Project Done on Behalf of
Sasol Technology (Pty) Ltd

Atmospheric Impact Report:
Sasol Secunda Facility

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Preface

Sasol's operations at the Secunda Facility (Synfuels) are required to comply with the Minimum Emissions Standards, which came into effect in terms of Section 21 of the National Environment Management: Air Quality Act (Act No 39 of 2004) on 1 April 2010. The Minimum Emission Standards were subsequently amended and the amendments were promulgated on 22 November 2013 (Government Gazette No. 37054), replacing the 2010 regulations. These standards require the operations to comply with standards for "existing plant" by 1 April 2015, and for "new plant" by 1 April 2020. Sasol intends submitting an application for postponement from the compliance timeframes In support of the submissions and to fulfil the requirements for these applications stipulated in the Air Quality Act and the Minimum Emissions Standards, an Atmospheric Impact Report (AIR) is required to substantiate the motivations for the postponement.

The facility in Secunda, Sasol Synfuels, produces synthesis gas (syngas) from coal by gasifying the coal at a temperature of 1300°C, using two types of reactors (circulating fluidised bed and Sasol Advanced Synthol™ reactors). The syngas is subsequently converted to produce components for making synthetic fuels as well as a number of downstream chemicals. Gas water and tar oil streams emanating from the gasification process are refined to produce ammonia and various grades of coke respectively.

Whilst the main air pollutants from the Secunda operations include sulfur dioxide (SO_2), nitric oxide (NO) and nitrogen dioxide (NO_2) – collectively known as NO_x, other pollutants to consider include particulate matter (PM), volatile organic compounds (VOCs), ammonia (NH_3), hydrochloric acid (HCl), hydrogen fluoride (HF), dioxins/furans and metals.

Airshed Planning Professionals (Pty) Ltd (hereafter referred to as Airshed) was appointed by Sasol to provide independent and competent services for the compilation of an Atmospheric Impact Report as set out in the Regulations Prescribing the Format of the Atmospheric Impact Report (Government Gazette No. 36904, 11 October 2013) and detailing the results of the dispersion model runs. The tasks to be undertaken consist of:

1) Review of emissions inventory for the identified point sources and identification of any gaps in the emissions inventory. It is preferable that gaps be estimated using an agreed emission estimation technique.
2) Prepare meteorological input files for use in one or more dispersion model to cover the applicable Sasol sites. Sasol will provide surface meteorological data and ambient air quality data from the Sasol ambient air quality monitoring stations. Surface meteorological data for three years, as required by the draft Dispersion Modelling Guidelines for Level 3 Assessments (Government Gazette No 35981 published 14 December 2012), is available for ambient air quality monitoring stations situated in both Sasolburg and Secunda.
3) Preparation of one or more dispersion model set up with Sasol's emissions inventory capable of running various scenarios for each of the point sources as specified by Sasol, in conjunction with Sasol Technology's Research and Development Department. The intent is to model delta impacts of the various emission scenarios against an acceptable measured airshed baseline.
4) Airshed will validate the dispersion model based on a fractional bias approach.
5) It is anticipated that each point source identified above will require 3 scenarios per component per point source to be modelled, in order to establish the delta impacts against the DEA-approved baselines. i.e.:
    a. Baseline – modelling is conducted based on the current inventory and impacts
    b. Compliance scenarios – modelling must be conducted based on compliance to the legislative requirement as stipulated within the Listed Activities and Minimum Emissions Standards (for both existing plant and new plant standards).

    c.   Alternative Emission Limits – the emission reductions as proposed by Sasol, where applicable and different from the baseline and / or compliance emission scenarios.

6) Comparison of dispersion modelling results with the National Ambient Air Quality Standards (NAAQS).

7) A report detailing the methodology used and model setup was compiled for purposes of a peer review. This report, together with the peer review report and comments from Airshed on the findings, is included as an annexure to this AIR.

8) Interactions with the Environmental Assessment Practitioner (EAP) to provide all necessary inputs into the EAP's compilation of documentation in support of Sasol's applications. Airshed will attend all Public Participation meetings scheduled by the EAP to address any queries pertaining to the dispersion model.

The Atmospheric Impact Report (AIR) was prepared in alignment the Regulations Regarding Air Dispersion Modelling following a 'fit for purpose' code of practice (Section 1.2; Government Gazette No. 37804 vol. 589; 11 July 2014). This approach aimed to present sufficient and pertinent information to assist stakeholders to assess the impacts associated with Sasol's applications for postponement of MES compliance timeframes.

Updates made to the AIR following conclusion of the public comment period

The following types of updates have been made to this document following the conclusion of the public comment period:

- updates that address stakeholder comments or queries or provide expanded explanations of key concepts;
- references to changes in regulations, for example the Regulations regarding Air Dispersion Modelling which were promulgated in July 2014; and,
- update cross-references; for example between the AIR and the motivation report.

A detailed list of changes is provided in Table B-1.

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List of Abbreviations

AQA	Air quality act
APCS	Air pollution control systems
ARM	Ambient Ratio Method
As	Arsenic
ASG	Atmospheric Studies Group
Cd	Cadmium
Co	Cobalt
CO	Carbon monoxide
CO_2	Carbon dioxide
Cr	Chromium
Cu	Copper
DEA	Department of Environmental Affairs
ESP	Electro static precipitator
g	Gram
g/s	Gram per second
FDG	Flue-gas desulfurisation
HCl	Hydrogen chloride
Hg	Mercury
HNO_3	Nitric acid
HF	Hydrogen fluoride
IPCC	Intergovernmental Panel on Climate Change
LMo	Monin-Obukhov length
m	Meter
m^2	Meter squared
m^3	Meter cubed
MIBK	Methyl isobutyl ketone
m/s	Meters per second
Mn	Manganese
NAAQ Limit	National Ambient Air Quality Limit concentration
NAAQS	National Ambient Air Quality Standards (as a combination of the NAAQ Limit and the allowable frequency of exceedance)
NEMAQA	National Environmental Management Air Quality Act
NH_3	Ammonia
Ni	Nickel
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
O_3	Ozone
OLM	Ozone Limiting Method
PBL	Planetary boundary layer
Pb	Lead
PM	Particulate matter
PM_{10}	Particulate matter with diameter of less than 10 µm

PM$_{2.5}$	Particulate matter with diameter of less than 2.5 μm
REL	Reference Exposure Limit
Sb	Antimony
SO$_2$	Sulfur dioxide
SO$_3$	Sulfur trioxide
SS1	Steam station 1
SS2	Steam station 2
TI	Thalium
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
V	Vanadium
VOC	Volatile organic concentrations
μ	micro
°C	Degrees celcius

Glossary

Advection	Transport of pollutants by the wind
Airshed	An area, bounded by topographical features, within which airborne contaminants can be retained for an extended period
Algorithm	A mathematical process or set of rules used for calculation or problem-solving, which is usually undertaken by a computer
Alternative Emission Limit	Ceiling or maximum emission limit requested by Sasol, with which it commits to comply
Assessment of environmental effects	A piece of expert advice submitted to regulators to support a claim that adverse effects will or will not occur as a result of an action, and usually developed in accordance with section 88 of the Resource Management Act 1991
Atmospheric chemistry	The chemical changes that gases and particulates undergo after they are discharged from a source
Atmospheric dispersion model	A mathematical representation of the physics governing the dispersion of pollutants in the atmosphere
Atmospheric stability	A measure of the propensity for vertical motion in the atmosphere
Building wakes	Strong turbulence and downward mixing caused by a negative pressure zone on the lee side of a building
Calm / stagnation	A period when wind speeds of less than 0.5 m/s persist
Cartesian grid	A co-ordinate system whose axes are straight lines intersecting at right angles
Causality	The relationship between cause and effect
Complex terrain	Terrain that contains features that cause deviations in direction and turbulence from larger-scale wind flows
Configuring a model	Setting the parameters within a model to perform the desired task
Convection	Vertical movement of air generated by surface heating
Convective boundary layer	The layer of the atmosphere containing convective air movements
Data assimilation	The use of observations to improve model results – commonly carried out in meteorological modelling
Default setting	The standard (sometimes recommended) operating value of a model parameter
Diagnostic wind model (DWM)	A model that extrapolates a limited amount of current wind data to a 3-D grid for the current time. It is the 'now' aspect, and makes the model 'diagnostic'.
Diffusion	Clean air mixing with contaminated air through the process of molecular motion. Diffusion is a very slow process compared to turbulent mixing.
Dispersion	The lowering of the concentration of pollutants by the combined processes of advection and diffusion
Dispersion coefficients	Variables that describe the lateral and vertical spread of a plume or a puff
Dry deposition	Removal of pollutants by deposition on the surface. Many different processes (including gravity) cause this effect.
Sasol Synfuels	Sasol Chemical Industries (Pty) Limited operating through its Secunda Synfuels Operations, formerly Sasol Synfuels (Pty) Limited. To avoid unnecessary confusion, the name "Sasol Synfuels" has been retained in this report.

Atmospheric Impact Report

1   ENTERPRISE DETAILS

1.1   Enterprise Details

The details of Secunda Complex operations are summarised in Table 1-1. The contact details of the responsible person, the emission control officer, are provided in Table 1-2.

Table 1-1: Enterprise details

Enterprise Name	Sasol Synfuels (Pty) Ltd
Trading as	Sasol Synfuels
Type of Enterprise	1979/002735/07
Company Registration Number	Synfuels Road Sasol Synfuels Secunda 2302
Registered Address	Private Bag X1000 Secunda 2302
Telephone Number (General)	017 610 2627
Fax Number (General)	
Company Website	www.sasol.com
Industry Type/Nature of Trade	Petrochemical industry
Land Use Zoning as per Town Planning Scheme	Industrial
Land Use Rights if Outside Town Planning Scheme	n/a

Table 1-2: Contact details of responsible person

Responsible Person Name:	Estelle Marais
Responsible Person Post:	Senior Manager SHE: Environment – Air quality and greenhouse gas
Telephone Number:	017 610 2895
Cell Phone Number:	079 509 9011
Fax Number:	017 610 4090
E-mail Address:	Estelle.marais@sasol.com
After Hours Contact Details:	079 509 9011
Name of VP SHE Secunda Synfuels Operations:	Simon van Renssen

1.2   Location and Extent of the Plant

Table 1-3: Location and extent of the plant

Physical Address of the Plant	Synfuels Road Sasol Synfuels Secunda, 2302
Description of Site (Where no Street Address)	Highveld Ridge Mpumalanga
Coordinates of Approximate Centre of Operations	The geographical co-ordinates have been excluded for security reasons but will be made available to the DEA under confidentiality arrangements.
Extent	24.05 km^2
Elevation Above Sea Level	1 597m
Province	Mpumalanga
Metropolitan/District Municipality	Gert Sibande District Municipality
Local Municipality	Govan Mbeki Local Municipality
Designated Priority Area	Highveld Priority Area

1.3   Atmospheric Emission Licence and other Authorisations

The following licences related to air quality management are applicable:

- Atmospheric Emission License:
  - Licence no. Govan Mbeki/Sasol Chemical Industries (Pty) Ltd 0016/2014/F01 27 March 2014 issued to Sasol Chemical Industries (Pty) Ltd operating through its Secunda Synfuels Operations
  - Licence no. Govan Mbeki/Sasol Chemical Industries (Pty) Ltd 0018/2014/F01 27 March 2014 issued to Sasol Chemical Industries (Pty) Ltd through its Secunda Chemical Operations (LOC)
  - Licence no. Govan Mbeki/Sasol Chemical Industries (Pty) Ltd Sasol Oil/0019/2014/F01 27 March 2014 issued to Sasol Chemical Industries (Pty) Ltd Sasol Oil
  - Licence no. Govan Mbeki/Sasol Chemical Industries (Pty) Ltd 0017/2014/F01 27 March 2014 issued to Sasol Chemical Industries (Pty) Ltd through the Secunda Chemical Operations (Solvents) (not affected)
  - Licence no. Govan Mbeki/Sasol Chemical Industries (Pty) Ltd Sasol Nitro 0020/2014/F01 27 March 2014 issued to Sasol Chemical Industries (Pty) Ltd Sasol Chemical Operations (Nitro) – not affected
  - Licence no. Govan Mbeki/Sasol Chemical Industries (Pty) Ltd 0021/2014/F01 27 March 2014 issued to Sasol Chemical Industries (Pty) Ltd through Secunda Chemical Operations (Polymers) (not affected)
- Other: None

2 NATURE OF THE PROCESS

2.1 Listed Activities

A summary of listed activities currently undertaken at Secunda Complex is provided in Table 2-1.

Table 2-1: Listed activities

Category of Listed Activity	Sub-category of the Listed Activity	Listed Activity name	Description of the Listed Activity
1	1.1	Solid Fuel Combustion installations	Solid fuels combustion installations used primarily for steam raising or electricity generation
	1.4	Gas Combustion Installations	Gas combustion (including gas turbines burning natural gas) used primarily for steam raising or electricity generation
2	2.1	Combustion installation	Combustion installation not used primarily for steam raising or electricity generation (furnaces and heaters)
	2.2	Catalytic cracking	Refinery catalytic cracking units
3	3.3	Tar processes	Processes in which tar, creosote or any other product of distillation of tar is distilled or is heated in any manufacturing process
	3.6	Synthetic gas production and clean up	The production and clean-up of a gaseous stream derived from coal gasification and includes gasification, separation and clean-up of a raw gas stream through a process that involves sulfur removal and Rectisol as well as the stripping of a liquid tar stream derived from the gasification process
4	4.2	Combustion installation	Combustion installation not used primarily for steam raising and electricity generation (except drying)
	4.7	Electric Arc Furnaces	Electric arc furnaces in the steel making industry
5	5.1	Storage and handling of ore and coal	Storage and handling of ore and coal not situated on the premises of a mine or works as defined in the Mines Health and Safety Act 29/1996
6	6	Organic Chemical Industry	The production or use in production of organic chemicals not specified elsewhere including acetylene, acetic, maleic or phthalic anhydride or their acids, carbon disulphide, pyridine, formaldehyde, acetaldehyde, acrolein and its derivatives, amines and synthetic rubber.
7	7.1	Production and or use in manufacturing of ammonia, fluorine, fluorine compounds, chlorine and hydrogen cyanide	Production and or use in manufacturing of ammonia, fluorine, fluorine compounds, chlorine and hydrogen cyanide and chlorine gas (excluding metallurgical processes related activities regulated under category 4)
	7.2	Production of acids	Production, bulk handling and or use of Sulfuric acid in concentration exceeding 10 %
8	8.1	Thermal treatment of General and Hazardous Waste	Facilities where general and hazardous waste are treated by the application of heat
	8.3	Burning Grounds	

2.2 Process Description

A description on the process units operating at Sasol Synfuels complex is provided below. Further information is contained in the motivation reports.

2.2.1   Utilities

2.2.1.1   Steam Plant

Steam is used in various processes throughout the factory and for generating electricity. The Steam plant generates steam from 17 boilers using fine coal and boiler feed water. Electricity is generated by means of 10 steam driven turbine generators.

Steam Plant (Unit 43 /243) supplies process steam for the Gasification process, as well as drive steam for the turbines at Synthol and Oxygen East. Make-up steam is let down to satisfy deficits on the MP and LP factory steam headers. The balance of the steam produced is used to generate electricity.

U43 and 243 both have eight Babcock boilers, while U243 has a ninth boiler built by ICAL. Electricity is generated in turbo-generator sets rated at 60MWe. There are 6 and 4 turbo-generators at both Unit 43 and Unit 243 respectively, resulting in combined generation capacity of 600MWe.

The operating philosophy of steam plant is such that the steam header pressure control is done by manipulating the boilers and turbo generator load.

2.2.1.2   Gas Turbines

Two gas turbines provide additional electricity generating capacity. Natural gas from Mozambique and Methane Rich Gas (MRG) from Cold Separation (Gas Circuit) are used as the feed streams.

The open cycle gas turbine (OCGT) power plant consists of 2 x GE PG9171 (E) gas turbine generators and associated plant. The nominal output from each gas turbine is approximately 104MW. The gas turbines utilise natural gas as fuel. The exhaust gas from the gas turbines is used to generate high pressure steam in Heat Recovery Steam Generator (HRSG). Each gas turbine have its own boiler (HRSG) with supporting boiler feed water pre-conditioning equipment as well as own blow down equipment. Each HRSG is at 163t/h MCR 40 bar (g) steam production.

There are two gas turbine (GT) trains which are operated independently in parallel. Each GT train has a maximum operating generation capacity of 104 MW during summer months and 110 – 118 MW during winter months. The GTs has a design generation capacity of 118 MW. The Gas Turbines supply electricity into the Eskom grid.

2.2.2   Gas Production

2.2.2.1   Coal processing

Coal is conveyed from Sasol Coal Supply (SCS) to Coal Processing (Unit 01 / 201) where it gets screened. The coarse fraction (oversize material) is conveyed to Coal Distribution (Unit 02 / 202) from where it is transferred via conveyer belts to tripper cars to fill the different bunkers of the gasifiers. The smaller fraction (undersized material) is transferred by means of gravity for dewatering purposes. The oversized material from the screens is transferred to a centrifuge where further dewatering takes place. The undersized material from the screens are transferred in a slurry launder to the thickener system where flocculent is added to aid in the settling of the coal particles. The underflow of the thickeners is pumped to the filter section where the slurry is dewatered by means of vacuum filtration. The filter cake is removed from the filter cloth with the aid of a compressed air cycle. The filter cake and centrifuge product combine to be used as feed to the Steam Plant (Unit 43 / 243).

84 Sasol® FBDB™ gasifiers (42 gasifiers at each unit, 10 and 210), are used to gasify coarse coal using high pressure superheated steam and oxygen. The Sasol® FBDB™ gasifier is a commercially proven process for the conversion of coal feedstock into synthesis gas. In this process, the following streams are formed:

- Raw gas which is transferred to Raw Gas Cooling and then to Rectisol for further purification
- Ash as a waste stream that is processed by the Inside Ash
- Gas Liquor (a water stream) is transferred to Gas Liquor Separation to separate tars, oils and solids from the aqueous phase.

Wet gasification coal (the coarse fraction) is sent to the coal storage at the top of each gasifier. Coal is loaded to each gasifier using batch operated coal locks. Inside the gasifiers, coal reacts with steam and oxygen mixture producing crude (raw) gas containing hydrogen, carbon dioxide, carbon monoxide, methane, steam, as well as small concentrations of hydrocarbons, tars, oils, phenols, ammonia and many more.

Hot gas leaving the gasifiers is quenched to remove solids and heavy tars and then cooled in heat exchangers at Raw Gas Cooling (units 11 & 211) before it is sent to Rectisol for further purification.

During gasification process, mineral matter contained in coal is oxidised and ash is produced. The ash is intermittently removed from the bottom of the gasifier via an automatically operated ash lock hopper, quenched with water and sent to Inside Ash unit for processing and disposal.

The gas liquor containing dissolved oil, phenols, tar acids, organic acids and ammonia, is worked-up in the Gas Liquor Separation, Phenosolvan, Ammonia Recovery and biological Water Recovery effluent treatment plants, before it is used as make-up water to the process cooling towers.

2.2.2.3 Rectisol

The main function of Rectisol is to remove acid gases, such as CO_2 and H_2S, together with other impurities from the raw gas produced by Gasification. The resulting cleaned gas, called pure gas, is the feedstock to the Synthol plant.

The CO_2 and H_2S-containing off gas streams are routed to Sulfur plant and Wet Sulfuric Acid for further processing.

2.2.3 Gas Circuit

2.2.3.1 Benfield

Tail Gas from Synthol (gas synthesis section) passes through a knock-out drum and a filter coalescer to remove any liquid droplets from the feed gas. The gas is then heated by heat exchange with hot potassium carbonate solution and enters the absorber column. CO_2 is absorbed from the gas stream into the potassium carbonate absorption medium. The cleaned gas then passes through a knock-out drum into the DEA system, which acts as a CO_2 removal polishing unit. The sweetened gas then passes through a cryogenic separation unit called Cold Separation.

The rich (loaded with CO_2) potassium carbonate solution is regenerated by flashing the solution and by reboil in the regeneration column. The CO_2 and steam mixture is released to atmosphere and the lean potassium carbonate is re-circulated to the absorber column. A similar recycle and regeneration process is used in the DEA system. The CO_2 and steam stripped from the DEA solution, joins the carbonate regeneration column and is released to atmosphere. Condensate is added to both regeneration columns (carbonate and DEA) to make up for the water lost to atmosphere.

The Synthol (SAS) reactors are based on high temperature Fischer – Tropsch technology and uses catalyst. The catalyst is manufactured at the Catalyst Manufacturing units.

The catalyst manufacturing units are exactly similar except that the East unit has two rotary kilns and two electric arc furnaces compared to only one of each piece of equipment at the West unit. Both units have only one ball mill circuit.

The required raw material is fed to the rotary kiln. The objective of the kiln is to burn off oily contaminants evaporate moisture and to produce the required catalyst.

2.2.4   Refining

2.2.4.1   Tar distillation units (UNIT 14/214)

The purpose of this unit is to fractionate crude tar, originating from Gasification, into different fractions, which is then used as feed for downstream units. These fractions (from low to high boiling point) include light naphtha, heavy naphtha, medium creosote, heavy creosote, residue oil and pitch.

2.2.4.2   Unit 27A

The purpose of Unit 27A is to remove the neutral oils contained in the HNO-DTA (high neutral oil depitched tar acids) feed, producing LNO-DTA (low neutral oil depitched tar acids). Unit 27A is the final processing step in the Tar Acid Value Chain (TAVC) on the Secunda site. The LNO-DTA consists mainly of phenols, cresols and xylenols) that are extracted from the gas liquor stream at Phenosolvan into crude tar acids (CTA), from where the majority of pitch is removed in the Primary Depitchers where the distillate product HNO-DTA is sent to Unit 27A.

2.2.4.3   Unit 74

The CTA feed stream to the Primary Depitcher at Phenosolvan is split into the side draw, HNO-DTA stream going to Unit 27A and the phenolic pitch bottoms stream that is fed to Unit 74. A secondary depitcher recovers the remaining PCX's from the phenolic pitch stream.

2.2.4.4   Coal tar Naphtha hydrogenation (Unit 15/215)

The purpose of this unit is to hydro treat a combined feed of Rectisol naphtha, light naphtha and heavy naphtha from Unit 14/214 to remove phenolic and nitrogen compounds. Olefin saturation and sulfur removal also takes place to produce a product acceptable for utilisation in the petrol pool. The liquid product is fed to a H_2S stripper where the sour water is removed from the product stream. The final product goes to storage to be used as blending component in petrol.

2.2.4.5   Creosote hydrogenation unit (Unit 228)

The purpose of this unit is to hydrotreat heavy tar derived cuts to produce creosote, naphtha and diesel. The plant receives medium creosote, heavy creosote and residue oil from units 14/214. The unit also receives MTP, FFC, coker gas oil and waxy oil transfer material from unit 39 and this if fed to the unit as a percentage of the U2/14's feed streams. The one product stream containing high naphthene and aromatic content is routed to the platformer, while the other stream (creosote diesel) is a final diesel blending component.

2.2.4.6   Naphtha hydrotreater, platformer and CCR (Unit 30/230 and Unit 31/231)

The naphtha hydrotreater is a catalytic refining process used to saturate olefins and remove oxygenates. The feed for the naphtha hydrotreater is naphtha cut originating from Synthol light oil, distillate naphtha from the distillate hydrotreater (Unit 35/235) and creosote naphtha from U228. After the hydrotreating reactors a high concentration hydrogen gas stream,

hydrogen sulphide (produced) rich gas stream and sour water (produces and added) is separated from the hydrocarbon stream at various points. The hydrocarbon stream is separated into an IP and platformer feed stream.

Platforming is a catalytic refining process employing a selected catalyst to convert low quality naphtha into an aromatic rich, high octane product while also yielding a LPG stream. The LPG stream is routed to U32/232 or to a petrol component tank depending on season. The hydrocarbon stream is routed to the petrol component tanks.

During a normal operating cycle, platforming catalyst deactivates due to excessive carbon build-up. The catalyst is continuously removed from the platforming reactors and sent to the CCR unit, where the carbon is burnt off the catalyst restoring the activity of the catalyst.

2.2.4.7   Catalytic distillation hydrotreater (Unit 78)

The U78 CD Hydro Unit is designed to individually hydro-isomerizes C5 and C6+ hydrocarbons for octane enhancement, and produce a diene-free C5 feedstock to the Skeletal Isomerization unit (U90) and eventually the TAME unit.

The C5 CDHydro product from the column's bottoms is routed to the Skeletal Isomerization unit, and eventually to the CDTame unit for TAME (tertiary amyl methyl ether) production. The C5 product can also be routed either to storage, directly to U79 or in combination of the mentioned scenarios.

2.2.4.8   CDTame unit (Unit 79)

The CDTame Unit 79 converts a C5 product from the C5 CDHydro column via the Skeletal Isomerization Unit 90, to produce TAME. This C5 stream from U90 is fed to U79 reactors to recover TAME product.

2.2.4.9   C5 Isomerisation (Unit 90)

The C5 Skeletal Isomerisation Unit (Unit 90) produces branched chained iso-amylenes from the C5 olefinic feed from the C5 CD-Hydro Unit (Unit 78) which are required as feed to the CD-TAME Unit (Unit 79).

The C5 olefinic feed is sent to a reactor from where the heavy ends of C6 and higher are sent to the C6 storage facilities in Tank Farm and the light ends are sent to the Catalytic Polymerisation Unit (Unit 32).   The bottoms product from the Debutaniser column is the C5 iso-amylene product that is sent to Unit 79.

2.2.4.10   Vacuum distillation (Unit 34/234)

The vacuum distillation unit (U34/234) separates the decanted oil (DO) stream from Synthol as well as the heavy components produced in U2/29. The products from this unit are light vacuum gas oil and heavy gas oil for unit 235 Diesel Hydrotreaters and a minimum amount of heavy fuel oil for U39 Carbo Tar.

2.2.4.11   Distillate hydrotreater (U35/235)

The purpose of this unit is hydrotreating. The plant receives heavy components from SLO and the lighter components from the vacuum distillation units (2/34). The hydrocarbon stream is separated into a naphtha, light diesel and a heavy stream. The naphtha stream is sent to the naphtha hydrotreaters (2/30), the distillate selective cracker (35DSC) and the light diesel is sent to the diesel component tanks.

2.2.4.12 Distillate selective cracker (U35)

The DSC unit consist of two main sections- the cracking/dewaxing reactor reaction and the fractionation section. The main function of the reactor is to crack the heavy feed material into diesel range boiling material and to isomerize n-paraffin into iso-paraffin. The DSC fractionation section main purpose is to separate reactor effluent material into very light gasoline boiling range material, a heavy diesel cut and a fuel oil cut.

2.2.4.13 Light oil fractionation (Unit 29/229)

The purpose of this unit is to perform the primary fractionation for the Refinery facilities. The feed to the unit is stabilised light oil (SLO) from Synthol. The unit produces a light C5/C6 stream for CD Hydro unit (U78), a naphtha product that feeds Octene and the Naphtha Hydro-treatment units (U2/30), a distillate stream that feeds Safol and Diesel Hydrotreaters (U2/35), a heavy product that feeds the vacuum distillation unit (U2/34).

2.2.4.14 Polymer hydrotreater (Unit 33/233)

The purpose of this unit is to convert olefins to the corresponding paraffins. The feed to the unit comes from U2/32. The hydrocarbon stream is separated into petrol and diesel component stream.

2.2.4.15 Catalytic polymerisation and LPG recovery (Unit 32 / 232)

The purpose of this unit is to produce motor fuels namely petrol, diesel and jet fuel from a stream of C3/C4. Saturated C3's and C4's are sold as LPG.

2.2.4.16 Sasol Catalytic Converter (Unit 293)

The SCC Super flex™ Process is a Fluidized Catalytic Cracking (FCC) process, similar in configuration to a refinery FCC unit. Low molecular weight olefins and paraffins are converted to ethylene and propylene in a reactor. High octane gasoline is also produced. The feed to the plant is C6/C7 from Tank Farm.

2.2.5 Tar, Phenosolvan and Sulfur

2.2.5.1 Gas Liquor Separation

The purpose of the gas liquor separation unit is to separate various gaseous, liquid and solid components from the gas liquor streams. Dissolved gases are removed from the gas liquor by expansion to almost atmospheric pressure. The different liquids and solids are separated in separators by means of physical methods based on settling time and different densities.

Separation takes place by gravity at controlled temperatures and atmospheric pressure. The feed to the gas liquor separation unit originates from the cooling and washing of the raw gas from coal gasification. The raw gas contains large amounts of water vapours (steam, carbonization water and coal moistures) and by-products from carbonization such as tar, oil, naphtha, phenols, chlorine, fluorine and fatty acids. It also contains dissolved gases (mostly NH_3, CO_2, and H_2) and small amounts of combustible gases and coal dust as well as inorganic salts.

Feed streams originate in:

- Gasification (unit 10/210);
- Gas cooling (unit 11/211);
- Rectisol (unit 12/212);
- Phenosolvan (unit 16/216);
- Coal Tar Filtration (CTF) (on the Western site only);
- Refinery Unit 14 and 74;

- Carbo Tar.

2.2.5.2   Phenosolvan

The Phenosolvan (Unit 16 / 216) and Ammonia Recovery (Unit 17 / 217) plants are mainly water purification plants with the purpose to remove impurities such as suspended solids and oil as well as to recover pitch, phenols, organic waste, carbon dioxide (CO_2), hydrogen sulphide (H_2S) and ammonia (NH_3) from the gas liquor before pumping the stripped gas liquor to Water Recovery (Unit 52 / 252) for re-use in the Synfuels factory as cooling water. Only phenols and ammonia are marketable products.

Unit 16 / 216 serves the purpose for gas liquor filtration, phenol and pitch extraction, solvent recovery and depitching of crude tar acids to produce depitched tar acids (DTA). Unit 17 / 217 serves the purpose for solvent recovery, acid gas removal, organic contaminants removal, ammonia recovery as well as purification and liquefaction of ammonia.

2.2.5.3   Sulfur Recovery

The plants receive the feed-gas from Rectisol for the absorption and conversion of H_2S prior to routing the H_2S lean gas to the stack. The off-gas from Sulfur plant is combined with the off-gas from Rectisol before being routed to the stack. The H_2S in the feed-gas from Rectisol is absorbed into the sulpholin liquor by means of venturi absorbers.

From the absorbers the liquor with absorbed H_2S goes into the reaction tanks where elemental sulfur is produced. In the reaction tanks vanadium (V) is an active oxidizing agent that oxidizes HS^- to elemental Sulfur. During this process vanadium is reduced to inactive vanadium (IV), which needs to be re-activated. The slurry from the reaction tanks is sent to two oxidizers arranged in series.

The sulfur slurry in the oxidizers is separated from the liquor by means of weirs in the last oxidizer. The Sulfur slurry from the last oxidizer falls directly into three (3) slurry tanks. From the slurry tanks, the slurry is pumped to decanters for the removal of the entrained liquor. The liquor is routed back to the process via the balance tank. The Sulfur rich cake from the decanters is re-pulped using wash condensate before it is pumped to the sulfur separator.

In the separator, the liquid sulfur is separated from water and sent down to the sulfur pit. From the pit, the liquid sulfur is transported by road trucks to the granulation plant for filtering and formation of sulfur granules.

During the conversion of HS^- to elemental sulfur and the re-oxidation of vanadium, salts such as NaSCN, $NaHCO_3$ and Na_2SO_4 are formed. A bleed stream from the discharge side of the circulation pump is routed to the sulphate plant to produce Sodium Sulphate as a by-product, thereby reducing the salt concentration of the circulation liquid.

2.2.5.4   Wet Sulfuric Acid Plant

The feed gas to Wet Sulfuric Acid (WSA) is sourced from Rectisol east (phase 3 and phase 4), which are routed to a knock out drum (per phase). The outlets of the knockout drums combine before Phenosolvan off gas joins the feed header into the WSA combustor where the feed gas is burned with fuel gas and hot air to form SO_2 containing process gas.

After combustion the process gas is cooled in a waste heat boiler. The formed process gas, after being cooled down, leaves the waste heat boiler and dilution air is introduced to ensure sufficient oxygen content before entering a NO_X converter. In the NO_X converter the nitrogen oxides are removed from the process gas. The reduction of the nitrogen oxides is carried out by the injection of ammonia into the process gas and subsequently passing the gas mixture over a catalyst where the nitrogen oxides react with the ammonia and are converted to nitrogen and water vapour.

From the NO_X converter the process gas is further processed in the SO_2 converter. The SO_2 in the process gas is oxidized catalytically. The SO_2 gas reacts with O_2 to form SO_3 gas. The formed SO_3 gas reacts with the water vapour present in the process gas through exothermic hydration reaction, resulting in the formation of the sulfuric acid gas (H_2SO_4).

The process gas then enters the Wet Sulfuric Acid (WSA) condenser where it is further cooled by means of air in a glass tube heat exchanger, and the remaining part of the hydration reaction and the condensation of sulfuric acid take place. The produced sulfuric acid has a concentration of 96.5 wt%, with a maximum acid mist content of 20 ppm (by volume) when leaving the top of the WSA condenser. The hot sulfuric acid product will leave the bottom of the WSA condenser.

Normally, if no special precautions are taken, condensations of sulfuric acid vapour will result in a mist of very small acid droplets. These very small droplets cannot be separated from the process gas in the WSA condenser. Thus to overcome this problem four mist control units are installed. The cleaned gas leaves the top of the WSA condenser. Even though all four mist control units are well in operation, the clean gas will contain a small amount of remaining acid mist which is reduced by the Wet Electrostatic Precipitator (WESP). The WESP consists of an empty column scrubber part, where the cleaned gas sprayed with weak acid and the precipitator part where the mist particles form a liquid film on the vertical collecting electrodes due to the strong electric field. The liquid film then runs down the electrodes to the scrubber sump and the cleaned gas proceeds to the stack where it's lead to the atmosphere.

2.2.5.5   Carbo Tar and Coal Tar Filtration

2.2.5.5.1   Coker (Unit 39)
The Delayed Coker Plant receives the so called bottom of the barrel products from upstream units to produce coke. The plant mainly operates in three different modes to produce three different types of coke. These modes are the normal MTP (medium temperature pitch) mode, WO (Waxy Oil) mode and the hybrid mode, which is a 70:30% blend between MTP and FCC (fluidised catalytic cracker) slurry.

Reactions and Catalyst
The Coker Plant produces green coke using a delayed coking process, which involves thermal cracking of the feedstock (pitch, waxy oil or FCC slurry) at elevated temperatures and long residence time at specific conditions. The basic reaction that takes place is: HC + Impurities = C + Impurities + Vapour (H_2O & Volatile material)

2.2.5.5.2   Calciner (Unit 75)
The coke calcining unit, (U75) receives green Coke from the Delayed Coker plant (U39) and thermally upgrades the green coke to produce calcined Coke. U39 processes three basic types of feed: Waxy Oil, Medium Temperature Pitch (MTP) and Hybrid (70%-30% MTP-FCC slurry blend) green coke. From these feed stocks, U39 produce seven different grades of green coke, of which five are calcined and sent to the market.

2.2.5.5.3   Coal Tar Filtration (Unit 96)
At Unit 096 tar is received from the Gas Liquor Separation units (Unit 13 and 213). Solids and water is removed from the tar. The solids get removed by means of decanters and filters while water gets removed by means of a force feed evaporator. The solids get trucked to the Mixing plant were it is mixed with fine coal and fed to the boilers. The final tar product is pumped to tank farm as feed for the Tar distillation units (Unit 14 and Unit 214).

2.2.5.5.4 Feed Preparation (Unit 86)

The purpose of the Feed Preparation Plant (U86) is to clean-up heavy residue streams from tanks and dams containing solids and water; the feed streams can vary depending on availability. The plant consists of two Trains; Train 1 processes Waxy Oil (WO) related product, which is obtained from the American Petroleum Institute (API) dams; and Train 2 processes the crude tar from various sources and also serves as a Coal Tar Filtration (CTF) contingency.

Train 1 can also be utilised to process tar when there is very high tank levels from Tank Farm (256TK 1401/2). Through the series of processes, water and solids are removed from the contaminated feed streams and made available to customers such as heating fuels and Tar Distillation Units (U(2)14).

2.2.5.5.5 Calciner (Unit 76)

This unit is a storage facility for final products from the calciner Unit 075 and distribution via rail and road trucks of different sizes, quantities and products.

2.2.6 Water and Ash

2.2.6.1 Multi hearth sludge incinerator

Waste activated sludge is burned in 4 twelve bed multi hearth type incinerators (2 per unit). Each incinerator has two burner chambers designed such that each chamber can be supplied with fuel gas. Combustion and cooling air is also introduced to the incinerator. Thickened waste activated sludge is fed into the incinerators. Off-gas, slurry and ash exit the incinerator.

2.2.6.2 HOW Incinerator

The purpose of the HOW incinerator is to burn concentrated high organic waste (HOW) and gas fumes from Phenosolvan and Ammonia recovery (U17/217).

The interior of the incinerator consists of a horizontal combustion chamber that has been lined with fireproof bricks out of a kind of ceramic that is extremely heatproof. The burner is a combination burner for optional or simultaneous combustion of fuel gas and HOW and is mounted to the front of the combustion chamber. The product is atomized with steam in the burner. Fuel gas serves as the pilot flame to ignite the HOW. For this reason the fuel gas flame must be kept burning permanently. Oxygen is required for combustion. In this case, a controlled quantity of air is provided to the burner called primary air (combustion air). Warm air containing combustion gases is let out to the atmosphere through the chimney.

2.2.6.3 Sewage Incinerator

The purpose of the domestic sewage plant is to treat all sewage from Secunda town and ablution facilities from Sasol Secunda site, upgrading it to render it suitable to discharge to the river. The process can be divided into sections

- Inlet works (primary treatment section)
- Biological Section (secondary treatment section)
- Polishing section (tertiary treatment section)

Untreated sewage enters the inlet works where screening and removal of grit takes place. The flow then moves to the biological section where the removal of soluble and particulate organic material is removed from raw sewage. The last section (polishing section) is where further removal of suspended solids takes place, as well as and the sanitation of effluent before the effluent is released to the river. The function of the sewage incinerator is to burn waste screenings from the primary treatment section. The products are ash and combustion gases.

2.2.6.4   Thermal Oxidizer

In order to prevent atmospheric pollution from the storage tanks and vessels that contain VOC's, it gets vented to a thermal oxidizer. It consists of a piping/ducting system to draw vapours from the following tanks:

- Oily Waste Tanks (TK2005/11/12)
- Phenolic Waste Tanks (TK2002/4)
- Organic Waste Tanks (TK2006)
- Flare knock out water (TK2003)
- Quarantine Waste Tank (TK2016)
- Recovered oil Tank (TK2009)
- APS storage tank (TK2512)
- Hydrocarbon Equalization Tank (TK2501)
- API Separator (TK2505)
- Recovered Oil Tank (TK2510)
- DAF Separator (DAF 2501)
- Area 10 Loading Arms (ME 1010/1011/1013)

2.3   Unit Processes

Unit process considered listed activities under the National Environmental Management Air Quality Act (NEMAQA) are summarised in Table 2-2.

Table 2-2: List of unit processes considered listed activities under NEMAQA

Name of the Unit Process	Unit Process Function	Batch or Continuous Process	Listed Activity Sub-category
Steam Plant	Produces steam for process units	Continuous	1.1
Gasification	Gasification of coal	Continuous	3.6
Gas cooling	Cooling of the gasification products, separation of the condensable products of gasification	Continuous	3.6
Tar Value Chain	Separation of the gasification tar stream	Continuous	3.3
Rectisol	Cleaning of the Gasification gas	Continuous	3.6
Phenosolvan	Processing of the Gasification water stream	Continuous	3.6
Sulfur Processing	Removal of H_2S from gas exiting the factory	Continuous	3.6
Wet Sulfuric acid	Removal of H_2S from gas exiting the factory, production of sulfuric acid	Continuous	7.2
Refinery	Production of synthetic fuels and products	Continuous	2
Solvents	Processing of chemicals	Continuous	6
Incineration	Incineration of waste products	Continuous	8.1

For completeness, all unit processes for the Sasol Secunda complex are listed in Table 2-3.

Table 2-3: Unit processes at Sasol Secunda

Unit Process	Function of Unit Process	Batch or Continuous Process
Utilities		
Coal milling process	There are 4 mills per boiler. The mill grinds the course coal to fine coal, which is known as pulverized fuel (PF). Primary air dries the coal and then transports the PF into the boiler furnace for combustion.	Continuous
De-aeration process	The feed water de-aerators make use of low pressure steam to heat up the feed water as well as to remove the oxygen from the feed water. Oxygen causes corrosion inside the boiler tubes if it is present. Chemical dosing into the de-aerator discharge line also helps to remove the oxygen.	Continuous
Combustion process	The PF is combusted in the 17 boilers and the hot flue gases are used to heat up the water in the water wall tubes. The hot flue gases containing ash and other gases are used to heat up the primary air while being extracted from the boiler furnace via the induced draught fans. The heated water is separated in the steam-water drum and reintroduced into the boiler to be superheated before supplied to the factory as superheated steam.	Continuous
Flashing process	Blow down from the steam/water and mud drum as well as drains are flashed in the blow down vessel to 4bar steam.	Continuous
Ash capture and handling process	The flue gas contains fly ash and coarse ash. The fly ash is separated from the flue gas using electrostatic precipitators. The ash which is not captured by the electrostatic precipitators is sent up the stack. The coarse ash falls from the furnace section into drag chains. Both the coarse and fly ash is mixed with water and pumped to the ash system.	Continuous
Electricity generation process	Excess superheated steam not used in the process is used to generate electricity in turbo-generators. There are 10 turbo generators with a capacity of 60MW.	Continuous
Burner oil for start-up process	Burner oil is used during start up and shutdown of boilers. Burner oil is also used when coal milling is stopped for maintenance.	Intermittent
Gas turbine	Power generation by burning natural gas	Continuous
Heat Recovery Steam Generator (HRSG)	Steam is generated using the hot off gas from the gas turbines. The steam generation includes a boiler, economisers, evaporators, and superheaters. Superheated steam is generated from this process at 425˚C and 4300kPag with a maximum flow of 163t/h per boiler.	Continuous
Gas Production		
Coal Processing		
Separation	Separation of fine and course coal	Continuous
Gasification		
Gasification and Raw Gas Cooling	Sasol® FBDB™ Gasification Process	Continuous
Rectisol		
Absorption	Washes the raw gas in order to remove CO_2, H_2S, BTEX's and other organic and inorganic compounds	Continuous
Regeneration	Purification of wash medium	Continuous
Gas Circuit		
Benfield		
Benfield	The purpose of the Benfield Process is to remove Carbon Dioxide from the tail gas entering the Cold Separation thereby preventing freeze blockages.	Continuous
Catalyst preparation		

Unit Process	Function of Unit Process	Batch or Continuous Process
Catalyst Manufacturing	Manufacturing of catalyst for the Synthol process.	Continuous (Arc furnace is semi-batch process)
Catalyst Reduction	The purpose of this system is to activate the catalyst before it is fed to the reactors.	Batch
Refinery		
Generic Refinery Unit Processes		
Tank	The feed tank serves as feed reserve tank. This is for a holdup for the polymerisation of the mixed feed components and for the separation of entering water.	Continuous
Vaporiser	The vaporizer separates the light ends from the heavy ends. Saturated high pressure (HP) steam is used to vapourise the feed.	Continuous
Distillation column	The purpose of the columns is to purify hydrocarbon streams as well as separation of the hydrocarbon streams into various components.	Continuous
CD Hydro Hydrogenation Columns	To hydrotreat and separate hydrocarbons.	Continuous
Separation and collection drums	It's used to separate streams into lighter and heavier components.	Continuous
Hydrotreating reactors	The reactors are used to saturate olefins and oxygenates. To remove nitrogen and sulfide components as well as removing other impurities in the presence of hydrogen.	Continuous
Platforming reactors	The reactors convert low quality naphtha into an aromatic rich, high octane product.	Continuous
U90-Skeletal isomerisation reactor	The purpose of the skeletal isomerization unit is to convert the C5 feed from the CD-Hydro unit to isoamylenes as feed to the CD-TAME unit	Continuous
Catalytic polymerisation	The purpose of this unit is to produce motor fuels namely petrol, diesel and jet fuel from a stream of C3/C4.	Continuous
Heat exchangers	There are a large number of heat exchangers that is used to heat up, cool down, vaporise and condense the hydrocarbon streams. There is a combination of product, product exchangers (two process exchangers exchanging energy) as well as product utility exchangers.	Continuous
Air coolers	The air coolers are used to cool down and condense hydrocarbon streams	Continuous
Ejectors	The equipment is used to generate a negative gauge pressure (vacuum). There are a number of plants in the refinery that utilises vacuum conditions for the separation of hydrocarbon streams	Continuous
Compressors	The compressors are used to increase and or maintain the high operating pressures of the refinery processes. There are reciprocal, centrifugal and turbine compressors used in the refinery environment	Continuous
Pumps	The pumps used in the refinery are centrifugal, multi stage and positive displacement pumps	Continuous
Electrical heaters	The electrically heater is normally not in operation. The heater is primarily provided for catalyst regeneration and is also used to heat up the main reactor for start-up.	Start-up and as required
Heaters	The heaters are used to heat up hydrocarbon and gas streams	Continuous
Superflex Catalytic Cracker	Low molecular weight olefins and paraffins are converted to ethylene and propylene in a reactor. High octane gasoline is also produced.	Continuous

Unit Process	Function of Unit Process	Batch or Continuous Process
Catalyst Fines system and Waste Heat Boiler	The purpose of the unit is to recover catalyst fines from the flue gas. The waste heat boiler cools the flue gas against boiler feed water to produce high pressure steam.	Continuous
Gas Clean-up equipment		
Reactors	The purpose of the unit is to remove oxygen, acid gasses and moisture from the process gas.	Continuous
DEA and Caustic sections		
Gas Dryers		
Liquid Dryers	The purpose of the unit is to remove water from the C3 stream.	Continuous
Propylene Refrigerant system	The propylene refrigeration system is a closed-loop system providing three levels of refrigeration, -39°C, -22°C and 4°C.	Continuous
Tar distillation units		
Water Stripper (14VL101/201; 214VL101/201)	The crude tar that is fed to the stripper is heated in a number of heat exchangers. This feed is then stripped of water in VL101. The overhead vapours of the stripper are then condensed and the water free crude tar is sent to VL102.	Continuous
Distillation Column (14VL102/202; 214VL102/202)	This column is operated at atmospheric pressure and superheated stripping steam is fed to the bottom section to control the temperature. The distillation tower is heated up by the tar furnace 14HT-101. The overhead vapours being mainly water and light naphtha are condensed. In the distillation tower 14VL-102 heavy naphtha, medium creosote and heavy creosote are recovered as side streams of the tower.	Continuous
Reflux Drum (14DM102/202; 214DM102/202)	The condensed vapours of both VL101 and Vl102 are fed to this drum where the water is separated from the light naphtha. The water overflows into the sewer, the hydrocarbons are partly sent as reflux to 14 VL101 and 14 VL102, and partly routed as light naphtha product to the tank.	Continuous
Flash Drum (14DM104/204; 214DM104/204)	The net bottom product of the distillation tower is withdrawn from the tar furnace (14HT-101) circulation stream and sent to the flash drum 14DM-104. In this drum, operating under vacuum, separation between pitch and residue oil is achieved by one stage flash evaporation.	Continuous
Heavy Creosote Process Vessel (14DM106/206; 214DM106/206)	This vessel stores heavy creosote which is a side draw from VL102 before it is pumped to tank farm.	Continuous
Medium Creosote Process Vessel (14DM107/207; 214DM107/207)	This vessel stores medium creosote which is a side draw from VL102 before it is pumped to tank farm.	Continuous
Heavy Naphtha Process Vessel (14DM108/208; 214DM108/208)	This vessel stores heavy naphtha which is a side draw from VL102 before it is pumped to tank farm.	Continuous
Pitch Drum (14DM109/209; 214DM109/209)	The bottoms product of 14DM104 is pitch, which passes via a barometric pipe to pitch cooler 14 ES114 and to the pitch drum 14DM109, from where it is pumped to Carbo Tar, unit 39 or Tank Farm.	Continuous
Residue oil Drum (14DM110/210; 214DM110/210)	The top product of the flash drum 14DM104 is residue oil, which is condensed in 14ES115, a steam producing heat exchanger, and then travels via 14DM111 along a barometric pipe to the residue oil drum 14DM110 from where it is pumped by 14PC108 to battery limit.	Continuous
Heaters (14HT101/201; 214HT101/201)	This furnace is used to heat a high circulating bottoms product from 14VL102 and thus control the temperature of the column.	Continuous
Unit 27A		

Unit Process	Function of Unit Process	Batch or Continuous Process
Neutral oil stripper (27VL101)	The purpose of this stripper is to remove the neutral oils contained in the HNO-DTA (high neutral oil depitched tar acids) feed, producing LNO-DTA (low neutral oil depitched tar acids).	Continuous
Flash Drum (27DM103)	This drum flashes the neutral oil from the water and the neutral oil rich stream goes to 27DM1 and the water rich stream is recycled back to the column.	Continuous
Separator Drum (27DM1)	The stream from 27DM103 that is rich in neutral oil is cooled and sent to 27DM1 for separation.	Continuous
	Unit 74	
Vacuum Distillation (74VL101)	This is a secondary depitcher column that flashes phenolic pitch and fractionate the stream to recover as much phenolic material possible in the side draw, without entraining catechol or any heavy ends. The column operates under a vacuum. The depitched tar acids are drawn off from the top of the column and are the product and the pitch at the bottom is sent to unit 14/214 and CarboTar.	Continuous
	Coal tar naphtha hydrogenation	
Feed Tank (15TK-101)	The feed tank serves as feed reserve tank. This is for a holdup for the polymerisation of the mixed feed components and for the separation of entering water.	Continuous
Vaporizer (15EX-101)	The vaporizer separates the light ends (Naphtha) from the heavy ends (residue oil). Saturated HP steam is used to vaporise the feed.	Continuous
Residue Stripper (15VL-101)	The purpose of the residue stripper is to strip the remaining low boiling components by means of super-heated recycle gas.	Continuous
Residue Oil Collection Drum (15DM-102)	Residue oil from the residue stripper is collected in the residue oil collect drum and is continuously pumped to tank farm.	Continuous
Pre-reactor (15RE-101)	The bottom of the pre-reactor accommodates a separator, which retains any entrained liquid droplets, before the hydrocarbon vapor mixture enters the pre-reactor. The pre-reactor is filled with catalyst.	Continuous
Main Reactor (15RE-102)	Recycle gas and a hydrocarbon vapour mixture passes through the main reactor. A quench stream of cold recycle gas is used between the two main reactor beds to prevent H_2S from reacting back to mercaptans or thiophenes and to prevent severe hydrogenation.	Continuous
HP separator (15DM-106)	Separates the raffinate from the gas.	Continuous
Medium Pressure Naphtha Water Separator (15DM-107)	The medium pressure naphtha water separator is a three phase separator, firstly to separate the gas liquid mixture and secondly to separate the organic aqueous liquid mixture. The gas/raffinate and condensate are separated under gravity, due to their density difference. The water and product is separated by a gooseneck. The entrained injection and reaction water separated is discharged from the bottom of the separator's water compartment directly to unit 16/216 as waste water, or to the oily water sewer during upset conditions	Continuous

Unit Process	Function of Unit Process	Batch or Continuous Process
H$_2$S Stripper (15VL-102)	The hydrogenated naphtha product is stripped of water, H$_2$S, NH$_3$ and other dissolved gases.	Continuous
Naphtha hydrotreater, platformer and CCR		
Naphtha reactors System	Saturation of olefins	Continuous
NHT Charge Heater	Heating of NHT reactor feed	Continuous
Separation drums	Hydrogen, uncondensed hydrocarbon gases and water are separated from the condensed reactor products.	Continuous
Stripper System	Removing of light ends (H$_2$S and water)	Continuous
Stripper Reboiler (Fired Heater)	Heating Stripper bottoms	Continuous
Splitter System	Splits between C$_5$+ and C$_5$-	Continuous
Splitter Reboiler (Fired Heater)	Heating Splitter bottoms	Continuous
Platformer Charge Heater	Heating Platformer reactor feed	Continuous
Platforming Reactors	Produces aromatics from paraffins and naphthenes	Continuous
Continuous Catalyst regeneration system	Regenerates Platformer catalyst on continuous basis	Continuous
Product Separator	H$_2$ is separated from the condensed Platformer product	Continuous
Debutanizer	Removes C$_4$- from final product	Continuous
Debutanizer Reboiler (Fired Heater)	Heating Debutanizer bottoms	Continuous
Catalytic distillation hydrotreater		
78VL-101 (Depentaniser)	Splits a liquid feed stream into C5 and C6+ streams. The C6+ stream is sent to the Alpha Olefin plants for Hexene extraction. The C5 stream is sent to 78VL-102 (CD Hydro Column)	Continuous
78VL-102 (CD Hydro Column)	Hydro-treats the C5 hydrocarbons to produce a diene-free feed to U90.	Continuous
CD Tame		
79RE-101 (Primary reactor)	79RE-101 (Primary reactor) – The first reaction between isoamylenes and methanol takes place in this reactor.	Continuous
79RE-103 (Secondary reactor)	The second reaction between isoamylenes and methanol takes place in this reactor.	Continuous
79VL-101 (CD TAME Column)	The last phase of reaction takes place in this column. This column also serves to separate the TAME product from the unreacted reactants.	Continuous
79VL-102 (Methanol Extraction Column)	Uses a water stream to extract methanol from the C5 Hydrocarbons. The C5 hydrocarbons are sent to storage, and the methanol-water stream is sent to 79VL-103.	Continuous
79VL-103 (Methanol recovery column)	The water-methanol stream from 79VL-101 is split into methanol and water streams. The methanol is recycled to the front end of the process, and the water is recycled to 79VL-102 where it is used to extract the methanol.	Continuous
C5 Isomerisation		
U90-Skeletal isomerisation unit	The purpose of the skeletal isomerization unit is to convert the C5 feed from the CD-Hydro unit to isoamylenes as feed to the CD-TAME unit	Continuous
Vacuum distillation		

Unit Process	Function of Unit Process	Batch or Continuous Process
Vacuum Distillation	The aim is to fractionate high boiling point hydrocarbons at low temperatures by lowering the pressure to ±2.5kPag using Decanted Oil from U20 and the heaviest fraction from U29 is fractionated to a Heavy and Light Gas Oil and Waxy Oil.	Continuous
Distillate hydrotreater		
Distillation	The fractionation of the feed oil material into components of similar boiling range.	Continuous
Light diesel stripping	Separation of diesel (medium cut material) range boiling material from the feed stream using distillation.	Continuous
Naphtha stripping	Separation of naphtha (light material) range boiling material from the feed stream using distillation.	Continuous
Hydrogenation	The conversion of oxygenates and olefins into paraffins .	Continuous
Catalyst Sulfiding	This is to regulate catalyst activity	Continuous
Water removal	Removal of water from the feed oil stream in a drum operated such that water settles in the drum's water boot.	Continuous
High temperature Separation	Separate a feed stream into a liquid and vapour streams in a drum at a high temperature.	Continuous
Low Temperature separation	Separate a feed stream into a liquid and gas streams in a drum at a low temperature.	Continuous
Hydrogen recycle	To reuse the hydrogen rich off gases leaving the cold separation drum.	Continuous
Heating	This is to preheat feed streams and cool down product streams.	Continuous
Distillate selective cracker		
Cracking reaction system	To selectively crack high-pour point components (predominately paraffins)	Continuous
Distillation	Fractionation of the heavy oil material	Continuous
Vacuum distillation	Separate the heavy distillate material mainly heavy diesel.	Continuous
Heating and Cooling	Preheat feed material and cool down product streams	Continuous
Water removal	Separate entrained water from feed stream	Continuous
Hot Temperature separation	Separate reactor product stream into a liquid and vapour stream.	Continuous
Hydrogen recycle	Recycle the off gas rich stream separate from the reactor liquid stream	Continuous
Catalyst sulfiding	To regulate the catalyst activity	Continuous
Light Oil Fractionation		
Atmospheric Distillation	The purpose of the unit is to fractionate the Stabilized Light Oil into different fractions of molecules used in downstream processes. The different fractions are C5/C6 to the CD Tame unit, Naphtha to Octene (and U30NHT), Light Diesel to Safol (and U35DHT) and a Heavy fraction to U34.	Continuous
Polymer Hydrotreater		
Polymer Hydrotreater	The purpose of the unit is to hydrotreat the polymer produced in the catalytic polymerisation unit to a paraffinic petrol and diesel/jet fuel fractions.	Continuous
Catalytic polymerisation and LPG recovery		
Catalytic polymerisation	The purpose of this unit is to produce motor fuels namely petrol, diesel and jet fuel from a stream of C3/C4 .	Continuous
LPG recovery	The purpose of this section is to recover unreacted paraffinic C3 and C4 material for LPG production.	Continuous
Sasol Catalytic Converter		
Pre-heat furnace	The purpose of this section is to vaporise the low molecule olefin and paraffin feed	Continuous

Unit Process	Function of Unit Process	Batch or Continuous Process
Superflex Catalytic Cracker	Low molecular weight olefins and paraffins are converted to ethylene and propylene in a reactor. High octane gasoline is also produced.	Continuous
Quench Column and Strippers Towers	The purpose of this unit is to remove heavy oil and separate the process gas from the gasoline phase.	Continuous
C4 and C5 CD Hydro Hydrogenation Columns	The purpose of this unit is to saturate olefins.	Continuous
Catalyst Fines system and Waste Heat Boiler	The purpose of the unit is to recover catalyst fines from the flue gas. The waste heat boiler cools the flue gas against boiler feed water to produced high pressure steam.	Continuous
Process Gas Compression (KC2501 – PGC)	The purpose of the unit is to compress the process gas.	Continuous
Gas Clean-up equipment		
Reactors	The purpose of the unit is to remove oxygen, acid gasses and moisture from the process gas.	Continuous
DEA and Caustic sections		
Gas Dryers		
SCC De-Propanizer (VL4001)	The purpose of the unit is to separate C4 molecules from the process gas.	Continuous
Chill Train, De-Methanizer and Cold Box	The purpose of the unit is to cool down the process gas and remove methane.	Continuous
C2 System which can be divided into the De-Ethanizer and C2 Splitter	The purpose of the unit is to separate C3 molecules from C2 molecules and to separate the C2 molecules into ethane and ethylene.	Continuous
PPU 5 which comprises of the FT De-Propanizer and C3 Splitter	The purpose of the unit is to separate C3 from C4 molecules and to separate the C3 molecules into propane and propylene.	Continuous
Liquid Dryers	The purpose of the unit is to remove water from the C3 stream.	Continuous
Propylene Refrigerant system	The propylene refrigeration system is a closed-loop system providing three levels of refrigeration, -39°C, -22°C and 4°C.	Continuous
Tar, Phenosolvan and Sulphur (TPS)		
Gas Liquor Separation		
Gas Liquor Separation	The purpose of the gas liquor separation unit is to separate various gaseous, liquid and solid components from the gas liquor streams. Dissolved gases are removed from the gas liquor by expansion to almost atmospheric pressure. The different liquids and solids are separated in separators by means of physical methods based on settling time and different densities.	Continuous
Phenosolvan		
Water Purification	The purpose of this system is to filter out any oil, tar and suspended solids.	Continuous
The extraction process	The purpose of the extraction system is to remove phenols from gas liquor by mixing gas liquor with di-isopropyl-ether (DIPE) to extract the phenols.	Continuous
DIPE recovery and Phenol production	The DIPE and phenols are then separated through several distillation processes.	Continuous
Ammonia Recovery (Unit17)	Recovering of ammonia from the gas liquor. The raffinate from Unit 16 / 216, with about 1% DIPE, is first sent to the de-acidifier to remove acid gases.	Continuous

Unit Process	Function of Unit Process	Batch or Continuous Process
Acid Gas Scrubber	The purpose of this system is to remove final traces of CO_2 from the ammonia.	Continuous
Fractionation system	The ammonia leaving the Acid Gas Scrubber overhead is firstly compressed prior to the fraction process to improve ammonia recovery. The distillate product of the fractionator (2)17VL-105 is NH3 and the bottoms product is organics. The ammonia is cooled down to form a liquid and expanded and the final ammonia product is sent to Tank Farm.	Continuous
Sulfur recovery		
Sulfur recovery	The purpose of the Sulfur Recovery unit is to reduce the amount of sulfur released into the atmosphere as hydrogen sulfide (H_2S) gas by producing elemental sulfur as a saleable product.	Continuous
Wet Acid		
Wet Sulfuric Acid	The purpose of the Wet Sulfuric Acid (WSA) unit is to reduce the amount of sulfur released into the atmosphere as hydrogen sulfide (H_2S) gas by producing sulfuric acid as a saleable product.	Continuous
Carbo Tar		
Coker	The Delayed Coker Plant receives bottom of the barrel products from upstream units to produce coke.	Continuous
Calciner	The coke calcining process is used to thermally upgrade green coke in order to remove associated moisture and combustible volatile matter (VCM) and to otherwise improve critical physical properties like the electrical conductivity, real density, etc.	Continuous
Coal Tar filtration	CTF utilises three solids removal processes and one water removal process.	Dump bins, decanters, force feed evaporator – continuous
	Solids are removed by means of gravity separation in the feed receiving dump bins, followed by solids removal by means of centrifugal separation in the decanter and lastly the final solids are removed by the pressure leaf filters. The water is removed by means of a forced feed evaporator system.	Filters - batch
Unit 86	The main unit processes for U86 Train 1 is heat exchange, centrifugation and distillation while the main processed for U86 Train 2 is heat exchange, distillation and then filtration. Tankage of product happens before and after processing.	All processes are continuous except for the batch filtration processes
Unit 76	The unit consists mainly of conveyors systems combined with storage silos. Loading and weighting facilities are also on site.	Continuous
Water and Ash		

Unit Process	Function of Unit Process	Batch or Continuous Process
Multi hearth sludge incinerators	The purpose of this system is to incinerate waste activated sludge from the biological treatment systems which treat industrial and domestic effluent respectively. The systems has 4 centrifuges per side to dry the sludge, which is then incinerated in 1 of 2 multiple stage hearth incinerators per side, with a temperature of around 780°C in the burning zone. The off-gas is sent to an emission treatment system before it passes into the atmosphere, while the coarse ash is sent to Outside ash for disposal.	Continuous
HOW incinerators	The purpose of this system is to incinerate high organic waste (HOW). The HOW, which is pumped from U17/217 to the HOW storage tank, is ignited by means of a fuel gas pilot flame inside a single chamber, refractory brick-lined incinerator. The combustion temperature is controlled at 950°C, and there are two burners. Steam is used to atomize the HOW. The only combustion product is off-gas.	Continuous
Sewage incinerator	The purpose of this incinerator is to burn screenings from primary treatment. It is a single chamber, furnace-type incinerator. The incinerator is manually filled with screenings .Diesel is used as a fuel, and the incinerator has two burners and one fan per burner. The combustion is automated. The products are off-gas and ash.	Batch
Waste Recycling Facility Thermal Oxidizer	Some of the enclosed storage and treatment tanks at WRF do not vent to the atmosphere but rather to the thermal oxidiser. It is introduced to the burners (which are kept burning with fuel gas) with air for combustion.	Continuous
Market and Process Integration (MPI)		
Flares		
Central corridor flares	A system consisting of 2 flare stacks, 2 relief headers and other associated equipment to collect and completely incinerate off-gases, off-specification gases and emergency venting.	As required
Solvents		
U2/36	Separation of Non-Acid chemicals from extraction water received from Synthol (U20) and subsequent separation of the NAC's into Alcohols and Carbonyls.	Continuous
U2/37	Separation of Raw Carbonyls into Acetone, Methyl-ethyl-ketone, Aldehydes and Methanol.	Continuous
U2/38	Separation of Raw Alcohols into Ethylol, Iso-propylol, Propylol, Iso-butylol, Sabutol and Sabutol bottoms.	Continuous
U38N	Purification of Propylol to pure Propanol and producing Propanol B as a by-product.	Continuous
U73	Purification of Ethylol to pure Ethanol and producing Ethanol Lights as a by-product.	Continuous
Unit 237n Ethanol (99)	The manufacture and purification of ethanol through reactive distillation	Continuous
Unit 590	The production of Ethyl acetate and subsequent purification through distillation	Continuous
Hexene (U300)	Production on 1-Hexene	Continuous
1-Octene Train 1 (U301)	Production of 1-Octene	Continuous
1-Octene Train 2 (U301)	Production of 1-Octene	Continuous
Regenerator (U302)	Recovery of Potassium Carbonate	Continuous
Safol (U303)	Production of detergent alcohol Safol™	Continuous
Octene Train 3 (U304)	Production of 1-octene from 1-heptene via reaction and distillation steps.	Continuous
Flare (Hexene and 590)	Destruction of organic gasses during emergency, start-up, shut down and upset conditions.	Intermittent
Polymers		
Polypropylene		
Co-catalyst preparation (TEA, Silane & IPA)	Batch preparation of Silane and IPA through dilution with Heptane and storage of TEA in hold up tanks.	Batch

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Unit Process	Function of Unit Process	Batch or Continuous Process
Polymerisation	To produce polypropylene powder.	Continuous
Extrusion	Conversion of polypropylene powder to pellets	Continuous
Flare	Destruction of hydrocarbon gases released during abnormal operations.	Batch
Bagging	Storage and bagging of pellets	Continuous
Monomers		
U24		
Ethane Crackers	Cracks the gas into an ethylene rich stream	Continuous
Quench Water System	Utilised for inter stage cooling	Continuous
Cracked Gas system	Compress gasses and creates the required pressure for transfer through all the subsequent processes	Continuous
Amine System Scrubber	Remove H_2S and CO_2 from the cracked gas	Continuous
Amine Regeneration System	Stripping off the contaminated amine	Continuous
Caustic Scrubber	Further removes any remaining CO_2	Continuous
Pre-Cooling and Drying	Cool down the gas in order to knock out all possible free moisture and heavy hydrocarbons	Continuous
Turbo Expanders	Utilised to expand the H_2 rich to facilitate the separation of the C_2 fractions remaining in the H_2 stream	Continuous
De-Methanizer	Separates CH_4 from the C_2/C_3 through distillation	Continuous
De-Ethanizer	Utilised to separate the C_3 + from the C_2 fractions	Continuous
C_2 Hydrogenation	C_2H_2 present in the C_2 gas is converted into C_2H_4 by means of hydrogenation.	Continuous
2nd Demethanizer	Serves as a second de-methanizing column stripping off CH_4 and H_2 from the C_2's	Continuous
C2 Splitter	The final separation stage where the only two gasses - ethylene and ethane enters the column and is separated by means of distillation	Continuous
C_3/C_4 Debutanizer	Separates C_3/C_4	Continuous
C_3/C_4 Hydrogenation	Selectively removes acetylene and dienes	Continuous
KC 6001/2	Is utilised to compress the ethylene into the ethylene header to Sasol 1	Continuous
U70		
70VL0101 De-ethanizer Distillation column	Removes C_2 components from C_3 condensate by means of LP steam. The C_2 components are recovered to U24	Continuous
70VL0102 De-propanizer Distillation column	Separates Propane from propylene (which is the final product) by means of LP steam	Continuous
70KX010 Ammonia compressor	Utilised for cooling purposes	Continuous
U280		
U280	Ethylene recovery unit, separate ethylene from C_2 stream	Continuous
U285		
PPU2(U285)	Separation of propylene from propylene rich stream	Continuous
U 288		
PPU3(U288)	Separation of propylene from propylene rich stream	Continuous
Product Pipelines	Product to tank farm and thereafter to customers.	Continuous
Feed pipelines	Transport feed from U23 and U223 to PPU's	Continuous
Bottoms pipelines	Transport splitter bottoms to Catpoly (U32 and 232)	Continuous
U-551 ME101/2	To convert hydrocarbons into CO_2	Batch
Oil		

Unit Process	Function of Unit Process	Batch or Continuous Process
Main flares		
057ME-0120	A system consisting of 2 flares (1 West and 1 East) to collect and completely incinerate off-gases, off-specification and emergency venting from High Pressure Tank Farm.	Continuous
257ME-0120		
Storage facility		
56	Storage of components, final products and blending	Continuous
256	Storage of components and final products	
257 / 057	Storage and blending of gasses	
57	Loading of products and gasses	
Ground level flare system West		
	A system utilized for the burning of mixed alcohols in a pit flare burner at low level	As required
LOC		
Central road loading	Loading of various products in road tankers. Various products are being loaded of which the products containing VOCs are loaded in excess of 50 000 m³/a	Batch
Central rail loading	Loading of various products in rail tankers. Various products are being loaded of which the products containing VOCs are loaded in quantities below 50 000 m³/a	Batch
Nitro		
Fertilisers		
Nitric Acid Process	Production of Nitric acid	Continuous
Ammonia Process	Production Of Ammonium Nitrate Solution	Continuous
LAN Fertilizer Process	Production of Granular Fertilizers	Continuous
Phosphorous Process	Production of Various grades of Liquid Fertilizers	Batch
Ammonia Process		
Ammonium Sulfate and Ammonium Chloride Processes	Production Of Ammonium Sulfate crystals	Continuous
Explosives		
20D	Preparation of raw materials	Semi-Continuous
D-Houses	Mixing and cartridging of explosive emulsion	Semi-Continuous
E-Houses	Cooling and Packaging of cartridged emulsion	Semi-Continuous
F2	Palleting of packed product	Semi-Continuous
Magazines	Storage of product	
Bulk Plant	Production of Bulk Matrix and DDS emulsion	Semi-Continuous

3 TECHNICAL INFORMATION

Raw material consumption for the listed activities applying for MES postponement is tabulated in Table 3-1. For completeness, the raw materials used by all process are included in Appendix C1 (Table C1-1), unless the informaiton is intellectual property (IP) or otherwise sensitive due to competition law. Pollution abatement technologies employed at Synfuels and Solvents for the listed activities applying for MES postponement are provided in Table 3-2 (all appliance and abatement equipment in use at Sasol Secunda provided in Appendix C; Table C1-2).

3.1 Raw Materials Used and Production Rates

Table 3-1: Raw materials used in listed activities seeking postponements

Raw Material Type	Design Consumption Rate	Rate Unit
Steam Station East and West		
Coal	84	t/h per boiler
Boiler feed water	610	t/h per boiler
Fuel oil	48	m^3/cold start up
Tar sludge East	0.066	t/h per boiler
Tar sludge West	0.37	t/h per boiler
Ammonia	90 (East) and 40 (West)	kg/precipitator/h (90%NH_3 East and 99% NH_3 West)
Air (total)	540	km_n^3/h/boiler
Low pressure (LP) steam (400kPag)	34	t/h per boiler
Tar value chain		
Unit 039 MTP	51	m^3/h
Unit 039 Waxy Oil	43	m^3/h
Unit 039 FCC Slurry	45	m^3/h
Unit 075 Green coke	112000	tons per year
Unit 075 Green coke Hybrid	17000	tons per year
Unit 076 Green Coke	60000	tons per year
Unit 096 Coal Tar	1327	m^3/day
Unit 096 Oil	484	m^3/day
Unit 086 Waxy Oil Train 1 API Oil	18	m^3/h per train
Unit 086 Train 1 Waxy Oil API Oil	18	m^3/h per train
Unit 086 Tar Train 2 Dam Tar	18	m^3/h per train
Unit 086 Tar Train 2 Raw Tar	18	m^3/h per train
Unit 086 Tar Train 2 Tank Sludge's	18	m^3/h per train
Unit 086 OBF Waxy Oil 12	18	m^3/h per train
Unit 086 OBF HFO 150	18	m^3/h per train
Superflex catalytic cracker		
C6/C7 feed	94.5	t/h
C2 rich gas	16	t/h
Unit 24 cracked gas	16	t/h
FT feed to VL7001	70	t/h

Raw Material Type	Design Consumption Rate	Rate Unit
Rerun gasoline	10	t/h
99% Hydrogen	0.52	t/h
Hydrogen to CD hydro columns	3000	Nm^3/h
PPU3 vent gas	3.5	t/h
PP2 carrier gas	5	t/h
HVGO	7	m^3/h
Caustic	3	t/h
Sulfur Recovery		
Offgas from Rectisol & Phenosolvan	200	kNm^3/h per absorber (8 absorbers in the factory)
Caustic soda	12	m^3/day per phase
SAV	8	tonnes/week (only when required)
ADA	8	tonnes/week (only when required)
NaSCN	40	tonnes/day (only when required)
Wet Sulfuric Acid		
Off gas from Rectisol & Phenosolvan	55	kNm^3/h
Potable water (Rand Water)	125	m^3/h supply to Proxa
Ammonia	15	Nm^3/h
Multi hearth biosludge incinerators		
Thickened waste activated sludge	508	m^3/day
HOW incinerators		
High organic waste	48	m^3/day

3.2 Appliances and Abatement Equipment Control Technology

Table 3-2: Appliances and abatement equipment control technology

Appliance Name	Abatement Appliance Type	Appliance function / purpose
Steam Stations		
ESPs (Boilers 1 – 17)	Electrostatic precipitators	Particulate removal
Sulfur recovery		
Cyclones	Cyclones	To reduce PM emissions
Superflex Catalytic Cracker (SCC)		
Cyclone System	Cyclones	To reduce PM emissions
Wet sulfuric acid		
Scrubber	Scrubber Wet Electrostatic Precipitator Selective Catalytic Reduction	Reduce SO_2, PM and NO_x emissions
Multi hearth biosludge incinerators		
Scrubber	Venturi Scrubber	Removal of particulate and gaseous emissions

4 ATMOSPHERIC EMISSIONS

The establishment of a comprehensive emission inventory for the listed activities seeking postponements formed the basis for the assessment of the air quality impacts from the Secunda Complex operations on the receiving environment.

4.1 Point Source Parameters

The point source parameters for those units applying for MES postponement are provided in Table 4-1. For completeness, the details for all point sources at the Sasol Secunda complex are provided in Appendix C2;Table C2-3,Table C2-4, and Table C2-5.

4.2 Point Source Maximum Emission Rates during Normal Operating Conditions

The point source emissions are provided, for units applying for MES postponement, in Table 4-2.

In cases where periodic compliance measurements are conducted, these are measured in accordance with the methods prescribed in Schedule A of the MES, and aligned with what is prescribed in the Atmospheric Emission Licence. These reflect the average of measurements conducted over a 3-hour period during normal operating conditions.

Table 4-1: Point source parameters

Point Source Number	Point Source Name	Point Source Coordinates*		Height of Release above Ground (m)	Height above Nearby Building (m)	Diameter at Stack Tip or Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow Rate (m³/hr.)	Actual Gas Exit Velocity (m/s)	Type of Emission (Continuous /Batch)
	**Steam Stations and Rectisol / Phenosolvan**									
1	Main Stack East	26.5575	29.14993	301	281	14.4	185	11870000	23 – 27	Continuous
2	Main Stack West	26.56014	29.16841	250	230	13.6	185	10558000	23 - 27	Continuous
	**Superflex Catalytic Cracker**									
3	SCC Main stack	26.55599	29.1639	90	80	3.6	190	314135	8.6	Continuous
	**Sulfur Recovery**									
4	Main Stack East	26.5575	29.14993	301	281	14.4	185	11870000	23 – 27	Continuous
5	Main Stack West	26.56014	29.16841	250	230	13.6	185	10558000	23 - 27	Continuous
	**Wet sulfuric acid**									
6	WSA stack	26.559278	29.167642	75	50.35	2.75	41	206600	9.73	Continuous
	**Multi hearth biosludge incinerators**									
7	Biosludge East	26.54617	29.1422	30	10	1.4	66	91616.953	15.7455018	Continuous
		26.54598	29.14155	30	10	1.4	65	87230.794	15.7782546	Continuous
8	Biosludge West	26.54096	29.14283	30	10	1.4	68	74985.327	13.530936	Continuous
		26.54111	29.14226	30	10	1.4	61	81082.862	14.7078725	Continuous
HOW Incinerators									
9	HOW East	26.5481	29.14257	15	7	1.9	354	211588.32	19.8836384	26.5481
10	HOW West	26.5432	29.14331	15	7	1.9	386	183686.66	17.9960849	26.5432

Table 4-2: Point source emission rates during normal operating conditions

Point Source Number	Point Source Name	Pollutant Name	Average Emission Rate		
			Emission Concentration (mg/Nm^3)	Averaging Period	Duration of Emission
1	Main Stack East (Boilers)	Particulates	92	Daily averages	Continuous
		SO$_2$	1 689		
		NO$_x$	1 167		
	Rectisol East	VOCs	14	Hourly*	Continuous
2	Main Stack West (Boilers)	Particulates	92	Daily averages	Continuous
		SO$_2$	1 689		
		NO$_x$	1 167		
	Rectisol West	VOCs	65	Hourly*	Continuous
3	Superflex Catalytic Cracker	Particulates	261		
4	Main Stack East (Sulfur Recovery)	H$_2$S	8 400		
5	Main Stack West (Sulfur Recovery)	H$_2$S	8 400		
6	Wet Sulfuric Acid	SO$_2$	790	Hourly*	Continuous
		NOx as NO$_2$	436		
		HF	0.35		
		NH$_3$	0.07		
		HCl	1.5		
		H$_2$SO$_4$	20		
		SO$_3$	233		
7	Biosludge East 1	Particulates	265	Hourly*	Continuous
		SO$_2$	43		
		NO$_x$	387		
		Sum of Pb, As, Sb, Cr, Co, Cu, Mn, Ni, V	1.22		

Point Source Number	Point Source Name	Pollutant Name	Average Emission Rate		
			Emission Concentration (mg/Nm^3)	Averaging Period	Duration of Emission
		Hg	0.50		
		Cd+Tl	0.01		
		HF	13.8		
		NH$_3$	22.8		
		HCl	8.7		
		Dioxins / Furans (ng TEQ/Nm^3)	<0.01		
7	Biosludge East 2	Particulates	260	Hourly*	Continuous
		SO$_2$	84		
		NO$_x$	460		
		Sum of Pb, As, Sb, Cr, Co, Cu, Mn, Ni, V	1.44		
		Hg	0		
		Cd+Tl	0.50		
		HF	53		
		NH$_3$	80		
		HCl	28		
		Dioxins / Furans (ng TEQ/Nm^3)	<0.01		
8	Biosludge West 1	Particulates	82	Hourly*	Continuous
		SO$_2$	26		
		NO$_x$	188		
		Sum of Pb, As, Sb, Cr, Co, Cu, Mn, Ni, V	12		
		Hg	0		
		Cd+Tl	0.5		

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Point Source Number	Point Source Name	Pollutant Name	Average Emission Rate		
			Emission Concentration (mg/Nm³)	Averaging Period	Duration of Emission
		HF	53		
		NH₃	80		
		HCl	28		
		Dioxins / Furans (ng TEQ/Nm³)	<0.01		
8	Biosludge West 2	Particulates	172	Hourly*	Continuous
		SO₂	below detection limit		
		NOₓ	533		
		Sum of Pb, As, Sb, Cr, Co, Cu, Mn, Ni, V	29		
		Hg	<0.01		
		Cd+Tl	0.01		
		HF	below detection limit		
		NH₃	0.35		
		HCl	0.01		
		Dioxins / Furans (ng TEQ/Nm³)	<0.01		
9	HOW East	Particulates	109	Hourly*	Continuous
		SO₂	23		
		NOₓ	1 375		
		Sum of Pb, As, Sb, Cr, Co, Cu, Mn, Ni, V	3.7		
		Hg	<0.01		
		Cd+Tl	0.01		
		HF	below detection limit		
		NH₃	0.35		

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Point Source Number	Point Source Name	Pollutant Name	Average Emission Rate		
			Emission Concentration (mg/Nm³)	Averaging Period	Duration of Emission
		HCl	0.01		
		Dioxins / Furans (ng TEQ/Nm³)	<0.01		
10	HOW West	Particulates	248	Hourly*	Continuous
		SO₂	below detection limit		
		NOₓ	1 182		
		Sum of Pb, As, Sb, Cr, Co, Cu, Mn, Ni, V	21.5		
		Hg	0.12		
		Cd+Tl	0.03		
		HF	below detection limit		
		NH₃	0.35		
		HCl	0.01		
		Dioxins / Furans (ng TEQ/Nm³)	<0.01		

*: Hourly averages are based on 3-hourly ad hoc sampling average measurements, as per Regulatory requirement

4.3   Point Source Maximum Emission Rates during Start-up, Maintenance and/or Shut-down

From a maintenance perspective, planned factory shutdowns are conducted yearly. The Sasol Synfuels plant consists of four 'phases'. Two phases are located at the Sasol Synfuels west factory; and two phases on the Sasol Synfuels east factory. Every year, one phase of the plant undergoes a "phase shutdown", and every four years, a "total shutdown" (representing two of the four phases) is undertaken. Statutory requirements sometimes drive the frequency of maintenance activities, for example, pressure vessel regulations drive boiler inspection schedules.

As for upset conditions, Section 30 of NEMA applies, and Sasol has not exceeded the 48 hour window in the preceding two years during start up, maintenance, upset and shutdown conditions, which has ensured that ambient impacts are limited in duration.

During maintenance activities, the real-time ambient air quality monitoring data is closely followed, to ensure that air quality does not exceed the national ambient air quality standards as a consequence of Sasol's activities. These activities are also communicated to the Licensing Authority as well as the communities around the facilities, normally through a newspaper notice.

The Atmospheric Impact Report Regulations require that the maximum emissions during start-up, shut down and upset conditions must be included within the AIR for the processes. This information is unfortunately not available for two practical reasons, explained below.

1. Since Sasol operates predominantly gaseous plants, operating the plant under start-up, shut down and upset condition is a period of high instability and for safety reasons, as few people as possible are allowed on the plant. Therefore ad hoc sampling under these conditions is a safety risk and therefore the sampling cannot be conducted. It should further be emphasised that the aim of the plant personnel is to get the plant back into operation as soon as possible and therefore the support required by sampling teams cannot be provided as the focus is on the returning the plant to stable operation as soon as possible.

    Another practical limitation is identification of the precise process conditions that will result in a maximum emission concentration. Since these conditions are unstable, large variations in plant conditions occur dynamically and pin pointing the exact combination of conditions at which to take the sample indicative of a maximum concentration is virtually impossible. Additional to the last mentioned, a maximum concentration may hypothetically exist for only a couple of minutes, however the prescribed legislation requires certain sampling techniques to be done over a period of at least an hour and then to be repeated for two times. Doing this under start-up, shut down and upset conditions are almost impossible due to the dynamics of a plant.

2. In the event where online monitoring is available, Sasol can attempt to make concentrations available for start-up, shut down and upset conditions, however in investigating this Sasol has realised that the maximum concentrations are higher than the calibration range of the instrument, meaning that the online instrument is yielding only its maximum value. Since the actual true maximum concentration is higher than the instrument maximum, the true actual concentration cannot be provided and therefore an accurate maximum concentration under start-up, shut-down and upset conditions cannot be included.

In mentioning the above, cognisance should be taken that Sasol's ambient air quality monitoring stations monitor ambient air quality over a 24-hour period and any upset, start-up or shut down events will reflect in the ambient air quality measurements and results. Therefore, maximum measured concentrations, although not quantified on site, is included in measured values for ambient air quality.

4.4 Fugitive Emissions

Fugitive emissions on the Secunda complex are managed and quantified through two fugitive emissions monitoring programs.

4.4.1 Fugitive VOC emissions

The first monitoring program is associated with fugitive VOC emissions. These emissions originate from various sumps, drains and from process equipment, such as product storage tanks, valves and pumps. The on-site monitoring of fugitive process emissions is associated with Leak Detection and Repair. A third party contractor is contracted to conduct leak detection, with the help of a sniffer, to identify and quantify the leaks associated with various process emissions. The report results are then included in a maintenance plan and the leaking process units are repaired per schedule. This process has been implemented for a period exceeding five years.

As a last resort, all VOC emissions, where arising from point sources, are detected by the monitoring stations surrounding the Secunda complex. These measurements reflect the total, combined effect of VOC emissions from across the entire Secunda complex, and Sasol conservatively assumes all ambient VOCs are attributable to the Secunda complex.

4.4.2 Dustfall monitoring

Fallout dust is governed by the fallout dust regulations; Government Gazette No. 36974, No. R. 827; 1 November 2013). Secunda has a number of fallout dust monitoring stations measuring the dust fallout on site. The dust fallout buckets are placed in locations where fallout of dust from coal stockpiles, fine ash dams and construction activities will occur, to ensure adequate control of most probable dust sources is in place. The Safety, Health and Environmental function at the Secunda site is responsible for the measurement and management of dust in accordance with the fallout dust regulations and an accredited third party is responsible for replacing and analysing the buckets on a monthly basis. The position of the buckets was determined by dispersion modelling conducted by an independent consultant.

The graphs for 2012/2013 sampling campaign for fallout dust are included in Appendix C3 (Figure C3-1 – C3-7). These graphs indicate that the facility's fallout dust is predominantly within the lower range considered acceptable for domestic areas, despite being an industrial site. Sasol inherently does not operate a process with large amounts of dust or large stock piles of possible fugitive dust emissions, with the exception of some coal stock piles, coarse ash heaps and fine ash dams. The operational fine ash dam is wet and therefore wind-blown dust is limited. The non-operational fine ash dam has natural vegetation on the sides, but the fins ash from this non-operational fine ash dam is harvested for rehabilitation purposes of other sites within the ash storage area.

The monitoring plan philosophy is that Sasol conduct monitoring and investigate spikes in the monitoring results. In the event that a spike is observed, the problem will be addressed to ensure fugitive fallout dust is maintained within the standard.

4.5 Emergency Incidents

Unplanned downtime events such as upset conditions are undesirable from a production perspective as well as an environmental perspective and Sasol endeavours to minimise unplanned downtime by conducting regular and pro-active maintenance and ensuring control of the process within their designed operating parameters. While unplanned downtime cannot be completely eliminated, it is minimised as far as practicably possible, and rectified with high priority.

The MES prescribes that start-up, shut-down, upset and maintenance events should not exceed 48 hours – and if they do, a Section 30 NEMA incident is incurred (as also indicated in the AEL). Sasol's Secunda operations can confirm that, in the preceding two years, its facility has not exceeded the 48 hour window during start up, maintenance, upset and shutdown conditions, which has ensured that ambient impacts are limited in duration.

Sasol owns and operates accredited ambient air quality monitoring stations in the vicinity of its Secunda plant. The real-time ambient air quality monitoring data is closely followed during upset conditions at the plant, to ensure that air quality does not exceed the national ambient air quality standards as a consequence of Sasol's activities. These activities are also communicated to the Licensing Authority.

5   IMPACT OF ENTERPRISE ON THE RECEIVING ENVIRONMENT

The report includes the results for three emission scenarios per pollutant (per point source where necessary), in order to establish the delta impacts against air quality limit values. The scenarios are as follows:

- *Baseline Emissions* – modelling conducted based on the current inventory and impacts
- *Minimum Emissions Standards* – modelling conducted based on plants theoretically complying with:
    - Existing Plant Standards, and;
    - New Plant Standards
- *Alternative Emission Limits* – the emission reductions as proposed by Sasol, where applicable and different from the other three emission scenarios.

5.1   Analysis of Emissions' Impact on Human Health

5.1.1   Study Methodology

5.1.1.1   Study Plan

The study methodology may conveniently be divided into a "preparatory phase" and an "execution phase". The basic methodology followed in this assessment is provided in Figure 5-1.

The preparatory phase included the following basic steps prior to performing the actual dispersion modelling and analyses:

1. Understand Scope of Work
2. Assign Appropriate Specialists (Appendix A)
3. Review of legal requirements (e.g. dispersion modeling guideline)
4. Prepare a Plan of Study for Peer Review
5. Decide on Dispersion Model

The Regulations regarding Air Dispersion Modelling (Gazette No 37804 vol 589; published 11 July 2014) was referenced for the dispersion model selection (Appendix B).

Three Levels of Assessment are defined in the draft Regulations Regarding Air Dispersion Modelling:
- Level 1: where worst-case air quality impacts are assessed using simpler screening models
- Level 2: for assessment of air quality impacts as part of license application or amendment processes, where impacts are the greatest within a few kilometers downwind (less than 50km)
- Level 3: require more sophisticated dispersion models (and corresponding input data, resources and model operator expertise) in situation:
    - where a detailed understanding of air quality impacts, in time and space, is required;
    - where it is important to account for causality effects, calms, non-linear plume trajectories, spatial variations in turbulent mixing, multiple source types & chemical transformations;
    - when conducting permitting and/or environmental assessment process for large industrial developments that have considerable social, economic and environmental consequences;
    - when evaluating air quality management approaches involving multi-source, multi-sector contributions from permitted and non-permitted sources in an airshed; or,

- when assessing contaminants resulting from non-linear processes (e.g. deposition, ground-level O_3, particulate formation, visibility)

The models recommended for Level 3 assessments are CALPUFF or SCIPUFF. In this study, CALPUFF was selected for the following reasons (as referenced in Figure 5-1 - *Model Aspects to Consider and Dispersion Models*):

- This Lagrangian Gaussian Puff model is also well suited to simulate low or calm wind speed conditions. Alternative regulatory models such as the US EPA AERMOD model treats all plumes as straight-line trajectories, which under calm wind conditions grossly over-estimates the plume travel distance.
- CALPUFF is able to perform chemical transformations. In this study the conversion of NO to NO_2 and the secondary formation of particulate matter was a concern.
- Convective conditions, frequently experienced in the region during summer, are effectively treated in CALPUFF.

The execution phase (i.e. dispersion modelling and analyses) firstly involves gathering specific information in relation to the emission source(s) and site(s) to be assessed. This includes:

- Source information: Emission rate, exit temperature, volume flow, exit velocity, etc.;
- Site information: Site building layout, terrain information, land use data;
- Meteorological data: Wind speed, wind direction, temperature, cloud cover, mixing height;
- Receptor information: Locations using discrete receptors and/or gridded receptors.

The model uses this specific input data to run various algorithms to estimate the dispersion of pollutants between the source and receptor. The model output is in the form of a predicted time-averaged concentration at the receptor. These predicted concentrations are added to suitable background concentrations and compared with the relevant ambient air quality standard or guideline. In some cases post-processing can be carried out to produce percentile concentrations or contour plots that can be prepared for reporting purposes.

The following steps were followed for the execution phase of the assessment:

- Decide on meteorological data input (Figure 5-1- CALMET). A summary of the model control options for CALMET is provided in Appendix D. Refer to Section 5.1.4.6.1.
- Prepare all meteorological model input files (Figure 5-1- CALMET)
  o Surface meteorological files
  o MM5 meteorological files
  o Topography
  o Land Use
- Select control options in meteorological model (Figure 5-1- CALMET)
  o Dispersion coefficients
  o Vertical levels
  o Receptor grid
- *Feedback to Project Team and revise where necessary*
- Review emissions inventory and ambient measurements
- *Feedback to Project Team and revise where necessary*
- Decide on dispersion model controls and module options (Figure 5-1- CALPUFF). A summary of the model control options for CALPUFF is provided in Appendix E. Refer to Section 5.1.4.6.3.
- Decide on dispersion module options (Figure 5-1- CALPUFF).

- o Sulfate and nitrate formation module (MESOPUFF or RiVAD)
  - o NO_2 formation (MESOPUFF or RiVAD)
  - o Model resolution
- *Feedback to Project Team and revise where necessary*
- Decide on modelling domain and receptor locations (Figure 5-1– CALPUFF and Simulations)
- *Feedback to Project Team and revise where necessary*
- Prepare all dispersion model input files (Figure 5-1- CALPUFF)
  - o Control options
  - o Measured ambient O_3 and NH_3 for chemical transformation module
  - o Meteorology
  - o Source data
  - o Receptor grid and discrete receptors
- Review all modelling input data files and fix where necessary
- Simulate source groups per pollutant and calculate air concentration levels for regular and discrete grid locations for the following scenarios (Figure 5-1–Simulations):
  - o Baseline (current) air emissions
  - o Change Baseline sources to reflect "Existing Plant"emissions standards
  - o Change Baseline sources to reflect "New Plant" emissions standards
  - o Change Baseline sources to reflect proposed Alternative Emission Limits, where applicable
- Compare against National Ambient Air Quality Standards (NAAQS)
- *Present Results to Project Team*
- Preparation of draft AIR
- *Present AIR to Project Team*
- Preparation of final AIR
- Updates to AIR in order to address stakeholder comments.
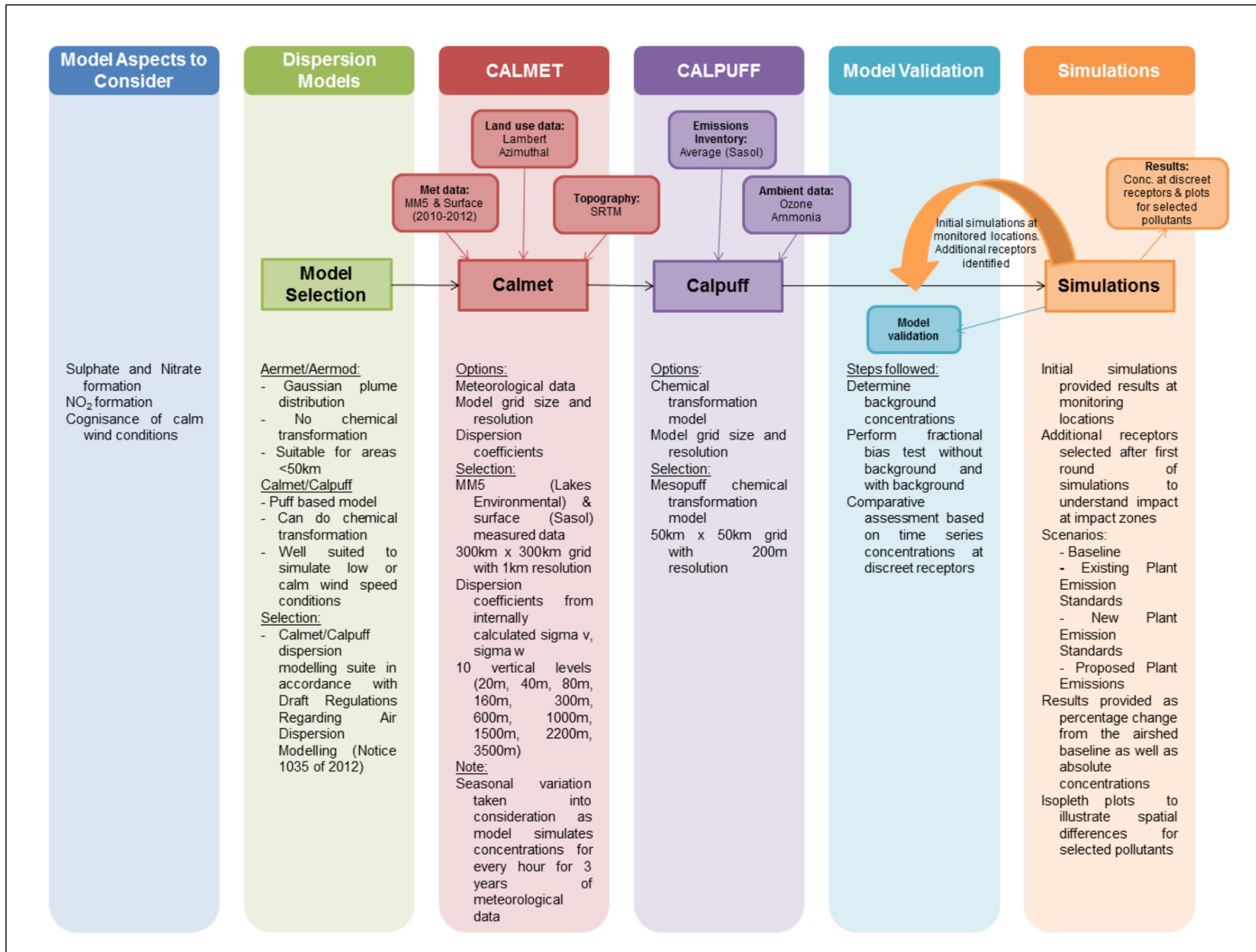
Figure 5-1: The basic study methodology followed for the assessment

In order to assess the impact of each of the postponements for which Sasol has applied, four emissions scenarios were modelled, with the results throughout the AIR presented as illustrated in Figure 5-2.

1. **Current baseline emissions**, reflective of the impacts of present operations, which are modelled as *averages* of measurements taken from continuous emission monitoring (where available) or periodic emission monitoring. This scenario is represented by the first column in the presentation of all AIR graphs (shown in blue in Figure 5-2). Baseline emissions were derived from accredited (ISO/IEC17025) 3rd parties and laboratories. Emissions measurements follow the requirements prescribed in Schedule A of GN 893. The reason baseline emissions were modelled as averages of measured point source emissions was to obtain a picture of long-term average impacts of Sasol's emissions on ambient air concentrations, which could be reasonably compared with monitored ambient concentrations, as a means of assessing the representativeness of the dispersion model's predictions. Modelling baseline emissions at a ceiling level, which is seldom reflective of actual emissions, would over-predict ambient impacts, and therefore not allow for reasonable assessment of the model's representativeness.

The following three scenarios are modelled to reflect the administrative basis of the MES, being ceiling emission levels. These scenarios are therefore theoretical cases where the point source is constantly emitting at the highest expected emission level possible under normal operating conditions, for the given scenario (i.e. the 100th percentile emission concentration).

2. **Compliance with the 2015 existing plant standards**. This is modelled as a ceiling emissions limit (i.e. maximum emission concentration) aligned with the prescribed standard, and reflects a scenario where abatement equipment is introduced to theoretically reduce emissions to conform to the standards. This scenario is represented by the second column in the presentation of all AIR graphs (shown in red in Figure 5-2). For example, this considers the renewal of ESPs and the implementation of low NO_x burners to meet Steam plant boiler existing plant standards, and some technology to theoretically achieve compliance with existing plant standards for H_2S emissions from the Sulfur Recovery plant;

3. **Compliance with the 2020 new plant standards.** This is modelled as a ceiling emissions limit (i.e. maximum emission concentration) aligned with the prescribed standard, and reflects a scenario where abatement equipment is introduced to theoretically reduce emissions to conform to the standards. This scenario is represented by the third column in the presentation of all AIR graphs (shown in green in Figure 5-2). For example, this considers the implementation of flue-gas desulphurisation (FGD) at the Steam plant's boilers, which would result in lowered flue gas temperatures from the boilers with a resulting detrimental effect on the co-dispersion of other pollutants including NO_x and PM; and,

4. **A worst-case scenario of operating constantly at the requested alternative emissions limits**, which have been specified as ceiling emissions limits (i.e. maximum emission concentrations). This scenario is represented by the fourth column in the presentation of all AIR graphs (shown in purple in Figure 5-2). It is re-emphasised that Sasol Synfuels will not physically increase its current baseline emissions (expressed as an average). In some instances the scenario appears higher than the baseline, only because it portrays the worst case outcome where the 100th percentile emission rate occurs under the 99th percentile worst meteorological conditions – and this is modelled assuming these conditions prevail for the entire duration of the modelling period. Sasol Synfuels seeks alternative emissions limits which are aligned with the manner in which the MES are stated and which accommodate the natural variability inherent in emissions under different operating conditions, and hence must request a ceiling emissions limit rather than an average emissions limit. The alternative emission limit is hence simply a different way of expressing current baseline

emissions (in cases where further abatement is not possible), or may even reflect a reduction in average baseline emissions (in cases where further abatement is possible, but not to a level which achieves compliance with the MES ceiling emissions limits).
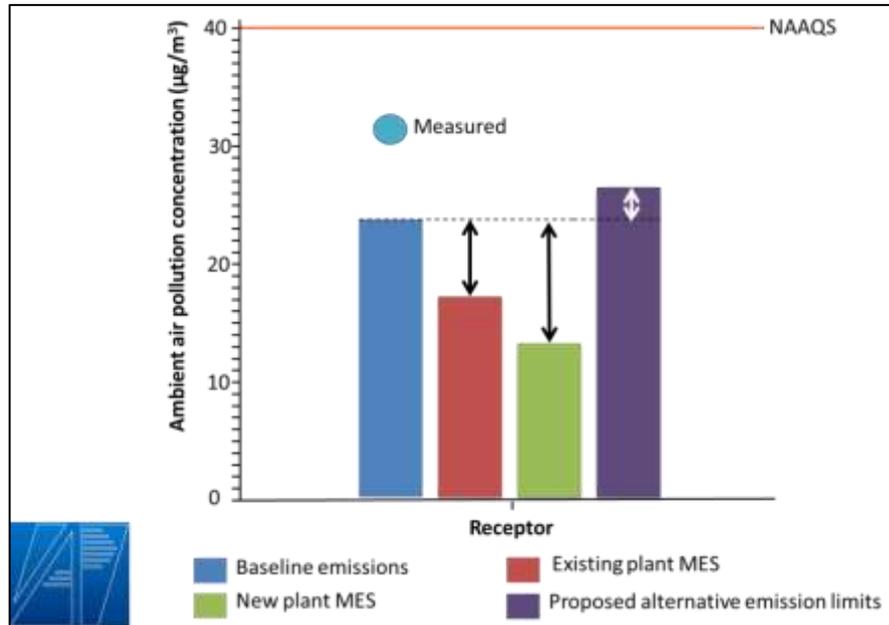
Figure 5-2: Schematic displaying how the dispersion modelling scenarios are presented, for each receptor point in the modelling domain

In Figure 5-2, the black arrows above the red and green bars reflect the predicted delta (change) in ambient impacts of Sasol Synfuels' baseline emissions versus the given compliance scenario. At a practical level, the white arrow on the purple bar represents the theoretical delta increase in short-term ambient impacts, where 100th percentile emissions occur, compared with the predicted impact of average current baseline emissions. The blue dot in Figure 5-2 represents physically measured ambient air quality, reflective of the total impact of all sources in the vicinity, as the 99th percentile recorded value over the averaging period. On a given day, there is a 99% chance that the actual measured ambient air quality would be lower than this value, but this value is reflected for the purpose of aligning with modelling requirements. The orange line represents the applicable National Ambient Air Quality Standard (NAAQS) or, where not available, relevant international health-effect screening level, used for interpretation of the dispersion modelling results, as described in Section 5.1.8.2.

