitzicht 51 Ho
13904	Folmink Delwery	Cinlo Bk	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Koppie Alleen 221 Ho
14061	Frans Meyer	Frans Jacob Meyer	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Lustfontein 346 Ip
15207	Glomix 109	W Botha	Po Box 902 Schweizer Reneke 2780	071 689 2845 (053) 963 2005	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Zandfontein 90 Ho

Mine Code	Mine Name	Mine Owner	Postal Address	Telephone & Fax Number	Commodity	Magisterial District & Province	Area	Province	Operational Status & Type Of Mining	Farm Names
15212	Glomix 109 Cc	Te Pieterse	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Vaalpoort 84 Ho; Zandfontein 90 Ho
14216	Grasplaats Minerale Regte Bk	Grasplaats Minerale Regte Bk	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Goudplaats 96 Ho; Grasplaats 97 Ho
14315	Hpj Viljoen Adr Site	Hpj Viljoen	Po Box 765 Schweizer Reneke 2780	(053) 050 0306 (053) 050 0330	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Bothashoek 141 Ho; Kameelkuil 88 Ho Ptn 7; Krompan 85 Ho Ptns 10&11; Vaalpoort 84 Ho Ptn 6
14244	Is Viljoen - London	Is Viljoen	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	London 112 Ho
14338	J Smit	J Smit	Po Box 1086 Schweizer Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Mooifontein 140 Ho
13964	Jaco Greyling Delwery	Multilayer Trading 282 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Krompan 85 Ho
14747	Jag Van Straten	Jag Van Straten	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	De Park 87 Ho; Kaalpan 337 Ho 1; Kareepan 336 Ho 4
14549	Jan Harms Burger	Jan Harms Burger	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Vleeschkraal 145 Ho
14339	Japie Van Straten	Japie Van Straten	Po Box 1086 Schweizer Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Springbok 85 Ho
14210	Jm Van Der Merwe	Jm Van Der Merwe	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	De Hoop 1098 Ho

Mine Code	Mine Name	Mine Owner	Postal Address	Telephone & Fax Number	Commodity	Magisterial District & Province	Area	Province	Operational Status & Type Of Mining	Farm Names
14821	Jm Van Der Merwe - Driehoek	Jm Van Der Merwe	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	De Hoop 198 Ho; Ptn Driehoek
14361	Jodeo Four (Pty) Ltd - Folmink - Diamandfontein	Jodeo Four (Pty) Ltd	Po Box 1086 Schweizer Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Diamandfontein 220 Ho
14353	John Callender Easby	John Callender Easby	Po Box 1086 Schweizer Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Smithskraal 1519 Ho
14442	Klossiespan	J & S Zerwick Trust	Po Box 4 Christiana 2680	(053) 441 3740 (053) 441	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Klossiepan 279 Ho
14286	Koos Lock	Koos Lock	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Maraetchesfontein 54 Ho
14017	Little Rock Trading 6 Bk	Little Rock Trading 6 Bk	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Kameelkuil 88 Ho
14746	Long Island - Vaalpoort & Grootpoort	Long Island Trading 400 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Grootpoort 83 Ho Ptn 1; Mooifontein 140 Ho Ptn 2; Vaalpoort 84 Ho Ptns 2 & 3; Vuurfontein 117 Ho Ptn 17
15127	Long Island Trading 400 Cc - Zandfontein	Long Island Trading 400 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Zandfontein 90 Ho
14561	Manette Boerdery (Pty) Ltd	Manette Boerdery (Pty) Ltd	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Springbok 191 Ho

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14349	Meondo Trading 72 (Pty) Ltd	Meondo Trading 72 (Pty) Ltd	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Ganspan 194 Ho
13860	Miramar Trading	Miramar Trading 57 Cc	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Mahempannen 217 Ho
14509	Monroe Mining Trading (Pty) Ltd	Monroe Mining Trading (Pty) Ltd	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	London 112 Ho Various
14401	Morning Dew Trading 97 Cc	Morning Dew Trading 97 Cc	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Mahempannen 217 Ho
14805	Mulder Mining - Pienaarsfontein	Mulder Mining Investments	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Pienaarsfontein 113 Ho
14209	Muller Van Der Merwe	Muller Van Der Merwe	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Hamburg 82 Ho
14807	Multi Layer Trading 282 Cc	Multi Layer Trading 282 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Kameelkuil 88 Ho
14326	Multilayer Trading 781 Cc	Multilayer Trading 781 Cc	Po Box 1086 Schweizer Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Grootpoort 83 Ho
14953	Multileayer Trading 903 - Doornhoek	Multileayer Trading 903 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Doornhoek 109 Ho
15051	Nicus Delwery	Amber Cascades Trading 3 Cc	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Kameelkuil 88 Ho
14633	Nicus Delwery - London	Monroe Mining (Pty) Ltd	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	London 112 Ho

