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ABBREVIATIONS AND ACRONYMS

ACSA	Airports Company South Africa
AEL	Atmospheric Emission Licence
AQ	Air Quality
AQMP	Air Quality Management Plan
AQO	Air Quality Officer
As	Arsenic
C_2H_4	Ethylene
C_6H_6	Benzene
CCT	City of Cape Town
Cd	Cadmium
Cl	Chlorine
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DEA&DP	Department of Environmental Affairs and Development Planning
DEA	Department of Environmental Affairs
F	Fluoride
GDPR	Gross Domestic Product Per Region
GHG	Greenhouse Gas
GN	Government Notice
GWP	Global Warming Potential
H_2O	Water
H_2S	Hydrogen sulfide
N_2O	Nitrous Oxide
NAAQS	South African National Ambient Air Quality Standards
NAEIS	National Atmospheric Emissions Inventory System
NEM:AQA	National Environmental Management: Air Quality Act 39 of 2004
NEMA	National Environmental Management Act 107 of 1998
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
O_3	Ozone
PAH	Polycyclic aromatic hydrocarbons
Pb	Lead
PCB	Polychlorinated biphenyl
PERO	Provincial Economic Review and Outlook
PM_{10}	Particulate Matter with an aerodynamic diameter of 10 µm or less
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter of 2.5 µm or less
SAAQIS	South African Air Quality Information System
SANBI	South African National Biodiversity Institute
SBIDZ	Saldanha Bay Industrial Development Zone
SO_2	Sulphur Dioxide
SO_x	Oxides of Sulphur
SoEOR	State of Environment Outlook Report

SRK	SRK Consulting (South Africa) (Pty) Ltd.
StatsSA CS	Statistics South Africa Community Survey
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
WCG	Western Cape Government
WHO	World Health Organisation
WWTW	Waste Water Treatment Works
$\mu g/m^3$	Micrograms per cubic meter

GLOSSARY

Aerosols	Liquid or solid particles small enough to become airborne.
Ambient air	All air outside buildings, stacks, and exterior ducts.
Atmosphere	The thin layer of gases surrounding earth which sustain life on the planet and which is composed mainly of nitrogen and oxygen. It consists of two main layers: the troposphere, which extends from sea level to about 17 km above sea level; and the stratosphere, which extends from 17 km above sea level to about 48 km above sea level.
Concentration	When an air pollutant is measured in ambient air it is referred to as the concentration of that pollutant in air. Ambient pollutant concentrations are measured for various reasons, e.g. to determine whether concentrations exceed health risk thresholds (air quality standards); to determine how different sources of pollution contribute to ambient air concentrations in an area; to validate dispersion modelling conducted for an area; to determine how pollutant concentrations fluctuate over time in an area; and to determine areas with the highest pollution concentrations.
Criteria Pollutant	Criteria pollutants are common air pollutants for which national ambient air quality standards or guidelines have been set. The pollutants have been identified as being a threat to health, well-being and the environment. In South Africa the following criteria pollutants have been identified: particulate matter (PM_{10} and $PM_{2.5}$), oxides of nitrogen (NO_x), sulphur dioxide (SO_2), ozone (O_3), carbon monoxide (CO), lead (Pb) and benzene (C_6H_6). The national standards have been established to determine the permissible limit of each pollutant in the ambient air. Within South Africa these pollutants are emitted from sources such as mining, industry, power generation, agricultural activities and transportation. Pollutants emitted from these sources form secondary pollutants, such as NO_2, photochemical oxidants (e.g. ozone), sulfates and nitrates, through chemical reactions in the atmosphere and a few are regarded as criteria pollutants.
Emissions	The discharge of pollution from a source of pollution.
Fugitive emissions	Emissions from outdoor sources or activities as a result of wind or anthropogenic activities. Dust emitted into the atmosphere through vents of buildings are also termed fugitive emissions.
GDPR	A subnational gross domestic product for measuring the size of a region's economy.
Greenhouse gas	Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation, and includes carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).
Heavy Metals	Metallic elements with high atomic weights, such as, mercury (Hg), chromium (Cr), cadmium (Cd), arsenic (As), and lead (Pb), which, even at low levels, can harm living organisms. They do not break down or decompose and tend to accumulate in plants, animals and people causing health concerns.
Particulate Matter (PM)	The collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface, and includes dust, smoke, soot, pollen and soil particles. Particulate matter can be principally characterised as discrete particles spanning several orders of magnitude in size, with inhalable particles falling into the following general size fractions: • PM_{10} (generally defined as all particles equal to and less than 10 microns in aerodynamic diameter; particles larger than this are not generally deposited in the lung);

- $PM_{2.5}$, also known as fine fraction particles (generally defined as those particles with an aerodynamic diameter of 2.5 microns or less);
- $PM_{10-2.5}$, also known as coarse fraction particles (generally defined as those particles with an aerodynamic diameter greater than 2.5 microns, but equal to or less than a nominal 10 microns); and
- Ultra-fine particles generally defined as those with an aerodynamic diameter of less than 0.1 microns.

1 INTRODUCTION

Air pollution is often only considered as an urban or industrial problem, however, it readily disperses and has the potential to affect large areas and spill over into rural districts. Many air pollutants, such as dust and carbon dioxide (CO_2) can be dispersed widely away from the source, where they can cause various biophysical and human impacts. Pollutants can remain toxic in the environment for prolonged periods, continuously affecting the receiving environment and posing a threat to human health and quality of life. Hence, continued efforts to reduce air pollution and greenhouse gas (GHG) emissions are essential.

This chapter on Air Quality details the current state of ambient air quality in the Western Cape, and discusses the pressures, state and impacts of air quality as well as the responses from the provincial, district and local authorities. The state of air quality in the Western Cape is tracked using the following indicators: particulate matter (PM), oxides of nitrogen (NO_x), sulphur dioxide (SO_2) and GHG emissions. Data regarding the spatial distribution of the sources of these pollutants within the Western Cape are provided and discussed in this chapter. Readers are encouraged to read this chapter along with those on climate change and energy due to the interconnectedness of these three themes.

2 DRIVERS AND PRESSURES

Anthropogenic (human) activities, when combined with environmental conditions, are one of the primary drivers and pressures affecting air quality. Typically, the sectors and commercial activities driving air pollution include transportation, industry, residential uses and commercial activities, which generate airborne pollutants primarily through combustion processes that release gaseous emissions into the atmosphere as well as fugitive emissions from industrial processes or the built environment.

In addition to the key drivers and pressures on air quality, the following emerging issues may affect air quality:

- **Transit Oriented Development** leading to reduced air pollution from traffic; and
- Provision for **Air Quality Offsets** in terms of the Air Quality Offsets Guideline published in 2016

Local climatic systems play a significant role in determining the characteristics and dispersion of air pollution across an area. The Western Cape has a diverse climate, as a result of the varied topography and the influence of the Indian Ocean (warm) and Atlantic Ocean (cold). Most of the province experiences a Mediterranean climate (Tyson and Preston-Whyte, 1988; Midgley *et al.*, 2005), comprising hot dry summers and cool wet winters. Winter weather is driven by cold fronts pushing in from the southern Atlantic Ocean, whilst summers are governed by a high pressure system over the sub-continent which reduces the rain from the cold fronts reaching the land (Figure 2-1). Due to the highly varied topography of the Western Cape, microclimates are evident through the interactions between the coastal zone, topographical obstructions (mountains) as well as land use patterns (Tyson, 2000).

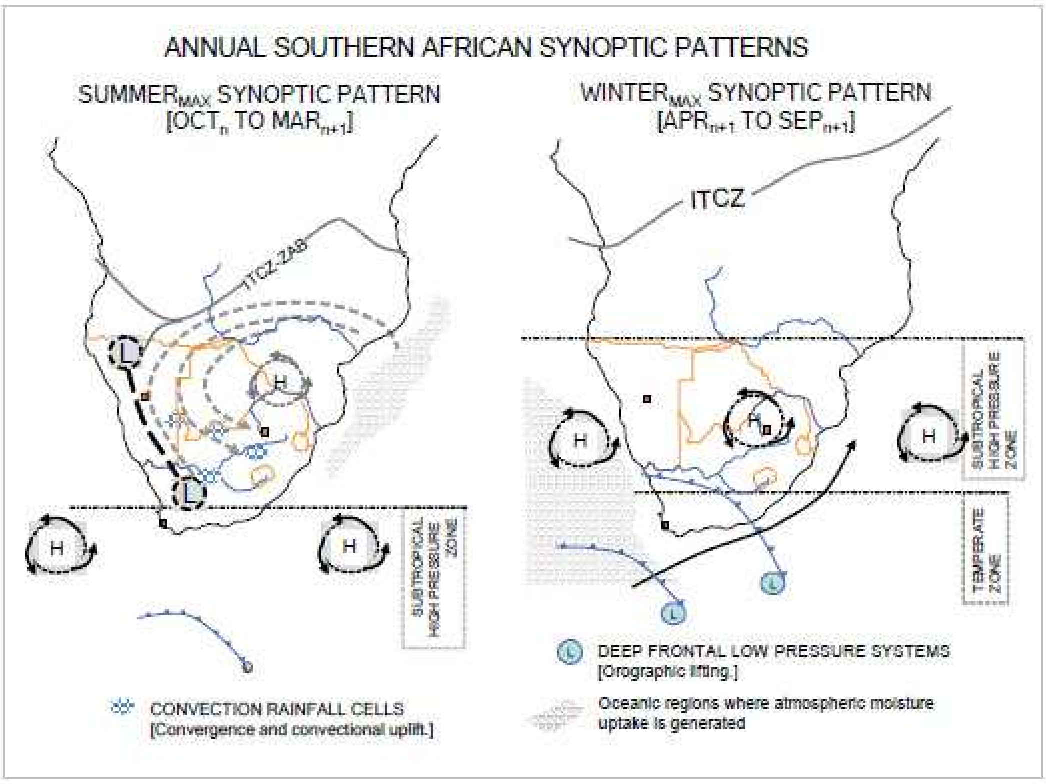

Figure 2-1: Synoptic weather patterns over Southern African summer (left) and winter (right)

Source: Scientific Electronic Library Online

2.1 Transportation

Vehicle emissions can be classified as primary or secondary pollutants. Primary pollutants from vehicle tailpipe emissions include: carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SO_2), oxides of Nitrogen (NO_x), particulate matter (PM) and lead (Pb) depending on the type of fuel that is used. Secondary pollutants exist due to chemical reactions that take place in the atmosphere and include: nitrogen dioxide (NO_2), photochemical oxidants (e.g. ozone), sulfates and nitrates. Increased traffic volumes increase vehicle emissions, although the introduction and implementation of low emission technologies may slow the rate of increase. The majority of motorised vehicles within the Western Cape use petrol or diesel.

Although the province has a well-developed transport network of airports, ports, public transport routes/roads and railway lines, the Energy Consumption and Carbon Dioxide equivalent (CO_2e) Emissions Database[1] for the Western Cape indicates that the transport sector is the second highest contributor of GHG emissions in the province (DEA&DP, 2017). This is because transport is the largest consumer of energy in the province (due to reliance on private vehicles), and therefore the emissions from transport are proportionally high. The conversion factors for liquid fuels are lower than those for electricity, which is mainly derived from coal-based power stations, which has a smaller proportional contribution to overall emission levels (Lize Jennings-Boom, Pers. comm, October 2017). Provincial traffic volumes are highest within the City of Cape Town (CCT) Metropolitan area, attributable to the fact that approximately two thirds of the province's population resides in the Greater Cape Town area.

The Port of Cape Town, one of the busiest container ports in South Africa, is considered a major source of localised pollution. Approximately six shipping vessels enter Cape Town harbour every

[1] The Energy Consumption and Carbon Dioxide Equivalent Emissions Database (CO_2e) only considers emissions related to energy consumption.

day, i.e. about 2 314 vessels per annum (Ntokozo Hlatshwayo, pers.comm, September 2017). Mossel Bay, on the south coast of the Western Cape Province, approximately 385 km east of Cape Town, is an active harbour mainly servicing the fishing industry and Mossgas (a facility which synthetically produces fuel from natural gas). It is the smallest commercial harbour in South Africa and only one to two vessels enter the Port of Mossel Bay every day (Vania Cloete, pers.comm, October 2017). The Port of Saldanha Bay, situated on the west coast of the Western Cape Province, approximately 140 km north-west of Cape Town, is South Africa's main iron ore export harbour, but also handles other bulk commodities and is an emerging service hub for the offshore oil and gas sector (DEA&DP, 2015).

Marine emissions originate primarily from diesel engines on ocean going vessels, tugs and tows, dredges, and other vessels operating inside ports (Browning, 2006). It is therefore important that the emissions from ships in ports are controlled and monitored. Large vessels at anchor off the coasts (Table Bay, Saldanaha Bay, St. Helena Bay, Mossel Bay etc.) could potentially have significant impacts on GHG emission, but are not monitored as "in port" activities. Use of shipping lanes was also found to increase mercury (Hg) emissions measured at Cape Point (Venter *et. al*., 2015).