5.1.1.3   CALPUFF/CALMET Modelling Suite

As discussed in the previous section, the CALPUFF model was selected for use in the current investigation to predict maximum short-term (1 and 24-hour) and annual average ground-level concentrations at various receptor locations within the computational domains. CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal (Scire et al, 2000a). It can accommodate arbitrarily varying point source, area source, volume source, and line source emissions. The CALPUFF code includes algorithms for near-source effects such as building downwash, transitional plume rise, partial plume penetration, sub grid scale terrain interactions as well as longer range effects such as pollutant removal due to wet scavenging and dry deposition, chemical transformation, vertical wind shear, overwater transport and coastal interaction effects.

It is intended for use on scales from tens of metres to hundreds of kilometres from a source (US EPA 1998). A number of dispersion coefficients options are accommodated, including

- stability-based empirical relationships such as the Pasquill-Gifford or McElroy-Pooler dispersion coefficients;
- turbulence-based dispersion coefficients (based on measured standard deviations of the vertical and crosswind horizontal components of the wind); and
- similarity theory to estimate the turbulent quantities using the micrometeorological variables calculated by CALMET

The most desirable approach is to use turbulence-based dispersion coefficients using measured turbulent velocity variances or intensity components, if such data are readily available and they are of good quality. However, since reliable turbulent measurements are generally not available, the next best recommendation is to use the similarity approach.

CALPUFF also has the capability to model the effects of vertical wind shear by explicitly allowing different puffs to be independently advected by their local average wind speed and direction, as well as by optionally allowing well-mixed puffs to split into two or more puffs when across-puff shear becomes important. Another refinement is an option to use a probability density function (pdf) model to simulate vertical dispersion during convective conditions.

CALPUFF includes parameterized chemistry modules for the formation of secondary sulfate and nitrate from the oxidation of the emitted primary pollutants, SO_2 and NO_x. The conversion processes are assumed to be linearly dependent (first-order) on the relevant primary species concentrations. Two options are included, namely the MESOPUFF II and RIVAD/ARM3 chemistry options. In both options, a fairly simple stoichiometric thermodynamic model is used to estimate the partitioning of total inorganic nitrate between gas-phase nitric acid and particle-phase ammonium nitrate. Ammonia and ozone concentrations are required as background values to the model.

CALPUFF uses dry deposition velocities to calculate the dry deposition of gaseous and particulate pollutants to the surface. These dry deposition velocities can either be user-specified or calculated internally in CALPUFF. A resistance-based model is used for the latter option. For gaseous pollutants, the resistances that are considered are the atmospheric resistance, the deposition layer resistance, and the canopy resistance. For particles, a gravitational settling term is included and the canopy resistance is assumed to be negligible. CALPUFF uses the scavenging coefficient approach to parameterize wet deposition of gases and particles. The scavenging coefficient depends on pollutant characteristics (e.g., solubility and reactivity), as well as the precipitation rate and type of precipitation. The model provides default values for the scavenging coefficient for various species and two types of precipitation (liquid and frozen). These values may be overridden by the user.

The CALPUFF modelling system consists of a number of components, as summarised in Table 5-1, however only CALMET and CALPUFF contain the simulation engines to calculate the three-dimensional atmospheric boundary layer conditions and the dispersion and removal mechanisms of pollutants released into this boundary layer. The other codes are mainly used to assist with the preparation of input and output data. Table 5-1 also includes the development versions of each of the codes used in the investigation.

Table 5-1: Summary description of CALPUFF/CALMET model suite with versions used in the investigation

Module	Version	Description
CALMET	v6.334	Three-dimensional, diagnostic meteorological model
CALPUFF	v6.42	Non-steady-state Gaussian puff dispersion model with chemical removal, wet and dry deposition, complex terrain algorithms, building downwash, plume fumigation and other effects.
CALPOST	V6.292	A post-processing program for the output fields of meteorological data, concentrations and deposition fluxes.
CALSUM	v1.4 [1]	Sums and scales concentrations or wet/dry fluxes from two or more source groups from different CALPUFF runs
PRTMET	v 4.495[1]	Lists selected meteorological data from CALMET and creates plot files
POSTUTIL	v1.641[1]	Processes CALPUFF concentration and wet/dry flux files. Creates new species as weighted combinations of modelled species; merges species from different runs into a single output file; sums and scales results from different runs; repartitions nitric acid/nitrate based on total available sulfate and ammonia.
TERREL	v3.69[1]	Combines dna grids terrain data
CTGPROC	v3.5[1]	processes and grids land use data
MAKEGEO	v3.2[1]	merges land use and terrain data to produce the geophysical data file for CALMET

Note [1]: These modules indicate version number as listed on http://www.src.com/calpuff/download/mod6_codes.htm (for CALPro Plus v6) [version number not given in GUI interface or 'About' information].

A summary of the main CALMET and CALPUFF control options are given in Appendices D and E, respectively.

5.1.2   Legal Requirements

5.1.2.1   Atmospheric Impact Report

In the event where an application for postponement is being made, Section 21 of NEM: Air Quality Act (AQA), Regulations 11 and 12 state:

1.   An application for postponement may be made to the National Air Quality Officer
2.   The application contemplated in Regulation 11 must include, amongst others, an Atmospheric Impact Report

The format of the Atmospheric Impact Report is stipulated in the Regulations Prescribing the Format of the Atmospheric Impact Report, Government Gazette No. 36904, Notice Number 747 of 2013 (11 October 2013) (Appendix B; Table B-1).

Sasol appointed Airshed to compile this AIR to meet the requirements of Regulation 12 (Postponement of compliance time frames) of the Listed Activities and Associated Minimum Emissions Standards (Government Gazette No. 37054, 22 November 2013) (Appendix B; Table B-2).

5.1.2.2   National Ambient Air Quality Standards (NAAQS)

Modelled concentrations will be assessed against NAAQS (Table 5-2), where they are prescribed by South African legislation. Where no NAAQS exists for a relevant non-criteria pollutant, health screening effect levels based on international guidelines are used. These are discussed with the results of dispersion modelling in Section 5.1.8.2.

Table 5-2: National Ambient Air Quality Standards

Pollutant	Averaging Period	Concentration (µg/m³)	Permitted Frequency of Exceedance	Compliance Date
Benzene (C₆H₆)	1 year	10	0	Immediate till 31 December 2014
	1 year	5	0	1 January 2015
Carbon Monoxide (CO)	1 hour	30000	88	Immediate
	8 hour[a]	10000	11	Immediate
Lead (Pb)	1 year	0.5	0	Immediate
Nitrogen Dioxide (NO₂)	1 hour	200	88	Immediate
	1 year	40	0	Immediate
Ozone (O₃)	8 hour[b]	120	11	Immediate
PM₂.₅	24 hour	65	4	Immediate till 31 December 2015
	24 hour	40	4	1 January 2016 till 31 December 2029
	24 hour	25	4	1 January 2030
	1 year	25	0	Immediate till 31 December 2015
	1 year	20	0	1 January 2016 till 31 December 2029
	1 year	15	0	1 January 2030
PM₁₀	24 hour	120	4	Immediate till 31 December 2014
	24 hour	75	4	1 January 2015
	1 year	50	0	Immediate till 31 December 2014
	1 year	40	0	1 January 2015
Sulfur Dioxide (SO₂)	10 minutes	500	526	Immediate
	1 hour	350	88	Immediate
	24 hour	125	4	Immediate
	1 year	50	0	Immediate

Notes: (a) Calculated on 1 hour averages. (b) Running average.

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to determine compliance with the relevant ambient air quality standards. Regulations regarding Air Dispersion Modelling were promulgated in Government Gazette No. 37804 vol. 589; 11 July 2014, and recommend a suite of dispersion models to be applied for regulatory practices as well as guidance on modelling input requirements, protocols and procedures to be followed. The Regulations regarding Air Dispersion Modelling are applicable –

(a) in the development of an air quality management plan, as contemplated in Chapter 3 of the AQA;
(b) in the development of a priority area air quality management plan, as contemplated in section 19 of the AQA;
(c) in the development of an atmospheric impact report, as contemplated in section 30 of the AQA; and,
(d) in the development of a specialist air quality impact assessment study, as contemplated in Chapter 5 of the AQA.

The Regulations have been applied to the development of this report. The first step in the dispersion modelling exercise requires a clear objective of the modelling exercise and thereby gives clear direction to the choice of the dispersion model most suited for the purpose. Chapter 2 of the Regulations present the typical levels of assessments, technical summaries of the prescribed models (SCREEN3, AERSCREEN, AERMOD, SCIPUFF, and CALPUFF) and good practice steps to be taken for modelling applications.

Dispersion modelling provides a versatile means of assessing various emission options for the management of emissions from existing or proposed installations. Chapter 3 of the Regulations prescribe the source data input to be used in the models. Dispersion modelling can typically be used in the:

- Apportionment of individual sources for installations with multiple sources. In this way, the individual contribution of each source to the maximum ambient predicted concentration can be determined. This may be extended to the study of cumulative impact assessments where modelling can be used to model numerous installations and to investigate the impact of individual installations and sources on the maximum ambient pollutant concentrations.
- Analysis of ground level concentration changes as a result of different release conditions (e.g. by changing stack heights, diameters and operating conditions such as exit gas velocity and temperatures).
- Assessment of variable emissions as a result of process variations, start-up, shut-down or abnormal operations.
- Specification and planning of ambient air monitoring programs which, in addition to the location of sensitive receptors, are often based on the prediction of air quality hotspots.

The above options can be used to determine the most cost-effective strategy for compliance with the NAAQS. Dispersion models are particularly useful under circumstances where the maximum ambient concentration approaches the ambient air quality limit value and provide a means for establishing the preferred combination of mitigation measures that may be required including:

- Stack height increases;
- Reduction in pollutant emissions through the use of air pollution control systems (APCS) or process variations;
- Switching from continuous to non-continuous process operations or from full to partial load.

Chapter 4 of the Regulations prescribe meteorological data input from onsite observations to simulated meteorological data. The chapter also gives information on how missing data and calm conditions are to be treated in modelling applications.

Meteorology is fundamental for the dispersion of pollutants because it is the primary factor determining the diluting effect of the atmosphere. Therefore, it is important that meteorology is carefully considered when modelling.

New generation dispersion models, including models such as AERMOD and CALPUFF[1], simulate the dispersion process using planetary boundary layer (PBL) scaling theory. PBL depth and the dispersion of pollutants within this layer are influenced by specific surface characteristics such as surface roughness, albedo and the availability of surface moisture:

- Roughness length (z_o) is a measure of the aerodynamic roughness of a surface and is related to the height, shape and density of the surface as well as the wind speed.
- Albedo is a measure of the reflectivity of the Earth's surface. This parameter provides a measure of the amount of incident solar radiation that is absorbed by the Earth/atmosphere system. It is an important parameter since absorbed solar radiation is one of the driving forces for local, regional, and global atmospheric dynamics.
- The Bowen ratio provides measures of the availability of surface moisture injected into the atmosphere and is defined as the ratio of the vertical flux of sensible heat to latent heat, where sensible heat is the transfer of heat from the surface to the atmosphere via convection and latent heat is the transfer of heat required to evaporate liquid water from the surface to the atmosphere.

Topography is also an important geophysical parameter. The presence of terrain can lead to significantly higher ambient concentrations than would occur in the absence of the terrain feature. In particular, where there is a significant relative difference in elevation between the source and off-site receptors large ground level concentrations can result. Thus the accurate determination of terrain elevations in air dispersion models is very important.

The modelling domain would normally be decided on the expected zone of influence; the latter extent being defined by the predicted ground level concentrations from initial model runs. The modelling domain must include all areas where the ground level concentration is significant when compared to the air quality limit value (or other guideline). Air dispersion models require a receptor grid at which ground-level concentrations can be calculated. The receptor grid size should include the entire modelling domain to ensure that the maximum ground-level concentration is captured and the grid resolution (distance between grid points) sufficiently small to ensure that areas of maximum impact adequately covered. No receptors however should be located within the property line as health and safety legislation (rather than ambient air quality standards) is applicable within the site.

Chapter 5 provides general guidance on geophysical data, model domain and coordinates system required in dispersion modelling, whereas Chapter 6 elaborates more on these parameters as well as the inclusion of background air concentration data. The chapter also provides guidance on the treatment of NO_2 formation from NO_x emissions, chemical transformation of sulfur dioxide into sulfates and deposition processes.

Chapter 7 of the Regulations outline how the plan of study and modelling assessment reports are to be presented to authorities. A comparison of how this study met the requirements of the Regulations is provided in Appendix B.

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[1] The CALMET modelling system require further geophysical parameters including surface heat flux, anthropogenic heat flux and leaf area index (LAI).

5.1.4   Atmospheric Dispersion Processes

CALPUFF initiates the simulation of point source plumes with a calculation of buoyant plume rise as discussed below in Section 5.1.3.1. Transport winds are extracted from the meteorological data file at the location of the stack and at the effective plume height (stack height plus plume rise). For near-field effects, the height of the plume in transition to the final plume height is taken into account. The puff release rate is calculated internally, based on the transport speed and the distance to the closest receptor.

As the puff is transported downwind, it grows due to dispersion and wind shear, and the trajectory is determined by advection winds at the puff location and height at each time step. The pollutant mass within each puff is initially a function of the emission rate from the original source. The pollutant mass is also subject to chemical transformation, washout by rain and dry deposition, when these options are selected, as is the case in this application. Chemical transformation and removal are calculated based on a one-hour time step.

Both wet and dry deposition fluxes are calculated by CALPUFF, based on a full resistance model for dry deposition and the use of precipitation rate-dependent scavenging coefficients for wet deposition. Pollutant mass is removed from the puff due to deposition at each time step. For the present modelling analyses, most options were set at "default" values, including the MESOPUFF II transformation scheme[2] and the treatment of terrain.

5.1.4.1   Plume Buoyancy

Gases leaving a stack mix with ambient air and undergo three phases namely the initial phase, the transition phase and the diffusion phase (Figure 5-3). The initial phase is greatly determined by the physical properties of the emitted gases. These gases may have momentum as they enter the atmosphere and are often heated and are therefore warmer than the ambient air. Warmer gases are less dense than the ambient air and are therefore buoyant. A combination of the gases' momentum and buoyancy causes the gases to rise (vertical jet section, in Figure 5-3). In the Bent-Over Jet Section, entrainment of the cross flow is rapid because, by this time, appreciable growth of vortices has taken place. The self-generated turbulence causes mixing and determines the growth of plume in the thermal section. This is referred to as plume rise and allows air pollutants emitted in this gas stream to be lifted higher in the atmosphere. Since the plume is higher in the atmosphere and at a further distance from the ground, the plume will disperse more before it reaches ground level. With greater volumetric flow and increased exit gas temperatures, the plume centreline would be higher than if either the volumetric flow or the exit gas temperature is reduced. The subsequent ground level concentrations would therefore be lower.

This is particularly important in understanding some of the dispersion model results in Section 5.1.7. As an example, consider the emissions from a boiler. With the introduction of retrofitted emission controls (e.g. wet scrubber or bag filters), the exit gas temperature and perhaps the volumetric flow would be lower than the original values. Thus it is quite possible that the resultant decrease in plume momentum and buoyancy may actually result in higher ground level concentrations despite the reduction in point source emission concentrations, due to the lower plume centreline.

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[2] A sensitivity study was carried out with the RIVAD II transformation scheme to examine the performance of the different approaches to calculating the SO_2 to SO_4 and NO_x to NO_3 transformation rates. The concentrations from the RIVAD II and the MESOPUFF II transformation schemes showed no real bias with the secondary particulate formation varying by -41% to 31% for the two schemes.
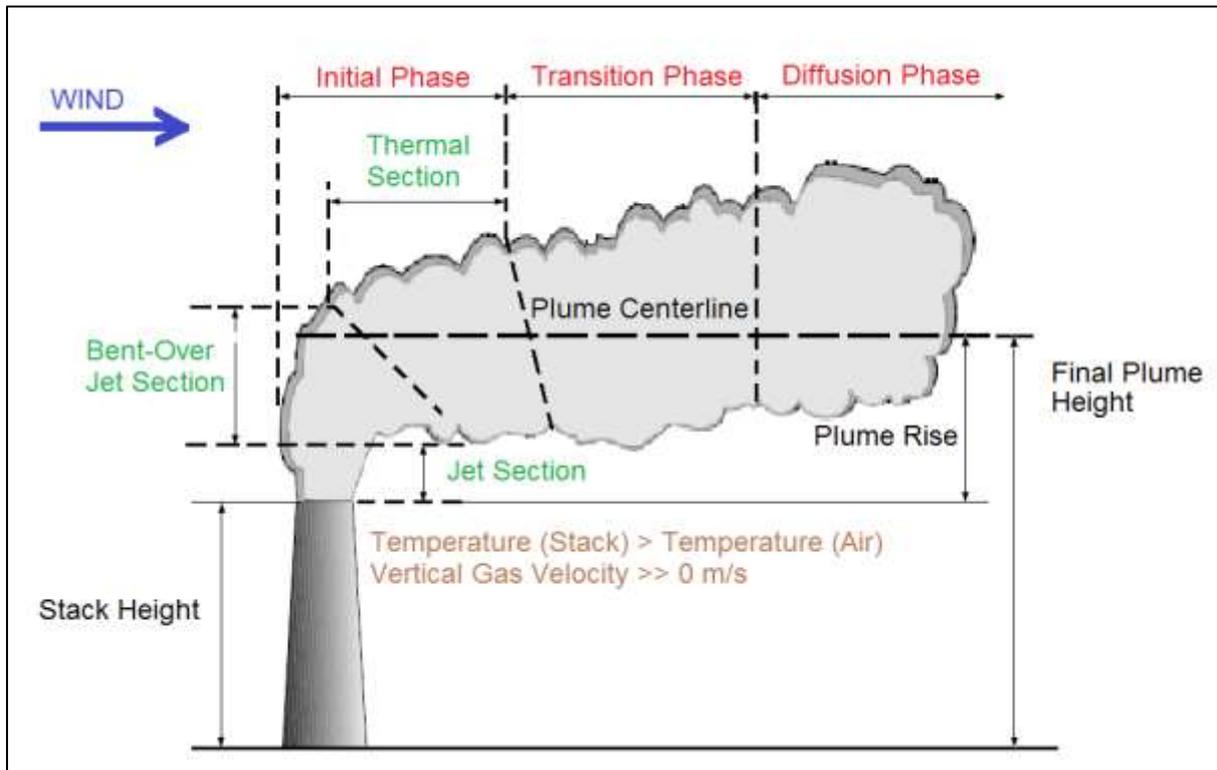
Figure 5-3: Plume buoyancy

5.1.4.2   Urban and Rural Conditions

Land use information is important to air dispersion modelling, firstly to ensure that the appropriate dispersion coefficients and wind profiles (specified as surface roughness) are used, and secondly, that the most appropriate chemical transformation models are employed. Urban conditions result in different dispersion conditions than in rural areas, as well as changing the vertical wind profiles. Urban conditions are also generally associated with increased levels of volatile organic compounds (VOCs), thereby influencing chemical equilibriums between the photochemical reactions of NO_x, CO and O_3.

It can be appreciated that the definition of urban and rural conditions for the dispersion coefficients and wind profiles, on the one hand, and chemical reactions on the other, may not be the same. Nonetheless, it was decided to use the US Environmental Protection Agency's (US EPA) guideline on air dispersion models (US EPA 2005), to classify the surrounding land-use as rural or urban based on the Auer method, which is strictly recommended for selecting dispersion coefficients.

The classification scheme is based on the activities within a 3 km radius of the emitting stack. Areas typically defined as rural include residences with grass lawns and trees, large estates, metropolitan parks and golf courses, agricultural areas, undeveloped land and water surfaces. An area is defined as urban if it has less than 35% vegetation coverage or the area falls into one of the use types in Table 5-3.

Table 5-3: Definition of vegetation cover for different developments (US EPA 2005)

Urban Land-Use		
Type	Development Type	Vegetation Cover
I1	Heavy industrial	Less than 5%
I2	Light/moderate industrial	Less than 10%
C1	Commercial	Less than 15%
R2	Dense/multi-family	Less than 30%
R3	Multi-family, two storey	Less than 35%

According to this classification scheme, the Sasol Secunda facility is classified as urban.

5.1.4.3   Nitrogen Dioxide Formation

Of the several species of nitrogen oxides, only NO_2 is specified in the NAAQS. Since most sources emit uncertain ratios of these species and these ratios change further in the atmosphere due to chemical reactions, a method for determining the amount of NO_2 in the plume must be selected.

Estimation of this conversion normally follows a tiered approach, as discussed in the draft Regulations Regarding Air Dispersion Modelling (Gazette No 35981 published 14 December 2012), which presents a scheme for <u>annual</u> averages:

> *Tier 1: Total Conversion Method*
> *Use any of the appropriate models recommended to estimate the maximum annual average NO_2 concentrations by assuming a total conversion of NO to NO_2. If the maximum NO_x concentrations are less than the NAAQS for NO_2, then no further refinement of the conversion factor is required. If the maximum NO_x concentrations are greater than the NAAQS for NO_2, or if a more "realistic" estimate of NO_2 is desired, proceed to the second tier level.*
> *Tier 2: Ambient Ratio Method (ARM) - Multiply NO_x by a national ratio of NO_2/NO. = 0.80*
> *Assume a wide area quasi-equilibrium state and multiply the Tier 1 empirical estimate NO_x by a ratio of NO_2/NO_x = 0.80. The ratio is recommended for South Africa as the conservative ratio based on a review of ambient air quality monitoring data from the country. If representative ambient NO and NO_2 monitoring data is available (for at least one year of monitoring), and the data is considered to represent a quasi-equilibrium condition where further significant changes of the NO/NO_2 ratio is not expected, then the NO/NO_2 ratio based on the monitoring data can be applied to derive NO_2 as an alternative to the national ratio of 0.80.*

In the Total Conversion Method, the emission rate of all NO_x species is used in the dispersion model to predict ground-level concentrations of total NO_x. These levels of NO_x are assumed to exist as 100% NO_2, and are directly compared to the NAAQS for NO_2. If the NAAQS are met, the Tier 2 methods are not necessary.

Although not provided in the draft Regulations (Gazette No 35981 published 14 December 2012), the conversion of NO to NO_2 may also be based on the amount of ozone available within the volume of the plume. The NO_2/NO_x conversion ratio is therefore coupled with the dispersion of the plume. This is known as the Ozone Limiting Method (OLM). Use of onsite ozone data is always preferred for the OLM method.

Ideally, the NO_2 formation should be dealt with in the dispersion model. CALPUFF has one such a module, known as the RIVAD / ARM3 chemical formulations. The RIVAD / ARM3 chemical formulations option in the CALPUFF model can be

used to calculate NO_2 concentrations directly in rural (non-urban) areas (Morris *et al.*, 1988). The RIVAD / ARM3 option incorporates the effect of chemical and photochemical reactions on the formation of nitrates and other deposition chemicals. However, since the Secunda study area was classified as urban (Section 5.1.4.2), the RIVAD / ARM3 chemical formulations should not be used.

Whilst the MESOPUFF II chemical transformation scheme, which is also included in the CALPUFF model accommodates NO_x reactions, these are only considering the formation of nitrates and not the NO /NO_2 reactions.

Given all of the above limitations, it was decided to employ the Ambient Ratio Method (ARM), i.e. the second version of the DEA Tier 2 option. The ARM ambient ratio method is based upon the premise that the NO_2/NO_x ratio in a plume changes as it is transported but attains an equilibrium value some distance away from the source (Scire and Borissova, 2011). In their study, Scire and Borissova analysed hourly monitored NO_2 and NOx data for 2006 at 325 monitoring sites throughout USA, which amounted to approximately 2.8 million data points for each species. These observations were grouped into a number of concentration ranges (bins), and the binned data were used to compute bin maximums and bin average curves. Short-term (1-hr) NO_2/NO_x ratios were subsequently developed based on bin-maximum data. Similarly, long-term (annual average) NO_2/NO_x ratios were based on bin-averaged data. The method was tested using the NO_2/NO_x ratios applied to the observed NOx at selected stations to predict NO_2, and then compared to observed NO_2 concentrations at that station. The comparison of NO_2 derived from observed NOx using these empirical curves was shown to be a conservative estimate of observed NO_2, whilst at the same time arriving at a more realistic approximation than if simply assuming a 100% conversion rate. More details of the adopted conversion factors are given in Appendix F.

5.1.4.4   Particulate Formation

CALPUFF includes two chemical transformation schemes for the calculation of sulfate and nitrate formation from SO_2 and NO_x emissions. These are the MESOPUFF II and the RIVAD / ARM3 chemical formulations. Whist the former scheme is not specifically restricted to urban or rural conditions; the latter was developed for use in rural conditions. Since the Secunda study area could be classified as urban (Section 5.1.5), the RIVAD / ARM3 chemical formulations should not be used. The chemical transformation scheme chosen for this analysis was therefore the MESOPUFF II scheme. As described in the CALPUFF User Guide it is a "pseudo first-order chemical reaction mechanism" and involves five pollutant species namely SO_2, sulfates (SO_4), NO_x, nitric acid (HNO_3) and particulate nitrate. CALPUFF calculates the rate of transformation of SO_2 to SO_4, and the rate of transformation of NO_x to NO_3, based on environmental conditions including the ozone concentration, atmospheric stability, solar radiation, relative humidity, and the plume NO_x concentration. The daytime reaction formulation depends on solar radiation and the transformation increases non-linearly with the solar radiation (see the SO_2 to SO_4 transformation rate equation (equation 2-253 in the CALPUFF User Guide). At night, the transformation rate defaults to a constant value of 0.2% per hour. Calculations based on these formulas show that the transformation rate can reach about 3 per cent per hour at noon on a cloudless day with 100 ppb of ozone.

With the MESOPUFF-II mechanism, NO_x transformation rates depend on the concentration levels of NO_x and O_3 (equations 2-254 and 2-255 in the CALPUFF User Guide) and both organic nitrates (RNO_3) and HNO_3 are formed. According to the scheme, the formation of RNO_3 is irreversible and is not subject to wet or dry deposition. The formation of HNO_3, however, is reversible and is a function of temperature and relative humidity. The formation of particulate nitrate is further determined through the reaction of HNO_3 and NH_3. Background NH_3 concentrations are therefore required as input to calculate the equilibrium between HNO_3 and particulate nitrate. At night, the NO_x transformation rate defaults to a constant value of 2.0% per hour. Hourly average ozone and ammonia concentrations were included as input in the CALPUFF model to facilitate

these sulfate and nitrate formation calculations (adjusting for the respective molecular weights of ammonium sulfate and ammonium nitrate).

The limitation of the CALPUFF model is that each puff is treated in isolation, i.e. any interaction between puffs from the same or different points of emission is not accounted for in these transformation schemes. CALPUFF first assumes that ammonia reacts preferentially with sulfate, and that there is always sufficient ammonia to react with the entire sulfate present within a single puff. The CALPUFF model performs a calculation to determine how much NH_3 remains after the particulate ammonium sulfate has been formed and the balance would then be available for reaction with NO_3 within the puff to form ammonium nitrate. The formation of particulate nitrate is subsequently limited by the amount of available NH_3. Although this may be regarded a limitation, in this application the particulate formation is considered as a group and not necessarily per species.

5.1.4.5 Ozone Formation

Similar to sulphate, nitrate and nitrogen dioxide, ozone (O_3) can also be formed through chemical reactions between pollutants released into the atmosphere. As a secondary pollutant, O_3 is formed in the lower part of the atmosphere, from complex photochemical reactions following emissions of precursor gases such as NO_x and VOCs (Seinfeld and Pandis, 1998). O_3 is produced during the oxidation of CO and hydrocarbons by hydroxyls (OH) in the presence of NO_x and sunlight (Seinfeld and Pandis, 1998). The rate of ozone production can therefore be limited by CO, VOCs or NO_x. In densely populated regions with high emissions of NO_x and hydrocarbons, rapid O_3 production can take place and result in a surface air pollution problem. In these urban areas O_3 formation is often VOC-limited. O_3 is generally NO_x-limited in rural areas and downwind suburban areas.

O_3 concentration levels have the potential to become particularly high in areas where considerable O_3 precursor emissions combine with stagnant wind conditions during the summer, when high insolation and temperatures occur (Seinfeld and Pandis, 1998). The effects of sunlight on O_3 formation depend on its intensity and its spectral distribution.

The main sectors that emit ozone precursors are road transport, power and heat generation plants, household (heating), industry, and petrol storage and distribution. In many urban areas, O_3 nonattainment is not caused by emissions from the local area alone. Due to atmospheric transport, contributions of precursors from the surrounding region can also be important. The transport of O_3 is determined by meteorological and chemical processes which typically extend over spatial scales of several hundred kilometres. Thus, in an attempt to study O_3 concentrations in a local area, it is necessary to include regional emissions and transport. This requires a significantly larger study domain with the inclusion of a significantly more comprehensive emissions inventory of NO_x and VOCs sources (e.g. vehicle emissions in Gauteng). Such a collaborative study was not within the scope of this report.

5.1.4.6 Model Input

5.1.4.6.1 Meteorological Input Data

The option of Partial Observations was selected for the CALMET wind field model which used both measured and observed meteorological data (refer to Appendix D for all CALMET control options). For measured data, use was made of PSU/NCAR mesoscale model (known as MM5). MM5 is an acronym for the Fifth-Generation NCAR/Penn State Mesoscale Model, which is a limited-area, nonhydrostatic, terrain-following sigma-coordinate model designed to simulate or predict mesoscale and

regional-scale atmospheric circulation. Terrestrial and isobaric meteorological data are horizontally interpolated with observations from the standard network of surface and rawinsonde stations. MM5 data for the period 2010 to 2012 on a 12 km horizontal resolution for a 300 km by 300 km was used. MM5 data was supplemented with surface field observations from the monitoring stations operated by Sasol. For CALMET, the surface data was consolidated into one source file, taking the most representative data set into account. Meteorological parameters provided for the Sasol monitoring stations in the Secunda surrounds are provided in Table 5-4.

Table 5-4: Meteorological parameters provided for the Sasol monitoring stations in the vicinity of Secunda

Monitoring Station	Latitude	Longitude	Closest Residential Area	Meteorology						
				WD	WS	Temp	Rel Hum	Press	Sol rad	Rain
Bosjesspruit	-26.605833	29.210833	Secunda	✓	✓	✓			✓	✓
Secunda Club	-26.523333	29.189667	Secunda	✓	✓	✓	✓	✓		✓
Langverwacht	-26.551667	29.112500	Secunda	✓	✓	✓	✓		✓	✓

5.1.4.6.2   Land Use and Topographical Data

Readily available terrain and land cover data for use in CALMET was obtained from the Atmospheric Studies Group (ASG) via the United States Geological Survey (USGS) web site at ASG. Use was made of Shuttle Radar Topography Mission (SRTM) (90 m, 3 arc-sec) data and Lambert Azimuthal land use data for Africa.

5.1.4.6.3   Dispersion Coefficients

The option of dispersion coefficients from internally calculated sigma v, sigma w using micrometeorological variables (u*, w*, L, etc.) was selected (refer to Appendix E for all CALPUFF control options).

5.1.4.6.4   Grid Resolution and Model Domain

The CALMET modelling domain included an area of 300 km by 300 km with a grid resolution of 1 km. The vertical profile included ten vertical levels up to a height of 3 500 m. The CALPUFF model domain selected for the point sources at the Secunda complex included an area of 50 km by 50 km with a grid resolution of 200 m.

5.1.5   Atmospheric Dispersion Potential

Meteorological mechanisms govern the dispersion, transformation, and eventual removal of pollutants from the atmosphere. The analysis of hourly average meteorological data is necessary to facilitate a comprehensive understanding of the dispersion potential of the site. The horizontal dispersion of pollution is largely a function of the wind field. The wind speed determines both the distance of downward transport and the rate of dilution of pollutants.

Sasol currently operates three meteorological stations in the Secunda area (viz. Bosjesspruit, Langverwacht and Secunda Club). For this assessment, data was provided for Bosjesspruit, Langverwacht and Secunda Club monitoring stations for

the period 2010 to 2012. Parameters useful in describing the dispersion and dilution potential of the site i.e. wind speed, wind direction, temperature and atmospheric stability, are subsequently discussed. A summary of the measured meteorological data is given in Appendix G.

5.1.5.1   Surface Wind Field

Wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below, reflect the different categories of wind speeds; the red area, for example, representing winds >6m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated.

The period wind field and diurnal variability for Langverwacht, Bosjesspruit and Secunda Club are provided in Figure 5-4, Figure 5-5, and Figure 5-6, respectively. The predominant wind direction at Langverwacht is from the east-northeast with high frequency of winds from this direction occurring during night-time conditions. The predominant wind direction for Bosjesspruit is from the northeast. The predominant wind direction at Secunda Club for the period 2010-2012 is from the west-northwest and from the northeast to east. More predominant westerly wind flow occurs during day-time conditions with an increase in eastlery flow during night-time conditions. The extracted wind flow from CALMET (Figure 5-7) at Secunda Club receptor point reflects similar wind flow as measured data with the predominant wind direction from the west-northwest and from the northeast to east.
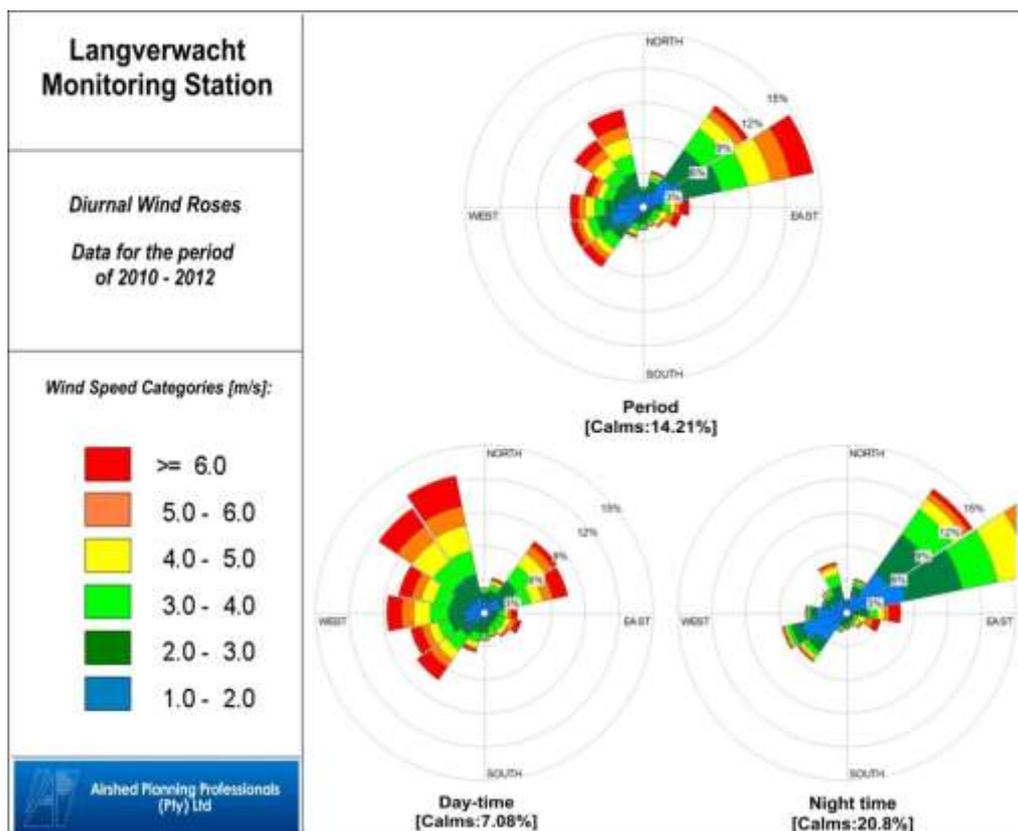
Figure 5-4: Period, day- and night-time wind rose for Langverwacht for the period 2010 - 2012
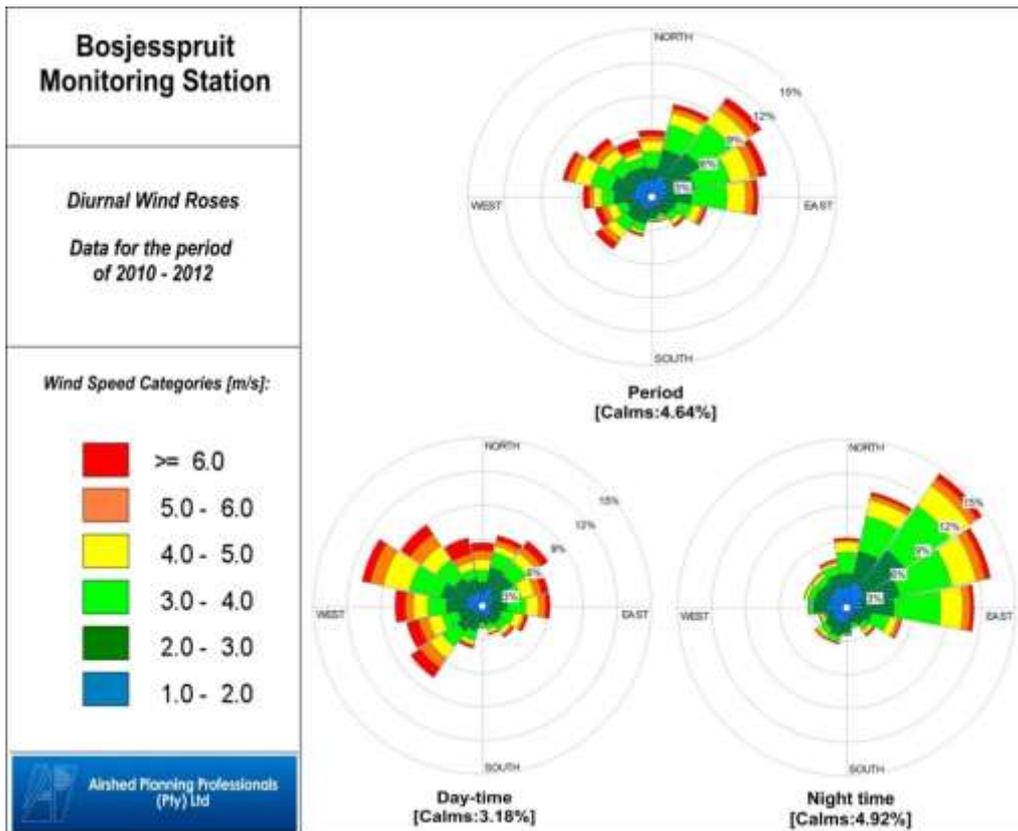
Figure 5-5: Period, day- and night-time wind rose for Bosjesspruit for the period 2010 - 2012
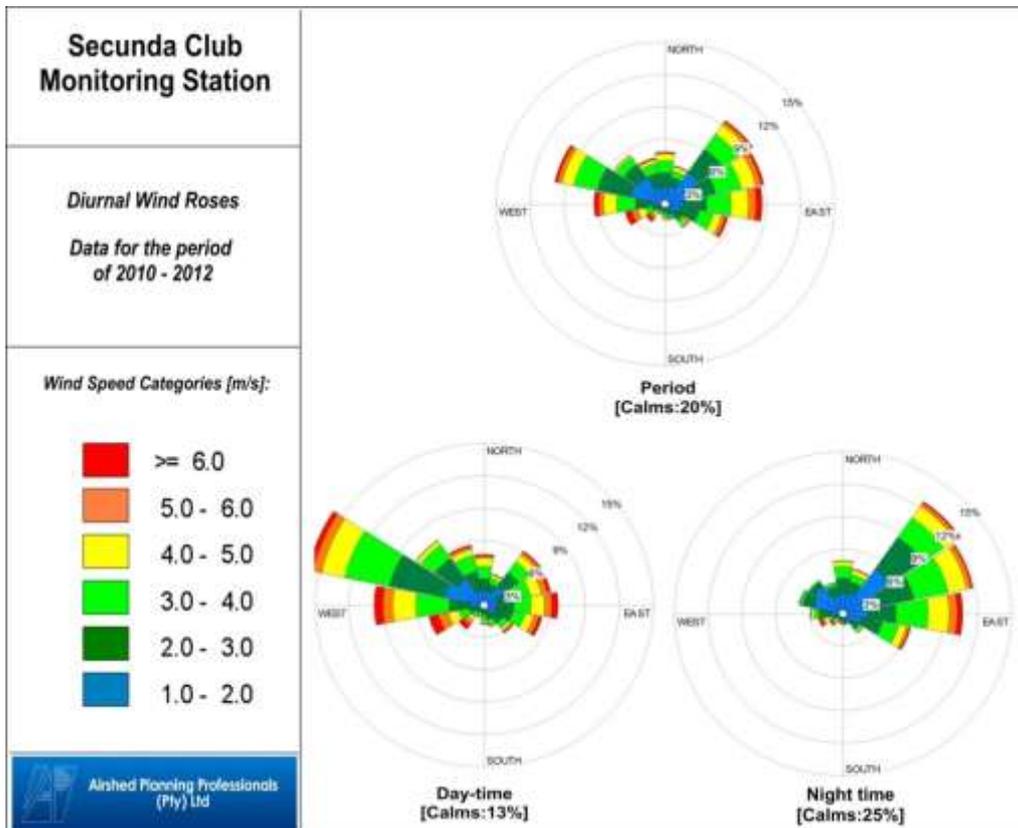
Figure 5-6: Period, day- and night-time wind rose for Secunda Club for the period 2010 - 2012

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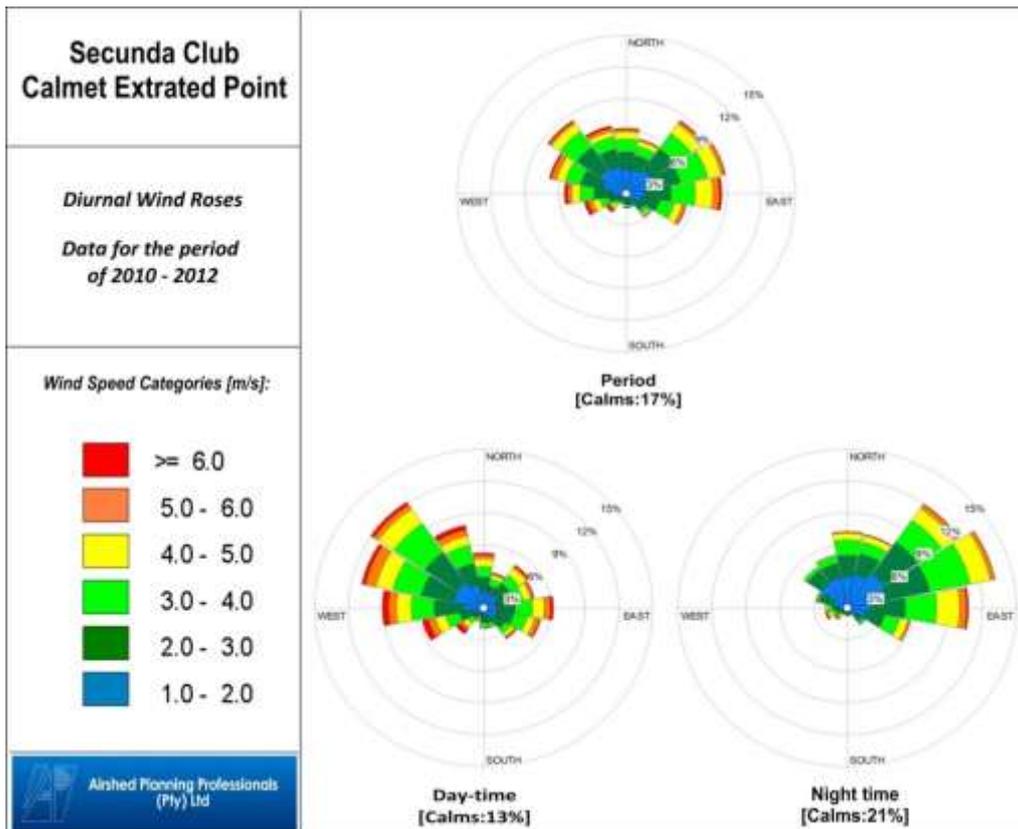
Figure 5-7: Period, day- and night-time wind rose for an extracted CALMET point at Secunda Club for the period 2010 - 2012

5.1.5.2   Temperature

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the emission plume and the ambient air, the higher the plume is able to rise), and determining the development of the mixing and inversion layers.

The average monthly temperature trends are presented Figure 5-8, Figure 5-9 and Figure 5-10 for Langverwacht, Bosjesspruit and Secunda Club respectively. Monthly mean and hourly maximum and minimum temperatures are given in Table 5-5. Average temperatures ranged between 2.7 °C and 19.6 °C. The highest temperatures occurred in February to March and the lowest in June to July. During the day, temperatures increase to reach maximum at around 15:00 in the afternoon. Ambient air temperature decreases to reach a minimum at around 07:00 i.e. just before sunrise.

Table 5-5: Monthly temperature summary (2010 - 2012)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hourly Minimum, Hourly Maximum and Monthly Average Temperatures (°C) **(2010 - 2012)**												
Langverwacht												
Minimum	15.3	14.1	12.3	8.5	4.4	-1.2	-1.3	1.6	7.6	11.1	13.1	14.5
Maximum	24.7	26.0	26.3	21.6	21.3	18.0	17.9	21.5	25.1	25.7	25.4	24.9
Average	19.5	19.6	18.7	14.3	11.7	7.0	7.3	10.8	15.6	17.9	18.8	19.5
Bosjesspruit												
Minimum	9.9	13.7	14.6	12.1	5.5	-3.7	-3.2	0.4	7.3	7.6	12.3	11.0
Maximum	18.0	25.1	25.9	21.9	19.2	11.4	12.6	17.2	21.2	22.0	22.8	22.0
Average	13.0	18.8	19.6	16.2	11.5	2.7	3.7	8.0	13.5	14.4	17.0	16.9
Secunda Club												
Minimum	14.4	13.6	12.7	9.4	6.1	1.6	1.2	3.7	8.7	11.3	10.4	14.2
Maximum	23.7	25.1	25.1	20.9	21.1	18.1	18.0	21.2	24.5	25.0	22.1	24.3
Average	18.7	19.0	18.3	14.5	12.7	8.8	8.8	11.8	15.9	17.7	15.8	18.9
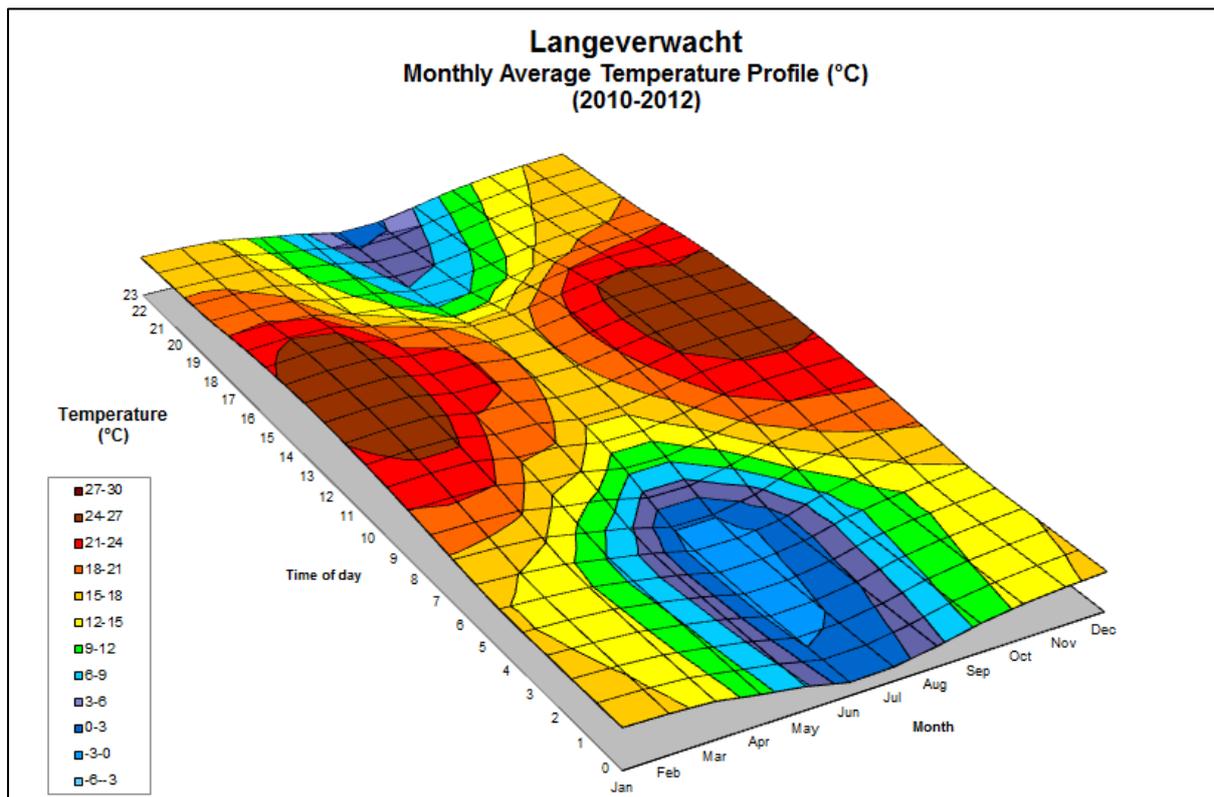
Figure 5-8: Monthly average temperature profile for Langverwacht (2010 – 2012)
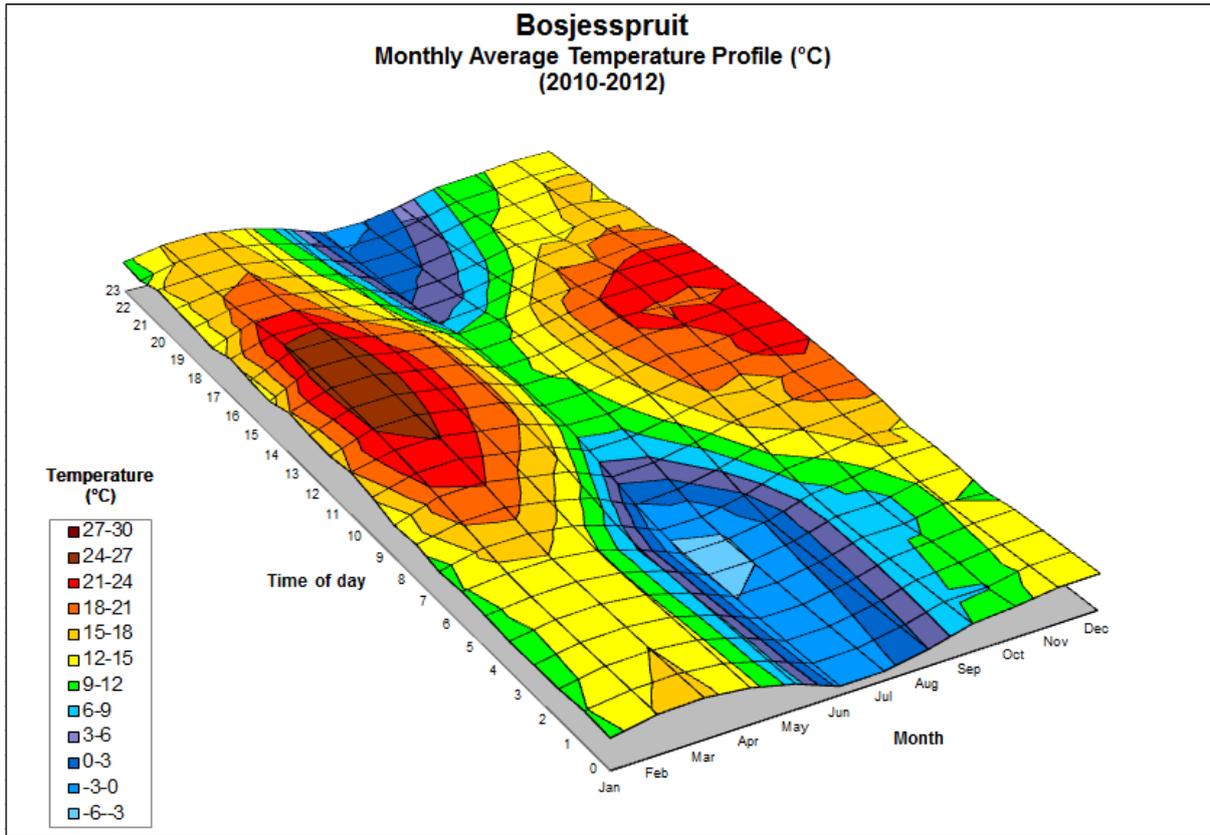
Figure 5-9: Monthly average temperature profile for Bosjesspruit (2010 – 2012)
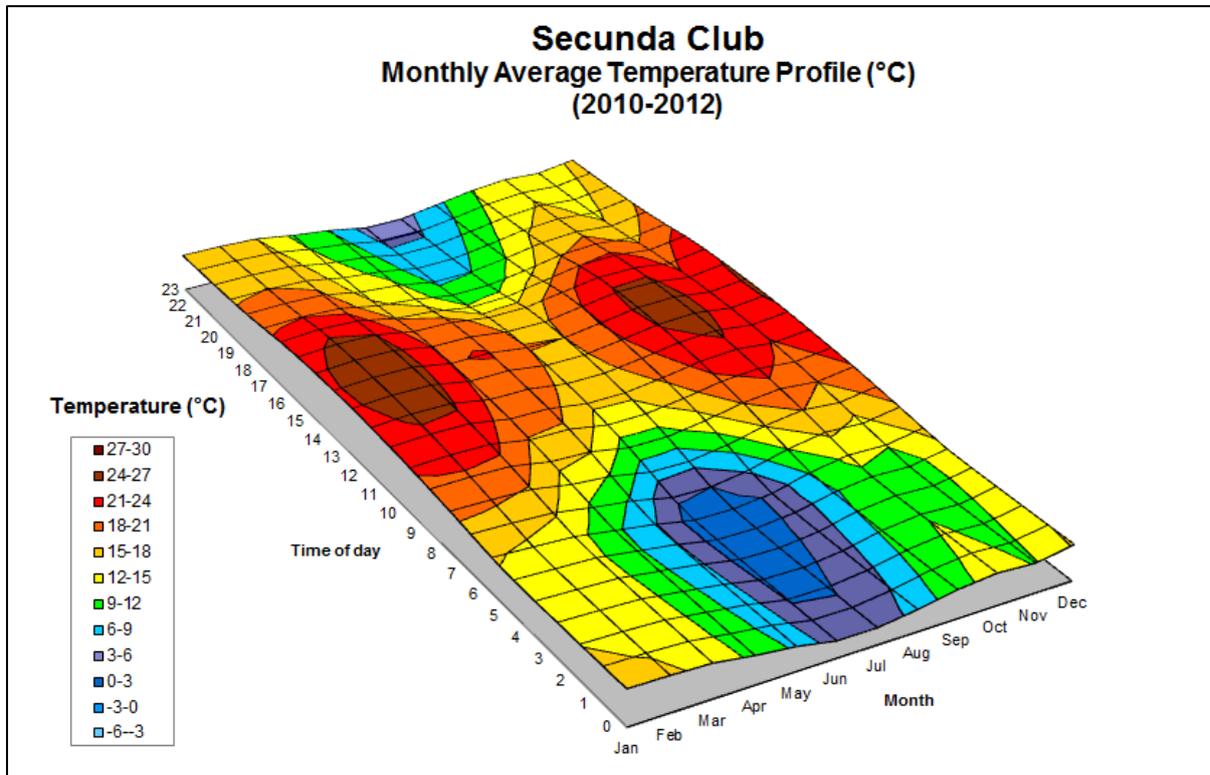
Figure 5-10: Monthly average temperature profile for Secunda Club (2010 – 2012)

The atmospheric boundary layer properties are described by two parameters; the boundary layer depth and the Monin-Obukhov length.

The Monin-Obukhov length (LMo) provides a measure of the importance of buoyancy generated by the heating of the ground and mechanical mixing generated by the frictional effect of the earth's surface. Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC, 2004). The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface. Night-times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds and lower dilution potential.

Diurnal variation in atmospheric stability, as calculated from on-site data, and described by the inverse Monin-Obukhov length and the boundary layer depth is provided in Figure 5-11. The highest concentrations for ground level, or near-ground level releases from non-wind dependent sources would occur during weak wind speeds and stable (night-time) atmospheric conditions.

For elevated releases, unstable conditions can result in very high concentrations of poorly diluted emissions close to the stack. This is called looping (Figure 5-11 (c)) and occurs mostly during daytime hours. Neutral conditions disperse the plume fairly equally in both the vertical and horizontal planes and the plume shape is referred to as coning (Figure 5-11 (b)). Stable conditions prevent the plume from mixing vertically, although it can still spread horizontally and is called fanning (Figure 5-11 (a)) (Tiwary & Colls, 2010).
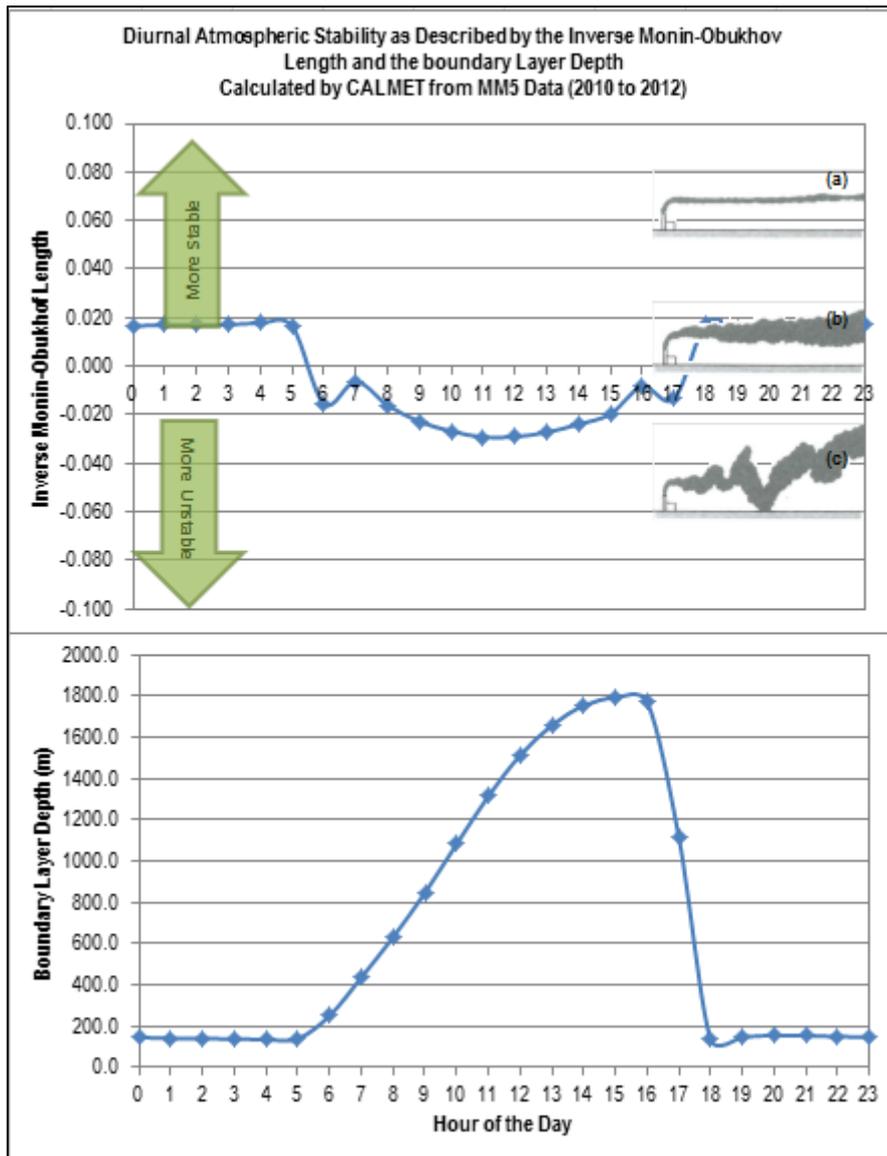
Figure 5-11: Diurnal atmospheric stability (extracted from CALMET at the Secunda Club monitoring point)

5.1.5.4   Air Quality Monitoring data

Time series of the measured ambient air quality data is provided in Appendix G. A summary of ambient data measured at Bosjesspruit, Secunda Club and Langverwacht for the period 2010 – 2012 is provided in Table 5-7, Table 5-8 and Table 5-9 respectively.

Table 5-6: Summary of the ambient measurements at Bosjesspruit for the period 2010-2012 (units: µg/m³)

Period	Hourly				Annual Average	No of recorded hourly exceedances
	Max	99th Percentile	90th Percentile	50th Percentile		
H₂S						
2010	696.72	61.04	3.86	0.03	3.17	
2011	329.42	88.88	16.42	3.47	7.64	
2012	290.24	104.79	11.74	1.30	6.83	
Period Average	*438.79*	*84.90*	*10.67*	*1.60*	*5.88*	
NH₃						
2010	274.32	37.90	8.12	1.24	3.61	
2011	155.97	24.39	3.36	0.11	1.58	
2012	320.66	105.25	16.68	1.35	7.69	
Period Average	*250.32*	*55.85*	*9.39*	*0.90*	*4.29*	
NO₂						
2010	374.90	123.58	44.36	12.89	20.25	20.00
2011	362.20	139.18	29.28	1.11	11.16	18.00
2012	234.70	83.63	34.65	9.72	14.94	1.00
Period Average	*323.93*	*115.46*	*36.10*	*7.91*	*15.45*	*13.00*
SO₂						
2010	494.15	175.51	57.92	8.29	21.80	5.00
2011	483.46	215.26	69.47	6.87	24.51	8.00
2012	576.51	221.95	64.22	9.18	24.66	12.00
Period Average	*518.04*	*204.24*	*63.87*	*8.11*	*23.66*	*8.33*

Table 5-7: Summary of the ambient measurements at Secunda Club for the period 2010-2012 (units: µg/m³)

Period	Hourly				Annual Average	No of recorded hourly exceedances
	Max	99th Percentile	90th Percentile	50th Percentile		
H₂S						
2010	570.31	33.66	9.33	1.84	4.06	
2011	160.59	51.16	9.85	3.11	5.37	
2012	228.05	40.27	11.12	2.74	5.31	
Period Average	*319.65*	*41.70*	*10.10*	*2.56*	*4.91*	
NH₃						
2010	342.55	55.82	9.72	1.64	4.75	
2011	343.88	75.81	15.84	1.62	5.91	
2012	196.76	18.25	1.83	-	1.01	
Period Average	*294.40*	*49.96*	*9.13*	*1.09*	*3.89*	

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Period	Hourly				Annual Average	No of recorded hourly exceedances
	Max	99th Percentile	90th Percentile	50th Percentile		
O₃						
2010	234.97	127.93	88.80	49.19	52.97	
2011	299.61	142.18	91.75	43.39	48.99	
2012	317.76	142.01	101.84	57.53	60.76	
Period Average	284.11	137.37	94.13	50.04	54.24	
NO₂						
2010	450.30	94.08	44.65	12.93	19.28	10.00
2011	450.30	100.22	45.16	13.11	19.64	15.00
2012	192.80	78.40	40.38	13.93	18.49	-
Period Average	364.47	90.90	43.39	13.32	19.14	8.33
SO₂						
2010	433.00	172.79	46.57	7.51	18.84	4.00
2011	459.60	172.52	42.84	4.15	16.16	6.00
2012	583.50	174.63	47.04	8.66	20.07	6.00
Period Average	492.03	173.31	45.49	6.77	18.36	5.33
Period	Daily				Annual Average	No of recorded daily exceedances
	Max	99th Percentile	90th Percentile	50th Percentile		
PM₁₀						
2010	127.79	74.53	54.76	26.39	30.15	3.00
2011	97.91	87.91	57.74	19.48	23.97	9.00
2012	86.65	73.17	57.13	27.99	30.43	3.00
Period Average	104.12	78.54	56.55	24.62	28.18	5.00

Period	Annual Average
Benzene	
2010	0.42
2011	1.21
2012	0.87
Period Average	0.83

Table 5-8: Summary of the ambient measurements at Langverwacht for the period 2010-2012 (units: μg/m³)

Period	Hourly				Annual Average	No of recorded hourly exceedances
	Max	99th Percentile	90th Percentile	50th Percentile		
H₂S						
2010	696.72	70.01	21.57	5.19	9.55	
2011	229.44	75.03	21.80	1.56	7.74	
2012	475.37	68.96	25.13	3.22	9.52	
Period Average	*467.18*	*71.33*	*22.83*	*3.32*	*8.94*	
NH₃						
2010	347.44	178.37	55.18	6.96	20.07	
2011	347.44	269.04	92.07	16.82	35.05	
2012	332.62	108.17	41.65	1.41	13.71	
Period Average	*342.50*	*185.19*	*62.97*	*8.40*	*22.95*	
O₃						
2010	873.09	176.17	108.97	47.47	54.77	
2011	452.35	125.69	89.19	44.85	49.60	
2012	752.95	134.34	99.07	53.12	56.64	
Period Average	*692.80*	*145.40*	*99.08*	*48.48*	*53.67*	
NO₂						
2010	135.90	74.82	39.89	14.39	18.74	-
2011	135.90	83.56	47.96	15.84	21.22	1.00
2012	181.50	72.14	40.37	13.49	17.98	-
Period Average	*151.10*	*76.84*	*42.74*	*14.57*	*19.32*	*0.33*
SO₂						
2010	461.80	152.45	40.79	7.73	17.06	7.00
2011	449.82	165.48	43.93	6.07	14.86	11.00
2012	525.81	176.59	48.39	7.48	17.54	7.00
Period Average	*479.14*	*164.84*	*44.37*	*7.09*	*16.49*	*12.00*
Period	Daily				Annual Average Max	No of recorded daily exceedances
	Max	99th Percentile	90th Percentile	50th Percentile		
PM₁₀						
2010	192.51	121.41	85.33	36.59	44.52	50.00
2011	157.94	157.40	82.88	28.03	36.96	32.00
2012	115.23	109.97	76.94	37.07	40.36	33.00
Period Average	*155.22*	*129.60*	*81.72*	*33.89*	*40.61*	*38.33*

Period	Hourly				Annual Average	No of recorded hourly exceedances
	Max	99th Percentile	90th Percentile	50th Percentile		
Benzene						
2010	1.62					
2011	1.06					
2012	1.68					
Period Average	*1.46*					

The following graphs summarise the observed concentrations of SO_2, NO_2 and PM_{10} at Bosjesspruit, Secunda Club and Langverwacht monitoring stations for the years 2010, 2011 and 2012. The NAAQS have been included in the graphs for:

- SO_2 hourly (permitted 88 hourly exceedances of 350 µg/m³) and daily average (permitted 4 daily exceedances of 125 µg/m³)
- NO_2 hourly average (permitted 88 hourly exceedances of 200 µg/m³); and,
- PM_{10} daily average (permitted 4 daily exceedances of 75 µg/m³; 2015 standards).

The hourly 99th percentiles for SO_2 were below the limit value of 350 µg/m³ at all three stations for all three years (Figure 5-12, Figure 5-14, and Figure 5-16). The daily 99th percentiles for SO_2 were below the limit value (125 µg/m³) at all the stations: Bosjesspruit (Figure 5-13), Secunda Club (Figure 5-15) and Langverwacht (Figure 5-17).
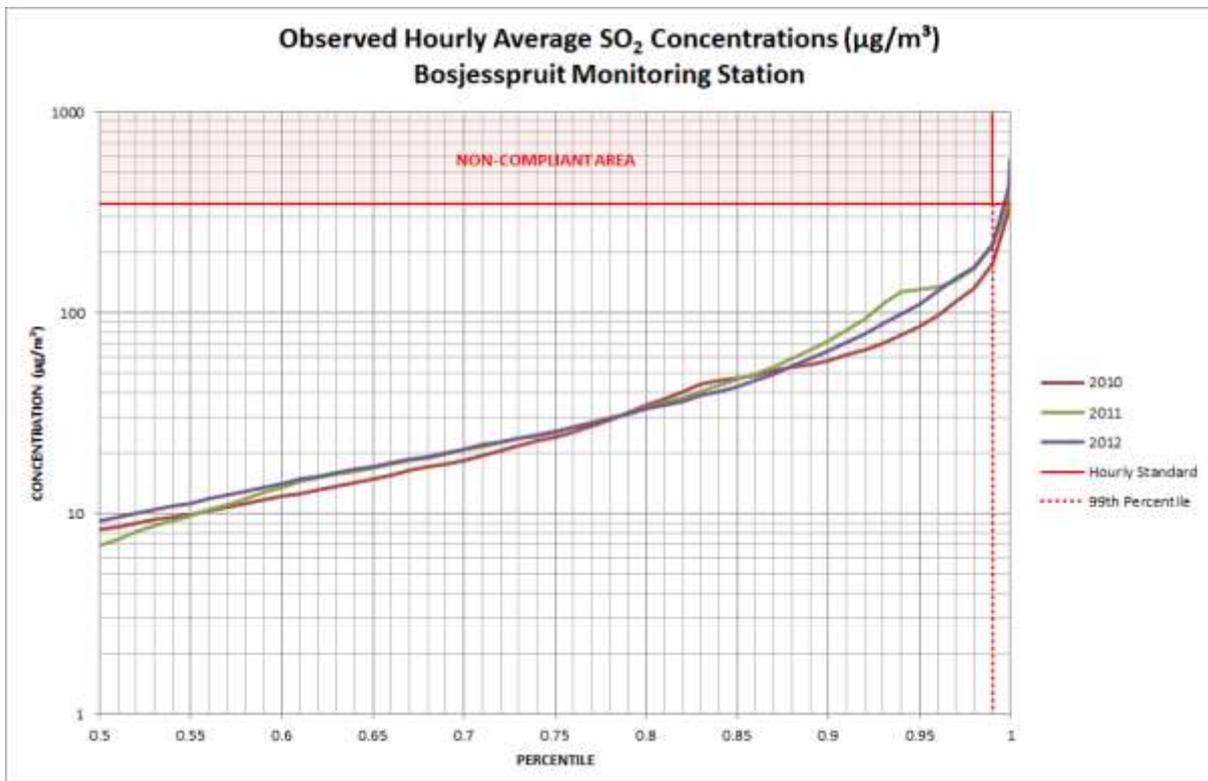
Figure 5-12: Observed hourly average SO₂ concentrations at Bosjesspruit

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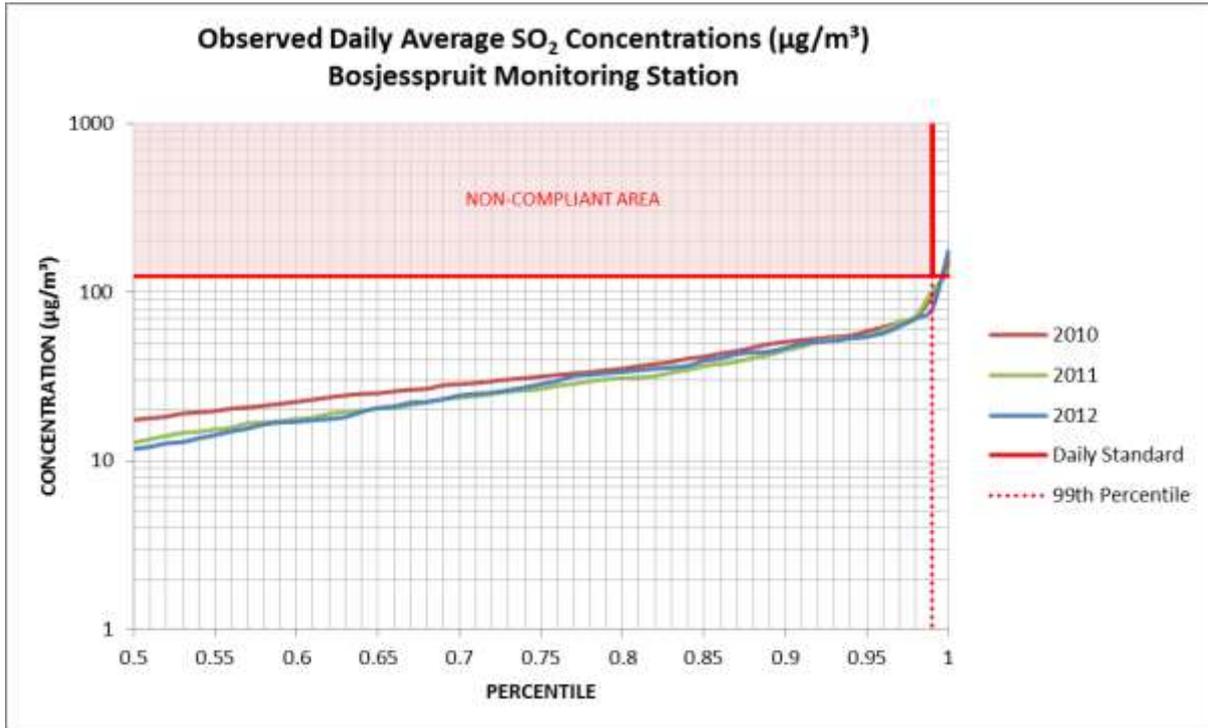
Figure 5-13: Observed daily average SO$_2$ concentrations at Bosjesspruit
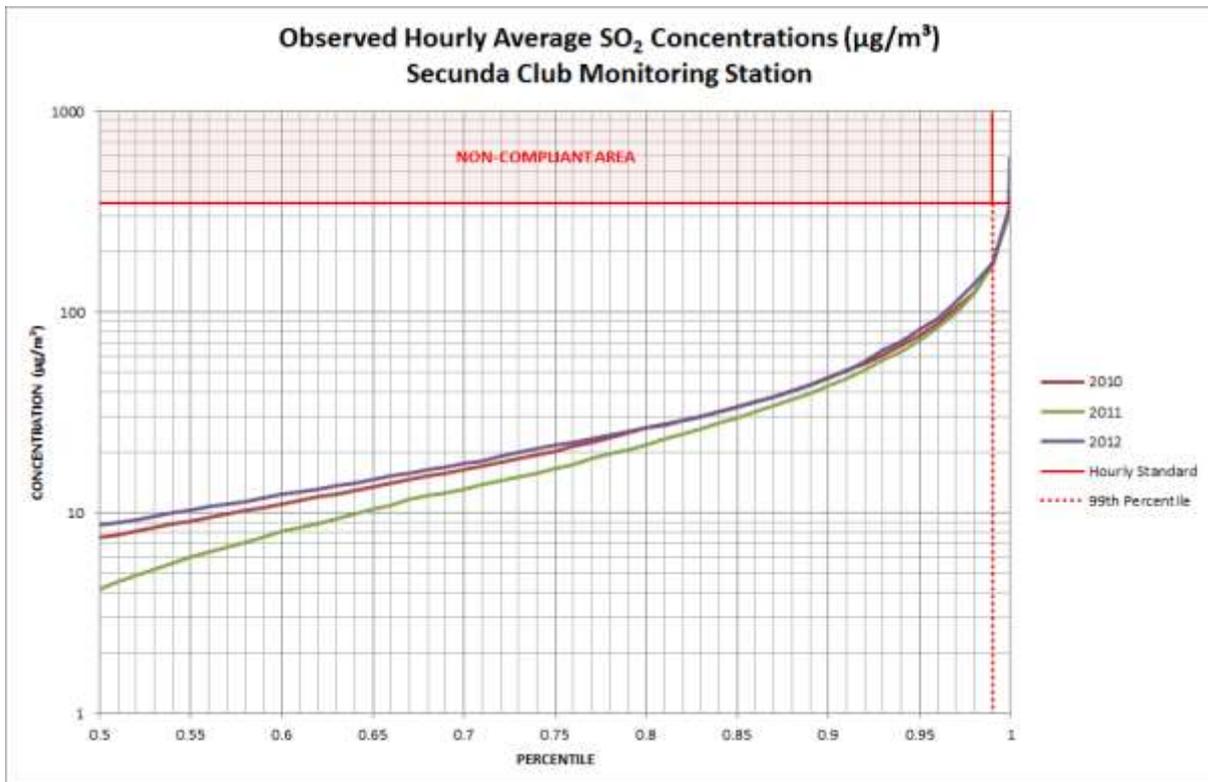
Figure 5-14: Observed hourly average SO$_2$ concentrations at Secunda Club
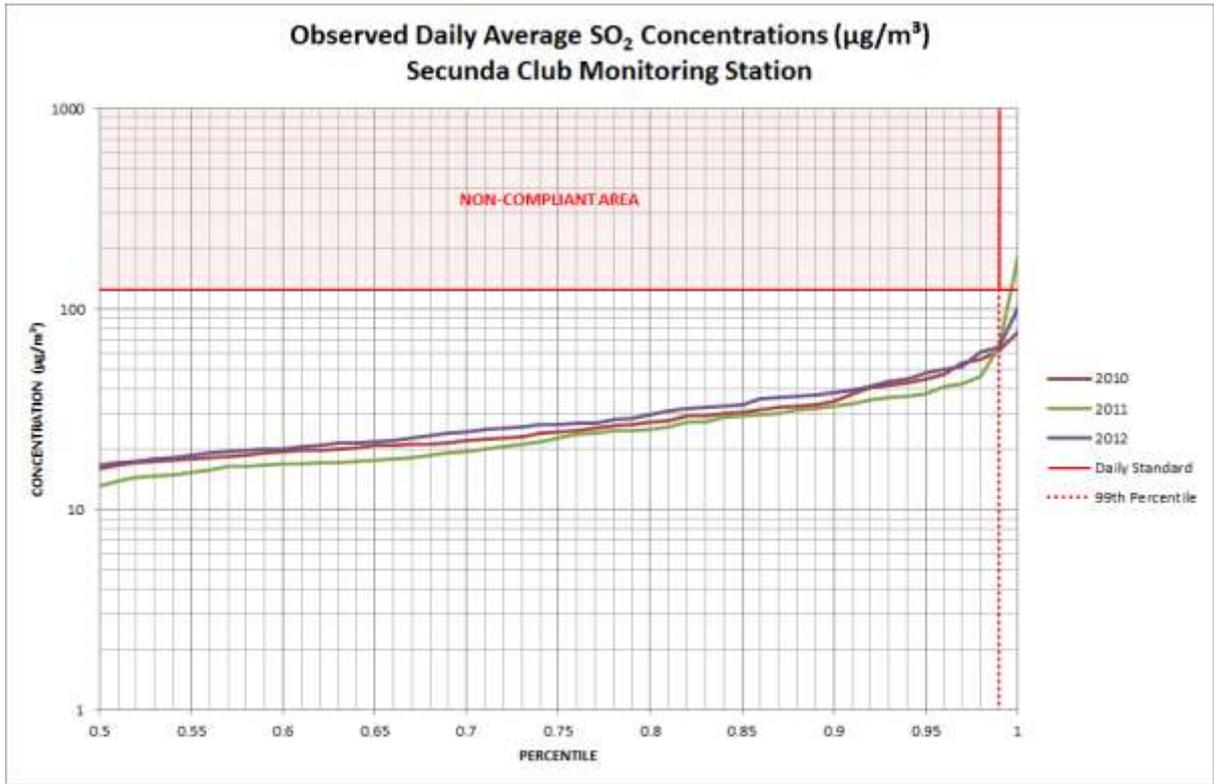
Figure 5-15: Observed daily average SO₂ concentrations at Secunda Club
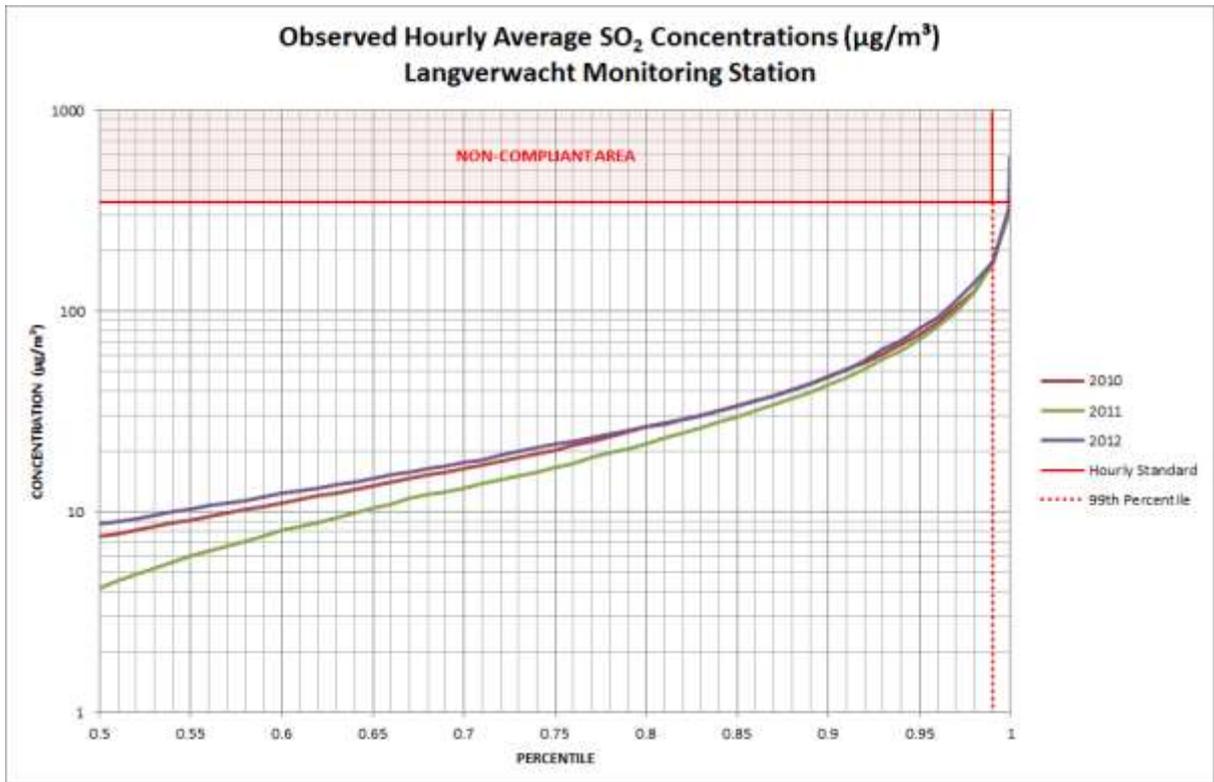
Figure 5-16: Observed hourly average SO₂ concentrations at Langverwacht
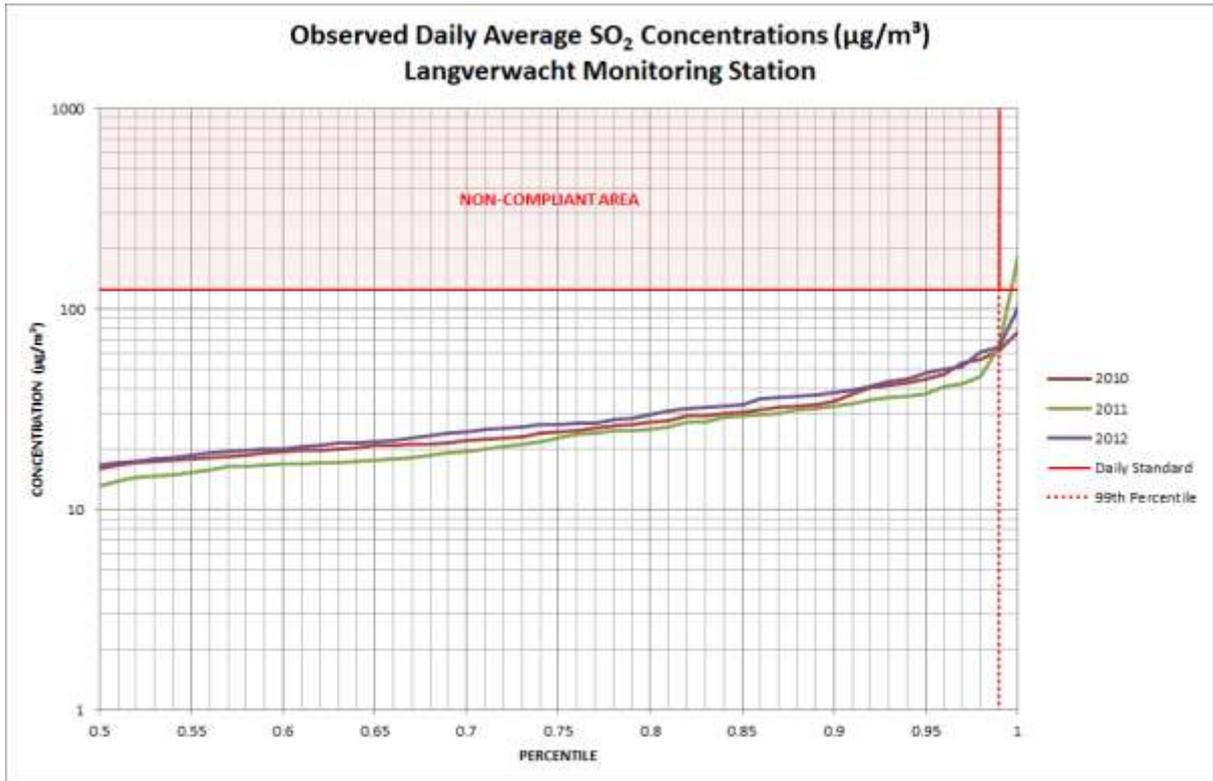
Figure 5-17: Observed daily average SO₂ concentrations at Langverwacht

The hourly 99th percentiles for NO₂ were below the limit value (200 µg/m³) at all three stations and for all three years (Figure 5-18, Figure 5-19, and Figure 5-20).
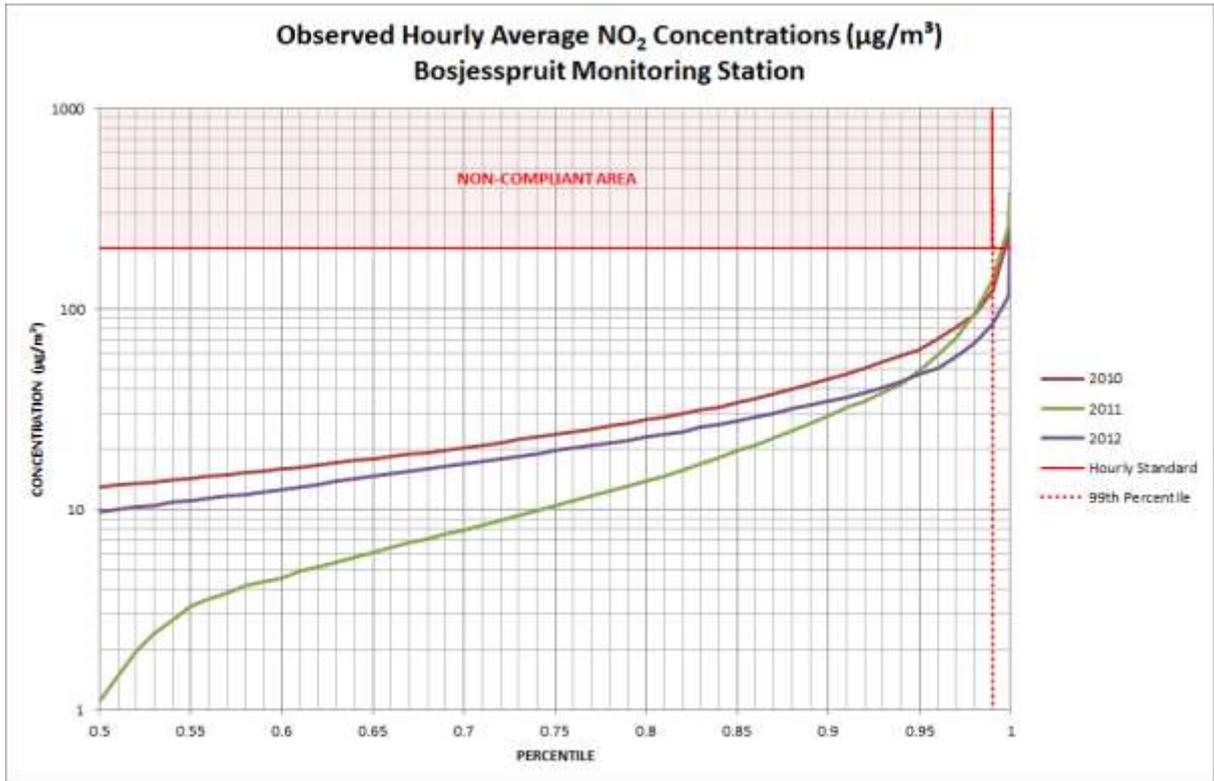
Figure 5-18: Observed hourly average NO₂ concentrations at Bosjespruit
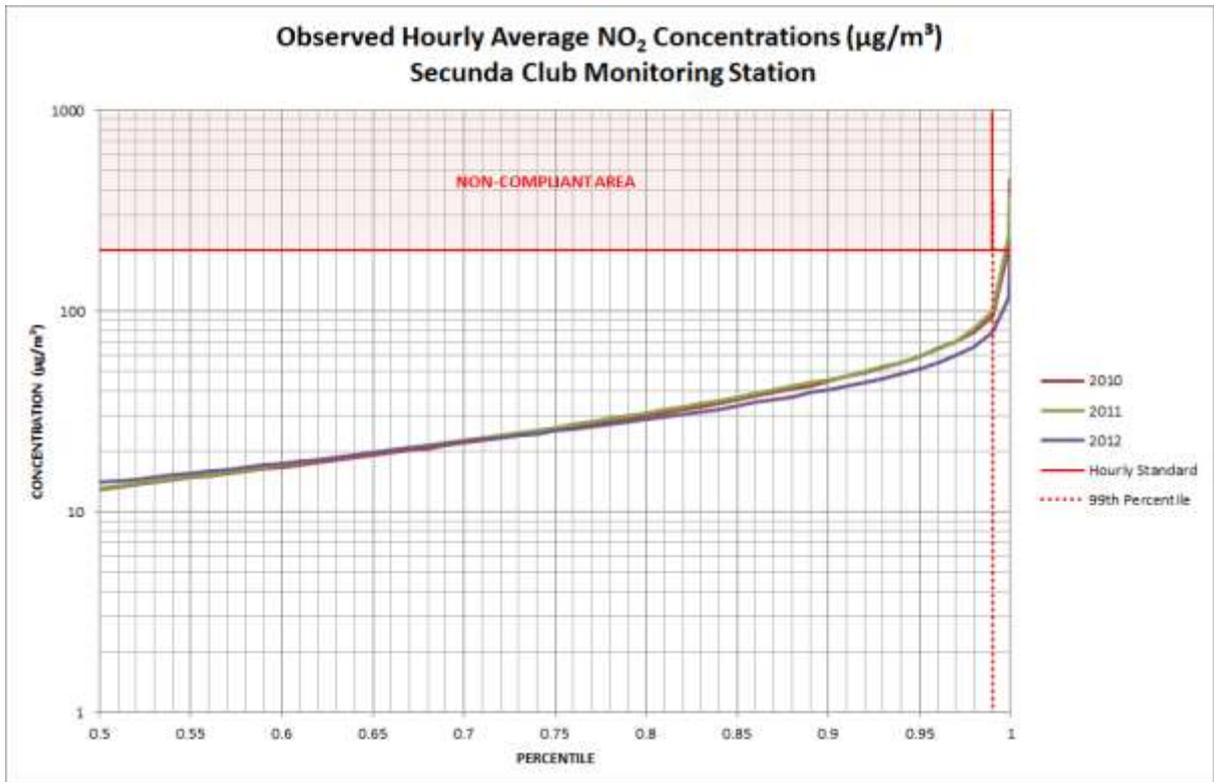
Figure 5-19: Observed hourly average NO₂ concentrations at Secunda Club
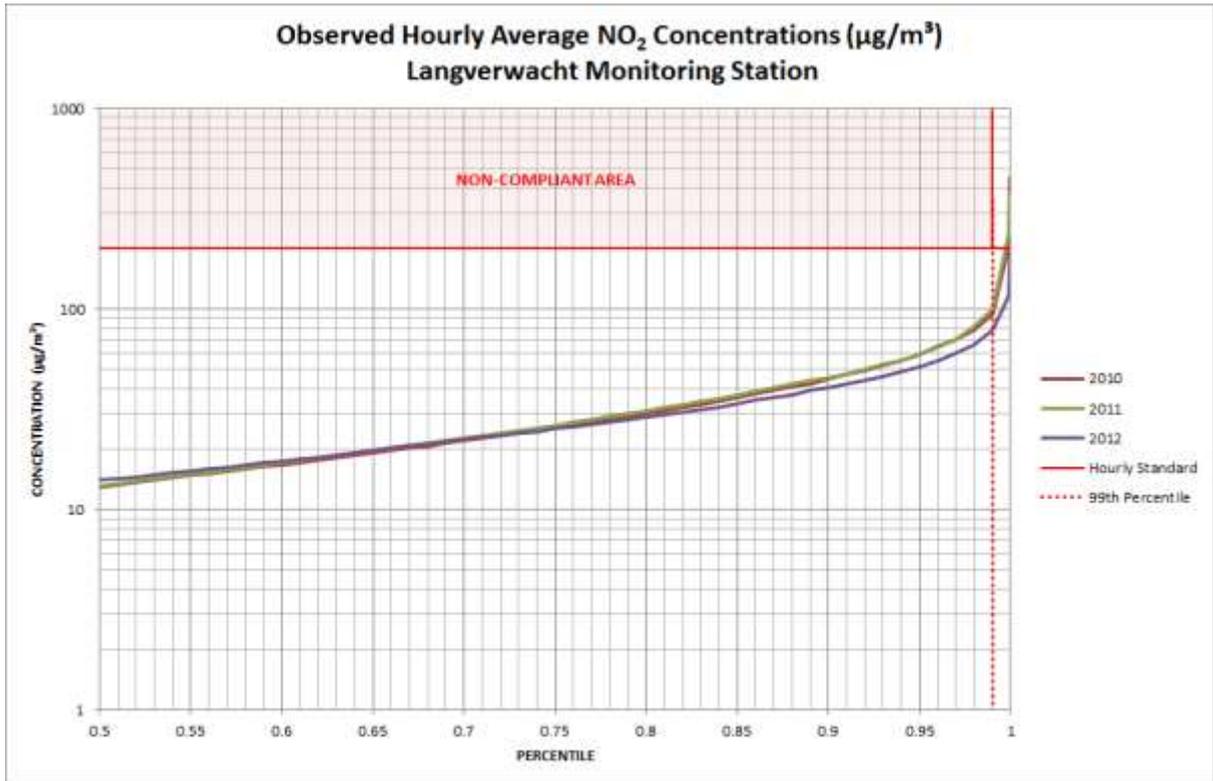
Figure 5-20: Observed hourly average NO₂ concentrations at Langverwacht

The daily 99th percentiles for PM₁₀ exceeded the limit value (75 µg/m³; 2015 standard) at both Secunda Club (Figure 5-21) and Langverwacht stations (Figure 5-22) for all three years. While the SO₂ and NO₂ annual averages were below the NAAQS, the PM₁₀ annual averages exceeded the 2015 limit value of 40 µg/m³ for all three years at Langverwacht and were close to the limit value at Secunda Club.
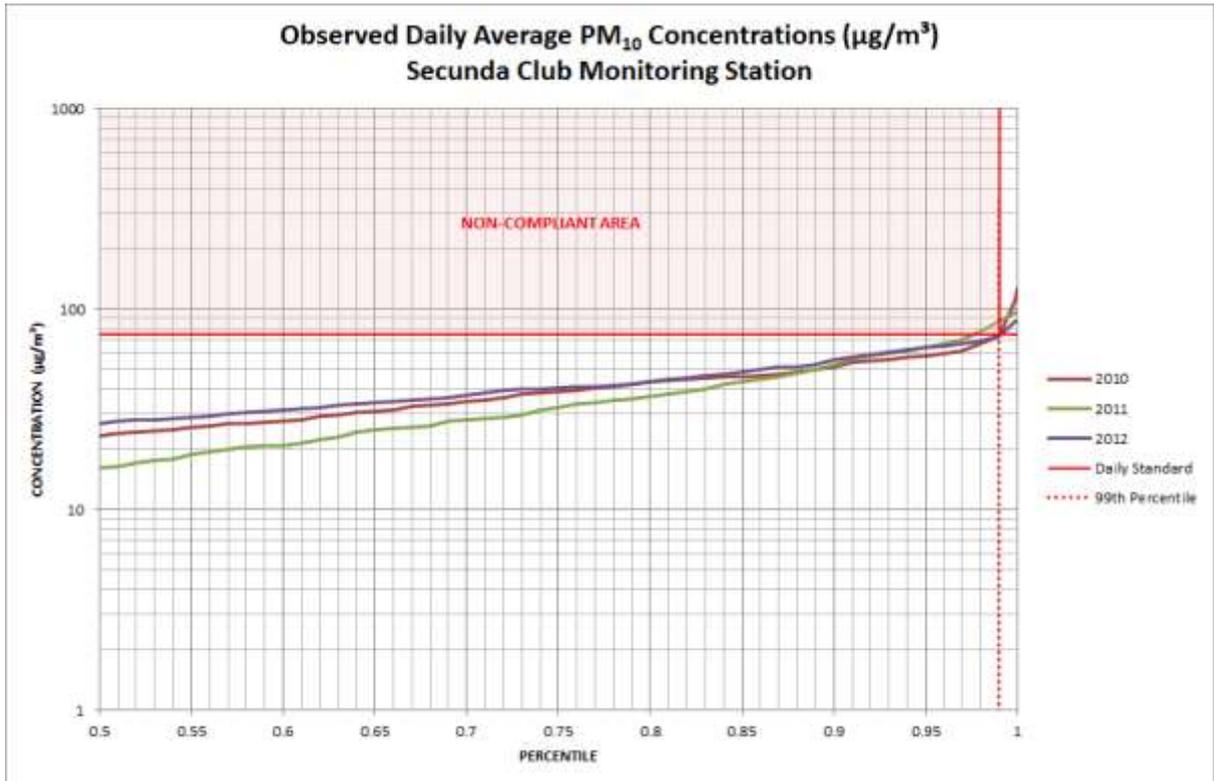
Figure 5-21: Observed daily average PM$_{10}$ concentrations at Secunda Club
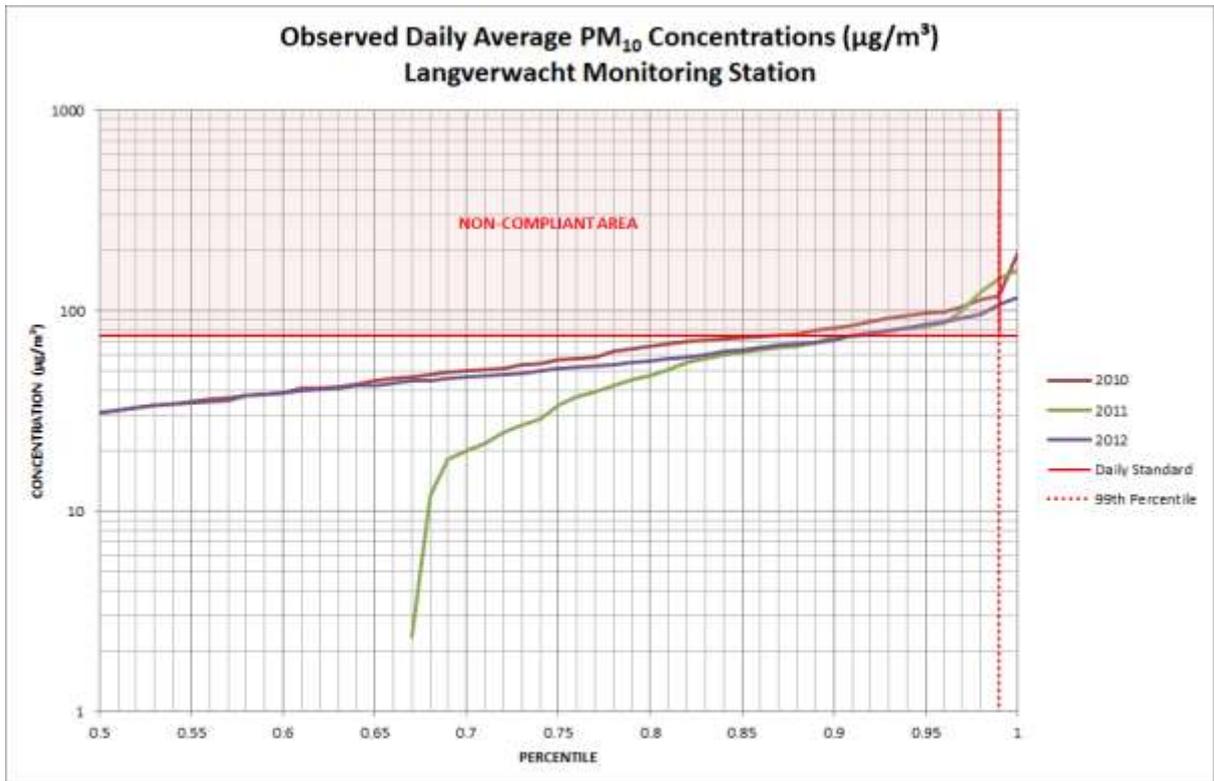
Figure 5-22: Observed daily average PM$_{10}$ concentrations at Langverwacht

Time series plots (mean with 95% confidence interval) of ambient SO_2, NO_2, H_2S, PM_{10}, and benzene concentrations measured at Bosjesspruit (Figure 5-23 and Figure 5-24), Secunda Club (Figure 5-25 to Figure 5-28), and Langverwacht (Figure 5-29 to Figure 5-32) show the variation of these pollutants over daily, weekly and annual cycles.

The daily SO_2 show a typically industrial signature with increased SO_2 concentrations as just before midday due to the break-up of an elevated inversion layer, in addition to the development of daytime convective conditions causing the plume to be brought down to ground level relatively close to the point of release from tall stacks. Increased NO_2 concentrations during peak traffic times (07:00 to 08:00 and 16:00 to 18:00) illustrate the contribution of vehicle emissions to the ambient NO_2 concentrations. The winter (June, July and August) elevation of SO_2 and NO_2 shows the contribution of residential fuel burning to the ambient SO_2 and NO_2 concentrations.

Monthly variation of PM_{10} shows a typical Highveld signature of elevated concentrations during winter months due to the greater contribution from domestic fuel burning, dust from uncovered soil and the lack of the settling influence of rainfall (Figure 5-27 and Figure 5-31).