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13842	Nj Botha Delwery & Dj Nieuwoudt	Nj Botha Delwery & Dj Nieuwoudt	Po Box 673 Schweizer-Reneke 2780	083 450 0314	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Biesielaagte 53 Ho
14903	Njj Viljoen	Nicolaas Jacobus Johannes Viljoen	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Blyvooruitzicht 51 Ho
14154	Njj Viljoen - Koppiesfontein	Overture Trading 1038 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Koppiesfontein 52 Ho
14627	Northern Node (Pty) Ltd - Doornhoek	Doornhoek 777 Glaudina Bk	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Doornhoek 165 Ho
14808	Oceanside Trading 139 Cc	Oceanside Trading 139 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Mimosa 61 Ho
13859	Oersonskraal Mining (Pty) Ltd	Oersonskraal Mining (Pty) Ltd	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Oersonskraal 250 Ho
14820	P Deale	Paul Coetzer Pretorius	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Hamburg 82 Ho
15144	Pb Laas	Pb Laas	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Bosmanfontein 330 Ho
14759	Pieter Gideon Van Zyl	Pieter Gideon Van Zyl	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Kleindoorns 192 Ho 4
14626	Quick Leap Investments 377 (Pty) Ltd	Quick Leap Investments 377 (Pty) Ltd	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Vaalboschbult 195 Ho
15206	Reivilo Delwery	Monroe Mining (Pty) Ltd	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	London 112 Ho

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14773	Rietput Delwery - Koppie Alleen	Cinlo Bk	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Koppie Alleen 221 Ho
13982	Rietput Delwery Cc - Biesieslaagte	Rietput Delwery Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Biesieslaagte 53 Ho
14424	River Queen Trading 194 - Ganspan	River Queen Trading 194 Cc	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Ganspan 194 Ho
14162	Sh Kayser Delwery	Gct Trust	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Bloemheuvel 327 Ho
14745	South East Node - Oersonskraal	Jc Kuhn	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Oersonskraal 250 Ho
15176	South East Node (Pty) Ltd (2)	South East Node (Pty) Ltd	Po Box 93 Schweizer-Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Oersonskraal 250 Ho
14354	South West Node (Pty) Ltd	South West Node (Pty) Ltd	Po Box 93 Schweizer Reneke 2780	(053) 963 1108 (053) 963 1165	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Houtvollop 111 Ho
14112	Sybrand Van Dyk	Sybrand Van Dyk	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Homanvley 110 Ho
14974	Triple S Delwery	Oceanside Trading 139 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Mimosa 61 Ho
14757	Triponza Trading - Vaalpoort	Triponza Trading 345 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Vaalpoort 84 Ho 3
15128	Trustees Hannes De Jager Trust	Trustees Hannes De Jager Trust	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Doornhoek 165 Ho

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14872	Vaalbosch Diamond (Pty) Ltd	Vaalbosch Diamond (Pty) Ltd	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (087) 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Vaalboschfontein 188 Ho
14461	Valley Junction Trading 132 Cc	Valley Junction Trading 132 Cc	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 087 231 7021	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Zandfontein 90 Ho
14229	Van Zyl Broers Oerson - Syfergat	Van Zyl Broers Oerson - Syfergat	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Diamonds Alluvial	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Syfergat 237 Ho
14684	Nirvana Crushers Cc	Nivana Crushers Cc	Po Box 705 Schweizer-Reneke 2780	(053) 963 2446 (053) 963 1162	Aggregate; Sand Natural	Schweizer - Reneke North-West	Schweizer - Reneke	North-West	Mine Opencast	Mimosa 616; Nirvana 9
14703	Matayo Diamond Mine	Matayo Trading 7 (Pty) Ltd	Po Box 13509 Sinoville 0129	(053) 953 0108 (086) 655 8049	Diamonds Alluvial	Vryburg North-West	Vryburg	North-West	Mine Opencast	Graspan 773
14277	Mc Barnardt Delwery	Mc Barnardt	Voortrekker St 2 Leeudoringstad 2640	072 996 0368	Diamonds Alluvial	Vryburg North-West	Vryburg	North-West	Mine Opencast	Bernauw 674 In 56; Constantia
13065	Kalahari Gold Ridge Mine	Harmony Gold Mining Company Ltd	Po Box 101 Mareetsane 2715	(018) 332 1101 086 545 0376	Gold; Silver	Vryburg North-West	Vryburg	North-West	Mine Opencast	Ferndale 286 Io 11; Gold Ridge 295 Io; Goldridge 407 Io; Nottingham 299 Io; Spanover 284 Io 1 & 4
11597	Pering Mine	Pering Base Metals (Pty) Ltd	Posnet Suite 253 Private Bag X30500 Houghton 2041	(011) 484 2240 (011) 484 2262	Zinc Metal Ic	Vryburg North-West	Vryburg	North-West	Mine Opencast	Pering 1022
12089	Noordkaap Steenwerke	Noordkaap Steenwerke Bk	Po Box 272 Stella 8650	(053) 983 0136 (053) 983 0136	Clay Brickmaking; Shale Brickmaking	Vryburg North-West	Vryburg	North-West	Mine Opencast	Biesjes Bult 5493 10 18&36; Chwaing 5489 & 14; Stella Municipality

Mine Code	Mine Name	Mine Owner	Postal Address	Telephone & Fax Number	Commodity	Magisterial District & Province	Area	Province	Operational Status & Type Of Mining	Farm Names
14597	Vryburg Crushers Cc	8 Mile Investments 169 (Pty) Ltd	Po Box 1086 Schweizer-Reneke 2780	(053) 963 1081 (053) 963 1081	Aggregate; Sand Natural	Vryburg North-West	Vryburg	North-West	Mine Opencast	Welgelegen 677 In