Emissions from airports (i.e. aircraft) are a significant contributor to atmospheric pollution. Based on information provided by Airports Company South Africa (ACSA), there are 90 airports located within the Western Cape Province, ranging from small landing strips to major airports, namely the Cape Town International Airport and the George Airport (DEA&DP, 2015).

Aircraft engines emit CO, CO_2, NO_x, SO_2, particulates, trace compounds and partly combusted hydrocarbons or volatile organic compounds (VOCs). Emissions are released at different rates, depending on the phase of operation the aircraft is in, such as take-off, landing, idling, climbing and taxiing (Schlenker and Walker, 2011), as well as on the height at which they are released. Nitrogen oxide emissions are generally higher during high power tasks, such as take-off and CO emissions are higher during low power tasks such as taxiing. NO_x and CO emissions are considered highest during idling (USEPA, 1996).

2.2 Industrialisation

Industrial sources in the Western Cape contribute to elevated gaseous and particulate matter emissions. The combustion of fuels utilised in the energy sector, such as paraffin, coal, heavy fuel oil and diesel, also emit VOCs and heavy metals into the environment from sources where industrial activities take place. Where electricity is used, emissions are in effect displaced to the location of the power plant, e.g. in Mpumalanga Province. The Western Cape is largely reliant on fossil fuel combustion, particularly in the West Coast District as due to the primary use of coal for industrial processes, which translates into an associated release of GHG emissions (DEA&DP, 2015).

The Provincial Economic Review and Outlook (PERO) Report (2017), indicates that manufacturing contributes approximately 15% towards the Gross Domestic Product per Region (GDPR) in the Western Cape, and is expected to grow by 2.2% per annum between 2015 and 2020 (WCG, 2015). A mix of electricity, coal and diesel will have to be used to sustain this growth in manufacturing output which will necessitate implementation of mitigation measures at source to reduce the impact of increased energy consumption.

There are numerous brickfields throughout the province (DEA&DP, 2011). Emissions released from brickworks include fugitive dust which is released during grinding and crushing processes, SO_x, NO_x, CO and CO_2 released during the combustion process, with VOC and methane being released from dryers and kilns.

Although oil and gas exploration has stalled since the drop in the oil price, the African oil sector is likely to stabilise, providing an opportunity for the Western Cape to service the sector. According to Transnet, 80 to 100 oil rigs are deployed off the west coast of Africa and a further 120 oil rigs pass via the southern tip of Africa each year (WCG, 2015). In the Western Cape, Saldanha Bay has been designated as the main oil rig repair hub; and hosts a large oil-storage facility. The country's leading gas (storage) facility is stationed at the Port of Mossel Bay near PetroSA's Mossgas gas-to-liquid refinery, operating as a service hub for the regional gas industry (DEA&DP, 2015).

The Saldanha Bay Industrial Development Zone (SBIDZ) was promulgated by the Minister of Trade and Industry in October 2013 (SBIDZ, 2017). It is situated on the outskirts of Saldanha Bay on a 330 hectare (ha) site. The SBIDZ is a joint project between national, provincial and local government, aiming at attracting key investors and companies operating in the upstream (offshore) oil and gas sector of the African east and west coasts (DEA&DP, 2015). The zone aims to deliver engineering services, marine repair and supply services to these enterprises. Consequently, it is probable that the concentration of industries will elevate ambient air pollution levels in the area.

2.3 Domestic fuel burning

According to the 2016 Community Survey, 97.5% of households within the Western Cape are supplied with electricity (StatsSA CS, 2016). However, burning of domestic fuels (e.g. wood, paraffin, coal, etc.) for heating and cooking remains commonplace within both rural and urban settlements, especially in informal residential areas. In areas supplied with electricity, some households tend to persist with domestic fuel, partly in response to high energy tariffs or out of personal preference.

Domestic fuel burning gives rise to indoor air pollution, exposing occupants to a number of pollutants that include particulate matter, CO, nitrogen dioxide (NO_2), SO_2, formaldehyde and polycyclic organic matter. Exposure to these pollutants can cause a number of health issues such as respiratory problems. Unsustainable harvesting of natural resources (e.g. wood) for domestic fuel is also a concern.

2.4 Fires

Veld fires are distinct pollution events contributing to poor air quality. Within the Western Cape, veld fires occur naturally during the dry summer, when temperatures rise and vegetation tends to dry out. Dry, windy conditions are also common in the Western Cape during this period. The size and intensity, as well as the occurrence (both in space and time), of veld fires depend directly on weather conditions, the composition of the vegetation (e.g. moisture content, volatile oils, percentage of moribund materials), and the weight of the consumable fuel/biomass per hectare (i.e. available fuel loading). The major pollutants from veld fires are particulate matter, CO and VOCs. NO_x are also

Knysna Fire, August 2017

released during veld fires, however they are emitted at variable rates, determined by combustion temperatures. Pollutants from veld fires may be highly dependent on the composition of the material on fire. Western Cape Fynbos may have a unique fire signature which includes emissions of mercury (Hg) and ozone (O_3) (Brunke, *et. al*, 2001).

Over the past three years, major fires have occurred in the Eden District, City of Cape Town and the Cape Winelands areas. The increased frequency of fires is strongly linked to the impacts of climate change across the province as this causes hotter and drier conditions, which increases fire risk.

Figure 2-2 shows the spatial distribution, including the extent and timing of fires in conservation areas managed by CapeNature from 1996 to 2016 (SANBI, 2017). It is evident that fires that occurred between 2007 and 2016 tended to have a smaller spatial distribution than those occurring between 1996 and 2006. However, new areas in the Overberg District Municipality were affected and there were repeat fires in the Hottentots-Holland Mountains between Wellington and Worcester, and across the Eden District Municipality.

Similar patterns of burning in natural areas not managed by CapeNature can be expected, which would contribute to the overall impact on air quality across the province. Fires impact on general health, mainly due to the significant volumes of particulate matter. Recently burnt areas are a source of dust and particulates, until vegetation re-establishes and anchors loose soil particles. In certain areas wind erosion may have a long term impact as vegetation growth may be hindered by fires, with certain vegetation types less resilient against fires while for others (for example fynbos) fire stimulates germination of seed, allowing for more rapid revegetation.

In addition to veld fires, fires are also used to burn agricultural wastes and other waste streams. Burning of flammable organic compounds, such as tyres and plastics, emits dense black smoke or soot consisting of impure carbon particles. Other contaminants released include carcinogens (i.e. cancer-causing substances) such as polycyclic aromatic hydrocarbons (PAHs), benzene (C_6H_6), dioxins, polychlorinated biphenyl (PCB) and volatised heavy metals.

2.5 Agriculture, forestry and fisheries

Agricultural activities are considered to be a significant contributor to particulate emissions. Between 2005 and 2015, the agricultural sector made the largest and second largest economic contributions to the West Coast and Central Karoo District Municipalities (both 23%) (WCG, 2017).

Dryland and wetland agricultural activities reduce air quality by entraining dust and releasing gases such as CO_2 during ploughing and harvesting. Emissions are seasonal, for example, high pollen counts from flowering canola in the Overberg District Municipality.

Farmers spray crops with insecticides and pesticides for the duration of the growing season. Exposure to pesticides poses a threat to human health (WHO, 2008) and the environment. A study by Melin *et* al, 2014 describing pollinator ecosystems services in South African agricultural systems identifies the use of pesticides as one of the pressures leading to ecosystem decline.

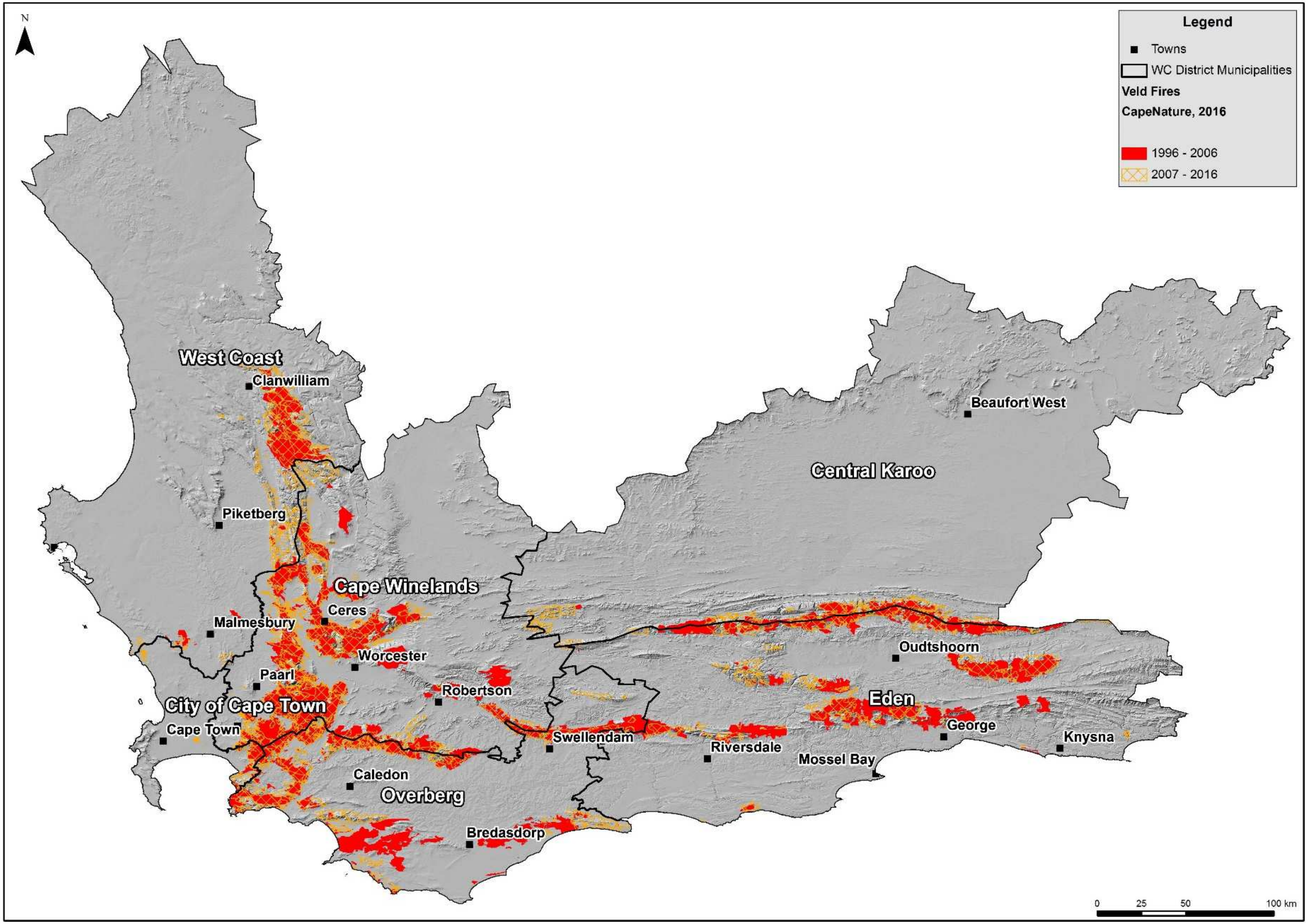

Figure 2-2: Veld fires located on CapeNature properties - 1996-2016 (SANBI, 2017)

Problems can arise if pesticides are inappropriately applied and/or become volatized. This can lead to contamination of air, soil and non-targeted vegetation, as occurs comparatively frequently in the Cape Winelands District Municipality. Bio-accumulation can also affect human and environmental health long-term.

Emissions associated with animal husbandry (pigs, sheep, goats and chickens) include ammonia and hydrogen sulphide, from manure and animal waste production (enteric fermentation) (USEPA, 1996). Livestock produce significant quantities of methane through enteric fermentation, mostly through burping and excretion of ruminant.

The Western Cape contributes significantly to revenue generated by South Africa's fisheries sector, with trawling contributing just under half of revenue (DEA&DP, 2013a). Odours emitted by fish processing facilities compromise air quality and measures to reduce odours from fishmeal processing facilities are being implemented in the province.

2.6 Waste water treatment works

Emissions released by waste water treatment works (WWTW) include odours and aerosols. Airborne pathogens are released by mechanical processes (aeration and denitrification) at WWTW, while VOCs are emitted by wastewater collection, treatment and storage systems, mostly by the volatisation of organic compounds at the liquid surface. Bioaerosols (airborne particles that are organic in nature) are released by processing units and can pose a threat to WWTW operators, and seldom disperse beyond the immediate vicinity of processing units.

Odour is the most noticeable form of pollution from the public perspective, and can be weather dependent. Compounds contributing to the smell of wastewater arise from the original composition of the sewage, biochemical changes during treatment and the addition of chemicals to sewage during the treatment process.

The operating conditions and capacity of WWTWs are important determinants of the intensity or extent of air pollution. Overloading, operational failures and maintenance backlogs can lead to discharge of substandard effluent back into the environment, thereby increasing the exposure time and release of airborne pollutants.