Large temporal and spatial variation is evident in H_2S with different time-period patterns evident at each of the monitoring stations. Benzene shows a strong daily periodicity with elevated concentrations at 06:00 and 18:00. Benzene concentrations at both monitoring stations were elevated during winter months.
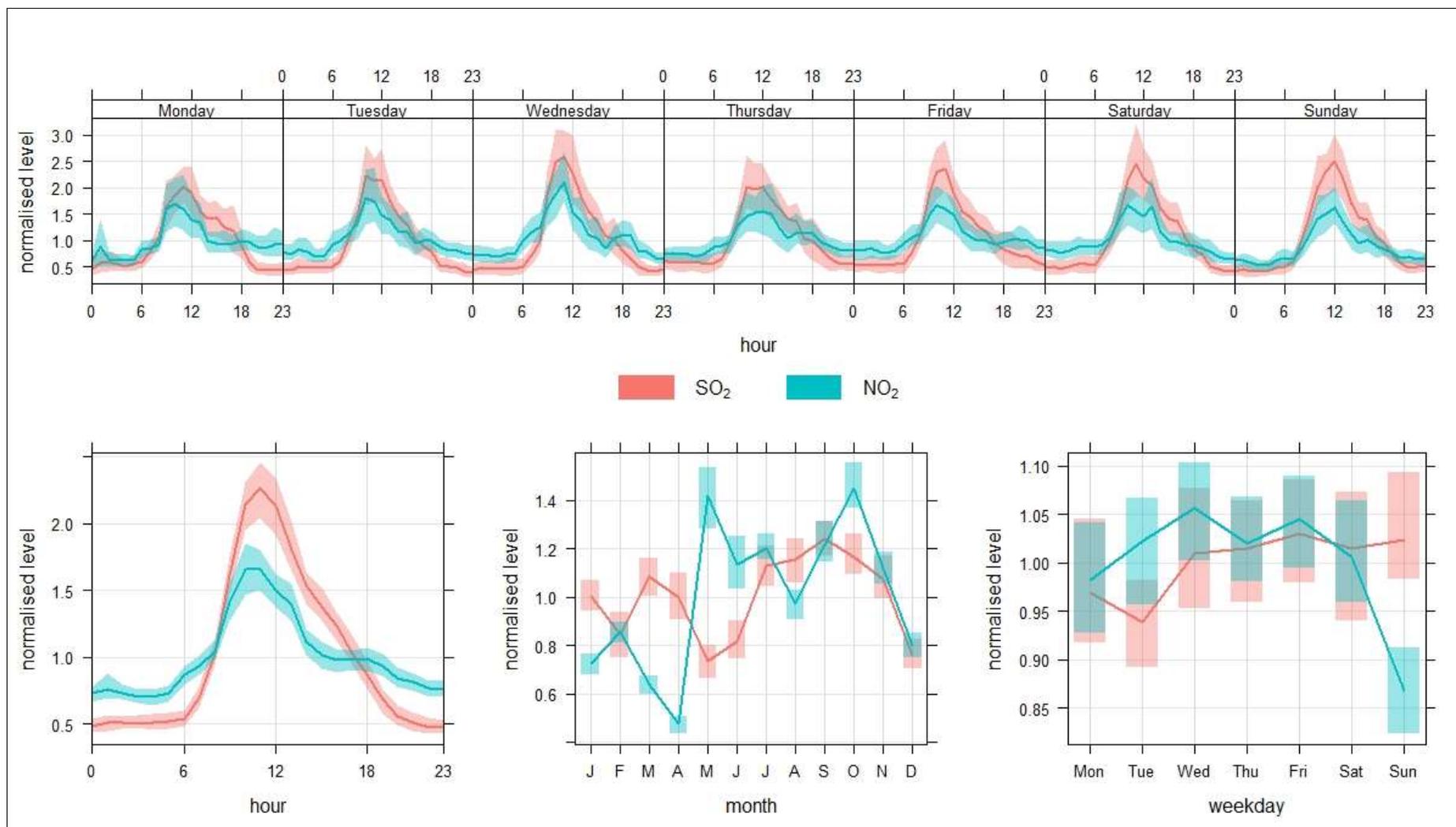
Figure 5-23: Time series plot of observed SO₂ and NO₂ concentrations at Bosjesspruit (shaded area indicates 95th percentile confidence interval)
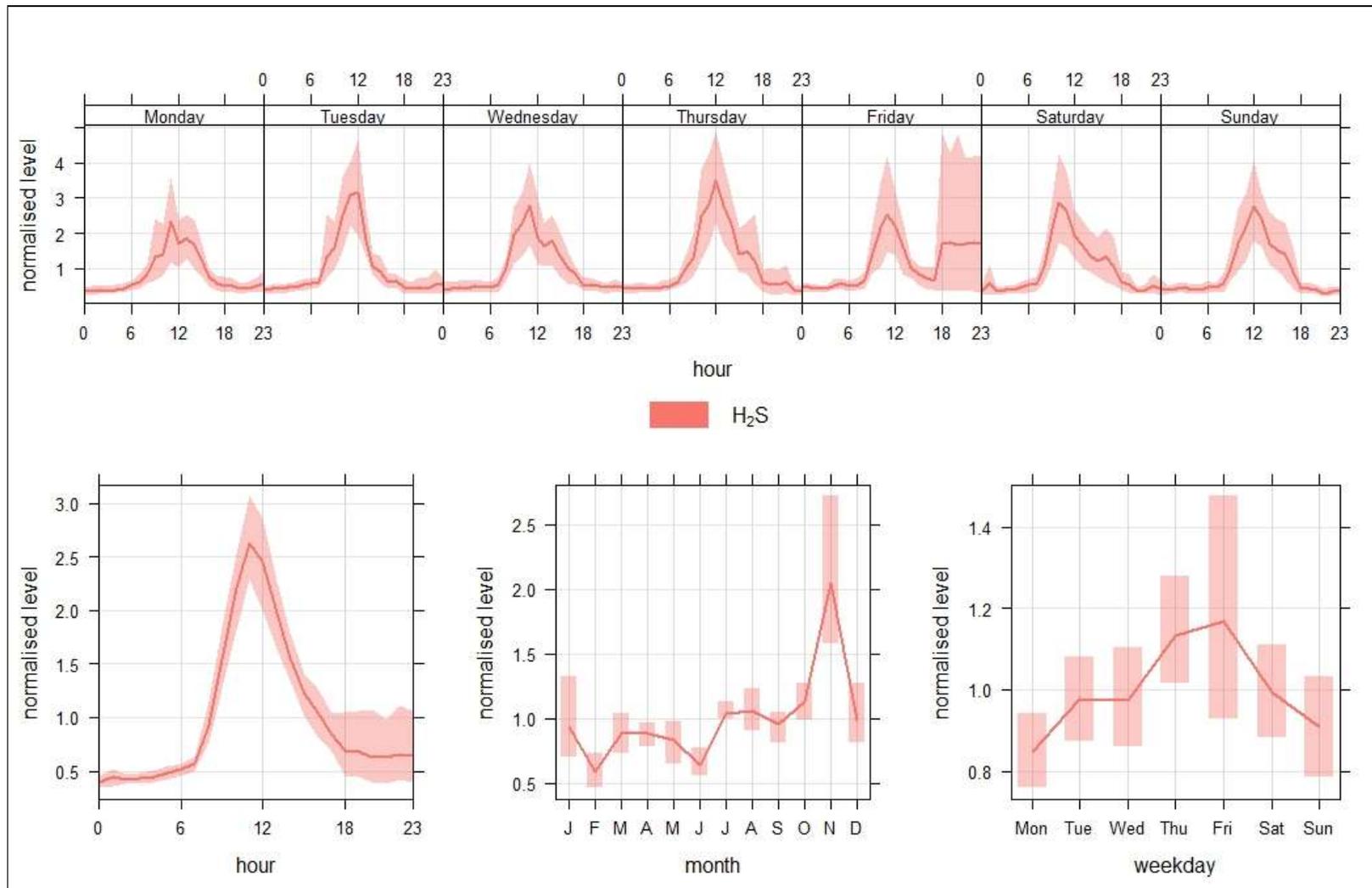
Figure 5-24: Time series plot of normalised observed H₂S concentrations at Bosjesspruit (shaded area indicates 95th percentile confidence interval)
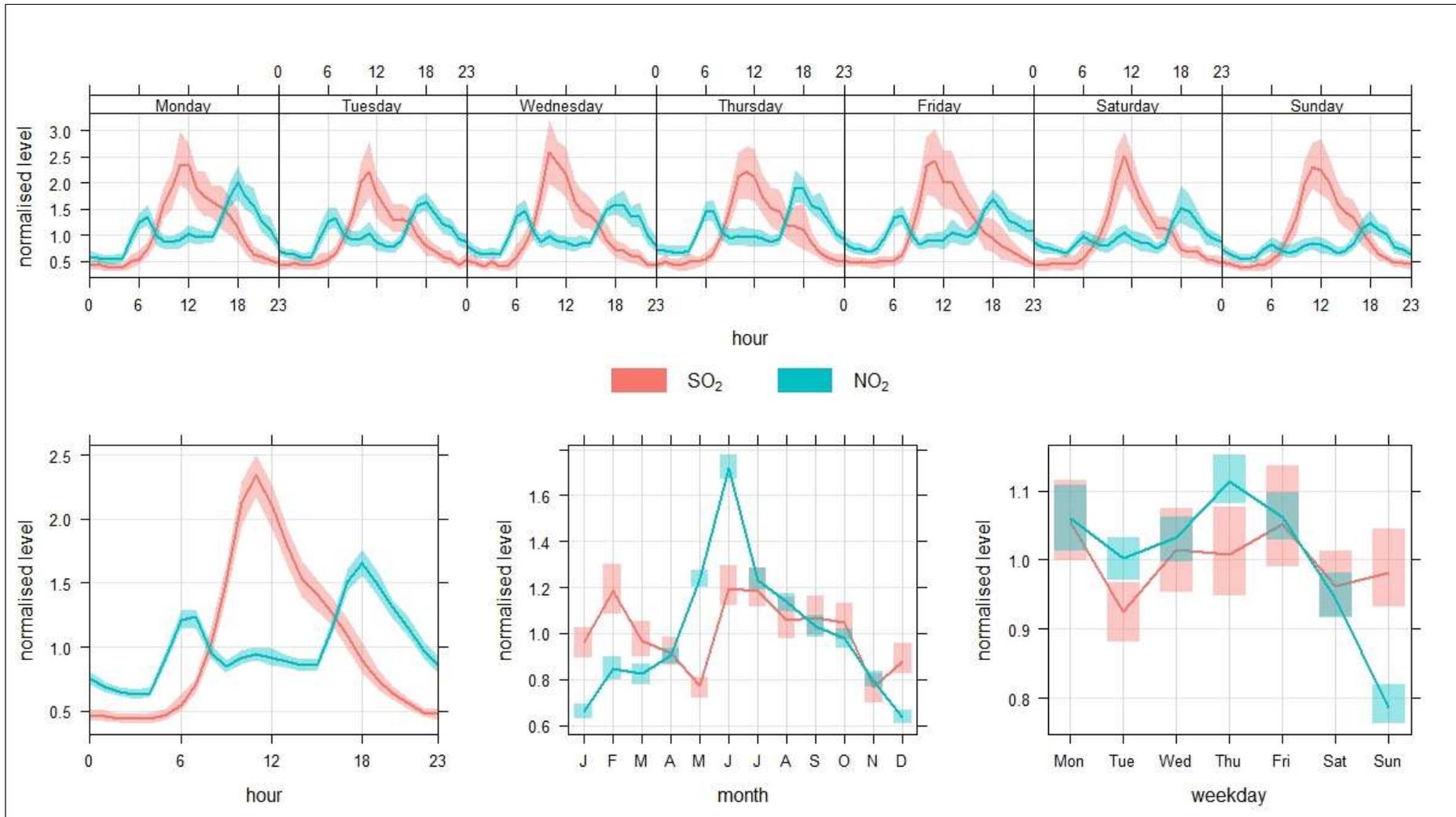
Figure 5-25: Time series plot of normalised observed SO₂ and NO₂ concentrations at Secunda Club (shaded area indicates 95th percentile confidence interval)
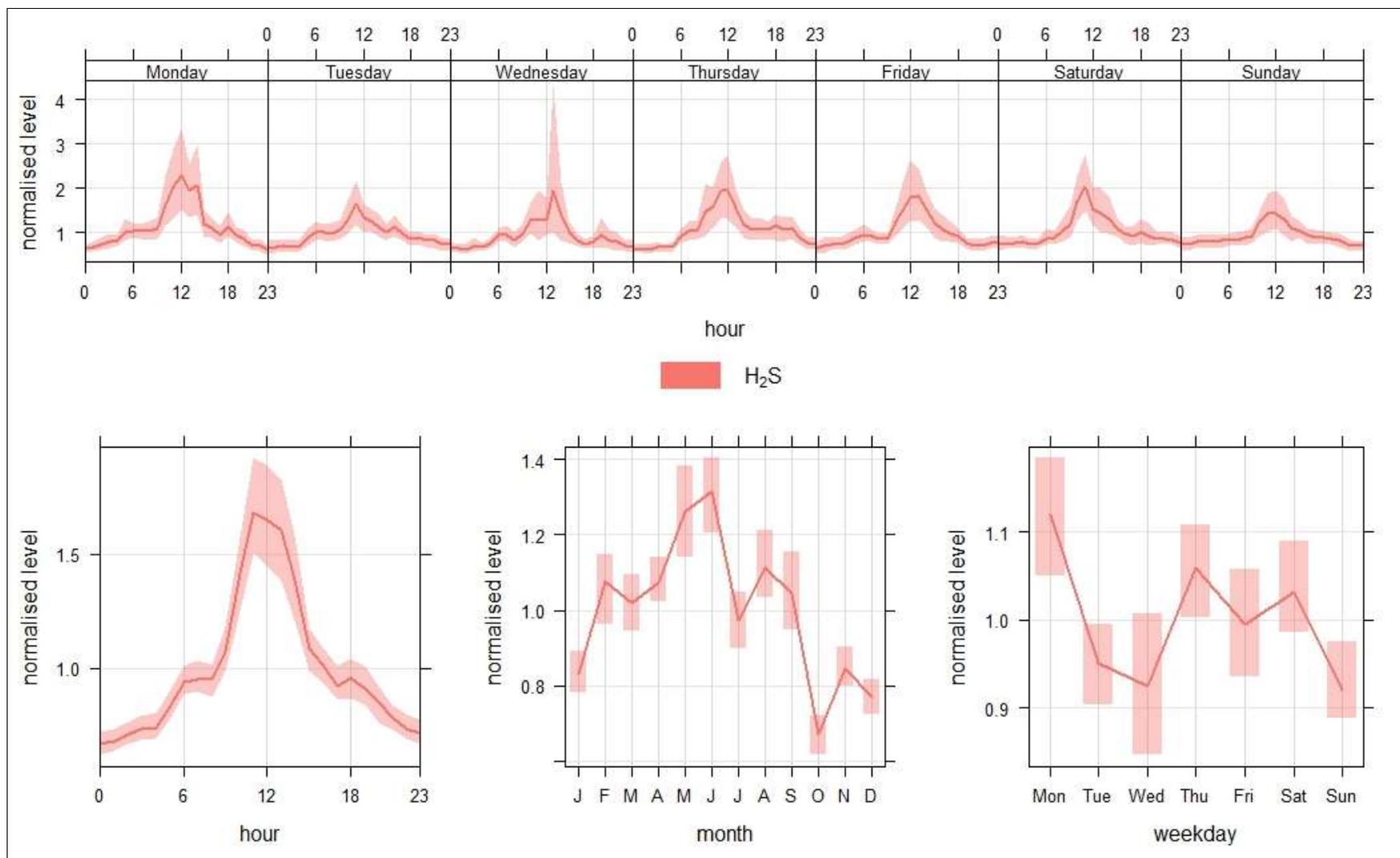
Figure 5-26: Time series plot of normalised observed H$_2$S concentrations at Secunda Club (shaded area indicates 95th percentile confidence interval)
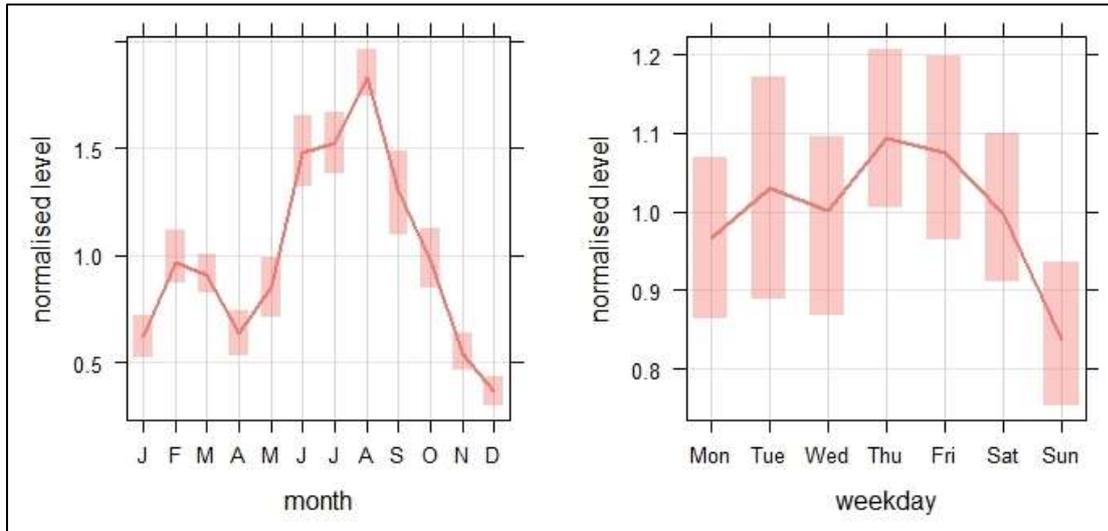
Figure 5-27: Time series plot of normalised observed PM₁₀ concentrations at Secunda Club (shaded area indicates 95th percentile confidence interval)
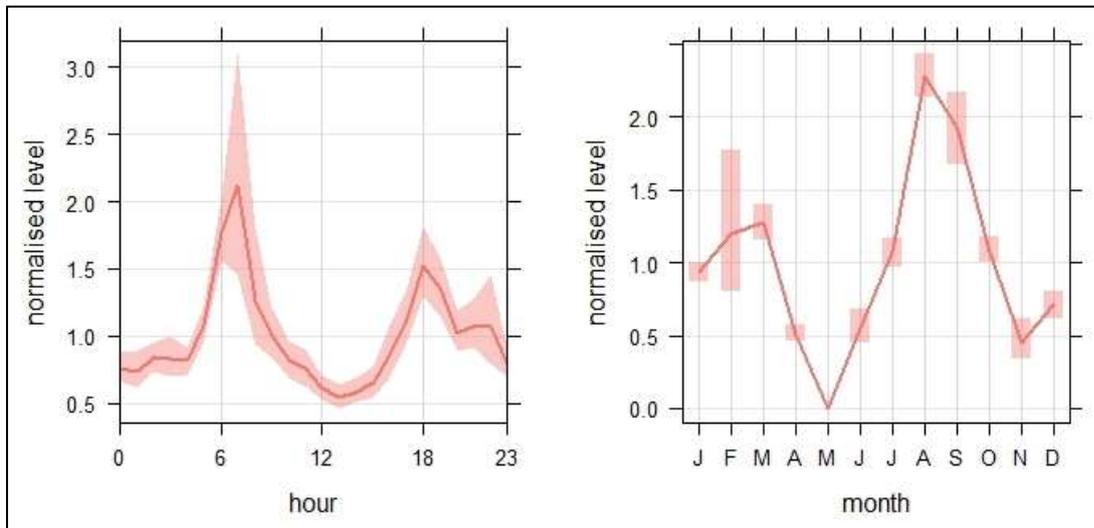
Figure 5-28: Time series plot of normalised observed benzene concentrations at Secunda Club (shaded area indicates 95th percentile confidence interval)
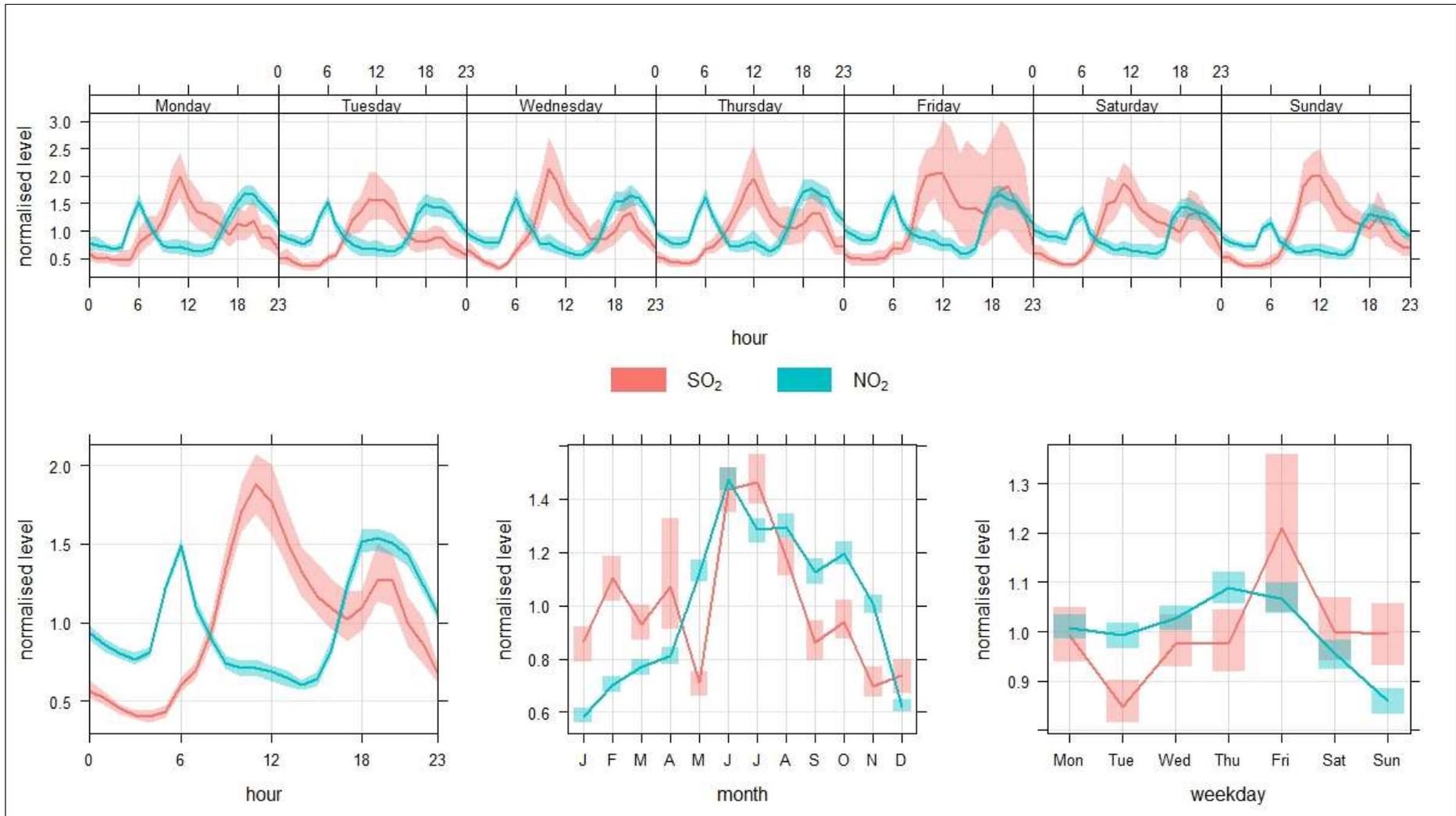
Figure 5-29: Time series plot of normalised observed SO₂ and NO₂ concentrations at Langverwacht (shaded area indicates 95th percentile confidence interval)
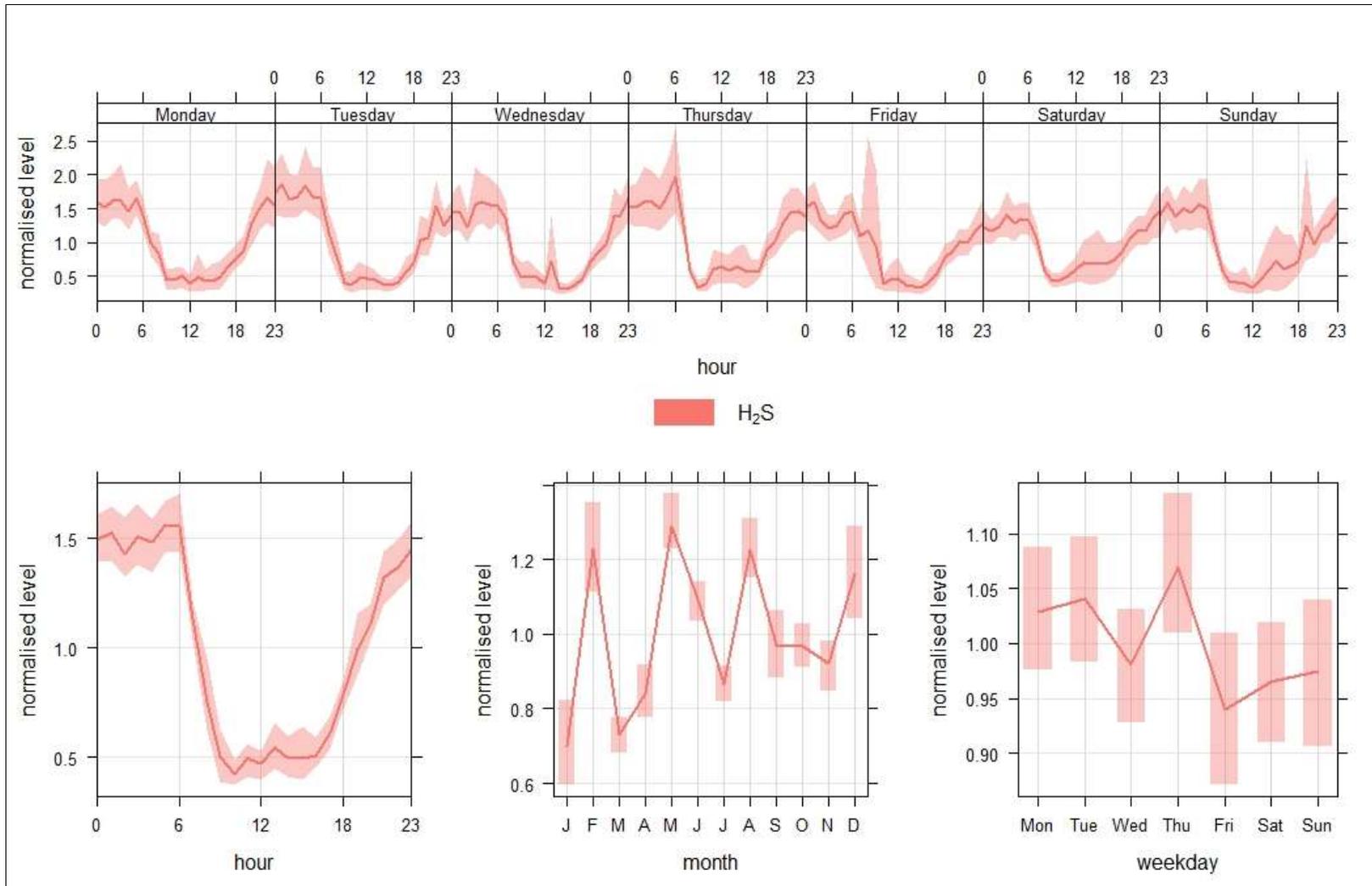
Figure 5-30: Time series plot of normalised observed H₂S concentrations at Langverwacht (shaded area indicates 95th percentile confidence interval)
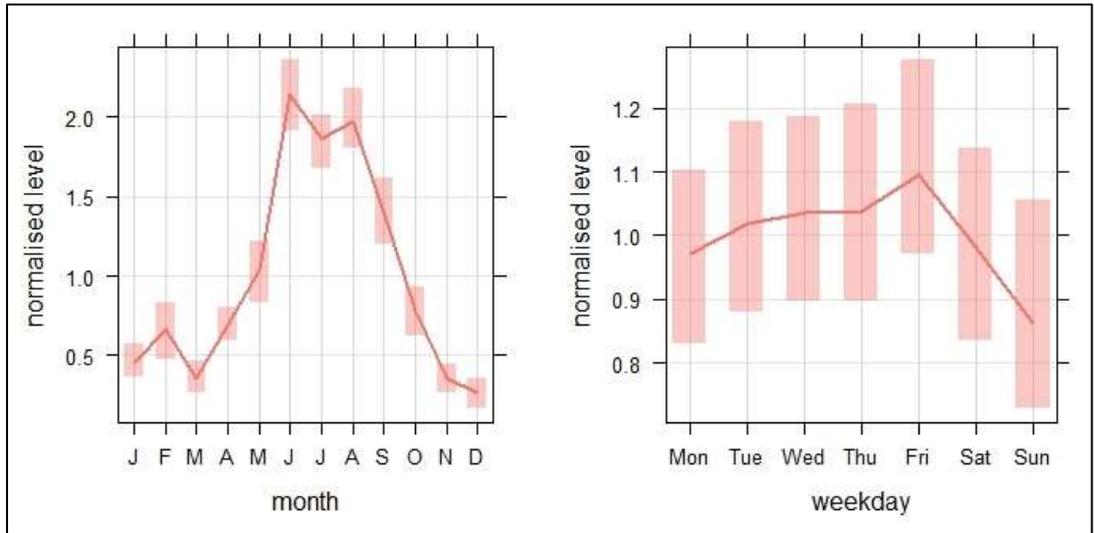
Figure 5-31: Time series plot of normalised observed PM$_{10}$ concentrations at Langverwacht (shaded area indicates 95th percentile confidence interval)
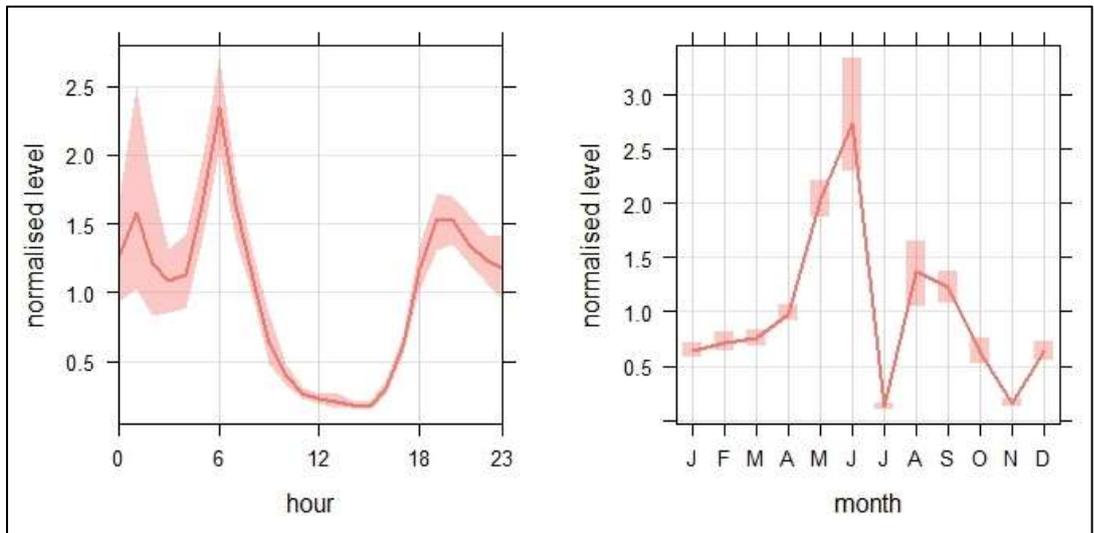
Figure 5-32: Time series plot of normalised observed benzene concentrations at Langverwacht (shaded area indicates 95th percentile confidence interval)

5.1.6   Model Performance

5.1.6.1   Understanding of Observed Concentrations

An analysis of the observed NO_2, SO_2, PM_{10} and H_2S concentrations at Bosjesspruit, Secunda Club and Langverwacht monitoring stations was completed, in which the concentration values have been categorised into wind speed and direction bins for different concentrations. This information is most easily visualised as polar plots, where the centre of the polar plot refers to the location of the monitoring station, as shown for NO_2 observations in Figure 5-33 (Bosjesspruit), Figure 5-36 (Secunda Club) and Figure 5-41 (Langverwacht). The corresponding SO_2 analyses are summarised in Figure 5-34 (Bosjesspruit), Figure 5-37 (Secunda Club) and Figure 5-42 (Langverwacht) with PM_{10} provided in Figure 5-38 (Secunda Club) and Figure 5-43 (Langverwacht) and H_2S provided in Figure 5-35 (Bosjesspruit), Figure 5-39 (Secunda Club) and Figure 5-44 (Langverwacht).

These polar plots (Carslaw and Ropkins, 2012; Carslaw, 2013) provide an indication of the directional contribution as well as the dependence of concentrations on wind speed. Whereas the directional display is fairly obvious, i.e. when higher concentrations are shown to occur in a certain sector, e.g. north-westerly for SO_2 at Bosjesspruit (Figure 5-34), it is understood that most of the high concentrations occur when winds blow from that sector. The presence of a high concentration pattern which is more symmetrical around the centre of the plot, it is an indication that the contributions are near-equally distributed, and occur under calm-wind conditions, as is displayed for NO_2 in Figure 5-41.

Furthermore, since the observed concentrations have also been categorised according to wind speed categories, it provides an indication of the plume height. As explained in Section 5.1.4.1 (plume buoyancy), stronger winds reduce the amount of plume rise, and may effectively increase ground level concentrations. However, since an increased wind speed also enhances plume dispersion, a concentration maximum would be reached for a wind speed where the plume rise and dilution effects cancel each other. These conditions would be different for day- and night-time atmospheric stabilities. It is expected that high ground level concentrations from elevated stacks would be more prevalent during stronger wind speeds during stable conditions than daytime, convective conditions, when the plume buoyancy is often not as effective in lifting the plume centreline. Low-level emissions behave differently, and higher concentrations would normally be observed during weak-wind conditions.

The NO_2 concentrations observed at Bosjesspruit (Figure 5-33) indicate that most of the high concentrations occur with north-westerly winds of between 5 m/s and 10 m/s. Slightly lower air concentration contributions were from the north to north-north-easterly direction with winds of about 10 m/s. Concentrations of less than 35 µg/m³ were observed with winds from the south-east. The north-westerly sector is clearly associated with the Sasol Secunda operations. Whilst the northerly sector may also include Sasol, it is also believed that other sources may contribute to these observations, including vehicular exhaust emissions, which can potentially be significant NO_2 emitters. The south-easterly observations are most likely due to emitters of NO_2 other than Sasol.

The SO_2 concentrations observed at Bosjesspruit (Figure 5-34) indicate that most of the high concentrations occur with north-westerly winds of between 5 m/s and 10 m/s and north/north-northeasterly winds of above 10 m/s. High concentrations were also measured with south-easterly winds above 10 m/s. As with NO_2, the contribution from the north-westerly sector, is most likely associated with the Sasol Secunda operations, whereas the other two directions are most likely due to other emitters of SO_2.

The H$_2$S concentrations observed at Bosjesspruit (Figure 5-35) indicate that most of the high concentrations occur with north-westerly winds of between 5 m/s and 10 m/s. Higher concentrations were also measured with south-easterly winds above 10 m/s. The concentrations from the north-westerly sector are most likely associated with the Sasol Secunda operations, whereas the concentrations from the south eastern sector are most likely due to other emitters of H$_2$S.

The NO$_2$ concentrations observed at Secunda Club (Figure 5-36) indicate that most of the high concentrations occur with south-westerly winds of less than 6 m/s. These are most likely due to emissions at the Sasol operations. Lower air concentration observation from the north, may be due to vehicular exhaust emissions and more remote sources of NO$_2$. Concentrations of less than 25 µg/m³ were also observed with winds from the south-east.

The SO$_2$ concentrations observed at Secunda Club (Figure 5-37) show three distinct wind directions, namely from the south-west (majority of high concentrations), the north (Secunda town and other more remote emitters) and south-east (remote emitters).

The PM$_{10}$ concentrations observed at Secunda Club (Figure 5-38) are mainly from the western sector where industrial, mining and vehicle activity sources are most likely to contribute to the concentrations. Lower particulate concentrations are associated with winds from the eastern sector.

The H$_2$S concentrations observed at Secunda Club (Figure 5-39) show highest concentrations associated with winds of ~10m/s. These are most likely due to emissions from Sasol operations.

The highest observed benzene concentrations at the Secunda Club (Figure 5-40) are associated with winds of 10 m/s or greater, from the south-west of the monitoring station, mostly likely due to emissions from Sasol operations.

The NO$_2$ concentrations observed at Langverwacht (Figure 5-41) observed high concentrations, during calm-wind conditions (most-likely localised emitters), with winds from a northerly and east-south-easterly directions. Two different sources are identified with northerly winds, one peak at about 4 m/s and the other at about 12 m/s. The east-south-easterly emitters are most likely due to Sasol operations, whereas the northerly observations are due to more remote sources of NO$_2$.

Mean SO$_2$ concentrations (about 100 µg/m³) were observed with winds from the north-north-east and east-south-east at Langverwacht (Figure 5-42). The east-south-easterly sector is most likely associated with the Sasol Secunda operations. Whilst the northerly sector may also include Sasol, it is also believed that other sources are likely to contribute to these observations.

The highest mean PM$_{10}$ concentrations at Langverwacht were observed with winds from the west-south-west at wind speeds of less than 2 m/s (Figure 5-43). The contributing sources of particulate matter would include vehicle entrainment, domestic fuel burning, industrial and mining activity.

The highest mean H$_2$S concentrations were observed with winds from the east-south-east, which is most likely associated with the Sasol Secunda operations (Figure 5-44).

The highest observed benzene concentrations at Langverwacht (Figure 5-45) are associated with winds of 10 m/s or greater, from the east of the monitoring station, mostly likely due to emissions from Sasol operations.
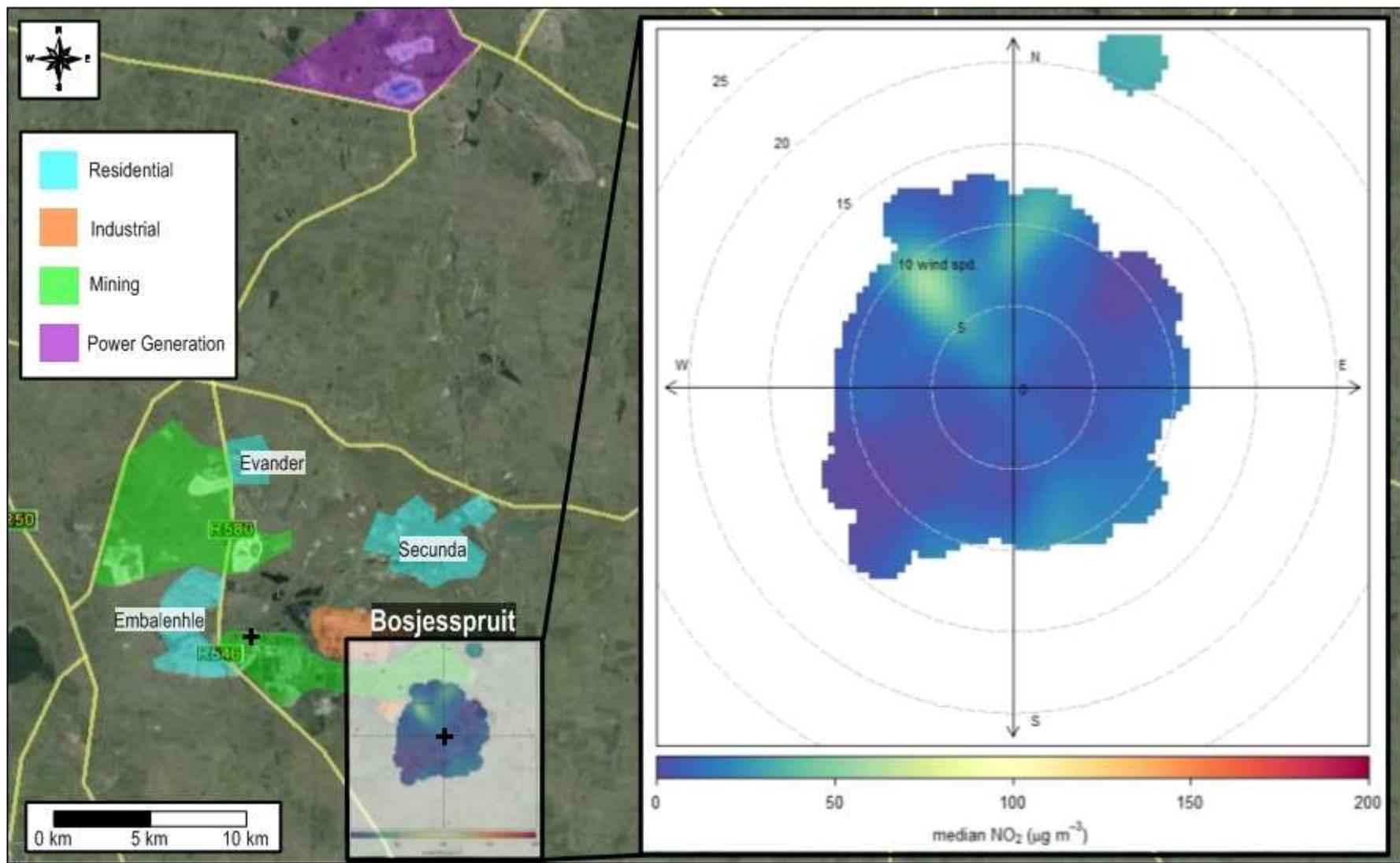
Figure 5-33: Polar plot of hourly median NO₂ concentration observations at Bosjesspruit for 2010 to 2012

Atmospheric Impact Report: Sasol Secunda Facility
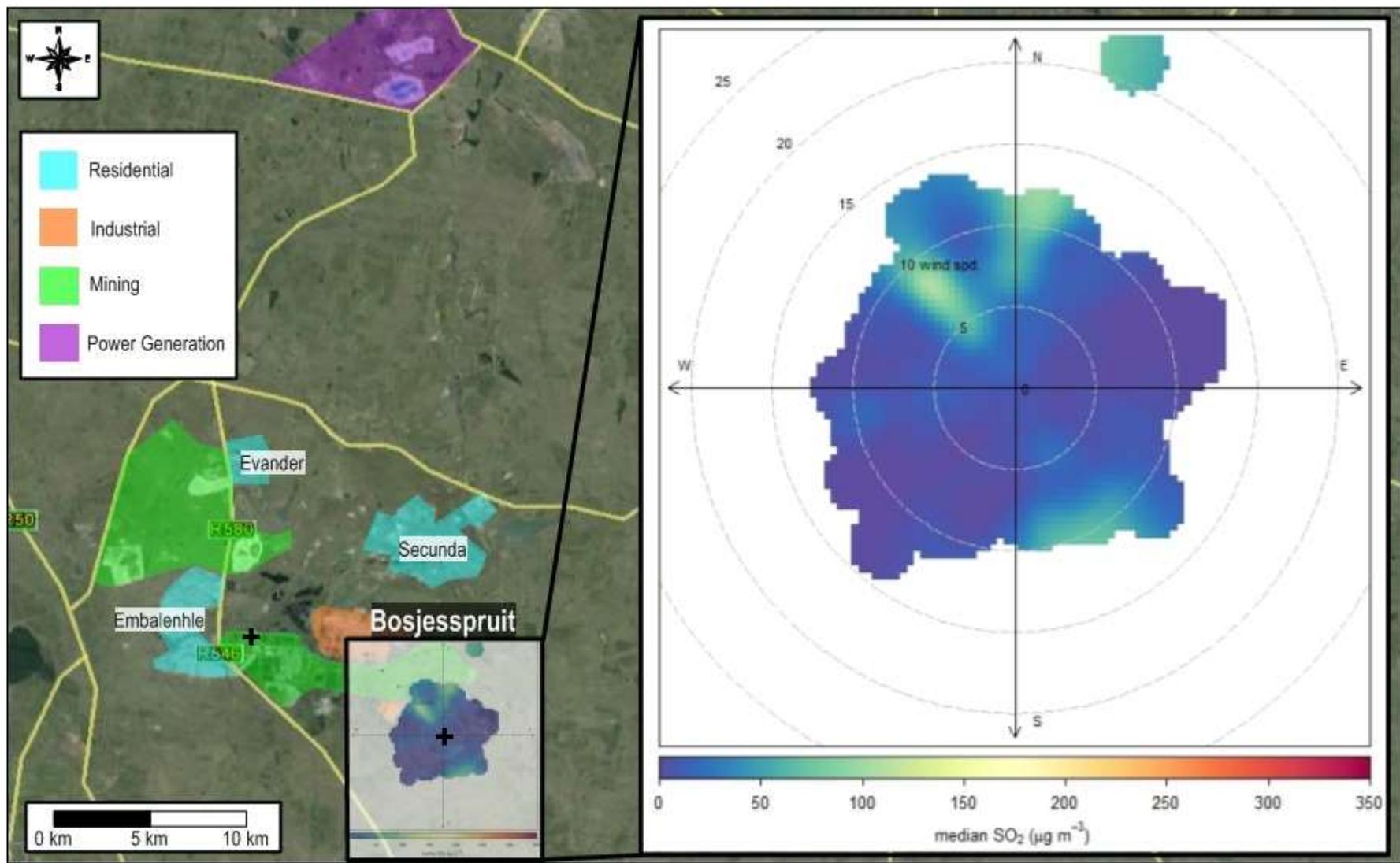
Figure 5-34: Polar plot of hourly median SO₂ concentration observations at Bosjesspruit for 2010 to 2012

Atmospheric Impact Report: Sasol Secunda Facility
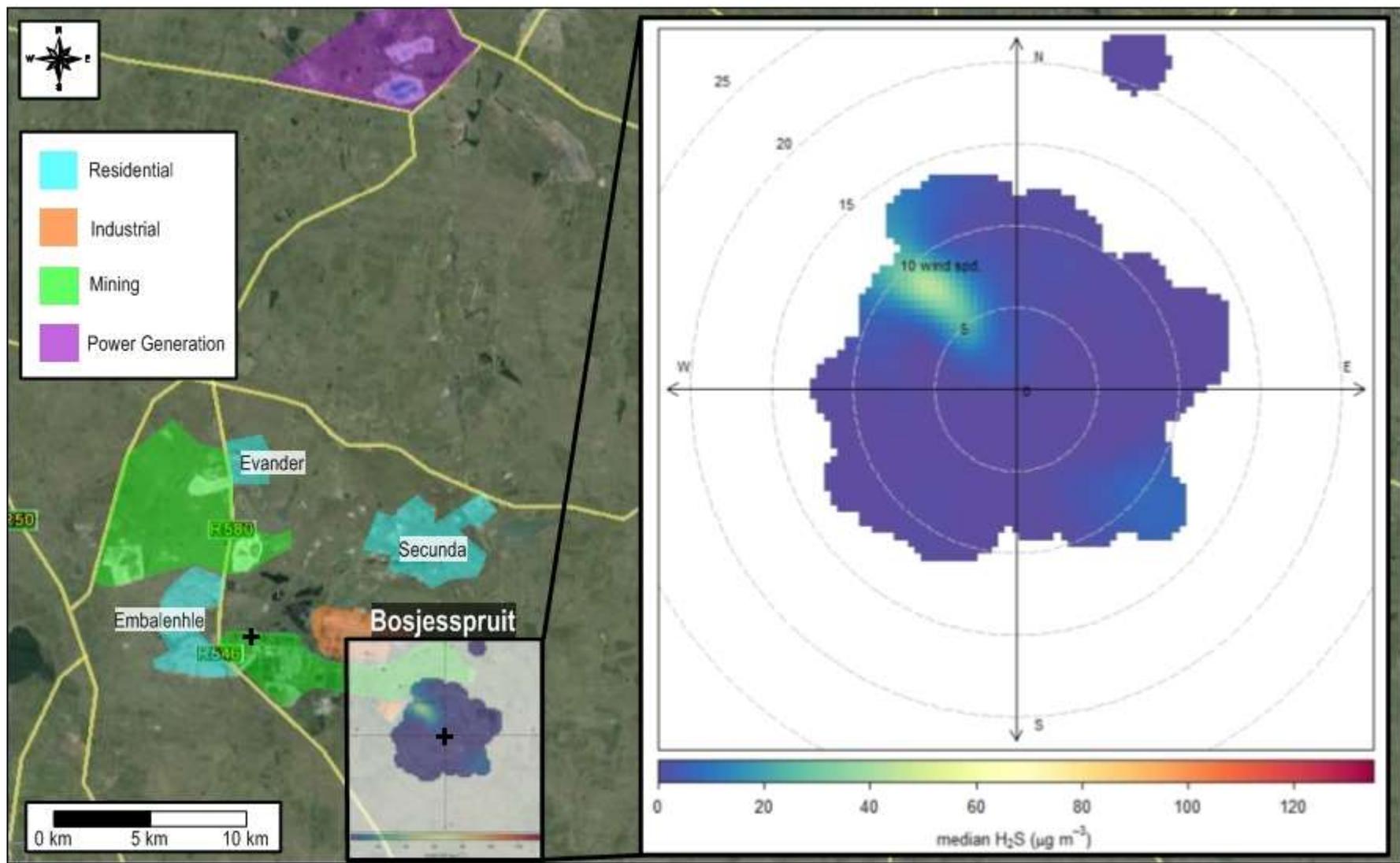
Figure 5-35: Polar plot of hourly median H₂S concentration observations at Bosjesspruit for 2010 to 2012

Atmospheric Impact Report: Sasol Secunda Facility
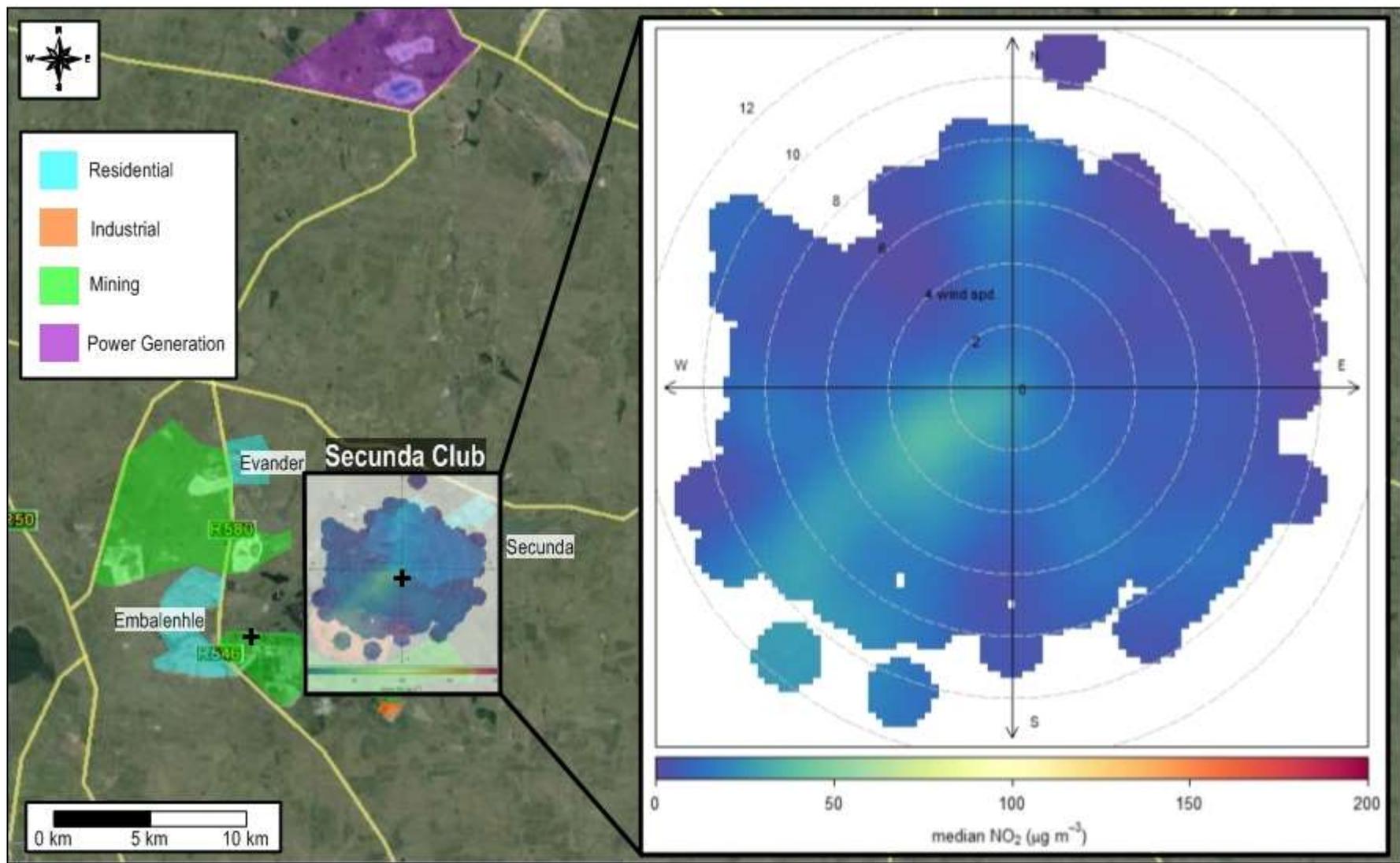
Figure 5-36: Polar plot of hourly median NO₂ concentration observations at Secunda Club for 2010 to 2012

Atmospheric Impact Report: Sasol Secunda Facility
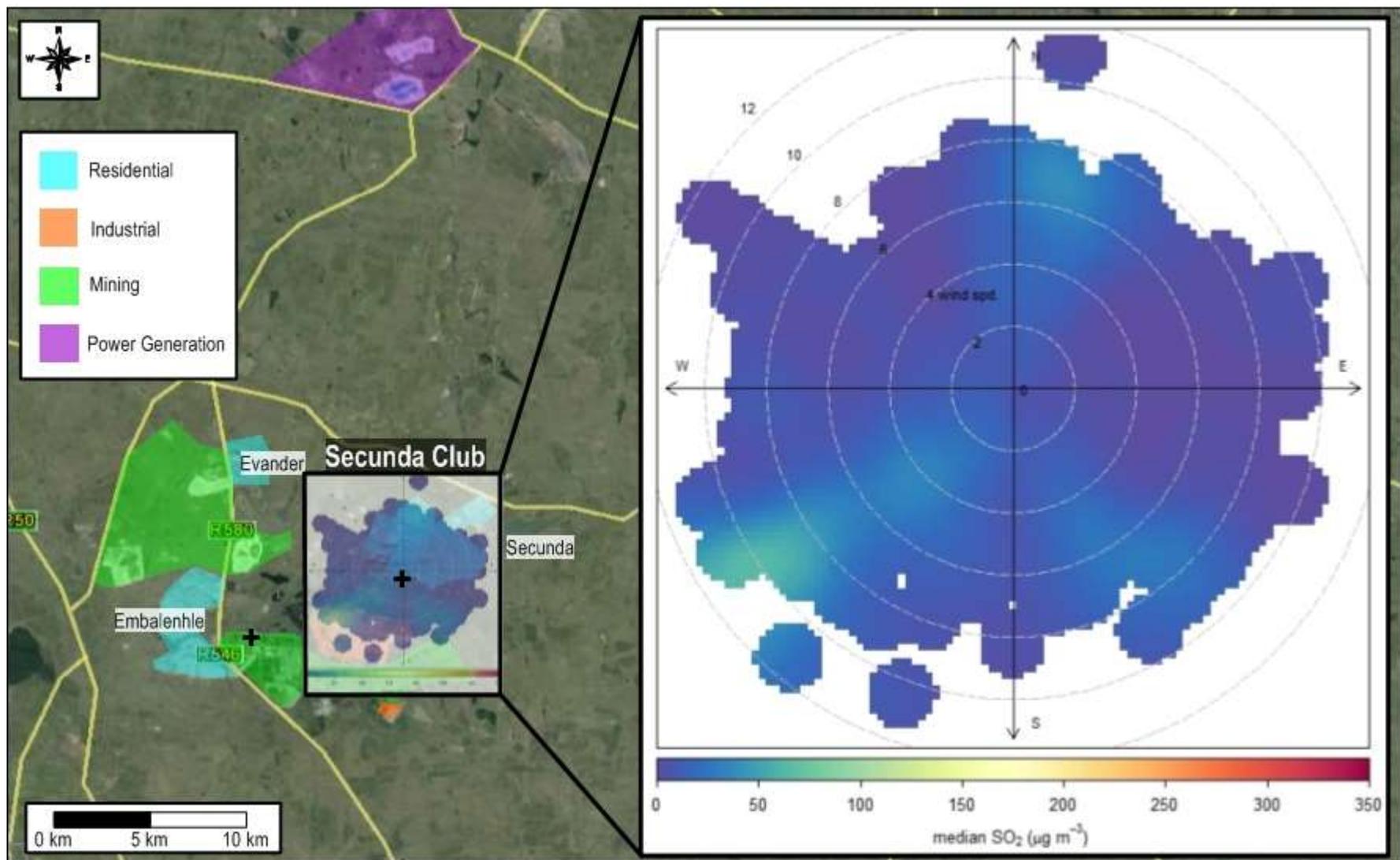
Figure 5-37: Polar plot of hourly median SO₂ concentration observations at Secunda Club for 2010 to 2012
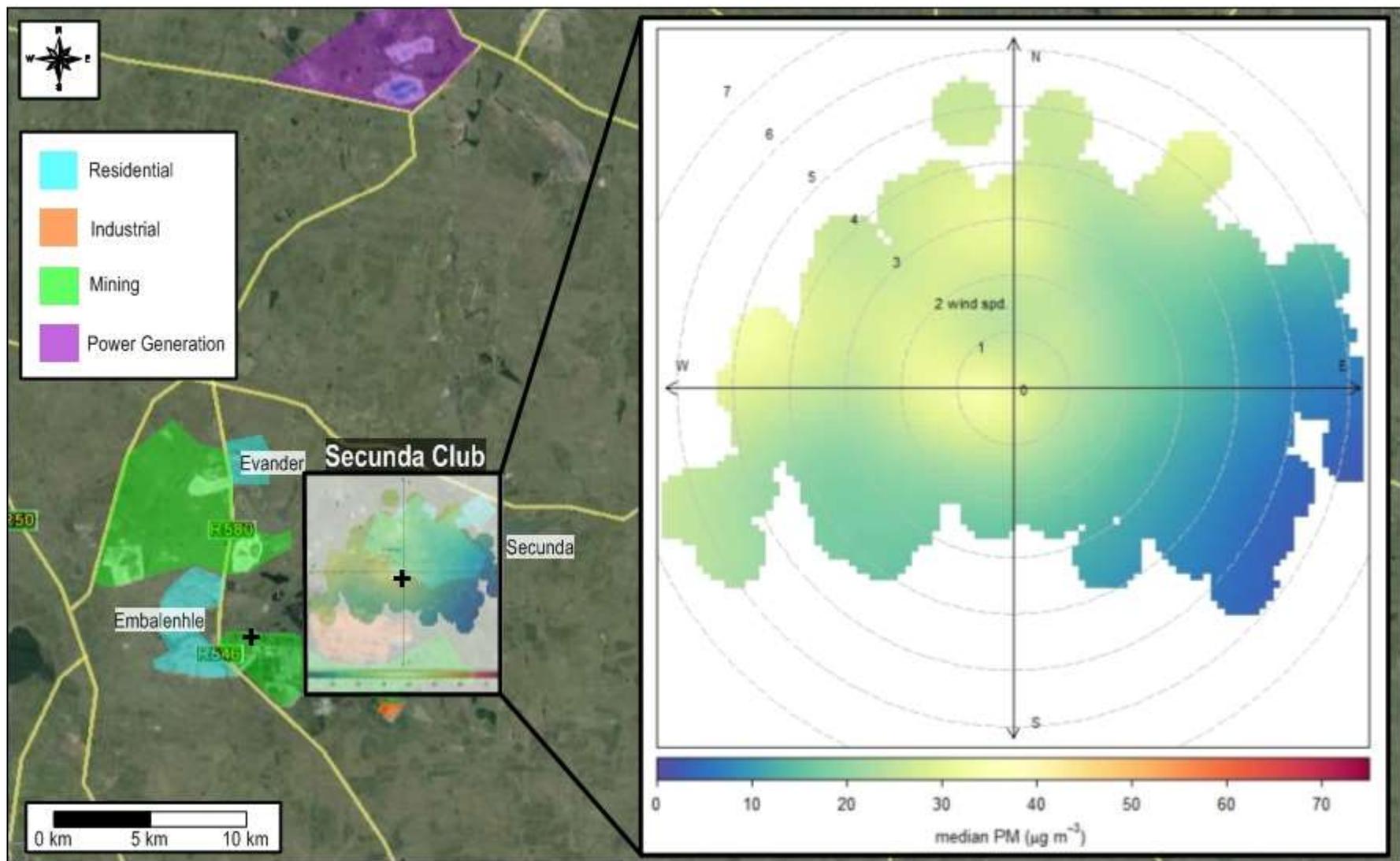
Figure 5-38: Polar plot of hourly median PM$_{10}$ concentration observations at Secunda Club for 2010 to 2012
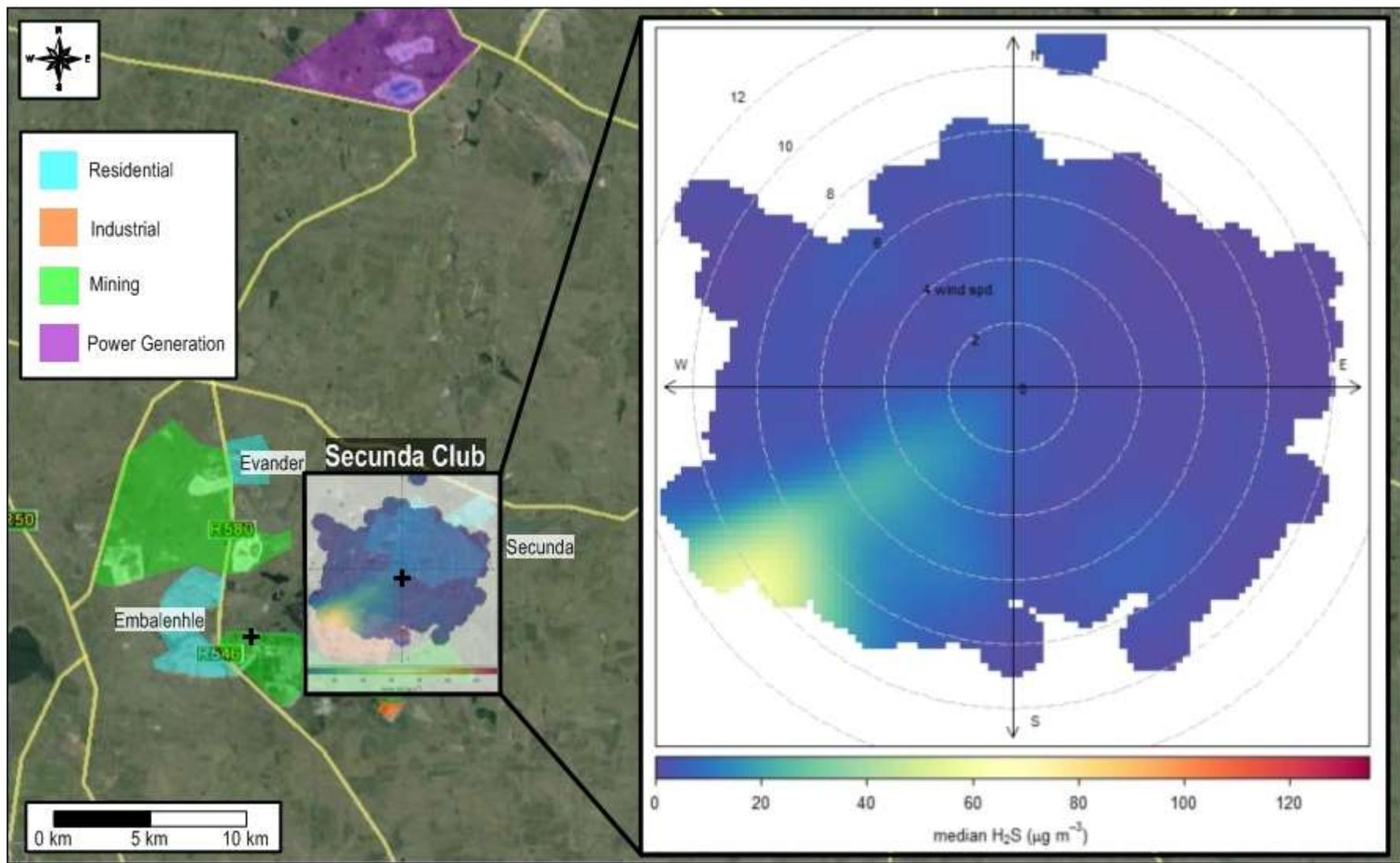
Figure 5-39: Polar plot of hourly median H₂S concentration observations at Secunda Club for 2010 to 2012

Atmospheric Impact Report: Sasol Secunda Facility
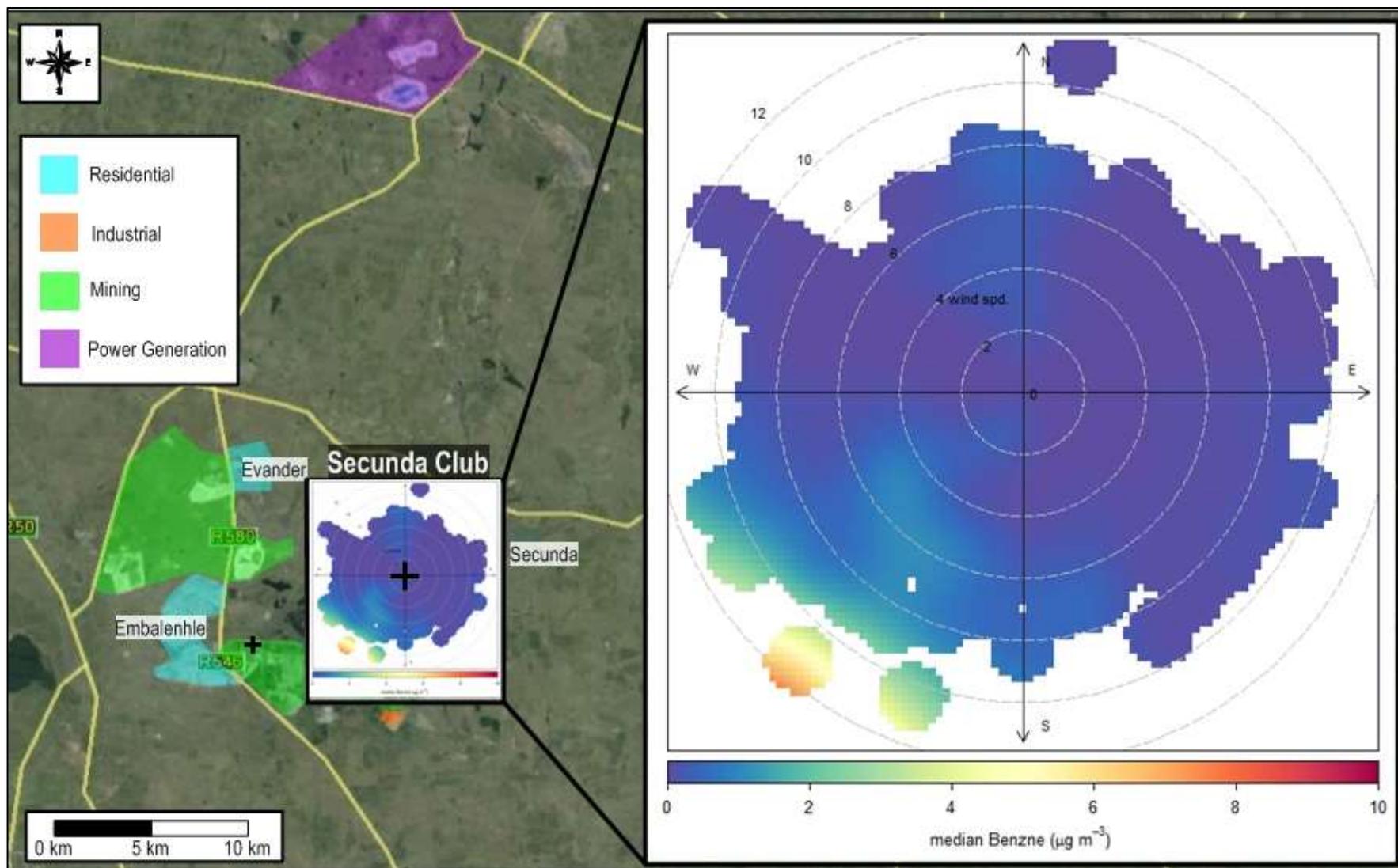
Figure 5-40: Polar plot of hourly median benzene concentration observations at Secunda Club for 2010 to 2012

Atmospheric Impact Report: Sasol Secunda Facility
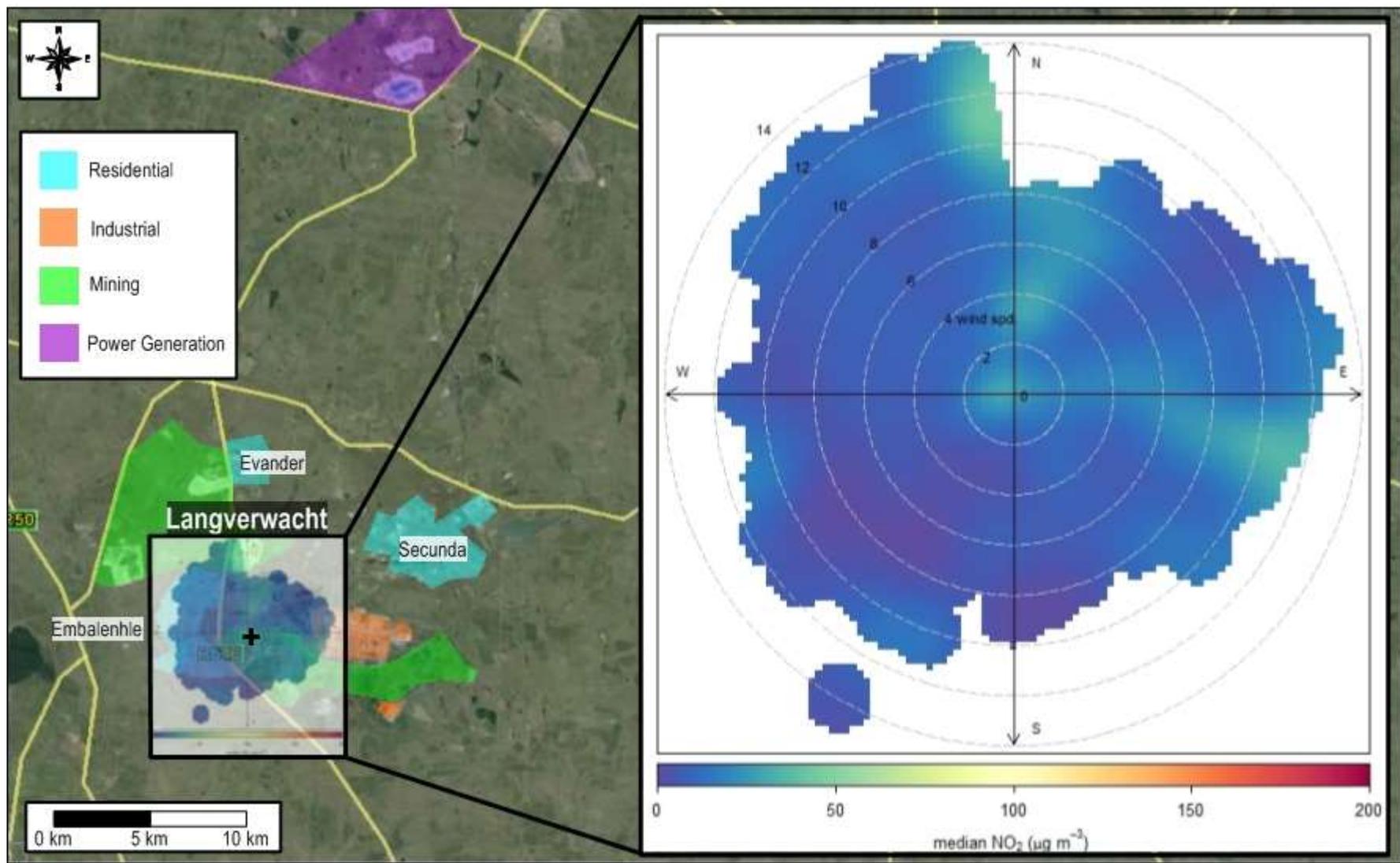
Figure 5-41: Polar plot of hourly median NO₂ concentration observations at Langverwacht for 2010 to 2012

Atmospheric Impact Report: Sasol Secunda Facility
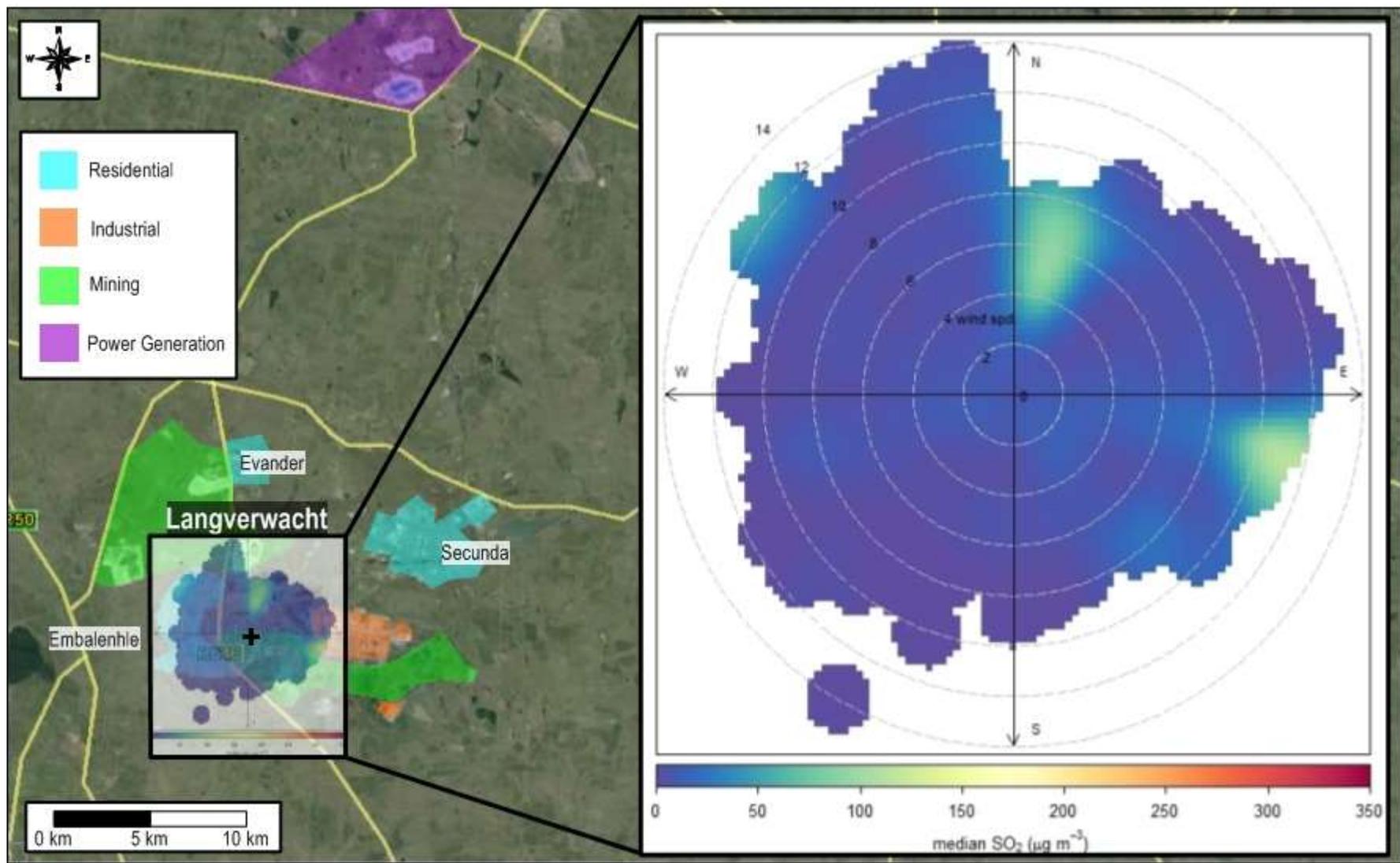
Figure 5-42: Polar plot of hourly median SO₂ concentration observations at Langverwacht for 2010 to 2012

Atmospheric Impact Report: Sasol Secunda Facility
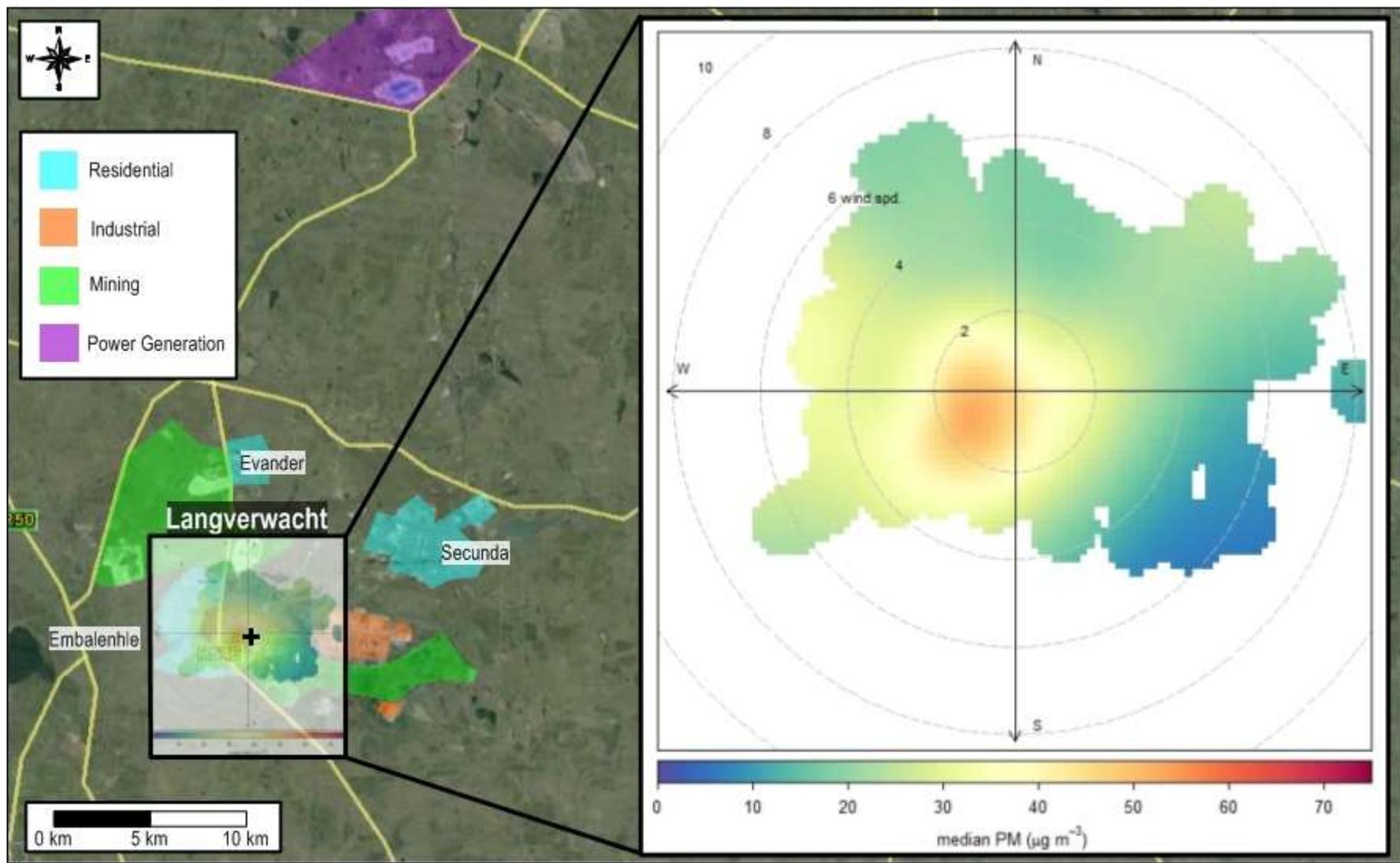
Figure 5-43: Polar plot of hourly median PM₁₀ concentration observations at Langverwacht for 2010 to 2012
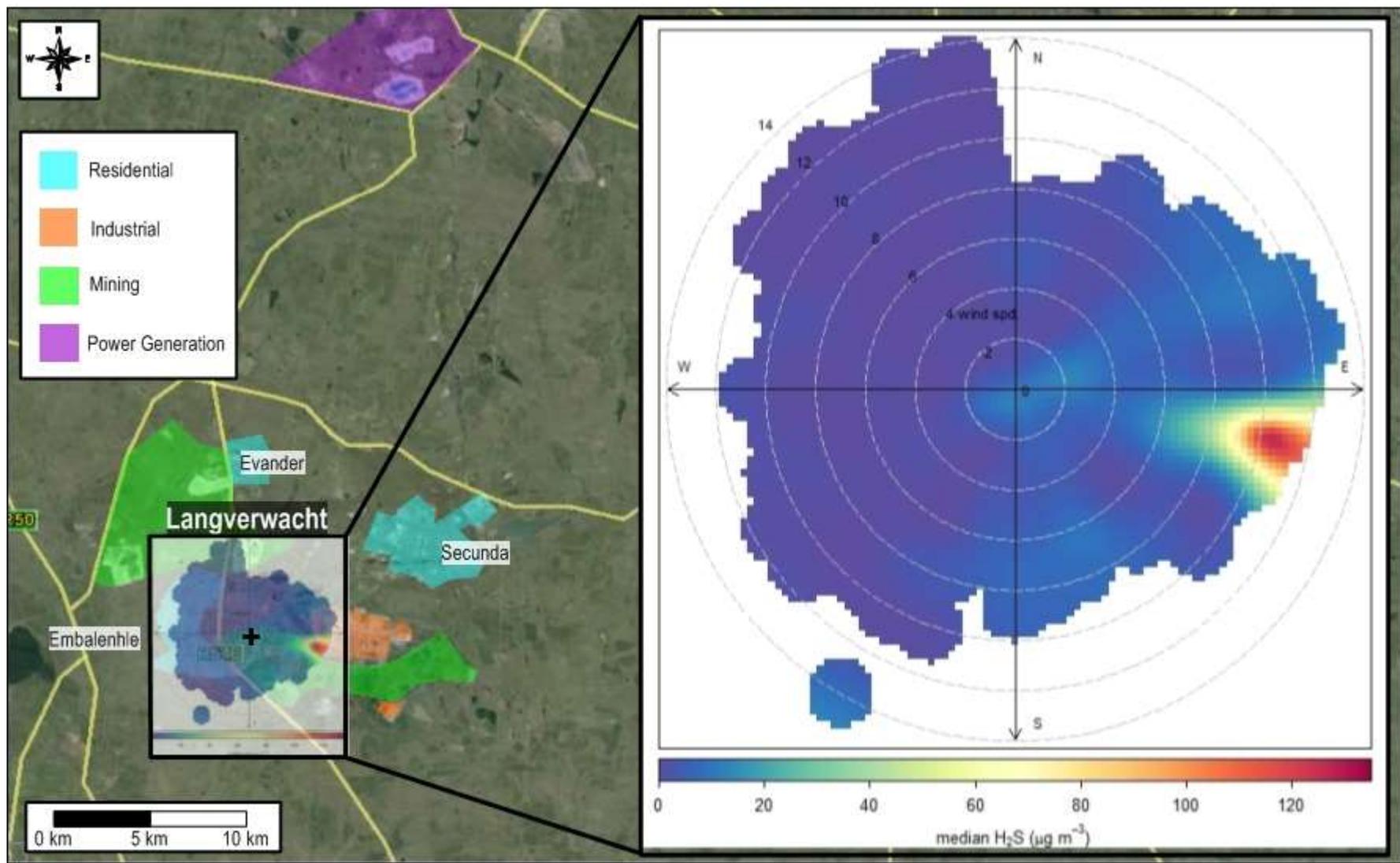
Figure 5-44: Polar plot of hourly median H₂S concentration observations at Langverwacht for 2010 to 2012

Atmospheric Impact Report: Sasol Secunda Facility
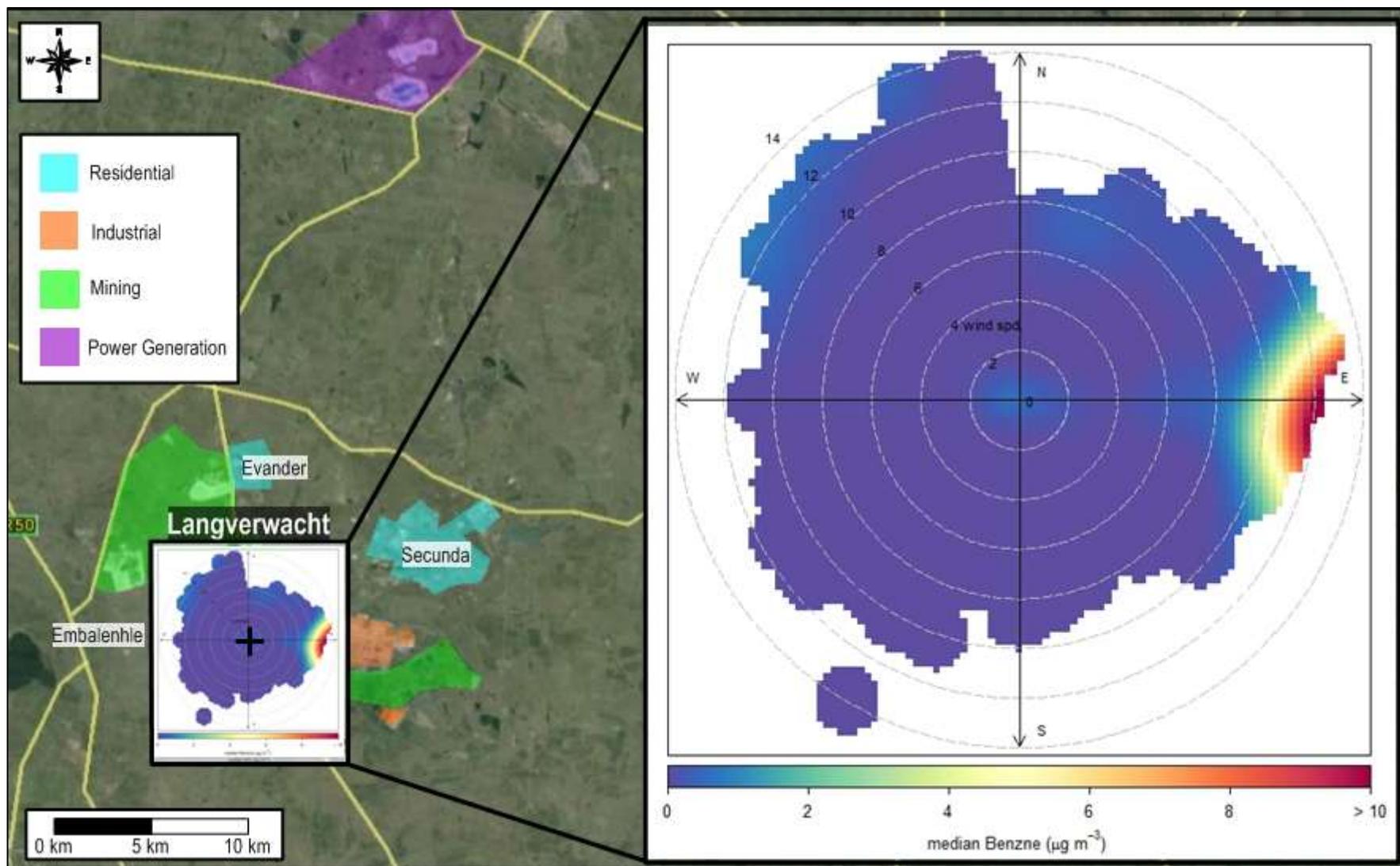
Figure 5-45: Polar plot of hourly median benzene concentration observations at Langverwacht for 2010 to 2012

Atmospheric Impact Report: Sasol Secunda Facility

Ambient concentrations of NO_2, SO_2, H_2S and PM_{10} measured by Sasol in Secunda help provide an understanding of existing ambient air concentrations as well as providing a means of verifying the dispersion modelling. Since the aim of the investigation is to illustrate the change in ground level concentrations from the current levels (i.e. baseline emission scenario) to those levels theoretically resulting from implementation of technical solutions to lower emissions to the promulgated emission limits (i.e. existing and new plant standards), the intension was not to comprehensively include all air emissions from the Sasol Secunda operation or those associated with activities other than Sasol. Unaccounted emissions include those from unintended leaks within the plant (fugitive emissions) and vents, as well as air emissions from other industries, emissions from activities occurring within the communities, and biomass burning (especially during winter season), as well as long-range transport into the modelling domain. However, information about community activities, such as the amount of traffic within the community and the amount of fuel used for heating is often difficult to estimate.

These emissions, when combined, may potentially add up to be a significant portion of the observed concentrations the modelling domain. In terms of the current investigation, the portion of air quality due to air emission sources that is not included in the model emissions inventory constitutes the background concentration.

Discrepancies between predicted and observed concentrations may also be as a result of process emission variations, and may include upset emissions and shutdown emissions. These conditions could result in significant under-estimating or over-estimating the ambient concentrations.

A summary of the predicted concentrations and their comparison with observations are given in Appendix H. In order to establish model performance under average emission conditions, it is not uncommon to use a certain percentile of predicted and observed concentrations for comparison. Although these may range from a 90th to 99.9th percentile, it was decided to use the DEA NAAQS for guidance. For criteria pollutants SO_2, NO_2 and PM_{10}, the NAAQS requires compliance with the 99th percentile. As hourly averages, this allows exceedances of the limit value of 88 hours (i.e. 1%) (SO_2 and NO_2) per year, and, for daily averages, 4 days (i.e. 1%) (PM_{10}) per year. To estimate the background concentrations not associated with the emission included in the simulations, the methodology described below was therefore adopted.

- For short-term (1-hour and 24-hour) predicted averaging periods, the 99th percentile value from the cumulative frequency distribution of the monitoring data (per year) were used.
- For the annual predicted averaging period (long-term), the observed concentration is used at the percentile where the modelled concentration becomes zero, but not less than the 50th percentile of the cumulative frequency distribution of the monitoring data (per year) were used.

The monitoring station at Secunda Club and Langverwacht are closer to the Sasol operations than the Bosjesspruit monitoring station. However, all three monitoring stations recorded fairly similar short-term SO_2 concentration values; viz. peaks of 479 µg/m³ (Langverwacht), 492 µg/m³ (Secunda Club), and 518 µg/m³ (Bosjesspruit), and 99th percentiles of 165 µg/m³ (Langverwacht), 174 µg/m³ (Secunda Club) and 204 µg/m³ (Bosjesspruit), respectively.

Table 5-9 is a summary of comparisons between predicted and observed SO_2 concentrations at Bosjesspruit. As shown in the table of the observed peak concentration, the predicted peak accounted for the observed peak. However, the difference between prediction and observation increases significantly when considering long-term comparisons (i.e. 50th percentile and annual average), clearly illustrating the contribution of emission sources not included in the dispersion model's emissions

inventory. Not shown in the table is the observed concentration at the percentile where the prediction was zero – considered to be the background or non-inventory ambient concentration - namely, 17.7 µg/m³ (average of 2010, 2011 and 2012).

Table 5-9: Comparison of predicted and observed SO₂ concentrations at Bosjesspruit monitoring station in Secunda

	Bosjesspruit			
	SO₂ Concentration (µg/m³)			Unaccounted Fraction*
	Predicted	Observed	Unaccounted	
Peak	519.7	547.1	27.4	5%
99th Percentile	124.7	204.1	79.4	39%
90th Percentile	2.8	58.8	56.0	96%
50th Percentile	0.0	7.9	7.9	100%
Annual Average	5.1	22.6	17.5	78%

* unaccounted fraction as a percentage of observed concentration

Table 5-10 is a summary of comparisons between predicted and observed SO₂ concentrations at Secunda Club. In contrast to Bosjesspruit, where the peak concentration was shown to be from Sasol operations, approximately 22% of the observed peak concentration was unaccounted for. Although this may still have resulted from the Sasol operations, it is also a possibility that another, even more localised source may have added to the observed peak.. A slightly lower concentration was predicted for the 99th percentile, which may be due to other sources in the Sasol complex or more remotely. The observed concentration at the zero prediction percentiles was determined to be 18.4 µg/m³ (average of 2010, 2011 and 2012).

Table 5-10: Comparison of predicted and observed SO₂ concentrations at Secunda Club monitoring station in Secunda

	Secunda Club			
	SO₂ Concentration (µg/m³)			Unaccounted Fraction
	Predicted	Observed	Unaccounted	
Peak	452.8	511.7	58.9	22%
99th Percentile	75.7	173.6	97.9	56%
90th Percentile	0.6	45.5	44.9	99%
50th Percentile	0.0	6.8	6.8	100%
Annual Average	2.7	18.4	15.7	85%

* unaccounted fraction as a percentage of observed concentration

Table 5-11 is a summary of comparisons between predicted and observed SO₂ concentrations at Langverwacht. Although not an exact match, the observed peak concentration was predicted to be from Sasol. In contrast to Secunda Club, the prediction was slightly higher than the observed peak concentration. As with the other two monitoring stations, the difference between prediction and observation increases significantly when considering long-term comparisons (i.e. 50th percentile and annual average). The observed concentration at the zero prediction percentiles was determined to be 16.5 µg/m³ (average of 2010, 2011 and 2012).

Table 5-11: Comparison of predicted and observed SO₂ concentrations at Langverwacht monitoring station in Secunda

	Langverwacht			
	SO₂ Concentration (µg/m³)			Unaccounted Fraction
	Predicted	Observed	Unaccounted	
Peak	576.6	493.3	0.0	0%
99th Percentile	79.8	164.8	85.1	52%
90th Percentile	0.4	44.4	44.0	99%
50th Percentile	0.0	7.1	7.1	100%
Annual Average	2.8	18.1	15.2	84%

* unaccounted fraction as a percentage of observed concentration

The performance evaluation was completed using the fractional bias method. Fractional bias is one of the evaluation methods recommended by the U.S. EPA for determining dispersion model performance (U.S. EPA 1992). Fractional bias provides a comparison of the means and standard deviation of both modelled and monitored concentrations for any given number of locations.

In this assessment, both short- and long-term fractional biases were computed. In this regards, the short- and long-term background concentrations were added to the predicted hourly and annual average concentrations prior to the calculation of the fractional bias. With the short-term fractional bias the 99th percentile (with background concentration for each year, as shown in Table 5-12) was compared to the same ranked monitored concentrations. The long-term fractional bias was based on the annual predicted mean and standard deviations (with estimated background concentration for each year) and observed concentrations.

Table 5-12: Estimated SO₂ background concentrations for Bosjesspruit, Secunda Club and Langverwacht

Year	SO₂ Concentration (µg/m³)					
	Bosjesspruit		Secunda Club		Langverwacht	
	Short-term	Long-Term	Short-term	Long-Term	Short-term	Long-Term
2010	35.8	16.3	110.6	22.4	81.1	17.1
2011	96.01	18.2	95.9	15.10	81.3	14.9
2012	106.3	18.7	97.9	17.35	92.9	17.54

In Figure 5-46, the fractional bias is plotted with the means on the X-axis and the standard deviations on the Y-axis. The box on the plot encloses the area of the graph where the model predictions are within a factor of two (corresponding to a fractional bias of between -0.67 and +0.67). The U.S. EPA states that predictions within a factor of two are a reasonable performance target for a model before it is used for refined regulatory analysis (U.S. EPA 1992). Data points appearing on the left half of the plot indicate an over-prediction and those on the right half of the plot represent under-predictions.

The fractional bias of the means for both short- and long-term predictions were less than 0.67, clearly showing good model performance (i.e. within a factor of two). Using the individual fractional biases, the model's prediction is shown to be well within a factor of two, with fractional biases of the mean ranging from 0.01 (Bosjesspruit, long-term) to 0.05 (Bosjesspruit, short-term), -0.04 (Secunda Club, short-term) to 0.13 (Secunda Club, long-term) and 0.15(Langverwacht, short-term) to -0.07 (Langverwacht, long-term).

The same calculations and comparisons were repeated for NO₂ predictions and observations. The CALPUFF predictions were specifically for NOₓ and the formation on HNO₃ and other nitrates using the MESOPUFF II chemical transformation mechanism, as discussed in Section 5.1.4.3.
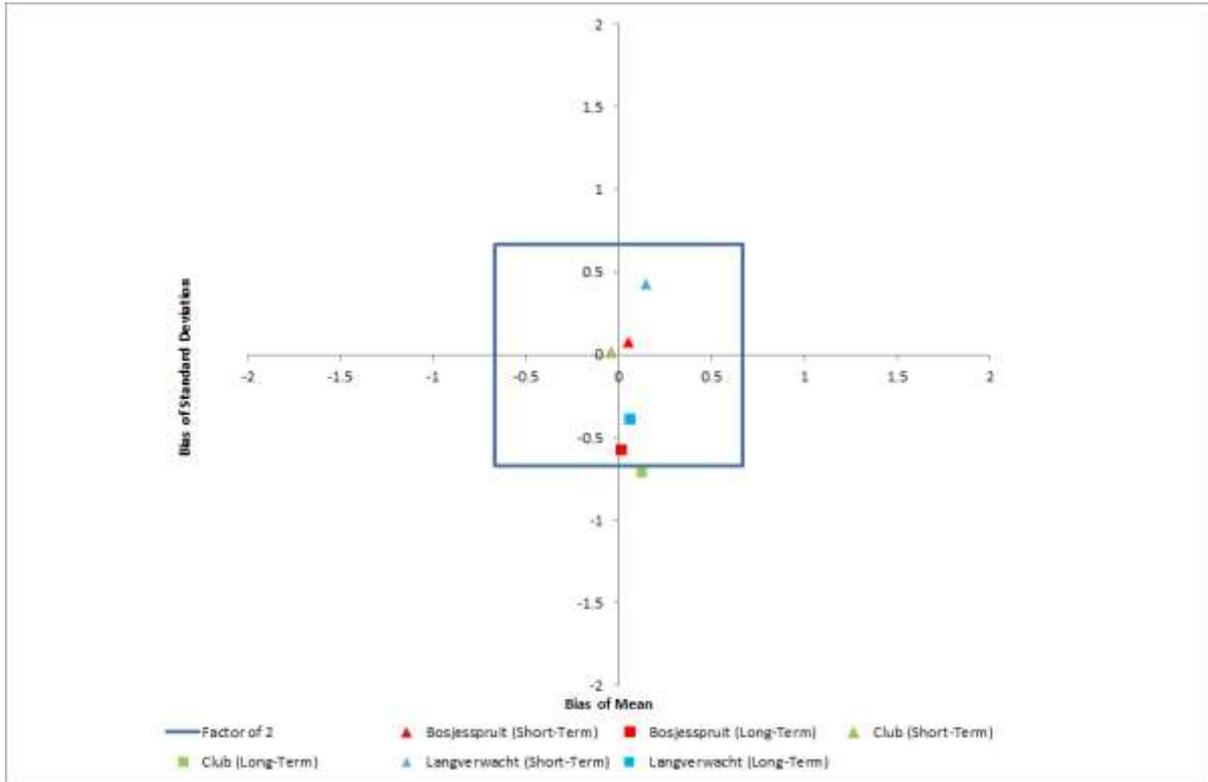
Figure 5-46: Fractional bias of means and standard deviation for SO₂

Table 5-12 is a summary of comparisons between predicted and observed NO_2 concentrations at Bosjesspruit. As shown in the table, significantly lower concentrations were predicted than the observed peak concentrations. This may be due to unaccounted NO_2 emitters as well as the rather simplistic methodology of applying a constant conversion rate from NO_x to NO_2 (Section 5.1.3.3). The 99th percentile compared better with only 19% unaccounted for in the observed concentrations. As for SO_2, the difference between prediction and observation increases significantly when considering long-term comparisons (i.e. 50th percentile and annual average), clearly illustrating the contribution of emission sources not included in the dispersion model's emissions inventory. Not shown in the table is the observed concentration at the percentile where the prediction was zero, namely 11.4 µg/m³ (average of 2010, 2011 and 2012).

Table 5-13: Comparison of predicted and observed NO₂ concentrations at Bosjespruit monitoring station in Secunda

	Bosjespruit			Unaccounted Fraction
	NO₂ Concentration (µg/m³)			
	Predicted	Observed	Unaccounted	
Peak	133.1	399.4	266.3	67%
99th Percentile	73.9	115.9	42.0	36%
90th Percentile	3.4	36.2	32.8	91%
50th Percentile	0.0	7.9	7.9	100%
Annual Average	3.0	15.5	12.5	81%

* unaccounted fraction as a percentage of observed concentration

Table 5-14 is a summary of comparisons between predicted and observed NO₂ concentrations at Secunda Club. Similar to Bosjespruit, the peak concentration observed was not predicted; however, the 99th percentile was relatively close to the observed value. Approximately 26% of the predicted concentration was unaccounted for in the observed concentrations. The observed concentration at the zero prediction percentiles was determined to be 14.4 µg/m³ (average of 2010, 2011 and 2012).

The predicted peak and 99th percentile NO₂ concentrations at Langverwacht (Table 5-17), compares more favourably than at Bosjespruit and Secunda Club. The observed 99th percentile concentration was also very similar to the predicted concentration with only a 15% difference. The observed concentration at the zero prediction percentiles was determined to be 22.6 µg/m³ (average of 2010, 2011 and 2012).

