TUBATSE CHROME (PTY) LTD

AIR QUALITY IMPACT ASSESSMENT UPDATE

STEELPOORT, LIMPOPO

08 FEBRUARY 2018

AIR QUALITY IMPACT ASSESSMENT UPDATE

STEELPOORT, LIMPOPO

TUBATSE CHROME (PTY) LTD

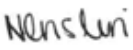
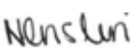
DRAFT

PROJECT NO.: 41100700
DATE: FEBRUARY 2018

WSP
BUILDING C, KNIGHTSBRIDGE
33 SLOANE STREET
BRYANSTON, 2191
SOUTH AFRICA

T +27 11 361 1380
F +27 11 361 1381
WSP.COM

QUALITY MANAGEMENT

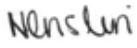
ISSUE/REVISION	FIRST ISSUE	REVISION 1	REVISION 2	REVISION 3
Remarks	Draft			
Date	February 2018			
Prepared by	Amber Sunderland			
Signature				
Checked by	Nicola Enslin			
Signature				
Authorised by	Nicola Enslin			
Signature				
Project number	41100700			
Report number	1 of 1			
File reference	41100700 – Tubatse Chrome AQIA Update 20180208.docx			

SIGNATURES

PREPARED BY

Amber Sunderland
Environmental Consultant

REVIEWED BY



Nicola Enslin
Associate

EXECUTIVE SUMMARY

This Air Quality Impact Assessment (AQIA) is an update of the original assessment completed by WSP Environmental (Pty) Ltd (WSP) in 2016. The 2016 report assessed the potential ambient air quality impacts associated with the proposed boiler expansion of the Samancor Chrome Ltd – Tubatse Chrome (Tubatse Chrome) ferrochrome production plant near Steelpoort in the Limpopo Province. The existing plant operates six furnaces, a pelletizing sintering plant (PSP) and a power generation facility consisting of two 15 MW turbines powered by six Heat Recovery Steam Generators (HRSGs). The existing power generation facility has a design capacity of 30 MW, however, the HRSGs generate approximately 9 MW. Tubatse chrome originally proposed to reach the design capacity of 30 MW with the addition of a 24 MW coal-fired boiler. However, since completion of the AQIA in 2016, Tubatse Chrome propose to meet the design capacity of the power generation facility with four 25 t/h Chain-Grated Boilers (CGBs) (instead of the coal-fired boiler) treated by a Bag Adsorption Desulphurizer Device (BADD). The aim of this AQIA is to assess the potential human health impacts associated with the construction, operation and decommissioning phases of the proposed project.

As part of the AQIA, a baseline assessment was undertaken which included a review of available meteorological data and an evaluation of the current ambient air quality situation. Meteorological parameters including wind speed, wind direction, temperature, rainfall and humidity were obtained from Tubatse Chrome's on-site meteorological station for the period January 2012 – December 2014. Additionally, site-specific modelled MM5 data was also sourced for the period January 2012 – December 2014. Ambient PM_{10} concentrations recorded by the site monitoring network were provided by for the period May 2013 – May 2015. Dust fallout monitoring data was also obtained from Tubatse Chrome's dust fallout monitoring network for the period January 2014 – May 2015. This dust fallout data was included in the baseline assessment and used for comparison with model predicted dust fallout levels. The potential impact of emissions from the plant was evaluated through using either qualitative or quantitative assessments. Potential impacts associated with the construction and decommissioning phases were qualitatively assessed based on typical sources of particulate emissions and the extent and duration of impact. The operational phase was quantitatively assessed in terms of seven model scenarios, namely:

- Scenario 1: Existing Plant;
- Scenario 2: Site Alternative One;
- Scenario 3: Site Alternative Two;
- Scenario 4: Site Alternative Three,
- Scenario 5: Proposed Plant with Site Alternative One;
- Scenario 6: Proposed Plant with Site Alternative Two; and
- Scenario 7: Proposed Plant with Site Alternative Three.

Impacts for each scenario were quantified through the compilation of an emissions inventory and subsequent dispersion modelling simulations. Key pollutants associated with on-site activities are identified as particulate matter of aerodynamic diameters of less than 10 and 2.5 microns (PM_{10} and $PM_{2.5}$ respectively), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2). Emission rates were provided for all point sources, while fugitive emissions were calculated using emission factors sourced from the United States Environmental Protection Agency (USEPA) AP-42 and the Australian Government National Pollutant Inventory (NPI) documents. Emission rates were input into to a Level 2 dispersion modelling platform, AMS/EPA Regulatory MODel (AERMOD), together with modelled meteorological MM5 data. Predicted ambient PM_{10}, $PM_{2.5}$, NO_2 and SO_2 concentrations were compared with the applicable National Ambient Air Quality Standards (NAAQS) to determine the potential for human health impacts.

BASELINE ASSESSMENT

- Based on the available meteorological data from the on-site weather station, the predominant wind direction is from the east (~ 20 % of the time), east-north-east (~ 15 % of the time) and north (~ 15 % of the time). Winds are generally fast, reaching wind speeds greater than 8 m/s. Calm conditions occurred relatively frequently, occurring approximately 22.25 % of the time;
- Monthly average ambient PM_{10} concentrations were provided for five monitoring stations surrounding Tubatse Chrome namely; Brine Dam 2, Colela, Ngululu Carriers, Palaneng and Steelpoort Town. During the period May – December 2013, all stations were compliant with the previous annual average PM_{10} standard of 50 ug/m^3. During the period May – December 2013 all stations fell below the previous annual average

standard of 50 ug/m^3. During January – December 2014, Brine Dam 2, Golela and Ngululu Carriers exceeded the previous annual average standard of 50 ug/m^3. Golela and Ngululu carriers also exceeded the current annual average standard of 40 ug/m^3 for the period January – May 2015. However, it should be noted that monthly average concentrations were conservatively compared against the annual average standard.