2.7 Mining and quarrying

Significant mining operations in the Western Cape Province include open cast mining and heavy beach sand operations, which emit fugitive dust (i.e. PM). Material handling activities, vehicle entrainment on unpaved roads, as well as wind erosion from open areas or discard/ slimes dams or product stockpiles are all potential sources of pollution. Vehicle exhaust emissions and mineral processing facilities also contribute to gaseous emissions.

Although mining is not a significant economic sector in the Western Cape, contributing 1% to the Western Cape economy (WCG, 2016b), a number of open cast operations are located in the West Coast District. These sites usually result in increased transport activities, as well as elevated methane and CO_2 emissions in the area, and should be carefully managed.

2.8 Waste disposal and treatment facilities

Emissions associated with landfill sites are predominantly odorous, gaseous and fugitive dust emissions. Both organic and inorganic compounds contribute to landfill gas emissions, which usually consist of between 40 to 60% methane (CH_4) and CO_2. Waste material such as general household waste, plastics and tyres are often burned at landfills, and the health implications of such informal and incomplete combustion can be severe, and emissions such as particulate matter, VOC and carcinogenic compounds are released. Odours generally arise from landfill gas, which is a mixture of gases produced as a result of waste decay, through an anaerobic process known as methanogenesis.

An activity that may also occur at waste management facilities is incineration of certain waste streams. Emissions from incineration are typically determined by the composition of the waste, the efficiency of the combustion conditions and the efficacy of installed abatement technology. Incinerator emissions may include CO_2, CO, NO_x, SO_2, particulate matter, ammonia, amines, VOCs, Polychlorinated biphenyls (PCBs), Polycyclic aromatic hydrocarbons (PAHs), metals and dioxins and furans.

Further information about (solid) waste treatment facilities in the province is included in the Waste Management Chapter.

3 STATE

3.1 Atmospheric pollutants

> ***Air Quality** is tracked using the following atmospheric pollutants as **indicators:***
> - *Particulate matter*
> - *Oxides of Nitrogen*
> - *Sulphur Dioxide*
> - *Greenhouse Gas Emissions*

Air quality management aims to estimate human exposure to criteria pollutants in order to manage air quality and the impacts of deteriorating air quality. Criteria pollutants can cause harm to human health and the environment (USEPA, 2017). The Department of Environmental Affairs (DEA) identified seven criteria pollutants, regulated by the South African National Ambient Air Quality Standards (NAAQS) which were promulgated on 24 December 2009: the seven criteria pollutants are nitrogen dioxide (NO_2); sulphur dioxide (SO_2); Ozone (O_3); particulate matter (PM_{10} and $PM_{2.5}$); benzene (C_6H_6); carbon monoxide (CO); and lead (Pb).

In accordance with Section 8 of the National Environmental Management: Air Quality Act 39 of 2004 (NEM:AQA), the Western Cape Department of Environmental Affairs and Development Planning (DEA&DP) monitors ambient air quality at 11 stations across the province. Air quality monitoring data measured at the stations is recorded on data loggers, and transferred via a modem to a server for storage and further processing. The data is quality controlled and used to inform compilation of daily and monthly reports. All data in the Western Cape Ambient Air Quality Monitoring Network is reported to the South African Air Quality Information System (SAAQIS) on a monthly and quarterly basis (DEA&DP, 2015).

Meteorological parameters (wind speed and direction, ambient temperature, pressure, relative humidity) are also measured (DEA&DP, 2015).

3.1.1 Particulate matter

Particulate matter is the collective name given to airborne particles that include dust, smoke, soot, pollen, ocean spray and soil particles. Particulate matter can either be emitted naturally (e.g. windblown dust) or generated through human activity (e.g. stack emissions). Particulate matter is categorised by particle size, viz. coarse particles (2.5-10 microns - PM_{10}), fine particles (less than 2.5 microns - $PM_{2.5}$), and ultrafine particles (less than 0.1 microns in diameter).

Southern Africa is generally an arid region and as such background particulate matter levels are often elevated in certain regions. Diurnal and seasonal variations are also evident (Bhawoodien Parker, pers. comm, October 2017).

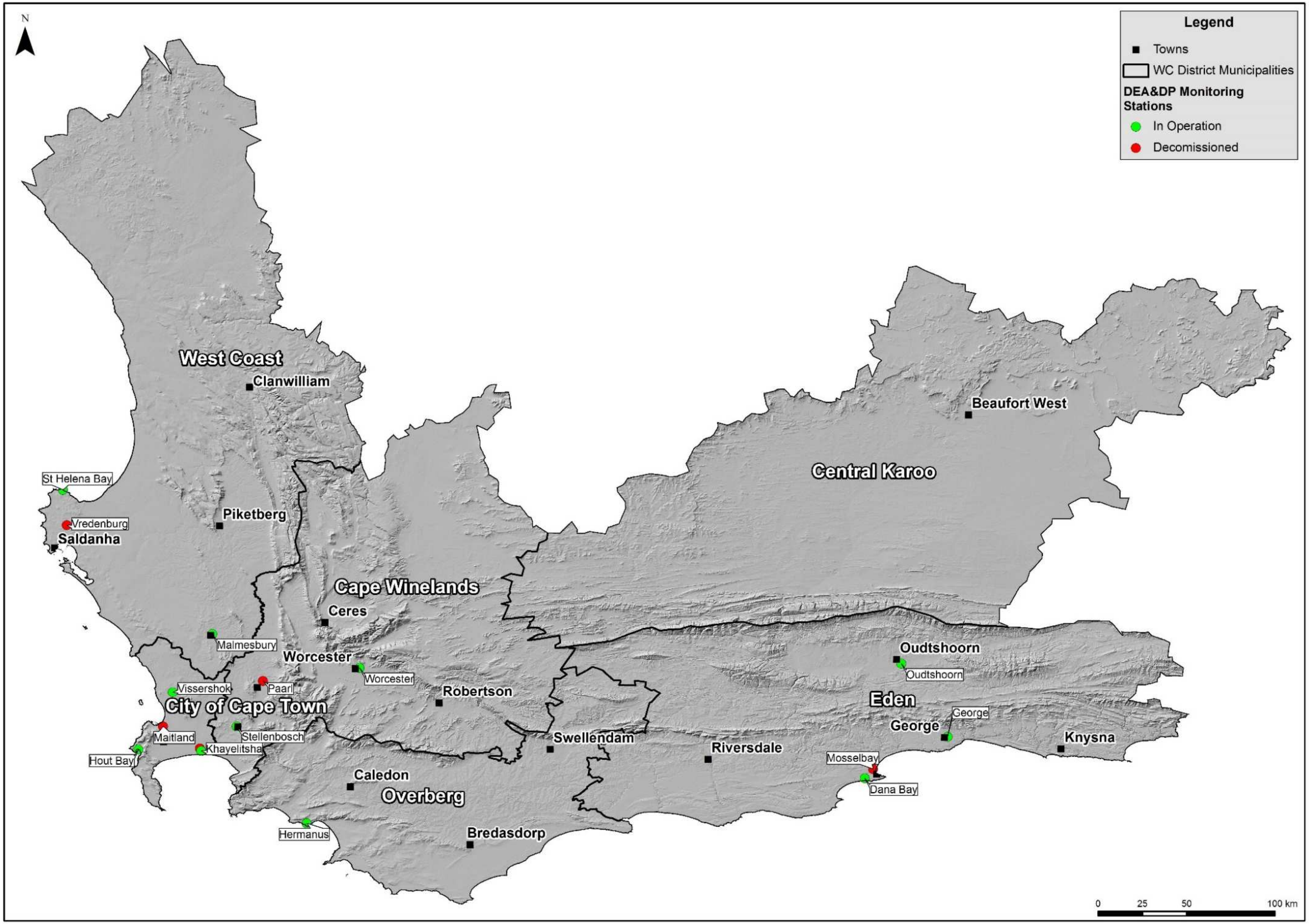

Figure 3-1: Location of the ambient air quality monitoring stations operated in the DEA&DP Ambient Air Quality Monitoring Network

Particulate matter can adversely affect human health including, respiratory illnesses (asthma and bronchitis) and cardiovascular diseases. It can also affect vegetation by inhibiting plants' photosynthetic properties by coating the leaves, thereby blocking the penetration of natural light. Also, deposition onto soils of various metals in particulate matter can be absorbed by vegetation, stunting plant growth. Uptake of metals by plants can also contaminate vegetables and fruit.

The NAAQS for inhalable particles are presented in Table 3-1.

Table 3-1: South African National Ambient Air Quality Standards for Particulate Matter

Pollutant	Standard	24-hour	Annual Average
Units		µg/m³	µg/m³
PM_{10}	South African Standard (*Effective until 31 December 2014*)[1]	120	50
PM_{10}	South African Standard (*Effective from 1 January 2015*)[1]	75	40
PM_{10} Frequency of exceedances allowed		4	0
$PM_{2.5}$	South African Standard (*Effective until 31 December 2015*)[2]	65	25
$PM_{2.5}$	South African Standard (*Effective from 1 January 2016 to 31 December 2029*)[2]	40	20
$PM_{2.5}$	South African Standard (*Effective from 1 January 2030*)[2]	25	15
$PM_{2.5}$ Frequency of exceedances allowed		0	0
1) As listed in the NEM:AQA. Government Gazette No. 32816. 24 December 2009			
2) As listed in the NEM:AQA. Government Gazette No. 35463. 29 June 2012			

Annual average PM_{10} concentrations monitored at selected DEA&DP monitoring stations, for the period between 2009 and 2016 are presented in Figure 3-2.

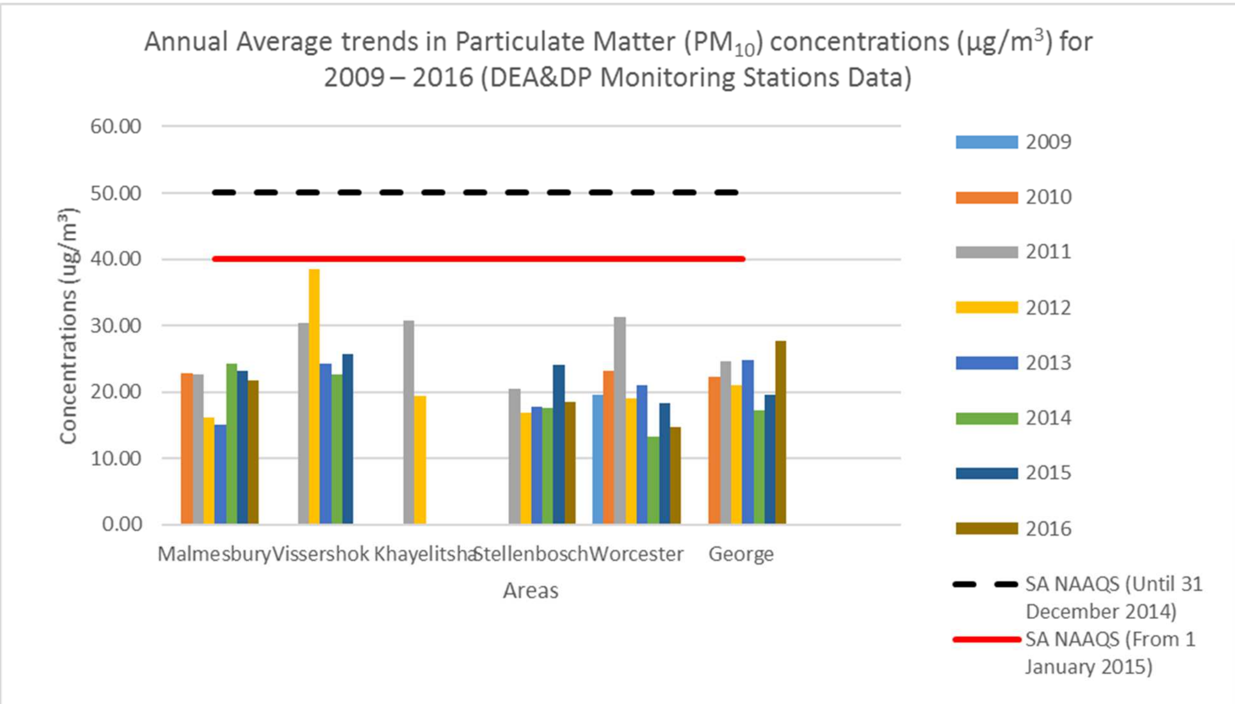

Figure 3-2: Annual average trends in Particulate Matter (PM10) concentrations (µg/m³) for 2009 – 2016

Source: DEA&DP monitoring stations data

All monitoring stations indicate that the monitored PM_{10} concentrations are below the annual average standard (threshold) of 50 µg/m^3 (which was in effect until 31 December 2014 – indicated in black) and 40 µg/m^3 (effective from 1 January 2015 – indicated in red). Year-on-year decreases are evident across areas; however longer time series data is required to confirm this trend. Monitoring at these locations should continue to facilitate early detection and management interventions where PM_{10} levels increase rapidly or approach guideline concentrations. It should be noted that a drier climate in the Western Cape (as projected by climate models) has the potential to increase the particulate matter even if anthropogenic sources are mitigated (Bhawoodien Parker, pers. comm, October 2017).