Table 5-14: Comparison of predicted and observed NO₂ concentrations at Secunda Club monitoring station in Secunda

	Secunda Club			Unaccounted Fraction
	NO₂ Concentration (µg/m³)			
	Predicted	Observed	Unaccounted	
Peak	117.5	351.4	233.9	67%
99th Percentile	44.8	91.2	46.4	51%
90th Percentile	0.9	43.5	42.6	98%
50th Percentile	0.0	13.4	13.4	100%
Annual Average	1.5	19.2	17.7	92%

* unaccounted fraction as a percentage of observed concentration

Table 5-15: Comparison of predicted and observed NO₂ concentrations at Langverwacht monitoring station in Secunda

	Langverwacht			Unaccounted Fraction
	NO₂ Concentration (µg/m³)			
	Predicted	Observed	Unaccounted	
Peak	149.4	178.5	29.1	16%
99th Percentile	44.4	77.1	32.7	42%
90th Percentile	1.7	42.9	41.2	96%
50th Percentile	0.0	14.6	14.6	100%
Annual Average	1.6	19.4	17.8	92%

* unaccounted fraction as a percentage of observed concentration

Background concentrations were estimated for short- and long-term concentrations for each of the three years of simulations, as summarised in Table 5-16.

Table 5-16: Estimated NO₂ background concentrations for Bosjesspruit, Secunda Club and Langverwacht

Year	NO₂ Concentration (µg/m³)					
	Bosjesspruit		Secunda Club		Langverwacht	
	Short-term	Long-Term	Short-term	Long-Term	Short-term	Long-Term
2010	39.6	16.7	44.3	18.1	38.4	17.3
2011	26.5	8.5	44.6	18.3	46.5	19.6
2012	32.2	12.3	38.9	16.7	38.9	16.4

Subsequently, short-term fractional biases (i.e. using the 99th percentile with background concentration for each year) as well as long-term fractional biases (i.e. annual concentrations with estimated background concentration for each year) were calculated for the three monitoring stations. The results are summarised in Figure 5-47.

Using the individual fractional biases of the means, the model's prediction is shown to be well within a factor of two, clearly showing good model performance, with fractional biases of the mean ranging from 0.04 (Bosjesspruit, long-term) to 0.10 (Bosjesspruit, short-term), 0.13 (Secunda Club, short-term) to 0.39 (Secunda Club, long-term) and 0.12 (Langverwacht, short-term) to 0.24 (Langverwacht, long-term).
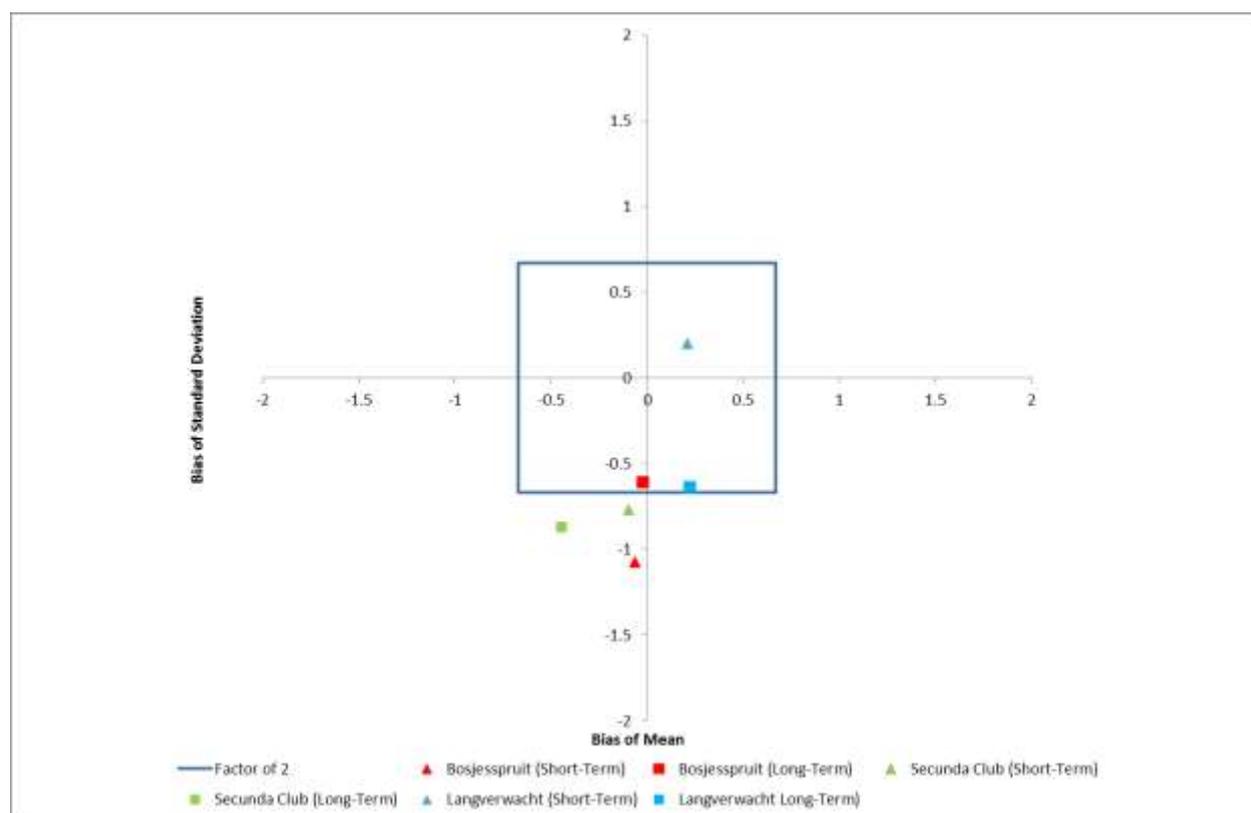
Figure 5-47: Fractional bias of means and standard deviation for NO₂

Table 5-17 is a summary of comparisons between predicted and observed H₂S concentrations at Bosjesspruit. Although the observed peak concentration was not predicted, the predicted 99th percentile was very close to the observed value. Based

on the 99th percentile, approximately 12% was unaccounted for in the observed concentrations. The observed concentration at the zero prediction percentiles was determined to be 4.2 µg/m³ (average of 2010, 2011 and 2012).

The predicted peak and 99th percentile H_2S concentrations at Secunda Club (Table 5-18), compares more favourably with observed concentrations. The observed 99th percentile concentration was slightly over predicted by the model and the peak observed concentration, under predicted by the model. The observed concentration at the zero prediction percentiles was determined to be 7.0 µg/m³ (average of 2010, 2011 and 2012).

Table 5-17: Comparison of predicted and observed H_2S concentrations at Bosjesspruit monitoring station in Secunda

	Bosjesspruit			
	H2S Concentration (µg/m³)			Unaccounted Fraction
	Predicted	Observed	Unaccounted	
Peak	255.3	409.7	154.4	38%
99th Percentile	61.2	84.3	10.3	27%
90th Percentile	0.0	0.9	0.9	100%
50th Percentile	0.0	0.9	0.9	100%
Annual Average	2.5	5.8	2.6	56%

* unaccounted fraction as a percentage of observed concentration

Table 5-18: Comparison of predicted and observed H_2S concentrations at Secunda Club monitoring station in Secunda

	Secunda Club			
	H2S Concentration (µg/m³)			Unaccounted Fraction
	Predicted	Observed	Unaccounted	
Peak	221.1	344.1	123.0	36
99th Percentile	38.0	43.8	5.8	13%
90th Percentile	0.0	2.6	2.6	100%
50th Percentile	0.0	2.6	2.6	100%
Annual Average	1.4	5.1	3.8	73%

* unaccounted fraction as a percentage of observed concentration

Table 5-19 is a summary of predicted H_2S concentrations compared with the observed concentrations at Langverwacht. Different from the other two monitoring locations, the peak concentration was significantly under-predicted by the model, but the 99th percentile was relatively close to the observed value. Based on the 99th percentile, approximately 29% of the observed concentration was unaccounted for. The observed concentration at the zero prediction percentiles was determined to be 16.1 µg/m³ (average of 2010, 2011 and 2012).

Table 5-19: Comparison of predicted and observed H₂S concentrations at Langverwacht monitoring station in Secunda

	Langverwacht			
	H₂S Concentration (µg/m³)			Unaccounted Fraction
	Predicted	Observed	Unaccounted	
Peak	282.8	572.5	289.7	51%
99th Percentile	40.9	74.4	33.5	45%
90th Percentile	0.0	3.1	3.1	100%
50th Percentile	0.0	3.1	3.1	100%
Annual Average	1.4	9.1	7.7	84%

* unaccounted fraction as a percentage of observed concentration

Background concentrations were estimated for short- and long-term concentrations for each of the three years of simulations, as summarised in Table 5-20.

Table 5-20: Estimated H₂S background concentrations for Bosjesspruit, Secunda Club and Langverwacht

Year	H₂S Concentration (µg/m³)					
	Bosjesspruit		Secunda Club		Langverwacht	
	Short-term	Long-Term	Short-term	Long-Term	Short-term	Long-Term
2010	5.9	0.9	9.9	3.2	22.9	8.9
2011	15.0	65.4	10.6	4.6	24.6	7.1
2012	0.0	0.0	10.8	3.4	24.4	7.0

The short-term fractional biases (i.e. using the 99th percentile with background concentration for each year) as well as long-term fractional biases (i.e. annual concentrations with estimated background concentration for each year) were calculated for the three monitoring stations. The results are summarised in Figure 5-48.

Using the individual fractional biases of the means, the model's prediction is shown to be well within a factor of two, with fractional biases of the mean ranging from 0.28 (Bosjesspruit, long-term) to 0.37 (Bosjesspruit, short-term), 0.07 (Secunda Club, short-term) to 0.53 (Secunda Club, long-term) and 0.04 (Langverwacht, short-term) to 0.65 (Langverwacht, long-term).
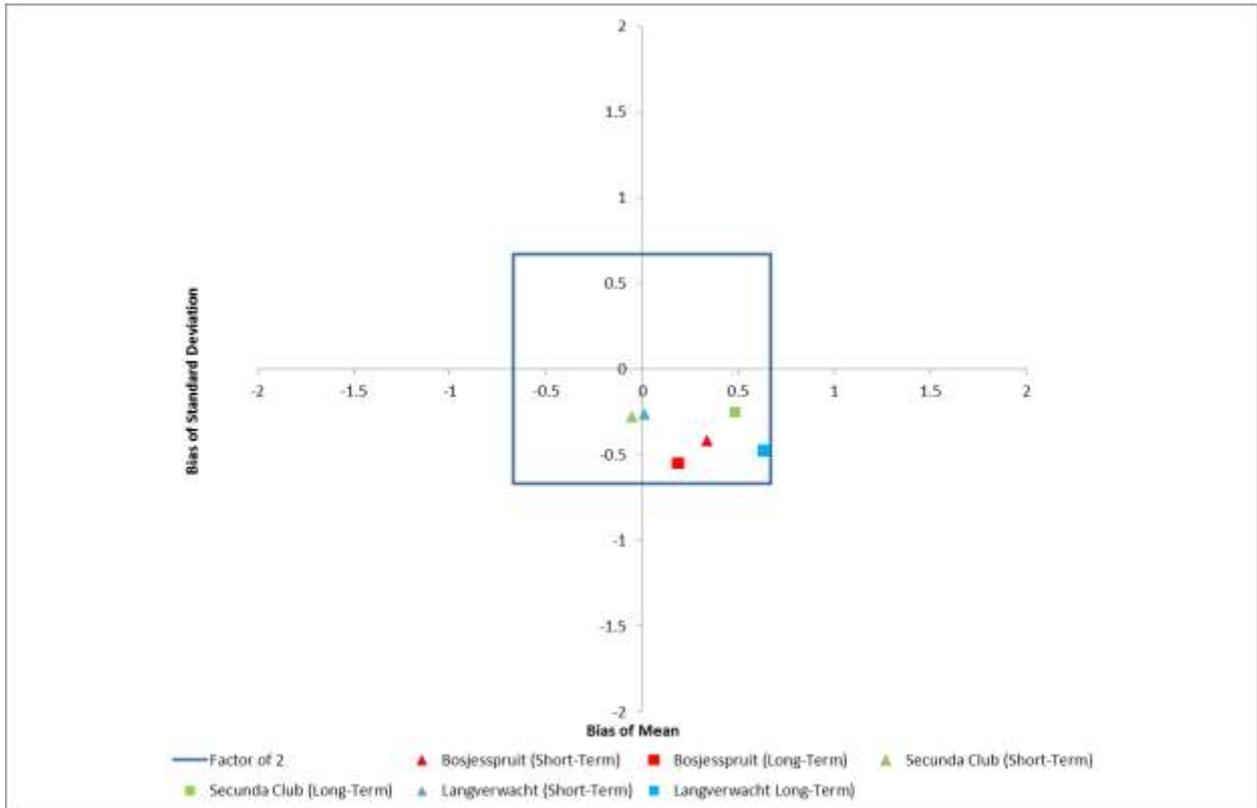
Figure 5-48: Fractional bias of means and standard deviation for H$_2$S

5.1.7 Scenario Emission Inventory

The source parameters and emissions per scenario were provided by Sasol for the assessment and are given in Table 5-21 and Table 5-22 respectively. It is important to note that scenarios for compliance with existing and new plant standards were prepared for all point sources, whether or not Sasol deemed compliance to be feasible or not, and hence these construe theoretical abatement outcomes. The motivation reports for Sasol's postponement applications outline reasons for which Sasol believes these theoretical point source reductions cannot be achieved.

Table 5-21: Source parameters per scenario provided for Sasol Secunda facility

Source Group	Source name	Height of Release Above Ground (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)
Scenario 1 – Baseline emissions						
Steam Stations	Main Stack East	301	14.4	185	11870000	20.2
	Main Stack West	250	13.6	185	10558000	20.2
Sulfur	Sulfur recovery	301	14.4	185	11870000	20.2

Source Group	Source name	Height of Release Above Ground (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)
Recovery	East					
	Sulfur recovery West	250	13.6	185	10558000	20.2
HOW Incinerators	HOW West	15	1.9	354	211588.324	19.9
	HOW East	15	1.9	386	183686.66	18.0
Biosludge Incinerators	Biosludge East	30	1.4	66	91616.9532	15.7
		30	1.4	65	87230.7939	15.8
	Biosludge West	30	1.4	68	74985.3274	13.5
		30	1.4	61	81082.8619	14.7
WSA	WSA	75	2.75	41	206600	9.7
Rectisol	Rectisol East	301	14.4	185	11870000	20.2
	Rectisol West	250	13.6	185	10558000	20.2
SCC	SCC	90	3.6	190	314135	8.6
Scenario 2a – Compliance with Existing Plant Standards						
Steam Stations	Main Stack East	301	14.4	185	11870000	20.2
	Main Stack West	250	13.6	185	10558000	20.2
Sulfur Recovery	Sulfur recovery East	301	14.4	185	11870000	20.2
	Sulfur recovery West	250	13.6	185	10558000	20.2
HOW Incinerators	HOW West	15	1.9	354	211588	19.9
	HOW East	15	1.9	386	183687	18.0
Biosludge Incinerators	Biosludge East	30	1.4	66	91617	15.7
		30	1.4	65	87231	15.8
	Biosludge West	30	1.4	68	74985	13.5
		30	1.4	61	81083	14.7
WSA	WSA	75	2.75	41	206600	9.7
Rectisol	Rectisol East	301	14.4	185	11870000	20.2
	Rectisol West	250	13.6	185	10558000	20.2
SCC	SCC	90	3.6	190	314135	8.6
Scenario 2b – Compliance with New Plant Standards						
Steam Stations	Main Stack East	301	14.4	75	9019127	15.4
	Main Stack West	250	13.6	75	8022236	15.3
Sulfur Recovery	Sulfur recovery East	301	14.4	75	9019127	15.3

Source Group	Source name	Height of Release Above Ground (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)
	Sulfur recovery West	250	13.6	75	8022236	15.3
HOW Incinerators	HOW West	15	1.9	354	211588	19.9
	HOW East	15	1.9	386	183687	18.0
Biosludge Incinerators	Biosludge East	30	1.4	66	91617	15.7
		30	1.4	65	87231	15.8
	Biosludge West	30	1.4	68	74985	13.5
		30	1.4	61	81083	14.7
WSA	WSA	75	2.75	41	206600	9.7
Rectisol	Rectisol East	301	14.4	185	11870000	20.2
	Rectisol West	250	13.6	185	10558000	20.2
SCC	SCC	90	3.6	190	314135	8.6
Scenario 3 – Alternative Emission Limits						
Steam Stations	Main Stack East	301	14.4	185	11870000	20.2
	Main Stack West	250	13.6	185	10558000	20.2
Sulfur Recovery	Sulfur recovery East	301	14.4	185	11870000	20.2
	Sulfur recovery West	250	13.6	185	10558000	20.2
HOW Incinerators	HOW West	15	1.9	354	211588	19.9
	HOW East	15	1.9	386	183687	18.0
Biosludge Incinerators	Biosludge East	30	1.4	66	91617	15.7
		30	1.4	65	87231	15.8
	Biosludge West	30	1.4	68	74985	13.5
		30	1.4	61	81083	14.7
WSA	WSA	75	2.75	41	206600	9.7
Rectisol	Rectisol East	301	14.4	185	11870000	20.2
	Rectisol West	250	13.6	185	10558000	20.2
SCC	SCC	90	3.6	190	314135	8.6

Table 5-22: Source emissions per scenario provided for Sasol Secunda facility

Source Group	Source name	Particulates (g/s)	SO$_2$ (g/s)	NO$_x$ (g/s)	Sum of Pb, As, Sb, Cr, Co, Cu, Mn, Ni, V (g/s)	Hg (g/s)	Cd+Tl (g/s)	HF (g/s)	NH$_3$ (g/s)	HCl (g/s)	H$_2$S (g/s)	SO$_3$ (g/s)	VOCs (benzene) (g/s)	H$_2$SO$_4$ (g/s)
Scenario 1 – Baseline emissions														
Steam Stations	Main Stack East	70.06	2 899.19	1 939.08										
	Main Stack West	62.32	2 578.74	1 725.55										
Sulfur Recovery	Sulfur recovery East										1 401.22			
	Sulfur recovery West										1 246.34			
HOW Incinerators	HOW West	1.62	0.06	7.31	0.14	0.00063	0.00022	0.03	0.01	0.05				
	HOW East	0.61	0.12	6.83	0.03	0.00005	0.00005	0.03	0.00	0.03				
Biosludge Incinerators	Biosludge East	1.40	0.07	1.95	0.06	-	0.00074	0.06	0.09	0.03				
		1.16	0.40	1.98	0.06	-	0.00022	0.05	0.11	0.02				
	Biosludge West	0.30	0.10	0.26	0.01	-	0.00053	0.06	0.09	0.03				
		1.17	0.03	4.39	0.03	-	0.00033	0.05	0.11	0.02				
WSA	WSA		10.67					0.01	0.003	0.06		3.13		0.27
Rectisol	Rectisol East												2.00	
	Rectisol West												10.00	
SCC	SCC	10.60												
Scenario 2a – Compliance with Existing Plant Standards														
Steam Stations	Main Stack East	166.81	5 838.42	1 834.89										
	Main Stack West	148.37	5 193.09	1 632.08										
Sulfur Recovery	Sulfur recovery East										700.61			
	Sulfur recovery West										623.17			

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Source Group	Source name	Particulates (g/s)	SO_2 (g/s)	NO_x (g/s)	Sum of Pb, As, Sb, Cr, Co, Cu, Mn, Ni, V (g/s)	Hg (g/s)	Cd+Tl (g/s)	HF (g/s)	NH_3 (g/s)	HCl (g/s)	H_2S (g/s)	SO_3 (g/s)	VOCs (benzene) (g/s)	H_2SO_4 (g/s)
HOW Incinerators	HOW West	0.54	1.09	4.34	0.01	0.00109	0.00109	0.02	0.22	0.22				
	HOW East	0.45	0.90	3.59	0.01	0.00090	0.00090	0.02	0.18	0.18				
Biosludge Incinerators	Biosludge East	0.43	0.87	3.48	0.01	0.00087	0.00087	0.02	0.17	0.17				
		0.42	0.83	3.32	0.01	0.00083	0.00083	0.02	0.17	0.17				
	Biosludge West	0.35	0.71	2.83	0.01	0.00071	0.00071	0.01	0.14	0.14				
		0.39	0.78	3.13	0.01	0.00078	0.00078	0.02	0.16	0.16				
WSA	WSA		10.67					0.01	0.003	0.06		2.49		0.27
Rectisol	Rectisol East												42.0	
	Rectisol West												37.0	
SCC	SCC	4.87												
Scenario 2b – Compliance with New Plant Standards														
Steam Stations	Main Stack East	83.41	834.06	1 251.09										
	Main Stack West	74.19	741.87	1 112.81										
Sulfur Recovery	Sulfur recovery East										443.62			
	Sulfur recovery West										394.58			
HOW Incinerators	HOW West	0.22	1.09	4.34	0.01	0.00109	0.00109	0.02	0.22	0.22				
	HOW East	0.18	0.90	3.59	0.01	0.00090	0.00090	0.02	0.18	0.18				
Biosludge Incinerators	Biosludge East	0.17	0.87	3.48	0.01	0.00087	0.00087	0.02	0.17	0.17				
		0.17	0.83	3.32	0.01	0.00083	0.00083	0.02	0.17	0.17				
	Biosludge West	0.14	0.71	2.83	0.01	0.00071	0.00071	0.01	0.14	0.14				
		0.16	0.78	3.13	0.01	0.00078	0.00078	0.02	0.16	0.16				
WSA	WSA		8.71					0.06	0.004	0.19		0.62		0.27

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Source Group	Source name	Particulates (g/s)	SO$_2$ (g/s)	NO$_x$ (g/s)	Sum of Pb, As, Sb, Cr, Co, Cu, Mn, Ni, V (g/s)	Hg (g/s)	Cd+Tl (g/s)	HF (g/s)	NH$_3$ (g/s)	HCl (g/s)	H$_2$S (g/s)	SO$_3$ (g/s)	VOCs (benzene) (g/s)	H$_2$SO$_4$ (g/s)
Rectisol	Rectisol East												21.7	
	Rectisol West												19.3	
SCC	SCC	4.06												
Scenario 3 – Alternative Emission Limits														
Steam Stations	Main Stack East	216.86	3 336.24	3 574.60										
	Main Stack West	192.89	2 967.48	3 179.49										
Sulfur Recovery	Sulfur recovery East (without WSA)										2 085.15			
	Sulfur recovery West (without WSA)										1 854.68			
	Sulfur recovery East (with WSA)										1 584.71			
	Sulfur recovery West (with WSA)										1 409.55			
HOW Incinerators	HOW West	30.37	1.09	81.42	0.46	0.006	0.003	0.152	0.217	0.217				
	HOW East	25.08	0.90	67.25	0.38	0.005	0.002	0.126	0.179	0.179				
Biosludge Incinerators	Biosludge East	15.48	2.61	17.04	0.04	0.015	0.001	0.487	0.818	0.487				
		14.78	2.49	16.27	0.04	0.014	0.001	0.465	0.781	0.465				
	Biosludge West	12.60	2.12	13.87	0.03	0.012	0.001	0.396	0.665	0.396				
		13.91	2.34	15.31	0.04	0.013	0.001	0.438	0.734	0.438				
WSA	WSA		10.67					0.015	0.003	0.06		3.94		
Rectisol	Rectisol East												50.0	
	Rectisol West												44.5	
SCC	SCC	13.40												

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Air quality standards are fundamental tools to assist in air quality management. The National Ambient Air Quality Standards (NAAQS) (Section 5.1.2.2) are intended to reduce harmful effects on health of the majority of the population, including the very young and the elderly. In this section, predicted ambient concentrations of criteria pollutants at specific sensitive receptors are compared against the promulgated local NAAQS (Table 5-2). Predicted ambient concentrations of non-criteria pollutants (for which NAAQS are not specified) at specific sensitive receptors, are compared against appropriate international health effect screening levels (listed in Table 5-27).

Prior to dispersion modelling, fifteen receptors were identified in the vicinity of the Secunda operations (within the 50-by-50 km modelling domain). Sensitive receptors included residential areas, ambient air quality monitoring stations and points of maximum predicted pollutant concentrations (Figure 5-49 and Table 5-23). Ambient air quality monitoring stations were the first receptors identified because comparison of the predicted concentrations could be compared with measured concentrations for model validation. Residential areas, both close to the point sources and further away, were then selected. After an initial model screening process, predicted points of maximum concentrations of criteria pollutants were included as sensitive receptors in all dispersion modelling. Grid intercept points corresponding with the identified receptors were given code names such as GR1 (Grid Receptor 1). Receptor code names have been included in figures and tables for the sake of brevity. Receptors are presented in the figures and tables in increasing distance from the main source of pollutants – the Steam Stations. In response to stakeholder comments, schools and clinics within the domain were identified and are now included in the sensitive receptor map (Figure 5-49) and in the isopleth plots in Section 5.1.8.
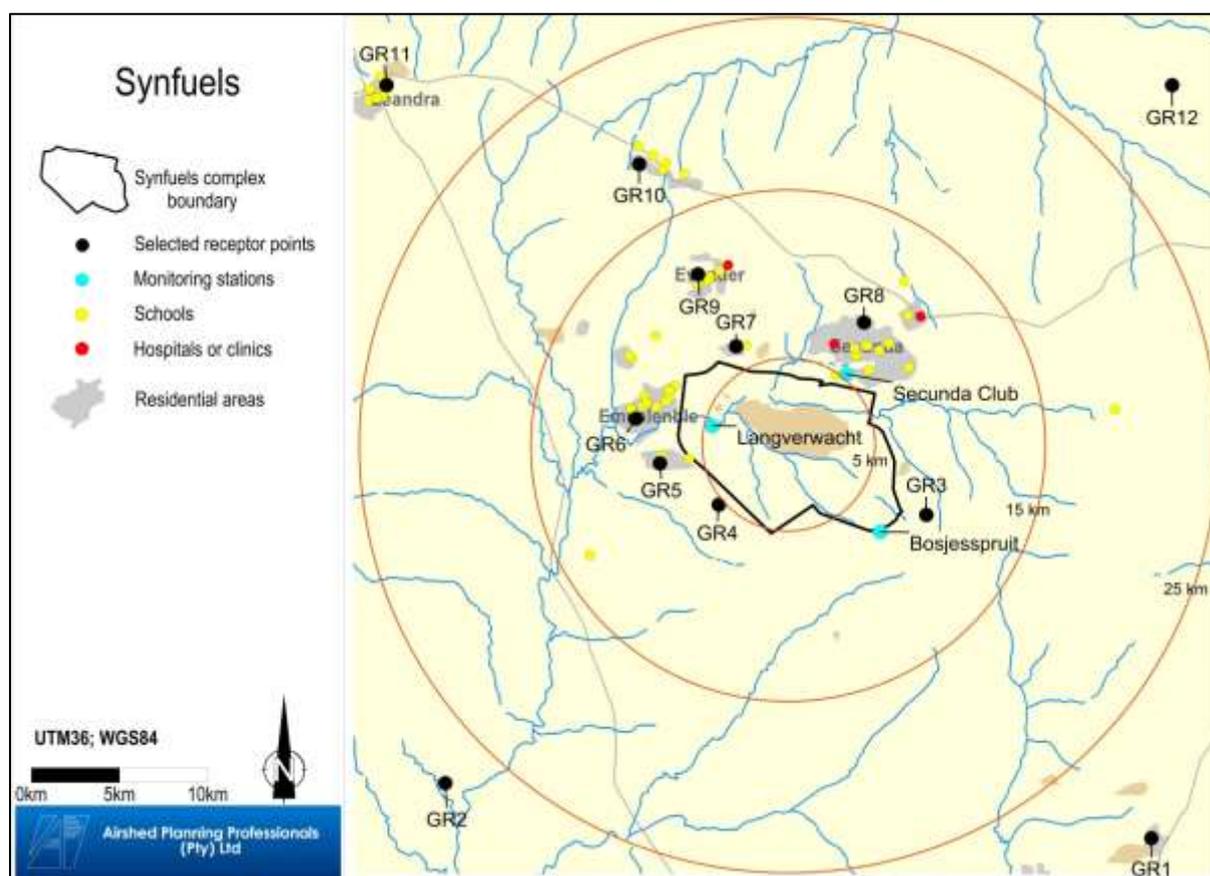
Figure 5-49: Receptors identified for assessment of impact as a result of Secunda operations

Table 5-23: Receptors identified for assessment of impact as a result of Secunda operations

Receptor code name [a]	Receptor details	Distance from source (metres)[b]
Langverwacht	SASOL Langverwacht monitoring station	4717.714
Secunda Club	SASOL Secunda Club monitoring station	4970.651
GR4	Edge of plume (ash disposal facility)	5648.012
GR7	Winkelhaak Mines	6394.214
Bosjessspruit	SASOL Bosjesspruit monitoring station	7324.395
GR5	Embalenhle - point of maximum predicted concentrations	7775.289
GR8	Northern boundary of Secunda	8041.975
GR3	Point of maximum predicted concentrations near Bosjesspruit	8851.271
GR6	Embalenhle (residential area)	9157.673
GR9	Evander (residential area)	11130.76
GR10	Kinross (residential area)	18376.47
GR2	SW (Edge of domain)	28262.32
GR12	NE (Edge of domain)	30158.32
GR1	SE (Edge of domain)	31042.69
GR11	NW (Edge of domain) Leandra (residential area)	31289.15

(a)　Code names used in Figures and Tables for brevity

(b)　Figures and tables present findings for receptors in increasing distance from site

Since the focus of the study is to illustrate the relative changes in ambient concentrations of pollutants theoretically arising from different point source emission scenarios, the predicted concentration differences from scenario to scenario were provided as percentages increase or decrease over the modelled baseline scenario ($C_{Baseline\ Scenarrio}$). However, these percentages need to also include concentrations attributable to other sources not accommodated in the model ($C_{Background}$). The change in concentration from any of the future source or source group scenario ($C_{S,\ Future\ Scenario}$) compared to the baseline source or source group scenario ($C_{S,\ Baseline\ Scenario}$) was therefore expressed as follows:

$$\frac{C_{S,\ Future\ Scenario} - C_{S,\ Baseline\ Scenario}}{C_{Baseline\ Scenario} + C_{Background}}$$

Equation 1

The average long-term background concentrations, as given in Table 5-24, were used in this expression rather than the short-term value. If the short-term background concentrations were to be used instead (i.e. a higher value), the comparison would be less optimistic since the denominator would be larger and the fraction therefore smaller. This offers a more conservative approach.

It should be noted that the changes in ground-level concentrations, at the receptors, between the scenarios shown in the results: (1) are theoretical changes and may not necessarily be technically possible, and; (2) represent the maximum achievable improvements and are, therefore, not indicative of the day-to-day average reduction at every receptor point cumulatively.

Table 5-24: Estimated background concentrations of SO₂, NO₂ and PM₁₀ for use in predicted concentration changes between scenarios

Monitoring Station	Background Concentration (µg/m³)			
	SO_2	NO_2	PM_{10}	H_2S
Bosjesspruit	18.2	11.4		57.5
Secunda Club	18.4	14.4	78.0	44.9
Langverwacht	16.5	22.6	123.2	75.6
Average	*17.7*	*16.1*	*100.6*	*59.3*

5.1.8.1 Criteria pollutants

The findings for each of the criteria pollutants (SO_2, NO_2 and PM) are presented for each of the sources or source groups identified in two figures. The first figure presents the predicted pollutant concentration (99th percentile) at the identified receptors (Table 5-23) for each of the emission scenarios (baseline operating conditions, emissions in theoretical compliance with Existing Plant Standards [2015] and New Plant Standards [2020], and the Alternative Emission Limits) relative to the appropriate NAAQS. The second figure presents the theoretical percentage change in ground-level concentrations between the emission scenarios. The predicted frequency of exceedance of NAAQS is provided in a table for all source groups comparing the impact as a result of the emission scenarios.

For the Secunda operations, the source groups are:

- Steam Stations (as the combined impact of both Main Stack East and Main Stack West)
- Biosludge Incinerators (as the combined impact of Biosludge East 1 & 2, Biosludge West 1 & 2)
- HOW (high organic waste) Incinerators (as the combined impact of Incinerator HOW East and HOW West)
- Wet Sulfuric Acid plant (acid mist and SO_3)
- SCC (particulates)
- Sulfur recovery units (H_2S)
- Rectisol (VOCs)

The following sections focus on predicted short-term impacts. Long-term impacts are addressed in Appendix I.

Isopleth plots have included for the Baseline Emissions and Alternative Emission Limit scenarios for the Steam Station emissions of SO_2, NO_2, PM, and H_2S.

5.1.8.1.1 Sulfur Dioxide (SO_2)

Ambient concentrations of SO_2 as a result of Secunda baseline operations (Figure 5-50) were predicted to fall below the hourly NAAQS, where impact on nearby receptors is mainly a result of emissions from the Steam Stations (Figure 5-51). If Sasol were theoretically able to comply with New Plant Standards for its Steam Station boilers, ambient SO_2 concentrations would be expected to drop below 75 µg/m³ at all receptors (Figure 5-51), resulting in a 20% or greater improvement relative to the airshed baseline (Figure 5-52). At Alternative Emission Limits ambient SO_2 concentrations were predicted to be less than 150 µg/m³, at all except two (Bosjesspruit and GR3) receptors (Figure 5-50 and Figure 5-51); equivalent to an increase of SO_2 ambient concentrations, relative to the airshed baseline, between 7.5% and 20.4% depending on the receptor (Figure 5-52). Despite this increase compliance with the NAAQS was predicted.

Isopleth plots are presented for the predicted 99th percentile hourly ground-level SO$_2$ concentrations as a result of the Baseline (Figure 5-59) and Alternative Emission Limits (Figure 5-60) from the Steam Stations. The maximum predicted 99th percentile ground-level concentrations were below the NAAQ limit concentration and as such the level presented in both figures represents 29% of the hourly limit (100 µg/m^3).
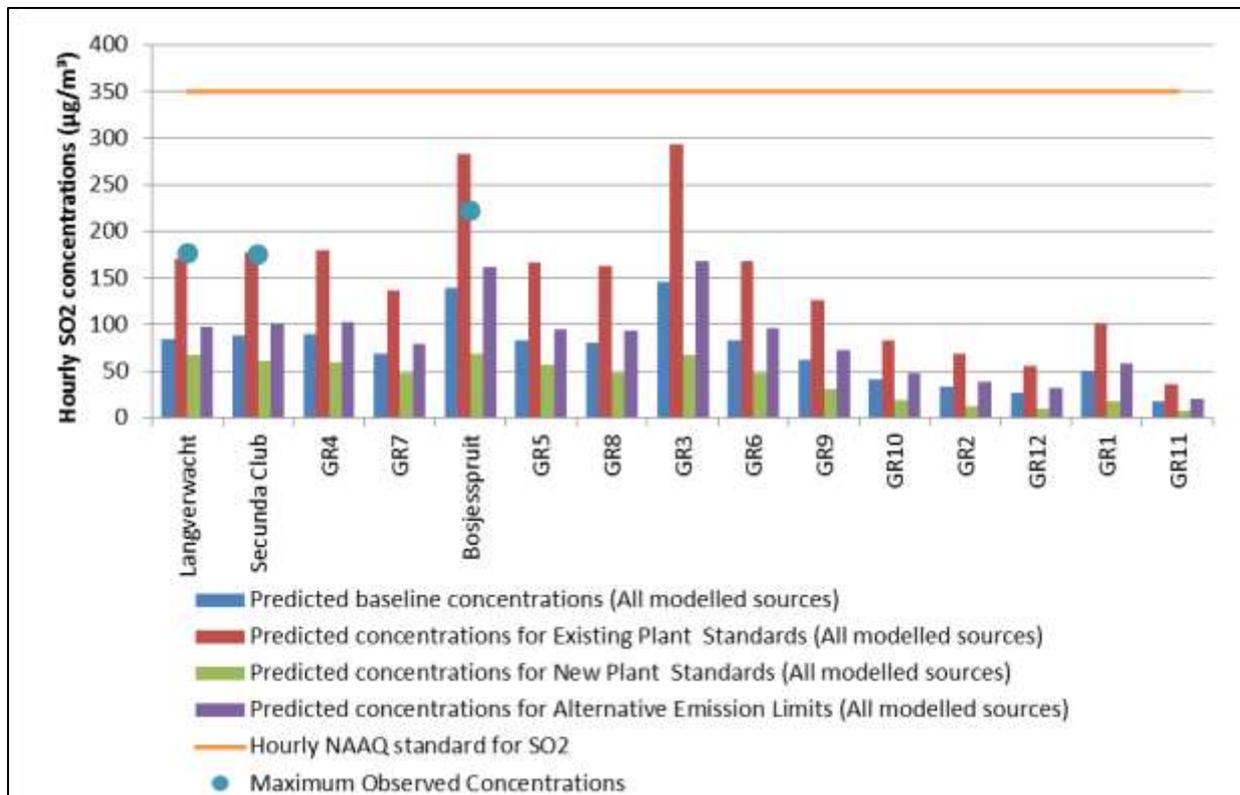
Figure 5-50: Predicted 99th percentile hourly SO$_2$ concentration at identified receptors for all modelled Synfuels sources (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
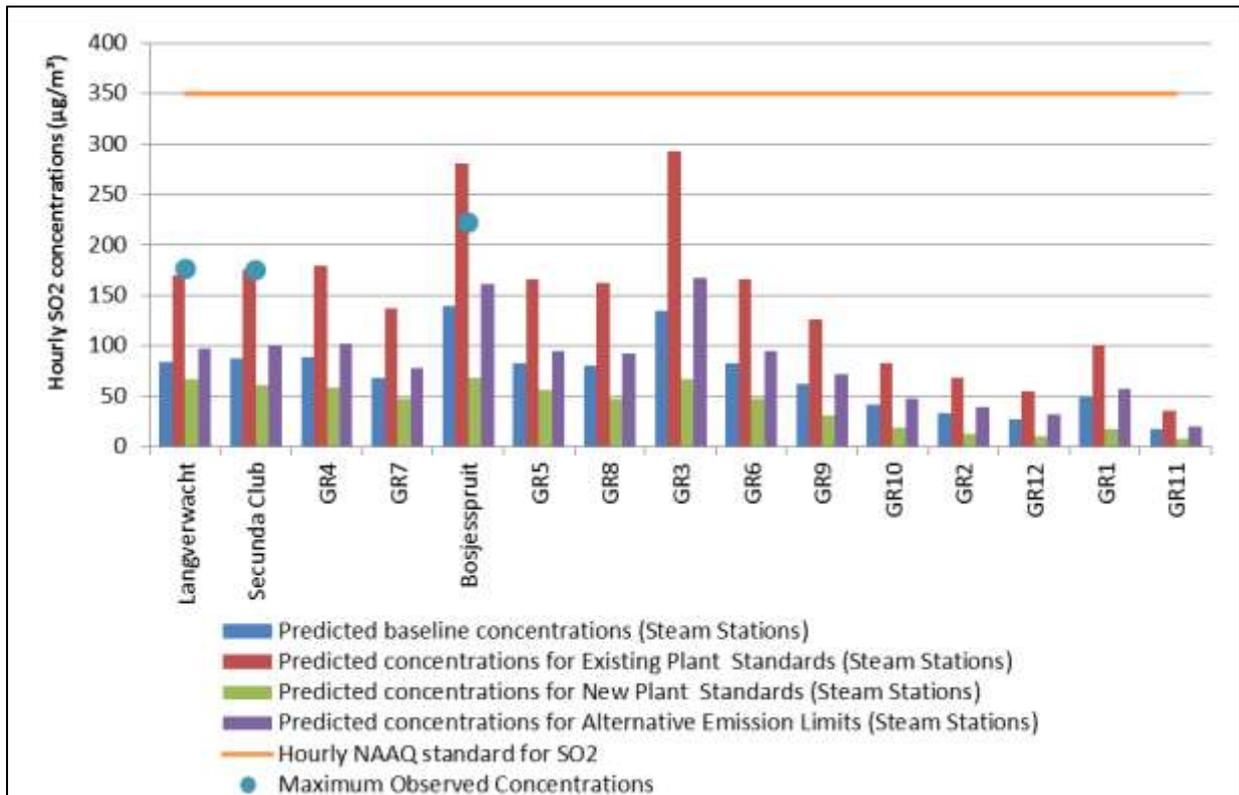
Figure 5-51: Predicted 99th percentile hourly SO₂ concentration at identified receptors for Synfuels Steam Stations (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
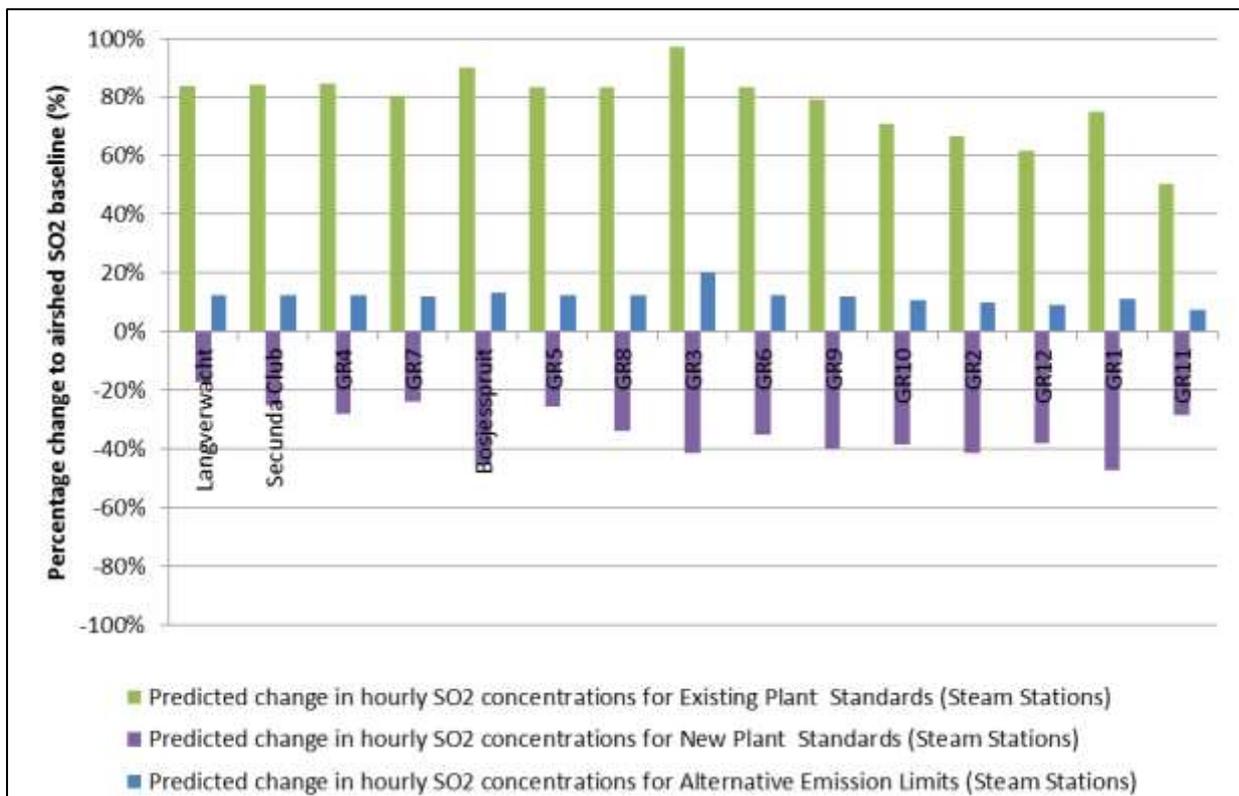
Figure 5-52: Theoretical change in SO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels Steam Stations (change calculated using Equation 1)

Impacts on ambient SO$_2$ concentrations as a result of the Biosludge and HOW incinerators are expected to be minimal compared with the Steam Stations (Figure 5-54, and Figure 5-56), where concentrations at all receptors for all scenarios are predicted to be less than 10 µg/m^3. Theoretical compliance with Existing and New Plant Standards for the incinerators will result in small increases in ambient SO$_2$ concentrations (~2% - Figure 5-55 and Figure 5-56), due to higher permitted emission rates compared with the current baseline operating emissions. At the Alternative Emission Limits, increased emissions from the Biosludge Incinerators were predicted to result in increased ambient SO$_2$ concentrations, by an average of 4%, relative to the airshed baseline.

Predicted ambient SO$_2$ concentrations as a result of emissions from the Wet Sulfuric Acid Plant were predicted to be less than 2 µg/m^3 for all scenarios (Figure 5-57) where theoretical compliance with New Plant Standards would results in less than a 1% improvement to the airshed baseline (Figure 5-58).
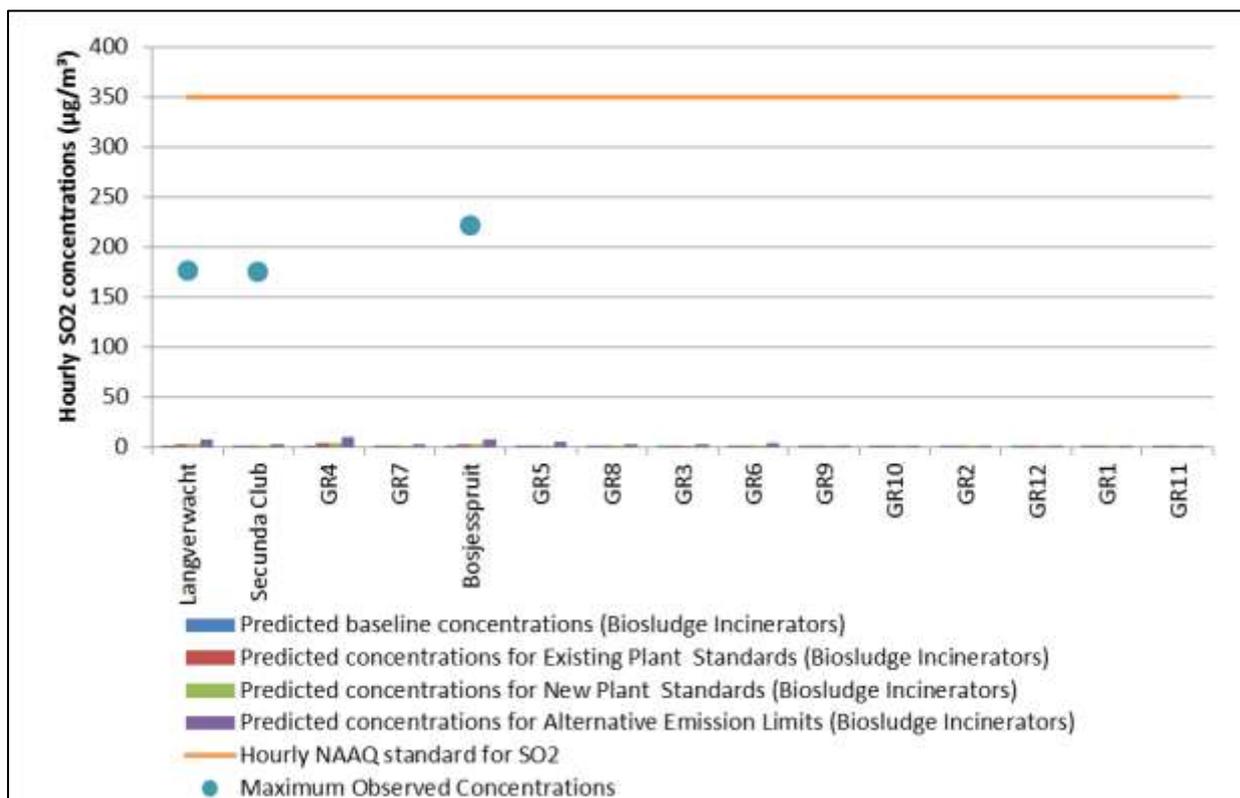
Figure 5-53: Predicted 99th percentile hourly SO$_2$ concentration at identified receptors for Synfuels Biosludge Incinerators (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
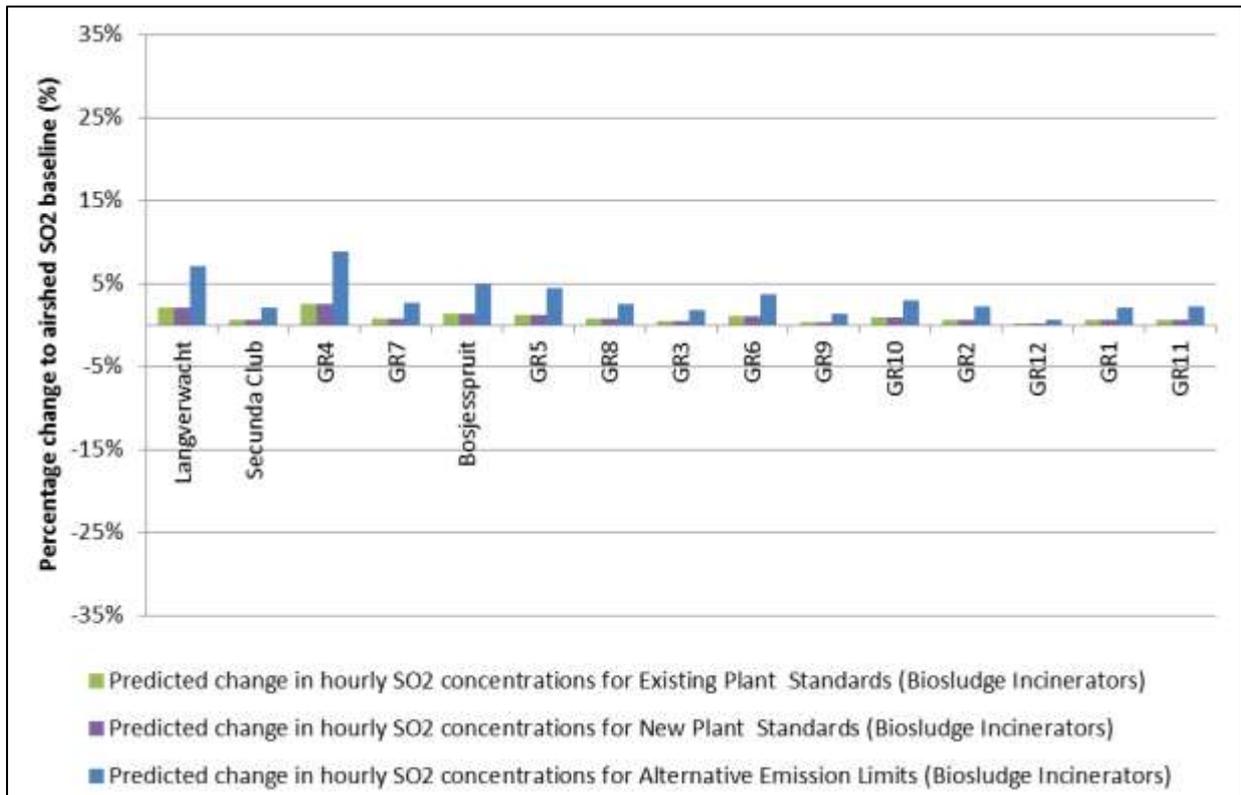
Figure 5-54: Theoretical change in SO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Sunfuels Biosludge Incinerators (change calculated using Equation 1)
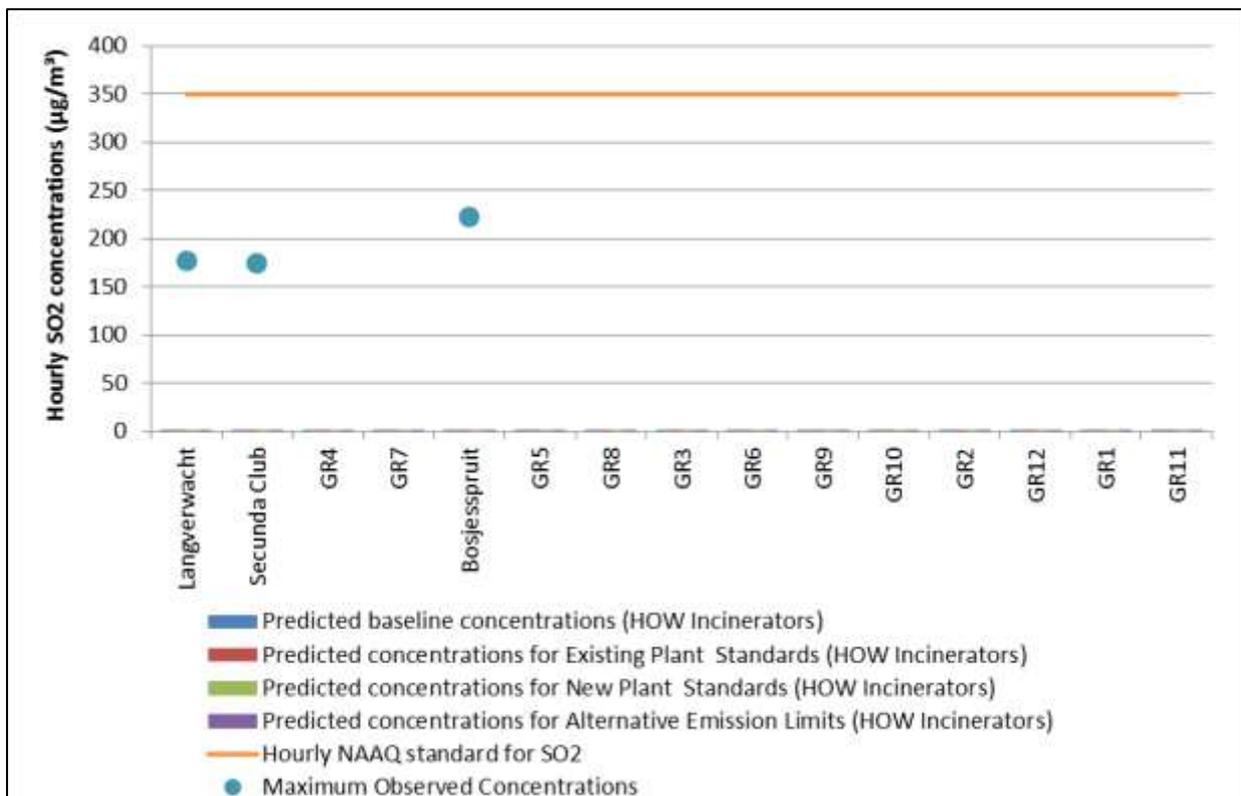
Figure 5-55: Predicted 99th percentile hourly SO₂ concentration at identified receptors for Synfuels HOW Incinerators (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
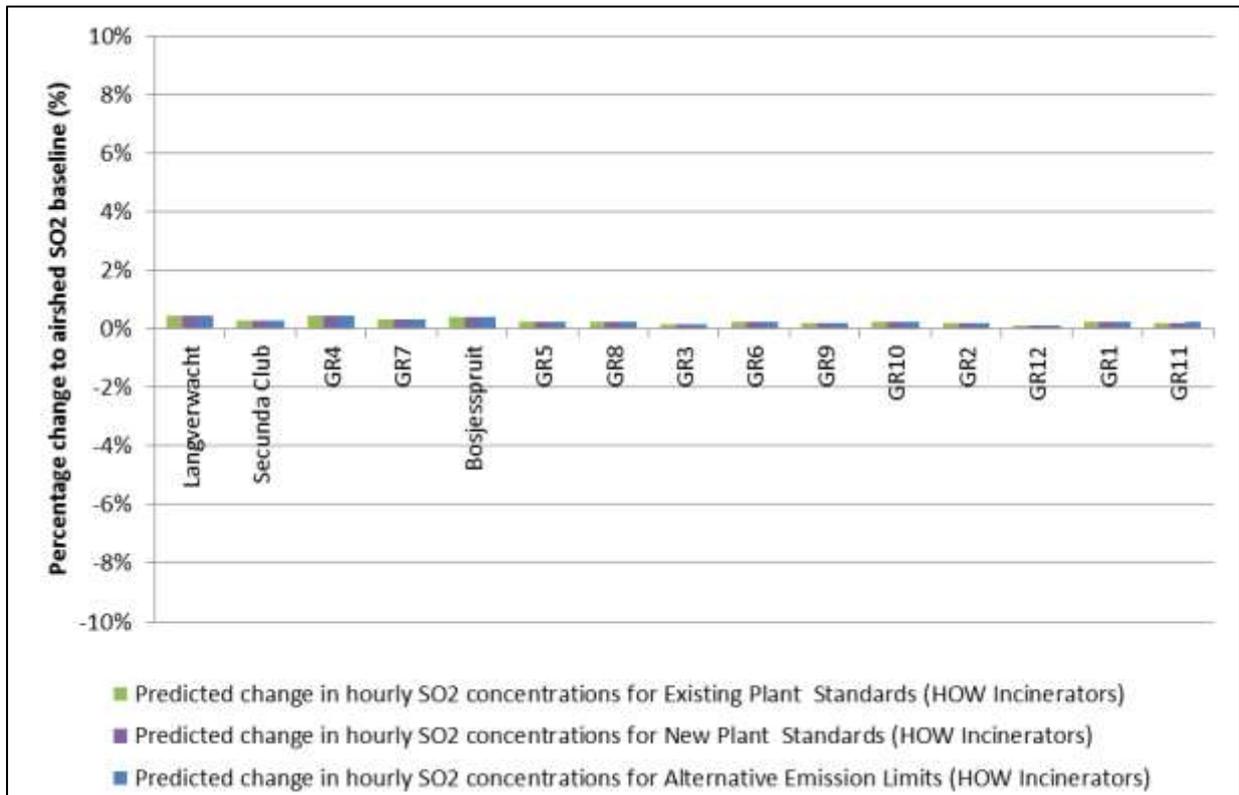
Figure 5-56: Theoretical change in SO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels HOW Incinerators (change calculated using Equation 1)
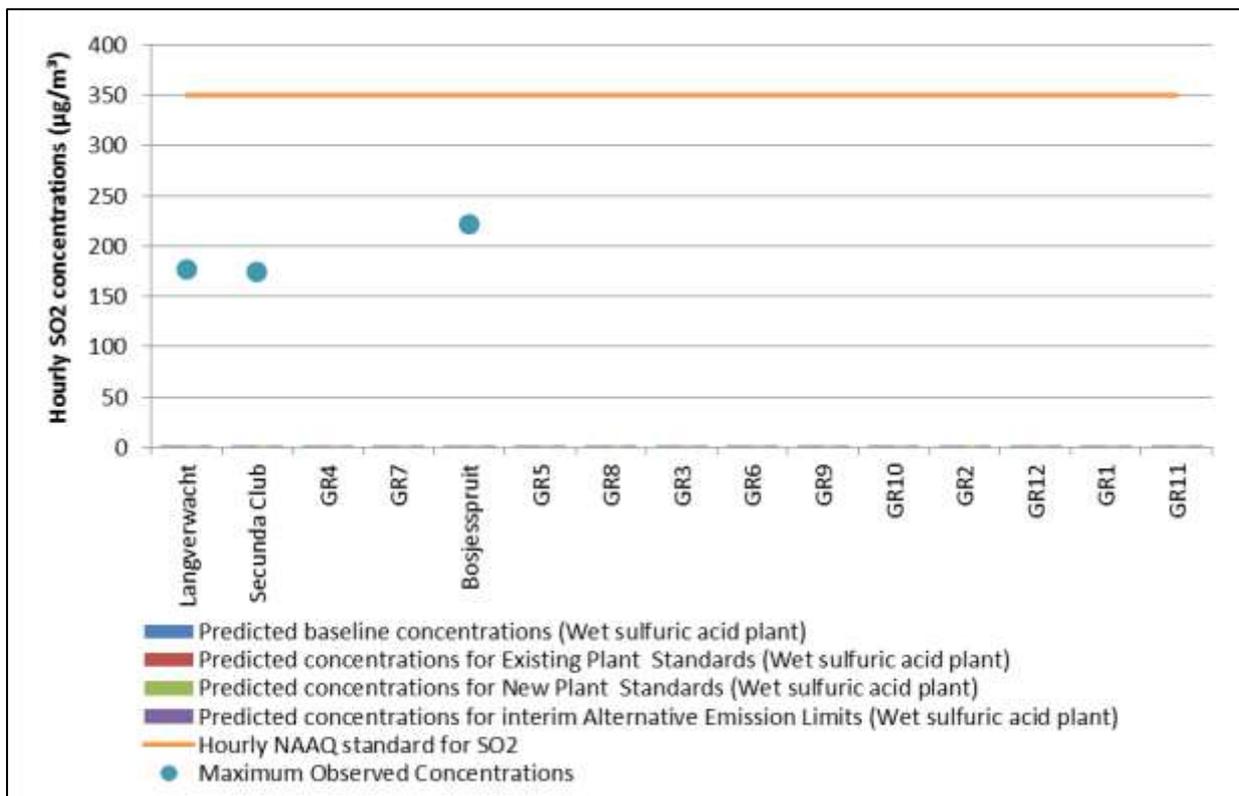
Figure 5-57: Predicted 99th percentile hourly SO₂ concentration at identified receptors for Synfuels Wet Sulfuric Acid Plant (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
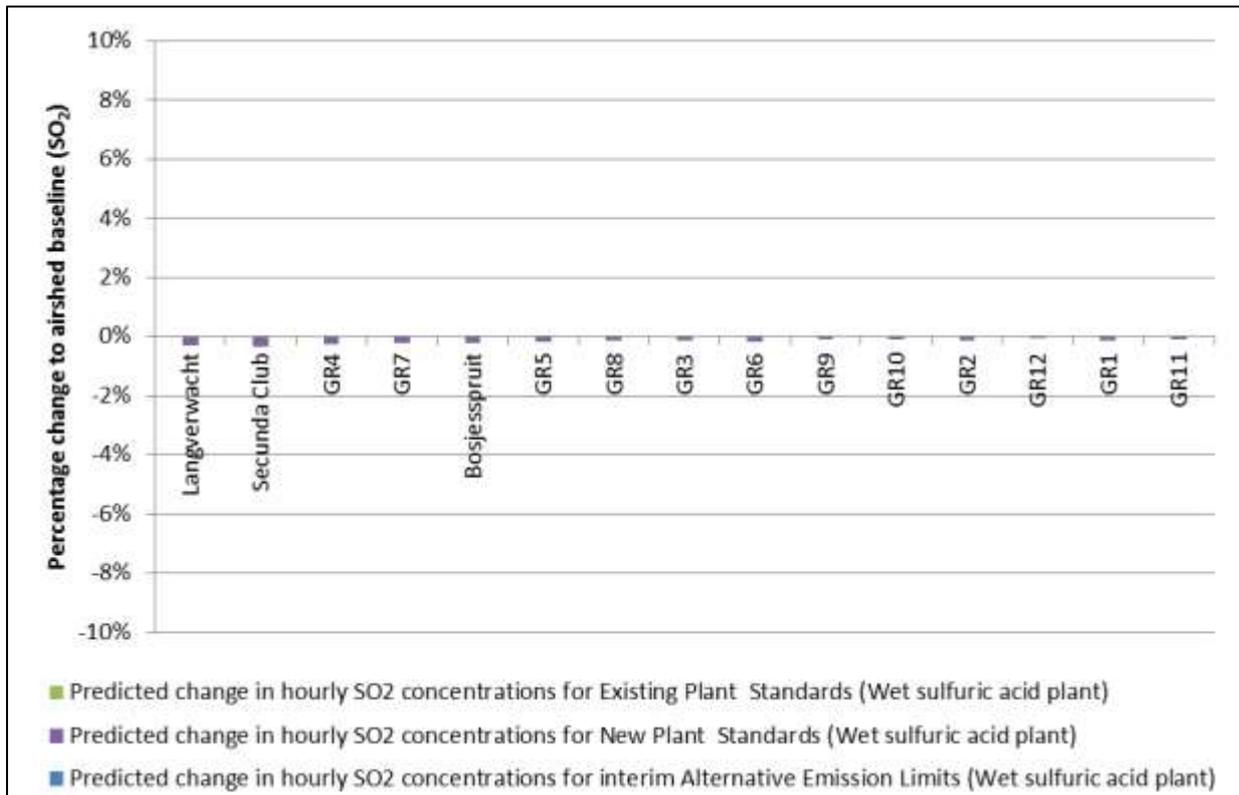
Figure 5-58: Theoretical change in SO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels Wet Sulfuric Acid Plant (change calculated using Equation 1)
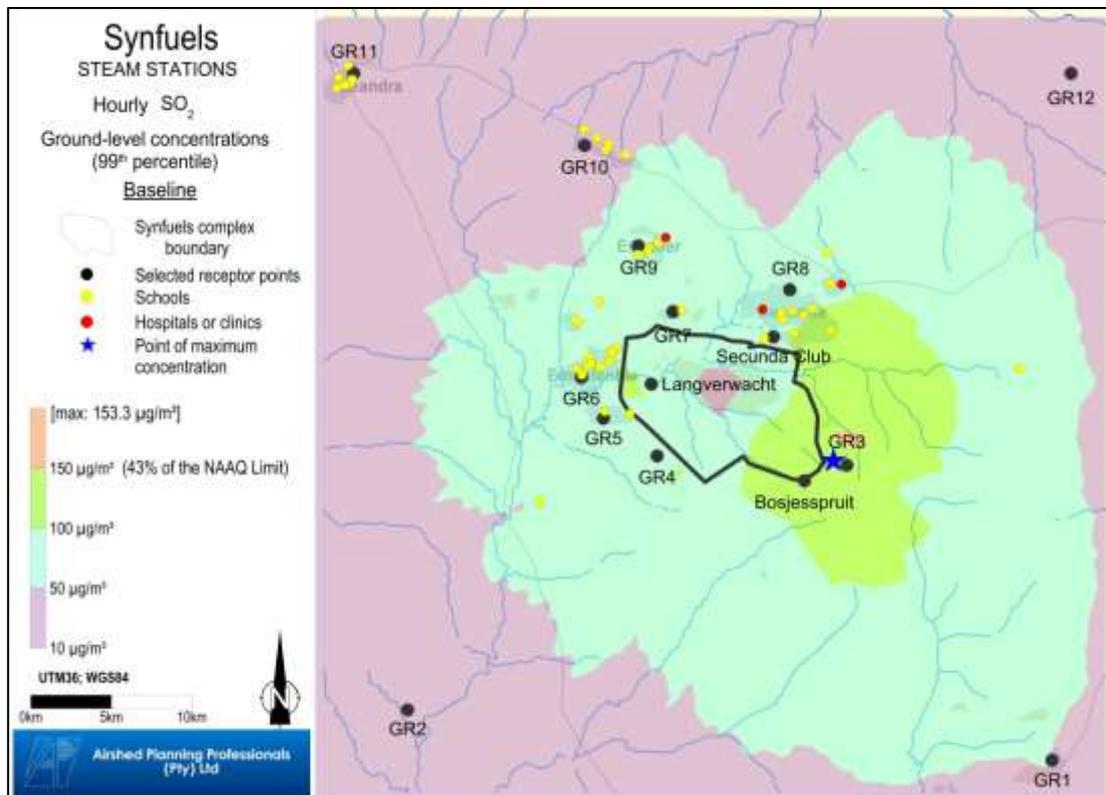
Figure 5-59: Predicted 99th percentile SO₂ concentrations as a result of Baseline emissions from the Steam Stations
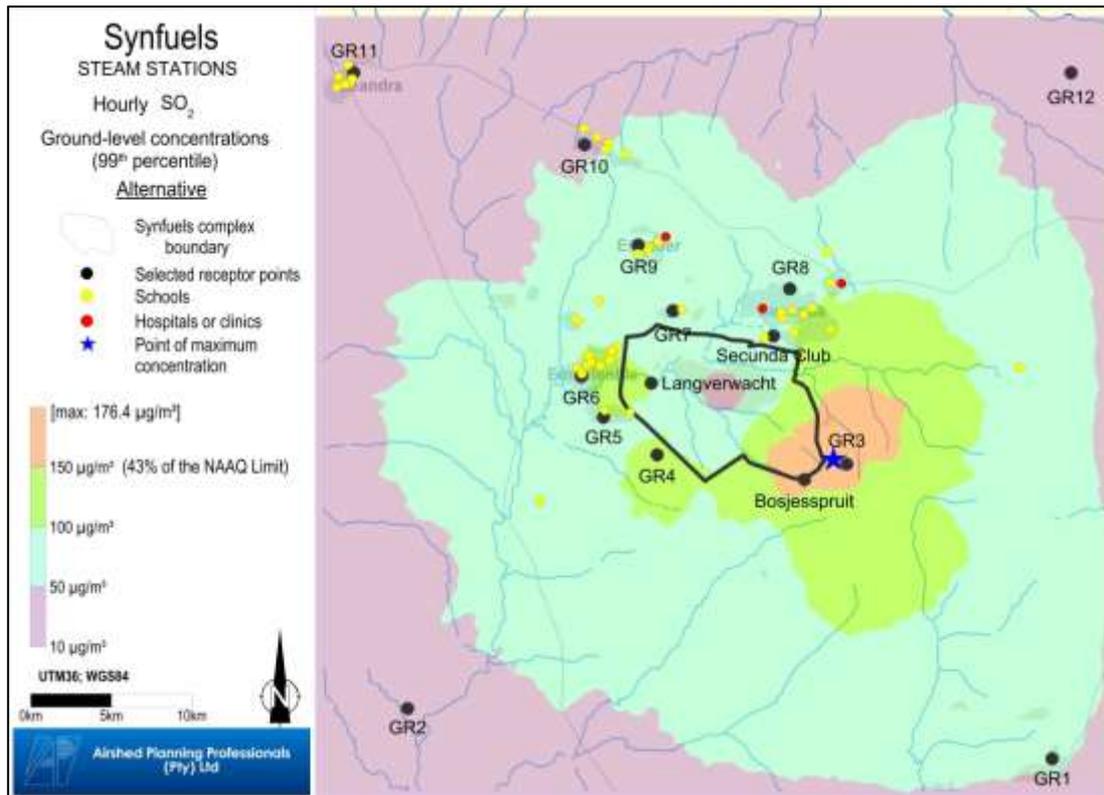
Figure 5-60: Predicted 99th percentile SO₂ concentrations as a result of Alternative Emission Limit emissions from the Steam Stations

5.1.8.1.2   Nitrogen Dioxide (NO₂)

The maximum predicted NO₂ concentrations are expected at receptors Bosjesssspruit and GR3 for the baseline (Figure 5-61 and Figure 5-62). This may be a result of atmospheric chemical transformations (conversion of NO to NO₂), where receptors located further away from operations, were predicted to have higher ambient NO₂ concentrations. Reductions in ambient NO₂ concentrations were predicted at all receptors due to theoretical compliance with Existing Plant Standards as a result of reduced emissions from the Steam Stations (Figure 5-63). Increases in ambient NO₂ concentrations are expected at the first 11 receptors (Figure 5-63) due to theoretical compliance with New Plant Standards, relative to the airshed baseline, as a result of changes to plume buoyancy. Alternative Emission Limits, as proposed for the Steam Stations, were predicted to result in increased ambient NO₂ concentrations (Figure 5-62) where ambient NO₂ increases between 28% and 57% were predicted (Figure 5-63). Isopleth plots are presented for the predicted 99th percentile hourly ground-level NO₂ concentrations as a result of the Baseline (Figure 5-64) and Alternative Emission Limits (Figure 5-65) from the Steam Stations. The maximum predicted 99th percentile ground-level concentrations were below the NAAQ limit concentration and as such the level presented in both figures represents 22% of the hourly limit (44 µg/m³).

Biosludge incinerator emissions, due to theoretical compliance with Existing Plant Standards, were predicted to result in elevated NO₂ concentrations at all receptors (less than 7.5% increase - Figure 5-66 and Figure 5-67) due to increases in the allowable emissions from the Biosludge Incinerators. The HOW incinerators (Figure 5-68) are a minor contributor to the ground-level impacts and compliance with Existing and New Plant Standards is likely to result in minor improvements (less than 3% - Figure 5-69). The Alternative Emission Limits proposed for the Biosludge and HOW Incinerators were predicted to result in increased ambient NO₂ concentrations of 35% and 32% on average, relative to the airshed baseline (Figure 5-67 and Figure 5-69).
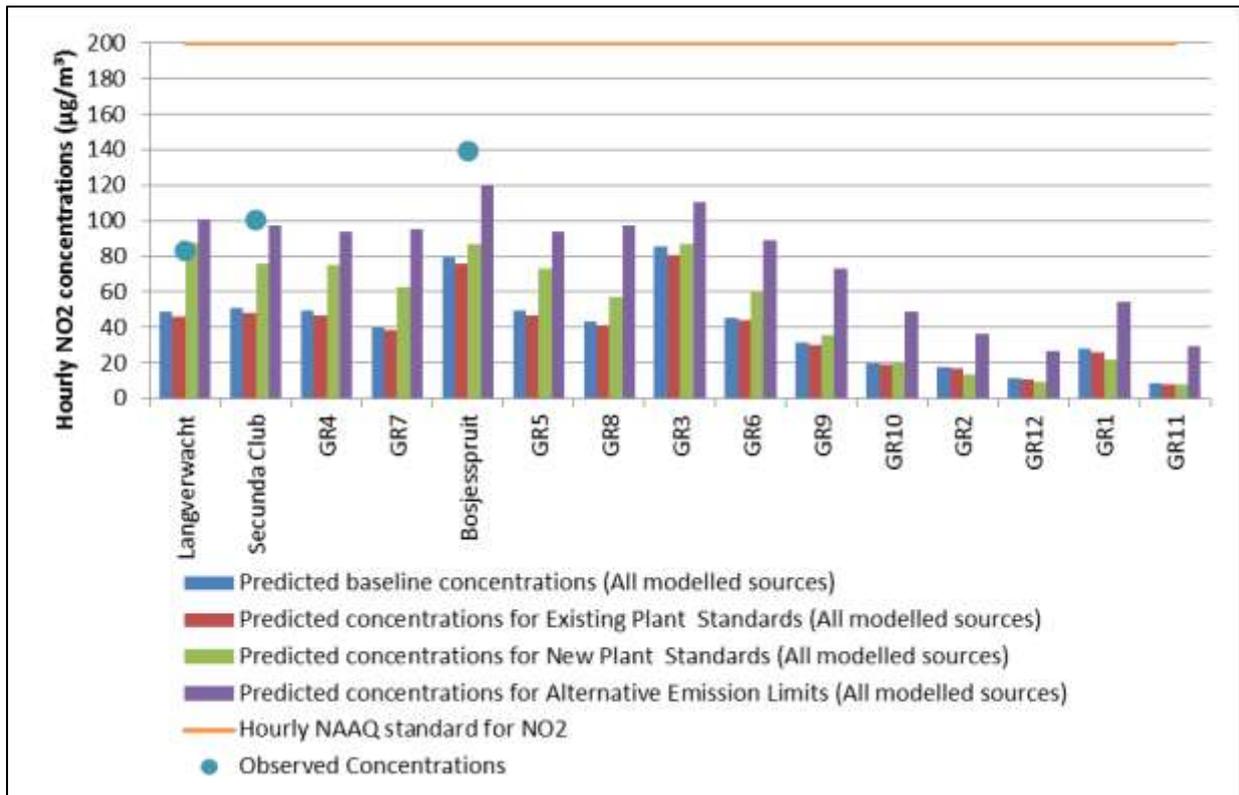
Figure 5-61: Predicted 99th percentile hourly NO₂ concentration at identified receptors for all modelled Synfuels sources (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
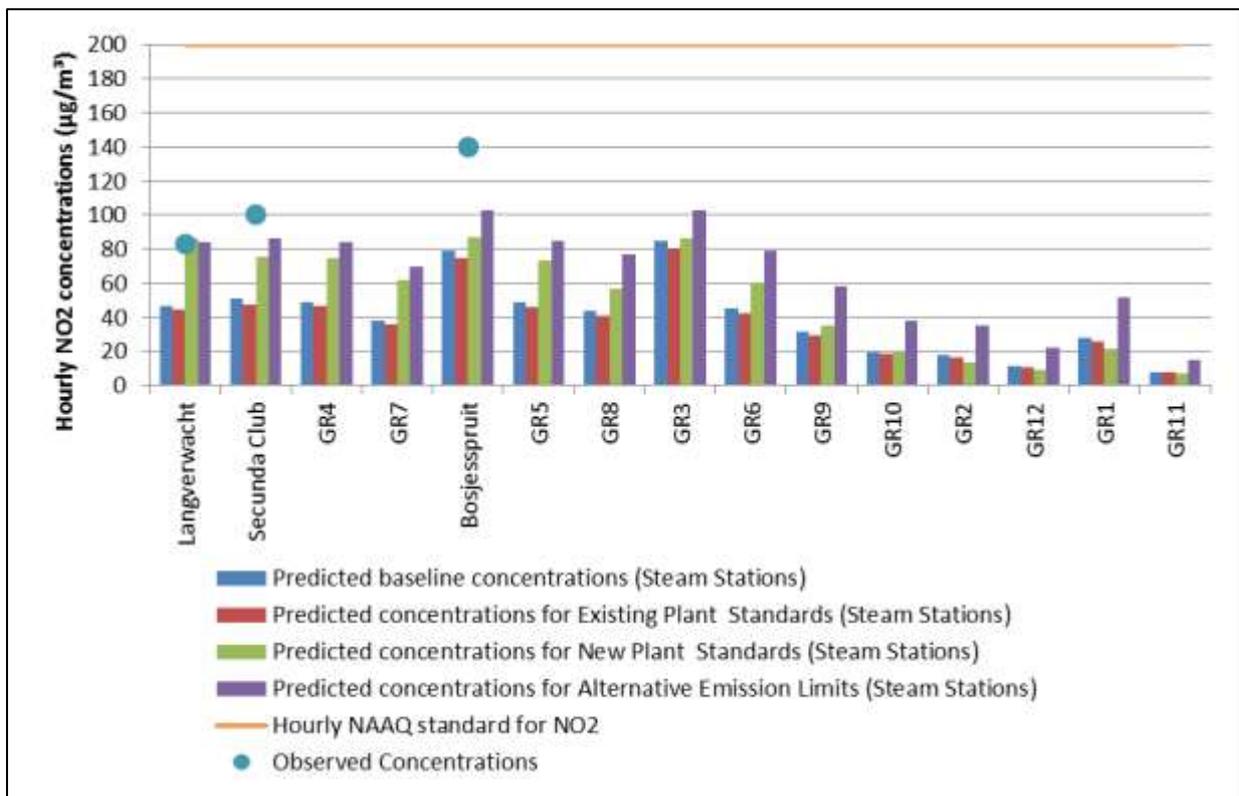
Figure 5-62: Predicted 99th percentile hourly NO₂ concentration at identified receptors for Synfuels Steam Stations (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
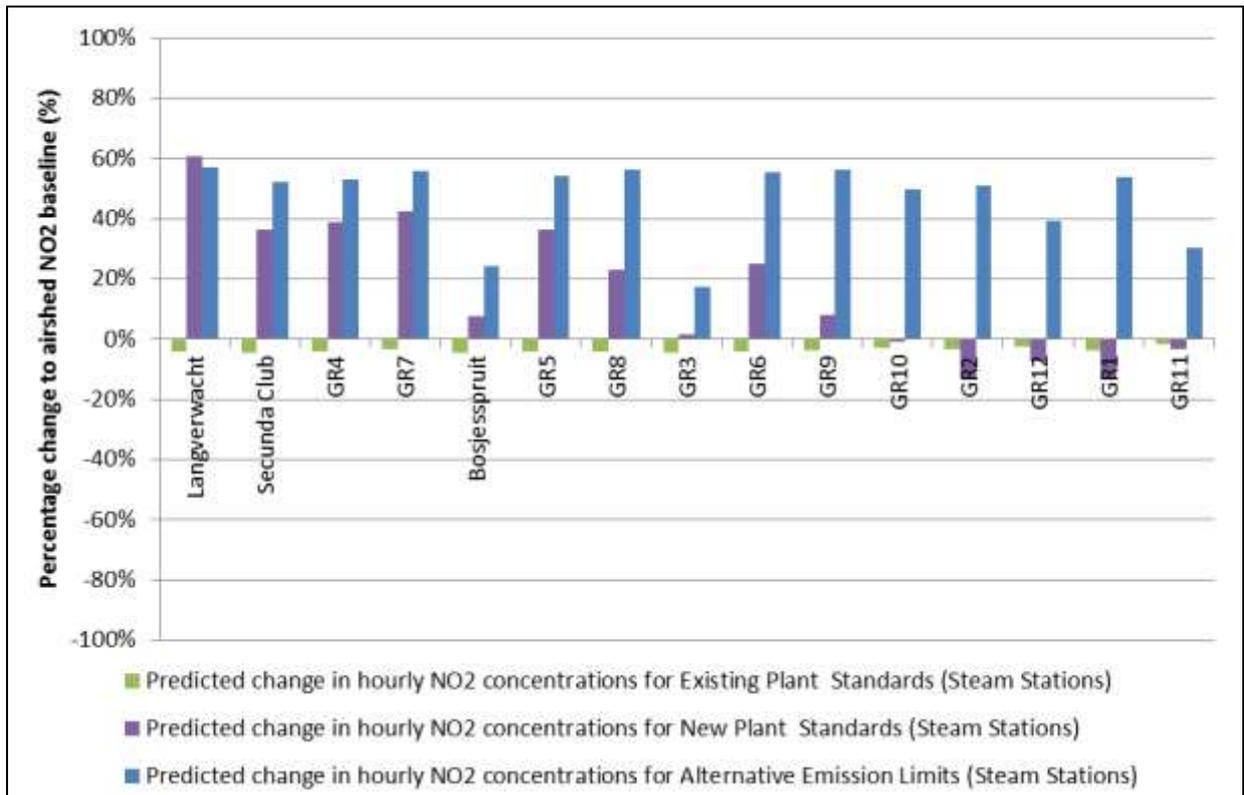
Figure 5-63: Theoretical change in NO₂ concentrations between scenarios and the airshed baseline at identified receptors for Synfuels Steam Stations (change calculated using Equation 1)
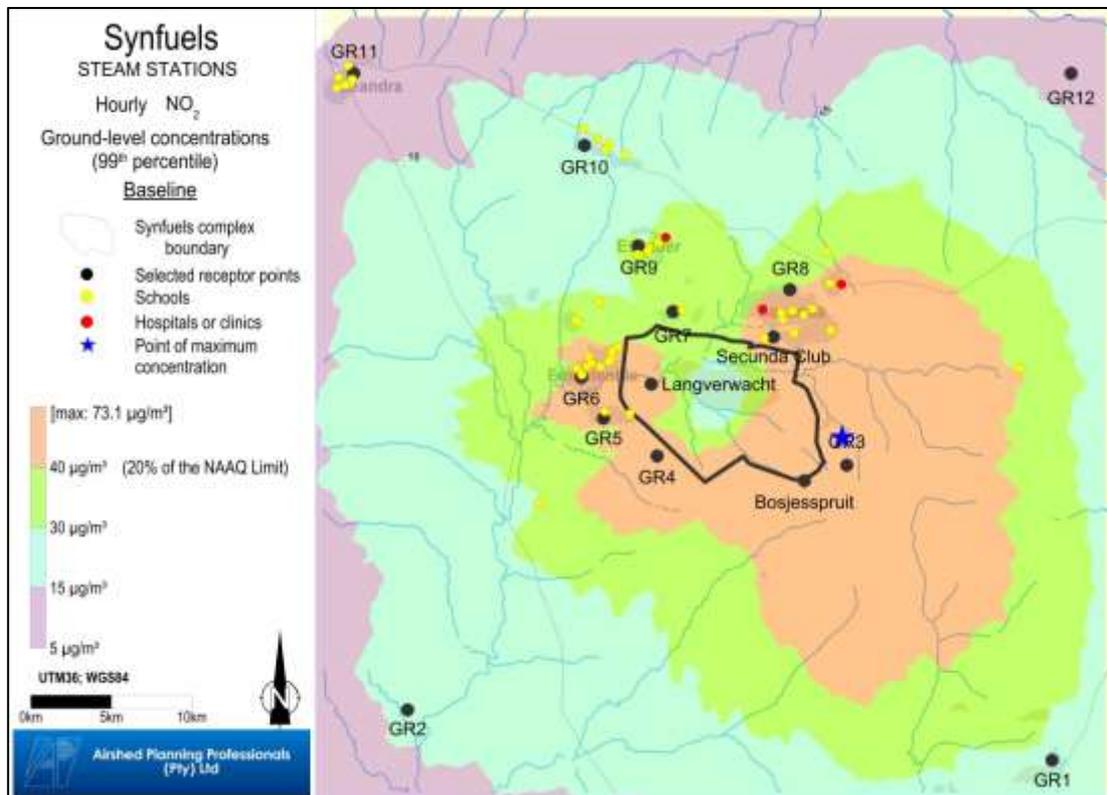
Figure 5-64: Predicted 99th percentile NO₂ concentrations as a result of Baseline emissions from the Steam Stations
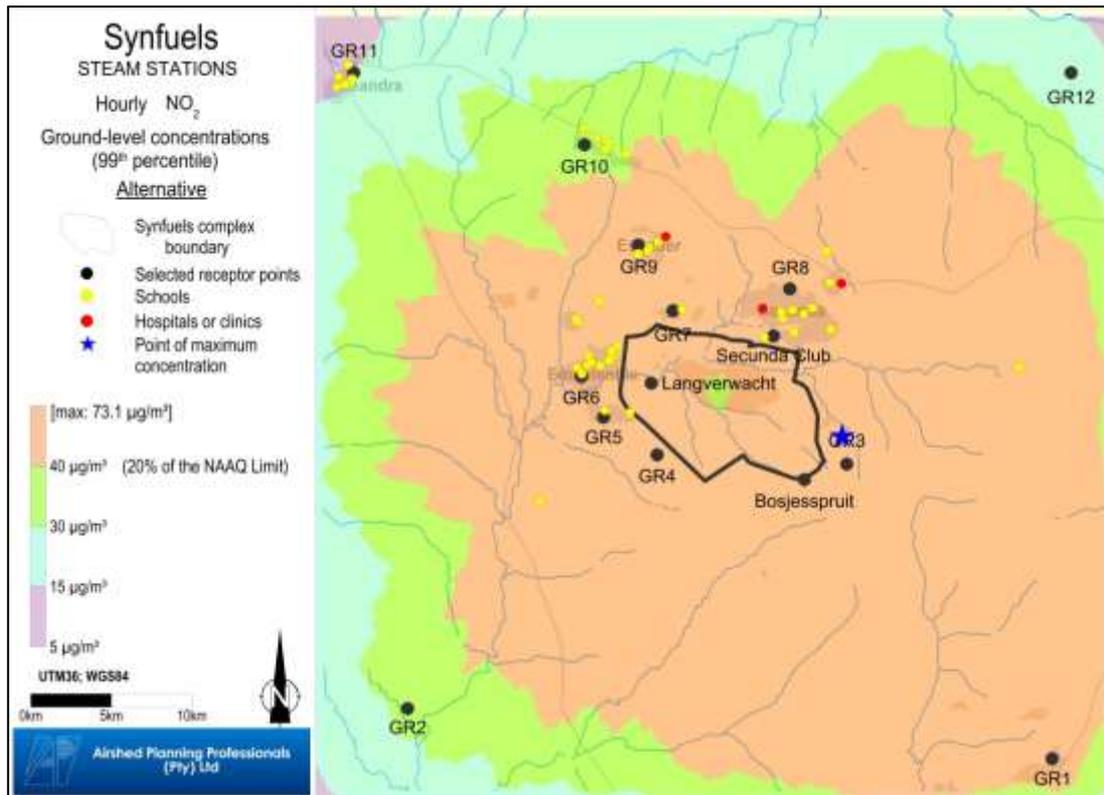
Figure 5-65: Predicted 99th percentile NO₂ concentrations as a result of Alternative Emission Limit emissions from the Steam Stations
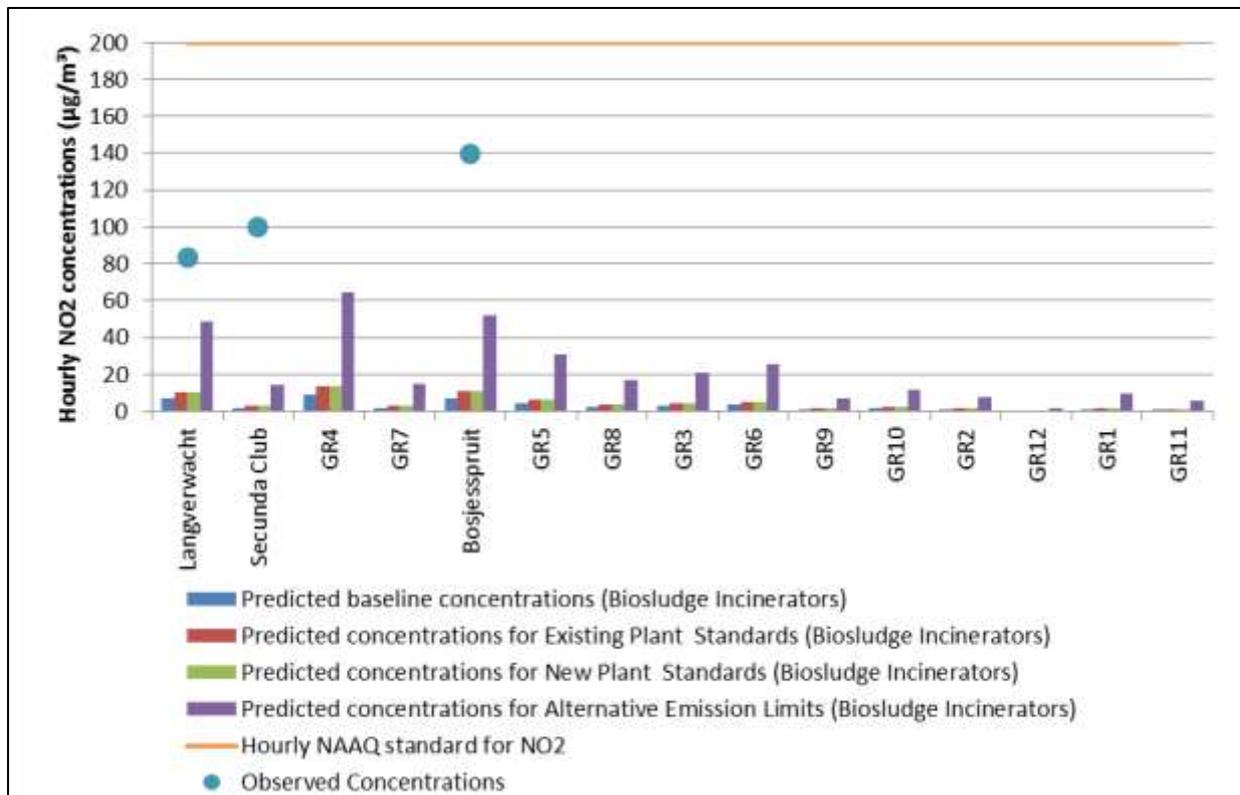
Figure 5-66: Predicted 99th percentile hourly NO₂ concentration at identified receptors for Synfuels Biosludge Incinerators (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
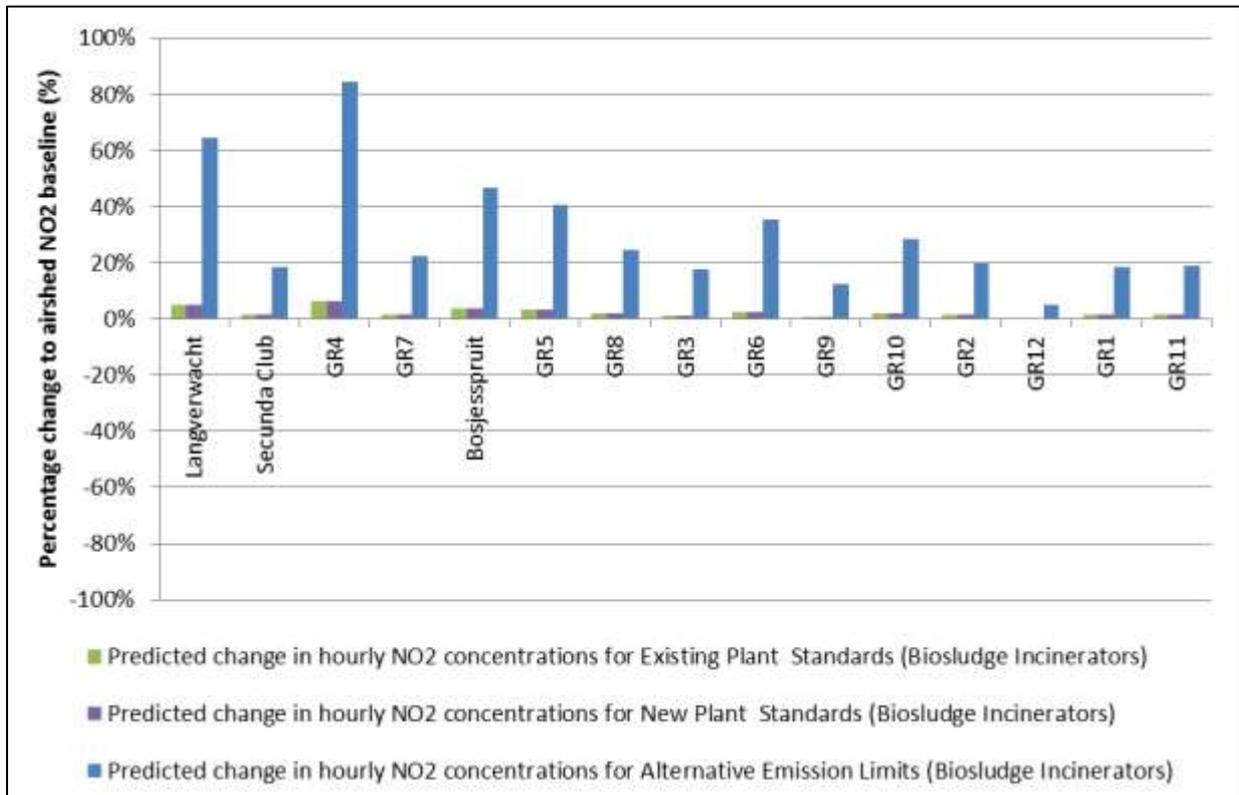
Figure 5-67: Theoretical change in NO$_2$ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels Biosludge Incinerators (calculated using Equation 1)
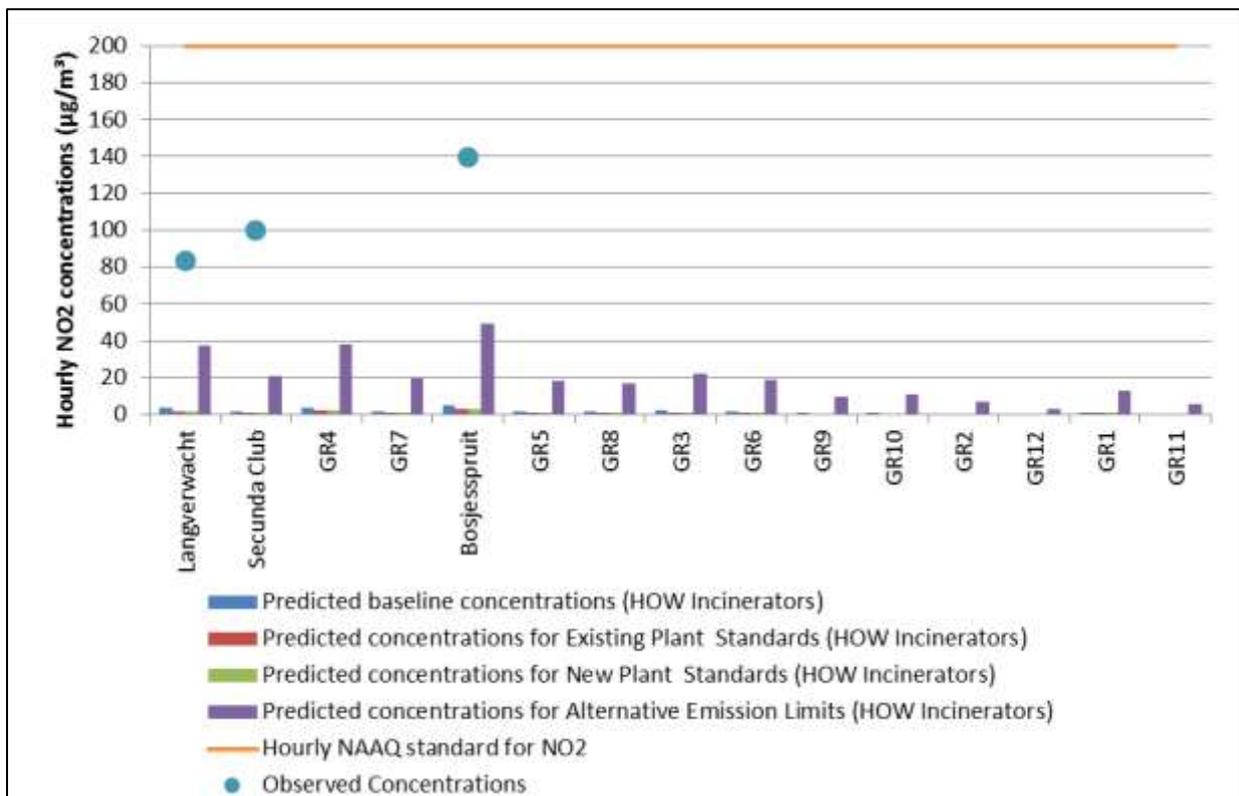
Figure 5-68: Predicted 99th percentile hourly NO$_2$ concentration at identified receptors for Synfuels HOW Incinerators (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
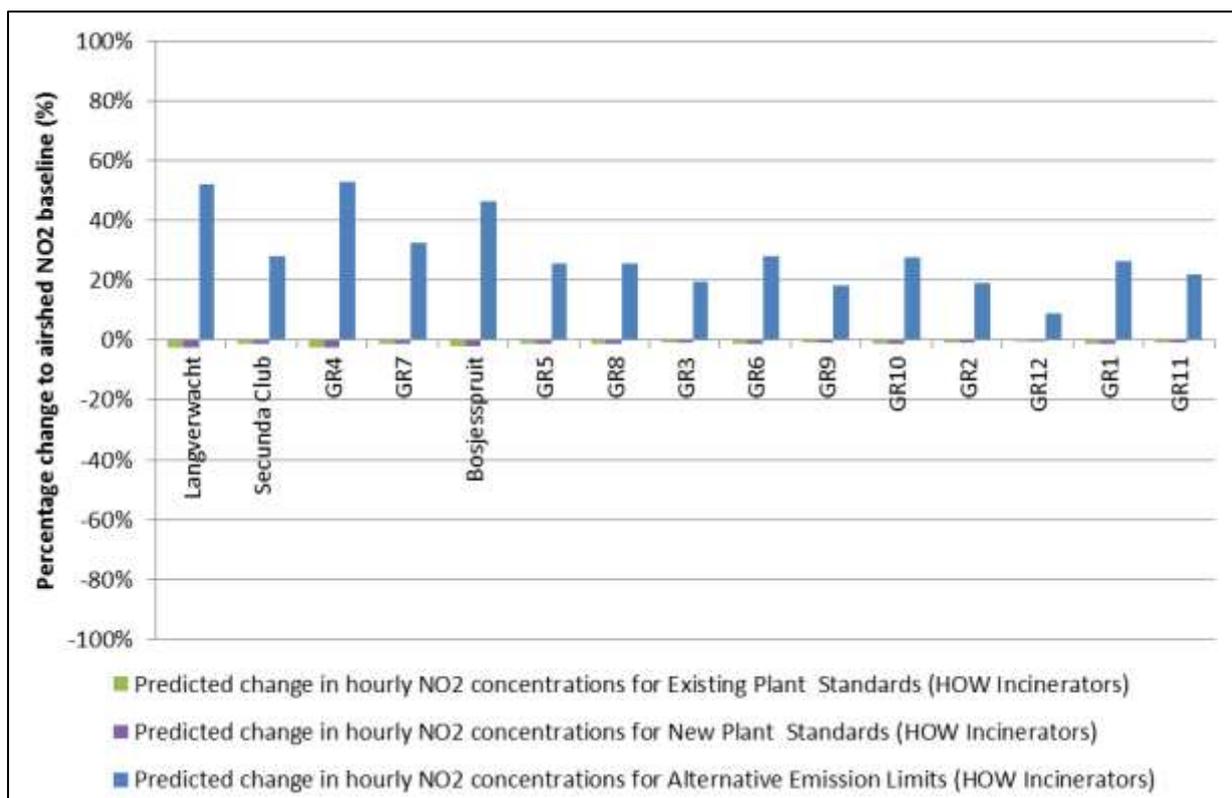
Figure 5-69: Theoretical change in NO$_2$ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels HOW Incinerators (calculated using Equation 1)

5.1.8.1.3   Particulate Matter (PM$_{2.5}$ and PM$_{10}$)

For particulate matter, NAAQS are available for PM$_{10}$ and PM$_{2.5}$. Ambient air quality impacts for both particulate fractions (i.e. PM$_{10}$ and PM$_{2.5}$) thus need to be considered.

Predicted concentrations of particulate matter (PM) were conservatively assumed to be PM$_{2.5}$ since it was not possible to establish the PM$_{2.5}$/PM$_{10}$ split. Monitoring of PM at the Secunda Club and Langverwacht monitoring stations, however, only includes PM$_{10}$ and therefore figures present predicted PM concentrations relative to the daily PM$_{10}$ NAAQS.

The current emissions from the source groups of concern at the Secunda operations result in low ground-level concentrations of particulates (PM); less than 30 µg/m^3 for all source groups (Figure 5-70). Further reductions (up to 5% reduction compared with the baseline operations) in ground-level PM concentrations are expected after compliance with Existing and New Plant Standards (Figure 5-71, Figure 5-75, Figure 5-77, and, Figure 5-79). Increased ambient PM concentrations were predicted for the Alternative Emission Limits proposed for the Steam Stations (3% on average), Biosludge (9% on average) and HOW Incinerators (4% on average) relative to the airshed baseline.