- Data was provided for Tubatse's dust fallout network of 11 units (eight non-residential and three residential) for the period January 2014 – May 2015. Unit FDO8 was non-compliant throughout the monitoring period, having eight exceedences of the non-residential standard (1200 mg/m^2/day) in 2014, and two (sequential) exceedences in 2015. All residential monitoring locations were compliant with the residential standard (600 mg/m^2/day) for the period January – December 2014, despite two exceedences at FD03 (non-sequential) and one exceedence at FOD10 in 2015.

IMPACT ASSESSMENT

Findings of the study are presented below.

CONSTRUCTION AND DECOMMISSIONING PHASE

- Based on a qualitative assessment, impacts associated with the construction and decommissioning phases are likely to be low, as associated particulate emissions result in localised concentrations and are limited to the duration of the construction and remediation period.

OPERATIONAL PHASE

- Predicted annual average PM_{10} concentrations are compliant at all receptor locations and across the study area for all model scenarios. Daily average PM_{10} concentrations are predicted to be non-compliant approximately 120 m beyond the site boundary for Scenarios 1, 5, 6 and 7, although compliant at all sensitive receptor locations. For the remaining scenarios (2, 3 and 4), daily average PM_{10} concentrations are predicted to be compliant at all sensitive receptors and across the study area;
- Predicted $PM_{2.5}$ concentrations are compliant with both the daily and annual average standard at all receptors and across the study area for all scenarios;
- Predicted NO_2 concentrations are compliant with both the hourly and annual average standard at all sensitive receptor locations and across the study area for all scenarios, despite the conservative assumption that all NO_x emissions comprise totally of NO_2; and
- Predicted annual average SO_2 concentrations are compliant at all receptor locations and across the study area for all scenarios. Daily and hourly average concentrations for Scenarios 1, 5, 6 and 7 are non-compliant approximately 360 and 140 m beyond the site boundary, although compliant at all sensitive receptor locations. For the remaining scenarios (2, 3 and 4), predicted daily and hourly average SO_2 concentrations are compliant at all sensitive receptors and across the study area.

RECOMMENDATIONS

CONSTRUCTION AND DECOMMISSIONING PHASE

- It is recommended that wet suppression and wind speed reduction mitigation techniques are employed throughput the duration of the construction and decommissioning phases.

OPERATIONAL PHASE

- It is recommended that existing and proposed mitigation techniques are maintained and that abatement machinery is regularly serviced according to supplier specifications; and
- It is recommended that dust fallout monitoring is continued to ensure compliance in surrounding areas.

AIR QUALITY CONSULTANT

Amber Sunderland is an Environmental Consultant registered as a Professional Natural Scientist with the Southern African Council for Natural Scientific Professions (SACNASP), with a Bachelor of Science Honours (Environmental Science) obtained from the University of KwaZulu-Natal, Westville Campus. Currently in her fourth year of consulting, most of her work has been focused on air quality impact assessments, air quality management planning, dispersion modelling and compilation of atmospheric emission inventories and licences. This report was internally reviewed by Nicola Enslin, who specialises in the field of air quality management and monitoring. She is actively involved in various air quality services including emission inventories, dispersion modelling, air quality impact assessments, air quality management plans, atmospheric emission licencing and Geographical Information Systems (GIS). She is registered as a Professional Natural Scientist with the Southern African Council for Natural Scientific Professions (SACNASP) and has over 10 years' of experience in air quality management and monitoring.

Declaration of Independence

I hereby declare that I am fully aware of my responsibilities in terms of the National Environmental Management Act 2006 EIA Regulations and that I have no financial or other interest in the undertaking of the activity other than the imbursement of consultants fees.

Name: Amber Sunderland

Company: WSP Environmental (Pty) Ltd

Signature: 

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

This Air Quality Impact Assessment (AQIA) is an update of the original assessment completed by WSP Environmental (Pty) Ltd (WSP) in 2016. The 2016 report assessed the potential ambient air quality impacts associated with the proposed boiler expansion of the Samancor Chrome Ltd – Tubatse Chrome (Tubatse Chrome) ferrochrome production plant near Steelpoort in the Limpopo Province. The existing plant operates six furnaces, a pelletizing sintering plant (PSP) and a power generation facility consisting of two 15 MW turbines powered by six Heat Recovery Steam Generators (HRSGs). The existing power generation facility has a design capacity of 30 MW, however, the HRSGs generate approximately 9 MW. Tubatse chrome originally proposed to reach the design capacity of 30 MW with the addition of a 24 MW coal-fired boiler. However, since completion of the AQIA in 2016, Tubatse Chrome propose to meet the design capacity of the power generation facility with four 25 t/h Chain-Grated Boilers (CGBs) (instead of the coal-fired boiler) treated by a Bag Adsorption Desulphurizer Device (BADD).

The aim of this AQIA is to qualitatively assess the potential human health impacts associated with the construction, operation and decommissioning phases of the proposed project. This AQIA will serve as a supporting document for the Basic Assessment.

1.1 TERMS OF REFERENCE

A summary of the scope of work performed by WSP in fulfilment of the requirements of the AQIA is provided below:

BASELINE ASSESSMENT

- Project background detailing process description and site layout;
- Review of applicable National ambient air quality legislation;
- Review of the potential pollutants and associated human health effects;
- Identification of neighbouring sensitive receptors, including adjacent communities and residential areas within the surrounding area; and
- Review of baseline ambient air quality and meteorological data for the area.