3.1.2 Oxides of nitrogen

Air quality guidelines and standards adopted in most countries and institutions tend to target NO_2, rather than for the full range of Nitrogen Oxide (NO_x) compounds, mainly because NO_2 is considered the most important compound from a human health perspective. NO_2 is formed through the oxidation of Nitric Oxide (NO), and is a natural gas with a strong odour. Small quantities can be produced by plants, soil and water, but human activities such as the combustion of fossil fuels and biomass are the major source of NO_2 in the air.

Human respiratory tract irritation could be a direct effect of NO_2 exposure. Since NO_2 is relatively insoluble, it can penetrate deep into the lungs and cause tissue damage. Effects of NO_2 exposure include alveolar tissue disruption and obstruction of the respiratory bronchioles. Long term effects of exposure include increased susceptibility to lung infections. The relevant South African Standards for ambient NO_2 levels are presented in Table 3-2.

Table 3-2: South African Ambient Air Quality Standards for NO_2

Pollutant	Standard	1-hour	Annual Average
Units		µg/m^3	µg/m^3
NO_2	South African Standard[3]	200 (106 ppb)	40 (21 ppb)
Frequency of exceedances allowed		88	0
3) As listed in the NEM:AQA. Government Gazette No. 32816. 24 December 2009			

The annual monitored NO_2 concentrations at selected DEA&DP monitoring stations, for the period between 2009 and 2016 are presented in Figure 3-3.

The annual data for NO_2 concentrations monitored at selected DEA&DP monitoring stations indicate no clear trends, although it is noted that elevated levels are recorded at Khayelitsha monitoring station, likely due to vehicle emissions in this dense, urban township. Vehicular and industrial emissions are likely to be responsible for the elevated NO_2 emissions in Stellenbosch and George.

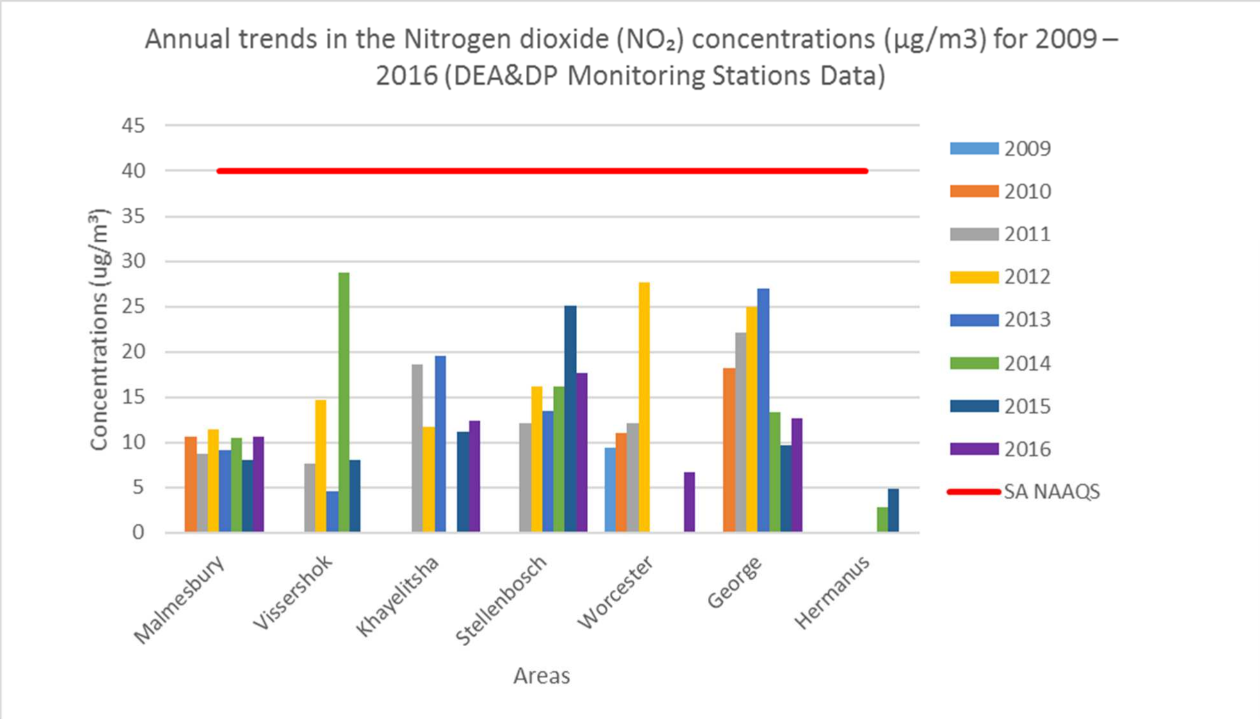

Figure 3-3: Annual average trends in the Nitrogen dioxide (NO_2) concentrations (µg/m³) for 2009 – 2016

Source: DEA&DP monitoring stations data

3.1.3 Sulphur dioxide

Sulphur Dioxide (SO_2) is a colourless gas with a strong odour. It is a primary pollutant, which reacts easily with other substances to form secondary pollutants such as sulphuric acid. Fossil fuels used by power plants and industrial facilities are the primary source of SO_2 into the atmosphere. Smelting and heavy equipment that burns fuel with a high sulphur content also contribute to higher emission levels (USEPA, 2017).

Sulphur Dioxide is damaging to human respiratory function when inhaled, causing coughing and shortness of breath. Long term exposure or exposure to a large dose can result in chronic respiratory disease and the risk of acute respiratory illness. Sulphur Dioxide can impact the receiving environment, including the acidification of waterbodies, plant growth impacts, a reduction in plant yields and the corrosion of natural and manmade structures.

The relevant South African Standards for ambient SO_2 levels are presented in Table 3-3.

Table 3-3: South African Ambient Air Quality Standards for SO_2

Pollutant	Standard	10 minutes	1-hour	24-hour	Annual Average
Units		µg/m³	µg/m³	µg/m³	µg/m³
SO_2	South African Standard[4]	500 (191 ppb)	350 (134 ppb)	125 (48 ppb)	50 (19 ppb)
Frequency of exceedances allowed		526	88	4	0
4) As listed in the NEM:AQA. Government Gazette No. 35463. 29 June 2012					

Annual average trends for SO_2 between 2009 and 2016 presented in Figure 3-4, indicate that monitored SO_2 concentrations at all monitoring stations are below the annual average limit of 50 µg/m³. Higher SO_2 concentrations are usually attributable to emissions released by industry.

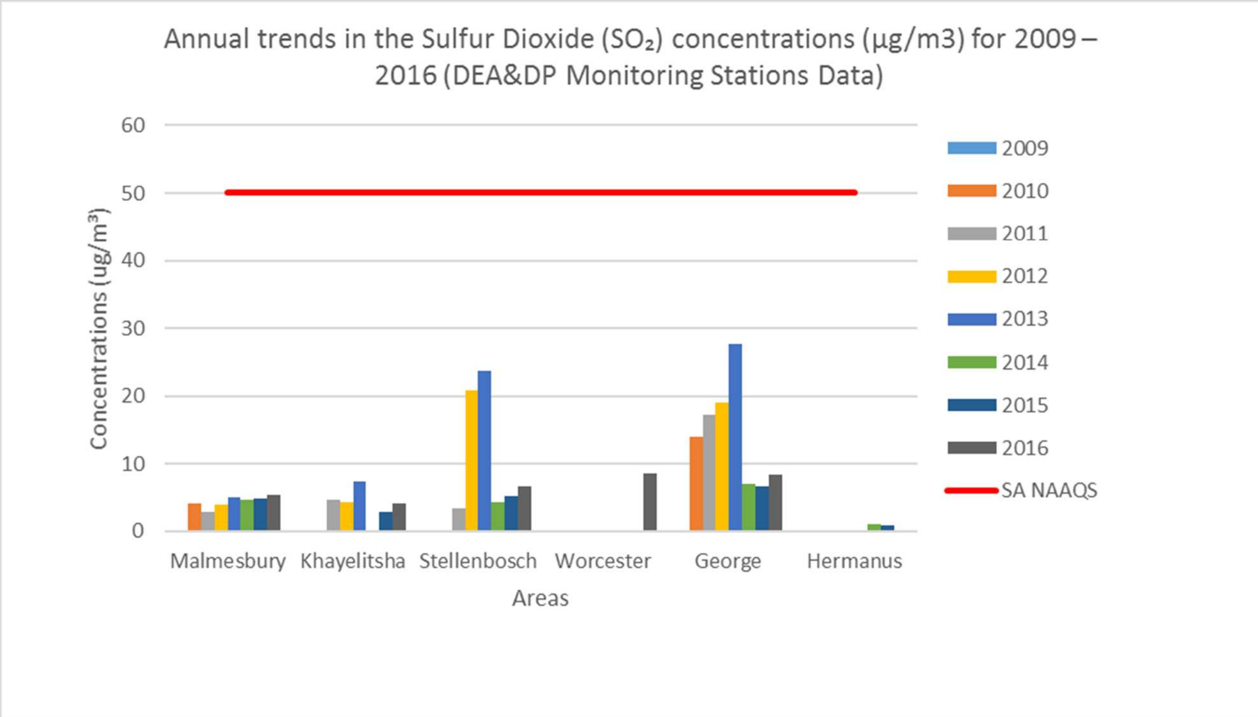

Figure 3-4: Annual average trends in the Sulphur Dioxide (SO_2) concentrations (µg/m³) for 2009 – 2016

Source: DEA&DP monitoring stations data

3.1.4 Greenhouse gas emissions

Greenhouse gases (GHG) is the collective term for gases in the earth's atmosphere which absorb and trap radiation within the thermal infrared range, a process also known as the Greenhouse Effect. Gases including water vapour (H_2O), carbon dioxide (CO_2), methane, nitrous oxide (N_2O) and ozone (O_3) are considered the primary GHG either due to high volumes or their effectiveness as a greenhouse gas[2]. Anthropogenic sources such as the combustion of wood, coal, liquid fuels and natural gases are major contributors to GHG emissions.

Water vapour is the most abundant GHG in the atmosphere, however, human activity has very little direct influence on its concentrations. Of the trace gases, CO_2 is the most abundant and its accumulation in the atmosphere is closely observed as an indicator of climate change. Carbon emissions from human activities are therefore monitored in order to gauge carbon's contribution to the Greenhouse Effect. The contribution from other GHGs is similarly tracked, and reported on in terms of their effect relative to carbon dioxide. This allows reporting in a single unit, namely "*carbon dioxide equivalent*" or "*CO_2e*", which gives an indication of combined global warming potential (GWP). Typically, for the sake of brevity, the total contribution is simply reported as "*carbon emissions*".

The DEA&DP compiled a Western Cape Emissions Inventory during 2006, mainly recording emissions from fuel burning equipment. During 2011, this was expanded into the Western Cape Air Pollutant and Greenhouse Gas Inventory, which houses data on point, non-point and mobile sources of air pollution in the Province (DEA&DP, 2015).

[2] Note that the GHGs considered for air quality purposes may differ from the six GHG emissions identified by the United Nations Framework Convention on Climate Change (UNFCCC) for reporting purposes to the UNFCCC, namely carbon dioxide, methane, nitrous oxide, hydroflourocarbons, perfluorocarbons and sulphur hexafluoride.

The DEA&DP also updates the Energy Consumption and Energy Related Greenhouse Gas Emissions Database for the Western Cape every two years, which is indicative of the Western Cape's pro-active engagement with energy and climate change challenges. The database was developed to support the province's strategic goals, specifically related to the Western Cape Climate Change Response Strategy (2014). Based on data from the 2017 Western Cape Energy Consumption and CO_2e Emissions Database Report, electricity use is the highest contributing energy source in the Western Cape, accounting for 60% of total carbon emissions (Figure 3-5).