Isopleth plots are presented for the predicted 99th percentile daily ground-level PM concentrations as a result of the Baseline (Figure 5-72) and Alternative Emission Limits (Figure 5-73) from the Steam Stations. The maximum predicted 99th percentile ground-level concentrations were below the daily NAAQ limit and as such the level presented in both figures represents 9% of the daily guideline (7 µg/m^3).
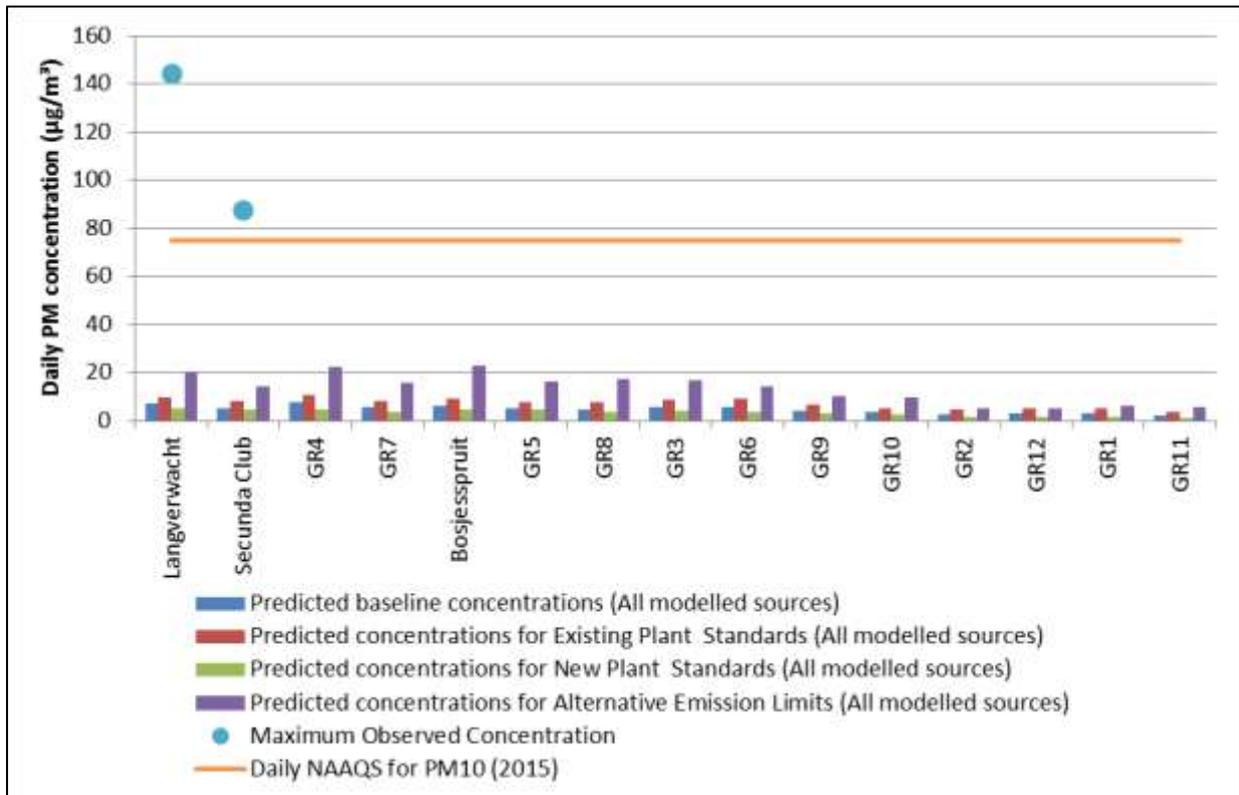
Figure 5-70: Predicted 99th percentile daily PM concentration at identified receptors for all modelled Synfuels sources (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
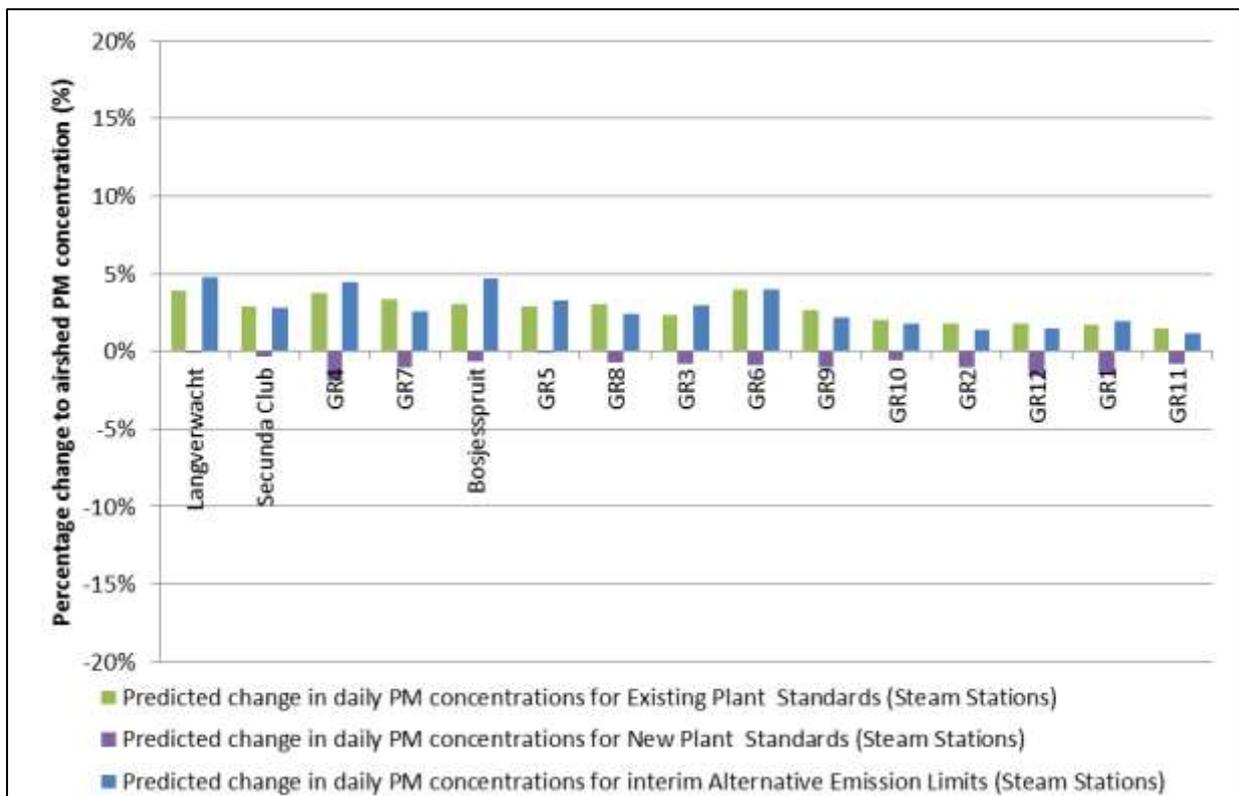
Figure 5-71: Theoretical change in PM concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels Steam Stations (change calculated using Equation 1)
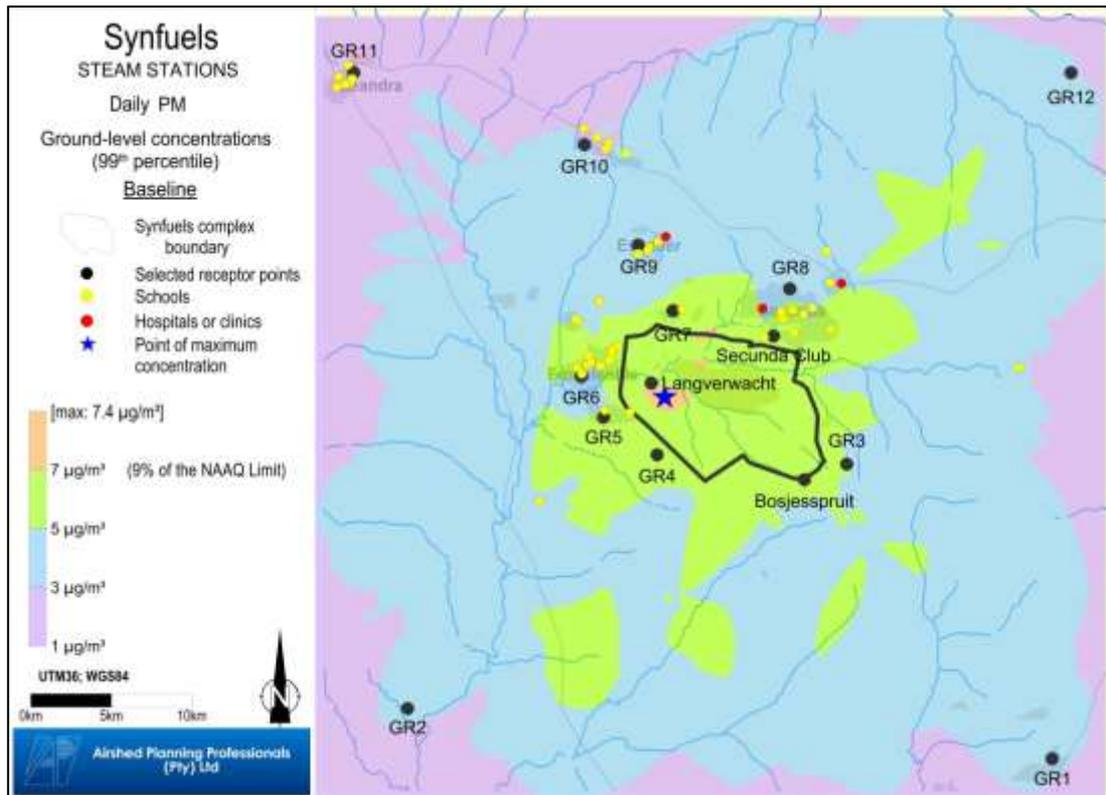
Figure 5-72: Predicted 99th percentile daily PM concentrations as a result of Baseline emissions from the Steam Stations
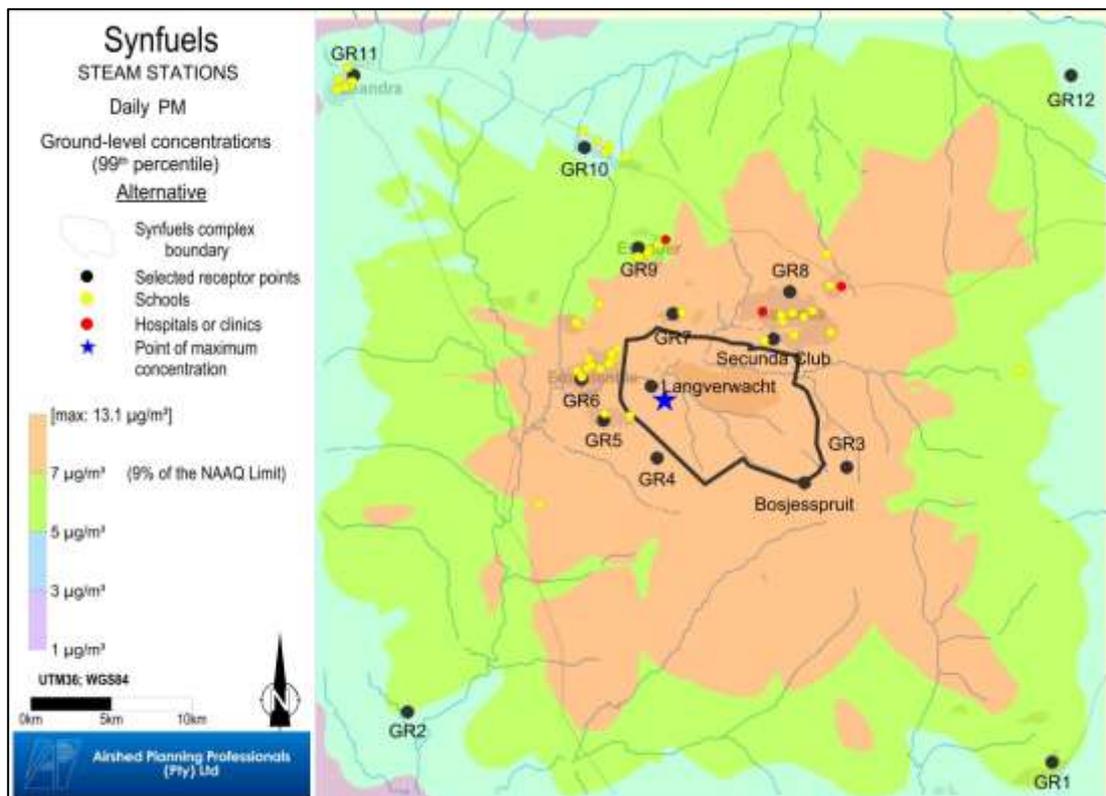
Figure 5-73: Predicted 99th percentile daily PM concentrations as a result of Alternative Emission Limit emissions from the Steam Stations
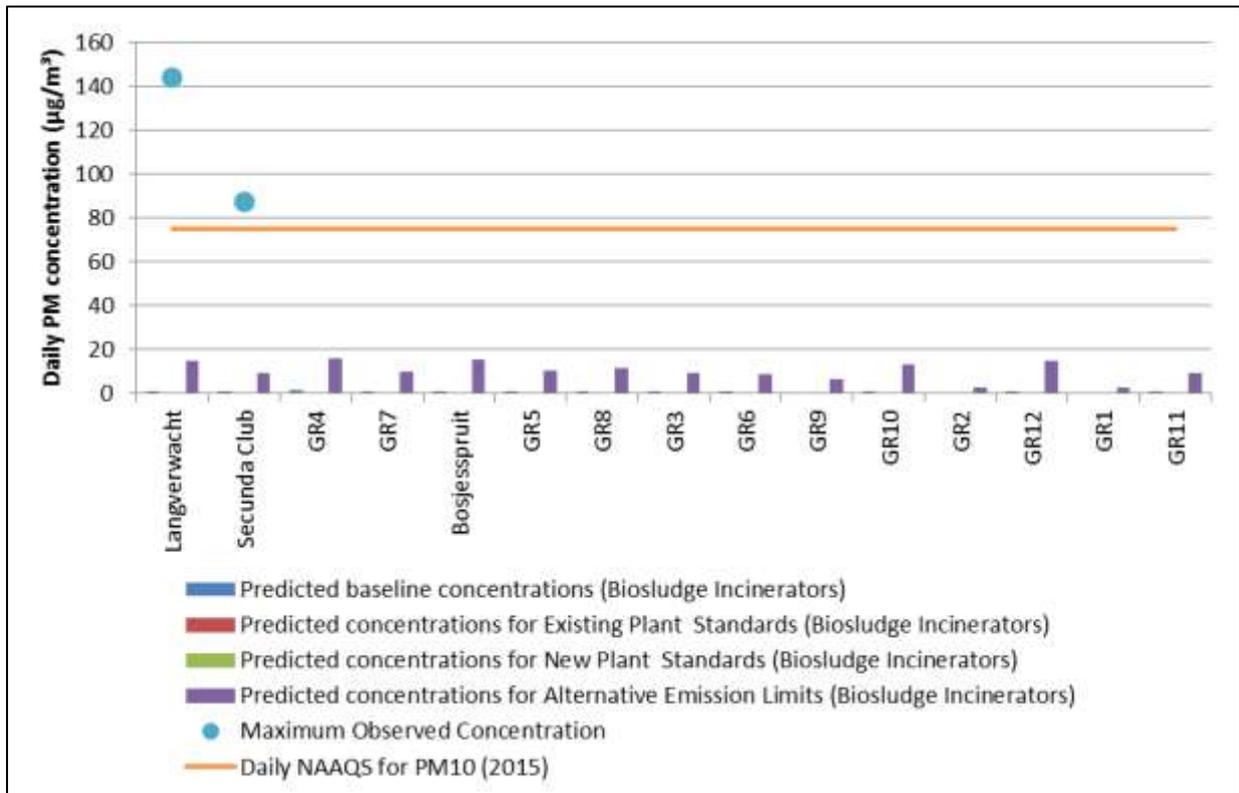
Figure 5-74: Predicted 99th percentile daily PM concentration at identified receptors for Synfuels Biosludge Incinerators (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
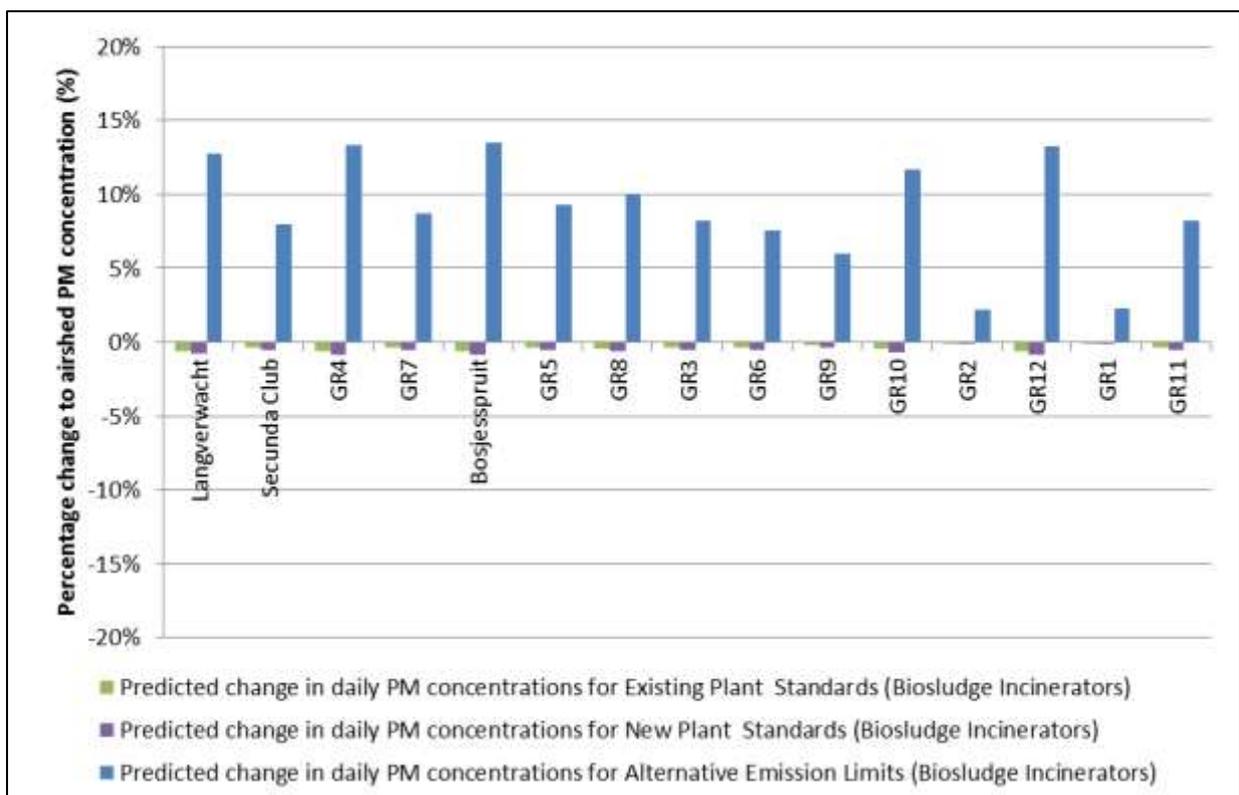
Figure 5-75: Theoretical change in PM concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels Biosludge Incinerators (change calculated using Equation 1)
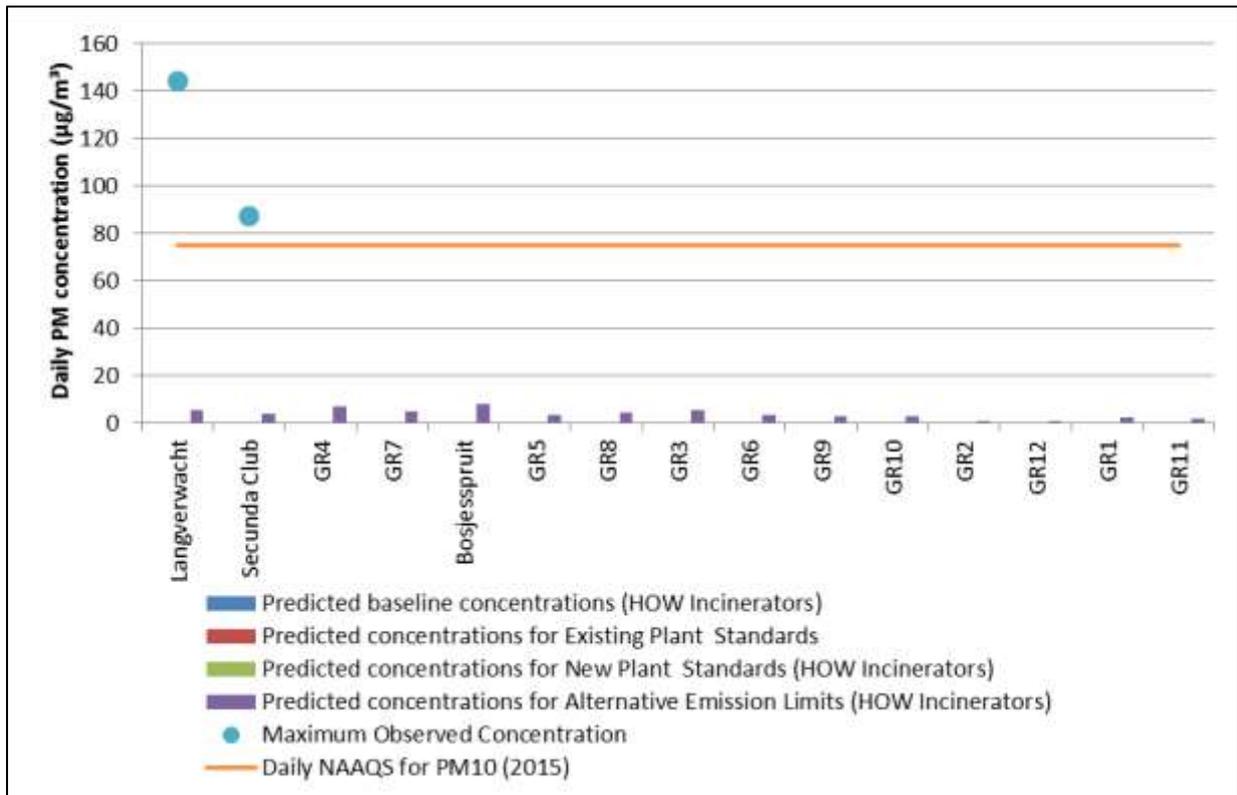
Figure 5-76: Predicted 99th percentile daily PM concentration at identified receptors for Synfuels HOW Incinerators (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
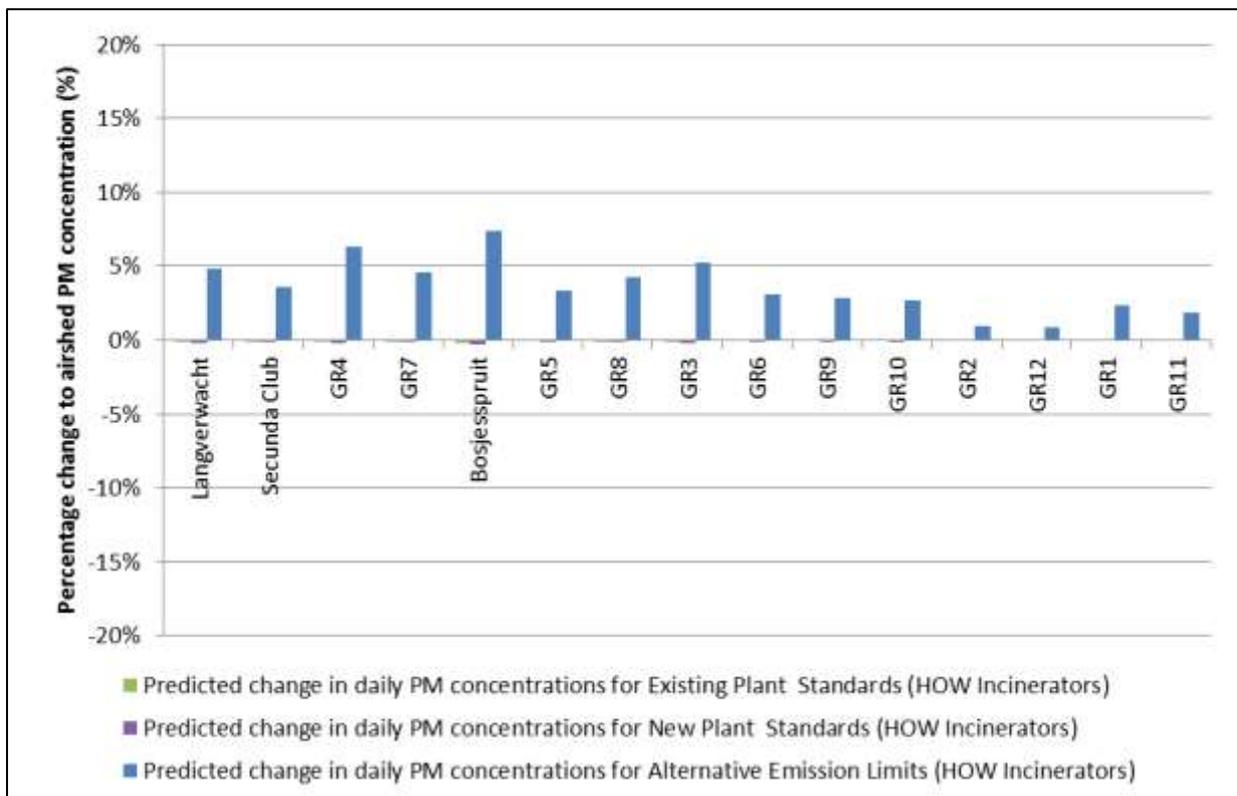
Figure 5-77: Theoretical change in PM concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels HOW Incinerators (change calculated using Equation 1)

Regarding the Secunda SCC, the interim Alternative Emission Limit is a ceiling limit of 330 mg/Nm^3 since the existing plant standard cannot be complied with in the interim. Therefore the Sasol Synfuels facility is requesting a postponement of the standard until a technology solution is implemented to allow compliance with the new plant standard in one abatement step. A smaller reduction was predicted for the interim Alternative Emission Limit in comparison to compliance with Existing and New Plant Standards (Figure 5-79) but the modelled interim alternative emission limit scenario demonstrates no significant increase in ambient air quality concentrations (less than 10 µg/m^3). While the SCC does not result in modelled ambient PM$_{10}$ concentrations above the NAAQS, measured ambient concentrations reflecting the cumulative contribution from all sources in the airshed indicate that ambient PM$_{10}$ concentrations do exceed the NAAQS. This is due to other sources of PM$_{10}$ emissions in the ambient environment.

Isopleth plots are presented for the predicted 99th percentile daily ground-level PM concentrations as a result of the Baseline (Figure 5-80) and Alternative Emission Limits (Figure 5-81) from the SCC (Catalytic Cracker). The maximum predicted 99th percentile ground-level concentrations were below the daily NAAQ limit and as such the level presented in both figures represents 4% of the daily guideline (3 µg/m^3).
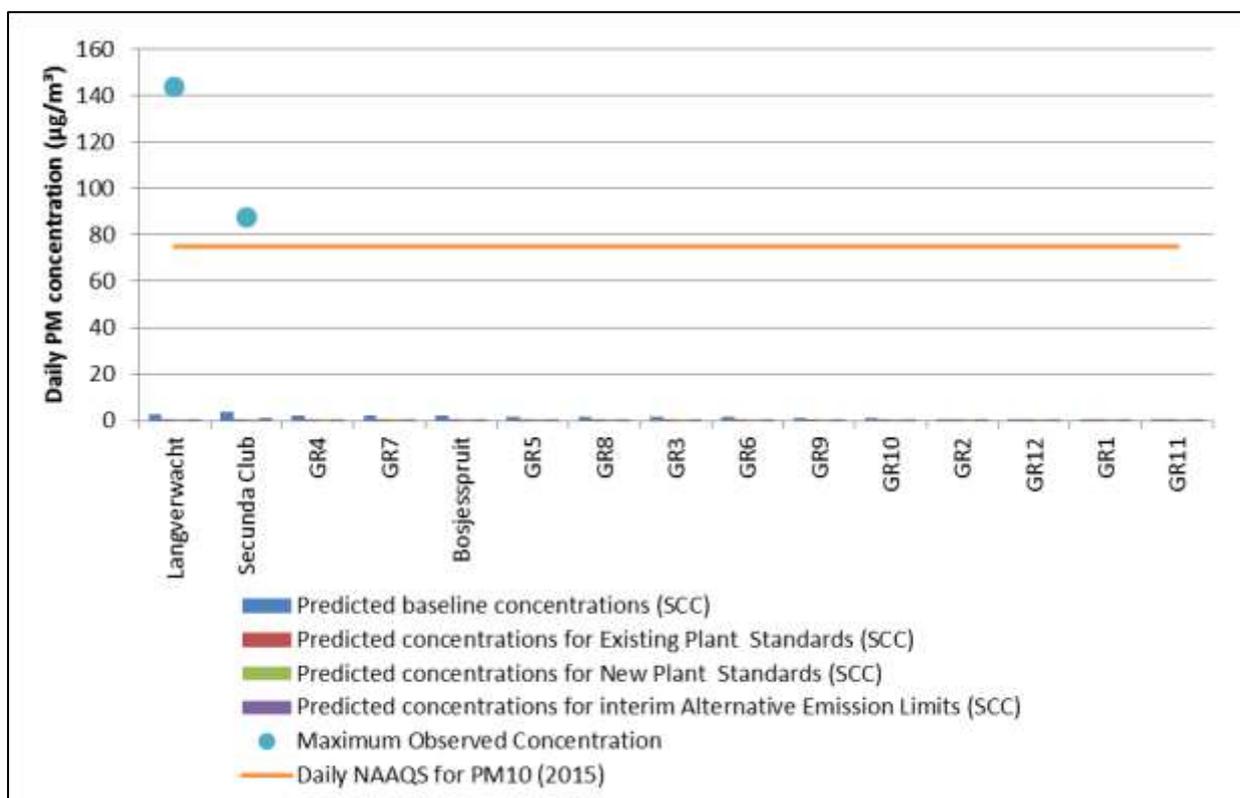
**Figure 5-78: Predicted 99th percentile daily PM concentrations at identified receptors for Synfuels SCC (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)**
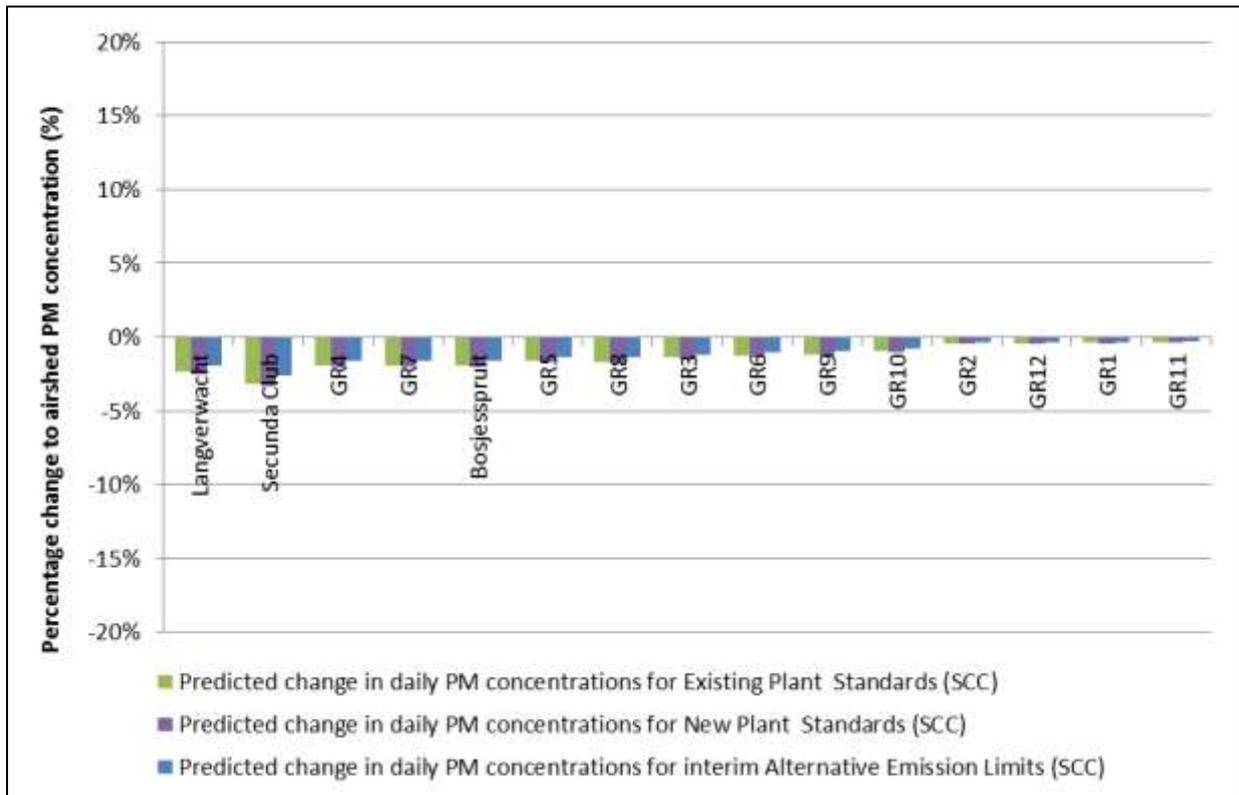
Figure 5-79: Theoretical change in PM concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels SCC (change calculated using Equation 1)
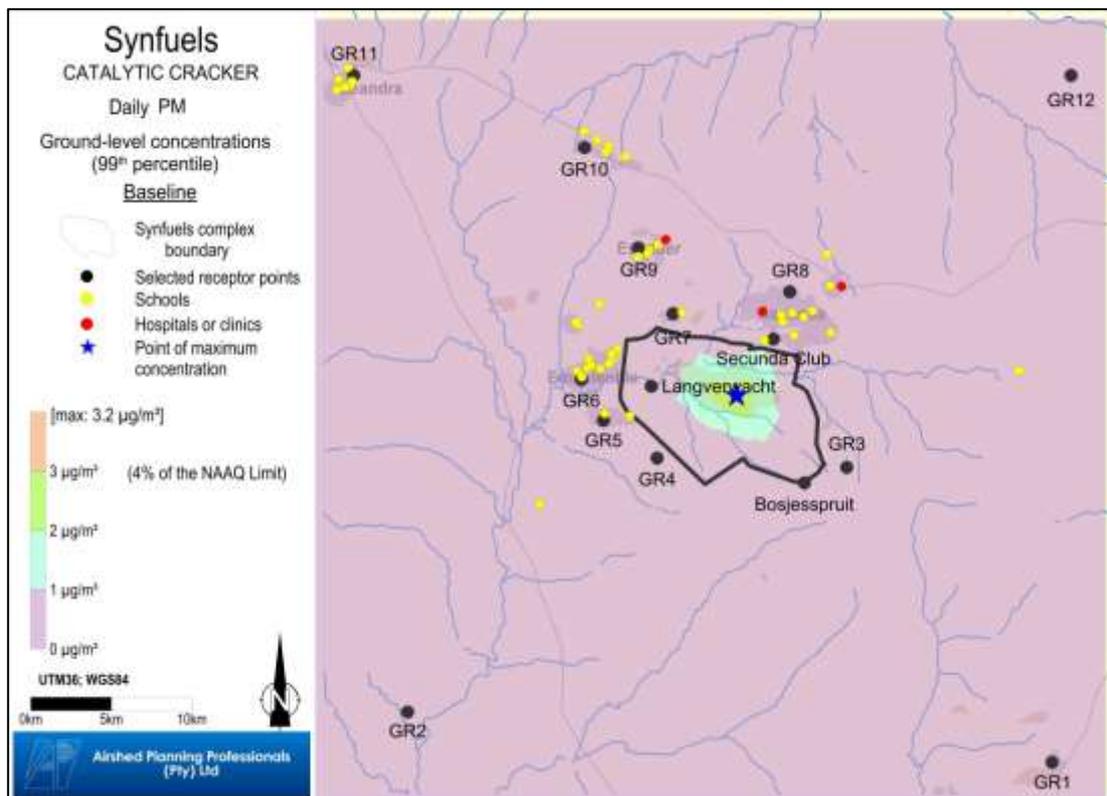
Figure 5-80: Predicted 99th percentile daily PM$_{10}$ concentrations as a result of Baseline Emission Limit emissions from the Catalytic Cracker
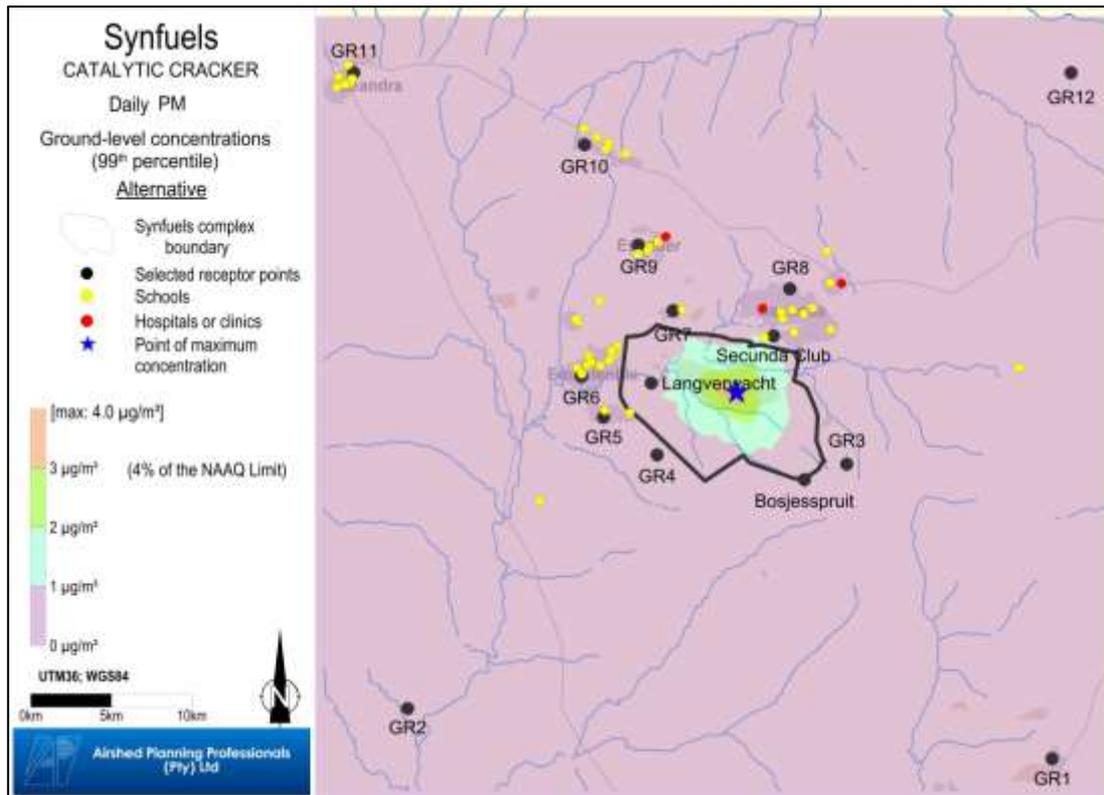
Figure 5-81: Predicted 99th percentile daily PM10 concentrations as a result of Alternative Emission Limit emissions from the Catalytic Cracker

The contribution of predicted PM_{10} to total predicted PM (including secondary particulate formation) was calculated for the Synfuels Steam Stations (Table 5-25). PM_{10} contribution to total PM varied by between 12.4 and 24.7% depending on the sensitive receptor, indicating the role of SO_2 and NO_2 emissions on particulate formation. The large contribution of secondary particulate formation is likely due to the high NH_3 levels in the area allowing for formation of ammonium sulfates and ammonium nitrates.

Table 5-25: Predicted 99th percentile daily PM10 and total PM concentration at identified receptors for Synfuels Steam Stations

Receptor	PM concentration ($\mu g/m^3$)	PM10 concentration ($\mu g/m^3$)	PM10 contribution
GR1	5.10	0.83	16.3%
GR2	4.31	0.73	17.0%
GR3	8.29	1.59	19.2%
GR4	10.15	1.64	16.1%
GR5	8.46	1.66	19.7%
GR6	7.41	1.70	23.0%
GR7	6.79	1.36	20.0%
GR8	7.34	1.09	14.8%
GR9	6.16	1.00	16.2%
GR10	5.06	0.95	18.8%
GR11	3.21	0.51	16.0%
GR12	4.78	0.59	12.4%
Bosjesspruit	8.67	2.14	24.7%
Secunda Club	7.67	1.33	17.4%
Langverwacht	9.24	1.98	21.5%

5.1.8.1.4   Total Volatile Organic Compounds (TVOC)

The predicted impact as a result of TVOC emissions from the combined Rectisol East and West plant operations was assessed against the NAAQS annual standard for benzene (5 µg/m³) (Figure 5-82 and Figure 5-83). Ambient TVOC concentrations from these sources were predicted to fall well within the annual standard.
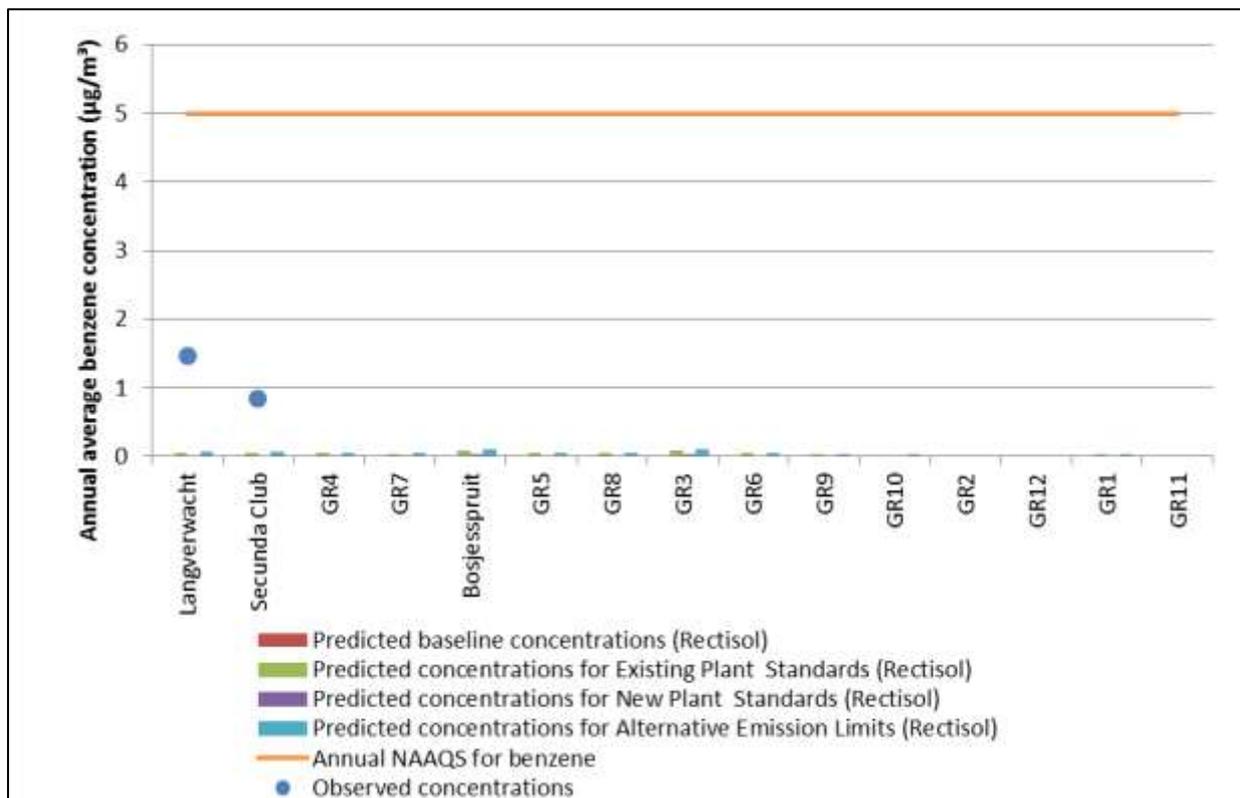
Figure 5-82: Predicted annual average TVOC concentrations at identified receptors for Synfuels Rectisol (relative to the annual NAAQS for benzene)

Figure 5-83 shows the impacts of the different scenarios more clearly, by repeating the graph for Figure 5-82 with the axis re-scaled.
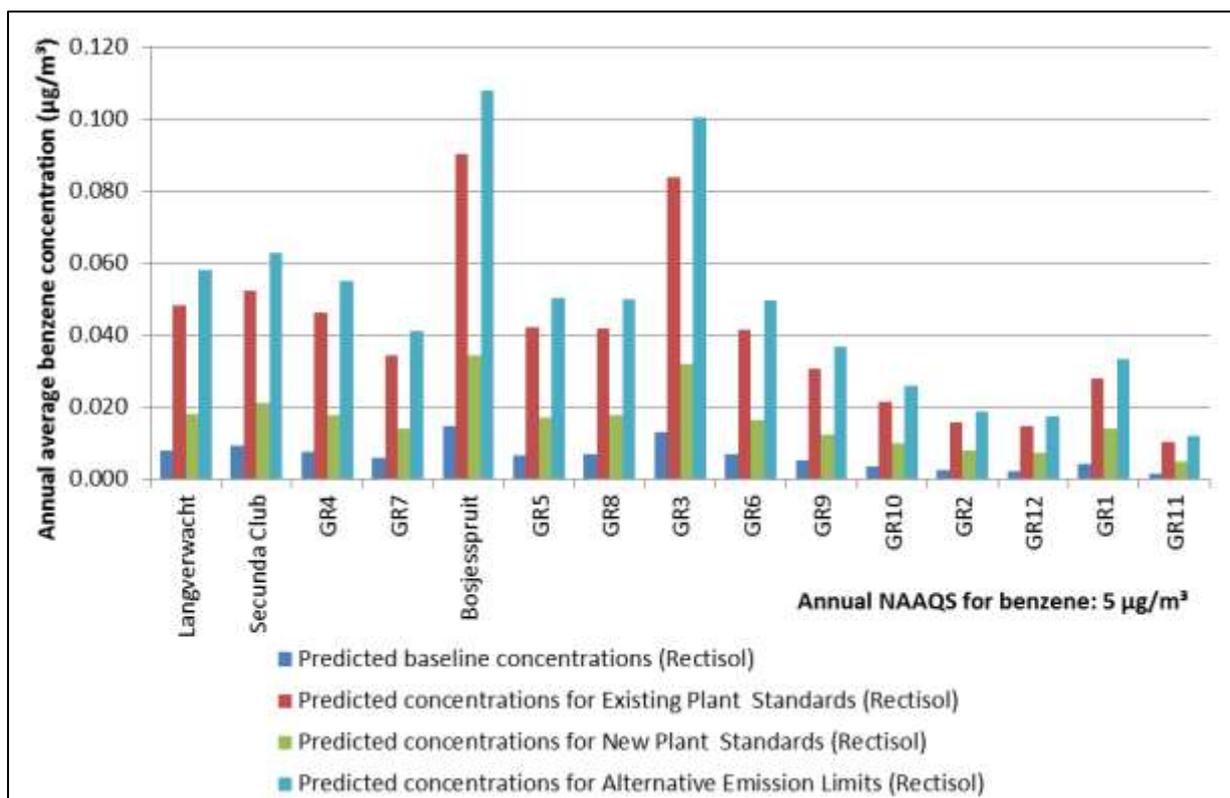
Figure 5-83: Predicted annual average TVOC concentrations at identified receptors for Synfuels Rectisol (relative to the annual NAAQS for benzene) (Based on Figure 5-82 with the y-axis rescaled for visibility)

Predicted baseline impacts on ambient VOC concentrations from current operations are no higher than 0.012 µg/Nm³. Predicted impacts at the existing plant standard ceiling limit are higher, since the ceiling value of 250 mg/Nm³ is modelled and not current average emissions. Theoretical compliance with New Plant Standards shows an improvement on theoretical compliance with Existing Plant Standards. At the proposed Alternative Emission Limit, the greatest differential in predicted ambient concentrations for existing plant standards compared with the requested alternative emission limit is 0.015 µg/Nm³ at Bosjesspruit. Operating at the alternative emission limit would not exceed 0.2% contribution towards the NAAQS.

5.1.8.2   Non-Criteria Pollutants

Ambient pollutant concentrations, either from the dispersion modelling or from direct physical measurements, are typically compared to defined standards or other thresholds to assess the health and/or environmental risk implications of the predicted or measured air quality. In South Africa, NAAQS have been set for criteria pollutants at limits deemed to uphold a permissible level of health risk and the assessment has accordingly been based on a comparison between the predicted concentrations and the NAAQS. The measured concentrations have been used to ascertain the representativeness of the modelling and to assess compliance with the NAAQS as a function of all sources of emissions.

Where NAAQS have not been set health-effect screening levels, appropriate for assessing the non-criteria pollutants emitted by Sasol Synfuels, were identified from literature reviews and internationally recognised databases. These non-criteria pollutants for which screening levels were identified, include the sulphur recovery plant as a source of H_2S; the wet sulphuric acid plant as a source of SO_3; and, various emissions from incinerators, namely lead, arsenic, antimony, chromium, cobalt, copper, manganese, nickel and vanadium. The health-effect screening levels used are listed in Table

5-26. In the case of H2S, Sasol commissioned an independent toxicologist to conduct a desktop study of suitable health benchmarks for use in the AIR (Annexure C).

Table 5-26: Most stringent health-effect screening level identified for all non-criteria pollutants assessed

Compound	Acute exposure[a] [units: µg/m³]	Chronic exposure[b] [units: µg/m³]
Lead (Pb)	[c]	[d]
Arsenic (As)	0.2 [g]	0.015 [g]
Antimony (Sb)	[c]	[d]
Chromium (Cr)	[c]	0.1 [e]
Cobalt (Co)	[c]	0.1 [f]
Copper (Cu)	100 [g]	[d]
Manganese (Mn)	[c]	0.05 [e]
Nickel (Ni)	0.2 [g]	0.014 [g]
Vanadium (V)	0.8 [f]	0.1 [f]
Hydrogen sulphide (H2S)	135 [h]	[d]
Sulfur trioxide (SO3)	22.5 [f]	[d]
Ammonia (NH3)	1184[f]	[d]
(a) Hourly concentrations compared with short-term / acute exposure health effect screening level		
(b) Annual concentrations compared with long-term / chronic exposure health effect screening level		
(c) No hourly health screening level		
(d) No annual health screening level		
(e) US-EPA IRIS Inhalation Reference Concentrations (µg/m³) – chronic		
(f) US ATSDR Maximum Risk Levels (MRLs) (µg/m³) - acute		
(g) Californian OEHHA (µg/m³) – acute		
(h) Haahtele *et al*., 1992 - acute (4-hour average)		

A screening exercise of non-criteria pollutants emitted from the Sasol Synfuels Facility (combined) Incinerators – including all non-criteria pollutants listed in Table 5-22 - was undertaken to identify pollutants that would be likely to exceed the most stringent health-effect screening levels identified. The non-criteria pollutants that would possibly exceed the screening level concentrations included: manganese (Mn), ammonia (NH3), hydrogen chloride (HCl), and, hydrogen fluoride (HF). Further analysis showed that predicted ground-level concentrations are likely to comply with the strictest health effect screening concentrations (Table 5-27).

Table 5-27: Screening of non-criteria pollutants against health effect screening levels

Compound	Acute exposure[a] [units: µg/m³]			Chronic exposure[b] [units: µg/m³]		
	Minimum concentration[c]	Maximum concentration[d]	Strictest health effect screening level	Minimum concentration[c]	Maximum concentration[d]	Strictest health effect screening level
Scenario 1 - Baseline emissions						
Mn				0.0000	0.0021	0.05 [e]
NH₃	0.0000	0.0031	1184 [f]			
HCl	0.0000	0.0276	2100 [g]			
HF	0.0000	0.0205	240 [g]			
Scenario 2a and 2b – Theoretical compliance with Existing and New Plant Standards						
Mn				0.0000	0.0002	0.05 [e]
NH₃	0.0000	0.1353	1184 [f]			
HCl	0.0000	0.1353	2100 [g]			
HF	0.0000	0.0137	240 [g]			
Scenario 3 – Alternative Emission Limits						
Mn				0.0000	0.0251	0.05 [e]
NH₃	0.0000	9.0631	1184 [f]			
HCl	0.0000	5.3992	2100 [g]			
HF	0.0000	5.3992	240 [g]			

(a) hourly concentrations compared with short-term / acute exposure health effect screening level

(b) annual concentrations compared with long-term / chronic exposure health effect screening level

(c) minimum concentration predicted across the 12 receptors (Table 5-23)

(d) maximum concentration predicted across the 12 receptors (Table 5-23)

(e) US-EPA IRIS Inhalation Reference Concentrations (µg/m³) – chronic

(f) US ATSDR Maximum Risk Levels (MRLs) (µg/m³) - acute

(g) Californian OEHHA (µg/m³) – acute

5.1.8.2.1 Sum of lead, arsenic, antimony, chromium, cobalt, copper, manganese, nickel and vanadium

Baseline emissions of the 'Sum of lead, arsenic, antimony, chromium, cobalt, copper, manganese, nickel and vanadium' from the Sasol Synfuels Facility Incinerators will exceed the Existing Plant Standards. The ambient impact of these emissions was modelled (at emission rates provide in Table 5-22) for the baseline emissions and if Existing and New Plant Standards were achieved. After accounting for the proportional contribution of each pollutant, predicted concentrations (99th percentile hourly and annual average) were compared with the appropriate strictest health effect screening levels. No exceedances of hourly / acute (Table 5-28) or annual / chronic (Table 5-29) screening levels were found. No exceedances of hourly / acute (Table 5-28) or annual / chronic (Table 5-29) screening levels were predicted for the Alternative Emission Limits.

Table 5-28: Predicted hourly ambient concentrations (µg/m³) of metal pollutants emitted from the Sasol Synfuels Facility Incinerators (a)

Receptor	Lead (Pb) (b)	Arsenic (As) (c)	Antimony (Sb) (b)	Chromium (Cr) (b)	Cobalt (Co) (b)	Copper (Cu) (d)	Manganese (Mn) (b)	Nickel (Ni) (c)	Vanadium (V) (e)
Scenario 1 - Baseline emissions – HOW Incinerators									
Langverwacht	0.0020	0.0003	0.0001	0.0041	0.0001	0.0033	0.0408	0.0281	0.0014
Secunda Club	0.0009	0.0002	0.0001	0.0019	0.0001	0.0016	0.0192	0.0132	0.0007
GR4	0.0019	0.0003	0.0001	0.0038	0.0001	0.0031	0.0382	0.0263	0.0013
GR7	0.0011	0.0002	0.0001	0.0021	0.0001	0.0017	0.0216	0.0149	0.0007
Bosjesspruit	0.0019	0.0003	0.0001	0.0038	0.0001	0.0031	0.0380	0.0262	0.0013
GR5	0.0009	0.0002	0.0001	0.0018	0.0000	0.0015	0.0183	0.0126	0.0006
GR8	0.0008	0.0001	0.0000	0.0016	0.0000	0.0013	0.0163	0.0112	0.0006
GR3	0.0010	0.0002	0.0001	0.0021	0.0001	0.0017	0.0213	0.0147	0.0007
GR6	0.0008	0.0001	0.0001	0.0017	0.0000	0.0014	0.0169	0.0117	0.0006
GR9	0.0005	0.0001	0.0000	0.0011	0.0000	0.0009	0.0108	0.0075	0.0004
GR10	0.0004	0.0001	0.0000	0.0009	0.0000	0.0007	0.0086	0.0059	0.0003
GR2	0.0003	0.0001	0.0000	0.0006	0.0000	0.0005	0.0061	0.0042	0.0002
GR12	0.0001	0.0000	0.0000	0.0003	0.0000	0.0002	0.0027	0.0018	0.0001
GR1	0.0006	0.0001	0.0000	0.0013	0.0000	0.0010	0.0128	0.0088	0.0004
GR11	0.0003	0.0000	0.0000	0.0006	0.0000	0.0005	0.0059	0.0041	0.0002
Scenario 1 - Baseline emissions – Biosludge Incinerators									
Langverwacht	0.007	0.006	0.001	0.015	0.001	0.057	0.015	0.014	0.014
Secunda Club	0.002	0.002	0.001	0.005	0.000	0.021	0.005	0.005	0.005
GR4	0.010	0.009	0.002	0.023	0.001	0.087	0.022	0.022	0.022
GR7	0.002	0.002	0.001	0.006	0.000	0.021	0.005	0.005	0.005
Bosjesspruit	0.008	0.007	0.002	0.018	0.001	0.067	0.017	0.017	0.017
GR5	0.005	0.005	0.001	0.011	0.000	0.042	0.011	0.011	0.011

Receptor	Lead (Pb) (b)	Arsenic (As) (c)	Antimony (Sb) (b)	Chromium (Cr) (b)	Cobalt (Co) (b)	Copper (Cu) (d)	Manganese (Mn) (b)	Nickel (Ni) (c)	Vanadium (V) (e)
GR8	0.003	0.002	0.001	0.006	0.000	0.023	0.006	0.006	0.006
GR3	0.003	0.003	0.001	0.007	0.000	0.027	0.007	0.007	0.007
GR6	0.003	0.003	0.001	0.008	0.000	0.030	0.008	0.008	0.008
GR9	0.001	0.001	0.000	0.003	0.000	0.010	0.003	0.003	0.003
GR10	0.002	0.002	0.000	0.004	0.000	0.016	0.004	0.004	0.004
GR2	0.001	0.001	0.000	0.003	0.000	0.011	0.003	0.003	0.003
GR12	0.000	0.000	0.000	0.001	0.000	0.002	0.001	0.001	0.001
GR1	0.001	0.001	0.000	0.003	0.000	0.012	0.003	0.003	0.003
GR11	0.001	0.001	0.000	0.002	0.000	0.007	0.002	0.002	0.002
Scenario 2a and 2b – Theoretical compliance with Existing and New Plant Standards – HOW Incinerators									
Langverwacht	0.0002	0.0000	0.0000	0.0005	0.0000	0.0004	0.0046	0.0032	0.0002
Secunda Club	0.0001	0.0000	0.0000	0.0002	0.0000	0.0002	0.0024	0.0016	0.0001
GR4	0.0002	0.0000	0.0000	0.0005	0.0000	0.0004	0.0046	0.0032	0.0002
GR7	0.0001	0.0000	0.0000	0.0003	0.0000	0.0002	0.0027	0.0019	0.0001
Bosjesspruit	0.0002	0.0000	0.0000	0.0005	0.0000	0.0004	0.0050	0.0034	0.0002
GR5	0.0001	0.0000	0.0000	0.0002	0.0000	0.0002	0.0023	0.0016	0.0001
GR8	0.0001	0.0000	0.0000	0.0002	0.0000	0.0002	0.0020	0.0014	0.0001
GR3	0.0001	0.0000	0.0000	0.0003	0.0000	0.0002	0.0027	0.0019	0.0001
GR6	0.0001	0.0000	0.0000	0.0002	0.0000	0.0002	0.0022	0.0015	0.0001
GR9	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001	0.0013	0.0009	0.0000
GR10	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001	0.0011	0.0007	0.0000
GR2	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0007	0.0005	0.0000
GR12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0002	0.0000
GR1	0.0001	0.0000	0.0000	0.0002	0.0000	0.0001	0.0015	0.0011	0.0001

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Receptor	Lead (Pb) (b)	Arsenic (As) (c)	Antimony (Sb) (b)	Chromium (Cr) (b)	Cobalt (Co) (b)	Copper (Cu) (d)	Manganese (Mn) (b)	Nickel (Ni) (c)	Vanadium (V) (e)
GR11	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0007	0.0005	0.0000
Scenario 2a and 2b – Theoretical compliance with Existing and New Plant Standards – Biosludge Incinerators									
Langverwacht	0.001	0.001	0.000	0.003	0.000	0.012	0.003	0.003	0.003
Secunda Club	0.000	0.000	0.000	0.001	0.000	0.004	0.001	0.001	0.001
GR4	0.002	0.002	0.000	0.004	0.000	0.016	0.004	0.004	0.004
GR7	0.000	0.000	0.000	0.001	0.000	0.004	0.001	0.001	0.001
Bosjesspruit	0.002	0.001	0.000	0.003	0.000	0.013	0.003	0.003	0.003
GR5	0.001	0.001	0.000	0.002	0.000	0.008	0.002	0.002	0.002
GR8	0.000	0.000	0.000	0.001	0.000	0.004	0.001	0.001	0.001
GR3	0.001	0.001	0.000	0.001	0.000	0.005	0.001	0.001	0.001
GR6	0.001	0.001	0.000	0.002	0.000	0.006	0.002	0.002	0.002
GR9	0.000	0.000	0.000	0.001	0.000	0.002	0.001	0.001	0.001
GR10	0.000	0.000	0.000	0.001	0.000	0.003	0.001	0.001	0.001
GR2	0.000	0.000	0.000	0.001	0.000	0.002	0.001	0.001	0.001
GR12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR1	0.000	0.000	0.000	0.001	0.000	0.002	0.001	0.001	0.001
GR11	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Scenario 3 – Alternative Emission Limits - HOW Incinerators									
Langverwacht	0.0348	0.0059	0.0021	0.0706	0.0019	0.0574	0.1345	0.0796	0.0246
Secunda Club	0.0179	0.0031	0.0011	0.0363	0.0010	0.0295	0.0615	0.0392	0.0127
GR4	0.0347	0.0059	0.0021	0.0705	0.0019	0.0574	0.1238	0.0734	0.0246
GR7	0.0205	0.0035	0.0012	0.0416	0.0011	0.0339	0.0687	0.0479	0.0145
Bosjesspruit	0.0379	0.0065	0.0023	0.0768	0.0020	0.0625	0.1200	0.0791	0.0268
GR5	0.0175	0.0030	0.0011	0.0355	0.0009	0.0289	0.0588	0.0395	0.0124

Receptor	Lead (Pb) (b)	Arsenic (As) (c)	Antimony (Sb) (b)	Chromium (Cr) (b)	Cobalt (Co) (b)	Copper (Cu) (d)	Manganese (Mn) (b)	Nickel (Ni) (c)	Vanadium (V) (e)
GR8	0.0153	0.0026	0.0009	0.0311	0.0008	0.0253	0.0523	0.0331	0.0108
GR3	0.0205	0.0035	0.0012	0.0417	0.0011	0.0339	0.0668	0.0391	0.0145
GR6	0.0164	0.0028	0.0010	0.0333	0.0009	0.0271	0.0548	0.0356	0.0116
GR9	0.0099	0.0017	0.0006	0.0201	0.0005	0.0164	0.0346	0.0227	0.0070
GR10	0.0080	0.0014	0.0005	0.0163	0.0004	0.0133	0.0276	0.0183	0.0057
GR2	0.0057	0.0010	0.0003	0.0115	0.0003	0.0094	0.0198	0.0127	0.0040
GR12	0.0024	0.0004	0.0001	0.0049	0.0001	0.0040	0.0085	0.0055	0.0017
GR1	0.0117	0.0020	0.0007	0.0238	0.0006	0.0193	0.0409	0.0270	0.0083
GR11	0.0055	0.0009	0.0003	0.0111	0.0003	0.0091	0.0191	0.0121	0.0039
Scenario 3 – Alternative Emission Limits - Biosludge Incinerators									
Langverwacht	0.005	0.001	0.000	0.011	0.000	0.009	0.106	0.073	0.004
Secunda Club	0.001	0.000	0.000	0.003	0.000	0.002	0.026	0.018	0.001
GR4	0.007	0.001	0.000	0.013	0.000	0.011	0.135	0.093	0.005
GR7	0.002	0.000	0.000	0.003	0.000	0.003	0.033	0.023	0.001
Bosjesspruit	0.005	0.001	0.000	0.009	0.000	0.007	0.092	0.063	0.003
GR5	0.003	0.001	0.000	0.006	0.000	0.005	0.065	0.044	0.002
GR8	0.001	0.000	0.000	0.003	0.000	0.002	0.027	0.019	0.001
GR3	0.002	0.000	0.000	0.004	0.000	0.003	0.042	0.029	0.001
GR6	0.003	0.000	0.000	0.005	0.000	0.004	0.052	0.036	0.002
GR9	0.001	0.000	0.000	0.002	0.000	0.001	0.016	0.011	0.001
GR10	0.001	0.000	0.000	0.002	0.000	0.002	0.021	0.014	0.001
GR2	0.001	0.000	0.000	0.002	0.000	0.001	0.016	0.011	0.001
GR12	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.002	0.000
GR1	0.001	0.000	0.000	0.002	0.000	0.002	0.020	0.014	0.001

Receptor	Lead (Pb) (b)	Arsenic (As) (c)	Antimony (Sb) (b)	Chromium (Cr) (b)	Cobalt (Co) (b)	Copper (Cu) (d)	Manganese (Mn) (b)	Nickel (Ni) (c)	Vanadium (V) (e)
GR11	0.001	0.000	0.000	0.001	0.000	0.001	0.011	0.008	0.000

(a) exceedances of strictest health screening level highlighted
(b) no hourly health screening level
(c) Californian OEHHA (µg/m³) – acute screening level of 0.2 µg/m³
(d) Californian OEHHA (µg/m³) – acute screening level of 100 µg/m³ over 1 hour
(e) US ATSDR Maximum Risk Levels (MRLs) (µg/m³) – acute MRL of 0.8 µg/m³

Table 5-29: Predicted annual ambient concentrations (µg/m³) of metal pollutants emitted from the Sasol Secunda Facility Incinerators (a)

Receptor	Lead (Pb) (b)	Arsenic (As) (c)	Antimony (Sb) (b)	Chromium (Cr) (d)	Cobalt (Co) (e)	Copper (Cu) (b)	Manganese (Mn) (f)	Nickel (Ni) (g)	Vanadium (V) (e)
Scenario 1 - Baseline emissions – HOW Incinerators
Langverwacht	0.0001	0.0000	0.0000	0.0002	0.0000	0.0001	0.0018	0.0012	0.0001
Secunda Club	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001	0.0012	0.0008	0.0000
GR4	0.0001	0.0000	0.0000	0.0002	0.0000	0.0001	0.0018	0.0012	0.0001
GR7	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0010	0.0007	0.0000
Bosjesspruit	0.0001	0.0000	0.0000	0.0002	0.0000	0.0002	0.0022	0.0015	0.0001
GR5	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0008	0.0006	0.0000
GR8	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0010	0.0007	0.0000
GR3	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001	0.0012	0.0008	0.0000
GR6	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0009	0.0006	0.0000
GR9	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0006	0.0004	0.0000
GR10	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0005	0.0004	0.0000
GR2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0002	0.0000
GR12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0001	0.0000
GR1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0003	0.0000
GR11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0002	0.0000
Scenario 1 - Baseline emissions – Biosludge Incinerators
Langverwacht	0.000	0.000	0.000	0.001	0.000	0.003	0.001	0.001	0.001
Secunda Club	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
GR4	0.000	0.000	0.000	0.001	0.000	0.003	0.001	0.001	0.001

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Receptor	Lead (Pb) (b)	Arsenic (As) (c)	Antimony (Sb) (b)	Chromium (Cr) (d)	Cobalt (Co) (e)	Copper (Cu) (b)	Manganese (Mn) (f)	Nickel (Ni) (g)	Vanadium (V) (e)
GR7	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Bosjesspruit	0.000	0.000	0.000	0.001	0.000	0.002	0.001	0.001	0.001
GR5	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
GR8	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
GR3	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
GR6	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
GR9	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
GR10	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
GR2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scenario 2a and 2b – Theoretical compliance with Existing and New Plant Standards – HOW Incinerators									
Langverwacht	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0001	0.0000
Secunda Club	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000
GR4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0001	0.0000
GR7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000
Bosjesspruit	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0002	0.0000
GR5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000
GR8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000
GR3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000
GR6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000
GR9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000
GR10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
GR2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
GR12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
GR1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
GR11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Scenario 2a and 2b – Theoretical compliance with Existing and New Plant Standards – Biosludge Incinerators									
Langverwacht	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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Receptor	Lead (Pb) (b)	Arsenic (As) (c)	Antimony (Sb) (b)	Chromium (Cr) (d)	Cobalt (Co) (e)	Copper (Cu) (b)	Manganese (Mn) (f)	Nickel (Ni) (g)	Vanadium (V) (e)
Secunda Club	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bosjesspruit	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GR11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Scenario 3 – Alternative Emission Limits – HOW Incinerators									
Langverwacht	0.0015	0.0003	0.0001	0.0031	0.0001	0.0025	0.0057	0.003	0.0011
Secunda Club	0.0011	0.0002	0.0001	0.0023	0.0001	0.0018	0.0039	0.002	0.0008
GR4	0.0016	0.0003	0.0001	0.0033	0.0001	0.0027	0.0057	0.004	0.0012
GR7	0.0009	0.0002	0.0001	0.0019	0.0001	0.0015	0.0032	0.002	0.0007
Bosjesspruit	0.0020	0.0003	0.0001	0.0040	0.0001	0.0032	0.0070	0.004	0.0014
GR5	0.0008	0.0001	0.0000	0.0016	0.0000	0.0013	0.0027	0.002	0.0006
GR8	0.0009	0.0002	0.0001	0.0018	0.0000	0.0015	0.0032	0.002	0.0006
GR3	0.0011	0.0002	0.0001	0.0022	0.0001	0.0018	0.0037	0.002	0.0008
GR6	0.0008	0.0001	0.0000	0.0016	0.0000	0.0013	0.0028	0.002	0.0006
GR9	0.0006	0.0001	0.0000	0.0011	0.0000	0.0009	0.0019	0.001	0.0004
GR10	0.0005	0.0001	0.0000	0.0010	0.0000	0.0008	0.0017	0.001	0.0003
GR2	0.0002	0.0000	0.0000	0.0005	0.0000	0.0004	0.0009	0.001	0.0002
GR12	0.0002	0.0000	0.0000	0.0003	0.0000	0.0003	0.0005	0.000	0.0001
GR1	0.0005	0.0001	0.0000	0.0009	0.0000	0.0008	0.0016	0.001	0.0003
GR11	0.0003	0.0001	0.0000	0.0006	0.0000	0.0005	0.0010	0.001	0.0002

Atmospheric Impact Report: Sasol Secunda Facility

Receptor	Lead (Pb) (b)	Arsenic (As) (c)	Antimony (Sb) (b)	Chromium (Cr) (d)	Cobalt (Co) (e)	Copper (Cu) (b)	Manganese (Mn) (f)	Nickel (Ni) (g)	Vanadium (V) (e)
Scenario 3 – Alternative Emission Limits – Biosludge Incinerators									
Langverwacht	0.0003	0.0002	0.0001	0.0006	0.0000	0.0023	0.0006	0.0006	0.0006
Secunda Club	0.0001	0.0001	0.0000	0.0003	0.0000	0.0010	0.0003	0.0003	0.0003
GR4	0.0003	0.0002	0.0001	0.0006	0.0000	0.0023	0.0006	0.0006	0.0006
GR7	0.0001	0.0001	0.0000	0.0003	0.0000	0.0010	0.0003	0.0003	0.0003
Bosjesspruit	0.0002	0.0002	0.0000	0.0005	0.0000	0.0019	0.0005	0.0005	0.0005
GR5	0.0001	0.0001	0.0000	0.0003	0.0000	0.0012	0.0003	0.0003	0.0003
GR8	0.0001	0.0001	0.0000	0.0002	0.0000	0.0009	0.0002	0.0002	0.0002
GR3	0.0001	0.0001	0.0000	0.0003	0.0000	0.0010	0.0003	0.0003	0.0003
GR6	0.0001	0.0001	0.0000	0.0003	0.0000	0.0010	0.0002	0.0002	0.0002
GR9	0.0001	0.0001	0.0000	0.0001	0.0000	0.0005	0.0001	0.0001	0.0001
GR10	0.0001	0.0001	0.0000	0.0001	0.0000	0.0005	0.0001	0.0001	0.0001
GR2	0.0000	0.0000	0.0000	0.0001	0.0000	0.0003	0.0001	0.0001	0.0001
GR12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
GR1	0.0000	0.0000	0.0000	0.0001	0.0000	0.0004	0.0001	0.0001	0.0001
GR11	0.0000	0.0000	0.0000	0.0001	0.0000	0.0002	0.0001	0.0001	0.0001

(a)   exceedances of strictest health screening level highlighted

(b)   no annual health screening level

(c)   Californian OEHHA (µg/m³) – chronic screening level of 0.015 µg/m3

(d)   US-EPA IRIS inhalation reference concentration – chronic (0.1   µg/m³)

(e)   US ATSDR Maximum Risk Levels (MRLs) (µg/m³) – chronic MRL of 0.1 µg/m³

(f)   US-EPA IRIS inhalation reference concentration – chronic (0.05 µg/m³)ᶦ

(g)   Californian OEHHA (µg/m³) – chronic screening level of 0.014 µg/m3

Dispersion modelling included assessing the ambient impact of H₂S emissions from the Synfuels Sulfur Recovery Plant. Predicted daily H₂S concentrations were compared against the WHO (2000) 24-hour health-based guideline (150 μg/m³) for Sulfur Recovery Plant Emissions (Figure 5-84); where no exceedances of the guideline were predicted. The Alternative Emission Limit proposed by Sasol is 12 500 mg/Nm³ which reflects the ceiling emission level that can be met given all current realities of normal operating conditions on the plant. The largest improvement in ambient concentrations of H₂S in relation to the airshed baseline would be under the theoretical compliance with New Plant Standards (Figure 5-85), while the largest increase to ambient H₂S across the airshed was predicted under the Alternative Emission Limit (Figure 5-84).

Isopleth plots are presented for the predicted 99th percentile daily ground-level H₂S concentrations as a result of the Baseline (Figure 5-86) and Alternative Emission Limits (Figure 5-87) from the Synfuels Sulfur Recovery Plant. The maximum predicted 99th percentile ground-level concentrations were below the WHO daily guideline and as such the level presented in both figures represents 3% of the daily guideline (4 μg/m³).
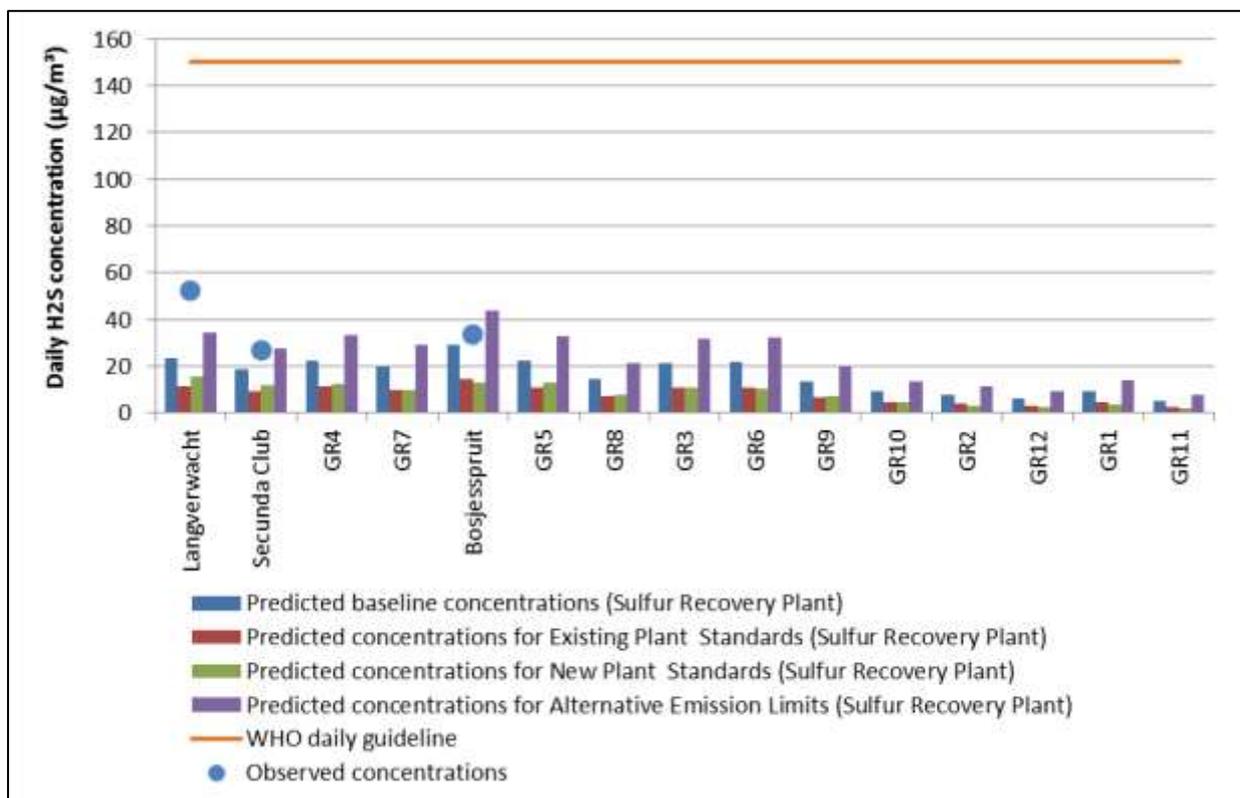
Figure 5-84: Predicted 99.9th percentile daily H₂S concentrations at identified receptors for Synfuels Sulfur Recover Plant compared against WHO (2000) guideline (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
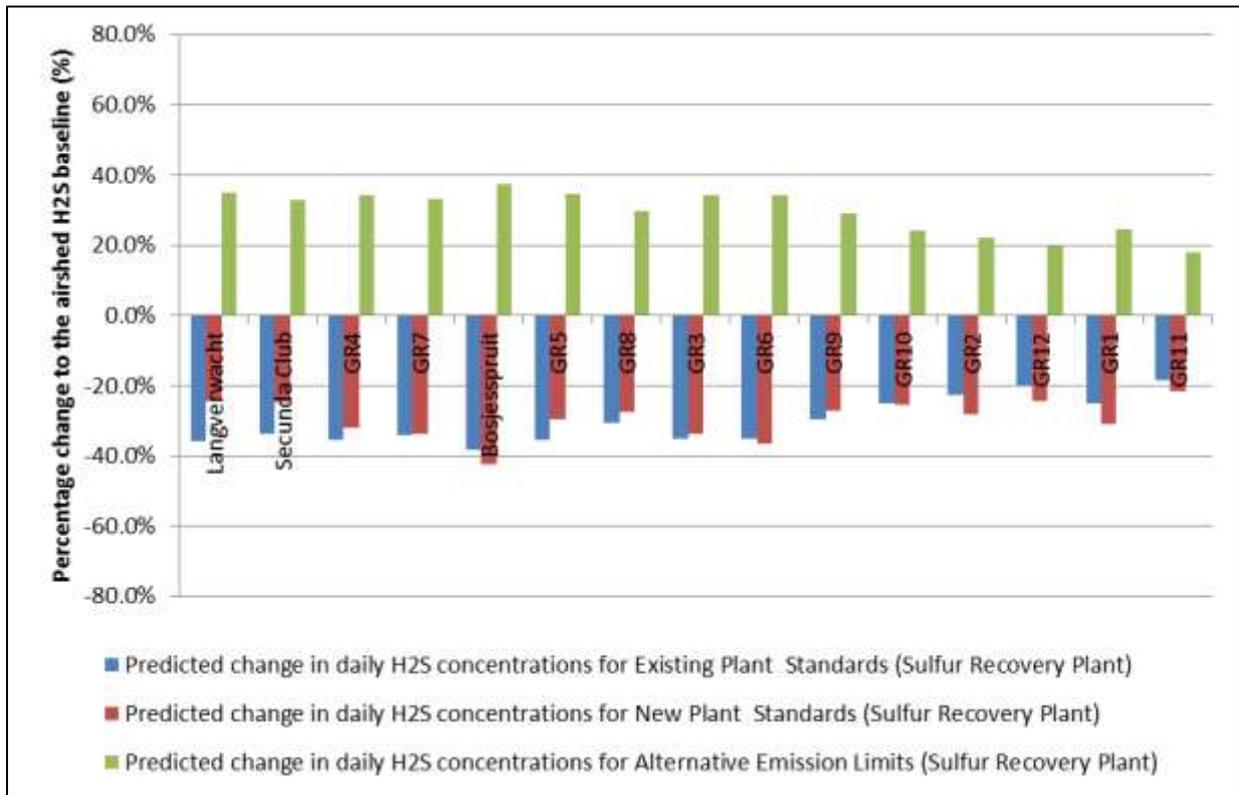
Figure 5-85: Theoretical change in H₂S concentrations between scenarios and the airshed baseline at the identified receptors for the Synfuels Sulfur Recovery Plant (change calculated using Equation 1)
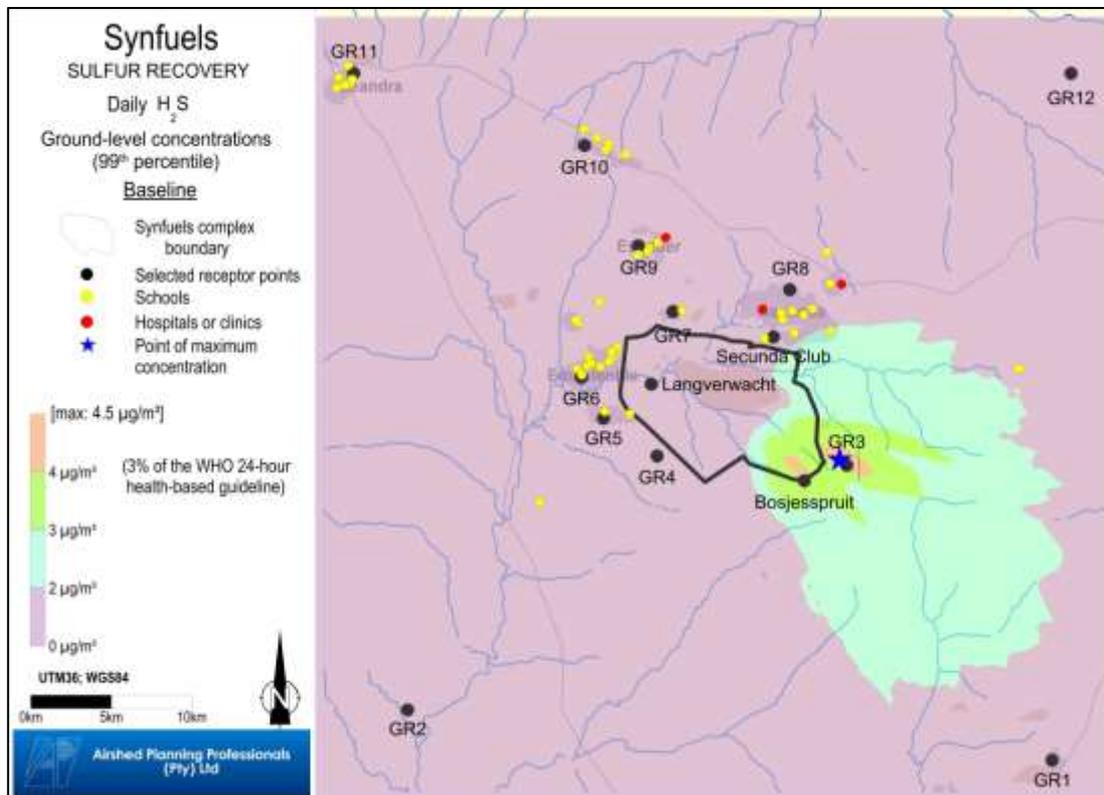
Figure 5-86: Predicted 99th percentile daily H₂S concentrations as a result of Baseline emissions from the Sulfur Recovery Plant
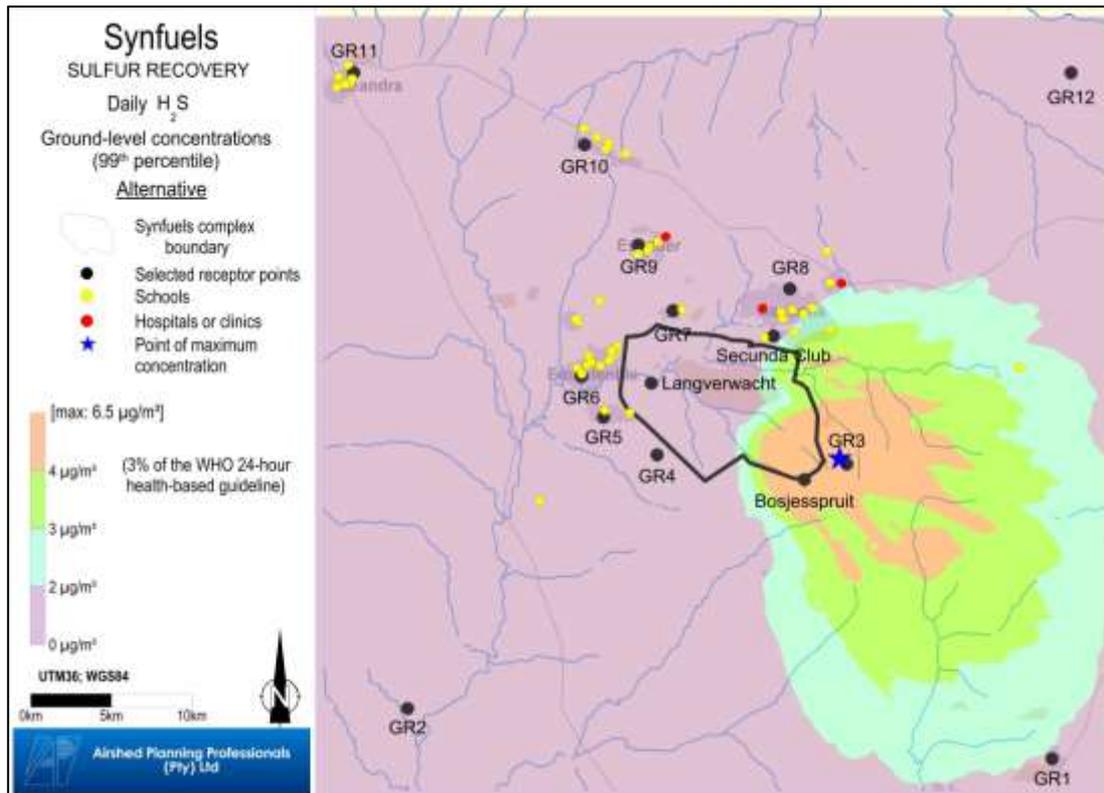
Figure 5-87: Predicted 99th percentile daily H2S concentrations as a result of Alternative Emission Limit emissions from the Sulfur Recovery Plant

The WHO daily guideline was considered to be too high to provide meaningful assessment of ambient H2S on the receptors and after consultation with Dr WCA van Niekerk (Infotox[3]), the predicted 4-hourly ambient H2S concentrations were compared against the more conservative 135 µg/m3 health effect screening level (4-hour average) recommended by Haahtele *et al.* (1992). At this exposure level, health effects include difficulty breathing, irritation of eyes, headache and nausea.

The dispersion modelling findings show that for the baseline emissions, and Alternative Emission Limit scenarios, receptors are not likely to experience H2S concentrations above the health-effect screening level (Figure 5-88), where the Alternative Emission Limit is likely to result in an increase in ambient H2S concentrations relative to the airshed baseline (Figure 5-89).

Isopleth plots are presented for the predicted 99th percentile 4-hourly ground-level H2S concentrations as a result of the Baseline (Figure 5-90) and Alternative Emission Limits (Figure 5-91) from the Synfuels Sulfur Recovery Plant. The maximum predicted 99th percentile ground-level concentrations were below the WHO daily guideline and as such the level presented in both figures represents 20% of the daily guideline (27 µg/m3).

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[3] Report to SASOL Document number 032-2013 Rev 1.0: Toxicological review for Hydrogen Sulphide
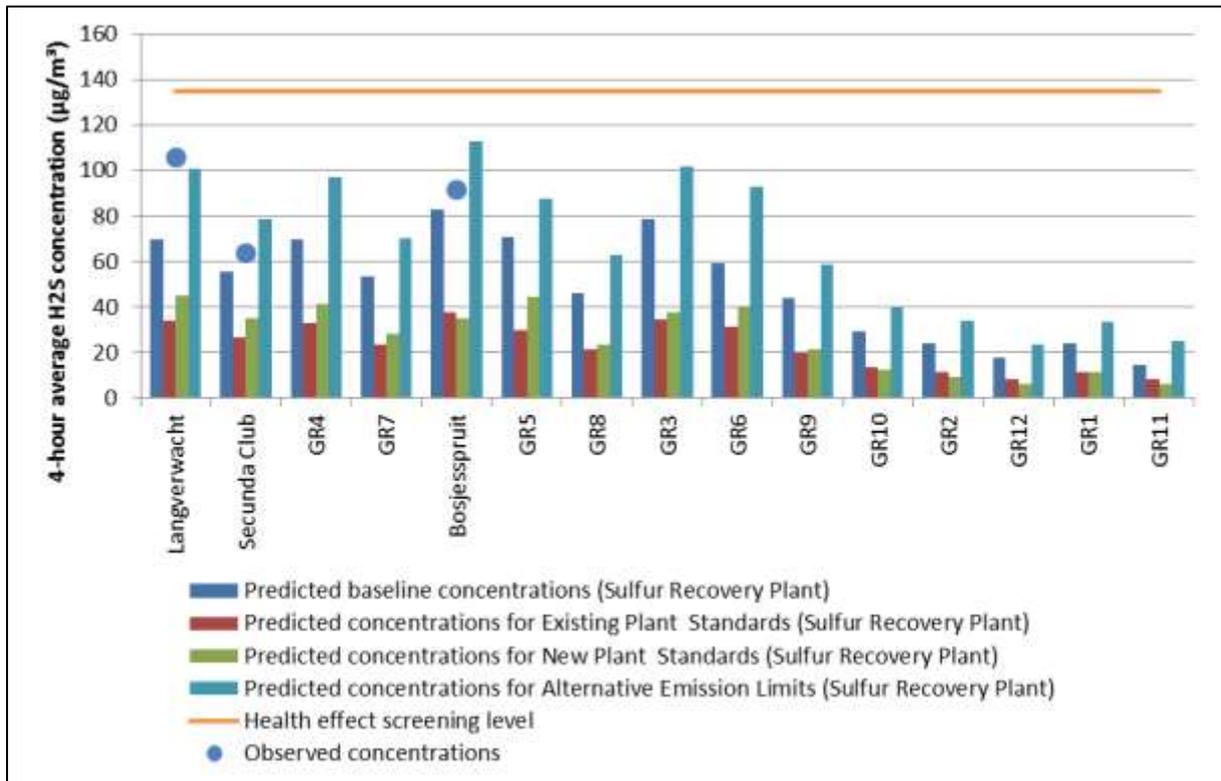
Figure 5-88: Predicted 99.9th percentile H₂S concentrations at identified receptors for Synfuels Sulfur Recovery Plant compared against Haahtele *et al.* (1992) guideline (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
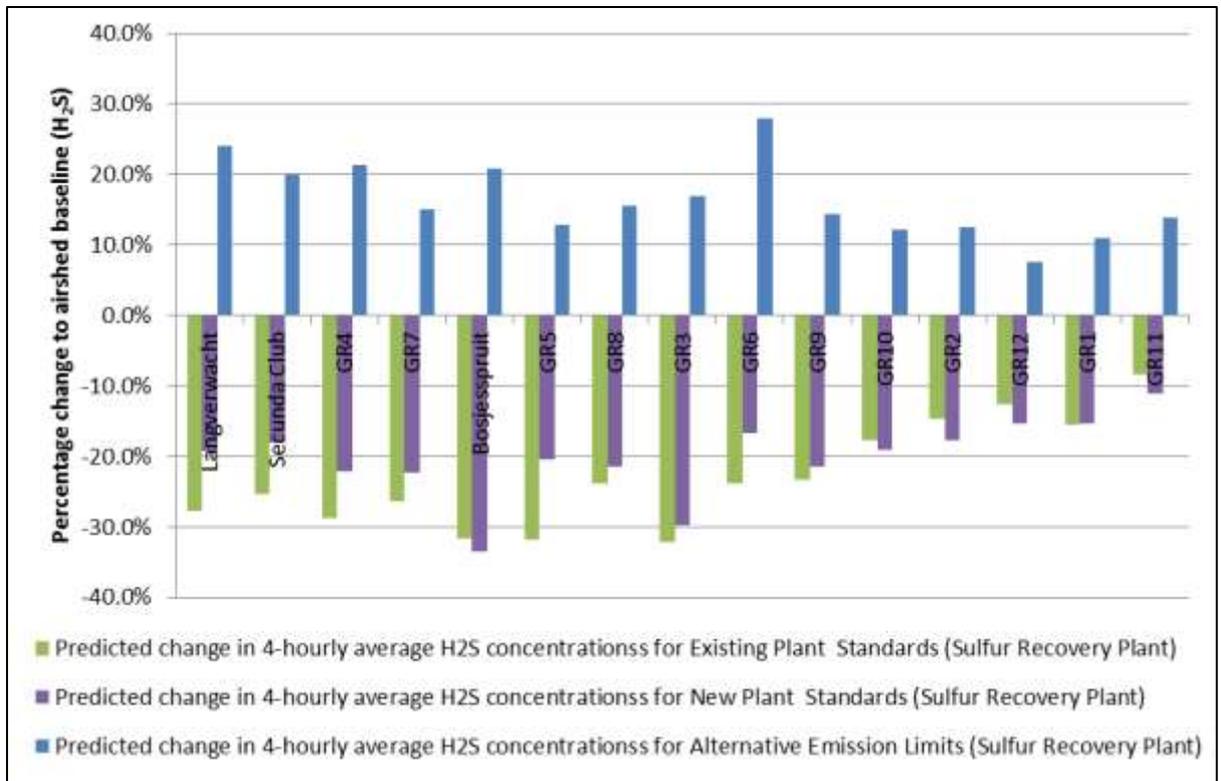
Figure 5-89: Theoretical change in H₂S concentrations between scenarios and the airshed baseline at the identified receptors for Sulfur Recovery Plant (change calculated using Equation 1)
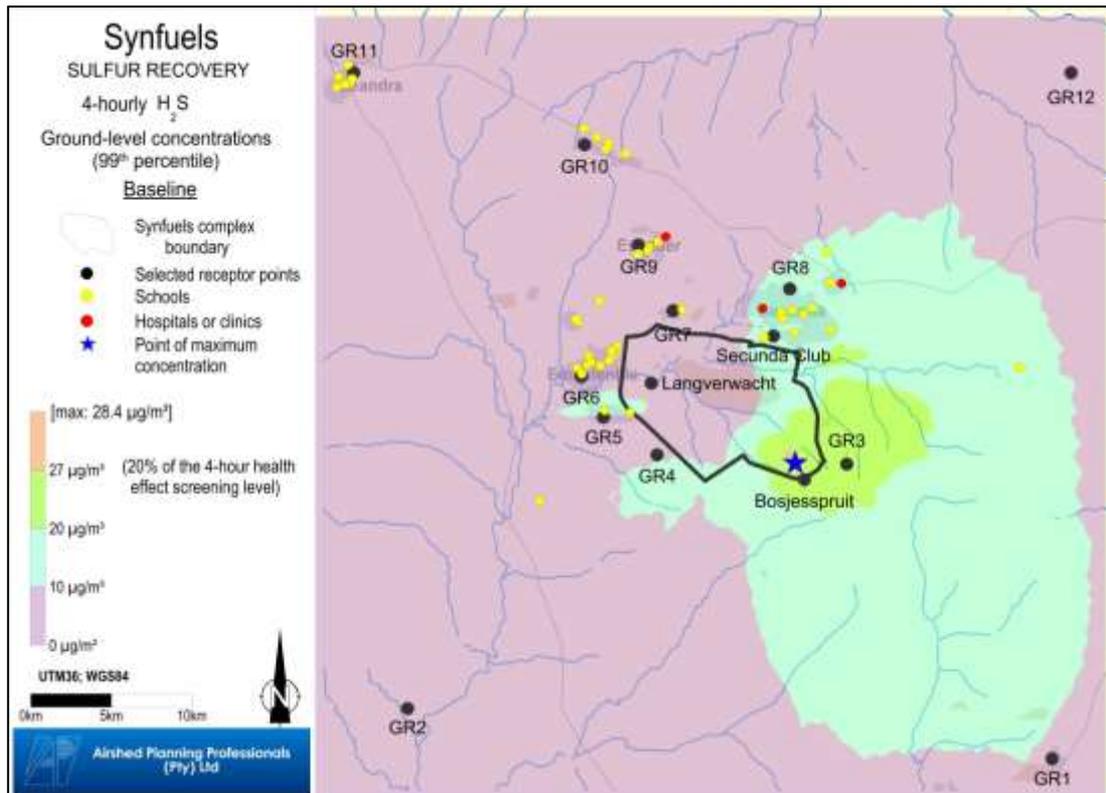
Figure 5-90: Predicted 99th percentile 4-hourly H₂S concentrations as a result of Baseline emissions from the Sulfur Recovery Plant
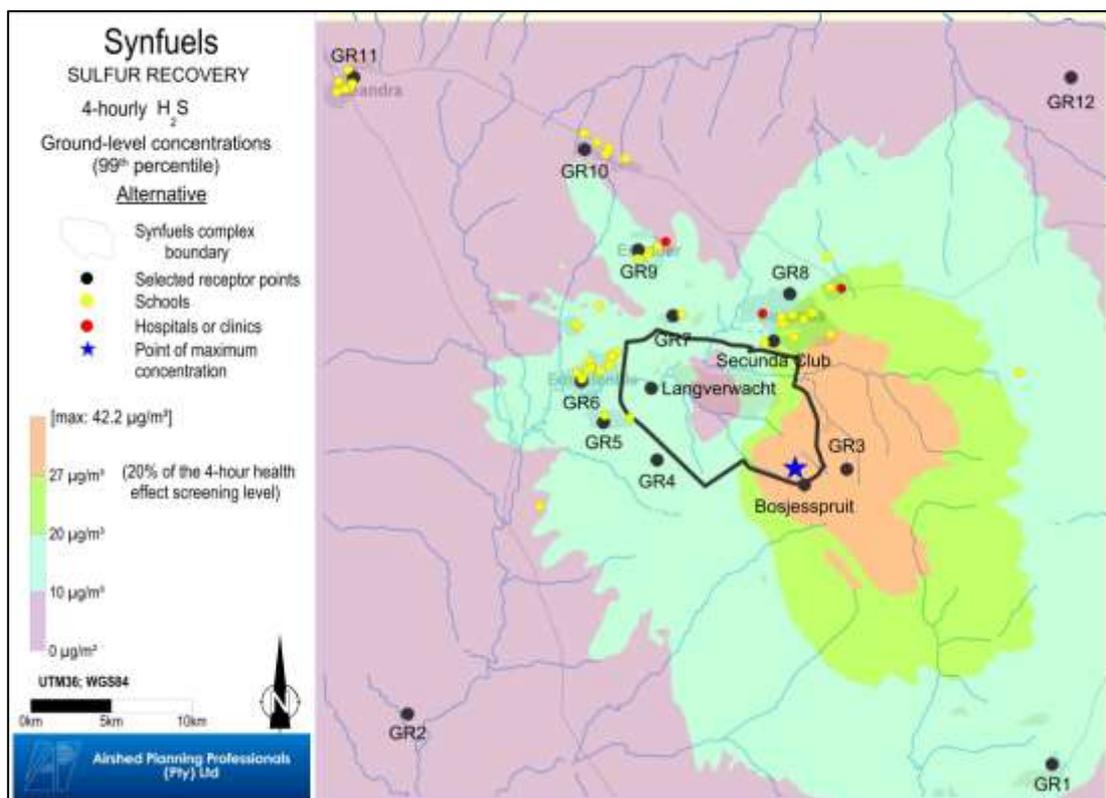
Figure 5-91: Predicted 99th percentile 4-hourly H₂S concentrations as a result of Alternative Emission Limit emissions from the Sulfur Recovery Plant

Dispersion modelling included assessing the ambient impact of sulfur trioxide (SO_3) and sulfuric acid (H_2SO_4) emissions (collectively known as acid mist) from the Synfuels Wet Sulfuric Acid Plant. Predicted hourly acid mist concentrations (Figure 5-92) were compared against the ASTDR (1999) acceptable ambient air concentration guideline for acid mist (22.5 $\mu g/m^3$). Repeating the graph with the y-axis re-scaled to show the ambient impacts of the different scenarios in raltion to the ASTDR (1999) hourly guideline found no exceedances of the guideline were predicted (Figure 5-93).
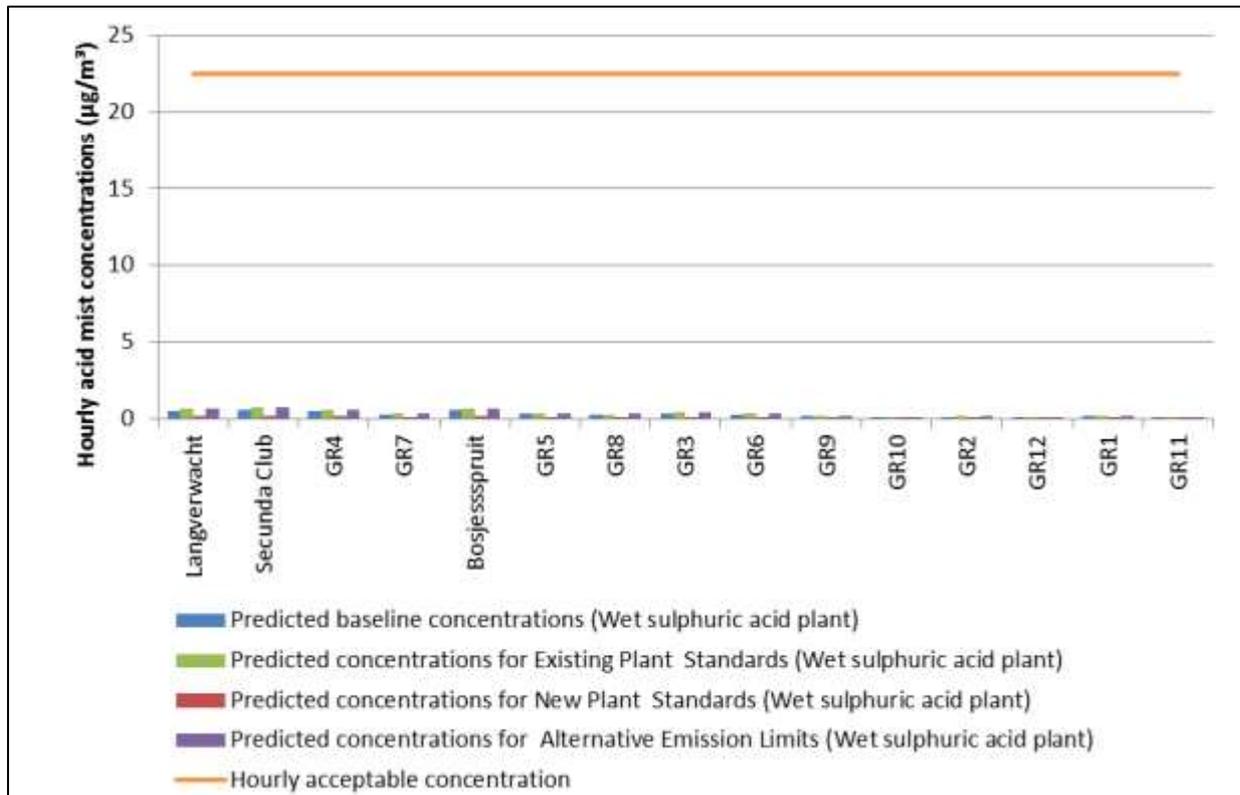
Figure 5-92: Predicted hourly acid mist (SO_3 and H_2SO_4) concentrations at identified receptors for Synfuels Wet Sulfuric Acid Plant
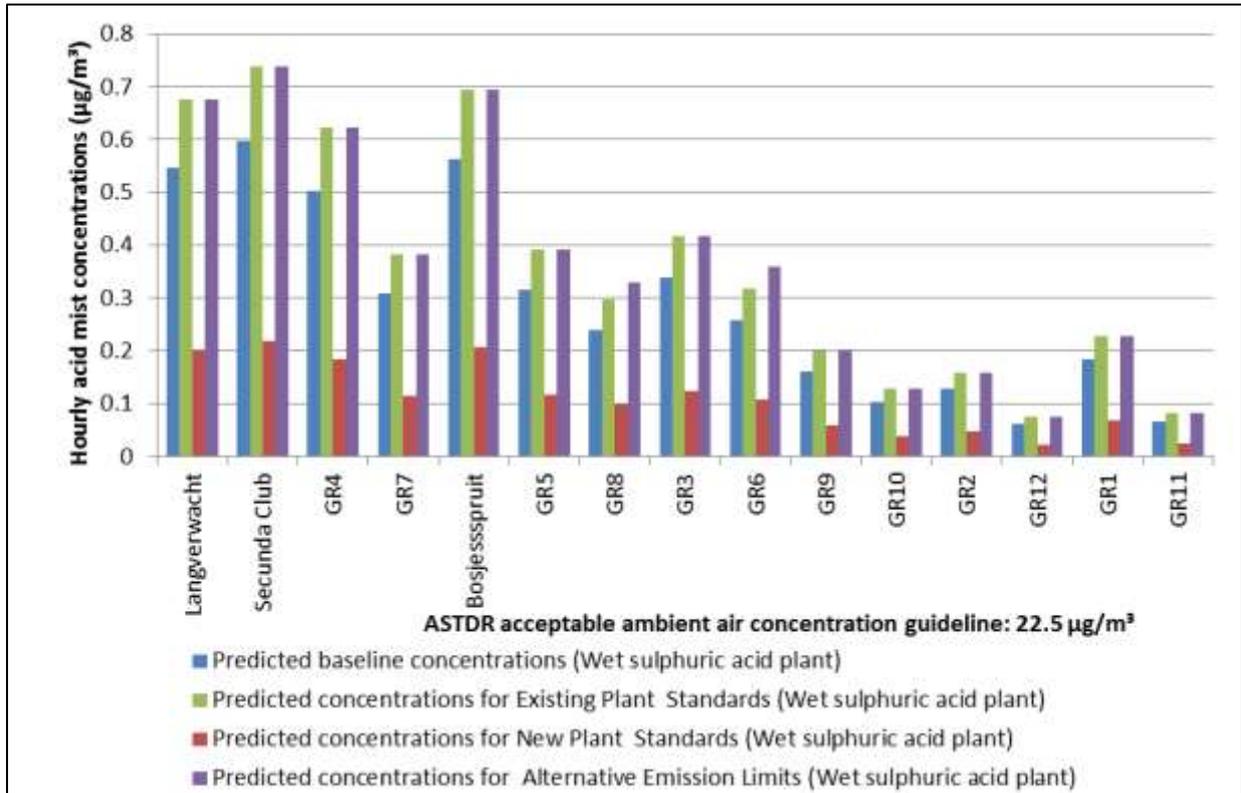
Figure 5-93: Predicted hourly acid mist (SO$_3$ and H$_2$SO$_4$) concentrations at identified receptors for Synfuels Wet Sulfuric Acid Plant (in relation to the ASTDR (1999) hourly guideline) (Based on Figure 5-92 with y-axis rescaled for clarity)

Predicted annual average ambient acid mist concentrations were calculated (Figure 5-94) and repeating the graph with the axis re-scaled to show the ambient impacts of the different scenarios in relation to the OEHHA (2008) chronic REL (Figure 5-95) found no exceedances of the chronic REL were predicted.
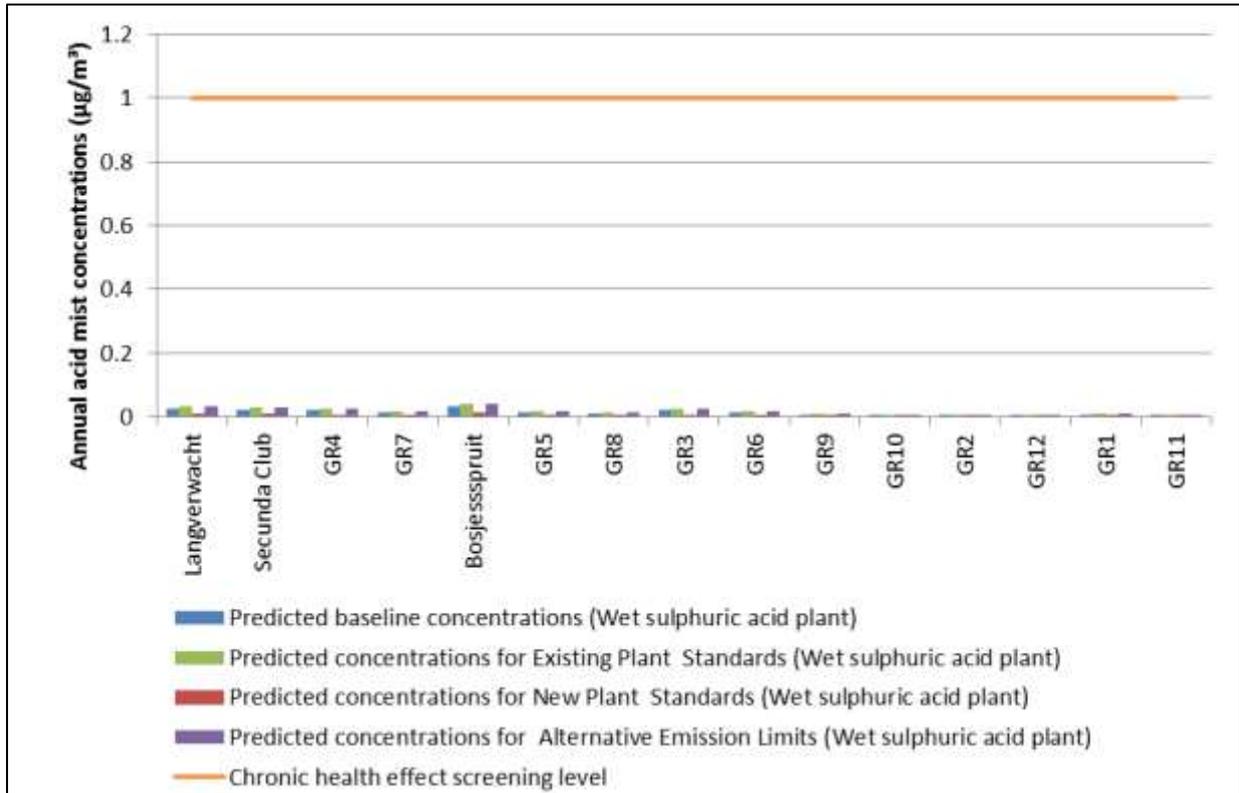
Figure 5-94: Predicted annual acid mist (SO₃ and H₂SO₄) concentrations at identified receptors for Synfuels Wet Sulfuric Acid Plant
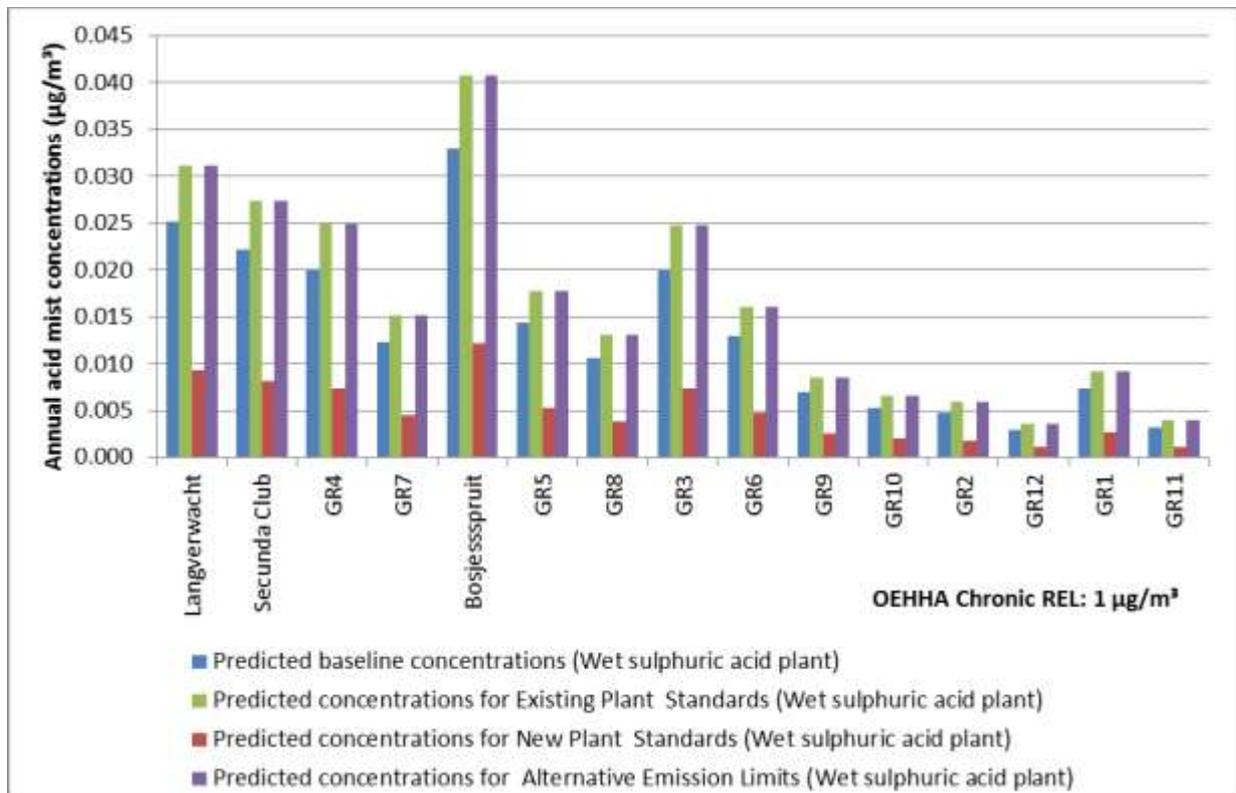
Figure 5-95: Predicted annual acid mist (SO₃ and H₂SO₄) concentrations at identified receptors for Synfuels Wet Sulfuric Acid Plant (in relation to the OEHHA (2008) chronic REL)

5.1.9   *Uncertainty of Modelled Results*

The main steps of uncertainty management are to:

- identify and understand uncertainties;
- understand whether uncertainties matter for decisions being made at the time;
- if they do matter, decide what to do about them; and,
- recommend a way forward.