IMPACT ASSESSMENT

- Qualitative assessment of the construction and decommissioning activities;
- Compilation of an emissions inventory for identified sources of emissions;
- Dispersion modelling simulations to assess ambient, ground-level particulate and gaseous concentrations and dust fallout levels for the existing and proposed facility; and
- Comparison of predicted concentrations to applicable National ambient air quality standards.

2 PROJECT BACKGROUND

2.1 PROCESS DESCRIPTION

Tubatse Chrome undergoes various operations including; Pelletizing and Sintering of chromite fines, Smelting and Reduction for the production of charge chrome, chrome recovery from slag, 30 MW Power Plants and Services to support the production process. Ferrochrome is produced as high carbon charge chrome, which is an alloy of chromium (50-52 %) and iron (34-38 %). Process flow diagrams and for current operations are provided in **Figure 2-1** and **Figure 2-2**.

2.1.1 *PELLETISING AND SINTERING*

The Pelletizing and Sintering process is the production of pellets from the fine ore concentrate produced by mining operations. Ore concentrate is milled together with coke breeze in a wet ball milling operation to the desired particulate size. Bentonite is then added to the process as a binder after which the mixture is pelletized. Sintering then takes place at about 1350°C (LPG gas is used as fuel in the sinter process), which gives the pellets physical strength to carry the load in the furnaces and allow for an easier reduction reaction. The final product pellets are screened to ensure the correct size is supplied to the furnaces. Undersized pellets are returned to the circuit. Off-gases from the sintering process are treated in scrubbers and all the solids are returned to the circuit for re-processing.

2.1.2 *SMELTING AND REDUCTION*

Ferrochrome production is essentially a carbothermic reduction operation, taking place at high temperatures. Chromite ore containing chrome oxide (Cr_2O_3) is reduced by carbonic materials or Reductants. Reductants used in the process are coal, anthracite, char and gas coke. Electrical energy is used through submerged arc open furnaces to generate enough energy for the reduction reaction to take place. Fluxes (quartzite and limestone) are added to alter the characteristic of the molten material in order to ensure effective tapping of the metal and slag. The ferrochrome and slag are drained from the furnaces at regular intervals by means of the tapping process. The ferrochrome is further treated through a crushing and screening process to ensure that it complies with the customer specifications before it is dispatched.

The ferrochrome slag is transported to the Chrome Recovery Plant (CRP) (consisting of a series of primary, secondary and tertiary crushers) where trapped ferrochrome is recovered through a hydrometallurgical process. Recovered ferrochrome is sent to the final products for sale as final product and processed slag is disposed on permitted slag dumps. Off-gasses generated by the smelting process is captured and passed through a bag filter plant for the removal of particulates. Bag filter dust captured are temporarily stored in a silo and thereafter disposed at an adequately authorised waste disposal facility (currently Holfontein).

2.1.3 *30 MW POWER PLANT*

Currently, six HRSGs recover heat energy from hot furnaces off-gas at Furnaces 1 to 6. The boilers generate steam from de-ionised water, which is then used to turn two turbines. The turbines are connected to generators, generating electricity for reuse in the electrical grid. Cooled steam exits the turbines and is transferred to air-cooled condensers, where it returns to a liquid state and is re-circulated for re-use in the process. The two existing turbines have a design capacity of 15 MW each (total of 30 MW), however, the power generation facility currently reaches approximately 9 MW of generated power. In order to reach the design capacity, Tubatse Chrome has proposed the addition of four 25 t/hour Chain-Grate Boilers (CGBs).

2.1.4 *PROPOSED BOILERS*

Flue gas from four proposed 25 t/hour CGBs will be fed to the proposed Bag Adsorption Desulphurization Device (BADD), having one point source of emissions (**Figure 2-3**). The proposed development includes the addition of

sealed limestone and ash silos, to be situated at one of three potential site alternatives (**Figure 2-4**). Limestone will be imported and transferred via a pneumatic process and therefore is likely to have negligible impact. Tubatse Chrome proposes to sell ash to brick manufacturing companies instead of dumping the material as waste. In this way, ash is to be dispensed directly from the proposed ash silo into sales trucks via hoppers. Additional coal will be stored at an existing bunker on-site to fuel the CGBs.

2.1.5 *SERVICES*

Internal dumping, storage and handling of raw materials, and final product are handled by supporting services. This includes all inbound and outbound logistics.