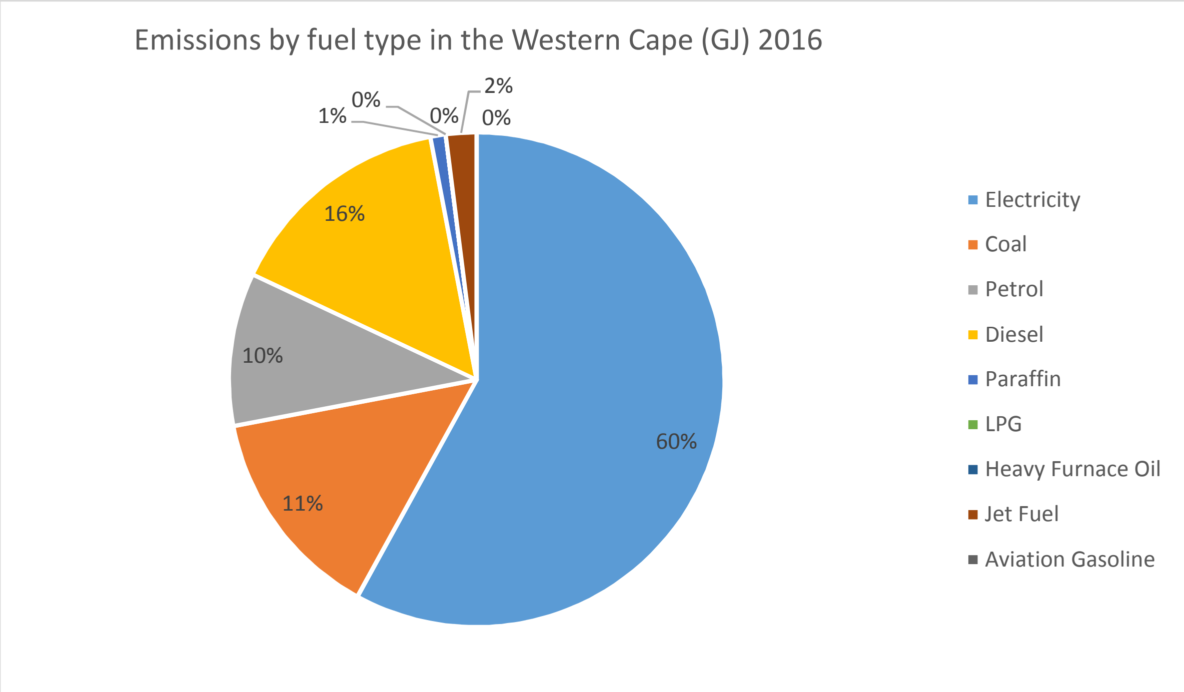

Figure 3-5: Emissions by fuel type in the Western Cape

Source: DEA&DP, 2017

The transport sector consumes the most energy in the Western Cape, followed closely by industrial use. Conversely, in terms of carbon emissions per sector, industrial usage accounts for approximately 36% of total emissions followed by transport at 30% and commercial usage at 10% (DEA&DP, 2017).

Carbon emissions per District Municipality are briefly described below; however for more information in this regard, please refer to the Energy and Climate Change Chapters.

In the City of Cape Town, the transport sector is the largest consumer of energy, followed by industry and residential use. In the Cape Town Metropolitan municipality, the use of electricity contributes 61% of total carbon emissions (Figure 3-6), while petrol and diesel use contribute 14% and 19% to carbon emissions respectively. As depicted in Figure 3-7, high carbon emissions in the West Coast District can be attributed to the primary consumption of coal for industrial processes (e.g. in boilers) (47%) (DEA&DP, 2017).

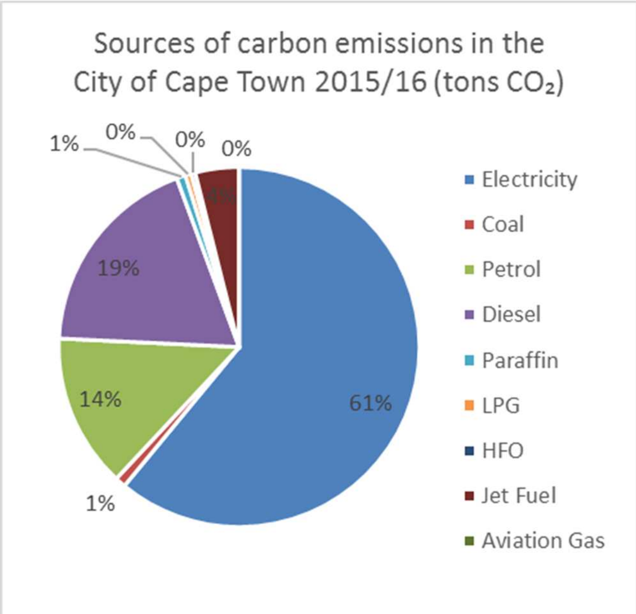

Figure 3-6: Sources of carbon emissions in the City of Cape Town

Source: DEA&DP, 2017

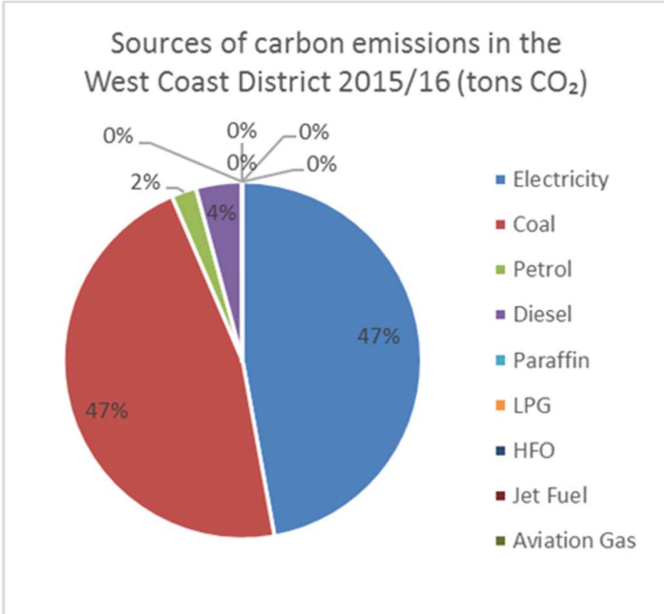

Figure 3-7: Sources of carbon emissions in the West Coast District

Source: DEA&DP, 2017

Figure 3-8 and Figure 3-9 illustrate carbon emissions in Cape Winelands and Overberg District Municipalities in the Western Cape. The highest contribution to carbon emissions in the Cape Winelands District is from electricity (77%), with the direct use of coal being the second highest contributor (8%). The highest source of carbon emissions in the Overberg District can be attributed to the use of electricity contributing 75%, followed by the use of diesel, contributing 11% (DEA&DP, 2017).

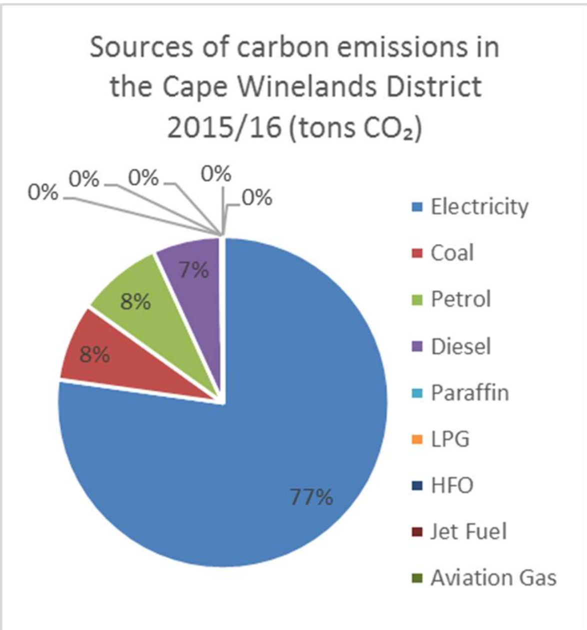

Figure 3-8: Sources of carbon emissions in the Cape Winelands District

Source: DEA&DP, 2017

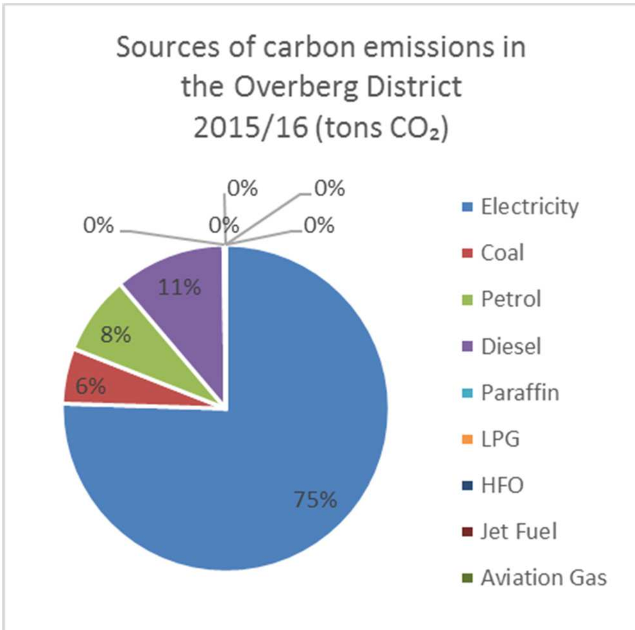

Figure 3-9: Sources of carbon emissions in the Overberg District

Source: DEA&DP, 2017

The sources of emissions in Eden and Central Karoo Districts are presented in Figure 3-8 and Figure 3-9. In the Eden District (Figure 3-10), the highest single source of carbon emissions is attributed to the use of electricity (56%). The Central Karoo District indicates a split between the use of electricity (46%) and diesel fuels (33%), as the highest contribution to carbon emissions (Figure 3-11) (DEA&DP, 2017). This is ascribed to the main overland route (the N1 highway) through the district, along which several refueling stations are located.

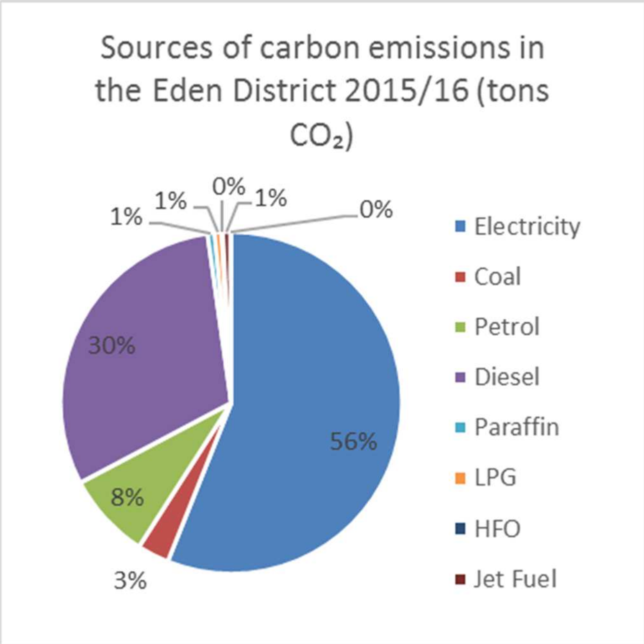

Figure 3-10: Sources of carbon emissions in the Eden District

Source: DEA&DP, 2017

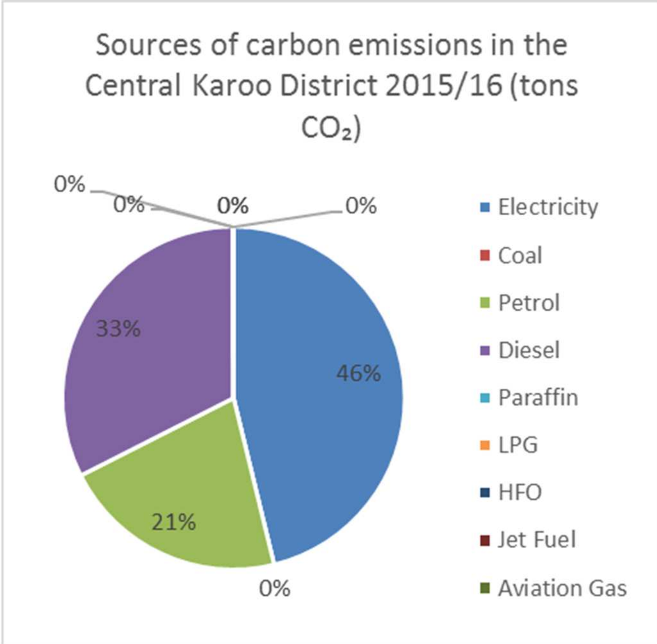

Figure 3-11: Sources of carbon emissions in the Central Karoo District

Source: DEA&DP, 2017

3.2 Air quality management per district

3.2.1 City of Cape Town

Most of the Western Cape's population resides within the Greater Cape Town area. This suggests that the majority of the province's emissions are generated within the Metropolitan area, increasing the risk of exposure to poor air quality in this area.

The main sources of ambient air pollution in the Cape Town Metropolitan area are NO_2, particulate matter and SO_2 emitted by industry, vehicles, electricity generation and domestic fuel use (heating and cooking) (DEA&DP, 2015). Indoor air pollution levels are also expected to be high, despite widespread electrification in the City (StatsSA CS, 2016). A significant number of households utilise domestic fuels such as gas, wood and paraffin for heating and cooking. The 2016 community survey reveals that approximately 2% of lighting needs, 9% of cooking needs and 14% of heating needs are powered by alternative fuel sources (StatsSA CS, 2016). Paraffin In lower income areas, elevated emission levels are expected due to the high reliance on domestic fuel burning.

The constant south-easterly wind during summer facilitates air pollution dispersion across the Metropolitan area (DEA&DP, 2015), contributing to windblown dust across the City. However, the south-easter, commonly referred to as the "Cape Doctor" also mixes the air and transports atmospheric pollution away from the city, although during extremely windy conditions it can elevate particulate matter levels through the dispersion of sea salt crystallisations.

The 2015 Western Cape State of Air Quality Management (DEA&DP, 2015) reports that PM_{10} concentrations in Khayelitsha exceeded the 24 hour average of 120 µg/m^3 on 10 occasions for the period 01 January 2011-31 December 2014. The 24 hour average of 75 µg/m^3 was exceeded on 3 occasions for the period 1 January 2015-31 December 2015.