Managing uncertainties attempts to eliminate the source of technical disagreements and failure to understand them often leads to a conclusion that all uncertainties need to be eliminated before project decisions can be made. The first decision about how to manage uncertainties relates to their significance given the decision being addressed. In the current context, the different parts of the investigation were grouped into similar uncertainty regimes, namely:

- dispersion model uncertainties;
- input data uncertainties;
- the methodology of validating model results; and,
- the methodology of expressing the modelled scenarios.

A comprehensive discussion on uncertainties is provided in Appendix .

As discussed in Section 5.1.5, the baseline predictions with the inclusion of estimated background concentrations performed well within the generally accepted (U.S. EPA 2005) "factor of two" accuracy of dispersion models. Unless greater general experience is gained or some further formal validation studies are conducted, it is not possible to say how much more confidence can be given to well-executed plume and puff models.

However, with the incremental differences between scenarios expressed as a ratio of the baseline concentration, the impact of model inaccuracies are essentially eliminated. As discussed in Appendix J, it is estimated that the ambient monitoring has an uncertainty of 5% with a 95% confidence interval and the emissions monitoring an uncertainty of 10% with a 95% confidence interval. Based on these uncertainties, it is estimated that the concentration ratios of the different emission scenarios have an uncertainty of -22.9% and +27.4%.

The Intergovernmental Panel on Climate Change (IPCC) produced a qualitative method for consistent communication of uncertainties in the IPCC Fifth Assessment Report. This Guidance Note has been summarised in Appendix K. On application of this guide, the results from this investigation is considered to be of "high confidence" based on a "high agreement" of the baseline predictions with observations, albeit based only on three monitoring sites, i.e. "medium evidence".

5.2   Analysis of Emissions' Impact on the Environment

Understanding the impact of deposition of atmospheric sulfur (S) and nitrogen (N) on South African ecosystems has been on-going since the late 1980's (Tyson *et al.* 1988), with much of the earlier work focussing on the circulation over the sub-continent (Tyson *et al.* 1996). More recent research has focussed on quantifying S and N deposition (Galpin and Turner

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1999, Zunckel et al. 1996, Scorgie and Kornelius 2009, Josipovic et al. 2010) and the subsequent impacts on ecosystems (Fey and Guy 1993, Van Tienhoven et al. 1995, Reid 2007, Bird 2011, Josipovic et al. 2011).

These studies estimating deposition of S and or N compounds to ecosystems present ranges of deposition rates where the differences are related to the distance from major industrial sources; the method of estimation (field work and/or calculation based on deposition velocities or dispersion modelling). As an indication, total S deposition over the industrialised Highveld of South Africa was modelled to range between 8 and 35 kg/ha/year with background levels of approximately 1 kg/ha/year (Scorgie and Kornelius 2009). In contrast, using ambient SO_2 concentrations and an inferential deposition model to calculate S deposition, Zunckel et al.(1996) estimated total S deposition of 13.9 kg/ha/year as maximum deposition rate on the Highveld. Estimates of nitrogen deposition range between 6.7 kg/ha/year (Collett et al. 2010) and 15 kg/ha/year (Scorgie and Kornelius 2009). Considering total acidic input from atmospheric sources, Josipovic and colleagues (2011) calculated a range of deposition rates between 15.8 and 23.2 kg/ha/year. All estimates are within the range of deposition rates for S and N as for some of the industrialised regions of Europe and North America (compared in Scorgie and Kornelius 2009, and Bird 2011) raising concern that the acidic loading of sulfur and nitrogen on the ecosystems of the Highveld – South Africa's most heavily industrialised region – could have implications for ecosystem functioning.

Establishing clear cause-effect relationships in complex ecosystem studies can be difficult, especially where the extent of visible damage is large and local emissions are low (Matzner and Murach 1995). Reasons include: time lags between stressor (high concentration of atmospheric pollutants) and visible symptomatic response of biota; interaction of natural factors (e.g. climate, soil and pests) and human activities (such as management, site history and air pollution); local ecosystem uniqueness and difficulty of extrapolating to larger scales; or, symptomatic responses that are not unique to the cause (e.g. defoliation) (Matzner and Murach 1995). The synergistic effect of pollutant cocktails can also add complexity to identifying causative pollutants (Emberson 2003).

Mobilisation of active forms of S and N into the atmosphere, and later as deposition onto ecosystems, can result in acidification of soils and freshwater systems, soil nutrient depletion, fertilization of naturally (usually nitrogen) limited systems and increased availability of metal ions (e.g. Al) disrupting ecosystem functioning (Rodhe et al. 1995) and changing plant and/or freshwater species diversity (Stevens et al. 2004). Although investigating the impact of atmospheric pollution from Sasol operations was beyond the scope of this study, some research findings suggest that grassland ecosystems of the Highveld are not yet affected by sulfur and nitrogen deposition (Reid 2007, Bird 2011); however, some areas may be approaching critical loads (Bird 2011, Josipovic et al. 2011).

6 COMPLAINTS

Year	Nature of complaints	Actions taken to investigate complaints	Causes of complaints identified	Measures taken to avoid reoccurrences in instances where the plant's operations were found to be the cause
2013	A total of 3 external Sasol related complaints were received during 2013. The following Sasol related complaints were received: 3 odour complaints were received, one related to H_2S odours, one related to sulfur odours and another related to general odours.	Sasol operates a complaint line where any environmental complaint can be registered. The environmental standby will investigate the complaint and ensure that the necessary steps are taken to reduce and manage the impact and to reduce the time of the incident.	Process upsets, parked trains at Trichardt junction yard and Sasol emissions during low wind conditions	An investigation form is sent to the relevant BU's SHERQ manager who launches a full investigation. Measures implemented to prevent a similar incident from reoccurring need to be specified and implemented. This is tracked from the Environmental Centre
2012	A total of 4 external Sasol Synfuels related complaints were received during 2012. The following Sasol Synfuels related incidents occurred and were handled during the past financial year: 1 complaint related to the formation of a white haze in Secunda was received during this period. 3 odour complaints were received, mostly related to ammonia and H_2S odours in Secunda.	Sasol operates a complaint line where any environmental complaint can be registered. The environmental standby will investigate the complaint and ensure that the necessary steps are taken to reduce and manage the impact and to reduce the time of the incident.	Process upsets, meteorological conditions unfavourable to adequate dispersion	An investigation form is sent to the relevant BU's SHERQ manager who launches a full investigation. Measures implemented to prevent a similar incident from reoccurring need to be specified and implemented. This is tracked from the Environmental Centre

7 CURRENT OR PLANNED AIR QUALITY MANAGEMENT INTERVENTIONS

An overview of approved air quality management improvement interventions, currently implemented and scheduled over the next 5 to 10 years, is detailed in the accompanying Motivation Report (Chapter 7).

8 COMPLIANCE AND ENFORCEMENT ACTIONS

No directives or compliance notices have been issued to Sasol Synfuels, Secunda in the last five years

9   ADDITIONAL INFORMATION

Beyond the requirements stipulated in the AIR Regulations and Dispersion Modelling Regulations, the following additional information is considered useful for better understanding the impacts of Sasol's activities and the implications of the requested postponements on ambient air quality. A brief description of each of these analyses is provided below, and referenced to where in the applications the information may be found.

a)   Polar plots

Polar plots have been provided in Section 5.1.6.1 of the AIR to visually demonstrate directional contribution as well as the dependence of concentrations on wind speed, in much the same way as a pollution rose does. The polar plots identify major contributing emissions sources impacting on a monitoring station and the direction of the impact. These polar plots do not replace isopleth plots, but rather provide additional information on the measured air quality in the region of the facility.

b)   Peer review of dispersion model

To provide increased certainty to both the DEA and the public that the dispersion modelling approach of Airshed is accurate, valid and representative, Sasol decided to take an additional step to appoint an independent international expert, Exponent Incorporated, to peer review the modelling methodology. The peer reviewer report is included in the application material. Furthermore, the peer reviewer's findings were addressed in the manner described by Airshed Planning Professionals in their written response, included as an appendix to the peer reviewer's report. Exponent Inc. is a world-renowned expert assisting the US-EPA with compliance modelling in similar instances in the United States

c)   Delta approach to assessing implications of postponements for ambient air quality

In assessing the impacts of Sasol's postponement applications on ambient air quality, a fit-for-purpose approach, as requested for by the Dispersion modelling Regulations, was taken to assess the results from the dispersion modelling, which is referred to as the "delta approach". The delta approach is premised on recognising that the difference between the current or "before additional compliance is implemented" emission scenario (i.e. the baseline scenario) and "after additional compliance is implemented" scenario (i.e. the 2020 MES compliance scenario) relates to the change in emissions from the point sources in question.

Therefore, the delta approach focuses on demonstrating the change in predicted ambient impacts of the various compliance scenarios, to guide decision makers toward better understanding the implications of the approval of postponements on air quality, and how compliance with the existing and new plant standards would impact on prevailing ambient air quality.

A detailed explanation of the scenarios modelled to highlight the delta changes in ambient air quality arising from retrofit of abatement technology is provided in Section 5.1.1.2 of the AIR. In summary, the four scenarios modelled include:

- Baseline Emissions – modelling conducted based on the current inventory and impacts
- Minimum Emissions Standards – modelling conducted based on plants theoretically complying with:
    - Existing Plant Standards, and
    - New Plant Standards

- Alternative Emission Limits – the proposed maximum emission concentrations, where applicable and different from the other three emission scenarios.

d) Toxicological review for hydrogen sulfide

Sasol has made application for postponement for certain non-criteria pollutants where NAAQS have not been set. In order to assess the ambient impacts of Sasol's emissions in these cases, benchmark limits were identified by the independent consultant that compiled the AIR, Airshed, from literature reviews of peer-reviewed studies available internationally. These non-criteria pollutants for which benchmarks were identified, include H_2S, SO_3 and various emissions from incinerators, namely lead, arsenic, antimony, chromium, cobalt, copper, manganese, nickel and vanadium. A summary of the screening levels used to assess non-criteria pollutants is provided in Section 5.1.8.2 of the AIR and in Section 6.2.5 of the motivation report for the additional postponements.

In the case of H_2S, since it is believed that Sasol is the dominant contributor to ambient concentrations, Sasol commissioned an independent toxicologist to conduct a detailed desktop study of suitable health benchmarks for use in the AIR. The toxicological review is included as Annexure C to the additional postponement application.

e) Estimating background ambient air pollutant concentrations

A background air concentration is normally defined as that concentration which would result from air emission sources outside the chosen modelling domain. This concentration can, for instance, be estimated by analysing observed air concentrations for those wind directions when it is blowing towards the sources included in the modelling domain. In other words, the observation point would be upwind from the sources being simulated by the dispersion modelling.

However, as used in the current investigation, background concentrations could also incorporate the contributions from air emission sources present in the modelling domain, but which were not included in the dispersion simulations. For example, air emissions from vehicle tailpipes can significantly contribute to the local ambient NO_2 concentrations. Although most of the sources of air emissions within the Sasol operations were included in the simulations, there remains some that were excluded, for instance fugitive emissions, but would add to the background concentration level.

Since these sources are not neatly located for easy analysis of upwind contributions, the procedure normally adopted to estimate background air concentrations could not be followed. Instead, the "background' concentration was established by comparing the predicted air concentrations with the observed air concentrations. The background concentration as used in this application therefore corresponds to the observed concentration value at a monitoring site when the simulated value at this site reached a near zero value. In other words, the observed residual air concentration was assumed to arise from other sources in the modelling domain.

With this method, the assumption is made that the model performs realistically and that the residual concentration determined this way is a good reflection of the emissions not included in the simulations. In an attempt to illustrate the model accuracy, the fractional bias was calculated for each monitoring station as described in Section 5.1.6.2. This methodology has been prescribed by the US EPA (U.S. EPA 1992) as an acceptable manner to illustrate the validity of atmospheric dispersion model. Given the good model performance, as measure by the fractional bias, it is assumed that the background concentration obtained using this methodology is reasonable estimates.

f) Ambient impacts of secondary particulates arising from Sasol emissions

As detailed in the AIR, one of the reasons for selection of the CALPUFF modelling suite is the fact this this enabled inclusion of the impact of the chemical conversion of sulphur dioxide and nitrogen oxides to secondary particulates within the dispersion model results. Thus, the predicted PM_{10} concentrations reflected in Section 5.1.8.1.3 of the AIR include direct emissions of PM_{10} plus secondary particulates formed from Sasol's emissions.

10 ANNEXURE A(I)

DECLARATION OF ACCURACY OF INFORMATION – APPLICANT

Name of Enterprise: _Sasol Synfuels_

Declaration of accuracy of information provided:

Atmospheric Impact Report in terms of section 30 of the Act.

I, _Willem Frederick Oosthuizen_ [*duly authorised*], declare that the information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of this Act.

Signed at _Secunda_ on this _11th_ day of _April 2014_

SIGNATURE

GM (SHE)
CAPACITY OF SIGNATORY

11   ANNEXURE A(II)

DECLARATION OF ACCURACY OF INFORMATION – APPLICANT

Name of Enterprise: _SECUNDA SYNFUELS OPERATIONS_

Declaration of accuracy of information provided:

Atmospheric Impact Report in terms of section 30 of the Act.

I, _SIMON VAN RENSSEN_ [duly authorised], declare that all additional information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of this Act.

Signed at _SECUNDA_ on this _16_ day of _SEPT 2014_

A. van Renssen
SIGNATURE

VICE PRESIDENT : SAFETY, HEALTH, ENVIRONMENT.
CAPACITY OF SIGNATORY

12   ANNEXURE B(I)

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: Reneé von Gruenewaldt

Name of Registration Body: South African Council for Natural Scientific Professions

Professional Registration No.: 400304/07

Declaration of independence and accuracy of information provided:

Atmospheric Impact Report in terms of section 30 of the Act.

I, Reneé von Gruenewaldt, declare that I am independent of the applicant. I have the necessary expertise to conduct the assessments required for the report and will perform the work relating the application in an objective manner, even if this results in views and findings that are not favourable to the applicant. I will disclose to the applicant and the air quality officer all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the air quality officer. The information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of this Act.

Signed at Midrand on this 31st day of March 2014

SIGNATURE

Principal Air Quality Scientist

CAPACITY OF SIGNATORY

13   ANNEXURE B(II)

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: Reneé von Gruenewaldt

Name of Registration Body: South African Council for Natural Scientific Professions

Professional Registration No.: 400304/07

Declaration of independence and accuracy of information provided:

Atmospheric Impact Report in terms of section 30 of the Act.

I, Reneé von Gruenewaldt, declare that I am independent of the applicant. I have the necessary expertise to conduct the assessments required for the report and will perform the work relating the application in an objective manner, even if this results in views and findings that are not favourable to the applicant. I will disclose to the applicant and the air quality officer all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the air quality officer. The additional information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of this Act.

Signed at Midrand on this 23rd day of September 2014

SIGNATURE

Principal Air Quality Scientist

CAPACITY OF SIGNATORY

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APPENDIX A: COMPETENCIES FOR PERFORMING AIR DISPERSION MODELLING

All modelling tasks were performed by competent personnel. Table A-1 is a summary of competency requirements. Apart from the necessary technical skills required for the calculations, personnel competency also include the correct attitude, behaviour, motive and other personal characteristic that are essential to perform the assigned job on time and with the required diligence as deemed necessary for the successful completion of the project.

The project team included two principal engineers, both with relevant experience of more than 25 years each and one principal scientist with 12 years relevant experience. One of the principal scientists managed and directed the project.

Verification of modelling results was also conducted by one of the principal engineers. The latter function requires a thorough knowledge of the

- meteorological parameters that influence the atmospheric dispersion processes and
- atmospheric chemical transformations that some pollutants may undergo during the dispersion process.

In addition, the project team included one senior and one junior staff member.

Table A-1: Competencies for Performing Air Dispersion Modelling

Competency	Task, Knowledge and Experience
Context	Communication with field workers, technicians, laboratories, engineers and scientists and project managers during the process is important to the success of the model
	Familiar with terminology, principles and interactions
	Record keeping is important to support the accountability of the model - Understanding of data collection methods and technologies

Knowledge	Meteorology:
	• Obtain, review and interpret meteorological data
	• Understanding of meteorological impacts on pollutants
	• Ability to identify and describe soil, water, drainage and terrain conditions
	    ○ Understanding of their interaction
	    ○ Familiarity with surface roughness`
	• Ability to identify good and bad data points/sets
	• Understanding of how to deal with incomplete/missing meteorological data

	Atmospheric Dispersion models • Select appropriate dispersion model • Prepare and execute dispersion model • Understanding of model input parameters • Interpret results of model
	Chemical and physical interactions of atmospheric pollutants • Familiarity with fate and transport of pollutants in air • Interaction of primary pollutants with other substances (natural or industrial) to form secondary pollutants
	Information relevant to the model • Identify potential pollution (emission) sources and rates • Gather physical information on sources such as location, stack height and diameter • Gather operating information on sources such as mass flow rates, stack top temperature, velocity or volumetric flow rate • Calculate emission rates based on collected information • Identify land use (urban/rural) • Identify land cover/terrain characteristics • Identify the receptor grid/site
	Legislation, regulations and guidelines in regards to National Environment Management: Air Quality Act (Act No 39 of 2004), including • Minimum Emissions Standards (Section 21 of Act) • National Ambient Air Quality Standards

Competency	Task, Knowledge and Experience
	• Regulations Regarding Air Dispersion Modelling • Atmospheric Impact Report (AIR)
Abilities	Ability to read and understand map information
	Ability to prepare reports and documents as necessary
	Ability to review reports to ensure accuracy, clarity and completeness
	Communication skills
	Team skills

APPENDIX B: COMPARISON OF STUDY APPROACH WITH THE REGULATIONS PRESCRIBING THE FORMAT OF THE ATMOSPHERIC IMPACT REPORT AND THE REGULATIONS REGARDING AIR DISPERSION MODELLING (GAZETTE No 37804 PUBLISHED 11 JULY 2014)

The Regulations prescribing the format of the Atmospheric Impact Report (AIR) (Government Gazette No 36094; published 11 October 2013) were referenced for the air dispersion modelling approach used in this study. Table B-1 compares the AIR Regulations with the approach used in Section 5.

The draft regulations regarding Air Dispersion Modelling (Gazette No 35981 published 14 December 2012) were referenced for the air dispersion modelling approach used in this study. The promulgated Regulations regarding Air Dispersion Modelling (Gazette No. 37804, vol 589; 11 July 2014) were consulted to ensure that the dispersion modelling process used in this assessment was in agreement with the updated regulations. Table B-2 compares the Regulations Regarding Air Dispersion Modelling with the approach used in Section 5. The only updates applied, following stakeholder comment, was to the receptors to include schools and clinics, as indicated on the isopleth plots in Section 5.1.8.

Table B-1: Comparison of Regulations for the AIR with study approach

Chapter	Name	AIR regulations requirement	Status in AIR (April 2014)	Status in AIR (updated in response to stakeholder comment)
1	Enterprise details	• Enterprise Details • Location and Extent of the Plant • Atmospheric Emission License and other Authorisations	Enterprise details included. Location of plant included. AEL numbers included.	(unchanged)
2	Nature of process	• Listed Activities • Process Description • Unit Processes	All detail included in the regulated format	Updated to include all sources at the Synfuel Complex operations (Section 2).
3	Technical Information	• Raw Materials Used and Production Rates • Appliances and Abatement Equipment Control Technology	All raw material information included. Information on abatement equipment is confined to the listed activities seeking postponement	Updated to include all raw materials information that is not confidential and proprietary information. Sensitive information will be made available to the Licensing Authorities upon request (Section 3.1 and 3.2).

4	Atmospheric Emissions	• Point Source Emissions
		  • Point Source Parameters
		  • Point Source Maximum Emission Rates during Normal Operating Conditions
		  • Point Source Maximum Emission Rates during Start-up, Maintenance and/or Shut-down
		• Fugitive Emissions
		• Emergency Incidents
			There is no information available regarding the maximum rates available, because these are not measured, and are impractical to measure; therefore only emissions rates during normal operating conditions are available. Information regarding fugitive sources has not been included, as the modelling only considers the sources for which Sasol are requesting postponements Information regarding emergency incidents was not included as the applications deal with normal operating conditions.	• Point Source Parameters and Emissions for MES compliant point sources have been included (Appendix C-1 of the AIR).
				• Emissions released during start-up, maintenance and/or Shut-down have been discussed (Section 4.3).
				• Management of fugitive emissions across the Synfuels complex has been described (Section 4.4) and dust fall out reported for seven sites between May 2012 and April 2013.
				• The history of Emergency Incidents during the period of assessment and planned management of future Emergency Incidents has been described (Section 4.5).

Chapter	Name	AIR regulations requirement	Status in AIR (April 2014)	Status in AIR (updated in response to stakeholder comment)
5	Impact of enterprise on receiving environment			
5.1	Analysis of emissions impact on human health	Must conduct dispersion modelling, must be done in accordance with Regulations; must use NAAQS	Completed as set out by the Regulations. For VOC's the total measured values were used in the analysis and not the modelling of only sources applying for postponement.	• Section 5.1.1.1 updated to include revision of AIR in response to stakeholder comments • Section 5.1.1.2 updated to clarify the emission scenario modelled and how to interpret the bar chart figures in the results • Section 5.1.2 updated to include appropriate cross-references. • Section 5.1.3 updated to reflect the promulgated Regulations regarding Air Dispersion Modelling (also applicable throughout document) • Section 5.1.8 receptor map to include schools and clinics as well as indicate distance away from the major point sources • The description of the process to identify sensitive receptors (Section 5.1.8) has been updated for clarity. • Section 5.1.8 updated with isopleth plots that show: schools and clinics in the modelling domain; multiple predicted pollutant concentration levels; the point of maximum predicted concentration; and, a more detailed legend to assist interpretation of the plots. • Section 5.1.8.2 updated to include a table of the most stringent health-effect screening levels against which predicted non-criteria pollutant concentrations were assessed.
5.2	Analysis of emissions impact on environment	Must be undertaken at discretion of Air Quality Officer.	Literature review included in AIR, further information also provided in the motivation reports	(unchanged)
6	Complaints	Details on complaints received for last two years	Included	(unchanged)
7	Current or planned air quality management interventions	Interventions currently being implemented and scheduled and approved for next 5 years.	Information on air quality interventions are included in detail in the motivation reports	Update to correct the chapter reference in the, supporting, Motivation report and the time period for planned interventions.
8	Compliance and enforcement history	Must set out all air quality compliance and enforcement actions undertaken against the enterprise in the last 5 years. Includes directives, compliance notices, interdicts, prosecution, fines	Included	(unchanged)
9	Additional		Included polar plots as an	Updated with list and explanation

Chapter	Name	AIR regulations requirement	Status in AIR (April 2014)	Status in AIR (updated in response to stakeholder comment)
	information		additional visualisation means of ambient air quality as monitored. Independent peer review of dispersion modelling methodology by international expert consultant.	of information included in, or annexed to, the AIR beyond the requirements, in order to support the decision-making process.

Table B-2: Comparison of Regulations regarding Air Dispersion Modelling with study approach

AIR Regulations	Compliance with Regulations	Comment
Levels of assessment • Level 1: where worst-case air quality impacts are assessed using simpler screening models • Level 2: for assessment of air quality impacts as part of license application or amendment processes, where impacts are the greatest within a few kilometers downwind (less than 50km) • Level 3: requires more sophisticated dispersion models (and corresponding input data, resources and model operator expertise) in situations: − where a detailed understanding of air quality impacts, in time and space, is required; − where it is important to account for causality effects, calms, non-linear plume trajectories, spatial variations in turbulent mixing, multiple source types, and chemical transformations; − when conducting permitting and/or environmental assessment process for large industrial developments that have considerable social, economic and environmental consequences; − when evaluating air quality management approaches involving multi-source, multi-sector contributions from permitted and non-permitted sources in an airshed; or, − when assessing contaminants resulting from non-linear processes (e.g. deposition, ground-level ozone (O_3), particulate formation, visibility)	Level 3 assessment using CALPUFF	This Lagrangian Gaussian Puff model is well suited to simulate low or calm wind speed conditions. Alternative regulatory models such as the US EPA AERMOD model treats all plumes as straight-line trajectories, which under calm wind conditions grossly over-estimates the plume travel distance. CALPUFF is able to perform chemical transformations. In this study the conversion of NO to NO_2 and the secondary formation of particulate matter were concerns.
Model Input Source characterisation	Yes	Only Point sources, characterised as per the Draft Regulations in Table 5-21
Emission rates: For new or modified existing sources the maximum allowed amount, volume, emission rates and concentration of pollutants that may be discharged to the atmosphere should be used	Yes	Baseline emission rates used in this investigation were based on an hourly average mass flow and concentration. The maximum allowable emission rates were used in the scenarios for 2015 and 2020 standards. The emission rates for the Alternative Emission Standards (i.e. the emission reductions as proposed by Sasol), used maximum emission rates Emission rates used for each scenario are provided in Table 5-22.

AIR Regulations	Compliance with Regulations	Comment
Meteorological data		
Full meteorological conditions are recommended for regulatory applications.	Yes	MM5 modelled meteorology (including upper air) corrected with on-site observed meteorology (surface meteorology) (Sections 5.1.4.6.1 and 5.1.5).
Data period	Yes	3 years (2010 to 2012)
Geographical Information		
Topography and land-use		Required for CALMET 3D meteorological file preparation (Section 5.1.4.6.2)
Domain and co-ordinate system	Yes	• Dispersion modelling domain: 50 x 50 km centred around Steam Station stacks • Flat terrain • UTM co-ordinate system (WGS84) (Section 5.1.4.6.4)
General Modelling Considerations		
Ambient Background Concentrations, including estimating background concentrations in multi-source areas	Yes	Section 5.1.5.4, Section 5.1.6.1, and Appendix G
NAAQS analyses for new or modified sources: impact of source modification in terms of ground-level concentrations should be assessed within the context of the background concentrations and the	Yes	Model predicted, 99th percentile ground-level concentrations compared against current observed concentrations and assessed for contribution to ambient concentrations. Used as an indication of how modifications to the plant will impact ambient concentrations.
Land-use classification	Yes	Section 5.1.4.6.2
Surface roughness	Yes	Computed from Land-use categories in the CALMET pre-processing step (Section 5.1.4.6.2).
Albedo	Yes	Computed from Land-use categories in the CALMET pre-processing step (Section 5.1.4.6.2).
Temporal and spatial resolution		
Receptors and spatial resolutions	Yes	Sections 5.1.4.6.4 and 5.1.8
Building downwash	No	Based on screening of nearby buildings and due to the height of release from the largest pollutant emitting sources (Steam Stations), it is unlikely that building downwash would significantly influence the plume.
Chemical transformations	Yes	Sections 5.1.4.3, Section 5.1.4.4, Section 5.1.4.5and Appendix F.
General Reporting Requirements		
Model accuracy and uncertainty	Yes	Section 5.1.6, Section 5.1.9, and Appendix J
Plan of study	Yes	Section 5.1.1.1
Air Dispersion Modelling Study Reporting Requirements	Yes	As per the Regulations Prescribing the Format of the Atmospheric Impact Report, Government Gazette No. 36904, Notice Number 747 of 2013 (11 October 2013) and as per the draft Regulations

AIR Regulations	Compliance with Regulations	Comment
Plotted dispersion contours	Yes	Regarding Air Dispersion Modelling (Government Gazette No. 35981 Notice 1035 or 2012, 14 December 2012). Section 5.1.8.

APPENDIX C: RAW MATERIALS, ABATEMENT EQUIPMENT AND ATMOSPHERIC EMISSIONS AT SASOL SECUNDA

C1: Raw Materials

Table C1-1: Raw materials used at Sasol Secunda

Raw Material Type	Maximum Permitted Consumption Rate (Volume)	Units (quantity/period)
Utilities		
Boilers		
Coal	84	tonnes/h per boiler
Boiler feed water	610	tonnes/h per boiler
Fuel oil	48	m³/cold start up
Tar sludge East	0.066	tonnes/h per boiler
Tar sludge West	0.37	tonnes/h per boiler
Ammonia	90 (East) and 40 (West)	kg/precipitator/h (90%NH₃ East and 99% NH₃ West)
Air (total)	540	kNm³/h per boiler
Low pressure (LP) steam (400kPag)	34	tonnes/h per boiler
Gas Turbines		
Natural Gas or Methane Rich Gas (MRG)	11 190	kJ/kWh (per gas turbine)
	27756	kg/h per gas turbine
Boiler feed water (condensate)	155.9	tonnes/h per HRSG
Low pressure (LP) steam (400kPag @ 174°C)	21.25	tonnes/h per boiler (de-aerator)
Gas Production		
Coal Processing		
Run-of-mine coal	60 000	tonnes/day (per unit)
Gasification and Raw Gas Cooling		
Coarse coal	1700	tonnes/day (per unit)
98.6⁺ vol% pure oxygen	370	kNm³/h
HP superheated steam	1550	tonnes/h
Rectisol		
Raw Gas	2430	kNm³/h per unit
Gas Circuit		
Benfield		
Tail Gas into Benfield	405	kNm³/h
Potassium carbonate recirculation rate	2100	m³/h
Carbonate system steam consumption	135	tonnes/h
DEA solution recirculation rate	270	m³/h
DEA system steam consumption	35	tonnes/h
Catalyst Manufacturing & Catalyst Reduction		
IP sensitivities		
Refining		
Tar Distillation (Unit 14 / 214)		
Crude Tar/ Depitched Tar (all 4 trains combined)	88	m³/h

Raw Material Type	Maximum Permitted Consumption Rate (Volume)	Units (quantity/period)
Unit 27A		
HNO-DTA	11.5	m^3/h
Unit 74		
Phenolic pitch	5.2	m^3/h
Coal Tar Naphtha Hydrogenation (Unit 15 / 215)		
Rectisol, Light and Heavy (containing coker naphtha and raffinate from Merisol) naphtha	21 (East)	m^3/h
	24 (West)	
	(Rectisol naphtha not less than 40% of the feed)	
Naphtha (containing coker naphtha and raffinate from Merisol) from Tar Distillation	Depends on the naphtha tank levels	m^3/h
Naphtha from Tar Distillation	Depends on the naphtha tank levels	m^3/h
Creosote Hydrogenation (Unit 228)		
Creosote from Tar Distillation including coker gas oil	45	m^3/h
	(Coker gas oil not to be more than 22% of the feed)	
Naphtha Hydrotreater, Platformer and CCR (Unit 30/230, 31/231)		
NHT hydrotreater	110 (East)	m^3/h
	105 (West)	
Platformer	85 at 95 RON	m^3/h
CCR	140	
Catalytic Distillation Hydrotreater (Unit 78)		
C5/C6 Hydrocarbons (From Co-monomers)	127	m^3/h
C5 Hydrocarbons from U229/29	95	m^3/h
C6/C7 Hydrocarbons	21	m^3/h
CD Tame (Unit 79)		
C5/C6 Hydrocarbons from Co-monomers	76	m^3/h
Methanol	18	m^3/h
C5 Isomerisation (Unit 90)		
C5 Hydrocarbons from Co-monomers	90	m^3/h
Vacuum Distillation (Unit 34 / 234)		
Decanted Oil	52	m^3/h
Distillate Hydrotreater (Unit 35 / 235)		
DHT feed from U29/229/34/234	107 (West)	m^3/h
	85 (East)	
Distillate Selective Cracker (Unit 35DSC)		
DHT distillate feed from U35 / 235	18	m^3/h
Light Oil Fractionation (Unit 29 / 229)		
Synthol light oil	255 (West)	m^3/h
	190 (East)	
Catalytic polymerisation and LPG recovery (Unit 32 / 232)		
Condensates	168 (West) (7 Reactors on line)	m^3/h

Raw Material Type	Maximum Permitted Consumption Rate (Volume)	Units (quantity/period)
	168 (East) (7 Reactors on line)	
Polymer Hydrotreater (Unit 33 / 233)		
Unhydrogenated petrol / diesel feed from unit 32/232	100	m³/h
Total Refinery West		
Hydrogen	36 800	Nm³/h
Total Refinery East		
Hydrogen	67 200	Nm³/h
Sasol Catalytic Converter		
Fresh C6/C7 Feed	94.5	tonnes/h
C2 Rich Gas	16	tonnes/h
U24 Cracked Gas	16	tonnes/h
FT Feed to VL7001	70	tonnes/h
Rerun Gasoline	10	tonnes/h
99% Hydrogen to reactor	0.52	tonnes/h
Hydrogen to CD Hydro Columns	3000	Nm³/h
PPU3 Vent Gas	3.5	tonnes/h
PP2 Carrier Gas	5	tonnes/h
HVGO	7	m³/h
Caustic	3	tonnes/h
Tar, Phenosolvan and sulfur		
Gas Liquor Separation		
Dusty Gas Liquor	906 000	kg/h per factory
Tarry Gas Liquor	352 000	kg/h per factory
Oily Gas Liquor	726 000	kg/h per factory
Trim and Final Cooler Return	234 000	kg/h per factory
Rectisol Return	4 600	kg/h per factory
Phenosolvan		
Gas Liquor	1760	m³/h per factory
Sulfur Recovery		
Offgas from Rectisol & Phenosolvan	200	kNm³/h per absorber (8 absorbers)
Caustic soda	12	m³/day per phase
SAV	8	tonnes/week (only when required)
ADA	8	tonnes/week (only when required)
NaSCN	40	tonnes/day (only when required)
Wet Sulfuric Acid		
Off gas from Rectisol & Phenosolvan	55	kNm³/h
Potable water (Rand Water)	125	m³/h supply to Proxa
Ammonia	15	Nm³/h
Carbo Tar and Coal Tar Filtration		
Unit 039 MTP	51	m³/h
Unit 039 Waxy Oil	43	m³/h
Unit 039 FCC Slurry	45	m³/h

Raw Material Type	Maximum Permitted Consumption Rate (Volume)	Units (quantity/period)
Unit 075 Green coke	112000	tonnes/year
Unit 075 Green coke Hybrid	17000	tonnes/year
Unit 076 Green Coke	60000	tonnes/year
Unit 096 Coal Tar	1327	m³/day
Unit 096 Oil	484	m³/day
Unit 086 Waxy Oil Train 1 API Oil	18	m³/h per train
Unit 086 Train 1 Waxy Oil API Oil	18	m³/h per train
Unit 086 Tar Train 2 Dam Tar	18	m³/h per train
Unit 086 Tar Train 2 Raw Tar	18	m³/h per train
Unit 086 Tar Train 2 Tank Sludge's	18	m³/h per train
Unit 086 OBF Waxy Oil 12	18	m³/h per train
Unit 086 OBF HFO 150	18	m³/h per train
Water and Ash		
Multi hearth sludge incinerator		
Thickened waste activated sludge	508	m³/day
HOW Incinerator		
High organic waste	48	m³/day
Sewage Incinerator		
Raw sewage and Domestic waste Screenings	440	kg/day
WRF TO		
Vent gas, Nitrogen and Air	1578	Nm³/h
Market and Process Integration		
Central Corridor Flares		
The flares are safety devices that need to flare gasses to protect equipment during process upset conditions		
Solvents		
Solvents West		
Reaction water ex Synthol		tonnes/h
Propanol plus		tonnes/h
Heavy aldehydes (C3 aldehydes)		tonnes/h
Ethanol 95%		tonnes/h
93 % ethanol for HPE (from EA)		tonnes/h
Solvents East		
Reaction water		tonnes/h
Aldehydes ex West		tonnes/h
Ethanol Effluent		tonnes/h
Ethyl acetate		
Ethanol 95 (E/A)		tonnes/h
Hexene		
Feed (C5- C7)		tonnes/h
NMP		tonnes/year
Methanol		tonnes/h
Octene		
Sweetened feed (total)		tonnes/h
Ethanol		m³/year

Raw Material Type	Maximum Permitted Consumption Rate (Volume)	Units (quantity/period)
NMP		tonnes/year
Potassium Carbonate		tonnes/year
Regenerator		
Potassium salt		kg/h
Stripper off gases		kg/h
Fuel gas		kg/h
Atomising steam		kg/h
Safol		
29VL106 Overheads		kg/h
229VL104 Sidedraw		kg/h
Acetonitrile		
HP Hydrogen		kg/h
Pure Gas		kg/h
Instrument air		kg/h
Octene Train 3		
1-Heptene feed from Hexene and Octene 1 (acid free)		
1-Heptene feed from Octene 2 (acidic)		
Syngas		
Hydrogen		
Polymers		
Polypropylene		
PP1		
Propylene		tonnes/year
Ethylene		tonnes/year
Hydrogen		tonnes/year
Nitrogen		tonnes/year
Heptane		tonnes/year
Catalyst		tonnes/year
Co- catalyst		tonnes/year
Silane		tonnes/year
Iso propanol		tonnes/year
1-Pentene		tonnes/year
PP2		
Propylene		tonnes/year
Ethylene		tonnes/year
Hydrogen		tonnes/year
Gas bleed from reactors and propylene recovery unit		kg/h
20 Caustic solution		kg – once per year
Monomers		
Monomers West		
C_2 Rich Gas (from Synfuels)		tonnes/h
60% C2H4		tonnes/h
40%C2H6		tonnes/h
Propane		kNm^3/h

Raw Material Type	Maximum Permitted Consumption Rate (Volume)	Units (quantity/period)
Low Pressure Gas		m^3/h
C_3 Condensate		m^3/h
Carrier gas		kNm^3/h
Ethane from SCC		tonnes/h
Ethane from U280		tonnes/h
Monomers East		
Condensate 2 to U288		tonnes/year
Condensate 3 to U288		tonnes/year
Condensate 3 to U285		tonnes/year
C2's to U280		tonnes/year
Oil		
Main flares		
Feed gas (off-gases, off specification gases and emergency venting)	Varying as and when required for safety purposes	tonnes/h
	Varying as and when required for safety purposes	tonnes/h
Ground level flares		
First flare burner		
Alcohols or off spec products	Varying as and when required for safety purposes	m^3/h
Ammonia flares		
Ammonia	Varying as and when required for safety purposes	kg/h
Propane	Varying as and when required for safety purposes	kg/h
Ethane	Varying as and when required for safety purposes	kg/h
Storage of hydrocarbons		
Various intermediate liquid material	Varying as and when required for safety purposes	
LOC		
Various products in road loading (Central road loading facility)	VOC containing products loaded in quantities exceeding 50 000 m^3/a	$m^3/year$
Various products in rail loading (Central rail loading facility)	VOC containing products loaded in quantities less than 50 000 m^3/a	$m^3/year$
Nitro		
Fertilisers		
Granulation Plant		
Ammonia		tonnes/year
Ammonium nitrate		tonnes/year
Ammonium sulfate		tonnes/year
Limestone		tonnes/year
Nitric Acid Plant		

Raw Material Type	Maximum Permitted Consumption Rate (Volume)	Units (quantity/period)
Ammonia		tonnes/day
Air		Nm^3/day
Water		m^3/day
Ammonium Nitrate Plant		
Ammonia		tonnes/year
Nitric Acid		tonnes/year
Liquid Fertilizer Plant		
Water		tonnes/year
Ammonia		tonnes/year
Potassium Chloride		tonnes/year
Urea		tonnes/year
Phosphoric Acid		tonnes/year
Ammonium Nitrate		tonnes/year
Zinc		tonnes/year
Ammonium Sulfate Plant		
Ammonia		kg/h
Sulfuric Acid		tonnes/year
Explosives (open burning grounds)		
Waste		kg/day

Some raw materials and/or consumption rates were excluded for proprietary or competition law sensitivities

Table C1-2: All appliances and abatement equipment used on unit processes at the Sasol Secunda complex

Appliance name	Appliance type/description	Appliance function/purpose
Not available	Electrostatic Precipitators	Reduce particulate emissions
Not available	Stainless Steel Filters	Reduce particulate emissions
Venturi Scrubber	Venturi Scrubber	Reduce particulate and gaseous emissions
Electrostatic precipitator	Wet Electrostatic precipitator	Reduce particulate and gaseous emissions
Reactor	DeNOx converter	Reduce NOx emissions
Flares	Flares	Combust organic gasses to CO_2 and H_2O
Bag house	Bag filters	Reduce particulate emissions
Cyclones	Cyclones	Reduce particulate emissions

C2: Point Source Emissions

Table C2-3: Point source parameters

Point Source code	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)	Emission Hours	Type of Emission (Continuous / Batch / Intermittent)
Utilities											
B1	West stack	26.5575	29.14993	250	230	13.6	185	10 025 400	23-27	24	Continuous
B2	East stack	26.56014	29.16841	301	281	14.4	185	11 278 580	23-27	24	Continuous
GT1	Gas Turbine stack	26.564167	29.165	40	37	5.3	548	3 176 904	40	24	Continuous
GT2	Gas Turbine stack	26.564167	29.164444	40	37	5.3	548	3 176 904	40	24	Continuous
Gas Production											
Rectisol East	Off gas to main stack	26.56014	29.16841	301	281	13.6	20 - 25	830 370	20-30	24	Continuous
Rectisol West	Off gas to main stack	26.5575	29.14993	250	230	14.4	20 – 25	830 370	20-30	24	Continuous
Gas Circuit											
Catalyst Manufacturing											
CM1	West Kiln Stack	26.55496	29.15655	25	-5	0.91	170	81 163	28.7	24	Batch
CM2	West Arc Furnace Stack	26.55509	29.15655	25	-5	1.6	35	190 211	34.3	24	Batch
CM3	East A Kiln Stack	26.55735	29.17548	25	-5	0.76	205	33 917	12	24	Batch
CM4	East Arc Furnace Stack	26.55773	29.17531	25	-5	1.6	73	43 720	5.35	24	Batch
CM5	East B Kiln Stack	26.55692	29.17537	25	-5	0.77	192	19 970	11.9	24	Batch
Refining											
Tar Distillation											
R1 (14HT101)	Tar Distillation Reboiler Stack Outlet	26.549167	29.183056	51.876	46.876	0.894	440	7 390	3.27	24	Continuous
R2 (14HT201)	Tar Distillation Reboiler Stack Outlet	26.549167	29.150833	51.876	46.876	0.894	440	7 390	3.27	24	Continuous

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Point Source code	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)	Emission Hours	Type of Emission (Continuous / Batch / Intermittent)
R3 (214HT101)	Tar Distillation Reboiler Stack Outlet	26.549167	29.134167	51.876	46.876	0.894	440	7 390	3.27	24	Continuous
R4 (214HT201)	Tar Distillation Reboiler Stack Outlet	26.549167	29.1175	51.876	46.876	0.894	440	7 390	3.27	24	Continuous
Creosote Hydrogenation											
R5 (228HT101)	Heater stack outlet	26.919722	29.282778	41.274	36.274	0.914	318	9 220	3.9	24	Continuous
Naphtha Hydrotreater, Platformer and CCR											
R6 (30HT101)	NHT charge heater stack outlet	26.550278	29.149722	51.876	46.876	1.22	298	6216	1.48	24	Continuous
R7 (30HT102)	Stripper Reboiler heater stack outlet	26.550278	29.149722	38.4	33.4	0.99	304	11527	4.16	24	Continuous
R8 (30HT103)	Platformer charge heater stack outlet	26.550278	29.149722	51.7	46.7	2.362	177	37722	2.39	24	Continuous
R9 (30HT104)	Debutanizer Reboiler heater stack outlet	26.550278	29.149722	43	38	1.28	360	8313	1.79	24	Continuous
R10 (30HT105)	Splitter Reboiler heater stack outlet	26.550278	29.149722	38.4	33.4	0.99	313	6856	2.47	24	Continuous
R11 (230HT101)	NHT charge heater stack outlet	26.924167	29.282778	51.9	46.9	1.22	298	9696	2.3	24	Continuous
R12 (230HT102)	Stripper reboiler stack outlet	26.923611	29.282778	38.4	33.4	0.99	304	8576	3.09	24	Continuous
R13 (230HT103)	Platformer Charge Heater stack outlet	26.922222	29.283056	51.7	46.7	2.362	177	40816	2.59	24	Continuous
R14 (230HT104)	Debutanizer reboiler stack outlet	26.923056	29.283056	43	38	1.28	360	3312	0.79	24	Continuous
R15 (230HT105)	Splitter reboiler stack outlet	26.923611	29.283056	38.4	33.4	0.99	313	7115	2.57	24	Continuous
Vacuum Distillation											
R17 (34HT101)	Vacuum heater stack outlet	26.550556	29.150278	32	27	1.27	321	10727	2.35	24	Continuous
R18	Vacuum heater stack outlet	26.924722	29.283056	32	27	1.27	321	10727	2.35	24	Continuous

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Point Source code	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)	Emission Hours	Type of Emission (Continuous / Batch / Intermittent)
(234HT101)											
				Distillate Hydroteater							
R19 (35HT101)	Reactor Charge Heater stack outlet	26.3825	29.143056	41.3	36.3	0.99	299	7865	1.916	24	Continuous
R20 (35HT102)	Fractionator Charge Heater stack outlet	26.3825	29.143056	44.2	39.2	1.35	345	11112	1.76	24	Continuous
R22 (235HT101)	Reactor Charge Heater stack outlet	26.921111	29.282778	41.3	36.3	1.308	299	6806	1.31	24	Continuous
R23 (235HT102)	Fractionator Charge Heater stack outlet	26.921111	29.282778	44.2	39.2	1.35	310	12641	2.45	24	Continuous
				Distillate Selective Cracker							
R24 (35HT103)	Reactor Charge Heater stack outlet	26.3825	29.143056	31.4	26.4	0.87	388	3495	1.63	24	Continuous
R25 (35HT104)	Fractionator Charge Heater stack outlet	26.3825	29.143056	35	30	0.99	221	3135	1.13	24	Continuous
R26 (35HT105)	Vacuum Charge Heater stack outlet	26.3825	29.143056	31	26	0.684	340	3728	2.82	24	Continuous
				Light Oil Fractionation							
R27 (29HT101)	Light Oil Splitter Reboiler stack outlet	26.550833	29.150556	48	43	1.808	280	21349	2.31	24	Continuous
R28 (29HT102)	Diesel Splitter Reboiler stack outlet	26.551389	29.151111	42.6	37.6	1.2	267	13708	3.37	24	Continuous
R29 (229HT101)	Light Oil Splitter Reboiler stack outlet	26.924722	29.283056	47.7	42.7	1.727	367	36129	4.28	24	Continuous
				Polymer Hydrotreating							
R30 (33HT101)	Stripper Reboiler stack outlet	26.551111	29.149722	34.9	29.9	1.53	300	15260	8300	24	Continuous
R31 (33HT102)	Charge Heater stack outlet	26.550833	29.149722	38.68	33.68	1.4	274	16055	10429	24	Continuous
R32 (33HT105)	Splitter Reboiler stack outlet	26.550833	29.149722	46	41	1.37	320	26830	18200	24	Continuous

Point Source code	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)	Emission Hours	Type of Emission (Continuous / Batch / Intermittent)
R33 (233HT101)	Stripper Reboiler stack outlet	26.925556	29.2825	34.9	29.9	1.53	300	15260	8300	24	Continuous
R34 (233HT102)	Charge Heater stack outlet	26.925556	29.2825	38.68	33.68	1.4	274	16055	10429	24	Continuous
R35 (233HT105)	Splitter Reboiler stack outlet	26.925556	29.2825	46	41	1.37	320	26830	18200	24	Continuous
Catalytic Polymerisation and LPG recovery											
R36 (32HT101)	Poly Debutanizer Reboiler stack outlet.	26.550556	29.150278	37.2	32.2	1.24	267	16520	13679	24	Continuous
R37 (32HT201)	Poly Debutanizer Reboiler stack outlet.	26.551667	29.150278	37.2	32.2	1.24	226	15266	12641	24	Continuous
R38 (32HT102)	Recycle Column Reboiler stack outlet.	26.551667	29.150278	51.5	46.5	2.13	309	86588	24300	24	Continuous
R39 (232HT101)	Poly Debutanizer Reboiler stack outlet.	26.928056	29.281667	37.2	32.2	1.24	267	17530	14516	24	Continuous
R40 (232HT201)	Poly Debutanizer Reboiler stack outlet.	26.928056	29.281667	37.2	32.2	1.24	226	18754	15529	24	Continuous
R41 (232HT102)	Recycle Column Reboiler stack outlet.	26.928056	29.281667	51.5	46.5	2.13	309	84654	23757	24	Continuous
Sasol Catalytic Converter											
SCC1 Stack	Main stack	26.55599	29.1639	80	76	1.067	232	410 000	12.5	24	Continuous
SCC2 (TK 1001)	Slurry Storage Tank – N$_2$ blanketing	26.55599	29.1639	11	N/A	N/A	N/A	N/A	N/A	24	Intermittent
SCC3 (TK 1002)	Fuel Oil Storage Tank – N$_2$ blanketing	26.55599	29.1639	11	N/A	N/A	N/A	N/A	N/A	24	Intermittent
SCC4 (TK 1003)	Fuel Oil Make–up Tank – N$_2$ blanketing	26.55599	29.1639	7	N/A	N/A	N/A	N/A	N/A	24	Intermittent
SCC5 (TK 3201)	DEA – Storage Tank – N$_2$ blanketing	26.55599	29.1639	9	N/A	N/A	N/A	N/A	N/A	24	Intermittent
SCC6 (TK 3202)	Slop Oil tank – N$_2$ blanketing	26.55599	29.1639	5.7	N/A	N/A	N/A	N/A	N/A	24	Intermittent
SCC7 (TK	Caustic Storage Tank – N$_2$	26.55599	29.1639	5.5	N/A	N/A	N/A	N/A	N/A	24	Intermittent

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Point Source code	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)	Emission Hours	Type of Emission (Continuous / Batch / Intermittent)
3401)	blanketing										
SCC8 (TK 3402)	Spent Caustic Tank – N₂ blanketing	26.55599	29.1639	5.5	N/A	N/A	N/A	N/A	N/A	24	Intermittent
Tar, Phenosolvan and Sulfur:											
Phenosolvan											
P1	Ammonia vent line at west stack	26.5575	29.14993	250	230	0.6	33	30	0.114		Intermittent
P2	Ammonia vent line at east stack	26.56014	29.16841	301	281	0.6	31	30	0.114		Intermittent
Wet Sulfuric Acid											
WSA1 (518ME-1003)	Wet Sulfuric Acid stack	26.559278	29.167642	75	65	2.75	41	206 600	9.73	24	Continuous
Carbo Tar and Coal Tar Filtration											
FPP1 (U86 TK201)	Storage and mixing Tank	26.54895	29.14649	18	12	N/A	N/A	N/A	N/A	24	Batch
FPP2 (U86 TK202)	Storage and mixing Tank	26.54887	29.14697	18	12	N/A	N/A	N/A	N/A	24	Batch
FPP3 (U86 TK203)	Storage and mixing Tank	26.54882	29.14697	18	12	N/A	N/A	N/A	N/A	24	Batch
FPP4 (U86 TK204)	Storage and mixing Tank	26.54876	29.14697	18	12	N/A	N/A	N/A	N/A	24	Batch
FPP5 (U86 ME514)	Stack	26.5487	29.14879	18	14	0.609	17.86	20 000	24	24	Batch
CT1 (39 TK101)	Waxy Oil 30 tank	26.54887	29.1483	10	6	N/A	N/A	N/A	N/A	24	Continuous
CT 2 (39 TK102)	Waxy Oil 30 tank	26.54896	29.14816	10	6	N/A	N/A	N/A	N/A	24	Continuous
CT3 (39 TK103)	Pitch tank	26.54899	29.14762	10	6	N/A	N/A	N/A	N/A	24	Continuous
CT4 (39 TK104)	Pitch tank	26.54887	29.14746	10	6	N/A	N/A	N/A	N/A	24	Continuous

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Point Source code	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)	Emission Hours	Type of Emission (Continuous / Batch / Intermittent)
CT5 (39 TK105)	Pitch tank	26.54875	29.14714	10	6	N/A	N/A	N/A	N/A	24	Continuous
CT6 (39 TK112)	FCC Slurry tank	26.54887	29.14746	10	6	N/A	N/A	N/A	N/A	24	Continuous
CT7 (39 TK 113)	FCC Slurry tank	26.54875	29.14714	10	6	N/A	N/A	N/A	N/A	24	Continuous
CT8 (39 TK 114)	FCC Slurry tank	26.54904	29.1472	10	6	N/A	N/A	N/A	N/A	24	Continuous
CT9 (39 TK 115)	FCC Slurry tank	26.54907	29.14731	10	6	N/A	N/A	N/A	N/A	24	Continuous
CT10 (39TK 201)	Fuel Oil 10	26.5487	29.14711	8	N/A	N/A	N/A	N/A	N/A	24	Continuous
CT11 (39TK 202)	Low Sulffur Heavy Fuel Oil	26.54877	29.14711	8	N/A	N/A	N/A	N/A	N/A	24	Continuous
CT12 (39TK 203)	Low Sulffur Heavy Fuel Oil	26.54884	29.14709	8	N/A	N/A	N/A	N/A	N/A	24	Continuous
CT13 (39TK 204)	Heavy Tar Oil	26.54891	29.14709	8	N/A	N/A	N/A	N/A	N/A	24	Continuous
CT14 (39 H101)	Stack	26.55026	29.14843	60	56	1.53	320	5.74	3.1	24	Continuous
Water and Ash:											
Multi Hearth Sludge Incinerators											
WA1 (52WK-2102)	Stack	26.54617	29.1422	30	10	1.2	80	41 063	10.08	24	Continuous
WA2 (52WK-2202)	Stack	26.54598	29.14155	30	10	1.2	80	41 063	10.08	24	Continuous
WA3 (252WK-2102)	Stack	26.54096	29.14283	30	10	1.2	80	40 298	9.89	24	Continuous
WA4 (252WK-2202)	Stack	26.54111	29.14226	30	10	1.2	80	40 298	9.89	24	Continuous

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Point Source code	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)	Emission Hours	Type of Emission (Continuous / Batch / Intermittent)
					HOW Incinerators						
HOW1 (052CI-101)	Chimney	26.5481	29.14257	15	7	1.8	600 (max)	74 731	8.15	24	Continuous
HOW2 (252CI-101)	Chimney	26.5432	29.14331	15	7	1.8	600 (max)	60 055	6.55	24	Continuous
					Sewage Incinerator						
SW1 (353IN101)	Chimney	26.53883	29.14611	10	5	0.8	231	4485	4.4	24	Batch
					WRF RTO						
WRF	Thermal oxidiser	26.55089	29.1434	20	15	1.25	815	1940	0.44	24	Continuous
Solvents											
1	Regenerator Stack (Octene)	26.5534028	29.1788083	66	63	Approx 1.2m	88.04	66654	16.93		
2	Stack for heater and regenerator	26.554425	29.180619	58	52	1	350	27000	9.6		
Polymers											
					Monomers West						
1	Furnace A stack	26.54283	29.154	34	30	0.7	300	43000	31		
2	Furnace B stack	26.54283	29.154	34	30	0.7	300	43000	31		
3	Furnace C stack	26.54283	29.154	34	30	0.7	300	43000	31		
4	Furnace D stack	26.54283	29.154	34	30	0.7	300	43000	31		
5	Furnace E stack	26.54283	29.154	34	30	0.7	300	43000	31		
LOC											
1	Central road loading	-29.1648	26.5487	2 -3 m	Not Applicable	Not Applicable	Fugitive emissions				
2	Central road loading	29.1608	26.5488	2 -3 m	Not Applicable	Not Applicable	Fugitive emissions				
Nitro											
1	Nitric Acid Stack	26.5918	29.18227	61	20.5	1.52	100	120 000	18.36		

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Point Source code	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Height Above Nearby Building (m)	Diameter at Stack Tip / Vent Exit (m)	Actual Gas Exit Temperature (°C)	Actual Gas Volumetric Flow (m³/hr)	Actual Gas Exit Velocity (m/s)	Emission Hours	Type of Emission (Continuous / Batch / Intermittent)
2	Ammonium Nitrate Production Plant Stack	26.58996	29.18286	45.3	38.8	0.8	76.5	20413	11.28		
3	Granular Fertilizer Production Plant Stack (LAN)	26.9775	29.4086	64	42	3	40	420000	12.38		
4	Ammonium Sulfate Stack	26.7142	29.4147	21		0.91	22.1	40 401	17.25		

Table C2-4: Tank sources for the Sasol Oil business unit

Point Source code	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Vapour Pressure (kPa)
Oil					
1	56 TK-1402			10.74	60
2	256 TK-9301			20.45	33
3	56TK-0107			14.25	45
4	56TK-0216			7.25	16
5	256TK-3812			7.25	>14
6	256 TK 3301			14.85	29
7	56TK-3301			14.85	32
8	56TK-3721			7.25	>14
9	256TK-3721			7.25	36
10	256TK-0148			11.87	23
11	256TK-3601			11.87	20
12	256TK-3602			9.6	>14
13	256TK-3706			7.25	>14
14	256TK-3811			7.25	>14
15	256TK-3705			7.22	>14
16	256TK-3851			6.4	>14
17	56TK-7301			7.5	>14
18	56TK-3706			7.25	>14
19	56TK-7302			7.5	>14
20	56TK-3601			11.89	40
21	56TK-3603			11.87	19
22	256TK-3850			6.4	>14
23	56TK-3602			9.6	46
24	56TK-3201			14.63	105
25	56TK-7303			12.8	>14
26	56TK-3811			7.25	20
27	56TK-3705			7.25	>14
28	56TK-3812			7.25	>14
29	56TK-3811			7.25	>14
30	256TK-0143			11.97	>14
31	256TK-3202			14.63	79
32	256TK-3201			14.63	80
33	56TK -0130			10	<14
34	56TK-0143			11.97	<14
35	56TK-0146			11.97	<14
36	56TK-0203			11.97	<14
37	56TK-3709			4.85	<14
38	56TK-3710			4.85	<14
39	56TK-3713			4.85	<14
40	56TK-3714			4.85	<14
41	56TK-3721			7.22	<14
42	56TK-3835			11.97	<14

Point Source code	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Vapour Pressure (kPa)
43	256TK-3713			4.85	>14
44	256TK-3714			4.85	>14
45	256TK-3835			11.97	>14
46	256TK-1401			10.7	60
47	256TK-1402			10.7	60
48	256TK-2902			14.8	55
49	256TK-3401			11.8	<14
50	256TK-3402			11.8	<14
51	256TK-9302			20.4	33
52	56TK-0113			14.35	>14
53	56TK-0121			9	<14
54	56TK-0122			9	<14
55	56TK-0214			8	>14
56	56TK-1401			10.7	<14
57	56TK-1601			9.6	35
58	56TK-2901			14.8	21
59	56TK-2902			14.8	21
60	56TK-3202			14.6	80.2
61	56TK-3401			11.8	>14
62	56TK-3402			11.8	<14
63	56TK-3901			12.8	>14
64	56TK-3902			12.8	<14
65	56TK-2903			26	<14
66	56TK-3501			14.35	<14
67	256TK-3301			14.35	32
68	256TK-3001			14.75	<14
69	256TK-2811			11.12	>14
70	256TK-2812			11.12	>14
71	56TK-3305			9.5	<14
72	256TK-3320			12.19	>14
73	56TK-3321			12.17	<14
74	56TK-3322			12.17	<14
75	56TK-3308			9.5	<14
76	56TK-3309			9.5	<14
77	56TK-1508			9	<14
78	256TK-1508			9	>14
79	56TK-1505			8.38	>14
80	256TK-1505			8	<14
81	56TK-1414			7	<14
82	56TK-1501			11.2	<14
83	56TK-1502			11.2	>14
84	256TK-1501			11.88	>14
85	256TK-1502			11.88	<14
86	56TK-3005			14.25	<14

Point Source code	Source name	Latitude (decimal degrees)	Longitude (decimal degrees)	Height of Release Above Ground (m)	Vapour Pressure (kPa)
87	56TK-3006			14.25	<14
88	256TK-3005			15.66	<14
89	256TK-3006			15.66	<14
90	56TK-3521			9.56	>14
91	256TK-2801			11.87	<14
92	256TK-2901			14.85	<14
93	256TK-2904			14.75	<14
94	56TK-3304			20.1	<14
95	256TK-3852			20.1	<14
96	256TK-3002			9.6	<14
97	56TK-0101			11.87	<14
98	56TK-0102			11.87	<14
99	56TK-0103			11.87	<14
100	56TK-0105			21.44	<14
101	56TK-0106			14.25	<14
102	256TK-0106			11.87	<14
103	256TK-0106			14.72	<14
104	56TK-0106				<14
105	56TK-0106			12.22	<14
106	56TK-0106			12.22	<14
107	256TK-0106			7.25	<14
108	56TK-0106			14.35	<14
109	258TK-0106			11	<14
110	258TK-0106			9.5	<14
111	Rail point 7 and 10 (to 2/56TK0216)			1	<14

The geographical co-ordinates have been excluded for security reasons but will be made available to the DEA under confidentiality arrangements.

Table C2-5: Point source emission rates during normal operating conditions

Point Source Code	Pollutant Name	Maximum Release Rate (mg/Nm³)[a]	Average Period	Duration of Emissions
Utilities				
B1 (U43)	Particulate matter	130	Daily	Continuous
	SO_2	2000	Daily	Continuous
	NO_x	1400	Daily	Continuous
B2 (2U43)	Particulate matter	130	Daily	Continuous
	SO_2	2000	Daily	Continuous
	NO_x	1400	Daily	Continuous
GT1	Particulate matter	10	Daily	Continuous
	SO_2	500	Daily	Continuous
	NO_x	300	Daily	Continuous
GT2	Particulate matter	10	Daily	Continuous
	SO_2	500	Daily	Continuous
	NO_x	300	Daily	Continuous
Gas Production				
Rectisol East (Off gas to main stack)	H_2S (measured as S)	13.5 t/hr (combined with West)	Daily	Continuous
	Total VOC's	300	Hourly	Continuous
	H_2S	12 500	Daily	Continuous
Rectisol West (Off gas to main stack)	H_2S (measured as S)	13.5 t/hr (combined with East)	Daily	Continuous
	Total VOC's	300	Hourly	Continuous
	H_2S	12 500	Daily	Continuous
Gas Circuit				
CM1 (West Kiln Stack)	Particulate matter	100	Hourly	Continuous
	SO_2	500	Hourly	Continuous
	NO_x expressed as NO_2	2000	Hourly	Continuous
CM2 (West Arc Furnace stack)	Particulate matter	100	Hourly	Continuous
	SO_2	500	Hourly	Continuous
	NO_x expressed as NO_2	500	Hourly	Continuous
CM3 (East Kiln A Stack)	Particulate matter	100	Hourly	Continuous
	SO_2	500	Hourly	Continuous
	NO_x expressed as NO_2	2000	Hourly	Continuous
CM4 (East Arc Furnace stack)	Particulate matter	100	Hourly	Continuous
	SO_2	500	Hourly	Continuous
	NO_x expressed as NO_2	500	Hourly	Continuous
CM5 (East Kiln B Stack)	Particulate matter	100	Hourly	Continuous
	SO_2	500	Hourly	Continuous
	NO_x expressed as NO_2	2000	Hourly	Continuous
Refining				
R1 (14HT101)	Particulate matter	120	Hourly	Continuous
	SO_2	1700	Hourly	Continuous
	NO_x expressed as NO_2	1700	Hourly	Continuous
R2 (14HT201)	Particulate matter	120	Hourly	Continuous

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Point Source Code	Pollutant Name	Maximum Release Rate (mg/Nm³)[a]	Average Period	Duration of Emissions
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R3 (214HT101)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R4 (214HT201)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R5 (228HT101)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R6 (30HT101)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R7 (30HT102)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R8 (30HT103)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R9 (30HT104)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R10 (30HT105)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R11 (230HT101)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R12 (230HT102)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R13 (230HT103)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R14 (230HT104)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R15 (230HT105)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R17 (34HT101)	Particulate matter	120	Hourly	Continuous

Point Source Code	Pollutant Name	Maximum Release Rate (mg/Nm³)[a]	Average Period	Duration of Emissions
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R18 (234HT101)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R19 (35HT101)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R20 (35HT102)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R22 (235HT101)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R23 (235HT102)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R24 (35HT103)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R25 (35HT104)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R26 (35HT105)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R27 (29HT101)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R28 (29HT102)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R29 (229HT101)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R30 (33HT101)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R31 (33HT102)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R32 (33HT105)	Particulate matter	120	Hourly	Continuous

Point Source Code	Pollutant Name	Maximum Release Rate (mg/Nm³)[a]	Average Period	Duration of Emissions
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R33 (233HT101)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R34 (233HT102)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R35 (233HT105)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R36 (32HT101)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R37 (32HT201)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R38 (32HT102)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R39 (232HT101)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R40 (232HT201)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
R41 (232HT102)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
SCC5 Stack	Particulate matter	330	Hourly	Continuous
	SO$_2$	3000	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	550	Hourly	Continuous
Tar, Phenosolvan and Sulfur (TPS)				
WSA1 (518ME-1003)	F as HF	30	Hourly	Continuous
	HCl (from primary production of hydrochloric acid)	25	Hourly	Continuous
	HCl (from primary production of hydrochloric acid)	100	Hourly	Continuous
	SO$_2$	2800	Hourly	Continuous
	SO$_3$	100	Hourly	Continuous
	NO$_x$	2000	Hourly	Continuous
Water and Ash				
WA1 (052WK-2102)	Particulate matter	890	Hourly	Continuous

Point Source Code	Pollutant Name	Maximum Release Rate (mg/Nm³)[a]	Average Period	Duration of Emissions
	CO	5000	Hourly	Continuous
	SO_2	150	Hourly	Continuous
	NO_x expressed as NO_2	640	Hourly	Continuous
	HCl	20	Hourly	Continuous
	HF	28	Hourly	Continuous
	Pb+As+Sb+Cr+Co+Cu+Mn+Ni+V	2.4	Hourly	Continuous
	Hg	0.85	Hourly	Continuous
	Cd+Tl	0.05	Hourly	Continuous
	TOC	50	Hourly	Continuous
	NH_3	47	Hourly	Continuous
	Dioxins and furans	0.1 (ng I-TEQ/Nm³)	Hourly	Continuous
WA2 (052WK-2202)	Particulate matter	890	Hourly	Continuous
	CO	5000	Hourly	Continuous
	SO_2	150	Hourly	Continuous
	NO_x expressed as NO_2	640	Hourly	Continuous
	HCl	20	Hourly	Continuous
	HF	28	Hourly	Continuous
	Pb+As+Sb+Cr+Co+Cu+Mn+Ni+V	2.4	Hourly	Continuous
	Hg	0.85	Hourly	Continuous
	Cd+Tl	0.05	Hourly	Continuous
	TOC	50	Hourly	Continuous
	NH_3	47	Hourly	Continuous
	Dioxins and furans	0.1 (ng I-TEQ/Nm³)	Hourly	Continuous
WA3 (252WK-2102)	Particulate matter	890	Hourly	Continuous
	CO	5000	Hourly	Continuous
	SO_2	150	Hourly	Continuous
	NO_x expressed as NO_2	640	Hourly	Continuous
	HCl	20	Hourly	Continuous
	HF	28	Hourly	Continuous
	Pb+As+Sb+Cr+Co+Cu+Mn+Ni+V	2.4	Hourly	Continuous
	Hg	0.85	Hourly	Continuous
	Cd+Tl	0.05	Hourly	Continuous
	TOC	50	Hourly	Continuous
	NH_3	47	Hourly	Continuous
	Dioxins and furans	0.1 (ng I-TEQ/Nm³)	Hourly	Continuous
WA4 (252WK-2202)	Particulate matter	890	Hourly	Continuous
	CO	5000	Hourly	Continuous
	SO_2	150	Hourly	Continuous
	NO_x expressed as NO_2	640	Hourly	Continuous
	HCl	20	Hourly	Continuous
	HF	28	Hourly	Continuous
	Pb+As+Sb+Cr+Co+Cu+Mn+Ni+V	2.4	Hourly	Continuous

Point Source Code	Pollutant Name	Maximum Release Rate (mg/Nm³)[a]	Average Period	Duration of Emissions
	Hg	0.85	Hourly	Continuous
	Cd+Tl	0.05	Hourly	Continuous
	TOC	50	Hourly	Continuous
	NH_3	47	Hourly	Continuous
	Dioxins and furans	0.1 (ng I-TEQ/Nm³)	Hourly	Continuous
SW1 (353IN101)	Particulate matter	25	Hourly	Continuous
	CO	75	Hourly	Continuous
	SO_2	50	Hourly	Continuous
	NO_x expressed as NO_2	200	Hourly	Continuous
	HCl	10	Hourly	Continuous
	HF	1	Hourly	Continuous
	Pb+As+Sb+Cr+Co+Cu+Mn+Ni+V	0.5	Hourly	Continuous
	Hg	0.05	Hourly	Continuous
	Cd+Tl	0.05	Hourly	Continuous
	TOC	10	Hourly	Continuous
	NH_3	10	Hourly	Continuous
	Dioxins and furans	0.1 (ng I-TEQ/Nm³)	Hourly	Continuous
HOW1 (052CI-101)	Particulate matter	25	Hourly	Continuous
	CO	75	Hourly	Continuous
	SO_2	50	Hourly	Continuous
	NO_x expressed as NO_2	200	Hourly	Continuous
	HCl	10	Hourly	Continuous
	HF	7	Hourly	Continuous
	Pb+As+Sb+Cr+Co+Cu+Mn+Ni+V	21	Hourly	Continuous
	Hg	0.27	Hourly	Continuous
	Cd+Tl	0.12	Hourly	Continuous
	TOC	50	Hourly	Continuous
	NH_3	10	Hourly	Continuous
	Dioxins and furans	0.1 (ng I-TEQ/Nm³)	Hourly	Continuous
HOW2 (252CI-101)	Particulate matter	25	Hourly	Continuous
	CO	75	Hourly	Continuous
	SO_2	50	Hourly	Continuous
	NO_x expressed as NO_2	200	Hourly	Continuous
	HCl	10	Hourly	Continuous
	HF	7	Hourly	Continuous
	Pb+As+Sb+Cr+Co+Cu+Mn+Ni+V	21	Hourly	Continuous
	Hg	0.27	Hourly	Continuous
	Cd+Tl	0.12	Hourly	Continuous
	TOC	50	Hourly	Continuous
	NH_3	10	Hourly	Continuous
	Dioxins and furans	0.1 (ng I-TEQ/Nm³)	Hourly	Continuous
Solvents				

Point Source Code	Pollutant Name	Maximum Release Rate (mg/Nm³)[a]	Average Period	Duration of Emissions
1 (Regenerator Stack, Octene)	Particulate matter	120	Hourly	Continuous
	Particulate matter	180	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	200	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	200	Hourly	Continuous
2 (HT 1901/HT1902)	Particulate matter	120	Hourly	Continuous
	Particulate matter	180	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	200	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	200	Hourly	Continuous
Polymers				
1 (Furnace A stack)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	243 t/a	Hourly	Continuous
2 (Furnace B stack)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	243 t/a	Hourly	Continuous
3 (Furnace C stack)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	243 t/a	Hourly	Continuous
4 (Furnace D stack)	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	243 t/a	Hourly	Continuous
5 (Furnace Estack))	Particulate matter	120	Hourly	Continuous
	SO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	1700	Hourly	Continuous
	NO$_x$ expressed as NO$_2$	243 t/a	Hourly	Continuous
Oil				
All sources	VOCs (non-thermal)	40000	24 hours	Continuous
LOC				
Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Nitro				
1 Nitric Acid Stack	NO	150 (actual temperature @ 6 % oxygen)	Hourly	Continuous
	NOx	2000	Hourly	Continuous
	NH$_3$	100	Hourly	Continuous
2 Ammonium Nitrate Stack	NH$_3$	300 mg N/Nm³	Hourly	Continuous
	NH$_3$	100	Hourly	Continuous

Point Source Code	Pollutant Name	Maximum Release Rate (mg/Nm³)[(a)]	Average Period	Duration of Emissions
	Particulate matter	100	Hourly	Continuous
3 Granular Fertilizer (LAN) stack	NH_3	180 mg/Nm³ on a wet basis	Hourly	Continuous
	NH_3	100	Hourly	Continuous
	Particulate matter	100	Hourly	Continuous
	Particulate matter	100	Hourly	Continuous
4 (Ammonium Sulfate Stack	NH_3	100	Hourly	Continuous
	NH_3	100	Hourly	Continuous
	Particulate matter	100	Hourly	Continuous
	Particulate matter	100	Hourly	Continuous
	SO_2	2800	Hourly	Continuous
	SO_3	100	Hourly	Continuous
	F as HF	30	Hourly	Continuous
	HCl (from primary production)	25	Hourly	Continuous
	HCl (from primary production)	100	Hourly	Continuous

(a) units are mg/Nm³ unless otherwise specified

C3: Fugitive emissions
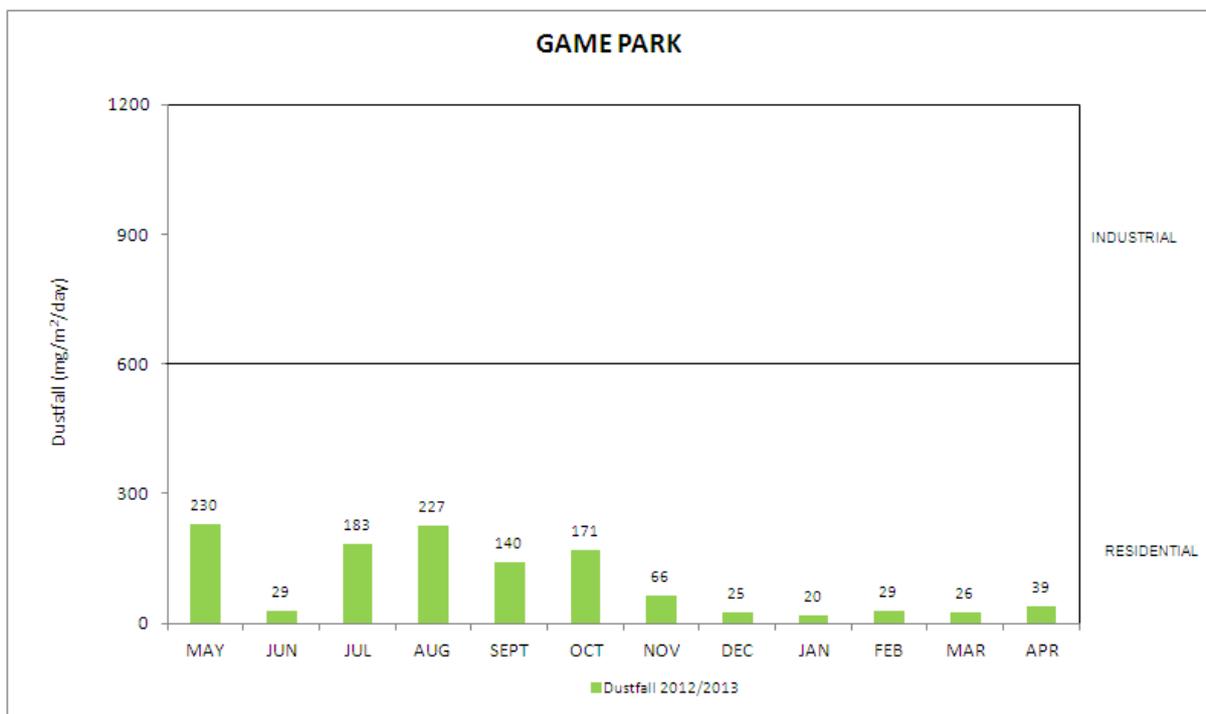
Figure C3-1: Dustfall rates at Site 5 (Game Park) between May 2012 and Apr 2013
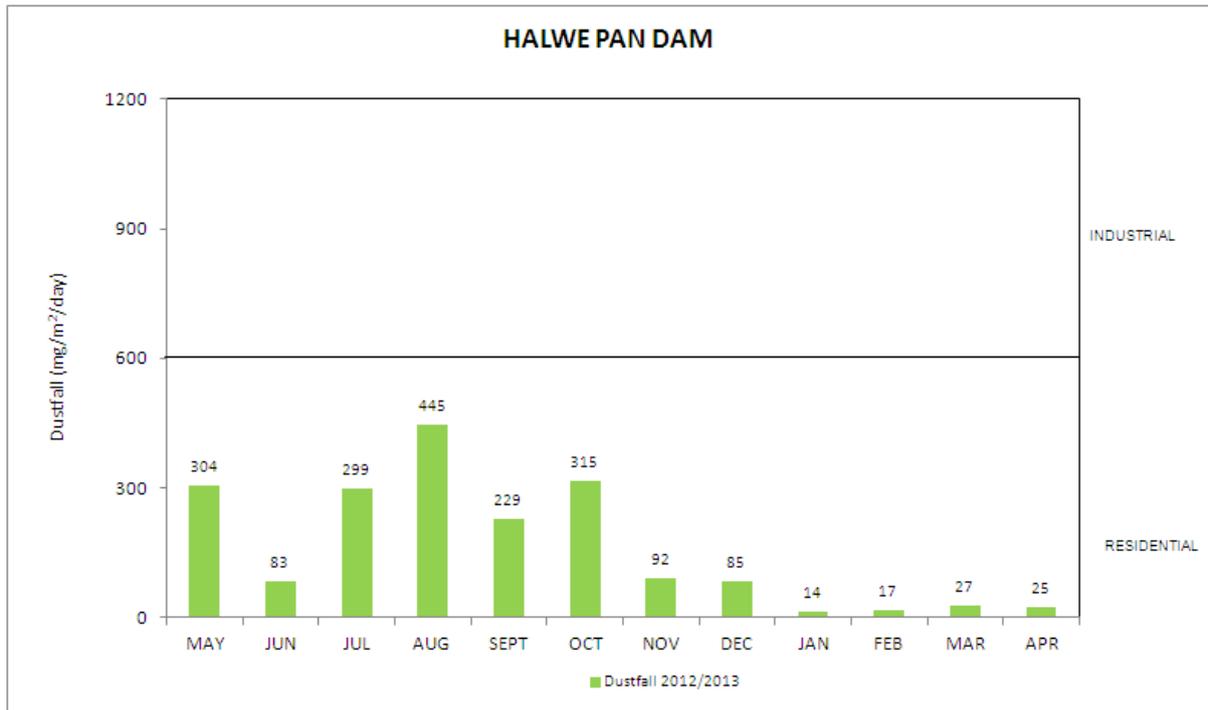
Figure C3-2: Dustfall rates at Site 6 (Halwe Pan Dam) between May 2012 and Apr 2013
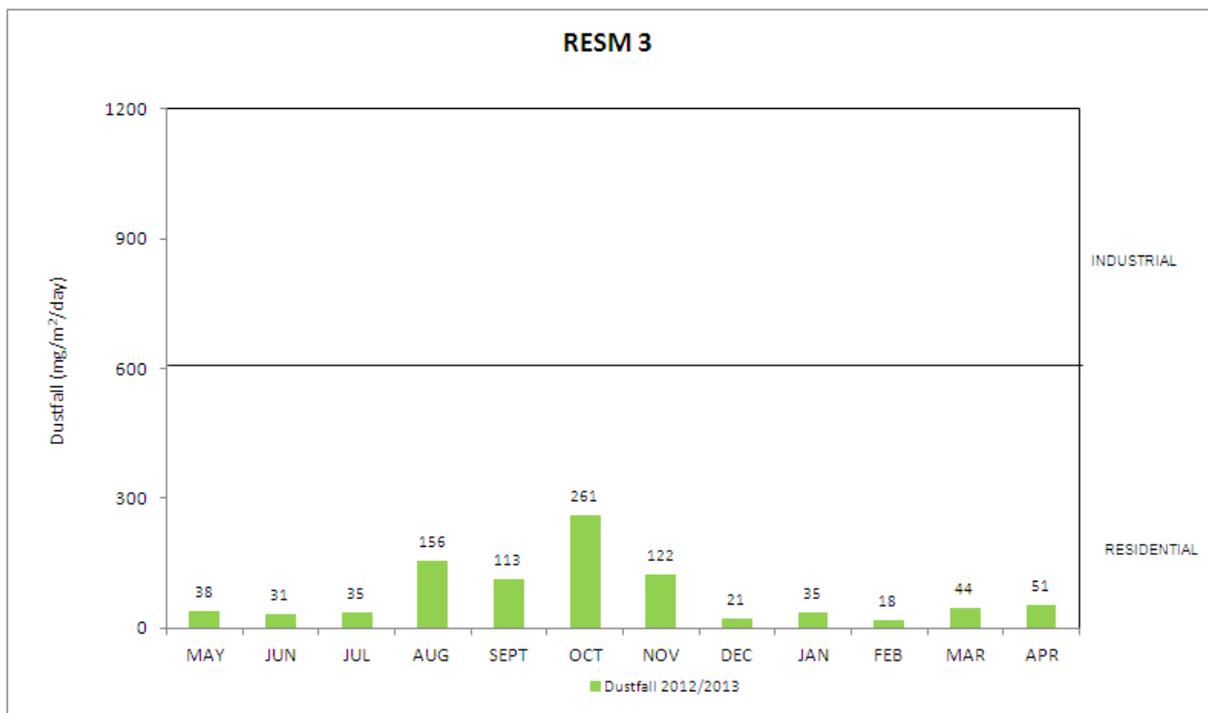
Figure C3-3: Dustfall rates at Site 7 (RESM 3) between May 2012 and Apr 2013
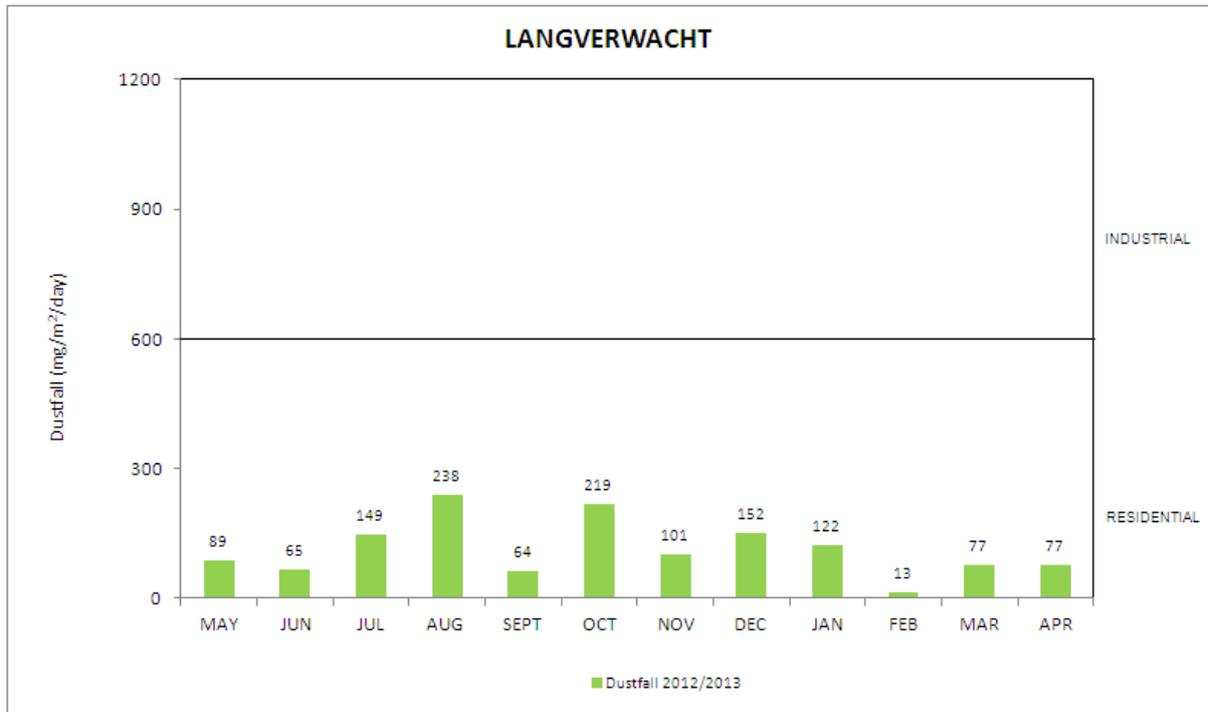
Figure C3-4: Dustfall rates at Site 8 (Langverwacht) between May 2012 and Apr 2013
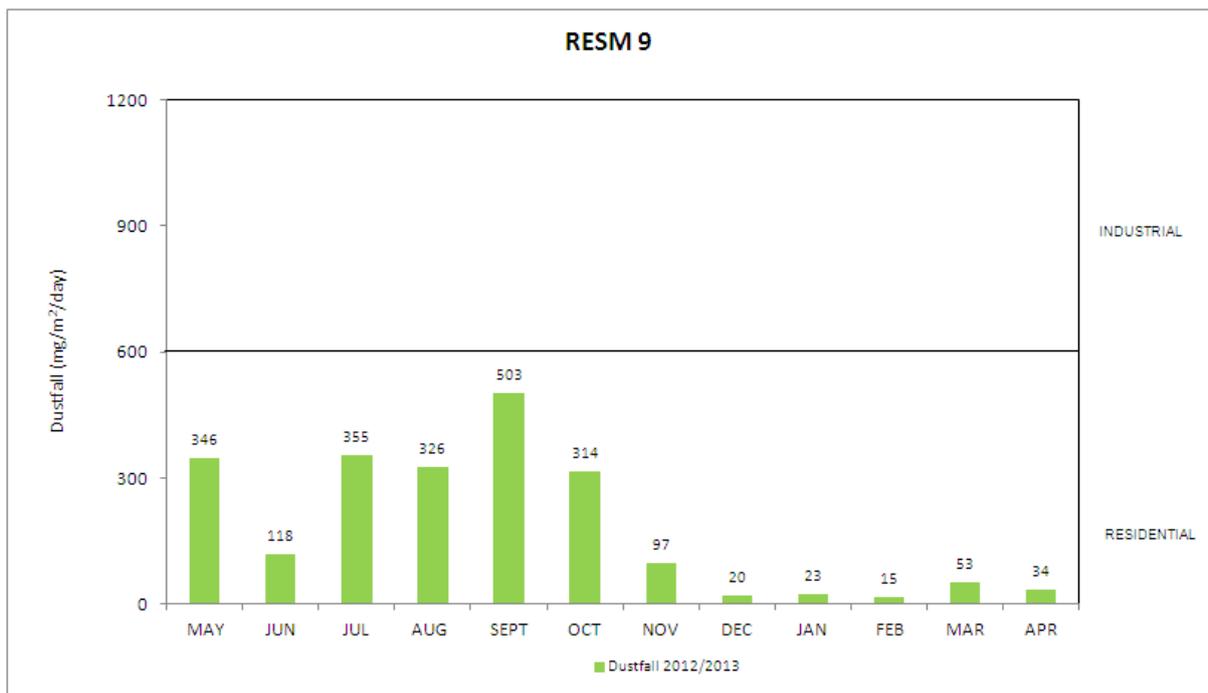
Figure C3-5: Dustfall rates at Site 9 (RESM 9) between May 2012 and Apr 2013
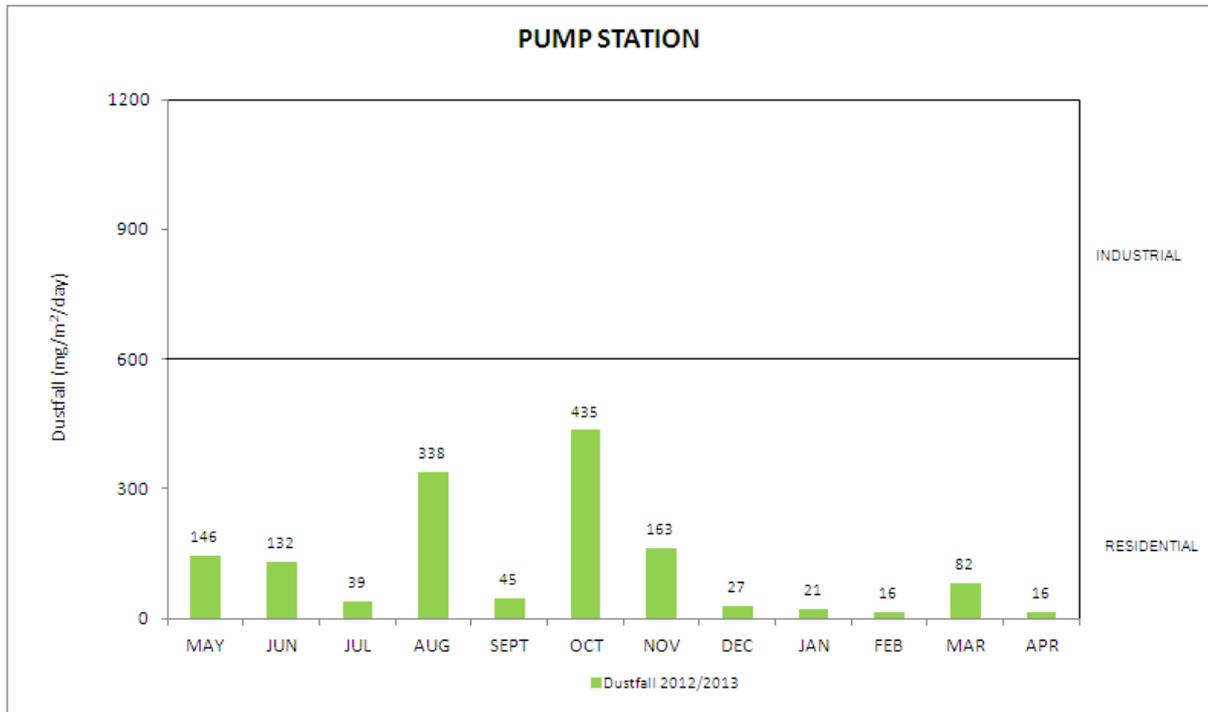
Figure C3-6: Dustfall rates at Site 10 (Pump Station) between May 2012 and Apr 2013
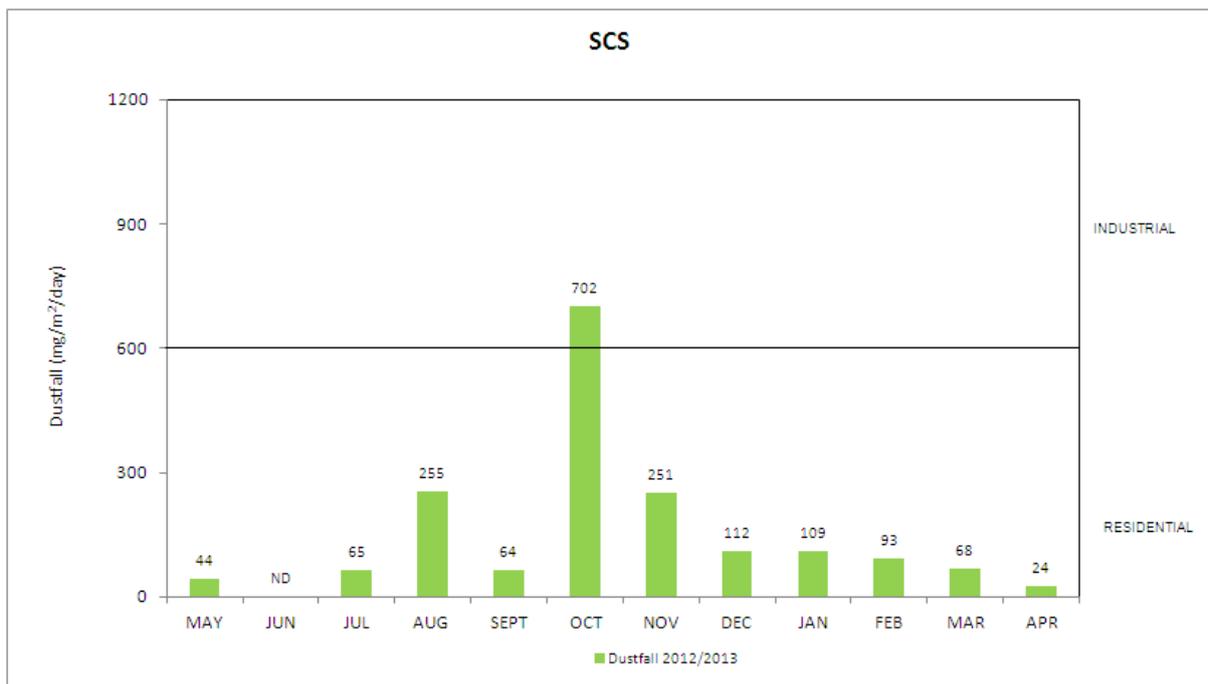
Figure C3-7: Dustfall rates at Site 11 (SCS) between May 2012 and Apr 2013

APPENDIX D: CALMET MODEL CONTROL OPTIONS

Table D-1: CALMET model control options

Run Type	Description of Run Type	Ease of Use and Representativeness	Data availability	Advantages	Disadvantages
No Observations	•Prognostic model data, such as MM5 to drive CALMET. •No surface or upper air observations input at all.	•Relatively simple to implement in model •Representative of regional meteorological conditions	MM5 data (Lakes Environmental) for 2010, 2011 and 2012 at 12km resolution for 300km by 300km study area (Secunda + Sasolburg)	•Simple to implement •Full spatial and temporal variability •No overwater data required •Cloud cover has spatial distribution •Eliminates need for complicated 7 user-input site-specific variables •Ideal as screening run as gives very good estimate	Resolution of prognostic data may potentially be too coarse to be representative of local conditions
Partial Observations	•Prognostic model data, such as MM5 to drive CALMET PLUS •One or more surface stations	•More difficult to implement than only prognostic (MM5) data. •Require 7 site-specific model parameters to be specified. •Difficulty in dealing with missing data. •Potential disagreement between prognostic and surface observations. •Very representative and considered 'refined modelling'	•MM5 data (Lakes Environmental) for 2010, 2011 and 2012 at 12km resolution for 300km by 300km study area (Secunda + Sasolburg) •Sasol operated surface meteorological weather stations (3 Sasolburg[4] and 3 Secunda[5])	•Full spatial and temporal variability •No overwater data required •Refined model run as using combined approach of numerical model and observations. •Ability to incorporate surface representative observation data when MM5 data is too coarse to fully pick up local effects.	•Surface data, especially winds may be different to that in the MM5 data file •User must include 7 site-specific variables •Data preparation and missing data
Observations Only	CALMET driven solely by surface, upper air and optional overwater and precipitation stations	•Require 7 site-specific model parameters to be specified. Difficulty in dealing with missing data. •Considered representative if sufficient observation stations and site specific choice of parameters by the modeller.	•Sasol operated surface meteorological weather stations (3 Sasolburg and 3 Secunda) •Closest upper air monitoring station is at OR Tambo International Airport (twice-daily soundings only)	Very good if upper air and surface stations are located close to the facility and if upper air data are recorded at sunrise and sunset.	•Upper air data typically 12 hourly, poor spatial and temporal resolution •Model has to interpolate between 12 hour soundings •Soundings at incorrect time of the day. •User has to deal with missing surface and upper air data

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[4] Steam Station 1 (WS, WD, TEMP, RH,AMB PRESS, SOL RAD, RAIN); AJ Jacobs (WS, WD,SO_2, NO_2, PM_{10}) and Leitrum (WS, WD,SO_2, NO_2, PM_{10})

[5] Club House (WS, WD, TEMP, RH, AMB PRESS, NO_x, NO_2, SO_2, PM_{10}); Bosjespruit (WS, WD, TEMP, Sol RAD, NO_2, SO_2) and Langverwagt (WS, WD, TEMP, RH, SOL RAD, NO_x, NO_2, SO_2, PM_{10})

APPENDIX E: CALPUFF MODEL CONTROL OPTIONS

Table E-1: CALPUFF model control options

Run Type	Description of Run Type	Ease of Use and Representativeness	Data availability	Advantages	Disadvantages
Sampling Function Puff	This sampling scheme employs radically symmetric Gaussian puffs and is suitable for far field.				
Sampling Function Slug	This sampling scheme uses a non-circular puff (a "slug), elongated in the direction of the wind during release, to eliminate the need for frequent releases of puffs. Used for near field during rapidly-varying meteorological conditions.				Takes a very long time to run.
Dispersion coefficients MDISP = 1	• Dispersion coefficients are computed from measured values of turbulence, sigma-v and sigma-w.	• The user must provide an external PROFILE.DAT file containing these parameters, and select a backup method out of options 2, 3 and 4 below in case of missing data.	• This measured data is not available in South Africa	• Very good if data is available.	• These measured parameters are not readily available in South Africa.
Dispersion coefficients MDISP = 2	• Dispersion coefficients are computed from internally-calculated sigma-v, sigma-w using micrometeorological variables (u*, w*, L, etc.).	• This option can simulate AERMOD-type dispersion when the user also selects the use of PDF method for dispersion in the convective boundary layer (MPDF = 1). Note that when simulating AERMOD-type dispersion, the input meteorological data must be from CALMET and cannot be ISC-type ASCII format data. The user should also be aware that under this option	• The data is obtained from MM5 input information.	• Based on improved theoretical work and is an improvement over Pasquill-Gifford.	• The coefficients are derived from other parameters.