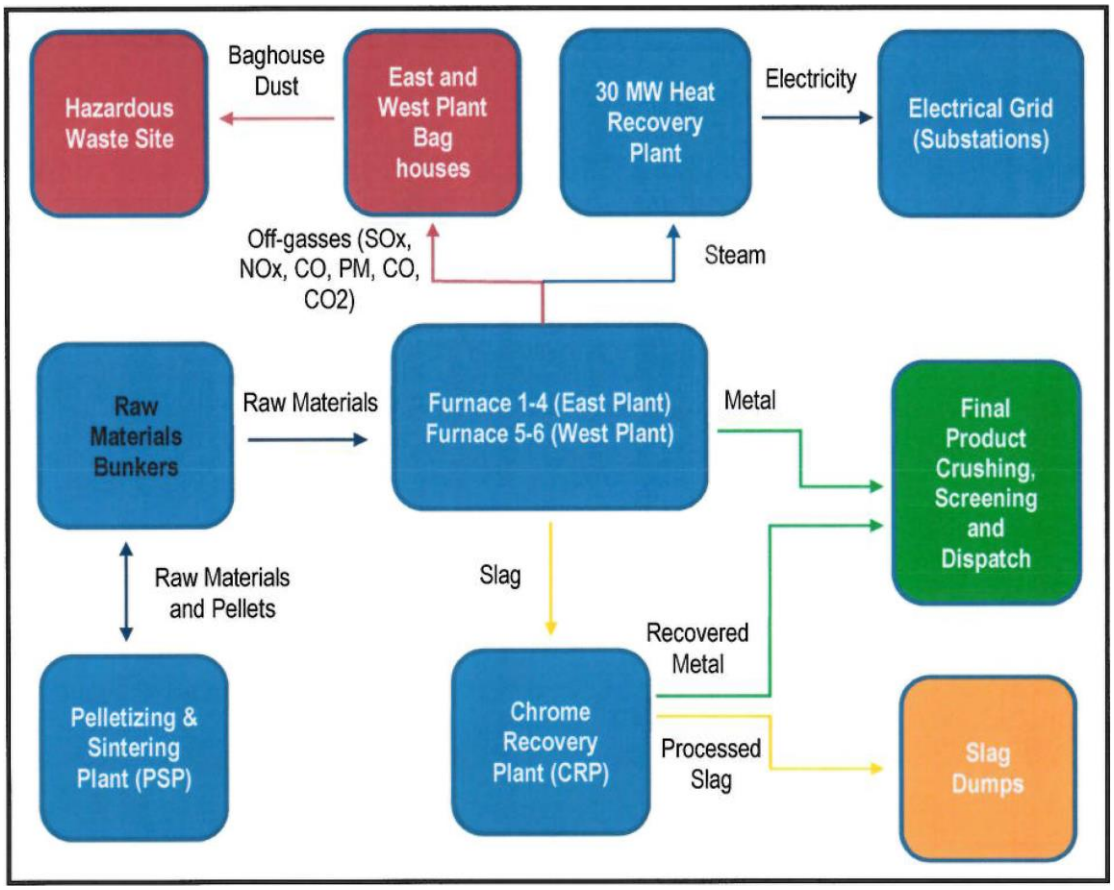


Figure 2-1: Process flow diagram of current operations at Tubatse Chrome.

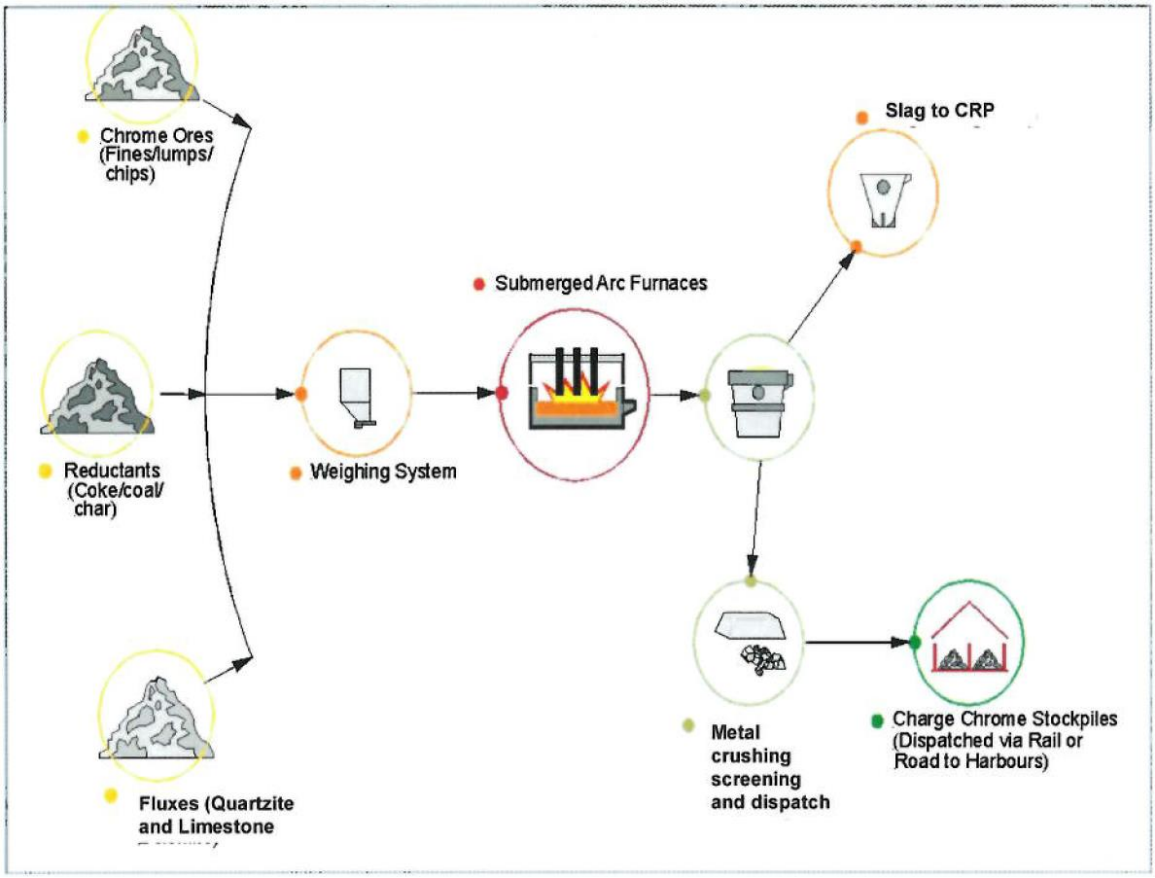


Figure 2-2: Ferrochrome production process at Tubatse Chrome.