Air quality complaints in the City of Cape Town relate mainly to fumes, odour and farmland/tyre/waste burning (DEA&DP, 2015). Between 2010 and 2015, the City of Cape Town inspected galvanizing facilities, illegal foundry operations, metal spray operations and hazardous waste incinerator operations and, where necessary, took appropriate action in an attempt to address and reduce complaints. Where applicable, complaints relating to odour emissions and smoke are referred to the Director of Public Prosecutions for consideration.

3.2.2 West Coast District

The West Coast District Air Quality Management Plan compiled in 2011, reports that sources of air pollution include industrial operations, agricultural activities, mining activities, veld fires, domestic fuel burning, vehicle tailpipe emissions, waste treatment and disposal and vehicle entrainment of dust. The West Coast District has a very high consumption of coal which is attributed to the primary use of coal for industrial processes within the district specifically in the vicinity of Saldanha Bay which results in particulate and gaseous emissions. The district is heavily dependent upon fossil fuels (DEA&DP, 2013). Air quality issues in the area are also linked to local industrial activities, specifically red dust from iron ore handling in Saldanha Bay and dust generated by lime production (DEA&DP, 2015). The Municipal Health Services in the Directorate Corporate and Community Services is responsible for air quality management in the West Coast District (WCDM, 2011).

Ambient monitoring is mainly undertaken by industries, notably by ArcelorMittal, Tronox and Transnet at the Port of Saldanha as well as Saldanha Bay local municipality. The Western Cape Government monitors air quality (NO_2, SO_2, O_3, PM_{10}, CO and CO_2) at 11 monitoring stations in the province, including one at Malmesbury (formerly at Vredenburg). Monitoring data from Malmesbury for the period from 2009-2015, (Section 3) shows that annual average concentrations of particulate matter, NO_2 and SO_2 are below the South African NAAQS.

3.2.3 Cape Winelands District

Stellenbosch, Paarl and other regions in the Cape Winelands District host numerous industrial activities as well as extensive agricultural areas and agri-processing facilities, which all contribute to air pollution. Monitoring data presented earlier in this chapter indicates that ambient PM_{10}, NO_2 and SO_2 concentrations in the district complied with South African NAAQS. Industrial activities and vehicle emissions release particulate matter, NO_2 and SO_2 into the atmosphere, while agricultural activities and farm fires, as well as fuels including coal and paraffin, used by low income households and industrial boilers further contribute to PM emissions in the district. The provincial air quality monitoring station at Worcester measures NO_2, O_3, PM_{10}, $PM_{2.5}$, SO_2, CO, CO_2 and meteorological data.

Air quality complaints in the Cape Winelands District generally relate to odour and agricultural sources, such as dust, crop spraying and farmland/tyre burning. The district has established an Air Quality Forum to discuss legislative requirements, compliance, and to formulate and implement action plans as a means to reduce impacts (DEA&DP, 2015).

3.2.4 Overberg District

Primary sources of air pollution in Overberg District include industrial operations which include fish factories and clay brick manufacturing, agricultural activities, biomass and domestic fuel burning, vehicle emissions, waste treatment and disposal and dust from unpaved roads. Emissions associated with these activities include particulate matter, VOCs, CO_2 and fugitive pesticides.

The ambient air quality in the municipality is generally good, however emissions from industrial boilers are likely to result in local areas of elevated concentrations of air pollutants (ODM, 2012). Air quality complaints in the district relate to offensive odour, dust, and smoke emitted from burning waste and veld fires (DEA&DP, 2015). Particulate matter concentrations are expected to be elevated in low income areas where wood is used as a primary fuel source. NO_x and particulate concentrations are expected to increase in the holiday towns during the holiday periods.

An Air Quality Management Plan (AQMP) was approved in 2012 and the municipality has established an Air Quality Forum with local municipalities to share information and raise awareness (DEA&DP, 2015). Air quality monitoring at the Mount Pleasant Primary School in Hermanus commenced in March 2014. Data recovery at the monitoring station was low due to power supply failures which resulted in analyser failures. The two pollutants, which have long terms trends i.e. O_3 and CO are below the NAAQS for the 2014-2015 monitoring period. As at December 2015, 5 facilities been issued Provisional Atmospheric Emission Licences (PAELs) in the municipality.

3.2.5 Eden District

Numerous industries, timber processing plants, brickfields and petrochemical operations are located within the Eden District Municipality. Emissions released by the PetroSA refinery in Mossel Bay occur during combustion processes, and include SO_2, CO, CO_2, NO_x, particulate matter, as well as VOCs (e.g. benzene) or heavy metals (e.g. lead).

The provincial air quality monitoring station at George monitors NO_2, O_3, PM_{10}, $PM_{2.5}$, SO_2, CO, CO_2 concentrations and meteorological data. Air quality complaints in the district relate predominantly to smoke and odour. Since 2010, odour-related complaints have decreased significantly, although remain a concern across the district. Eden District Municipality commissioned an air quality study and the mitigation measures were incorporated into an Action Plan, with assigned implementation deadlines. The district continues to actively engage in this process and manage air quality within the area (DEA&DP, 2015).

Fuel consumption in the Eden District is very high, attributable to the key national road (N2 highway) which traverses the district, connecting urban centres on the west and southern coasts, as well as the harbours of Saldanha Bay, Cape Town, Mossel Bay, and the Eastern Cape.

Biomass burning and domestic fuel burning in low income households also contribute to air pollution within the district, in the form of particulate matter (soot), oxides of sulphur (SO_x) and NO_x. Based on the monitoring data presented in the chapters above, the Eden District has elevated levels of SO_2 emissions, although results indicate a steady decline since 2013. Numerous recent fires would also have increased atmospheric emissions in the Eden District (refer to Section 2.4).

3.2.6 Central Karoo District

Due to the lack of industrialisation in the Central Karoo District, emissions within the district emanate mainly from the use of fuels such as diesel and petrol for transportation. Domestic fuel combustion of coal, paraffin and wood for cooking and heating purposes is also prevalent. The district is also rich in minerals including uranium and shale gas and there has been much interest around mining these resources in future. (CKDM, 2016).

Very few complaints relating to air quality are received in the district. Complaints received relate mainly to offensive odour and waste/tyre burning, particularly at the Beaufort West landfill (DEA&DP, 2015).

4 IMPACTS

4.1. Climate change

Air quality and climate change are integrally linked – it is anticipated that air quality in many parts of the world will worsen as a result of climate change, with consequences for public health (USEPA, 2009). Climate change arises due to the emission of greenhouse gases which trap heat in the atmosphere and can alter the earth's climatic systems.

Scientific projections of climate change have confirmed rising global temperatures and shifting rainfall patterns. It is also likely that more regular extreme weather events such as heat waves or high intensity rainfall may occur. Extreme weather events and changing weather patterns could result in ecosystem degradation and biodiversity challenges, a shift in agricultural resources, changes in the distribution ranges of disease vectors (e.g. malaria mosquitoes) and negative impacts on social welfare and development.

For more information with regards to climate change in the Western Cape, please refer to the Climate Change Chapter of the SoEOR.

4.2. Brown haze

Cape Town's pollution levels are regarded as generally acceptable to good, due to the measures enforced over the years and the cleansing effect of the south-easterly winds. However, the "Cape Town brown haze", - a dense brown smog - descends over Cape Town, especially during the winter months. It is the result of the accumulation of gaseous and particulate pollution, especially when there is a pronounced temperature inversion and stable atmospheric conditions. The brown haze extends throughout most of the Cape Town Metropolitan area and is most intense during the winter morning hours with highly visible levels of pollution. Studies of the brown haze conducted in 1997 and 2005 attributed the majority of the total visible pollution to vehicular emissions, specifically particulates (Wicking-Baird *et al.*, 1997). Other provincial towns, including George, also experience less intense brown haze events.

Diesel vehicles, accounting for 49% of all the vehicular emissions, were identified as the main cause of the brown haze. The balance of the haze is attributed to industrial emissions and residential biomass (wood) burning. In response to the rising concerns, the City of Cape Town has prepared an action plan to reduce the impacts. The Air Quality Management Plan for the City of Cape Town presents objectives to be implemented at the local level (CCT, 2005).

4.3. Health effects

Air pollution, as with other types of pollution and nuisance factors, can lead to immediate (acute) health problems or can contribute to general (chronic) deterioration in health. Typically, higher intensity pollution from industrial sources or from indoor air pollution, will cause direct and immediate health problems. Pollutants such as PM_{10}, sulphur dioxide (SO_2), nitrogen dioxide (NO_2), lead (Pb), ozone (O_3) and carbon monoxide (CO) contribute to these adverse health effects.

A study on outdoor air pollution in South Africa (undertaken in 2007) estimated that in the year 2000, outdoor urban air pollution was linked to nearly 1% of all deaths (Norman *et al*., 2007). The link between poor air quality and health effects include the following:

- Exposure to indoor air pollution has been implicated, with varying degrees of evidence, as a causal agent of several diseases in developing countries including acute respiratory infections, middle ear infection, chronic obstructive pulmonary disease, lung cancer (from coal smoke), asthma, cancer, tuberculosis, perinatal conditions and linked low birth weight and diseases of the eye such as cataracts and blindness;
- Increased ozone has adverse effects upon human respiratory functions as it triggers asthma and causes lung cancer; and
- Anthropogenic sources of air pollution such as the release of NO_2 and SO_2 from industrial processes decreases lung function, increases mucus secretion and aggravates asthma.

Health risks from indoor air pollution are typically greater in high population density, poorer communities, and it is estimated that 80% of fuel-combustion related respiratory ailments in Cape Town are attributable to residential wood burning (Scorgie, 2012). The social cost of exposure to airborne pollutants (in homes) include direct medical expenses, loss of productivity, and reduced life expectancy.

The DEA&DP completed a comprehensive human health risk assessment in 2016, inclusive of epidemiological studies to determine the human health risk associated with exposure to air pollutants in selected areas of the Western Cape. Key findings of the study included that:

- The Paarl and Bluedowns areas required a more in-depth understanding of air pollution, since the socio-economic factors of individuals linked to poor air quality makes individuals living in these areas more vulnerable to the likely impacts of air pollution;
- The Dunoon (Milnerton) and Khayelitsha areas require further investigation in terms of respiratory illness amongst children and cardio-pulmonary effects amongst adults, respectively, as neither could be directly linked to air pollution in these areas, particularly since all measured pollutants were below the thresholds specified in the National Ambient Air Quality Standards; and

- Air pollution could likely be one of the largest threats to human health and the economy of the Western Cape; however, this requires further investigation.

The implementation of air quality measures in the areas highlighted for further study has been recommended in order to determine the most economically effective manner in which to reduce likely impacts of air pollution in the Western Cape (DEA&DP, 2016b).

4.4. Impacts on biodiversity

Air pollution can directly affect the fauna and flora, while indirect impacts are induced through the contamination of soil and water resources. The effects are highly dependent on the levels of exposure as well as the type of contaminant, therefore making the location and sources of pollution important factors in determining the precise effects on biodiversity.

The most common pollutants adversely affecting flora include SO_2, Fluoride (F), Chlorine (Cl), ozone (O_3) and Ethylene (C_2H_4). These result in "burning" at leaf tips or margins, stunted growth, premature leaf growth, delayed maturity, premature blossoming and reduced yield or quality. Typically, these effects would occur closer to large urban, and industrial areas, and specifically around point sources of pollution, such as power generation plants, smelters, incinerators, landfill sites, pulp and paper mills, and other fossil fuel burning sites.

Animals inhale pollutants or absorb them through their skin. Pollutants such as O_3, SO_2 and NO_2 mainly affect the respiratory system. Heavy metals (e.g. Pb, arsenic [As], and cadmium [Cd]) and hazardous chemicals released by industrial processes can affect the circulatory, respiratory, gastrointestinal, and central nervous systems of animals.

High concentrations of SO_2 in the atmosphere can also combine with water vapour to form sulphuric acid, which precipitates as acid rain. Acid rain has adverse effects on natural habitats and can kill small insect and freshwater life forms, and has the ability to degrade buildings through leaching processes.

4.5. Economic effects

The effects of poor air quality on environmental health, human health and livestock can translate into significant economic impacts on a local, regional and national scale. These impacts can manifest as reduction in productivity, direct expenditure or through a diffuse decline in the economic value of land. Direct costs relate to air pollution abatement costs, infrastructure or technology required to reduce emissions, and healthcare expenditure. Poor air quality can reduce property values, or can diminish the overall environmental conditions which underpin certain economic sectors, such as tourism or commerce.

4.6. Transboundary pollution

Air pollutants can disperse over wide areas. As such, transboundary air pollution is a factor that could influence the air quality of municipalities in the Western Cape (DEA&DP, 2015), as pollutants from one district may cross boundaries into another district. Airborne pollutants are easily distributed by the local or regional atmospheric circulation patterns, meaning that the longer the pollutants remain airborne, the further they can travel. Studies have shown that pollutants from industrial areas in the Mpumalanga Highveld and Gauteng contribute to air pollution in the Western Cape (Abiodun *et al.*, 2014; Nzotungicimpaye *et al.*, 2014).