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Run Type	Description of Run Type	Ease of Use and Representativeness	Data availability	Advantages	Disadvantages
		the CALPUFF model will be more sensitive to the appropriateness of the land use characterization.			
Dispersion coefficients MDISP = 3	• Pasquill-Gifford (PG) dispersion coefficients for rural areas (computed using the ISCST3 multi-segment approximation) and McElroy-Pooler (MP) coefficients in urban areas.	• The current default selection is MDISP = 3, which is ISC-type dispersion. Given the demonstrated improved characterization of dispersion provided by AERMOD, and EPA's intention to replace ISC with AERMOD, use of AERMOD-like dispersion (MDISP = 2, and MPDF = 1) is also acceptable, but likely will be of most benefit for short-range complex flow applications.		• Simple to use if you don't have detailed meteorological information. This option can be run using fairly basic meteorological data.	• Based on discreet classification scheme (not continuous function). Based on field experiments done elsewhere, may or may not be representative of Highveld area. Previous projects done using this scheme however have provided good correlation over this area.
Dispersion coefficients MDISP = 4	• Same as MDISP = 3, except PG coefficients are computed using the MESOPUFF II equations				
Dispersion coefficients MDISP = 5	• CTDM sigmas are used for stable and neutral conditions. For unstable conditions, sigmas are computed as in MDISP=3 described above.	• When selecting this option, the user must provide an external PROFILE.DAT file, and select a backup method out of options 2, 3 and 4 above in case of missing data.			
Chemical transformation RIVAD	• Pseudo-first-order chemical mechanism for SO_2, SO_4^{2-}, NO, NO_2, HNO_3, and NO_3 - (RIVAD/ARM3 method)	• RIVAD is a 6-species scheme wherein NO and NO_2 are treated separately. • In the RIVAD scheme the conversion of SO_2 to sulfates is not RH-dependent. • The conversion of NO_x to nitrates is	• In order to use the RIVAD scheme, the user must divide the NO_x emissions into NO and NO_2 for each source. • Two options are specified for the ozone concentrations: (1) hourly ozone concentrations	• In several tests conducted to date, the results have shown no significant differences between the RIVAD and MESOPUFF II options.	• User has to input the NO and NO_2 emissions which are not always known for all sources. • User has to input the ozone concentrations which are not always known.

Run Type	Description of Run Type	Ease of Use and Representativeness	Data availability	Advantages	Disadvantages
		RH-dependent.	from a network of stations, or (2) a single user defined ozone value. • The background ammonia concentrations required for the HNO_3 /NH_4NO_3 equilibrium calculation can be user-specified or a default value will be used.		• The model is restricted to rural conditions.
Chemical transformation MESOPUFF II	• Pseudo-first-order chemical mechanism for SO_2, SO_4^{2-}, NO_x, HNO_3, and NO_3 - (MESOPUFF II method)	• MESOPUFF II is a 5-species scheme in which all emissions of nitrogen oxides are simply input as NO_x. • In the MESOPUFF II scheme, the conversion of SO_2 to sulfates is dependent on relative humidity (RH), with an enhanced conversion rate at high RH. • The conversion of NO_x to nitrates is RH-dependent.	• The MESOPUFF II scheme assumes an immediate conversion of all NO to NO_2. • Two options are specified for the ozone concentrations: (1) hourly ozone concentrations from a network of stations, or (2) a single user defined ozone value. • The background ammonia concentrations required for the HNO_3 /NH_4NO_3 equilibrium calculation can be user-specified or a default value will be used.	• In several tests conducted to date, the results have shown no significant differences between the RIVAD and MESOPUFF II options for sulfate and nitrate formation. • The model is applicable to both urban and rural conditions.	• User has to input the ozone concentrations which are not always known. • NO to NO2 conversion.is not included. In model.
User-specified diurnal cycles of transformation rates					
No chemical conversion					

Scire and Borissova (2011) analysed hourly monitored NO_2 and NOx data for 2006 at 325 monitoring sites throughout USA (approximately 2.8 million data points for each species). These observations were grouped into a number of concentration bins and were used to compute bin maximums and bin average curves. Short-term (1-hr) NO_2/NOx ratios were developed on bin-maximum data, whereas the long-term (annual average) NO_2/NOx ratios were based on bin-averaged data. The method was subsequently tested using the NO_2/NOx ratios applied to the observed NOx at selected stations to predict NO_2, and then compared to observed NO_2 concentrations at that station. As illustrated in the examples, Figure F-1 and Figure F-2, using these empirical curves provide a reasonable estimate of the observed NO_2 can be obtained, albeit mostly more conservative. In Figure F-3, the method is compared to the assumption of 100% conversation over the short-term, which clearly illustrates the extreme conservatism, especially at elevated concentrations.
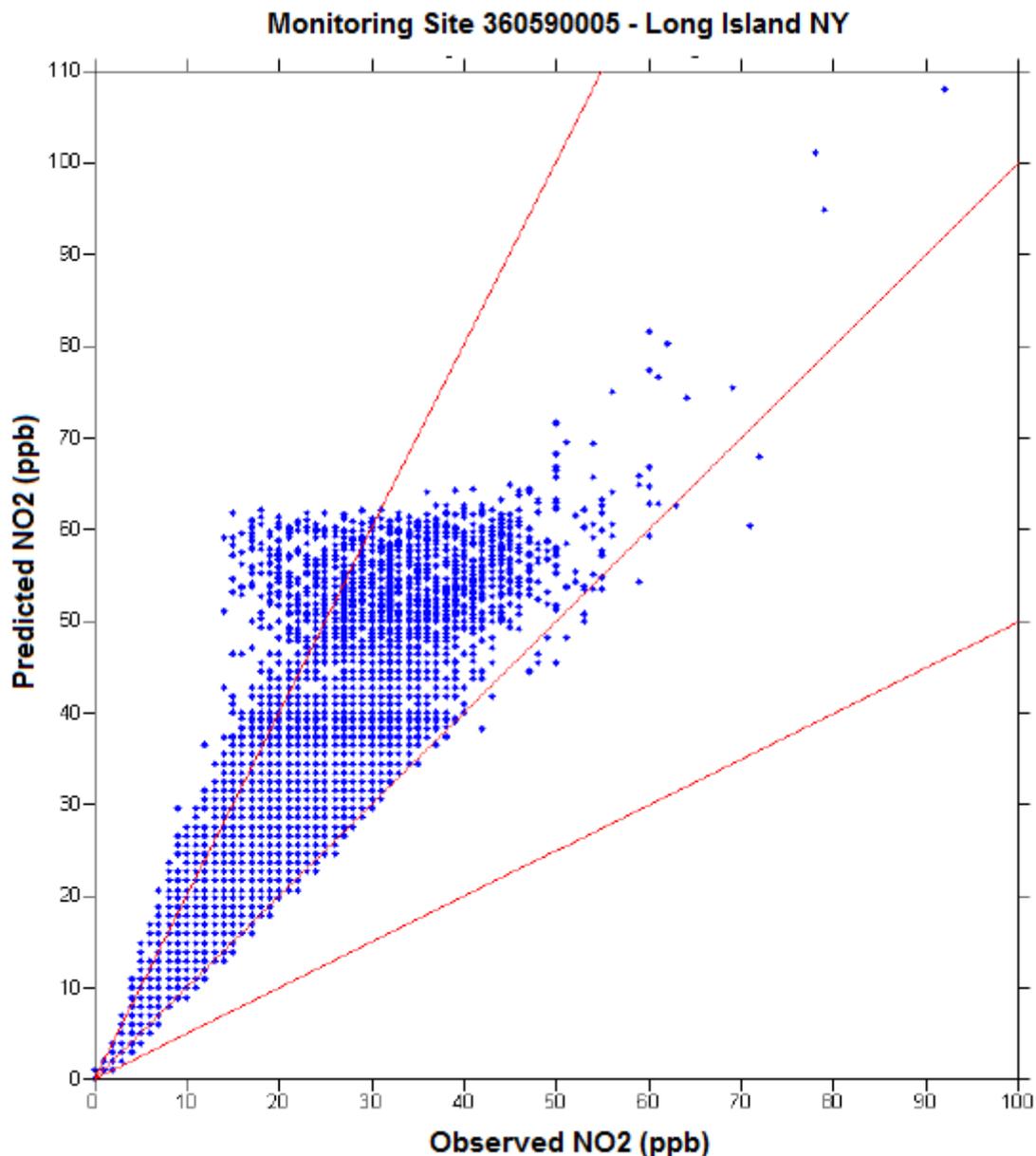
Figure F-1: Comparison of observed with predicted NO₂ concentrations (Long Island, NY) using the short-term NO₂/NOₓ ratios (Scire and Borissova, 2011)
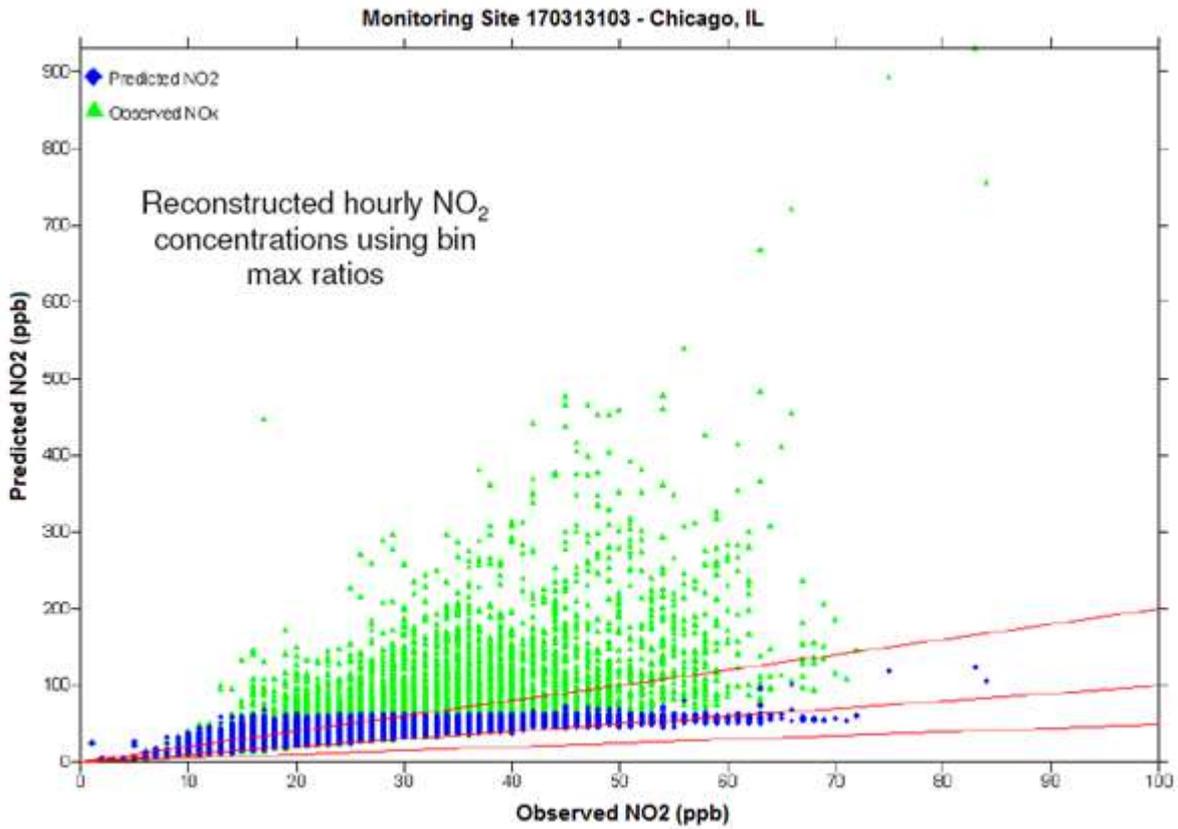
Figure F-2: Comparison of observed with predicted NO$_2$ concentrations (Chicago, IL) using the derived short-term NO$_2$/NO$_x$ ratios (Scire and Borissova, 2011)
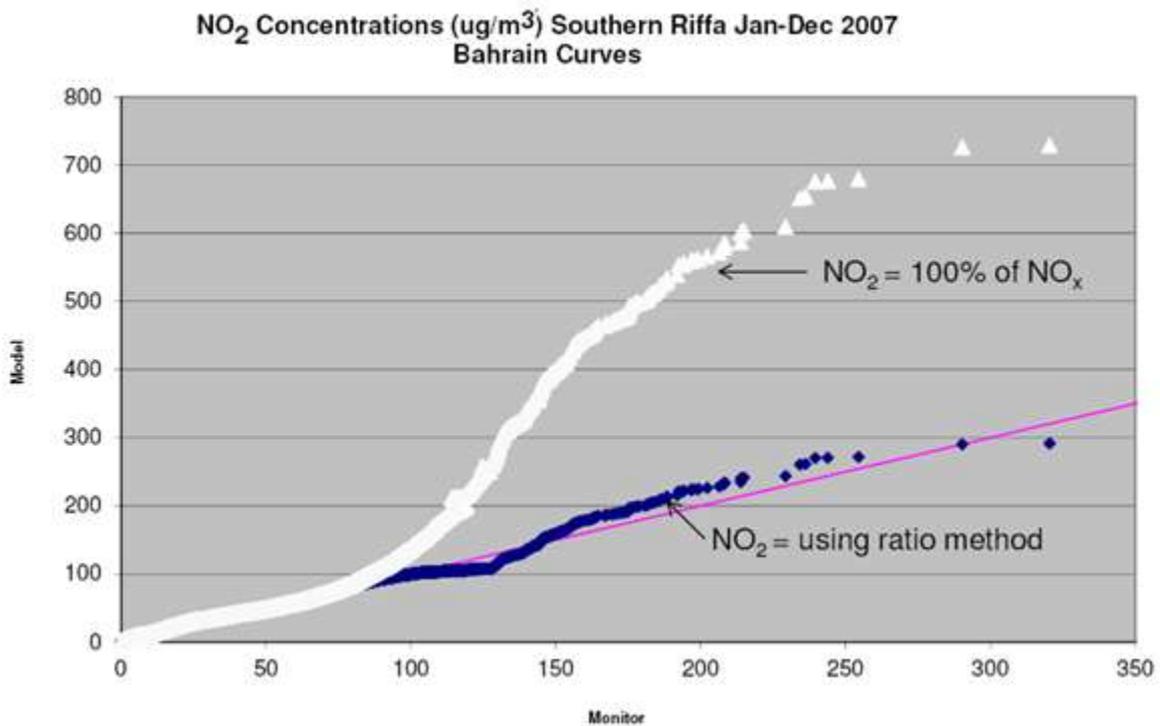
Figure F-3: Observed versus predicted NO$_2$ concentrations (Bahrain) using the derived short-term NO$_2$/NOx ratios (Scire and Borissova, 2011)

It was decided that the NO_2/NO_x conversion factors described by Scire and Borissova (2011) and as given in Table F-1, will be employed in this study. Observed NO_2/NO_x ratios at the Sasolburg monitoring stations were also analysed and compared to the factors in the table (Figure F-4). It is shown in the table and Figure F-4 that the Scire and Borissova ratios would also be applicable in the current study since it would produce estimates similar or more conservative than if the actual NO_2/NO_x ratios at the site would have been used instead.

Table F-1: NO_2/NOx conversation ratios for NO_2 formation

Bin	Concentration (µg/m³)			NO_2/NO_x Ratios			
				Secunda		Scire and Borissova 2011	
	Min	Max	Centre	Club 2010-2012	Langverwacht 2010-2012	Bin Average	1-Hour Max
1	0	19	9	0.796	0.720	0.7980	0.9938
2	19	38	28	0.731	0.678	0.8130	0.9922
3	38	75	56	0.663	0.597	0.7306	0.9844
4	75	113	94	0.563	0.466	0.5544	0.9094
5	113	150	132	0.503	0.370	0.4370	0.7477
6	150	188	169	0.464	0.277	0.3553	0.6085
7	188	235	212	0.405	0.182	0.3013	0.4976
8	235	282	259	0.378	0.122	0.2559	0.4173
9	282	329	306	0.329	0.110	0.2276	0.3543
10	329	376	353	0.229	0.127	0.2081	0.3056
11	376	423	400	0.300	0.128	0.1852	0.2684
12	423	470	447	0.203	0.110	0.1809	0.2404
13	470	517	494	0.145	0.124	0.1767	0.2194
14	517	564	541		0.110	0.1546	0.2035
15	564	611	588	0.176	0.077	0.1524	0.1912
16	611	658	635		0.085	0.1476	0.1813
17	658	705	682		0.077	0.1402	0.1726
18	705	752	729		0.089	0.1363	0.1645
19	752	846	799			0.1422	0.1527
20	846	940	893			0.1223	0.1506
21	940	1128	1034			0.1087	0.1474
22	1128	1316	1222			0.1110	0.1432
23	1316	1504	1410			0.1112	0.139
24	1504	1786	1645			0.1165	0.1337
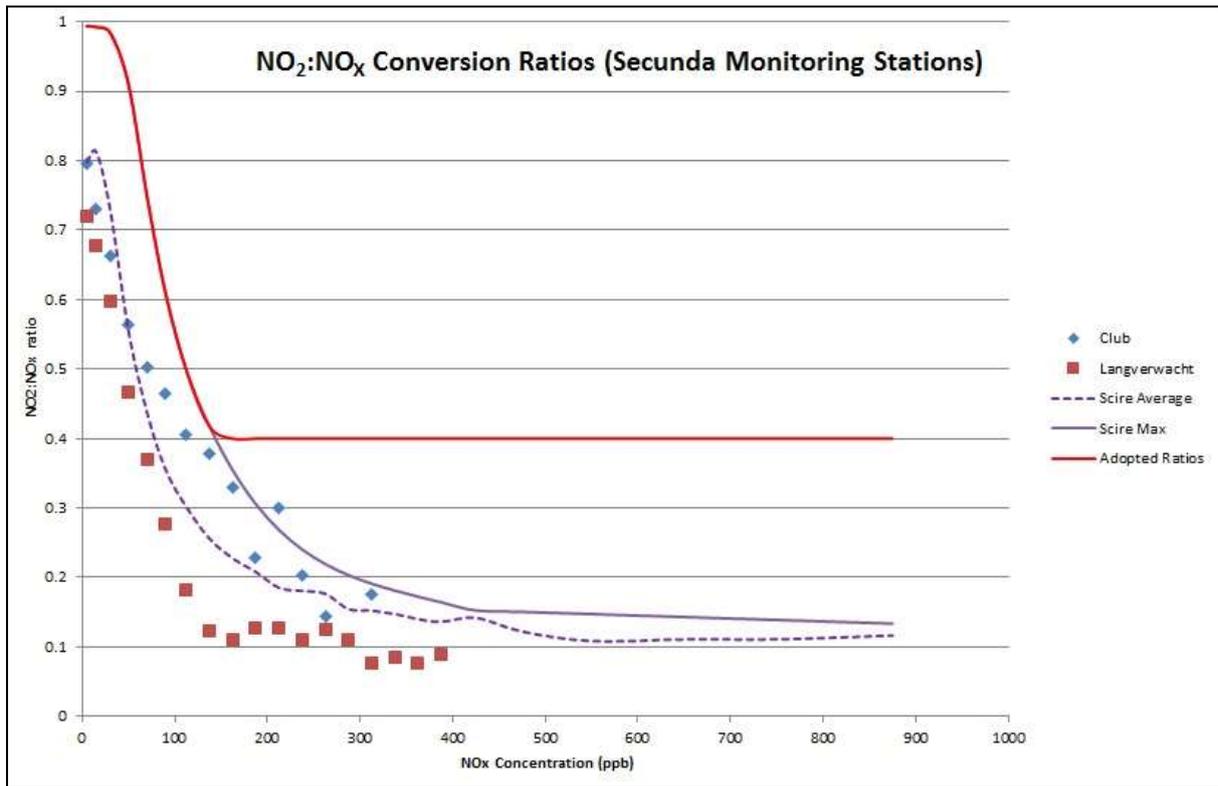
Figure F-4: NO₂/NOx conversation ratios for Secunda monitoring stations

A summary of the time series plots for the measured data as provided by Sasol is given in the following section.
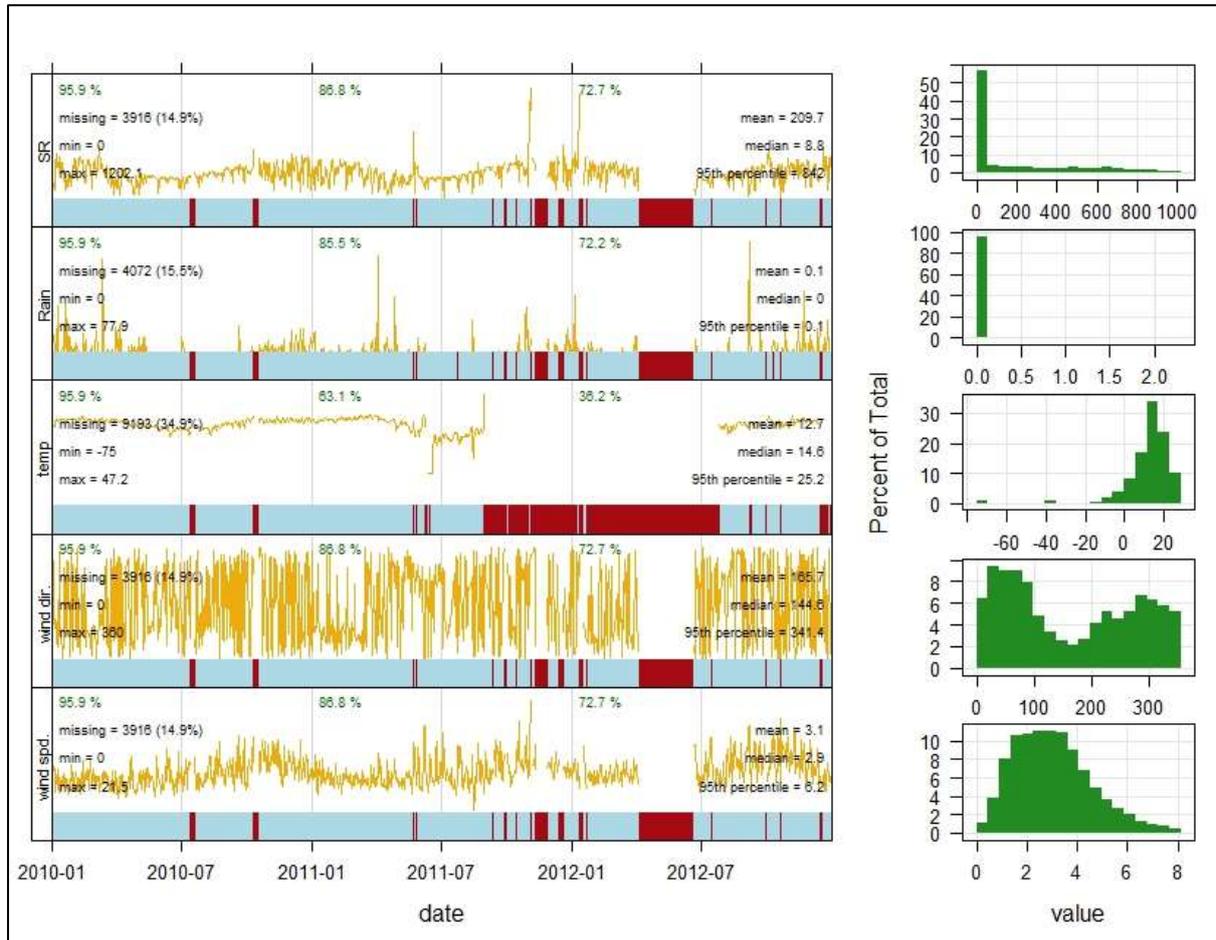
Figure G-1: Summary of meteorological data received for Bosjesspruit (2010-2012)

**Figure G2: Summary of ambient data received for Bosjesspruit (2010-2012)**
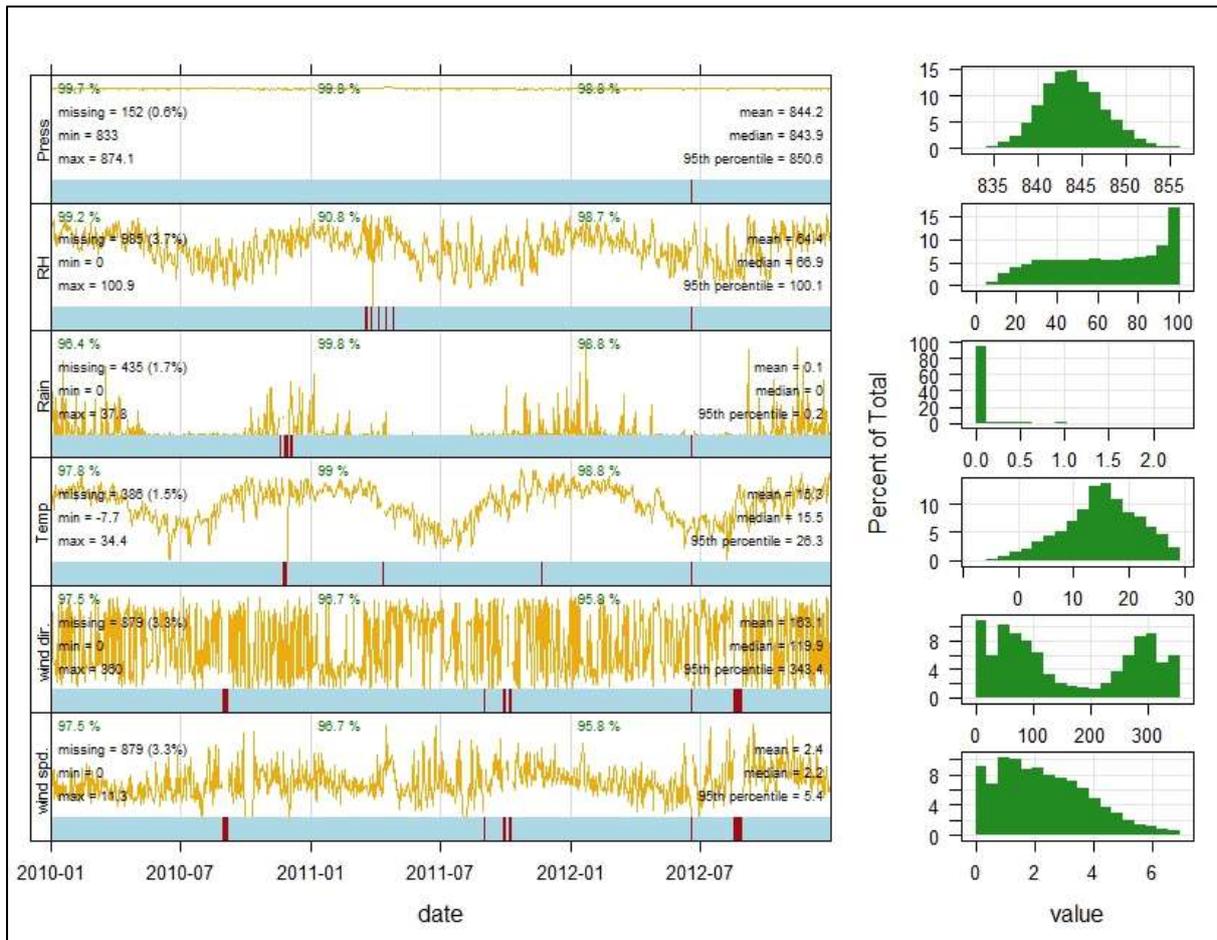
**Figure G-3: Summary of meteorological data received for Secunda Club (2010-2012)**
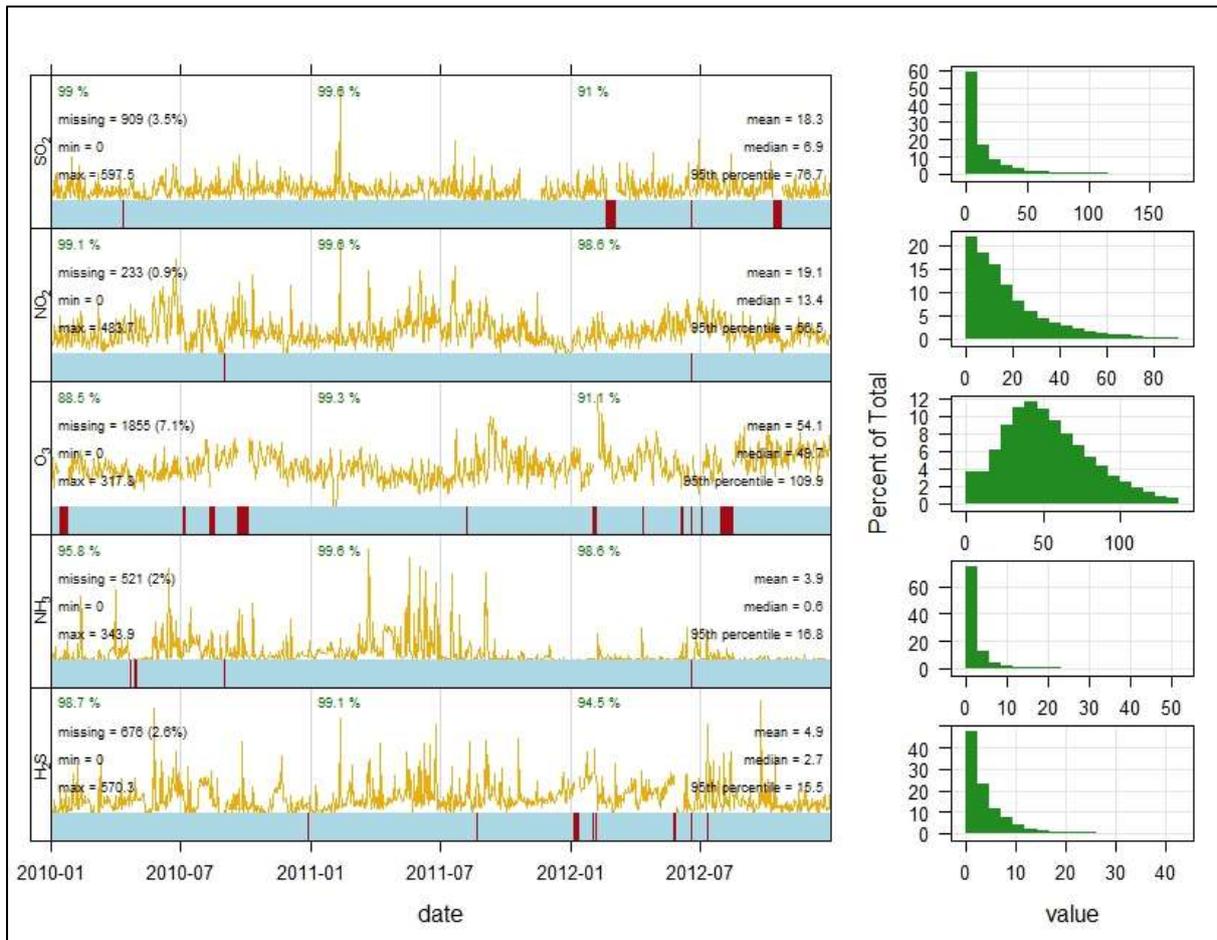
Figure G-4: Summary of ambient data received for Secunda Club (2010-2012)
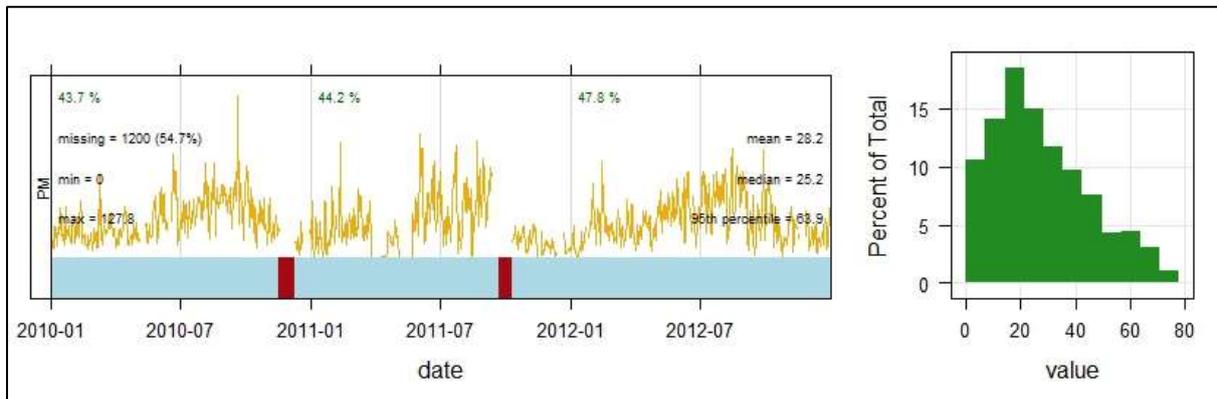
Figure G-5: Summary of daily PM data received for Secunda Club (2010-2012)
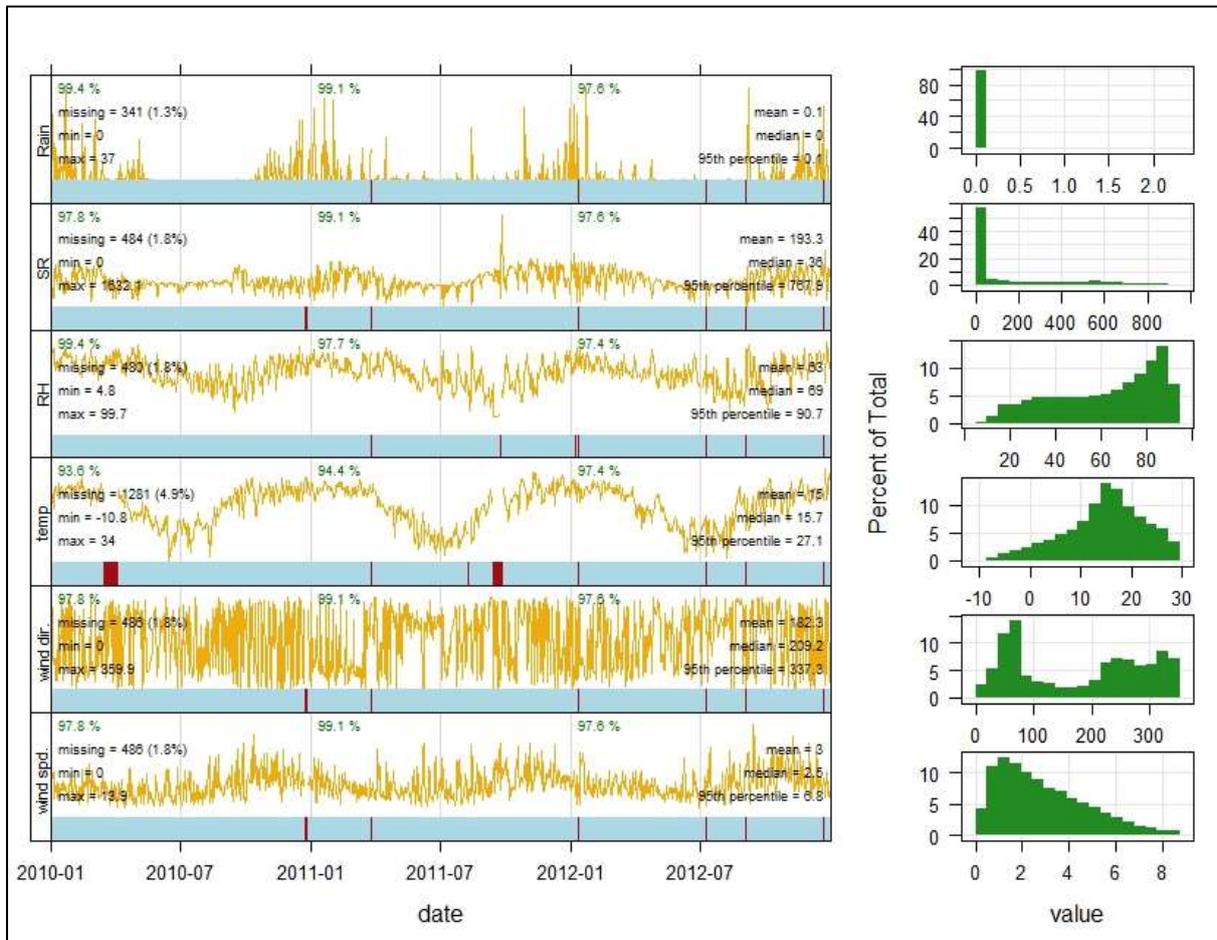
Figure G-6: Summary of meteorological data received for Langverwacht (2010-2012)
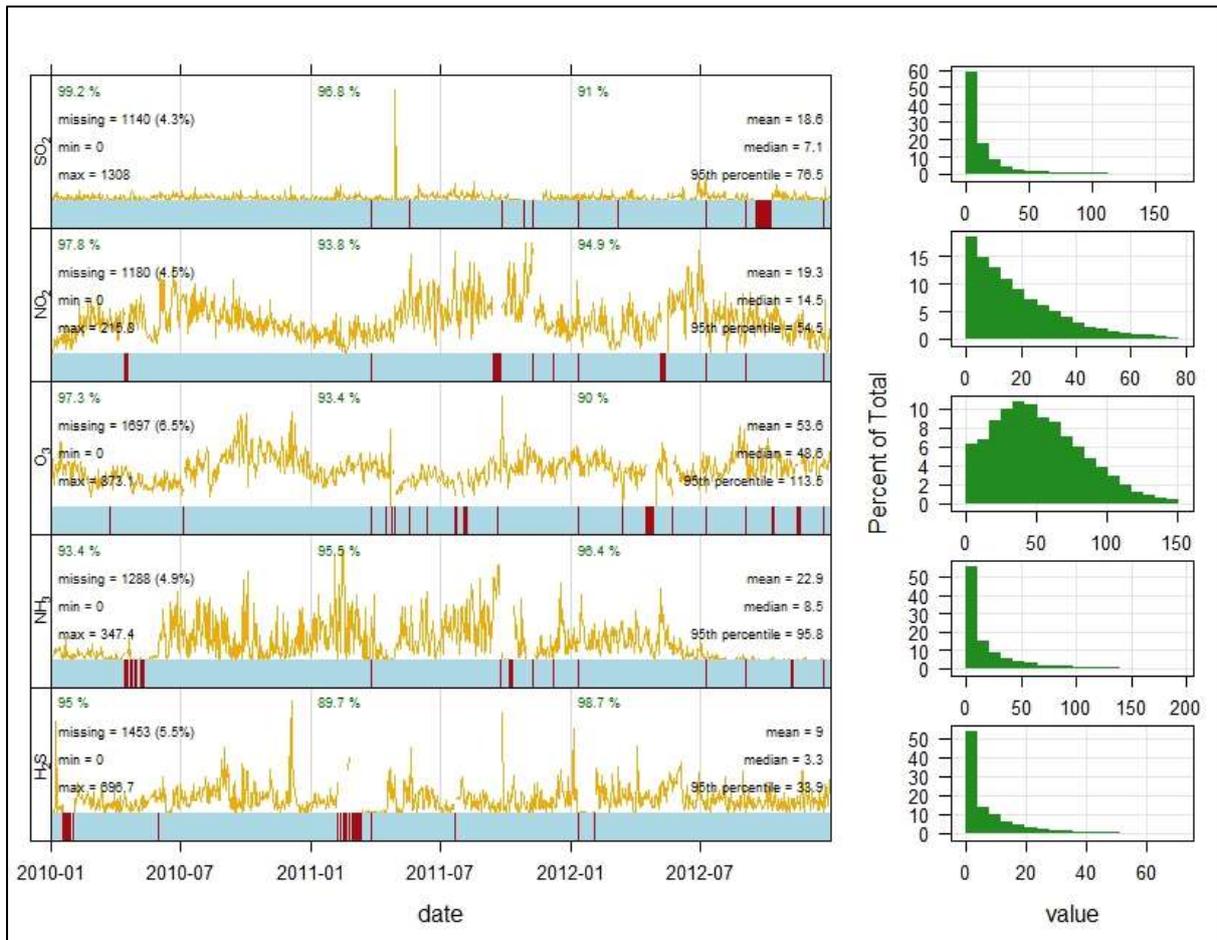
Figure G-7: Summary of ambient data received for Langverwacht (2010-2012)
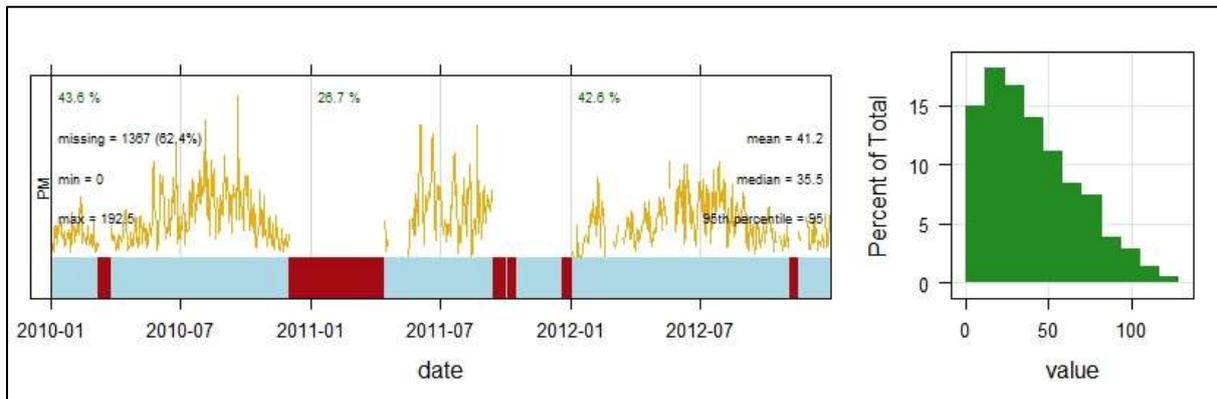
Figure G-8: Summary of daily PM data received for Langverwacht (2010-2012)

APPENDIX H: PREDICTED BASELINE AND OBSERVED AIR CONCENTRATIONS

The following tables summarise the predicted baseline SO_2, NO_2 and H_2S concentrations at the Bosjesspruit, Secunda Club and Langverwacht monitoring site locations, respectively. The peak (maximum), 99th, 90th, 50th and annual average values are given for each of the simulated years, 2010, 2011 and 2012. The corresponding observed concentration values are also summarised in the tables for comparison. Estimates of long-term background concentrations were obtained from the observed values at the ranked position when no contributions from the simulated sources were predicted.

Table H-1: Predicted and observed SO₂ concentration statistics

| | Year | SO₂ Concentration (µg/m³) | | | | | |
| | | Bosjesspruit | | Secunda Club | | Langverwacht | |
		Predicted	Observed	Predicted	Observed	Predicted	Observed
Maximum	2010	511.53	510.62	423.63	462.05	627.65	485.45
	2011	488.22	499.51	440.39	474.68	450.17	455.27
	2012	559.34	631.30	494.30	598.42	652.07	539.07
	Average	*519.70*	*547.14*	*452.77*	*511.72*	*576.63*	*493.26*
99th Percentile	2010	139.7	175.5	62.5	173.0	71.3	152.45
	2011	118.7	216.0	76.9	172.8	84.2	165.48
	2012	115.6	222.0	87.6	174.9	83.7	176.59
	Average	*124.7*	*204.5*	*75.7*	*173.6*	*79.8*	*164.84*
90th Percentile	2010	3.5	57.9	0.2	46.6	0.3	40.79
	2011	2.2	72.7	0.4	42.9	0.3	43.93
	2012	2.7	64.2	1.3	47.1	0.6	48.39
	Average	*2.8*	*65.0*	*0.6*	*45.5*	*0.4*	*44.37*
50th Percentile	2010	0.0	8.3	0.0	7.5	0.0	7.73
	2011	0.0	7.0	0.0	4.2	0.0	6.07
	2012	0.0	9.2	0.0	8.7	0.0	7.48
	Average	*0.0*	*8.1*	*0.0*	*6.8*	*0.0*	*7.09*
Annual Average	2010	6.1	21.8	2.1	18.9	2.5	17.35
	2011	4.5	25.1	2.5	16.2	2.9	17.48
	2012	4.6	24.7	3.4	20.1	3.2	19.35
	Average	*5.1*	*23.9*	*2.7*	*18.4*	*2.8*	*18.06*
Background (observed value when prediction indicated no contribution)	2010		15.5		21.4		17.06
	2011		19.0		15.1		14.86
	2012		17.9		17.6		17.54
	Average		*17.5*		*18.0*		*16.49*

Table H-2: Predicted and observed NO$_2$ concentration statistics

| | | NO$_2$ Concentration (µg/m³) | | | | | |
| | | Bosjespruit | | Secunda Club | | Langverwacht | |
		Predicted	Observed	Predicted	Observed	Predicted	Observed
Maximum	2010	126.3	514.9	110.6	485.3	163.8	137.1
	2011	130.5	408.9	115.6	375.8	117.2	216.6
	2012	142.5	274.5	126.4	193.1	167.2	181.9
	Average	*133.1*	*399.4*	*117.5*	*351.4*	*149.4*	*178.5*
99th Percentile	2010	80.1	124.0	37.4	94.4	37.1	75.1
	2011	71.3	139.7	45.7	100.6	48.7	83.9
	2012	70.2	83.9	51.2	78.7	47.5	72.4
	Average	*73.9*	*115.9*	*44.8*	*91.2*	*44.4*	*77.1*
90th Percentile	2010	4.9	44.5	0.5	44.8	1.7	40.0
	2011	2.8	29.4	0.8	45.3	1.7	48.1
	2012	2.5	34.8	1.6	40.5	1.6	40.5
	Average	*3.4*	*36.2*	*0.9*	*43.5*	*1.7*	*42.9*
50th Percentile	2010	0.0	12.9	0.0	13.0	0.0	14.4
	2011	0.0	1.1	0.0	13.2	0.0	15.9
	2012	0.0	9.8	0.0	14.0	0.0	13.5
	Average	*0.0*	*7.9*	*0.0*	*13.4*	*0.0*	*14.6*
Annual Average	2010	3.6	20.3	1.2	19.3	1.5	18.8
	2011	2.7	11.2	1.4	19.7	1.7	21.3
	2012	2.7	15.0	1.9	18.6	1.7	18.0
	Average	*3.0*	*15.5*	*104.8*	*19.2*	*1.6*	*19.4*
Background (observed value when prediction indicated no contribution)	2010		16.7		23.3		22.1
	2011		5.1		0.0		24.0
	2012		12.5		19.7		21.6
	Average		11.4		14.4		22.6

Table H-3: Predicted and observed H$_2$S concentration statistics

		H$_2$S Concentration (µg/m³)					
		Bosjespruit		Secunda Club		Langverwacht	
		Predicted	Observed	Predicted	Observed	Predicted	Observed
Maximum	2010	253.6	750.0	207.4	613.9	305.5	750.0
	2011	238.4	312.4	214.6	172.9	224.4	511.7
	2012	273.9	166.8	241.4	245.5	318.4	455.8
	Average	*255.3*	*409.7*	*221.1*	*344.1*	*282.8*	*572.5*
99th Percentile	2010	68.9	64.6	31.7	35.9	36.2	72.3
	2011	58.2	104.0	38.4	54.5	43.9	85.3
	2012	56.7		43.8	41.0	42.6	65.6
	Average	*61.2*	*84.3*	*38.0*	*43.8*	*40.9*	*74.4*
90th Percentile	2010	0.0	0.0	0.0	2.0	0.0	5.5
	2011	0.0	1.7	0.0	3.5	0.0	1.3
	2012	0.0		0.0	2.4	0.0	2.5
	Average	*0.0*	*0.9*	*0.0*	*2.6*	*0.0*	*3.1*
50th Percentile	2010	0.0	0.0	0.0	2.0	0.0	5.5
	2011	0.0	1.7	0.0	3.5	0.0	1.3
	2012	0.0		0.0	2.4	0.0	2.5
	Average	*0.0*	*0.9*	*0.0*	*2.6*	*0.0*	*3.1*
Annual Average	2010	3.0	3.9	1.1	4.3	1.2	10.1
	2011	2.3	7.7	1.3	5.9	1.4	8.6
	2012	2.3		1.8	5.2	1.6	8.7
	Average	*2.5*	*5.8*	*1.4*	*5.1*	*1.4*	*9.1*
Background (observed value when prediction indicated no contribution)	2010		2.0		7.1		17.0
	2011		6.4		6.4		15.2
	2012				7.4		16.0
	Average		*4.2*		*7.0*		*16.1*

APPENDIX I: DAILY AND ANNUAL AMBIENT CONCENTRATIONS

Sulfur dioxide (SO₂)

Daily

Daily SO$_2$ concentrations (99th percentile) were not predicted to exceed the daily NAAQS at any of the identified receptors (Figure I-2, Figure I-6, Figure I-8, and Figure I-10) where the highest concentrations are predicted as a result of emissions from Steam Stations (Figure I-2). Daily average SO$_2$ concentrations were also predicted to decrease under theoretical compliance with New Plant Standards at the Steam Stations (Figure I-3). The Alternative Emission Limits was predicted to result in increases in daily SO$_2$ concentrations of less than 10% relative to the airshed baseline, at all 15 receptors. Minor changes are expected as a result of Existing and New Plant Standards from Biosludge and HOW Incinerators and the Wet Sulfuric Acid Plant (Figure I-7, Figure I-9, and Figure I-11).
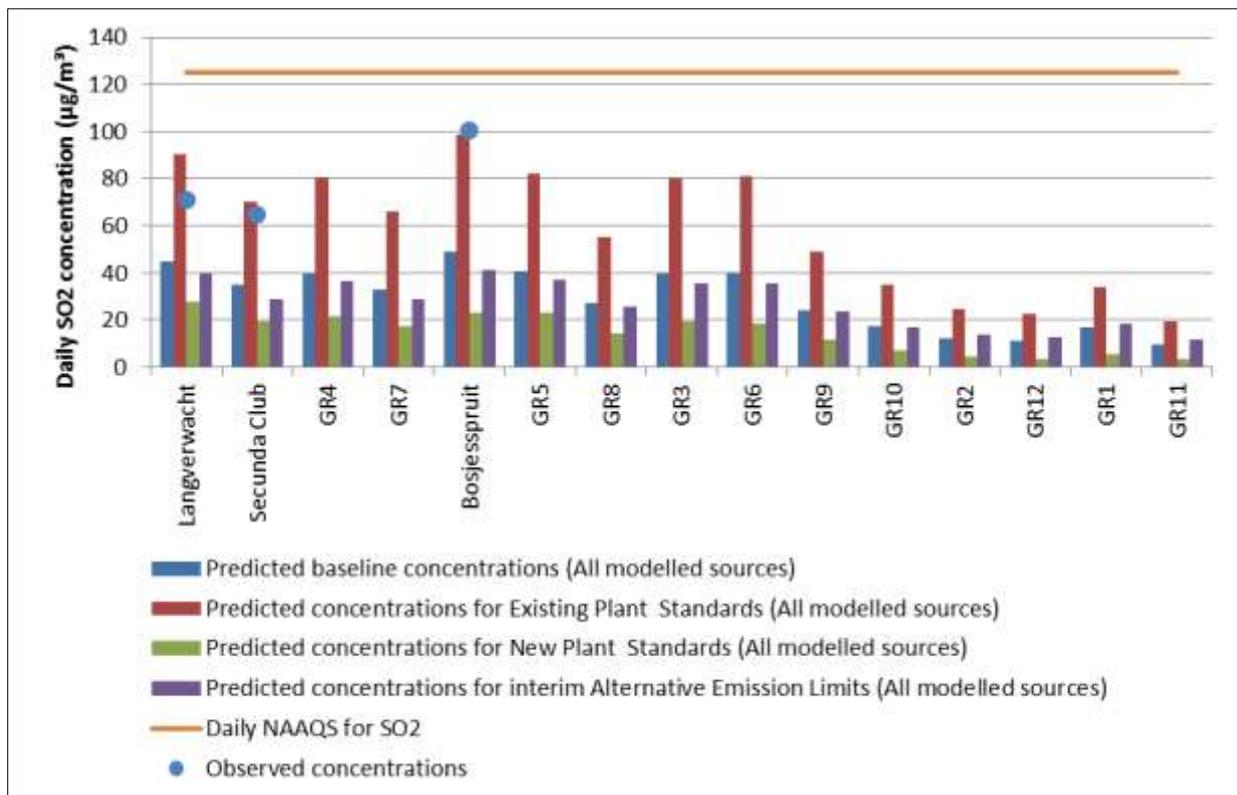
Figure I-1: Predicted 99th percentile daily SO₂ concentrations at identified receptors for all modelled Synfuels sources (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
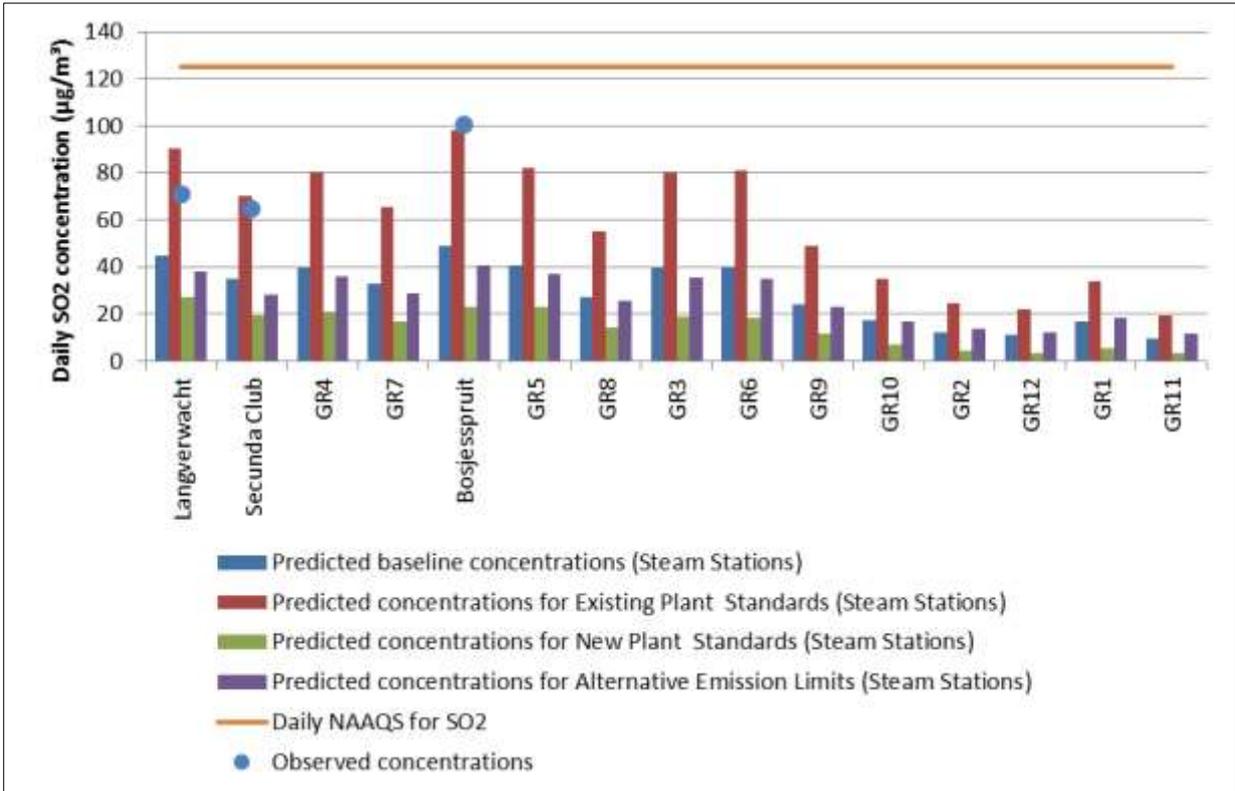
Figure I-2: Predicted 99th percentile daily SO₂ concentrations at identified receptors for Synfuels Steam Stations (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
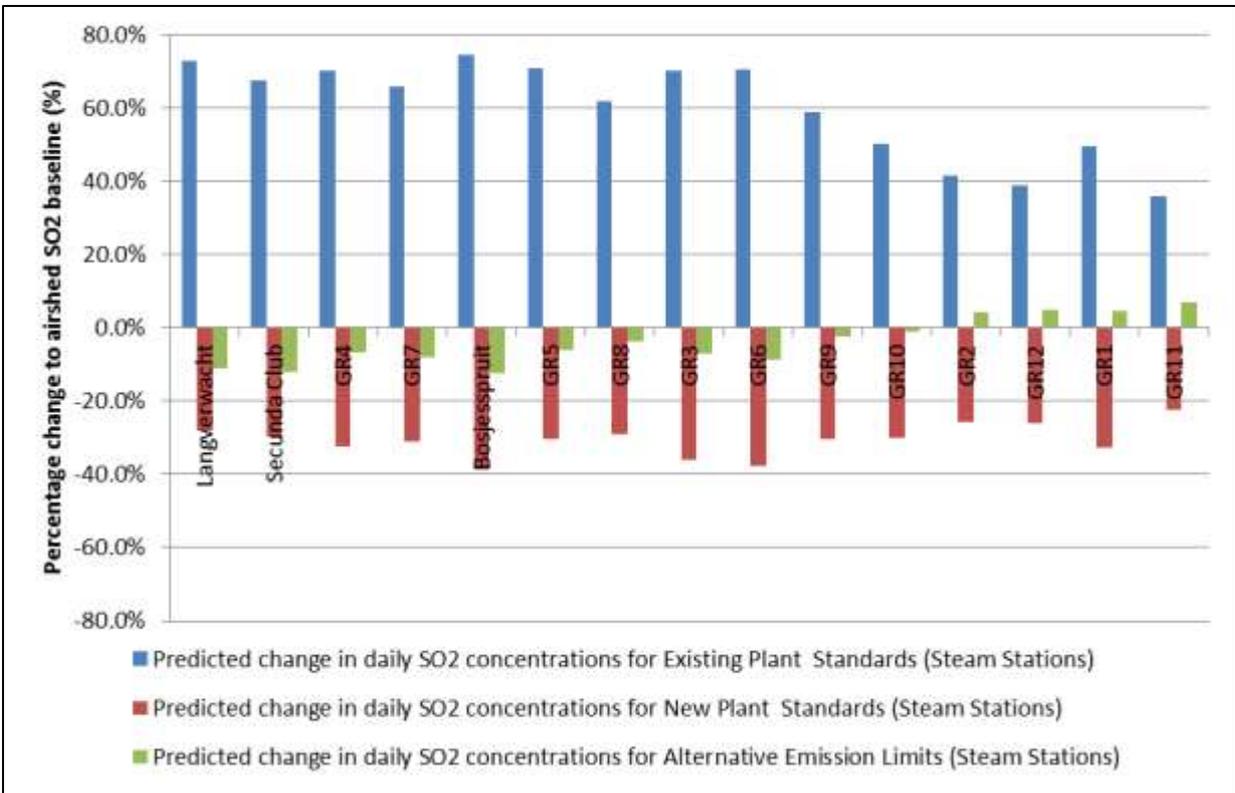
Figure I-3: Theoretical change in SO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels Steam Stations (change calculated using Equation 1)
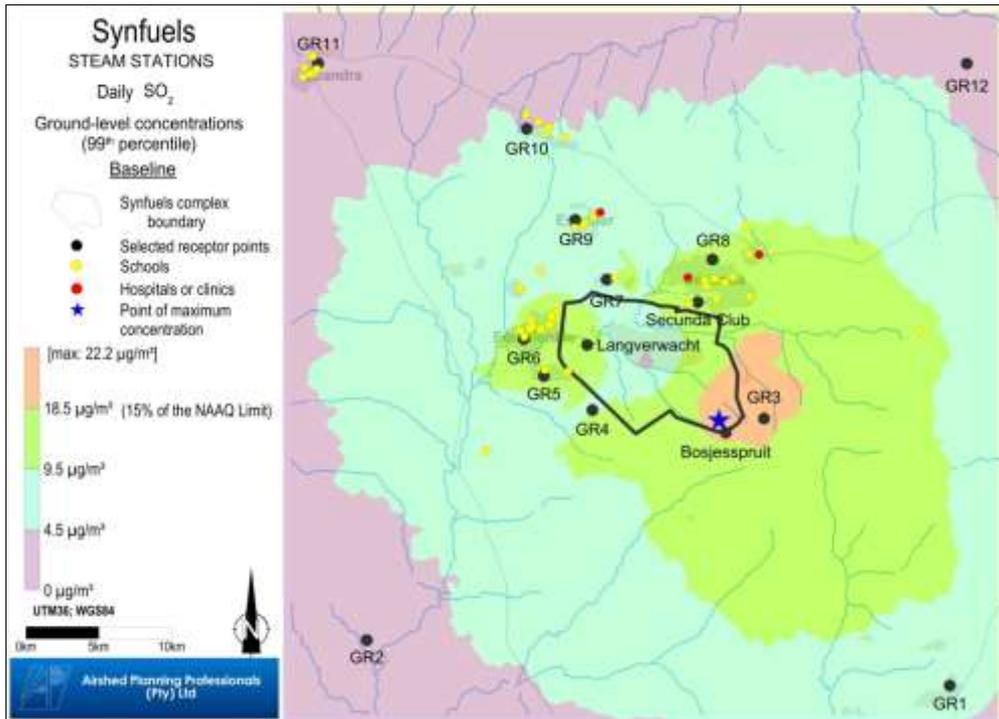
Figure I-4: Predicted 99th percentile daily SO₂ concentrations as a result of Baseline emissions from the Steam Stations
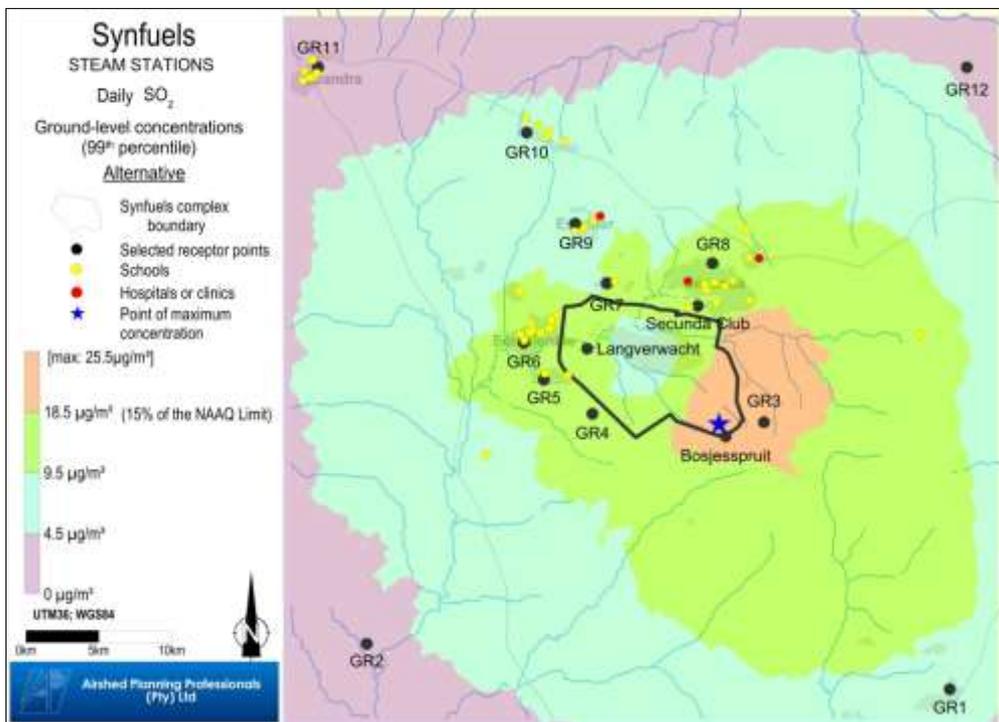
Figure I-5: Predicted 99th percentile daily SO₂ concentrations as a result of Alternative Emission Limit emissions from the Steam Stations
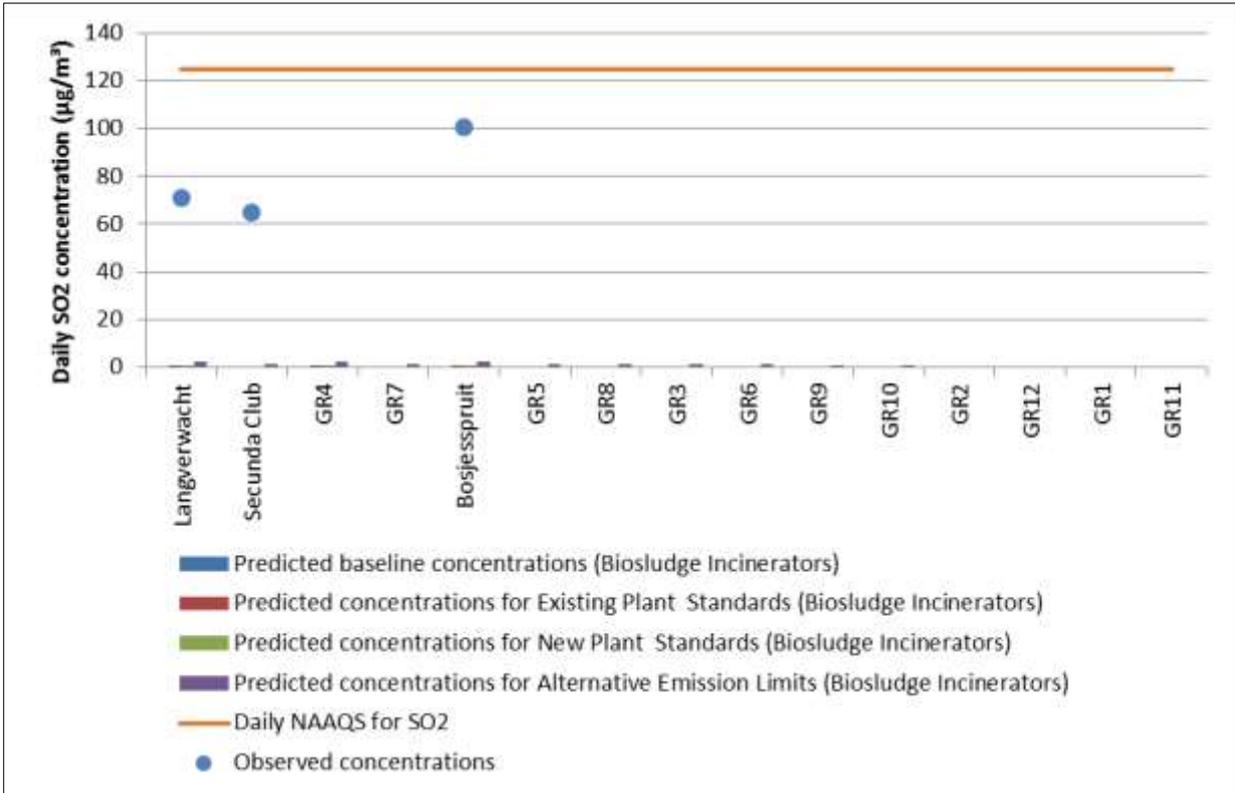
Figure I-6: Predicted 99th percentile daily SO₂ concentrations at identified receptors for Synfuels Biosludge Incinerators (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
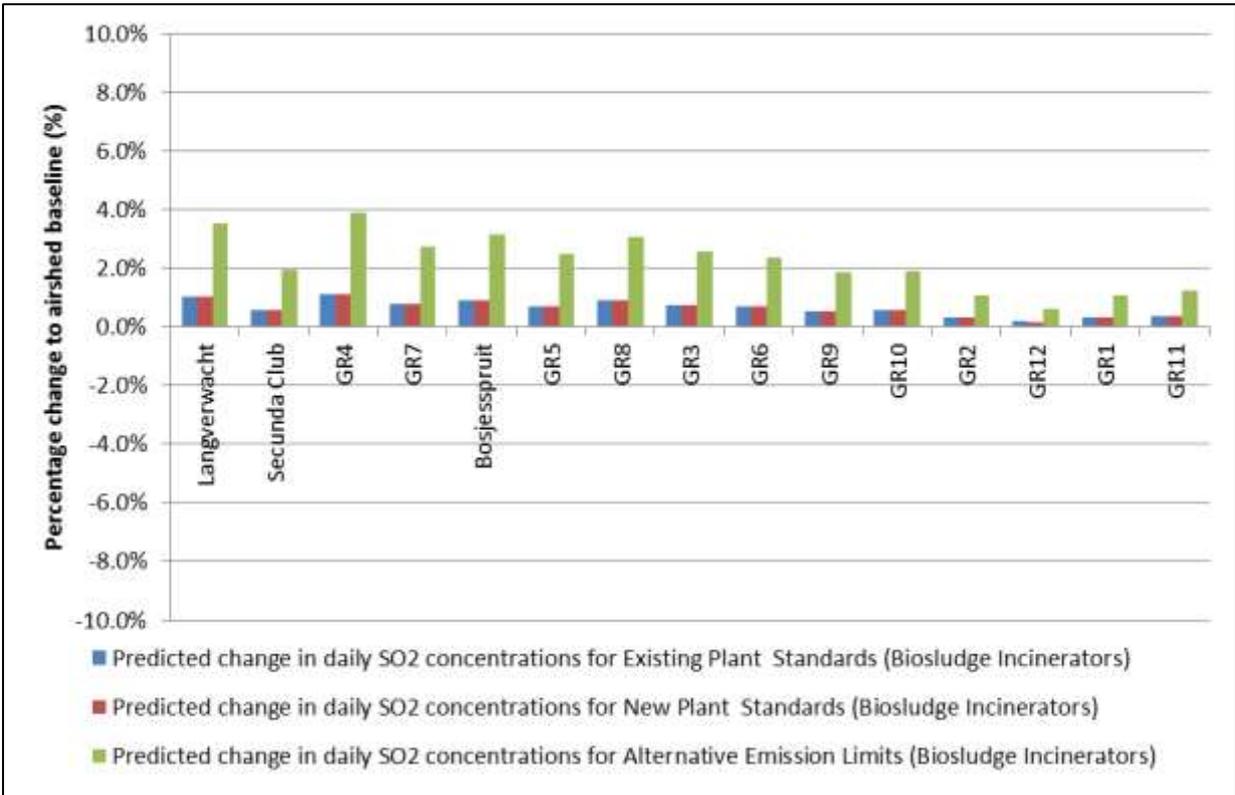

Figure I-7: Theoretical change in SO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels Biosludge Incinerators (change calculated using Equation 1)
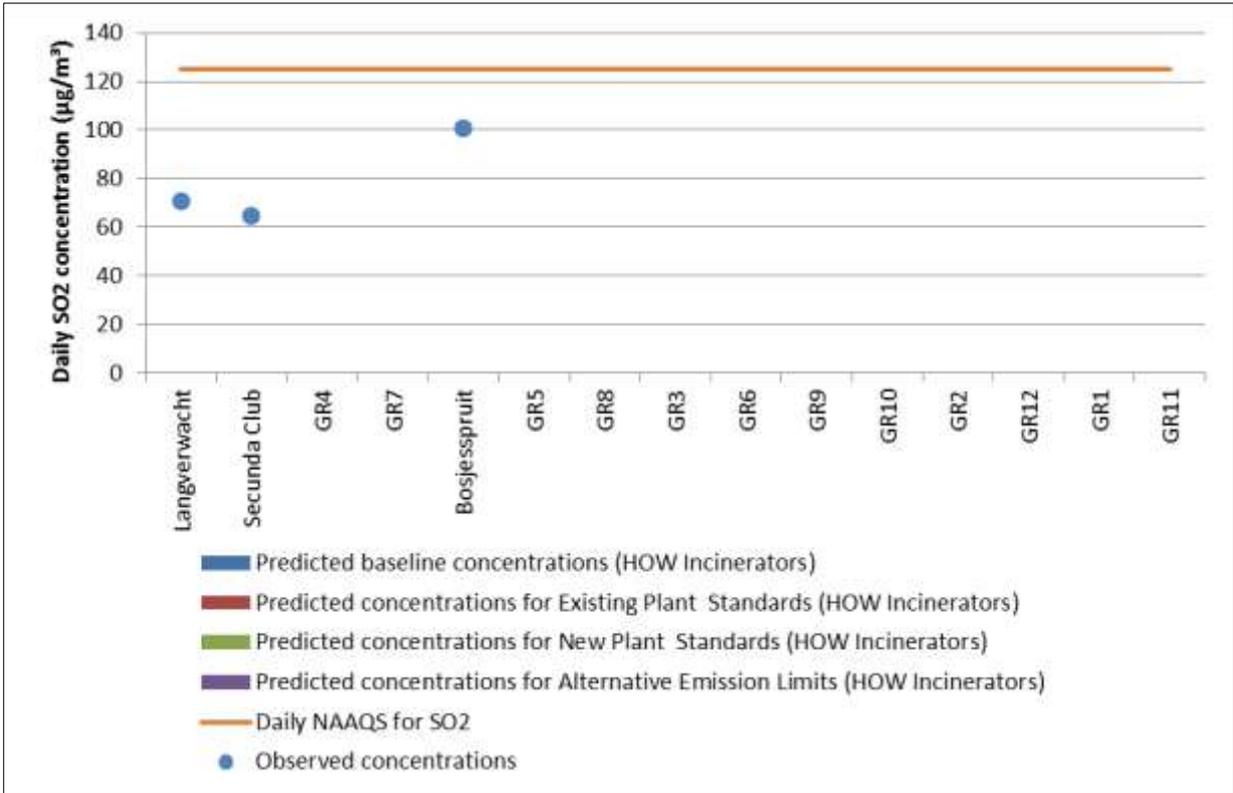
Figure I-8: Predicted 99th percentile daily SO₂ concentrations at identified receptors for Synfuels HOW Incinerators (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
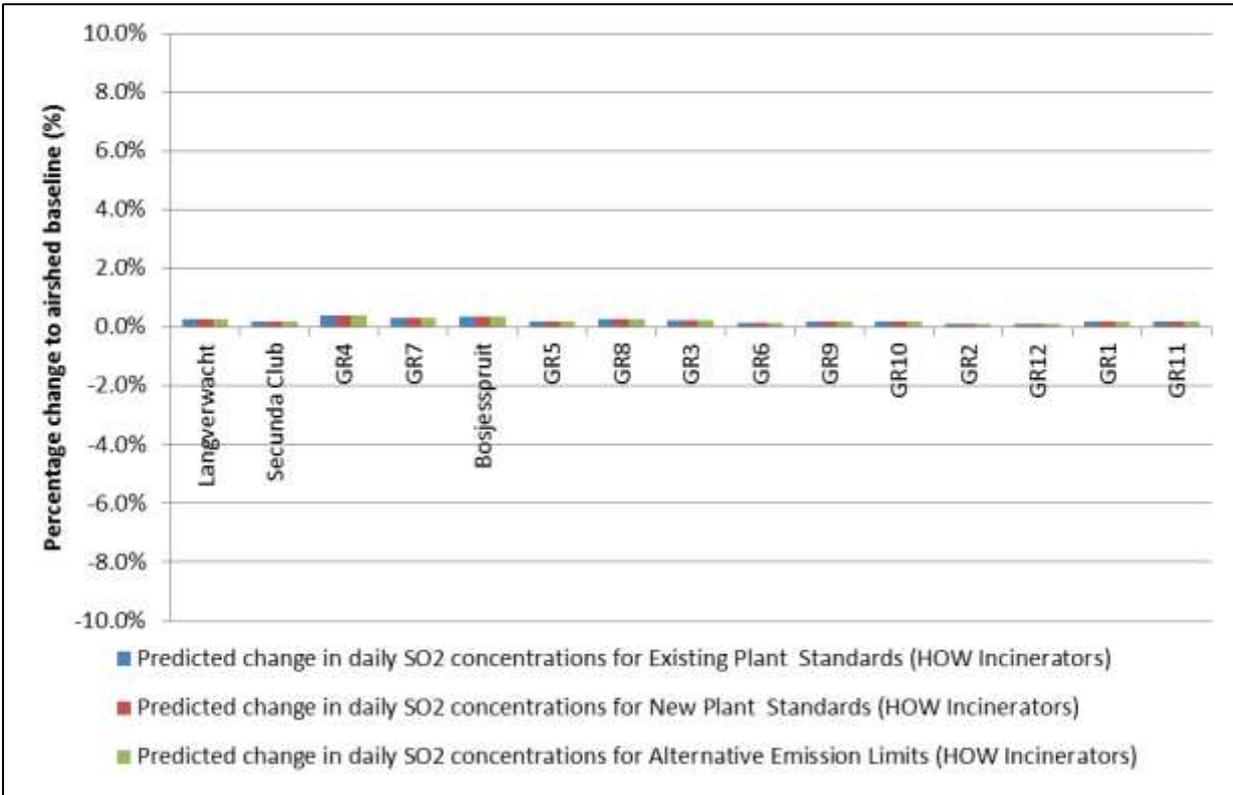
Figure I-9: Theoretical change in SO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels HOW Incinerators (calculated using Equation 1)
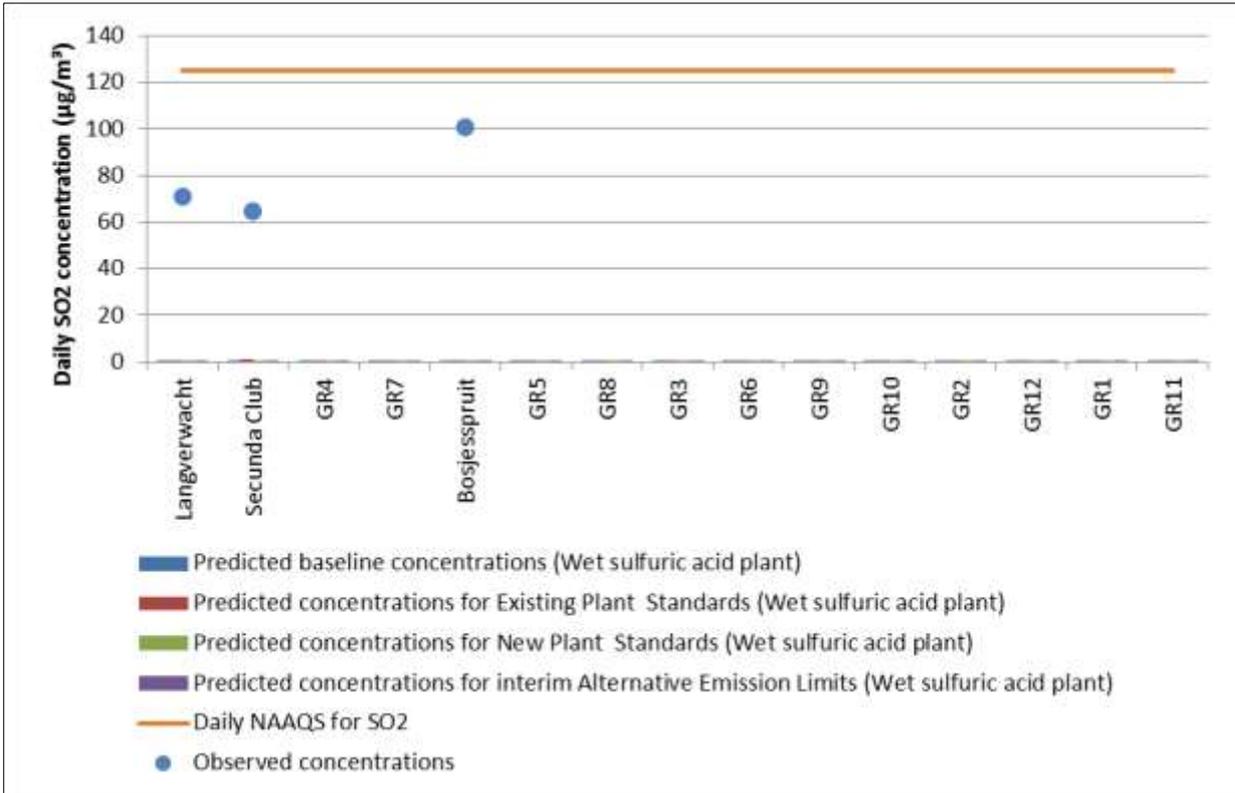
**Figure I-10: Predicted 99th percentile daily SO₂ concentrations at identified receptors for Synfuels Wet Sulfuric Acid Plant (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)**
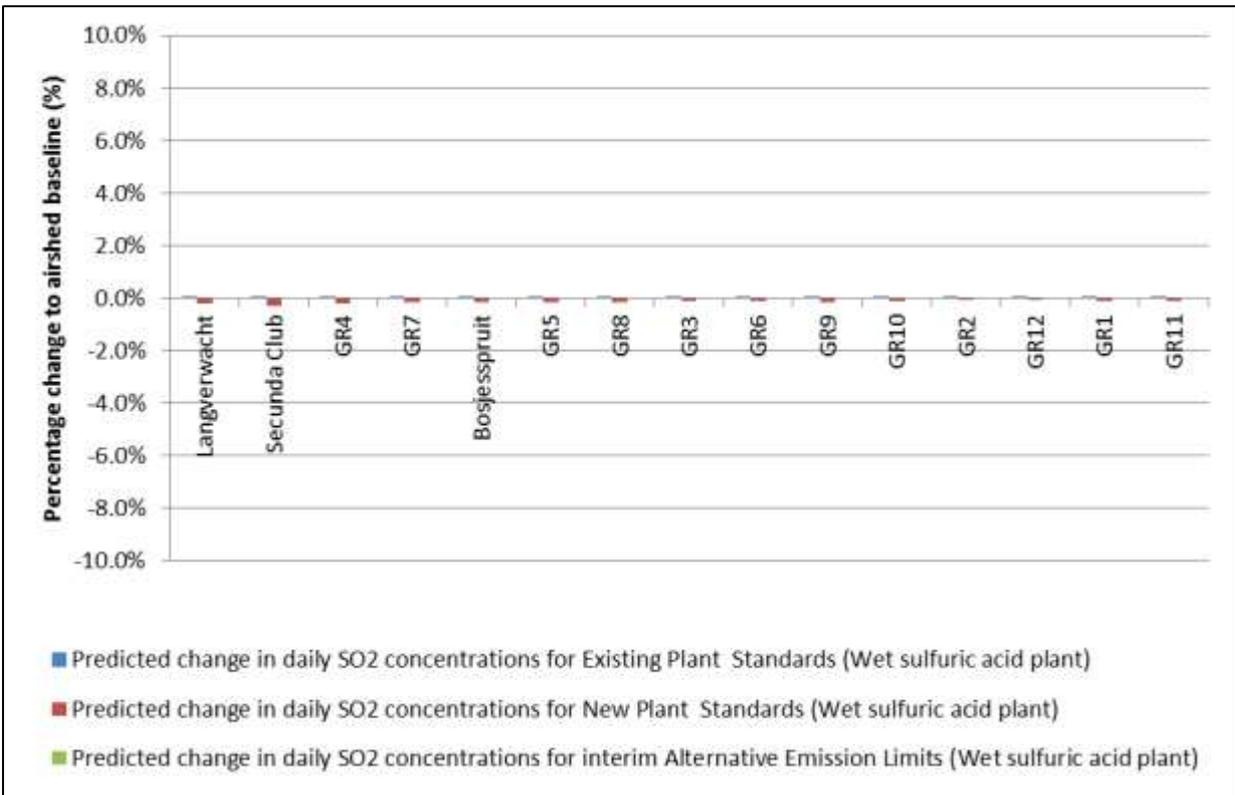

Figure I-11: Theoretical change in SO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels Wet Sulfuric Acid Plant (calculated using Equation 1)

Annual

Predicted annual ambient SO₂ concentrations (Figure I-12) show similar trends as for hourly (Section 5.1.8.1.1) and daily average concentrations (above). The source with the largest impact is Steam Stations (Figure I-13). Improvements in annual ambient SO₂ concentrations reach a maximum of 11.3% at near Bosjesspruit (GR3) as a result of the Steam Stations theoretically complying with New Plant Standards (Figure I-14). Alternative Emission Limits were predicted to result in an increase in annual SO₂ by less than 5% relative to the airshed baseline, at all receptors (Figure I-14).
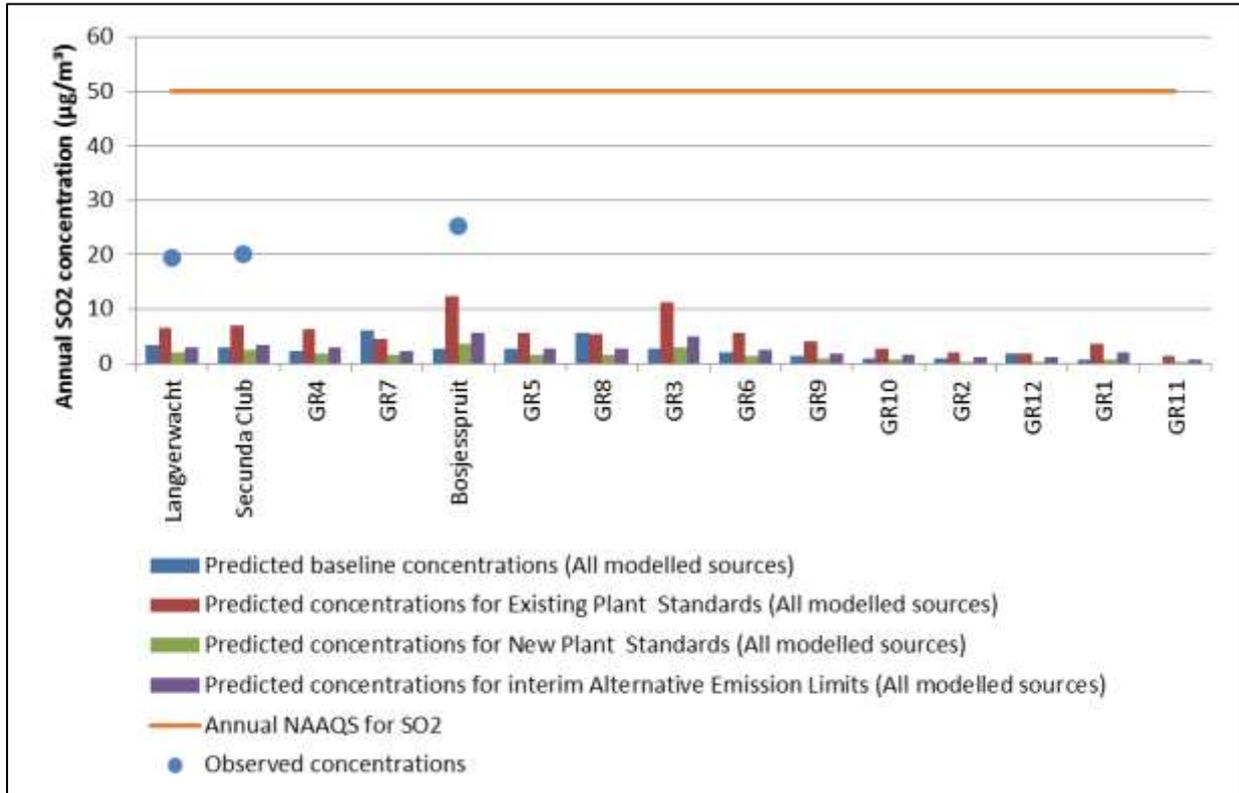
Figure I-12: Predicted annual SO₂ concentrations at identified receptors for all modelled Synfuels sources (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
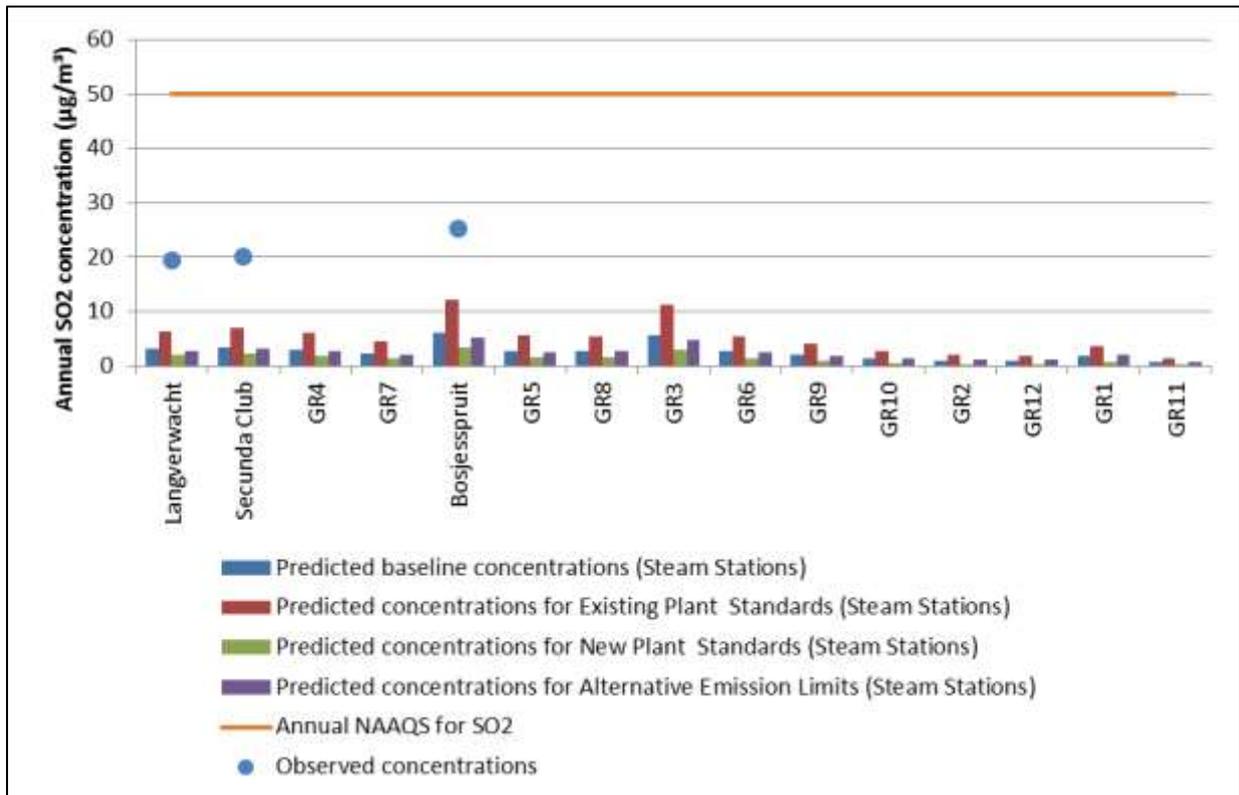
Figure I-13: Predicted annual SO₂ concentrations at identified receptors for Synfuels Steam Stations (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
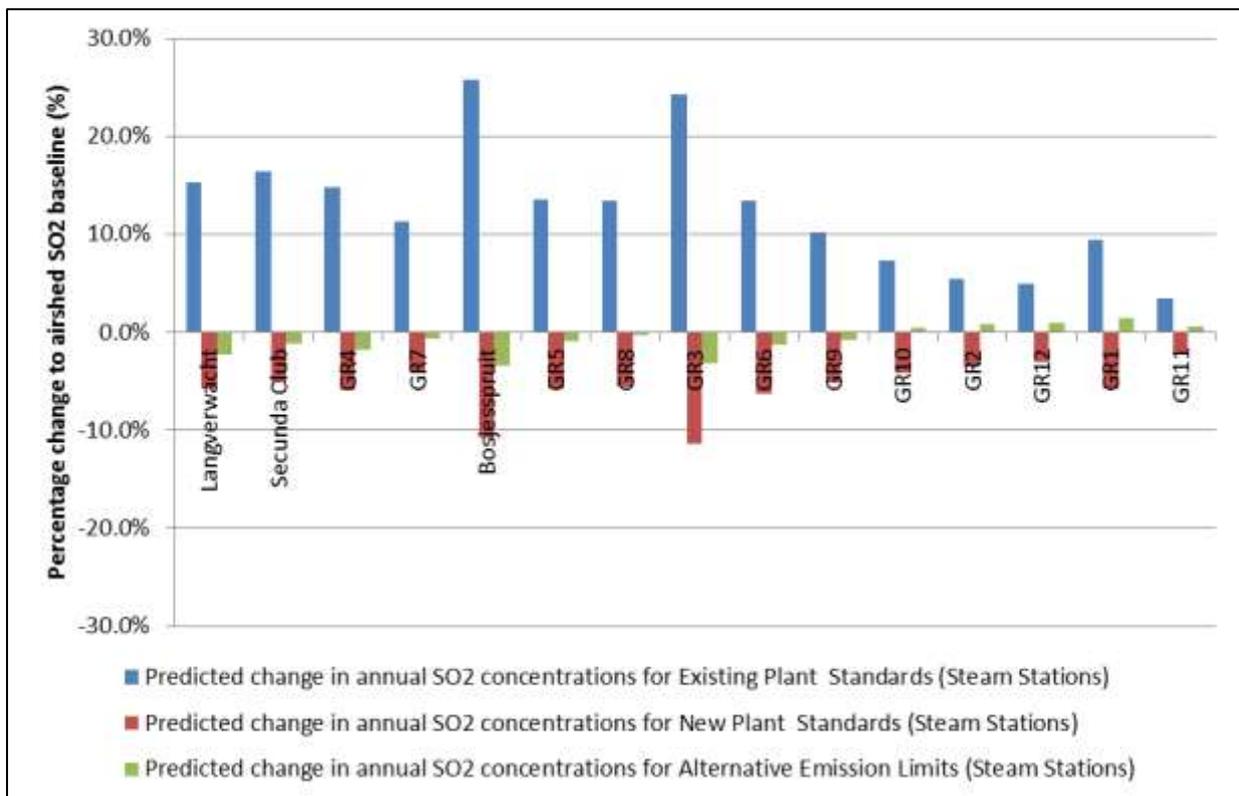
Figure I-14: Theoretical change in SO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels Steam Stations (calculated using Equation 1)
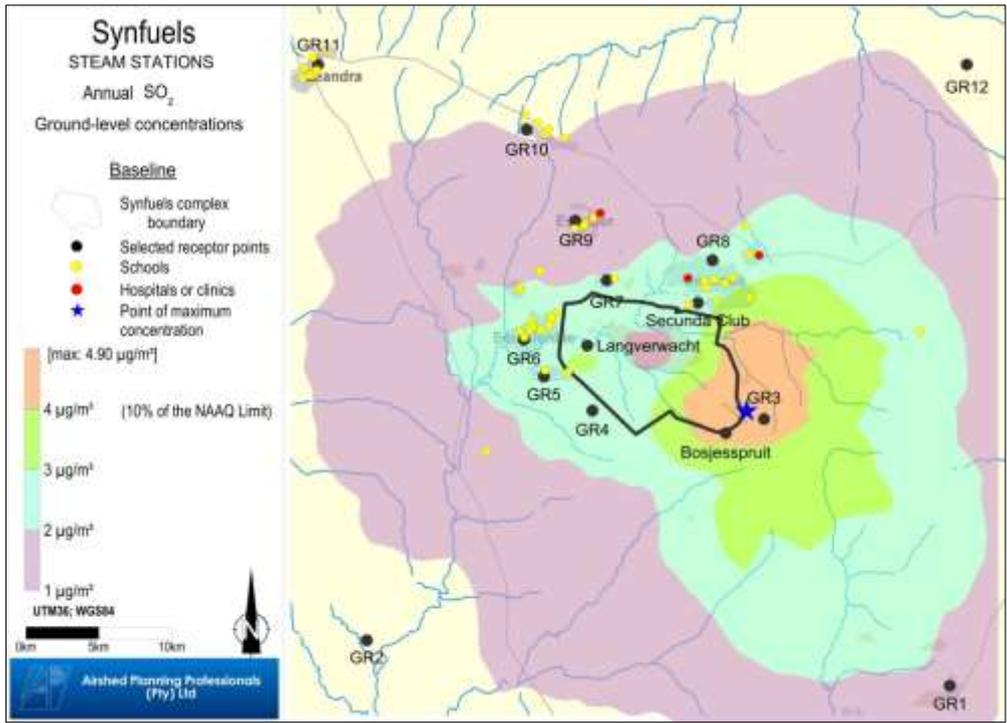
**Figure I-15: Predicted annual SO₂ concentrations as a result of Baseline emissions from the Steam Stations**
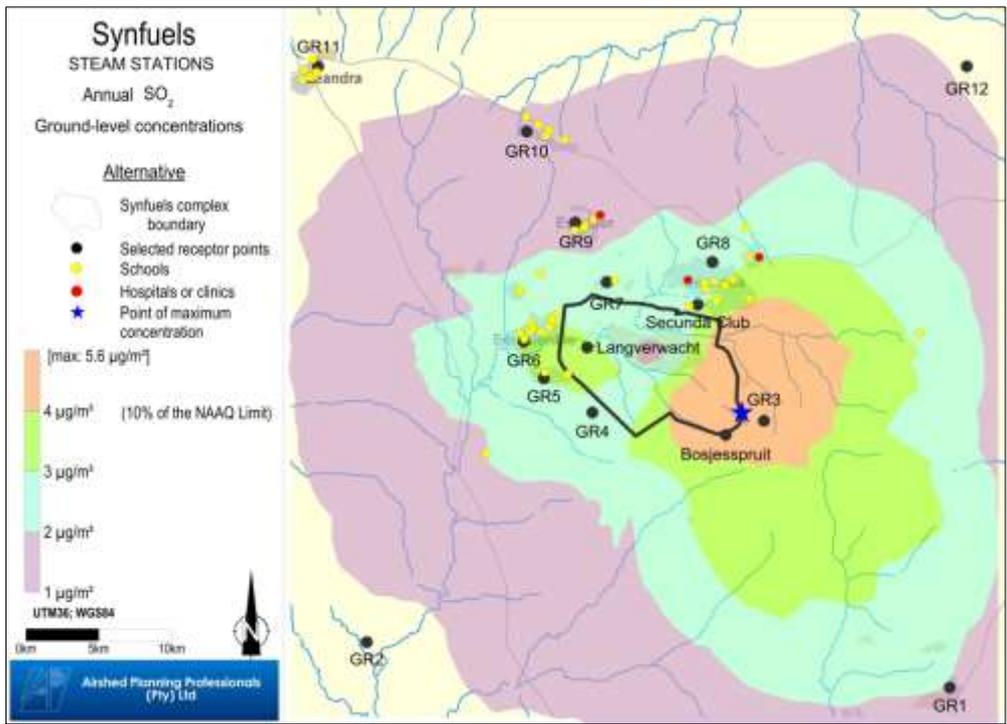
Figure I-16: Predicted annual SO₂ concentrations as a result of Alternative Emission Limit emissions from the Steam Stations
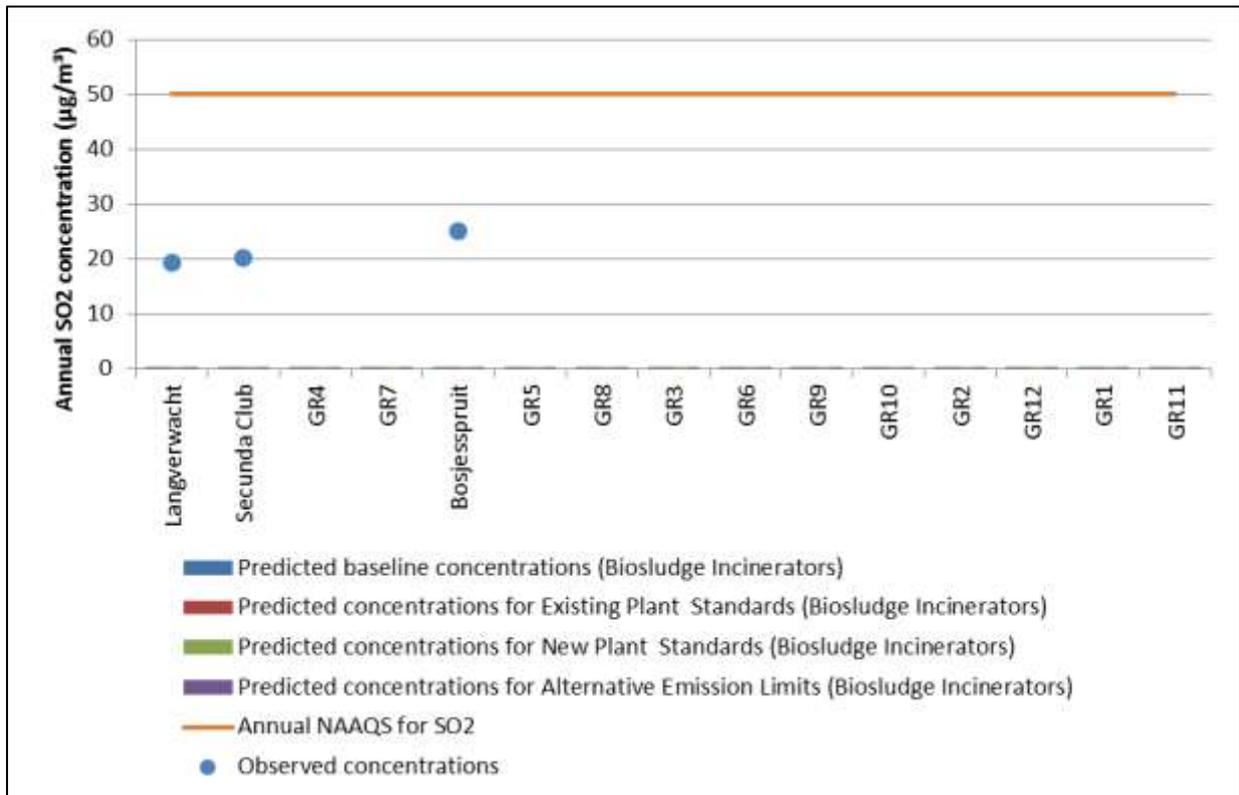
Figure I-17: Predicted annual SO₂ concentrations at identified receptors for Synfuels Biosludge Incinerators (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
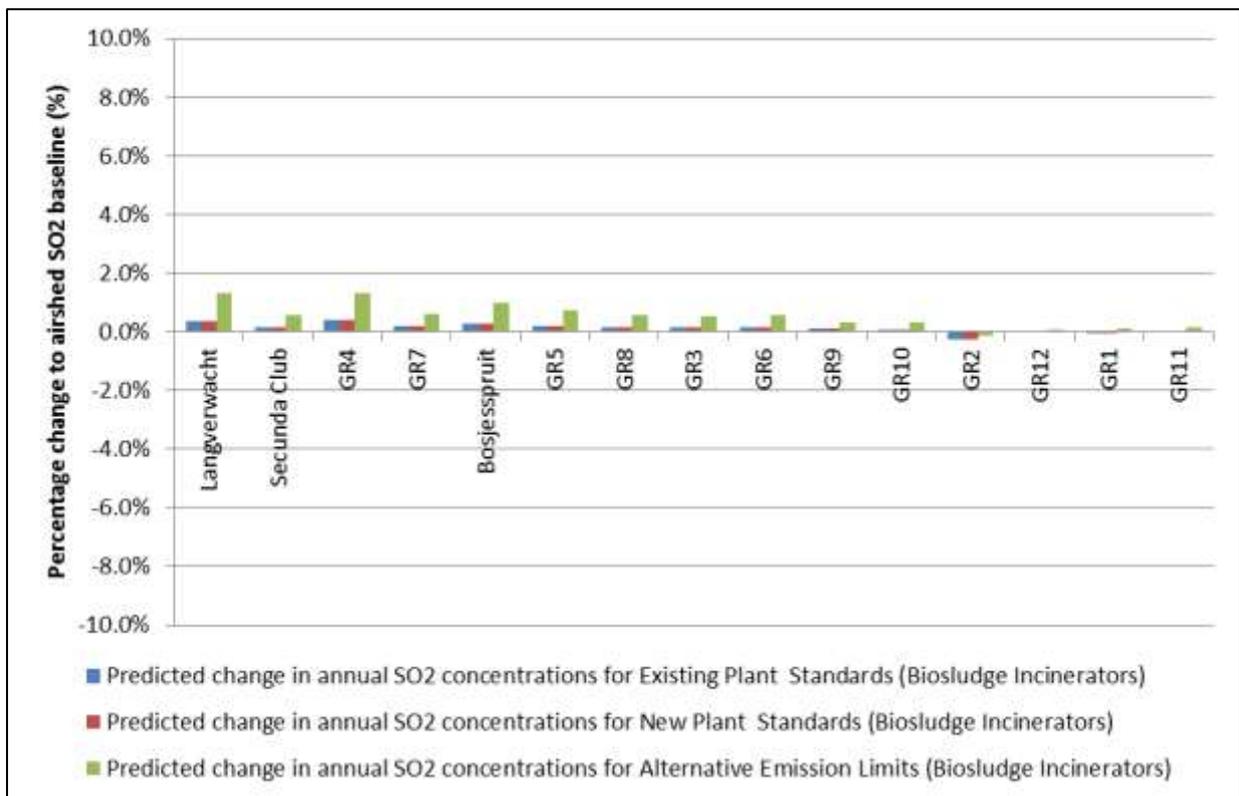