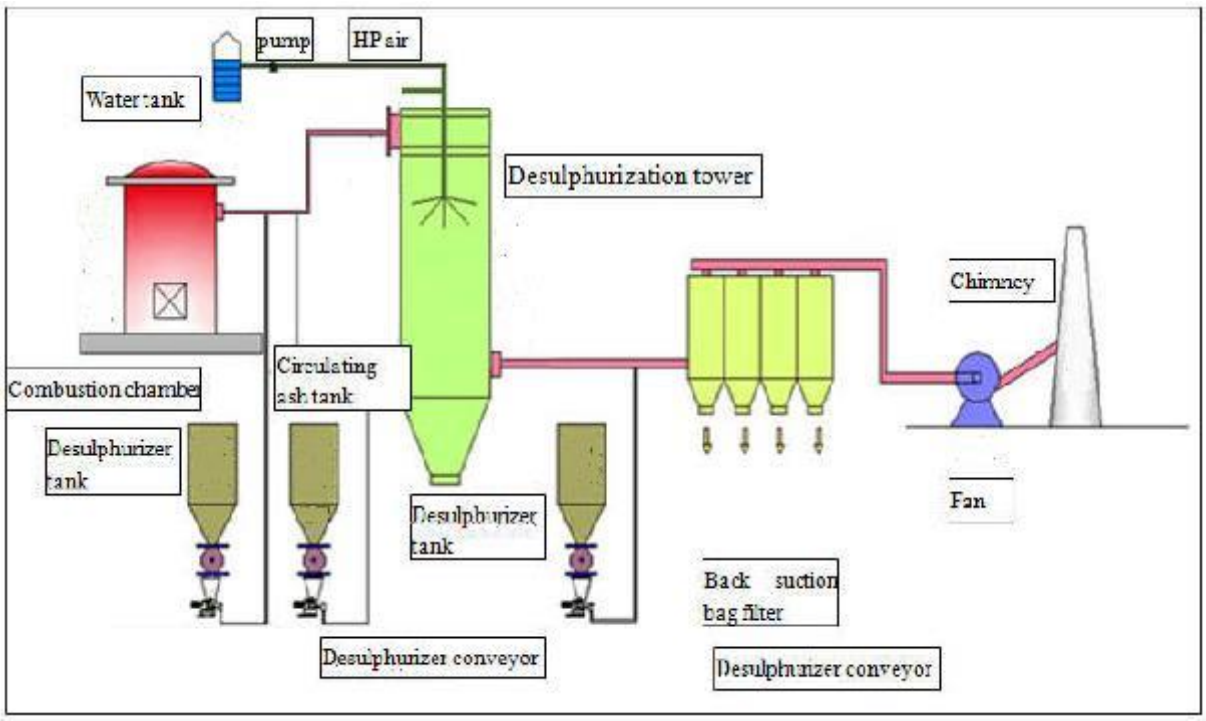


Figure 2-3: Flow chart of proposed Bag Adsorption Desulphurizer Device.

Figure 2-4: Proposed site alternatives for the boiler expansion at Tubatse Chrome.

3 AIR QUALITY LEGISLATION

The National Environmental Management: Air Quality Act 39 of 2004 (NEMAQA), which repeals the Atmospheric Pollution Prevention Act (APPA) of 1965, came into effect on 11 September 2005, with the promulgation of regulations in terms of certain sections resulting in the APPA being repealed entirely on 1 April 2010. Key features of the current legislation include:

- A decentralisation of air quality management responsibilities;
- The identification and quantification of significant emission sources that then need to be addressed;
- The development of ambient air quality targets as goals for driving emission reductions;
- The use of source-based (command-and-control) measures in addition to alternative measures, including market incentives and disincentives, voluntary programmes, and education and awareness;
- The promotion of cost-optimized mitigation and management measures;
- Stipulation of air quality management planning by authorities, and emission reduction and management planning by sources; and
- Access to information and public consultation.

The NEMAQA introduced a management system based on ambient air quality standards and corresponding emission limits to achieve them. Two significant regulations stemming from the NEMAQA have since been promulgated, namely:

- GNR 1210 on 24 December 2009 (Government Gazette 32816) National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Ambient Air Quality Standards; and
- GNR 248 on 31 June 2010 (Government Gazette 33064) National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) List of Activities Which Result in Atmospheric Emissions Which Have or May Have a Significant Detrimental Effect on the Environment, Including Health, Social Conditions, Economic Conditions, Ecological Conditions or Cultural Heritage.

The National ambient standards for air quality were based primarily on guidance offered by two standards set by the South African National Standards (SANS), namely:

- SANS 69:2004 Framework for implementing National ambient air quality standards; and
- SANS 1929:2005 Ambient air quality – Limits for common pollutants.

SANS 69:2004 makes provision for the establishment of air quality objectives for the protection of human health and the environment as a whole. Such air quality objectives include limit values, alert thresholds and target values.

SANS1929:2005 uses the provisions in SANS 69 to establish air quality objectives for the protection of human health and the environment, and stipulates that limit values are initially set to protect human health. The setting of such limit values represents the first step in a process to manage air quality and initiate a process to ultimately achieve acceptable air quality Nationally. The limit values presented in this standard are to be used in air quality management but have only become enforceable as revised under GNR 1210 since 24 December 2009. National ambient air quality standards for criteria pollutants generally have specific averaging periods; compliance timeframes, permissible frequencies of exceedence and reference methods.

3.1 AMBIENT AIR QUALITY STANDARDS

The priority pollutants as defined by the Act are sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (PM_{10}), particulate matter ($PM_{2.5}$), ozone (O_3), benzene (C_6H_6), lead (Pb) and carbon monoxide (CO). The legislated standards for ambient air quality as it relates to Tubatse Chrome are presented in **Table 3-1**.

Table 3-1: National Ambient Air Quality Standards.