Atmospheric circulation over the Western Cape could therefore transfer the impact of air pollution to areas further north along the west coast and the Atlantic Ocean and inland or along the east coast.

Transboundary air pollution is particularly difficult to address as it is often subject to scientific uncertainty and economic and political relations between regions. Current knowledge of the extent of transboundary pollution is also limited (DEA&DP, 2010). The declaration of transboundary priority areas / corridors has been identified as a potential means to manage transboundary pollution (DEA&DP, 2015). Given the comparatively good air quality in the Western Cape (and neighbouring provinces), transboundary impacts may not be significant at this stage.

4.7. Stratospheric ozone depletion

Several substances, including Chlorofluorocarbons (CFCs), have the ability to rise through the atmosphere and interact and breakdown stratospheric ozone molecules. The ozone layer plays a significant role in filtering ultraviolet radiation from the sun and a reduction (due to human industrial activity) could have direct impacts on health and the natural environment. This includes sunburn, skin cancer and eye damage. South Africa is located at the southern tip of Africa, and is the African country closest to the region of high ozone depletion over the Antarctic (the "*ozone hole*") and most at risk to increased levels of radiation.

5 RESPONSES

5.1 Mitigation and adaptation

Because of the increase in priority pollutant and GHG emissions there is a direct link between air quality and climate change, with cross-sectoral implications. The strong causal linkage between air quality management and climate change requires the spheres of government to work co-operatively to achieve air quality and climate change targets in an integrated manner (DEA&DP, 2015; DEA&DP, 2016c).

Although the DEA is mandated with air quality management in South Africa and is responsible for developing and implementing legislation to mitigate the effects thereof, all spheres of government need to respond to climate change, and therefore also indirectly manage air quality. In the Western Cape, DEA&DP's Directorate: Air Quality Management is responsible for the implementation and oversight of air quality management, planning, regulating and monitoring; with the Directorate: Climate Change being responsible for coordination of responses to climate change (DEA&DP, 2015). For more information on these strategies, please refer to the Climate Change and Energy Chapters of the SoEOR.

5.2 Policy, tools and legislation

The Bill of Rights enshrined in the Constitution states that South Africans have the right to an environment that is not harmful to their health and well-being. To enable and give effect to this right, the NEMA and the NEM:AQA were promulgated to create mechanisms through which control over air quality in South Africa can be exercised.

The 2012 National Framework for Air Quality Management commenced on 29 November 2013, with the purpose of achieving the objectives of the NEM:AQA, through planning mechanisms that promote holistic and integrated air quality management through pollution prevention and minimisation at the source, and through impact management (DEA, 2013). The Framework provides norms and standards for all technical aspects of air quality management in South Africa.

The main objective of the NEM:AQA can be summarised as the protection of the environment and human health, in a sustainable development framework, through reasonable measures of air pollution control. A summary of the regulations promulgated under NEM:AQA, to date is presented in Annexure A.

To further give effect to the public right to a healthy living environment, municipalities were granted executive authority over air pollution control within their areas of jurisdiction. An appropriate contribution from each municipality within the province, in conjunction with oversight from the provincial government, is required to ensure the implementation of the NEM:AQA across the province. Since 2008, 12 Municipal by-laws, in respect of air quality management have been gazetted in the Western Cape (DEA&DP, 2015).

The City of Cape Town, Eden District, West Coast District and Overberg District's Air Quality Management by-laws were approved and gazetted in 2010, 2012, 2013 and 2015 respectively. Due to a High Court challenge in respect of the scrap metal recovery sector, the City of Cape Town has commenced a review of its Air Quality Management by-law. The Cape Winelands District has developed a draft Air Quality Management by-law which is in the process of public review. The Central Karoo District has not yet developed an Air Quality by-law; however consultation with DEA&DP is underway as the by-law will need to take the proposed shale gas development into consideration (DEA&DP, 2015).

There are various responses in the form of policies, tools and legislation across all spheres applicable to air quality. These responses are listed in Annexure B. Other responses to air quality are discussed below.

5.2.1 South African air quality standards

Air quality guidelines and standards are fundamental to effective air quality management, as they define an acceptable relationship between the source of atmospheric emissions and downstream receptors. The NEM:AQA defines air quality that is not harmful to human health and well-being through the promulgation of the National Ambient Air Quality Standards (DEA, 2009) (DEA, 2012) and provides the regulatory tools and mandates for government to deliver the desired outcome (DEA&DP, 2015).

The DEA has issued national ambient air quality guidelines for criteria pollutants such as sulphur dioxide (SO_2), lead (Pb), nitrogen dioxide (NO_2), Benzene, PM_{10}, $PM_{2.5}$ and carbon monoxide (CO), in order to support management practices. These ambient air quality guidelines indicate acceptable daily exposure limits for the majority of the population, including the very young and the elderly. Hydrogen sulfide (H_2S) is a major constituent of odorous gases, and an appropriate standard would therefore take a measure of subjectivity out of the measurement of odours.

5.2.2 Air quality management plans

Section 15(1) and (2) of the NEM:AQA requires that provinces and municipalities develop specific AQMPs to manage air quality in their regions. In order for these plans to be effective, the AQMPs need to be reviewed every five years to establish whether the identified air quality management goals and targets have been effectively implemented and whether they are still valid in terms of new developments and economic growth.

In accordance with this requirement, DEA&DP developed the Western Cape AQMP, which was adopted in 2010. The plan was developed in phases, and included a status quo assessment of air quality management, public engagement and, ultimately, the compilation of a plan that includes the Vision, Mission and Goals for air quality management in the province, and that identifies actions required to meet the objectives of the plan. A Steering Committee and three Working Groups were established to ensure the successful implementation of the AQMP.

The vision for air quality management is "*Clean and healthy air for all in the Western Cape*", and goes hand-in-hand with a mission *"To ensure the effective and consistent implementation of sustainable air quality management practices, by all spheres of government, relevant stakeholders and civil society to progressively achieve and efficiently maintain clean and healthy air in the Western Cape*".

All municipalities within the Western Cape, with the exception of Oudtshoorn, Breede Valley, Beaufort West and Langeberg Local Municipalities (which have compiled draft plans) have adopted their AQMPs, which have been included as sector plans in their Integrated Development Plans (IDPs) (DEA&DP, 2015).

5.2.3 Atmospheric emission licensing

The NEM:AQA sets out the legal requirements for Air Quality Officers and Licensing Authorities to regulate air quality management, and implement the atmospheric emission licensing system in the province, furthermore promoting the access to information.

Significant efforts are being made to capacitate local authorities sufficiently to take over the role as licensing authorities (DEA&DP, 2011). Unfortunately, significant capacity constraints remain at local level, both in terms of financial and human resources. This could result in poor levels of implementation of the constitutional obligation to ensure a healthy living environment for citizens. Capacity constraints, in conjunction with the lack of real-time air pollution information, also hinder rapid response to pollution incidents.

The Licensing Authorities in the Western Cape have embraced the atmospheric emission licensing process. As at 31 December 2015, a total of 43 PAELs and 73 AELs were being regulated within the province. The Western Cape currently has designated Environmental Management Inspectors, who are empowered to enforce any authorisations issued under their mandated legislation, including licences such as AELs issued in terms of the NEM:AQA.

DEA&DP's Directorate: Air Quality Management initiated an AEL Compliance Inspection Programme in 2013, and applied strategic enforcement action on targeted sectors that are likely to have a significant environmental impact in the province. DEA&DPs Air Quality Officers and Environmental Management Inspectors, together with the Metropolitan, District and Local Municipalities, undertake compliance inspections of facilities throughout the Western Cape that trigger the Section 21 Listed Activities (DEA&DP, 2015).

5.2.4 Ambient air quality monitoring

DEA&DP commissioned its first air quality monitoring station in 2008. To date, 16 locations have been monitored, with 11 currently in operation and reporting on various air quality parameters. Each set of parameters measured aims to include complementary parameters, i.e. SO_2, ozone (O_3) and NO_2 (vehicle emissions and combustion), PM_{10} and carbon monoxide (CO) (combustion), and hydrogen sulphide (H_2S) and carbon dioxide (CO_2) (odour and combustion), which provides an indication of the possible causes of air pollution in an area. Meteorological parameters (wind speed and direction, ambient temperature, pressure, relative humidity) are also measured to provide the context within which the air quality is measured.

The information recorded at each monitoring station assists in reporting on air quality (DEA&DP, 2015). The list of monitoring stations together with the parameters measured is provided in Annexure C.

Routine passive sampling is also undertaken at various industries or activities throughout the province where air pollution can become a threat. In addition, the City of Cape Town and the Saldanha Bay Municipality have installed air quality monitoring equipment as part of the Western Cape Ambient Air Quality Monitoring Network in the Western Cape Province. These stations are used to inform planning and management, and respond to specific pollution incidences.

5.3 Knowledge management

5.3.1 Authority structures and mandates

Air quality management in the Western Cape is administered through a dedicated Air Quality Management unit set up in DEA&DP Directorate: Air Quality Management, along with a Provincial Air Quality Officer as well as Air Quality Officers (AQO) in district and local municipalities. The Oudtshoorn Local Municipality is the only Local Municipality without a designated AQO (DEA&DP, 2015).

An important aspect of air quality management that is often overlooked is the role of implementing agents – e.g. transport planning, the energy sector or human settlements planning departments in the province. Air quality management is not only about monitoring and corrective action, but needs to include pro-active design and planning that will integrate positive emissions profiles into day-to-day social and economic functioning.

5.3.2 Air quality officers forums

The National Framework on Air Quality Management requires that every province establish a Provincial-Municipal Air Quality Officers Forum and convene quarterly forum meetings in order to facilitate the effective, efficient and cohesive functioning of the forum (DEA, 2013). The Western Cape Provincial Air Quality Officer's Forum takes place quarterly and serves as a platform for Western Cape air quality officers to discuss air quality matters and coordinate progress on the implementation of the NEM:AQA, as well as the 2012 National Framework. In addition, the forum provides Air Quality Officials the opportunity to build, strengthen and/or fine-tune their air quality management interventions and to share experiences, challenges and plans going forward.

In 2012, two District Municipalities (WCDM and EDM) had established Municipal Air Quality Officers/Industry Forums. The municipal forums convene quarterly and are attended by industries that operate under Section 21 Listed Activities of NEM:AQA, the Local Municipal Air Quality Officers, as well as DEA&DP Air Quality Officers. These forums serve as platforms to communicate important air quality matters to the industries and Local Municipalities in their respective areas.

5.3.3 AQMP working groups

The AQMP Steering Committee and the Provincial Western Cape AQMP Working Groups are considered as the primary mechanism identified to implement the AQMP objectives. The AQMP Working Groups are held concurrently with the Western Cape Air Quality Officer Forums. Working Groups that have been established include:

- Working Group I – Air Quality Management and Climate Change;
- Working Group II – Air Quality Education and Awareness Raising; and
- Working Group III – Compliance Monitoring and Enforcement.

Each Working Group has identified initial priorities for implementation in the Province.

6 CONCLUSION

OUTLOOK: STABLE WITH A SLIGHT IMPROVEMENT

Air pollution knows no boundaries, as pollutants can easily disperse widely. By reducing air pollution, we are able to reduce associated acute and chronic health effects, such as respiratory illness, and the adverse effects on the environment. The major drivers of air pollution differ between the districts, but include mostly industrialisation, transportation and the use of domestic fuels, including wood, for cooking and heating.

The number of air quality monitoring stations within the province has increased steadily affording the authorities a better and improving understanding of the state of air quality. The overall air quality situation within the Western Cape Province is positive insofar as ambient air quality monitoring information indicates that air quality is largely compliant with the South African National Ambient Air Quality Standards, with a gradual improvement evident. However, various hotspots of poor air quality are evident. Ongoing management is therefore required in order to maintain acceptable levels of air quality across the province.

Additional monitoring would help determine the spatial and temporal extent of pollution sources and concentrations, to guide action to improve air quality. The lack of consistent long-term air quality monitoring records constrains air quality management in the province: it is therefore imperative that more consistent monitoring be undertaken, a better spatial coverage be achieved and that operational procedures and processes for instrument repair and maintenance be reviewed to reduce the potential for data losses (DEA&DP, 2011).

Effective air quality management requires effective engagement and collaboration between various spheres of government. An integrated approach will facilitate mutually reinforcing planning and effective system design. For example, if spatial planning can deliver an efficient city form, it will help to improve transport efficiency and, in turn, improve overall air quality.

Air quality in the Western Cape has an overall stable outlook. Table 6-1 contains an overview of the key pressures, impacts, challenges, progress and critical areas for action. Table 6-2 contains the anticipated changes or outlook for future Air Quality in the province.