Figure I-18: Theoretical change in SO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels Biosludge Incinerators (calculated using Equation 1)
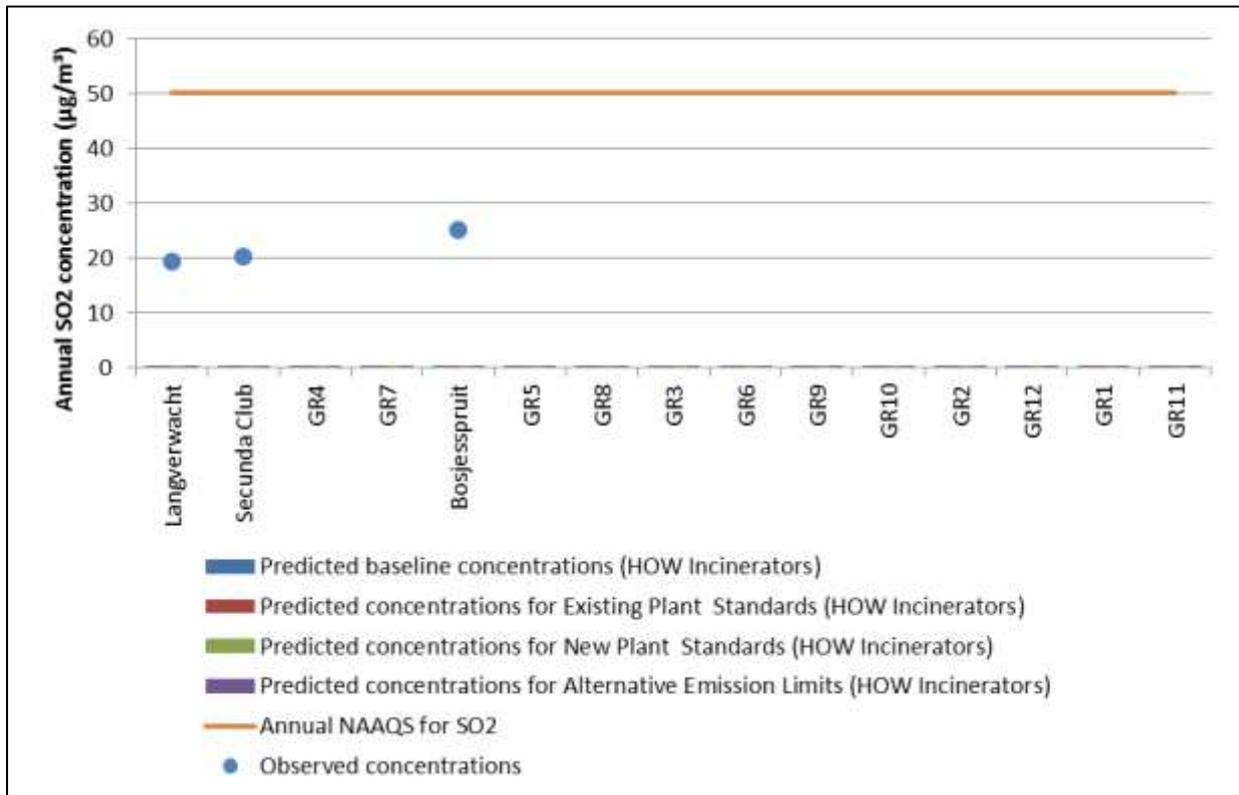
Figure I-19: Predicted annual SO₂ concentrations at identified receptors for Synfuels HOW Incinerators (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
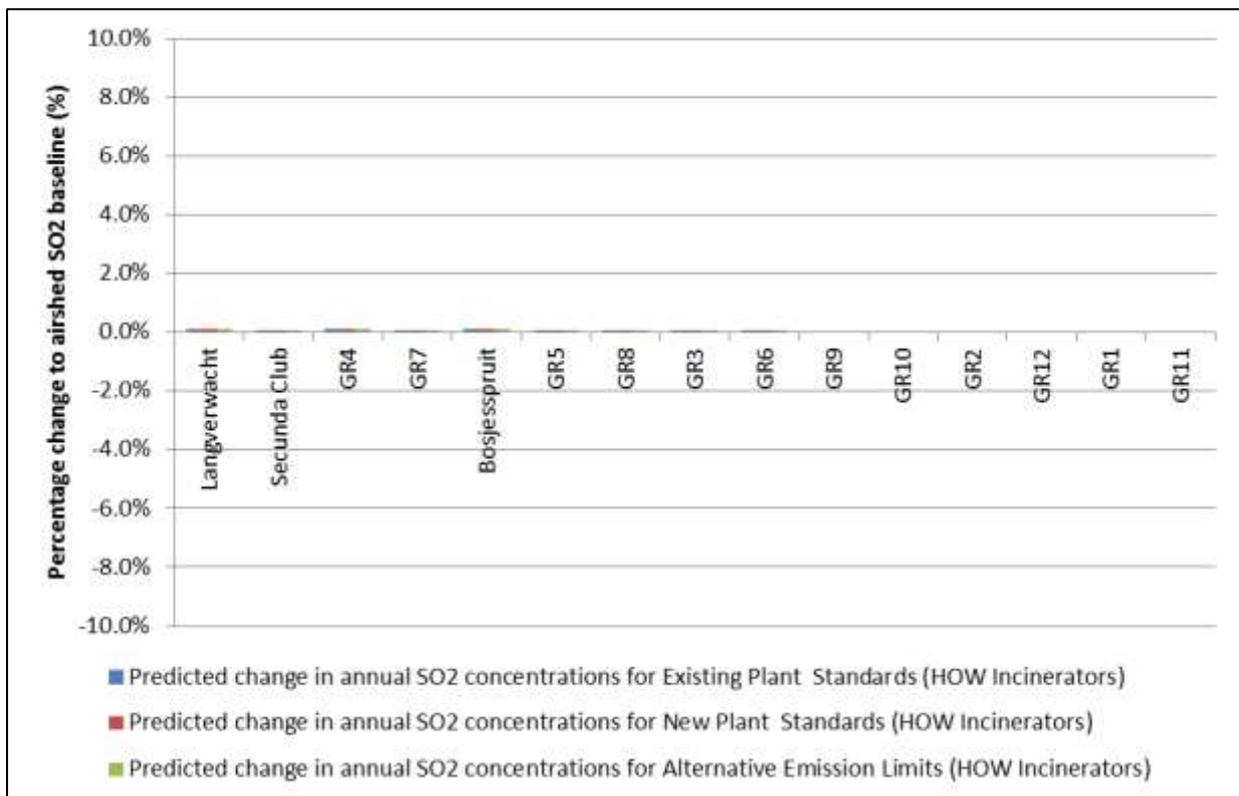
Figure I-20: Theoretical change in SO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels HOW Incinerators (calculated using Equation 1)
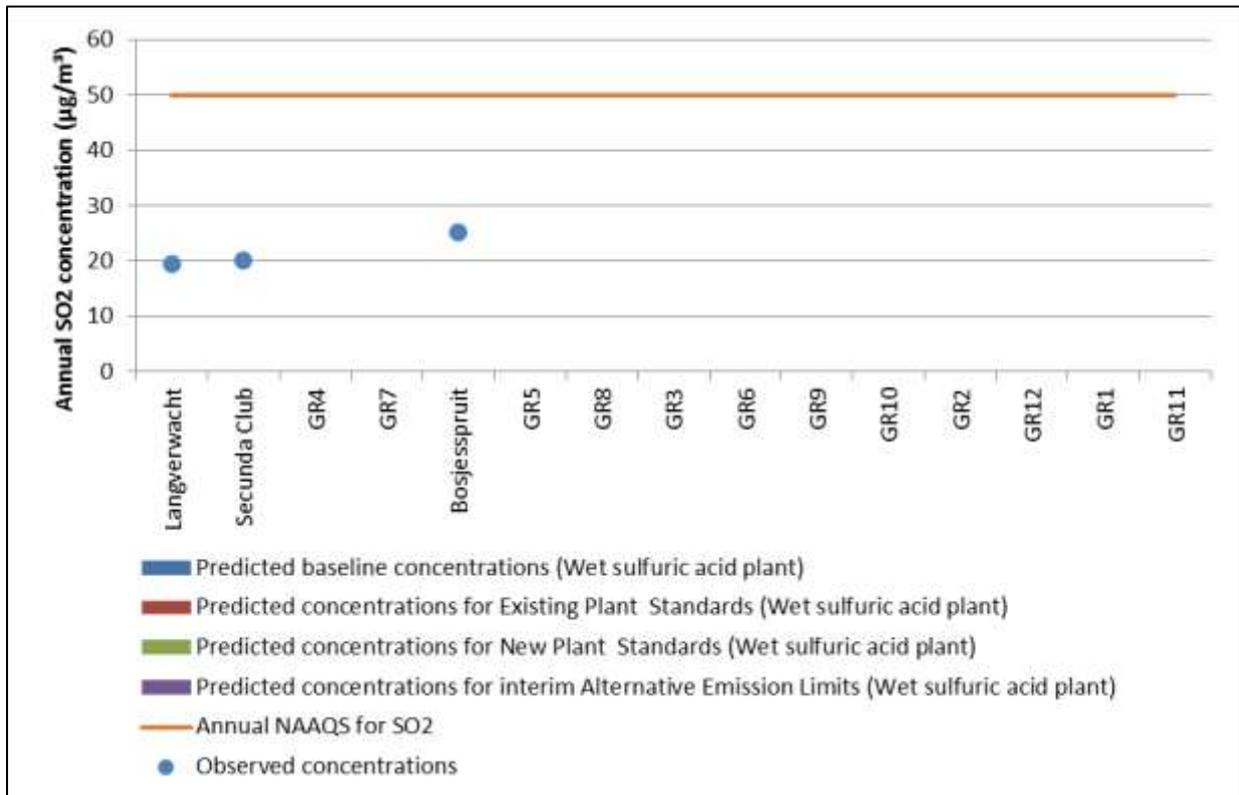
Figure I-21: Predicted annual SO₂ concentrations at identified receptors for Synfuels Wet Sulfuric Acid Plant (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
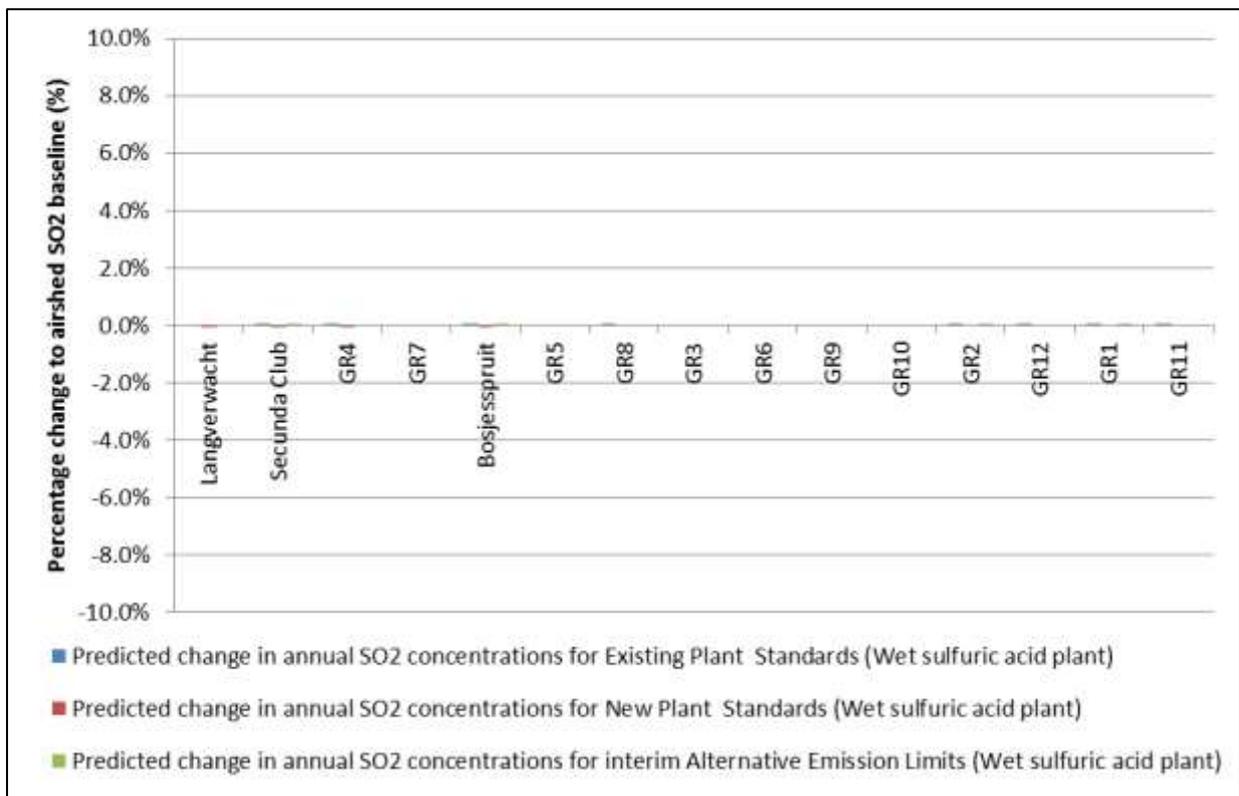
Figure I-22: Theoretical change in SO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels Wet Sulfuric Acid Plant (calculated using Equation 1)

Nitrogen dioxide (NO$_2$)

Annual

Predicted annual average ambient NO$_2$ concentrations fell below NAAQS for all sources assessed for all scenarios (Figure I-23, Figure I-24, Figure I-28, and, Figure I-30). The maximum improvement was predicted (0.7%) at Bosjespruit as a result of Steam Stations theoretically complying with Existing Plant Standards (Figure I-25). Theoretical compliance with New Plant Standards and the Alternative Emission Limits scenarios both predicted increases in annual NO$_2$ at some receptors – mostly those closer to the plant – where the maximum increase predicted was 9.1% at Bosjespruit for the Alternative Emission Limit scenario (Figure I-25).
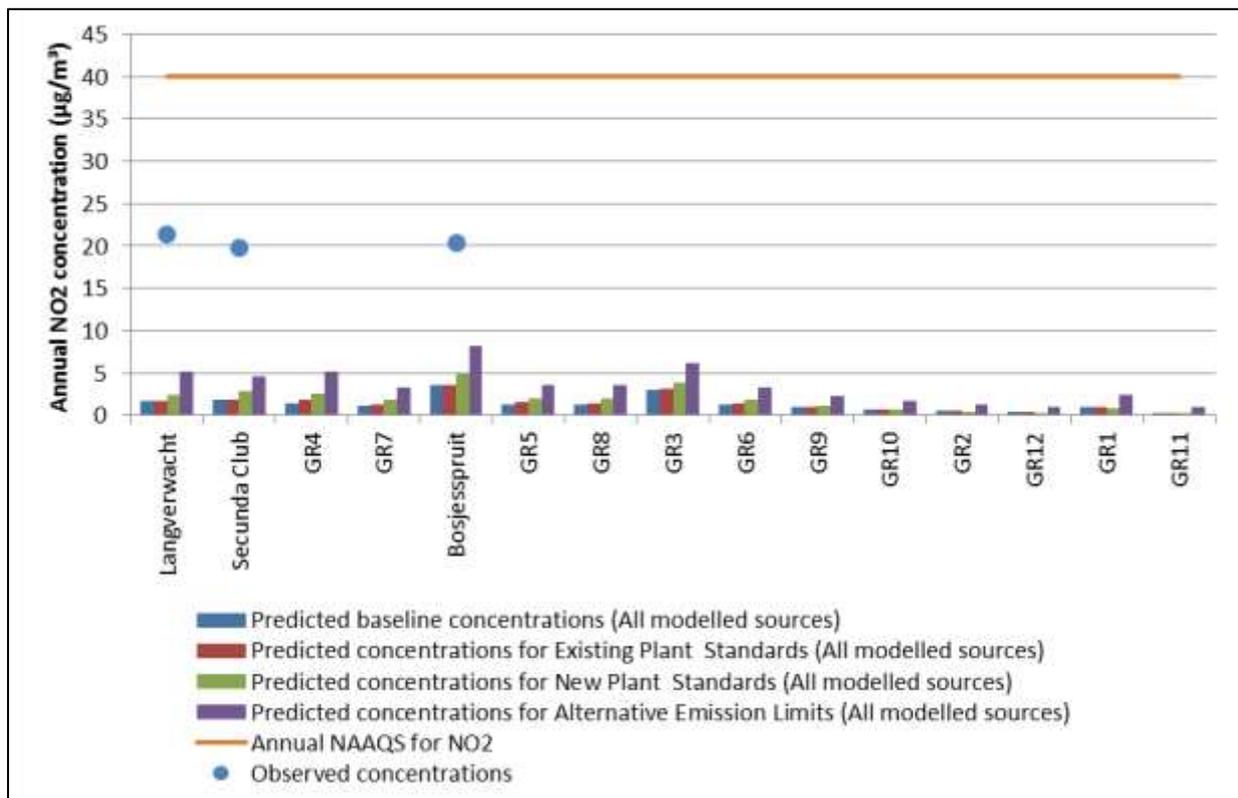
Figure I-23: Predicted annual NO$_2$ concentrations at identified receptors for all modelled Synfuels sources (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
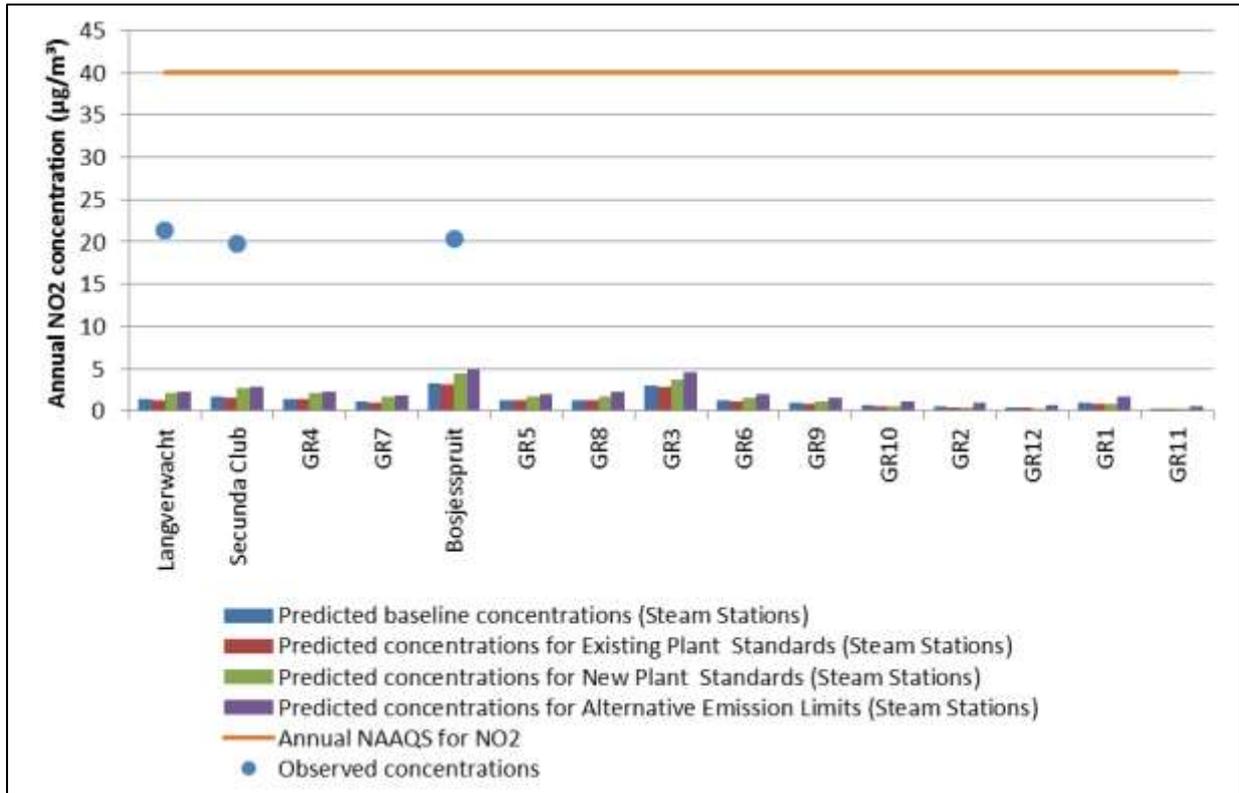
Figure I-24: Predicted annual NO₂ concentrations at identified receptors for Synfuels Steam Stations (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
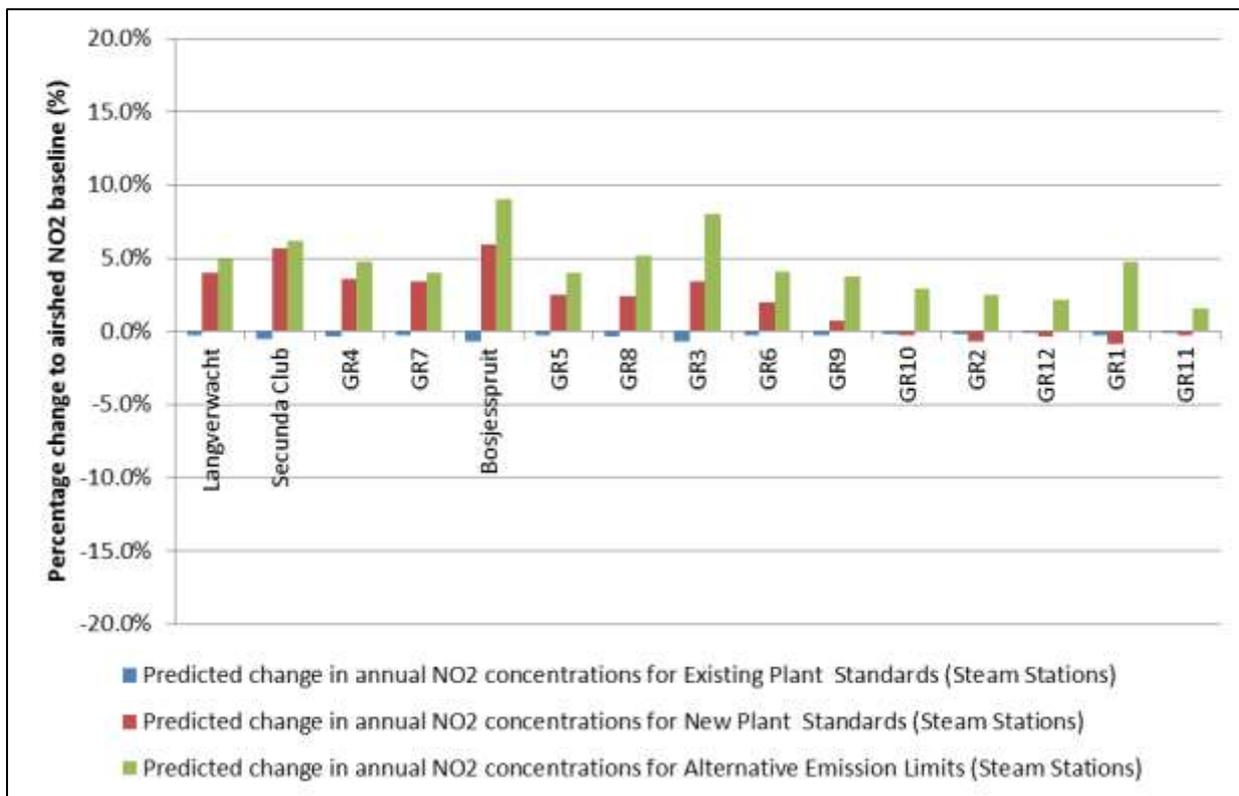

Figure I-25: Theoretical change in NO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Secunda Steam Stations (calculated using Equation 1)
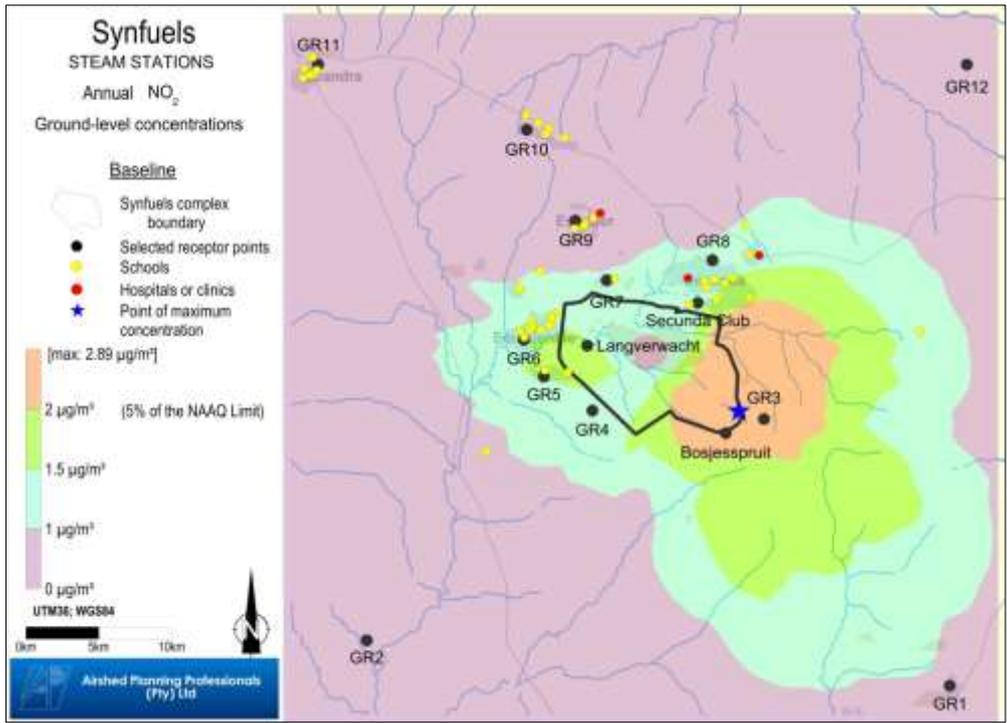
Figure I-26: Predicted annual NO₂ concentrations as a result of Baseline emissions from the Steam Stations
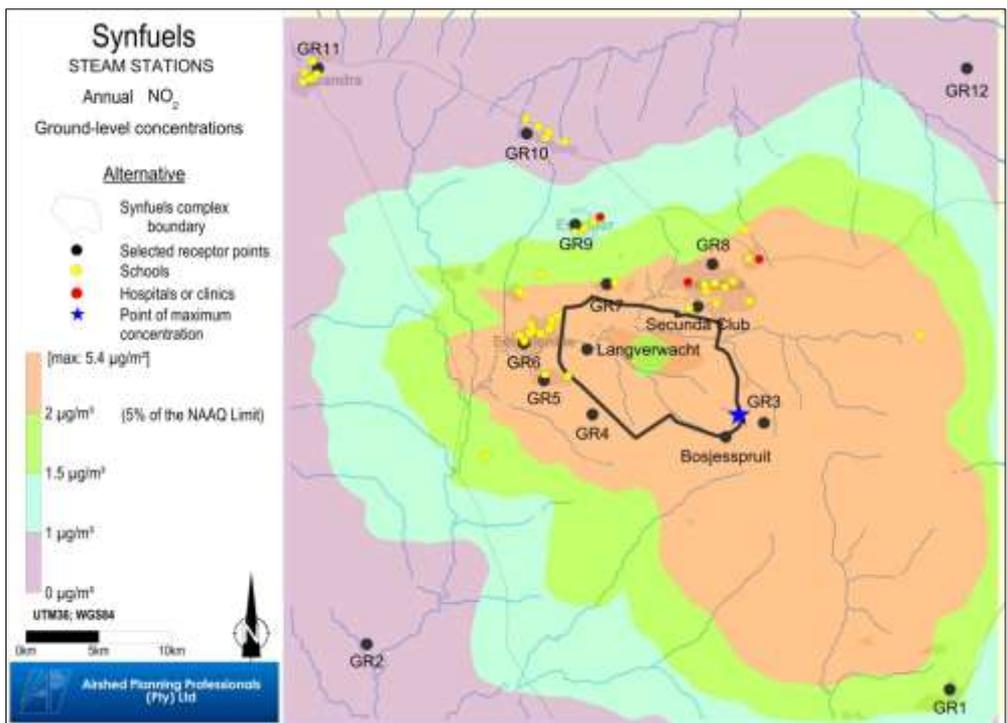
**Figure I-27: Predicted annual NO₂ concentrations as a result of Alternative Emission Limit emissions from the Steam Stations**
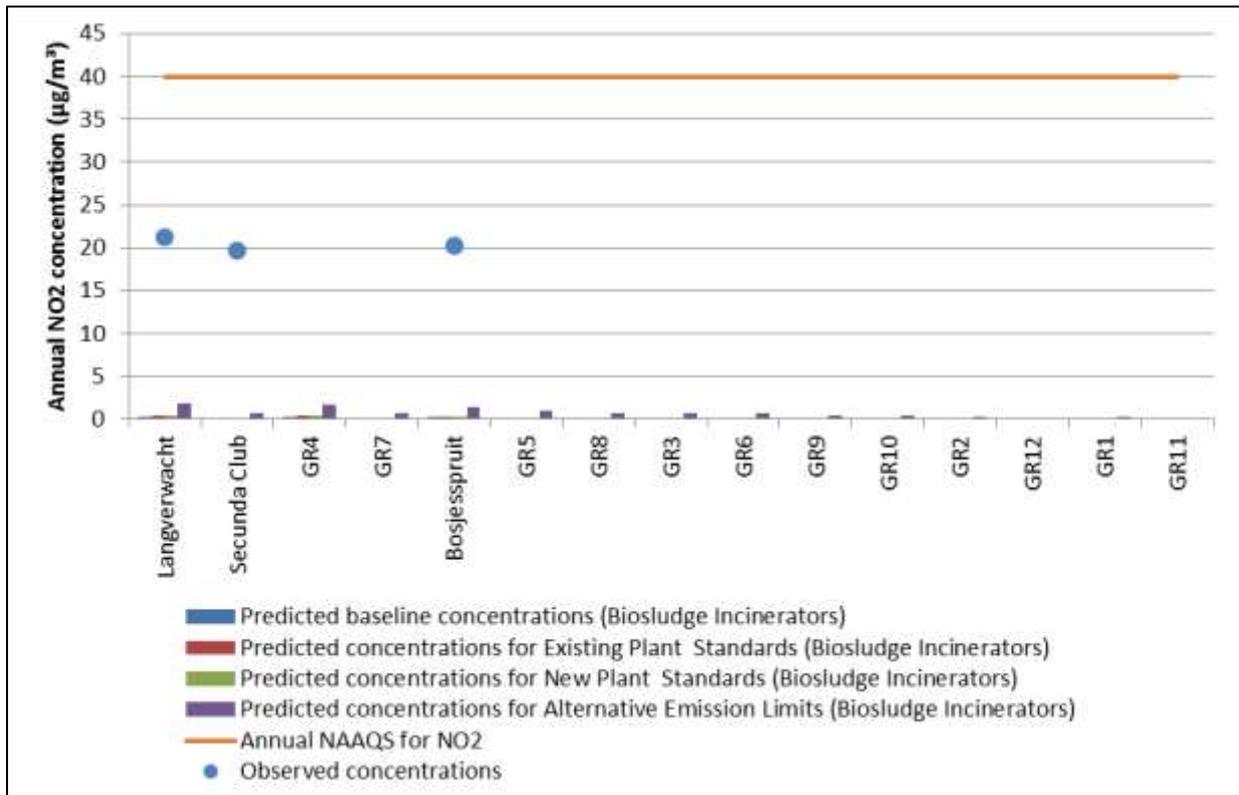
Figure I-28: Predicted annual NO₂ concentrations at identified receptors for Synfuels Biosludge Incinerators (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
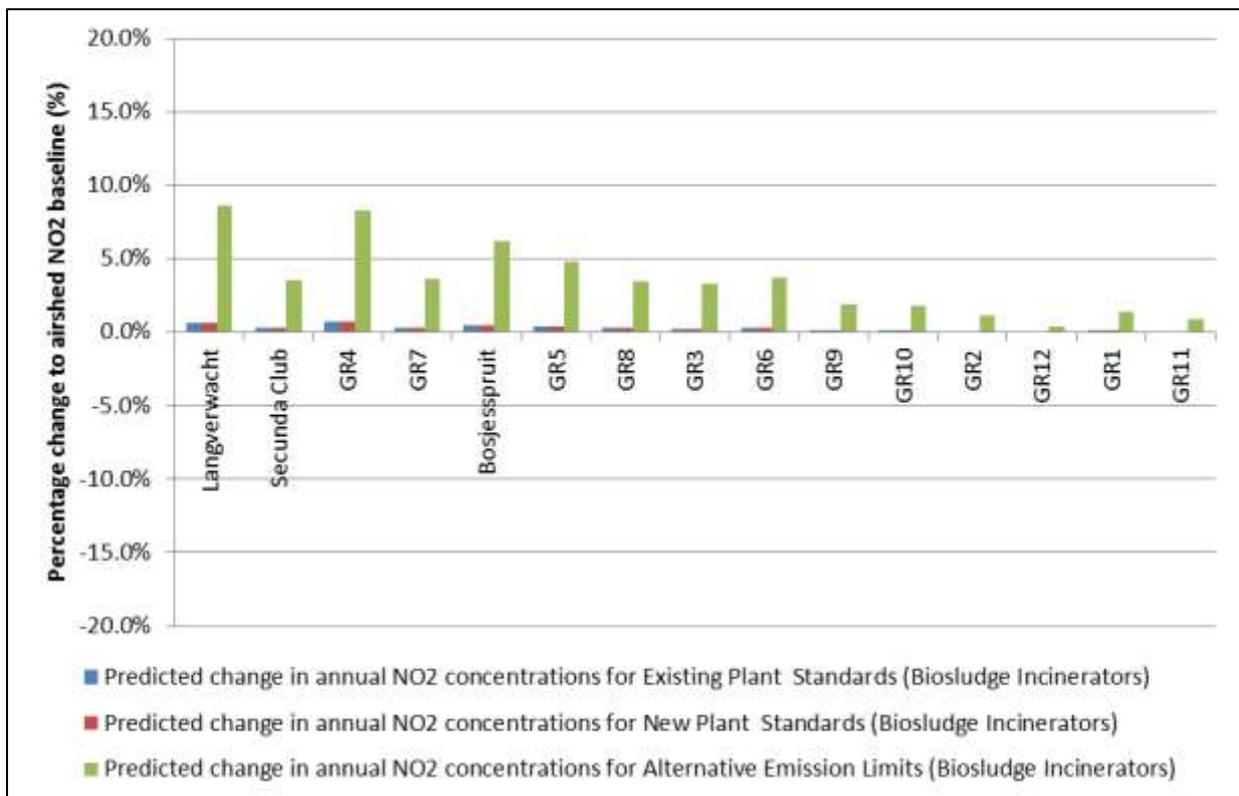

Figure I-29: Theoretical change in NO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels Biosludge Incinerators (calculated using Equation 1)
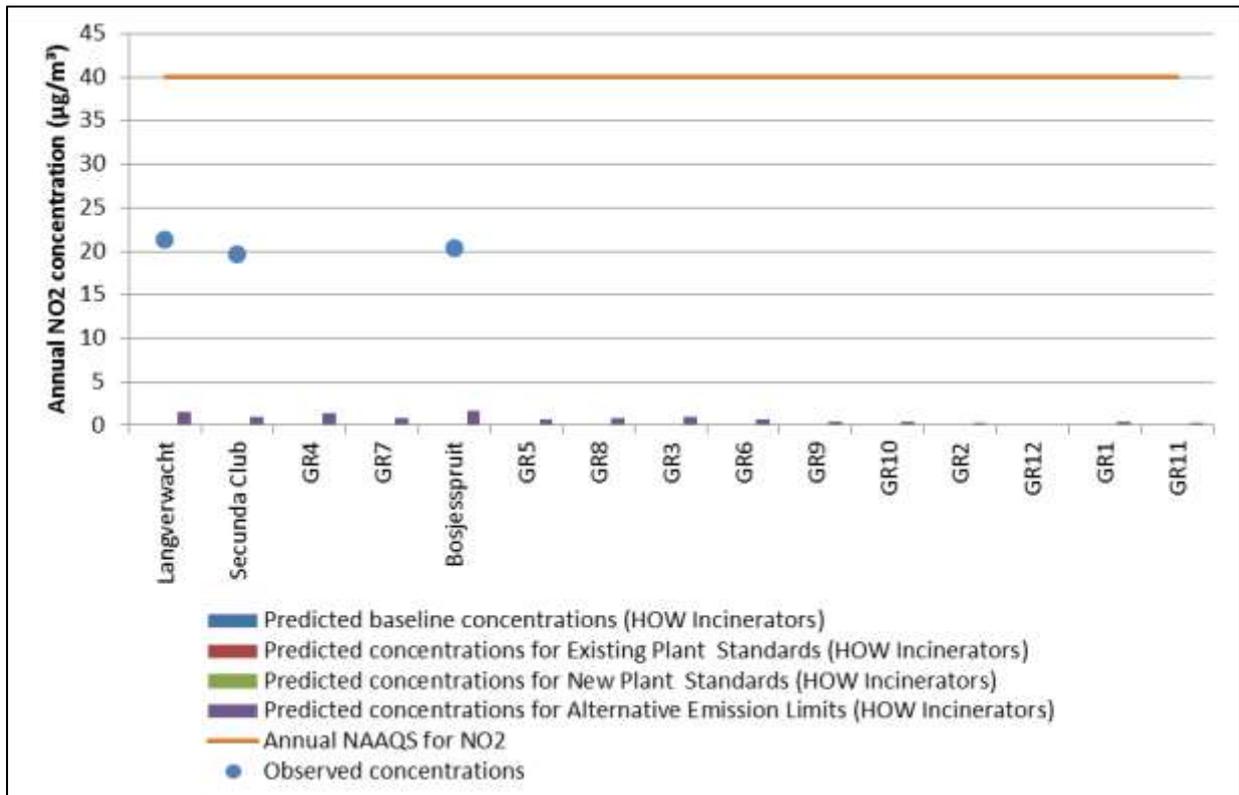
Figure I-30: Predicted annual NO₂ concentrations at identified receptors for Synfuels HOW Incinerators (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
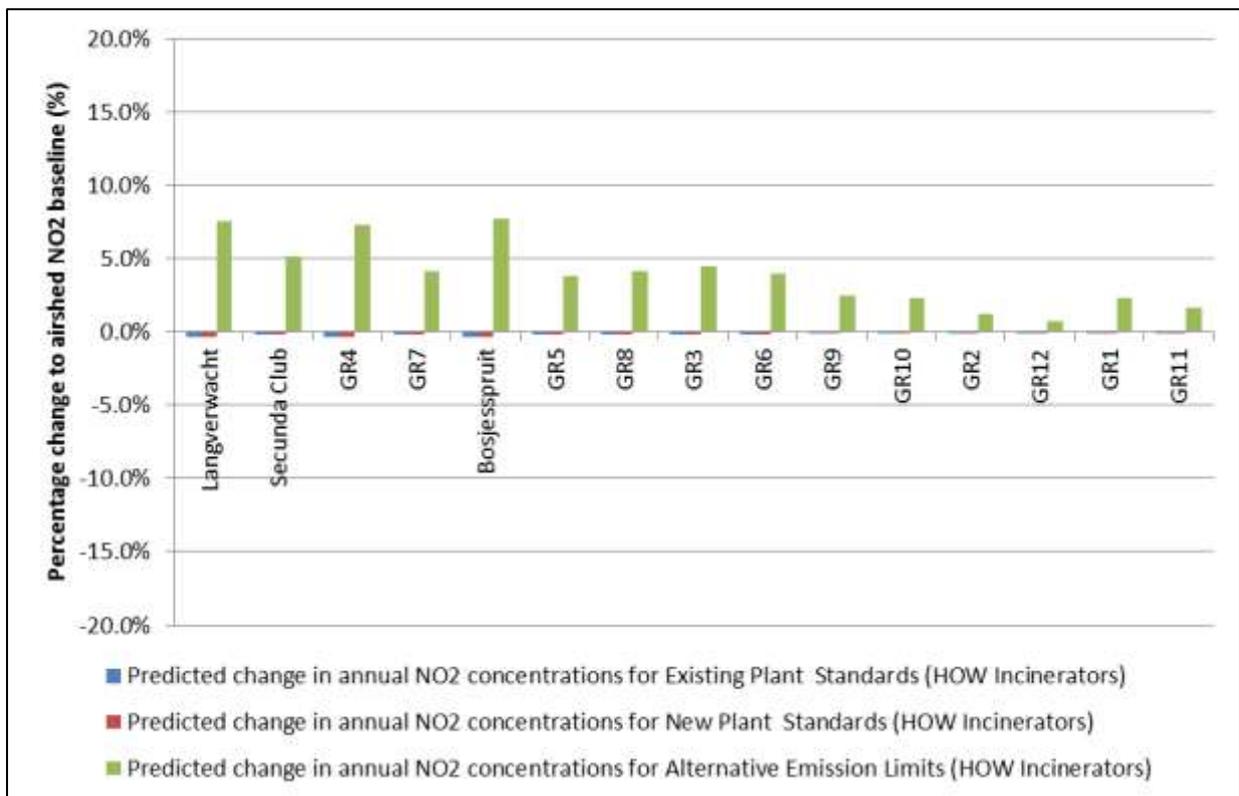

Figure I-31: Theoretical change in NO₂ concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels HOW Incinerators (calculated using Equation 1)

Particulate matter (PM)

Annual

Annual ambient PM concentrations were predicted to be less than 4 µg/m³ at all receptors for all sources and scenarios assessed (Figure I-32); below the NAAQS for annual average PM (Figure I-33, Figure I-37, Figure I-39, and Figure I-41). Theoretical compliance with Existing Plant Standards would result in increased ambient annual PM concentrations as a result of the Steam Stations (Figure I-34). Improvements in ambient PM concentrations as a result of the Steam Stations and Incinerators theoretically meeting New Plant Standards are less than 2.5% in all cases (Figure I-38, and, Figure I-40). Increases in annual PM concentrations were predicted to be less than 10% at all receptors as a result of the Alternative Emission Limits (Figure I-34, Figure I-38, Figure I-40, and, Figure I-42).
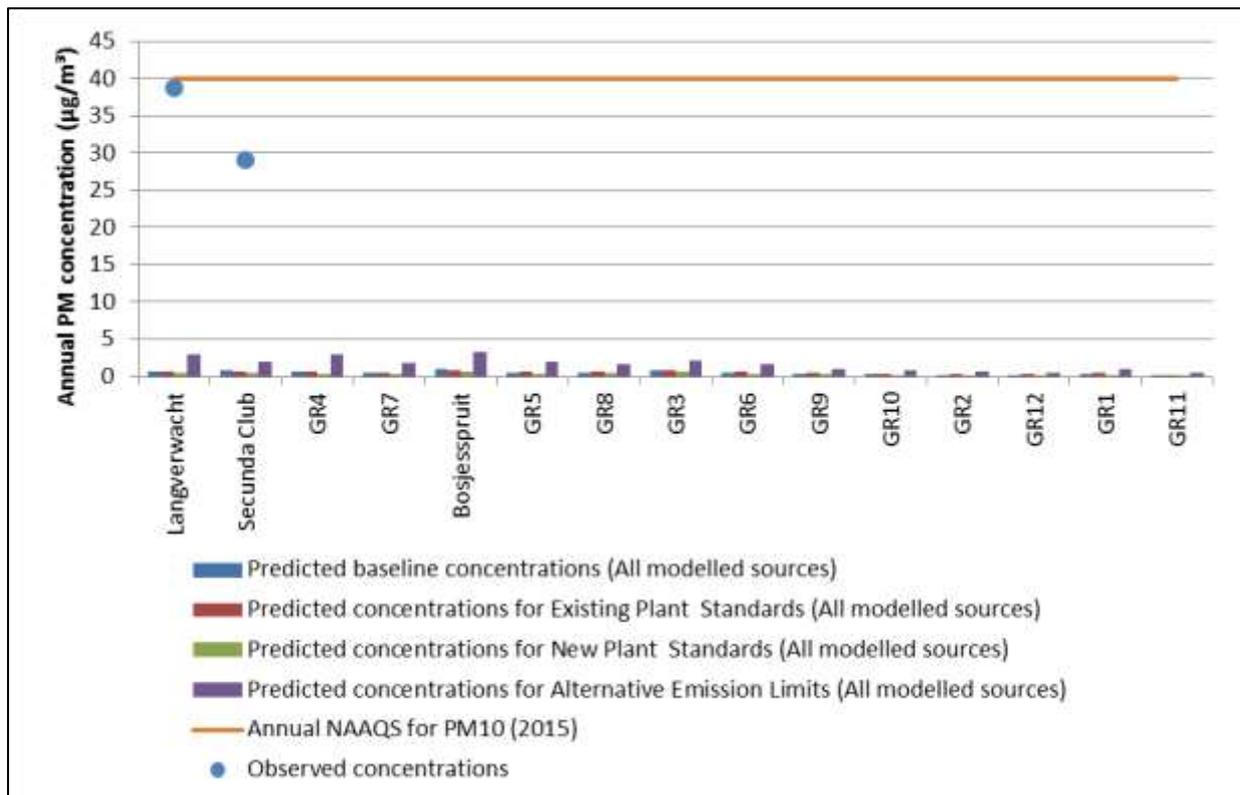

Figure I-32: Predicted annual PM concentrations at identified receptors for all modelled Synfuels sources (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
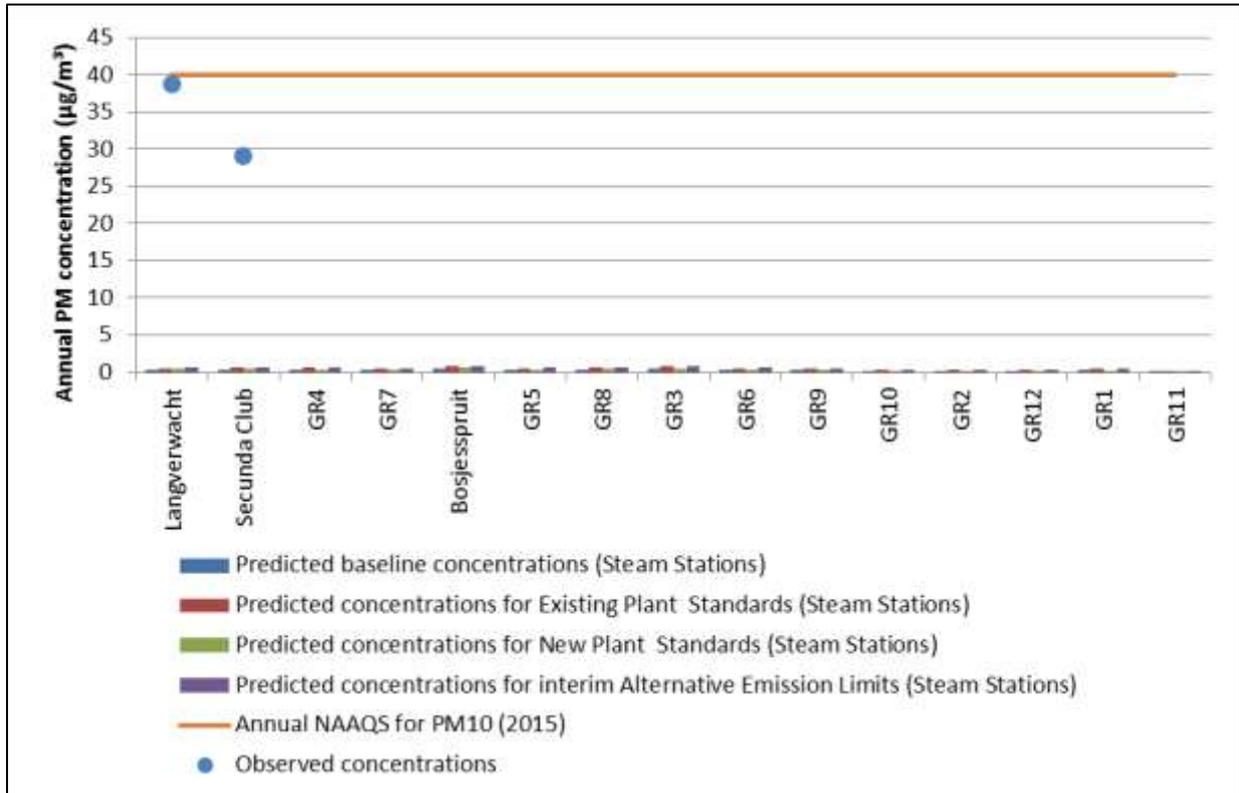
Figure I-33: Predicted annual PM concentrations at identified receptors for Synfuels Steam Stations (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
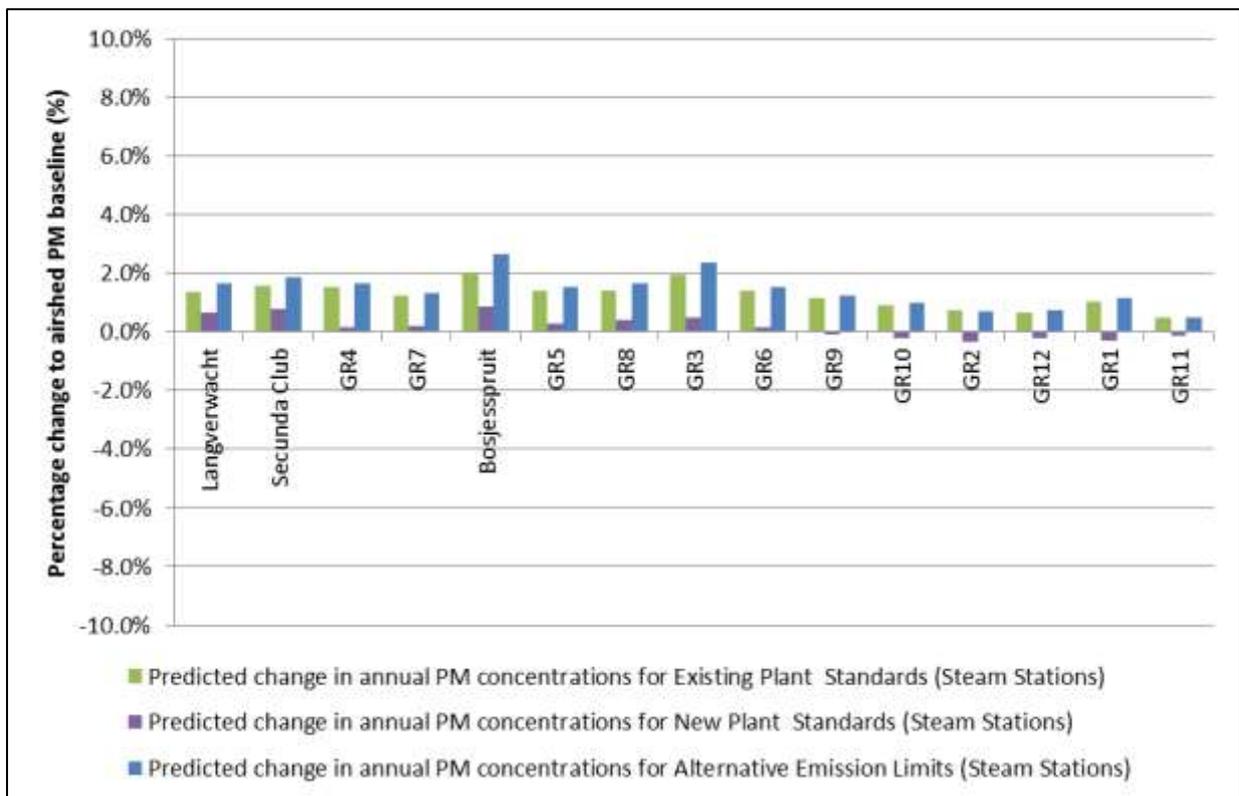
Figure I-34: Theoretical change in PM concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels Steam Stations (calculated using Equation 1)
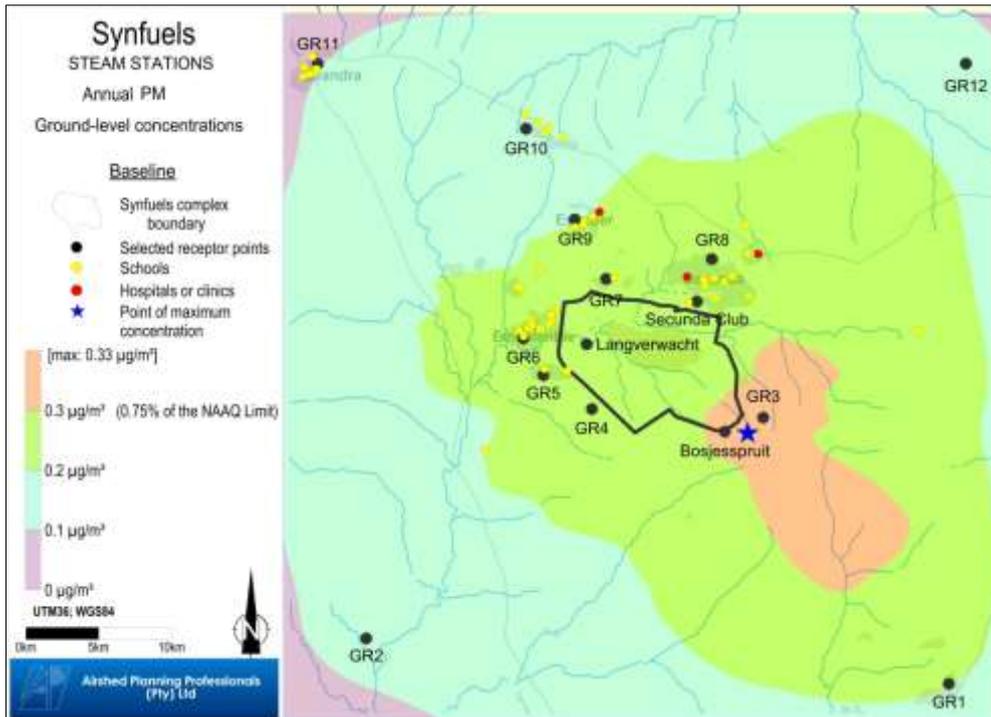
Figure I-35: Predicted annual NO₂ concentrations as a result of Baseline emissions from the Steam Stations
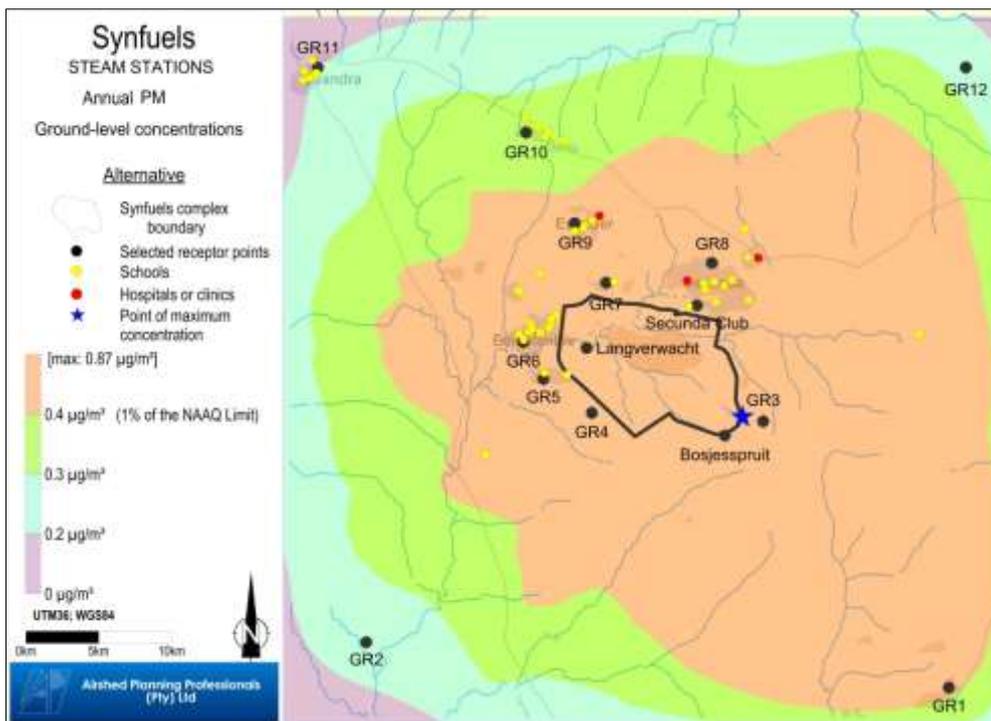
Figure I-36: Predicted annual NO₂ concentrations as a result of Alternative Emission Limits emissions from the Steam Stations
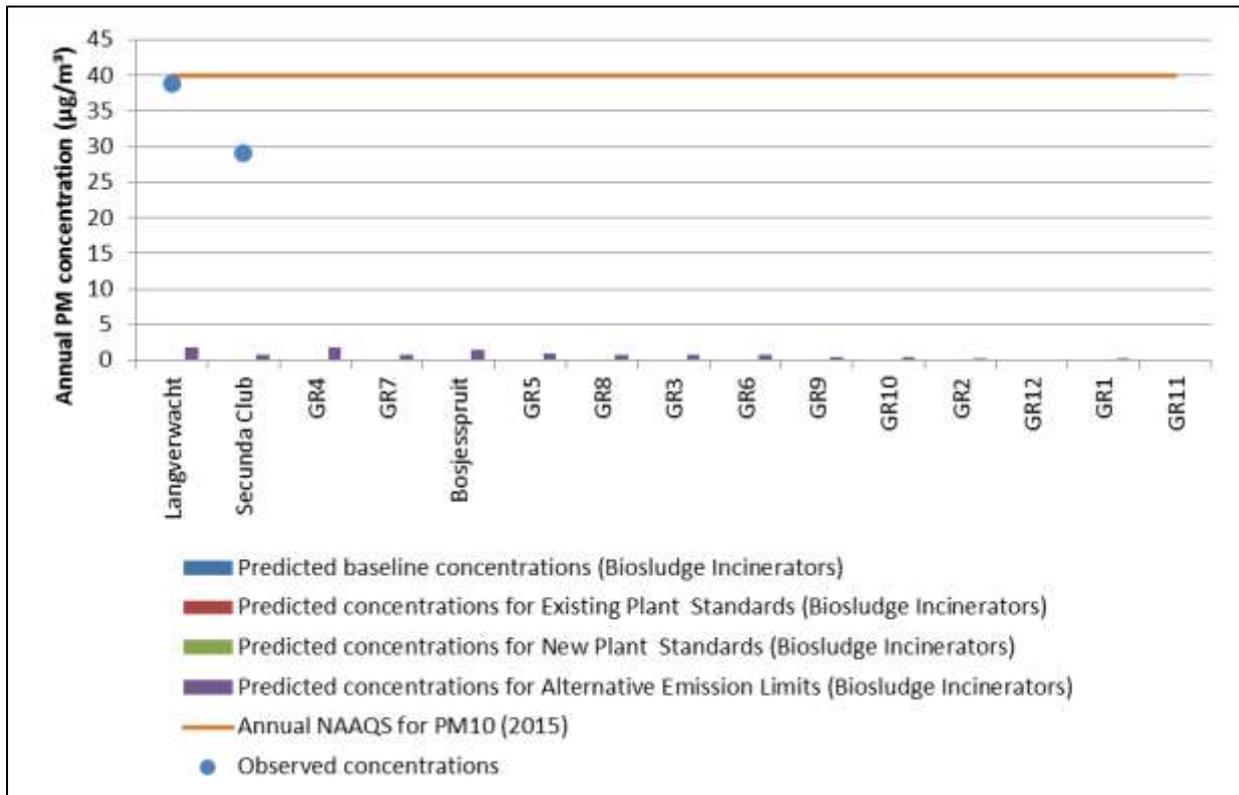
Figure I-37: Predicted annual PM concentrations at identified receptors for Synfuels Biosludge Incinerators (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
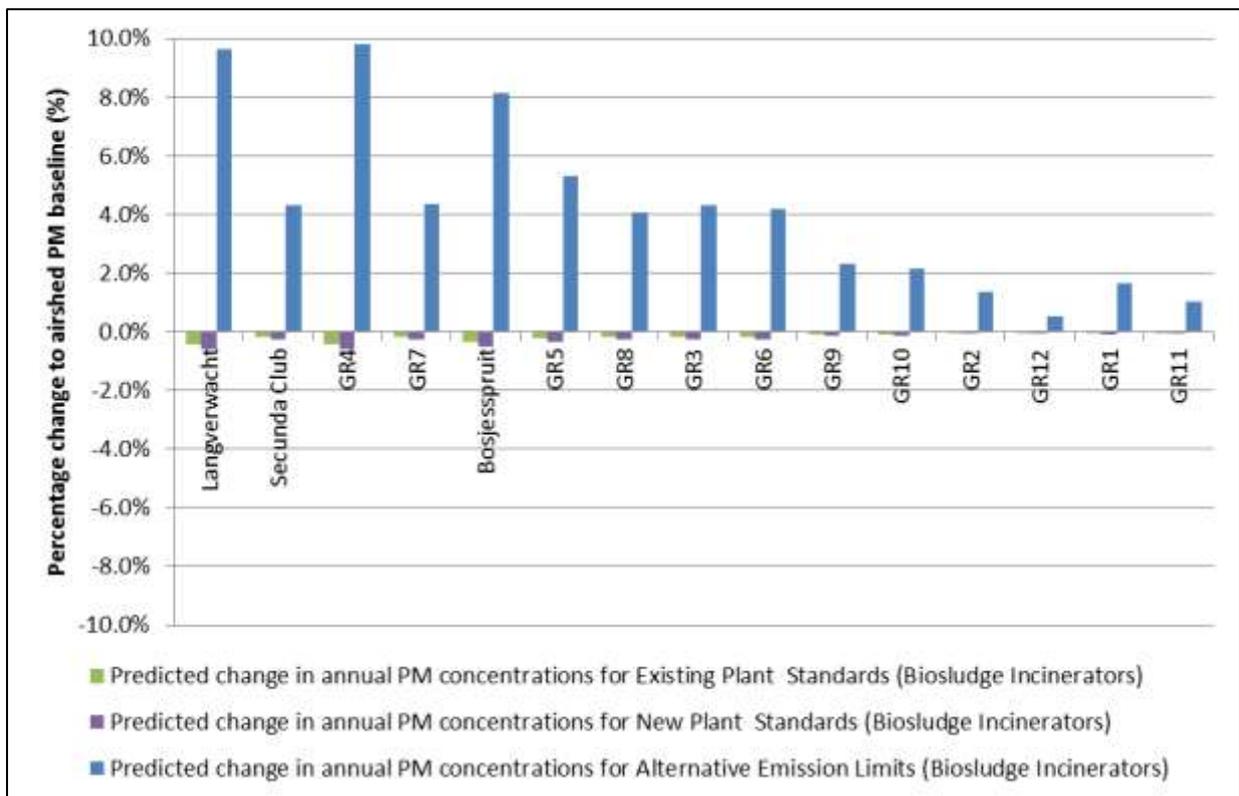

Figure I-38: Theoretical change in PM concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels Biosludge Incinerators (calculated using Equation 1)
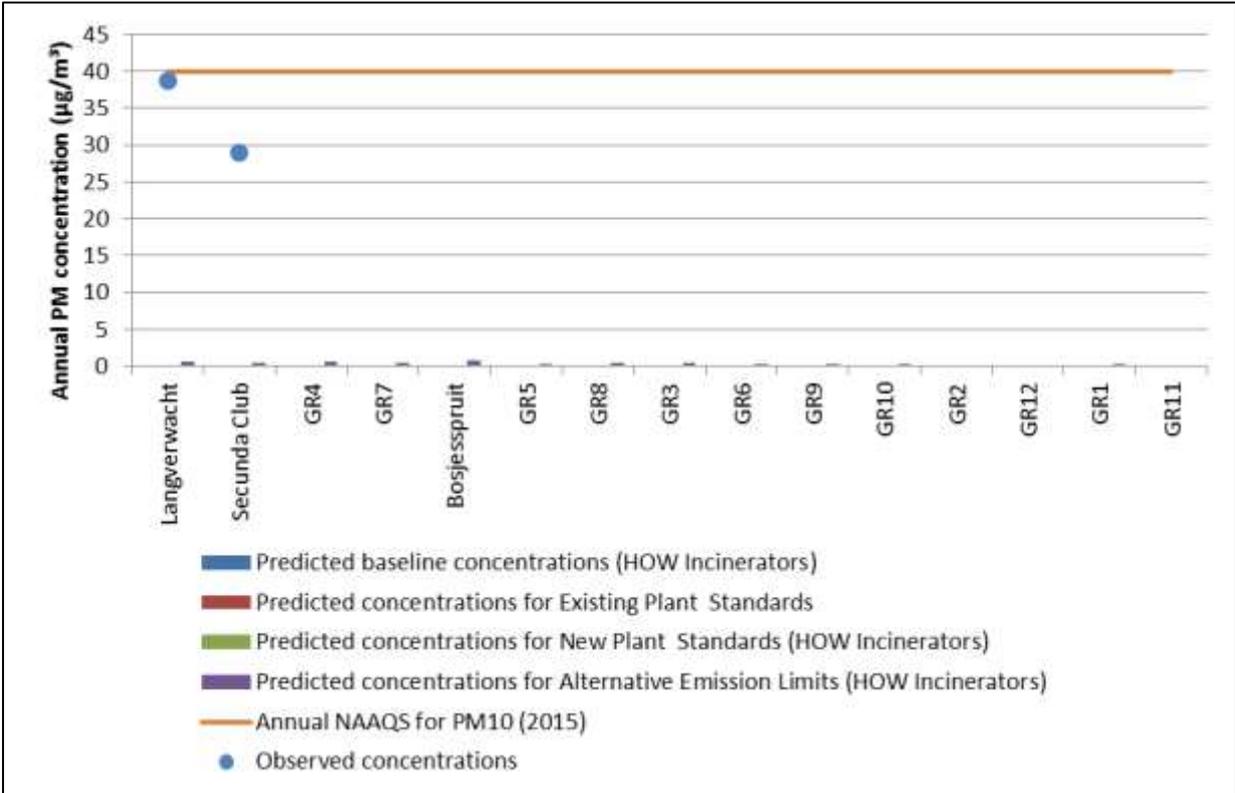
Figure I-39: Predicted annual PM concentrations at identified receptors for Synfuels HOW Incinerators (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)
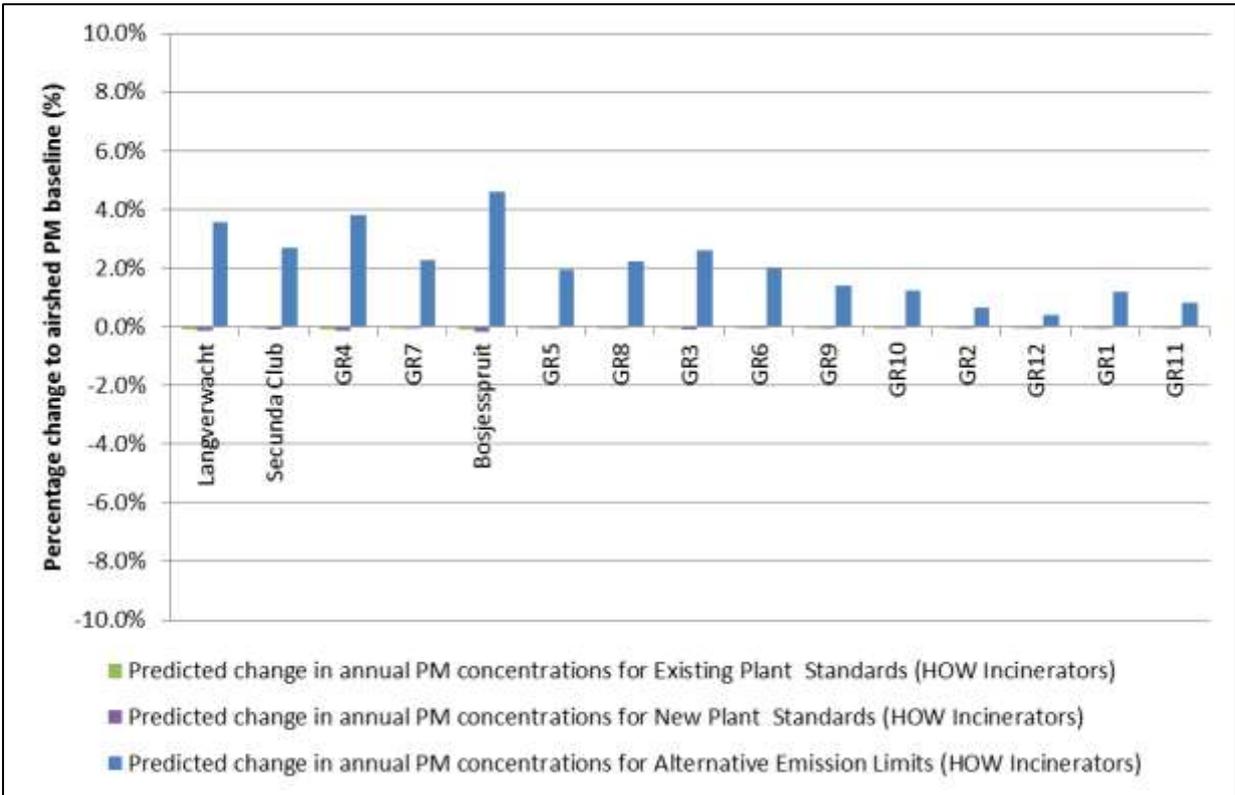
Figure I-40: Theoretical change in PM concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels HOW Incinerators (calculated using Equation 1)
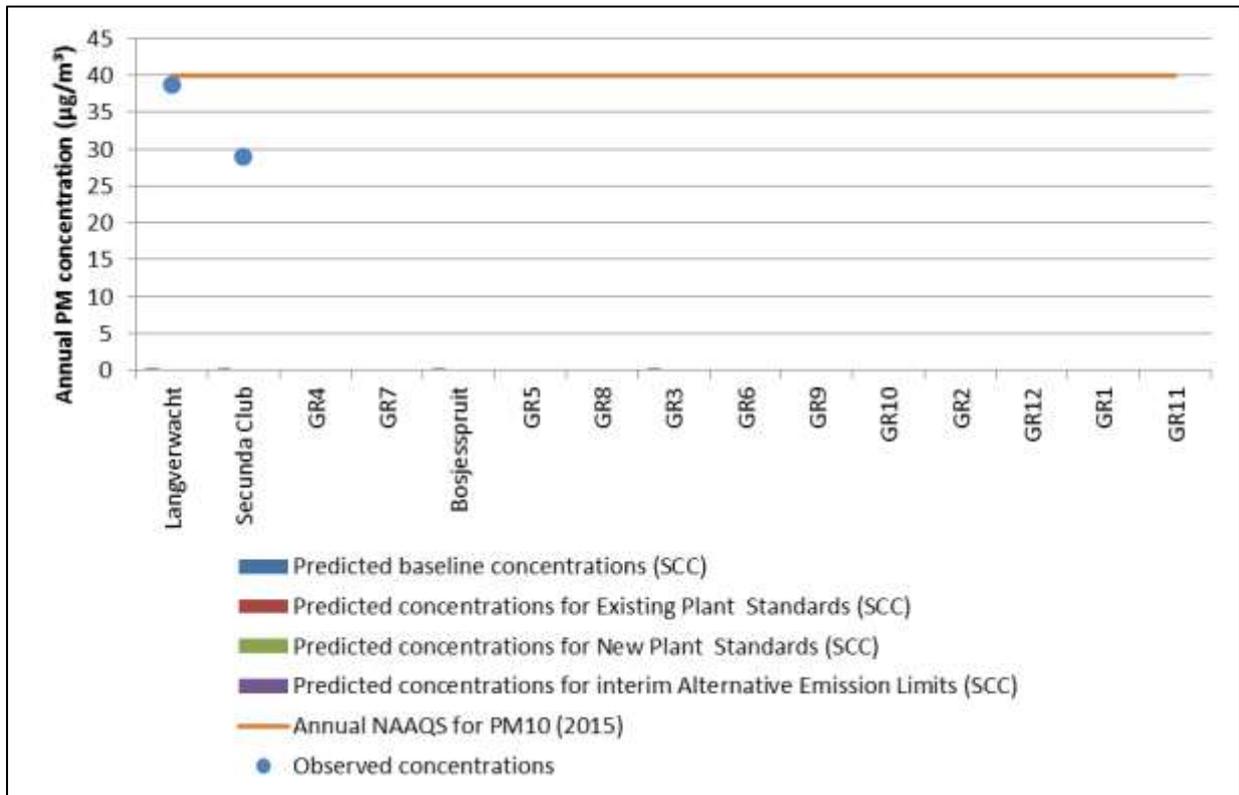
**Figure I-41: Predicted PM concentrations at identified receptors for Synfuels SCC (receptor code names as detailed in Table 5-23, where locations are shown in Figure 5-49)**
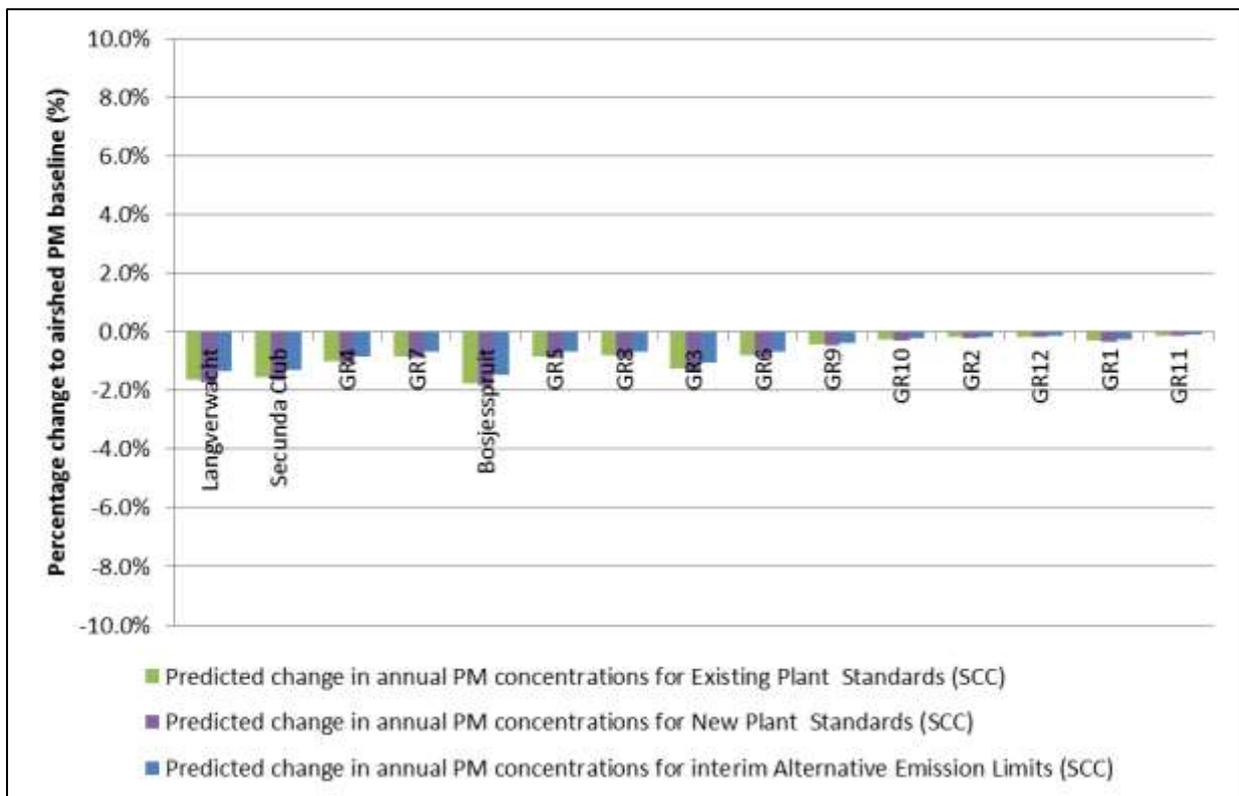

Figure I-42: Theoretical change in PM concentrations between scenarios and the airshed baseline at the identified receptors for Synfuels SCC (calculated using Equation 1)

## APPENDIX J: MANAGEMENT OF UNCERTAINTIES

Dispersion Model Uncertainties

In the US EPA Guideline on Air Quality Models (U.S. EPA, 2005), the need to address the uncertainties associated with dispersion modelling is acknowledged as an important issue that should be considered. The US Guideline divides the uncertainty associated with dispersion model predictions into two main types (U.S. EPA, 2005), as follows:

- Reducible uncertainty, which results from uncertainties associated with the input values and with the limitations of the model physics and formulations. Reducible uncertainty can be minimized by improved (i.e., more accurate and representative) measurements and improved model physics.
- Inherent uncertainty is associated with the stochastic (turbulent) nature of the atmosphere and its representation (approximation) by numerical models. Models predict concentrations that represent an ensemble average of numerous repetitions for the same nominal event. An individual observed value can deviate significantly from the ensemble value. This uncertainty may be responsible for a ± 50% deviation from the measured value.

Atmospheric dispersion models are often criticised for being inadequate since "…*it is only a model approximating reality*", and therefore include inherent uncertainty. Both reducible and inherent uncertainties mean that dispersion modelling results may over- or under-estimate measured ground-level concentrations at any specific time or place. However, the US EPA Guideline on Air Quality Models (U.S. EPA, 2005) also states that:

"Models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in highest estimated concentrations of +/- 10 to 40 per cent are found to be typical, i.e., certainly well within the often-quoted factor of two accuracy that has long been recognized for these models. However, estimates of concentrations that occur at a specific time and site are poorly correlated with actually observed concentrations and are much less reliable."

To minimise the overall uncertainty, but specifically the "reducible uncertainty", the following simple principles were followed in the investigation:

- Understanding the objectives of the investigation;
- Demonstrating that the model inputs are as correct as possible;
- Understanding and stating the model performance limitations;
- Demonstrating that the modelling process has been conducted appropriately and in line with both local DEA requirements and international practice;
- Including any validating information from monitoring that might be available; and
- To be conservative in cases where there is greater uncertainty (e.g. conversion of NO to NO_2).

Although the existence of model uncertainty is well-accepted, it does not exclude the use of dispersion modelling results in making important air quality impact decisions. The uncertainties should simply be acknowledged and understood that, given their inherent uncertainty, current dispersion models are a "best-case" approximation of what are otherwise very complex physical processes in the atmosphere. An accepted dispersion model (i.e., CALPUFF) was selected for the analysis to minimize some of these uncertainties. The US EPA states that when dispersion models such as CALPUFF are used to assess ground-level concentration and when a sufficiently large number of meteorological conditions are considered, the

modelling results should ideally fall well within the often quoted "factor of two" accuracy for these modelled (U.S. EPA, 2005).

Validation of Predictions

Model verification and validation (V&V) are the primary processes for quantifying and building credibility in numerical models. There are distinct differences between the two processes, as described below:

- Verification is the process of determining that a model implementation accurately represents the developer's conceptual description of the model and its solution.
- Validation is the process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model.

Whilst V&V cannot prove that a model is correct and accurate for all possible scenarios, it can provide evidence that the model is sufficiently accurate for its intended use.

A rigorous V&V programme was not completed as part of the study; however, regular sanity checks on model results and comparisons with observations were done, as discussed in Section 5.1.6. An attempt was also made to quantify the level of agreement between observed data and model prediction, as well as the predictive accuracy of the model once the necessary adjustments have been made (such as including the estimated background concentrations). In this regard, the CALPUFF model's performance was evaluated by comparing the modelling results for the years 2010, 2011 and 2012 to the Sasol monitoring data collected over the same time period. In particular, the predicted SO_2 and NO_2 concentrations arising from the Secunda operations were include in the comparison.

The performance evaluation was completed using the fractional bias method, since this statistical technique is one of the evaluation methods recommended by the U.S. EPA for determining dispersion model performance (U.S. EPA 1992). Both short- and long-term fractional biases were computed for SO_2 and NO_2 as predicted and observed at the three monitoring stations; Bosjesspruit, Secunda Club, and, Langverwacht. The fractional biases of the means were shown to be well within a factor of two, which the U.S. EPA consider to be a reasonable performance target for a dispersion model before it is used for refined regulatory analysis (U.S. EPA 1992).

Scenario Simulations

Since the focus of the study has been to illustrate the relative changes with the introduction of different emission conditions (i.e. emission rates, exit gas temperatures and velocities), whilst maintaining the same stack heights and diameters, it is expected that the model errors would mostly be similar in magnitude between the different modelling scenarios. Therefore, expressing the changes as incremental and relative to the baseline scenario, it is expected that these errors would mostly cancel each other out.

It should also be noted that the average long-term background concentrations (Table 5-24) were used in this expression rather than the short-term value, which offers a more conservative approach.

Ambient Monitoring Uncertainty

Sasol operates a total of three ambient air quality monitoring stations in and around Secunda, namely at Bosjesspruit, Secunda Club and Langverwacht. Data for 2010, 2011 and 2012 all three stations were included in this investigation.

All of the abovementioned monitoring stations are ISO/IEC17025 accredited, to ensure data integrity and data quality as well as to ensure that the data obtained from the monitoring stations are representative of the ambient air when measured. Data availability and credibility is maximised through:

- Regular (at least on a weekly basis) visits of the monitoring stations to ensure the stations are functioning properly.
- Dynamic calibrations are conducted on at a quarterly basis, however where possible more frequent calibrations have been done.
- Certified calibration gas is used and obtained from reputable vendors
- Inter-laboratory comparisons are done between Sasol's Sasolburg and Secunda monitoring stations as well as between Sasolburg, Secunda and a third party calibration laboratory.
- Participation in the National Metrological Laboratory's national inter-laboratory comparisons to ensure that the system is in line with the rest of the accredited laboratories in South Africa.

Although the ISO/IEC 17025 System requires a quarterly data availability of 80%, Sasol's internal data availability, tracked on a monthly Scorecard, is a monthly data availability of 90%.

Based on the uncertainty calculations completed as per the ISO/IEC17025 requirements, Sasol's uncertainty in measurements on its ambient air quality monitoring stations is between 3% and 5% with a level of confidence of 95%. This has been confirmed through inter-laboratory comparisons and is confirmed on a regular basis.

Upper Air Meteorological Data

Although meteorological data from the monitoring stations described in the previous section are available for input into the CALPUFF dispersion model, there is a lack of upper air meteorology. The lack of appropriate meteorological information is often the single most important limiting factor in modelling accuracy. It is also the most subjective in deciding just how many data are needed, from which location and how accurate they must be.

The CALMET wind field model requires, as a minimum, meteorological data from at least one surface and an upper air station. This information is then used to "seed" the three-dimensional wind field with an initial solution of a relatively simple mass conservation model. CALMET does not include momentum, energy, or moisture conservation equations, and is therefore classified as a diagnostic model.

It is expected, that a wind field developed using all the parameters that could influence the flow, thermal and turbulence mechanisms should improve the accuracy of the dispersion predictions. MM5 is a three-dimensional, non-hydrostatic prognostic mesoscale models. MM5 is the fifth generation NCAR/Penn State Mesoscale model. The model includes a multiple-nesting capability, non-hydrostatic dynamics and four-dimensional data assimilation (Dudhia et al., 1999). The MM5 model uses all the conservation equations and has more refined parameterisations for processes that cannot be simulated directly. The main advantages and disadvantages of these models are detailed below.

Advantages of MM5:
- has the ability to assimilate local meteorological data;
- has realistic dynamical and physical formulations, suitable for simulations in South Africa's environment;
- can produce realistic meteorological fields in data-sparse regions; and

- is flexible enough to couple output meteorological fields to dispersion model runs at any resolution.

Disadvantages of MM5:
- has relatively high computational demands;
- requires a large amount of user knowledge and expertise to produce reliable and convincing results; and
- do not themselves include dispersion models, and the associated dispersion models do not necessarily comprise all of the features required for regulatory assessments (e.g. building effects).

MM5 data for the study domain was purchased from Lake Environmental that has proven record of generating MM5 data ready for use in the US EPA's AERMOD and CALPUFF dispersion modelling suites. The dataset included the years 2010, 2011 and 2012 at 12km resolution for a 300km by 300km study area.

The MM5 prognostic model together with the meteorological observations provide a 'first-guess field', which is then modified by the CALMET diagnostic model to take account of terrain and land-use features that are at a smaller spatial scale than the terrain used by the prognostic model. The main purpose of this approach is to increase the horizontal resolution of the meteorological fields.

Emission Inventory Uncertainty

In addition to meteorological input data, the uncertainty associated with the emissions inventory needs to be accommodated in the results. All emissions used in the simulations of the baseline scenario were based on either iso-kinetic measurement campaigns or continuous emissions monitoring (CEM).

Sasol makes use of reputable sampling companies for its third party measurement campaign and also operates CEM devices in certain of its plants. Although there is currently no quality accredited system for online monitoring devices within a stack, Sasol is using the same principles as for its ambient air quality monitoring stations, i.e. the ISO/IEC17025 principles to manage the quality of the data received from its online monitoring network.

All third party (and *ad hoc*) sampling requests (or requirements) within the Sasol Group have to comply with AQA Section 21, Schedule 2 of the Listed Activities and Minimum Emission Standard. Furthermore, Sasol has, as far as possible, standardised on US EPA sampling methodologies. Analyses of the samples are also done by an ISO/IEC17025 accredited laboratory to further control the quality of the results.

Where ad hoc sampling is done, Sasol's philosophy is aligned with the requirements of the AQA Section 21, namely that all point sources must be sampled at least once a year.

Continuous Emission Monitoring

Due to the lack of a National Accreditation system for CEM, uncertainty in measurements cannot be confirmed at this stage, however based on the uncertainty associated with sampling, Sasol has

- a 10% uncertainty factor associated with its online particulate measurements; and
- an uncertainty below 10% for gases, the based on the accuracy of the completed calibrations, as well as the accuracy of the calibration gases (this uncertainty ranges between 5% and 10%).

These uncertainties are with a level of confidence of 95%.

Third-Party Emission Monitoring

The uncertainty associated with third-party emission's measurements is considered to be up to 10% with a level of confidence of 95%. This uncertainty is based on the isokineticity of the isokinetic sampling, as well as the uncertainty associated with the sample taking and chemical analysis of gaseous components.

According to the Sasol quality control system, all third-party contractors for isokinetic sampling need to comply with the following control criteria:

- Their entire sampling staffs undergo the training associated with the UK-based Monitoring Certification Scheme (MCERTS): Manual Stack emissions monitoring program (MCERTS 2011);
- An electronic automated sampler is used for all isokinetic sampling;
- The pitot tubes used for sampling is calibrated at least on a quarterly basis;
- The pneumatic pressure sensors on the sampler is also calibrated on at least a quarterly basis; and
- The dry gas meters are checked on a regular basis and replaced every 6 months.

The CEM data is logged per second, and then averaged. In this way, all process upsets are captured within the database. The CEM data used in this investigation were based on an hourly average mass flow and concentration.

Ad-Hoc Emissions Sampling

SANAS is compiling an accreditation system for *ad hoc* sampling and as soon as this system is in place, the uncertainty of the measurements will be confirmed; however it is not expected to be higher than 10%.

Sasol is also in the process of conducting an international peer review on its third party contractors to determine whether there is a potential higher uncertainty in its measurements.

The Minimum Emissions Standards requires that sampling be conducted at normal operating conditions; therefore the emissions information included in the dispersion model is aligned with normal operating conditions on site. The sampling schedule is communicated to the plant managers with the aim of having process conditions as representative as possible to normal operations. Sampling upset conditions often poses a challenge from both a logistical and safety point of view, since safety requirements require as few people as possible on the plant during severe upset conditions and therefore sampling cannot be done during such conditions.

$PM_{2.5}$ and PM_{10} Air Emissions

All particulate matter was assumed to be $PM_{2.5}$ since it was not possible to establish the $PM_{2.5}$/PM_{10} split.

Non-Sasol Air Emissions

No attempt was made to estimate the emissions from non-industrial activities within regional communities. Instead, the community contribution (and other sources) of a particular compound was discussed in Section 5.1.6.1.

APPENDIX K: GUIDANCE NOTE ON TREATMENT OF UNCERTAINTIES

The Intergovernmental Panel on Climate Change (IPCC) produced a Guidance Note for lead authors of the IPCC Fifth Assessment Report on consistent treatment of uncertainties. These notes define a common approach and calibrated language that can be used broadly for developing expert judgments and for evaluating and communicating the degree of certainty in findings of the assessment process. Communicating the degree of certainty in key findings relies on expressing the:

- Confidence in the validity of a finding, based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgment) and the degree of agreement. Confidence is expressed qualitatively.
- Quantified measures of uncertainty in a finding expressed probabilistically (based on statistical analysis of observations or model results, or expert judgment).

The Guidance Note proposes the use of the following dimensions to evaluate the validity of a finding: the type, amount, quality, and consistency of evidence (summary terms: "limited," "medium," or "robust"), and the degree of agreement (summary terms: "low," "medium," or "high"), as summarised in the figure below.
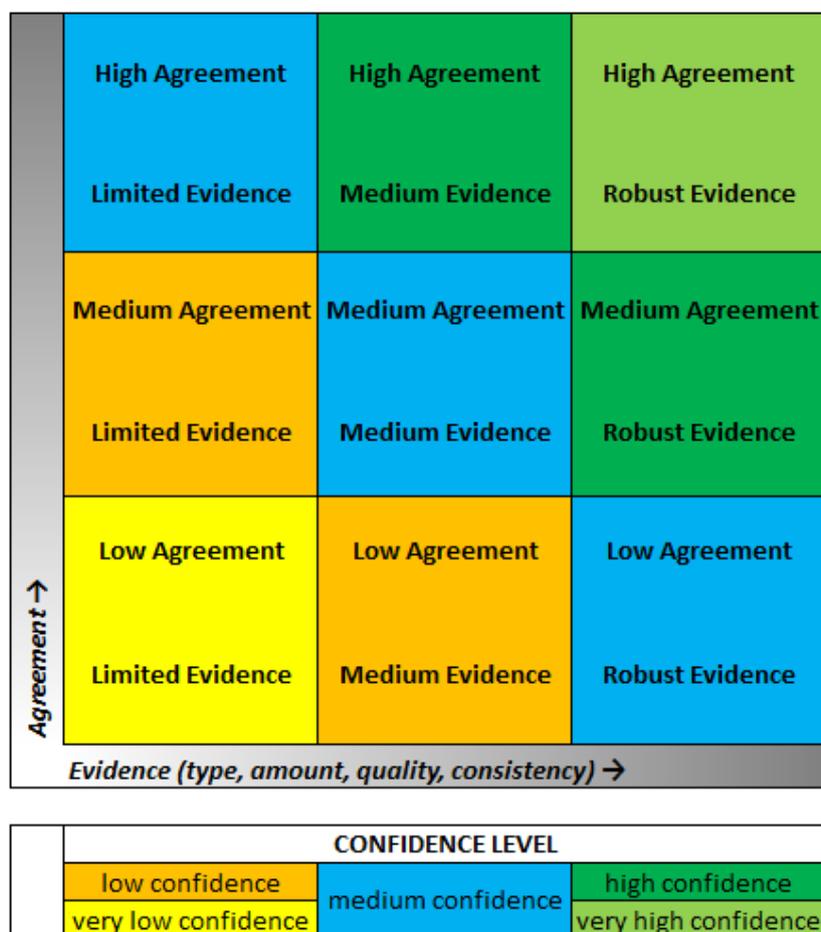

Figure K-1: A depiction of evidence and agreement statements and their relationship to confidence. Confidence increases towards the top-right corner as suggested by the increasing strength of shading. Generally, evidence is most robust when there are multiple, consistent independent lines of high-quality evidence.

Generally, evidence is most robust when there are multiple, consistent independent lines of high-quality evidence. The guide further provides advice for a traceable account describing the evaluation of evidence and agreement, as follows:

- For findings with high agreement and robust evidence, present a level of confidence or a quantified measure of uncertainty.
- For findings with high agreement or robust evidence, but not both, assign confidence or quantify uncertainty when possible. Otherwise, assign the appropriate combination of summary terms for your evaluation of evidence and agreement (e.g., robust evidence, medium agreement).
- For findings with low agreement and limited evidence, assign summary terms for your evaluation of evidence and agreement.
- In any of these cases, the degree of certainty in findings that are conditional on other findings should be evaluated and reported separately.

A level of confidence is expressed using five qualifiers: "very low," "low," "medium," "high," and "very high." It synthesizes the author teams' judgments about the validity of findings as determined through evaluation of evidence and agreement. Figure K-1 depicts summary statements for evidence and agreement and their relationship to confidence. There is flexibility in this relationship; for a given evidence and agreement statement, different confidence levels could be assigned, but increasing levels of evidence and degrees of agreement are correlated with increasing confidence. Confidence cannot necessarily be assigned for all combinations of evidence and agreement in Figure H-1. Presentation of findings with "low" and "very low" confidence should be reserved for areas of major concern, and the reasons for their presentation should be carefully explained. Confidence should not be interpreted probabilistically, and it is distinct from "statistical confidence." Additionally, a finding that includes a probabilistic measure of uncertainty does not require explicit mention of the level of confidence associated with that finding if the level of confidence is "high" or "very high."

Likelihood, as defined in Table K-1, provides calibrated language for describing quantified uncertainty. It can be used to express a probabilistic estimate of the occurrence of a single event or of an outcome (e.g., a climate parameter, observed trend, or projected change lying in a given range). Likelihood may be based on statistical or modelling analyses, elicitation of expert views, or other quantitative analyses.

Table K-1: Likelihood scale

Term	Likelihood of the Outcome
Virtually certain	99-100% probability
Very likely	90-100% probability
Likely	66-100% probability
About as likely as not	33 to 66% probability
Unlikely	0-33% probability
Very unlikely	0-10% probability
Exceptionally unlikely	0-1% probability

The categories defined in this table can be considered to have "fuzzy" boundaries. A statement that an outcome is "likely" means that the probability of this outcome can range from ≥66% (fuzzy boundaries implied) to 100% probability. This implies that all alternative outcomes are "unlikely" (0-33% probability). When there is sufficient information, it is preferable to specify the full probability distribution or a probability range (e.g., 90-95%) without using the terms in Table K-1. "About as likely as not" should not be used to express a lack of knowledge.