Pollutant	Averaging Period	Concentration (µg/m^3)	Frequency of Exceedence	Compliance Date
Particulate Matter (PM_{10})	24 hours	120	4	Immediate – 31 Dec 2014
		75	4	01 Jan 2015
	1 year	50	0	Immediate – 31 Dec 2014
		40	0	01 Jan 2015
Particulate Matter ($PM_{2.5}$)	24 hours	65	4	Immediate – 31 Dec 2015
		40	4	01 Jan 2016 – 31 Dec 2029
		25	4	01 Jan 2030
	1 year	25	0	Immediate – 31 Dec 2015
		20	0	01 Jan 2016 – 31 Dec 2029
		15	0	01 Jan 2030
Sulphur Dioxide (SO_2)	10 minutes	500	526	Immediate
	1 hour	350	88	Immediate
	24 hours	125	4	Immediate
	1 year	50	0	Immediate
Nitrogen Dioxide (NO_2)	1 hour	200	88	Immediate
	1 year	40	0	Immediate

3.2 NATIONAL DUST FALLOUT STANDARDS

The National Dust Control Regulations (No. R.827) were promulgated on 01 November 2013 in terms of Section 53(o), read with Section 32 of the NEMAQA. The acceptable dust fall rates, as included in the National Dust Control Regulations, expressed in units of mg/m^2/day over a typical 30-day averaging period are presented in **Table 3-2**.

Table 3-2: National dust fallout standards.

Restriction Areas	Dust fallout rate (mg/m^2/day, 30-day average)	Permitted frequency of exceeding dust fall rate
Residential Area	D <600	Two within a year, not sequential months
Non-residential Area	600 < D < 1200	Two within a year, not sequential months

4 HEALTH AND ENVIRONMENTAL IMPACTS

4.1 PARTICULATE MATTER

Particulate matter (PM) refers to solid or liquid particles suspended in the air. PM varies in size from particles that are only visible under an electron microscope to soot or smoke particles that are visible to the human eye. PM contributes greatly to deteriorations in visibility, as well as posing major health risks, as small particles (PM_{10}) can penetrate deep into lungs, while even smaller particle sizes ($PM_{2.5}$) can enter the bloodstream via capillaries in the lungs, with the potential to be laid down as plaques in the cardiovascular system or brain. Health effects include: respiratory problems, lung tissue damage, cardiovascular problems, cancer and premature death. Acidic particles may damage buildings, vegetation and acidify water sources (US EPA, 2011).

4.2 SULPHUR DIOXIDE

SO_2 is produced via the combustion of sulphur rich fuel. SO_2 is a major respiratory irritant, resulting in respiratory illnesses, alterations in pulmonary defences and aggravation of existing cardiovascular disease. SO_2 may also create sulphuric acid as a result of its water solubility, producing acid rain. Once emitted, SO_2 may oxidize in the atmosphere to produce sulphate aerosols, which are harmful to human health, limit visibility and in the long term have an effect on global climate (Seinfeld and Pandis, 1998; Fenger, 2002; US EPA, 2011).

4.3 NITROGEN OXIDES

Under high temperature conditions nitrogen and oxygen atoms in the air react to form nitric oxide (NO). NO is a colourless gas that is non-toxic, but is transformed into NO_2 when it is oxidised in the atmosphere. Elevated NO_2 concentrations may lead to asthma, emphysema, bronchitis, damage to lung tissue and even premature death. NO_x may lead to biological imbalances and mutations in vegetation, limits visibility and contributes to the formation of acid rain via the production of nitric acid (HNO_3). Further oxidation of NO_2 may lead to the formation of nitrate aerosols, which further limit visibility and affect the natural environment. Most importantly, however, NO_x contributes to the formation of tropospheric O_3, an important atmospheric oxidant, a major air pollutant and a key greenhouse gas (Seinfeld and Pandis, 1998; Fenger, 2002; US EPA, 2011).

5 BASELINE ASSESSMENT

5.1 LOCALITY AND STUDY AREA

The Tubatse Chrome plant is located within the Greater Tubatse Local Municipality, which forms part of the Sekhukhune District Municipality in the Limpopo Province. The site is situated within a rural area approximately 1 km from the town of Steelpoort, along the R555 (**Figure 5-1**). The surrounding land-use is predominantly open space, consisting of mountains and valleys, with mining and agricultural activities occurring intermittently. Industrial activities are seen to the west, north and east of the site. Residential areas are situated beyond the industrial activities, to the west (~ 3.5 km), north-west (~ 1 km), north (~ 1.5 km), north-east (~ 0.2 km) and east (~ 0.2 km) of the site, and are characteristically low income areas. Farm/cultivated land is identified immediately north (across the R555) and to the east of the site. Areas to the south-east, south and south-west of the site are mostly mountainous open space (**Figure 5-2)**.