Table 6-1: Overview of key air quality aspects

Aspect	Summary
Pressures	• Transportation (especially diesel) • Domestic fuel burning • Veld fires • Industrialisation
Impacts	• Brown haze • Indoor air pollution • Impacts on environment and biodiversity • Economic impacts • Health effects • Transboundary air pollution • Carbon footprint / climate change (ozone depletion)
Challenges	• Limited availability of monitoring data (spread and historical) for the province • Understanding and management of Transboundary Air Pollution • Obstacles in the implementation of renewable solutions / technologies which will reduce emissions • Reduction of vehicle emissions

Progress	• Operational monitoring stations • Update of District and Provincial AQMP • Promulgation of Bylaws • Implementation of licensing procedures and compliance monitoring • Authority structures and mandates / forums • Air quality compliant with the South African National Ambient Air Quality Standards • Legislation promulgated to address GHG levels
Critical areas for action	• Improve coverage of monitoring network • Improve capacity in terms of licensing and compliance monitoring • Remove obstacles to innovative (green) urban development • Revolutionise transportation systems

Table 6-2: Summary of the outlook for air quality in the Western Cape

Indicator	Quantification	Desired State/Targets	Trend
Atmospheric pollutants	• Particulate Matter (PM_{10}) – below SA NAAQS and indicates a steady decline.	Remain below the NAAQS, with steadily declining emission rates and ambient concentrations across the province.	**Improving**
	• Nitrogen Dioxides (NO_2) – below SA NAAQS; however no visible trend in data.		**No change**
	• Sulphur dioxide (SO_2) – below SA NAAQS with key hotspot areas.		**No change**
	• Greenhouse gases (GHG) – increase in levels but stable per capita.		**No change**
Air Quality Management at District Level	• Increased commitment to air quality related matters – complaints registers, AQMP updates, AQ Forums, By-Laws, Air Quality Officer appointments); and • Increased number of monitoring stations.	Continual commitment to air quality issues in the Province	**Improving**

Indicator	Quantification	Desired State/Targets	Trend
Key atmospheric pollutants per district	**City of Cape Town** • Declining concentrations of particulate matter, NO_2 and SO_2 at the DEA&DP monitoring stations (all below the SA NAAQS); • Main sources of ambient air pollution include NO_2, particulate matter and SO_2 which are attributed to industrial operations, vehicle emissions, electricity generation and domestic fuel use; • General smog problem ("brown haze□) – linked to vehicle emissions, over Cape Town (mainly during winter months); and • Complaints relate to fumes, odour and farmland/tyre/waste burning – where applicable complaints referred to Director of Public Prosecutions for consideration.		**Improving**
	West Coast • Concentrated emissions from industries using fossil fuels on site; • Air Quality concerns linked to local industrial activities (i.e. red dust from iron ore handling in Saldanha Bay, dust from lime production in Matzikama and malodorous fishmeal production in St. Helena Bay); and • Complaints investigated by trained team of Environmental Management Inspectors.		**No change**
	Cape Winelands • Concentrations of particulate matter, NO_2 and SO_2 at the DEA&DP monitoring stations are below the SA NAAQS, although are increasing; • Main sources of ambient air pollution are industrial and agricultural activities and vehicle emissions; and • Complaints relate to dust, crop spraying, and farmland/tyre burning – District Air Quality Forum formulates and implements specific action plans.		**No change**
	Overberg • Highest per capita vehicle ownership, indicating potential issues over time; • Emissions from industries in the Overberg District include particulate matter, VOC, CO_2 and fugitive pesticides; and • Complaints relate to odour, dust and smoke.		**No change**

Indicator	Quantification	Desired State/Targets	Trend
	Eden District • Concentrations of particulate matter, NO_2 and SO_2 at the DEA&DP monitoring stations are below the SA NAAQS, although increasing; • Emissions from industries and petrochemical operations, specifically in the Mossel Bay area; and • Complaints relate to smoke and odour.		**No change**
	Central Karoo • Transportation and domestic fuel consumption related emissions; • Shale gas production expected to elevate methane and CO_2 emissions; and • Complaints relate to odour and waste/tyre burning.		**No change**

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Annexure A

Table A1: Regulations promulgated in terms of NEM:AQA

Legislation	Commencement Date	Description / Purpose
National Ambient Air Quality Standards	24 December 2009 (GN. 1210 of Gazette No. 32816)	The notice provides for the assessment of ambient air quality standards in terms of Section 5.2.1.3. of the National Framework for Air Quality Management in South Africa.
List of 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	01 April 2010 (GN 248 of Gazette No. 33064)	The regulations make provision for minimum emission standards to apply to both permanently operated plants and for experimental (pilot) plants with a design capacity to the one of a listed activity, as it is applicable under normal working conditions.
National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter less than 2.5 micron metres ($PM_{2.5}$)	29 June 2012 (GN 486 of Gazette No. 35463)	The regulations make provision for the regulation of particulate matter of aerodynamic diameter less than 2.5 micron metres ($PM_{2.5}$).
National Dust Control Regulations	01 November 2013 (GN 827 of Gazette No. 36974)	The regulations prescribe general measures for the control of dust in all areas.
Declaration of a small boiler as a controlled emitter and establishment of emission standards	01 November 2013 (GN 831 of Gazette No. 36973)	The regulations regulate the emissions and requirements as set out for any small boiler under normal operating conditions subject to the provisions for start-up, soot-blowing and incidences of abnormal conditions.
Regulations Prescribing the Format of the Atmospheric Impact Report	02 April 2015 (GN 747, as amended by GNR 284)	The regulations make provision for any person required to submit an atmospheric impact report in terms of Section 30 of the NEM:AQA to do so in the prescribed format.
National Atmospheric Emission Reporting Regulations	02 April 2015 (GN 283)	The regulations are for the reporting of data on sources of atmospheric emissions to National Atmospheric Emissions Inventory System (NAEIS) and compilation of atmospheric emission inventories.
Amendments to the List of 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	12 June 2015 (GN 551 of Gazette 38863)	The regulations make provision for additional requirements in terms of when waste ceases to be waste as per section 1 of the National Environmental Management: Waste Act 59 of 2008, as amended. Further amendments were made to the following listed activities: Sub-category 2.1 (Combustion installations) Subcategory 3.4 (Char, Charcoal and Carbon Black Production) Subcategory 4.3 (Primary Aluminium Production) Subcategory 5.3: Clamp Kilns for Brick Production
Declaration of Small-scale Char And Small-scale Charcoal Plants as Controlled Emitters and Establishment of Emission Standards	18 September 2015 (GN. 602 of Gazette No. 39220)	The regulations make provision for small-scale char and small-scale charcoal plants as controlled emitters and establishment of emission standards (production capacity smaller than 20 tonnes per month).

Legislation	Commencement Date	Description / Purpose
Regulations Prescribing the Atmospheric Emission Licence (AEL) Processing Fee	11 March 2016 (GN. 250 of Gazette No. 39805)	The regulations make provision for an applicant of an AEL to pay the prescribed processing fees, as indicated in the Annexure A, before or on the date of the submission of the application or as directed by the licensing authority.
Regulations for the Procedure and Criteria to be followed in the Determination of an Administrative Fine in terms of section 22a of the Act	18 March 2016 (GN. 332 of Gazette 39833)	The regulations provide for the determination of administrative fine, as well as for an applicant to pay the applicable AEL processing fee as stipulated. The regulations make provision for the payment of an administrative fee, in addition to the administrative fee payable in terms of section 24G of NEMA
Air Quality Offsets Guideline	18 March 2016 (GN. 333 of Gazette No. 39833)	The regulations make provision for guidance on situations under which offsets can be applied during the implementation of the atmospheric emission licensing system stipulated in Chapter 5 of NEM: AQA. Also provides guidance in terms of principles that should be adhered to in recommending and implementing offsets as well as the responsibilities of the different role players.
National Pollution Prevention Plans Regulations	08 January 2016 (GN. 5 of Gazette No. 39578)	The regulations intend to provide for a tool for authorities to obtain information pertaining to greenhouse gases. The regulations stipulate that companies conducting particular processes that emit greenhouse gases directly into the atmosphere must prepare, submit and implement a pollution prevention plan in respect of the greenhouse gases.
Declaration of Greenhouse Gases as Priority Air Pollutants	08 January 2016 (GN. 6 of Gazette No. 39578)	The notice intends to declare greenhouse gases as priority air pollutants. The notice stipulates that people conducting certain listed production processes which result in the emission of greenhouse gases that are listed as priority air pollutants must prepare and submit a pollution prevention plan.
National Greenhouse Gas Emission Reporting Regulations	03 April 2017 (GN. 622 of Gazette No. 40762)	The regulations intend to provide for the reporting of greenhouse gases. The regulations make the reporting of greenhouse gases mandatory, and allow for data that could be more accurate and reliable.

Annexure B

Table B1: Summary of policy, tools and legislation

Responses	Year	Description
International Responses	1998	Clean Air Initiative Africa
	1998	Air Pollution Information Network Africa
	2002	Kyoto Protocol (Ratified by South Africa in March 2002)
	2015	Paris Agreement (Ratified by South Africa in November 2016)
National Responses	2004	National Environmental Management: Air Quality Act 39 of 2004
	2007 & 2012	National Framework for Air Quality Management
	2011	National Climate Change Response White Paper
	2017	Greenhouse Gas Reporting Regulations
Provincial Responses	2016	Western Cape Air Quality Management Plan
Local Authority Responses	1997 & 2004	Brown Haze studies 1 and 2
	2005	City of Cape Town Air Quality Management Plan
	2010	City of Cape Town Air Quality Management By-Law (sets limits for light obscuration from tailpipe emissions for compression ignition engines i.e. diesel vehicles)
	Various	Air Quality Management Plans of Drakenstein, Eden, West Coast, Cape Winelands
	2009	City of Cape Town Fleet Greening Framework
	2010 – 2015	Local Municipal Air Quality Management By-laws (City of Cape Town, Eden District, West Coast District and Overberg District)

Annexure C

Table C1: DEA&DP Operational Ambient Air Quality Monitoring Network

Municipal Area	Location	Date Commenced
DEA&DP's Western Cape Ambient Air Quality Monitoring Network		
Cape Winelands	Traffic Department, van Riebieck Rd, Paarl	March 2008 – May 2009*
Eden	Voorbaai electrical substation, Mosselbay	August 2008 – February 2010*
West Coast	Vredenburg High School, Vredenburg	April 2008*
Cape Winelands	Meirings Park Electrical Substation, Worcester	July 2009
West Coast	Swartland High School, Malmesbury	April 2010
Eden	Municipal Swimming Pool, George	July 2010
City of Cape Town	Panther Park, Berkeley Rd, Maitland	August 2010*
Eden	Bongolethu Clinic, Oudtshoorn	April 2011
West Coast	HP Williams Primary School, St Helena Bay	April 2011
City of Cape Town	Khayelitsha Training Centre, Khayelitsha	May 2011-December 2014*
City of Cape Town	Khayelitsha District Hospital, Khayelitsha	January 2015
City of Cape Town	Morningstar Small Holdings, Vissershok	September 2011
Cape Winelands	CWDM Office, Bird Street, Stellenbosch	October 2011
Eden	Dana Bay Reservoir, Dana Bay	November 2011
City of Cape Town	Sentinel Primary School, Hout Bay	March 2014
Overberg	Mount Pleasant Primary School, Hermanus	March 2014
City of Cape Town's Ambient Air Quality Monitoring Network		
City of Cape Town	Molteno	1992
City of Cape Town	Goodwood	1993
City of Cape Town	Athlone	1993
City of Cape Town	City Hall, City of Cape Town	1994
City of Cape Town	Tableview	1994
City of Cape Town	Foreshore, City of Cape Town	1995
City of Cape Town	Bothasig	1995
City of Cape Town	Khayelitsha, Site C, Khayelitsha	2002
City of Cape Town	Bellville South, Bellville	2003
City of Cape Town	Wallacedene	2006
City of Cape Town	Atlantis	2008
City of Cape Town	Plattekloof Reservoir, Plattekloof	2013
Saldanha Bay's Ambient Air Quality Monitoring Network		
Saldanha Bay	Saldanha Bay Harbour	July 2014
Saldanha Bay	Louwville substation	July 2014
Saldanha Bay	Saldanha Bay Substation	*
** Monitoring station has been decommissioned*		

Table C2: Other Air Quality Monitoring Stations

Station Location	Air Quality Parameters Measured
Worcester	SO_2, O_3, NO_2, CO, PM_{10} and full meteorological parameters
Malmesbury	SO_2, O_3, NO_2, CO, PM_{10} and full meteorological parameters
George	SO_2, O_3, NO_2, CO, PM_{10} and full meteorological parameters
Visserhok	O_3, NO_2, CO, PM_{10}, and full meteorological parameters
St. Helena Bay	H_2S, CO_2, TRS and full meteorological parameters
Oudsthoorn	H_2S, CO2 and full meteorological parameters
Stellenbosch	SO_2, O_3, NO_2, CO, CO_2, PM_{10} & $PM_{2.5}$, and full meteorological parameters
Khayelitsha	SO_2, O_3, NO_2, CO, CO_2, PM_{10}, $PM_{2.5}$ and full meteorological parameters
Dana Bay	H_2S, and full meteorological parameters full met only added in 2016
Hout Bay	H_2S and full meteorological parameters
Hermanus	SO_2, O_3, NO_2, CO, CO_2, PM_{10} & $PM_{2.5}$ and full meteorological parameters

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