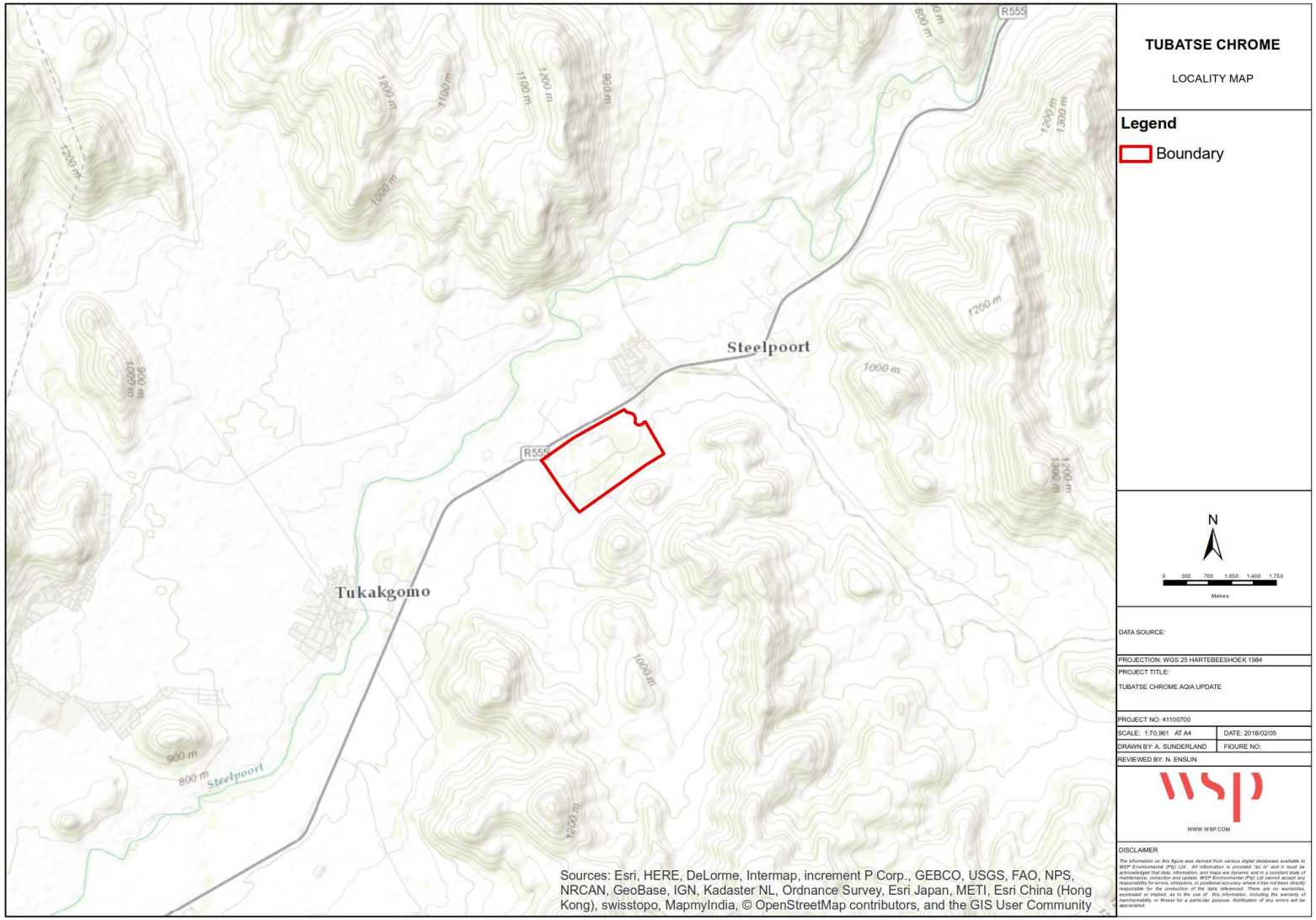


Figure 5-1: Locality map of Tubatse Chrome.

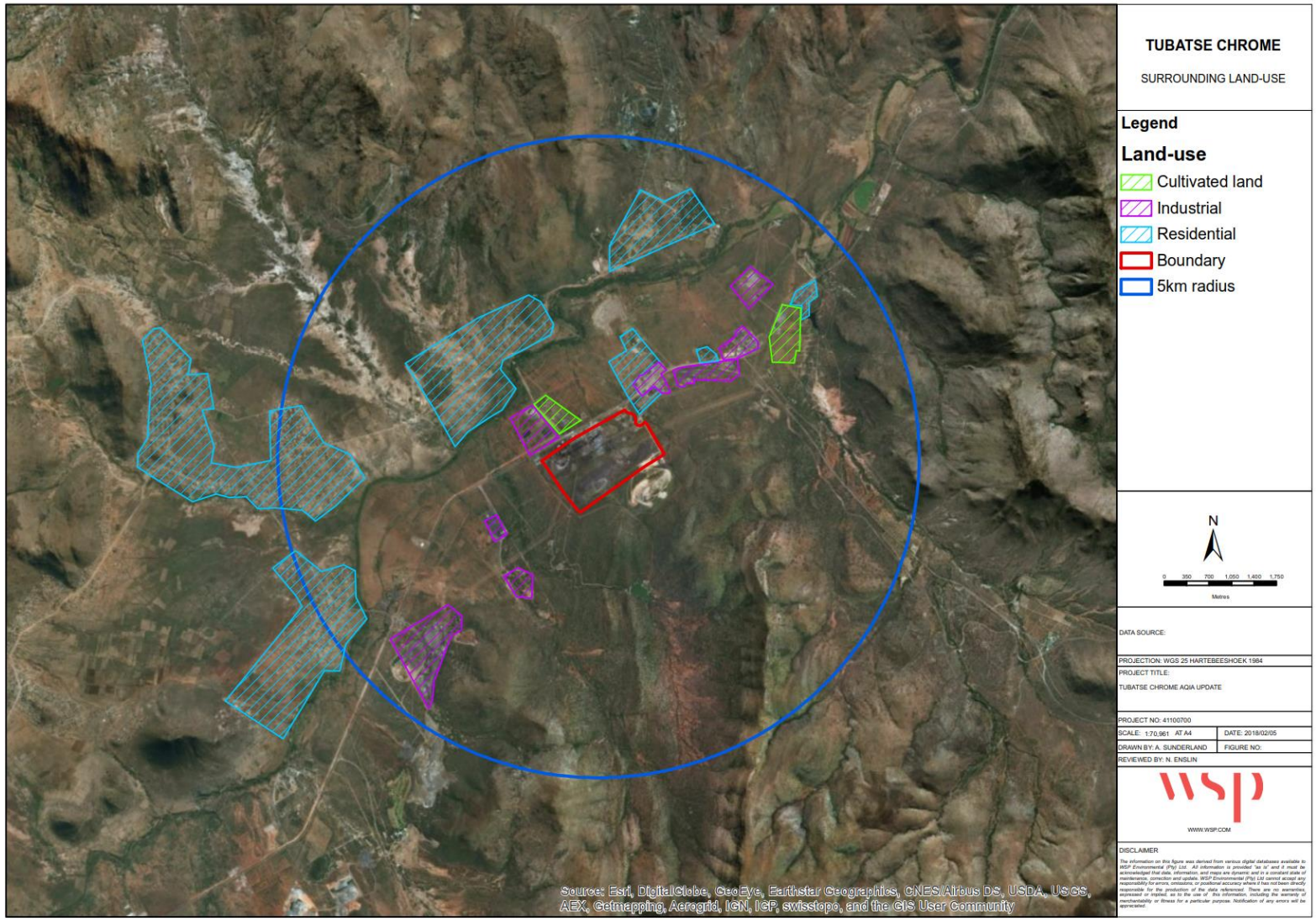


Figure 5-2: Surrounding land use at Tubatse Chrome.

5.2 CLIMATE AND METEROLOGY

The climatology of a particular place is controlled primarily by its latitude, which determines the amount of solar radiation that is received, its distance from the sea and the height above sea level. Secondary influences on climate are the general circulation of the atmosphere, the nature of the underlying surface and topography. South Africa lies in the sub-tropical high-pressure belt, which causes the general circulation over the sub-continent to be generally anti-cyclonic above 700 hPa for most of the year.

Tubatse Chrome is situated near Steelpoort, within the Limpopo Province. The western sector of the province is characterised with semi-arid conditions, while the eastern sector is largely sub-tropical (Africon and Environomics Joint Venture (A&E JV), 2004). Tubatse Chrome is situated in this sub-tropical climate zone. Though the Province has recent records of severe weather extremities such as droughts (2001 – 2004) and floods (2000) (Reason et al., 2005), Limpopo generally experiences long sunny days and dry weather conditions (Tshiala et al., 2011). Rainfall occurs mainly during the summer months. Warm days are often interrupted by short-lived thunderstorms (Tshiala et al., 2011) associated with strong convection that is typically experienced inland. Winters months are mild and mostly frost free (A&E JV, 2004). Wind patterns recorded from major towns suggest that winds generally blow from the east, east-north-east and north-easterly directions (A&E JV, 2004).

Transport of pollutants is dependent on the state of the atmosphere (i.e. the stability regime) and circulation of air. Atmospheric transport within the area occurs both vertically and horizontally. Vertical transport is primarily due to deep convection. This convection transports air and any air pollutants contained therein from the surface into the upper atmosphere. Vertical motion is eventually inhibited due to the absolutely stable layers found preferentially at ~700 hPa, ~500 hPa and ~300 hPa on no-rain days. These stable layers trap pollutants at lower atmospheric levels and so influence the transport of pollutants over the whole of Southern Africa (Cosijn and Tyson, 1996; Garstang *et al*., 1996).

On a more local scale, vertical motion and hence dispersion of pollutants is inhibited by surface inversions that form during the night predominantly during winter. These inversions are a result of radiation cooling at the surface and are most pronounced just before sunrise. In the presence of sunlight, the inversions begin to break down through convective heating and the height of the mixed layer is increased, allowing for dispersion of pollutants trapped at lower levels (Cosijn and Tyson, 1996; Tyson and Preston-Whyte, 2000).

In terms of horizontal transport, local winds may transport pollutants within the vicinity of their source. These include: anabatic and katabatic winds, valley and mountain winds, and mountain-plain and plain-mountain winds (Tyson and Preston-Whyte, 2000). On a larger scale, various synoptic systems affect atmospheric circulation over the region as well as circulation over the whole of southern Africa. These systems include: continental highs, ridging highs, westerly lows, westerly waves and easterly waves, which transport air and any pollutants contained within over larger distances (Garstang *et al*., 1996; Tyson *et al*., 1996).

With respect to the Tubatse Chrome study area, transport associated with continental highs occurs all year round, but with greater frequency during winter. Easterly waves show an annual cycle, peaking in summer, with extremely seldom occurrences in winter. Transport associated with ridging highs and westerly waves dominates during winter (Garstang *et al*.,1996; Tyson and Preston-Whyte, 2000). During winter, ambient air quality can either deteriorate with the occurrence of continental highs, which decrease the dispersion potential of the atmosphere or improve as a result of westerly waves, which transport clean, mostly maritime air over the region. During summer, frontal and convective storms reduce ambient pollutant concentrations hence improving air quality in the region.

Recirculation is also important in the transport of pollutants and occurs frequently over southern Africa due to the high frequency of anticyclonic circulations (Garstang *et al*., 1996; Freiman and Piketh, 2003). Recirculation occurs when air is transported away from its source and returns in the opposite direction after rotating cyclonically or anticyclonically. Recirculation can occur at a number of scales from sub-continental to regional, and an interaction between different scales of wind systems results in further recirculation (Tyson *et al*., 1996; Tyson and Preston-Whyte, 2000; Freiman and Piketh, 2003).

5.3 METEOROLOGICAL OVERVIEW

Tubatse Chrome has an on-site meteorological monitoring station that measures various meteorological parameters. As such, wind speed, wind direction, surface temperature, humidity and rainfall data was collected for period January 2012 to December 2014. The percentage data recovery for parameters recorded at the Tubatse Chrome meteorological station is above 80 % and is thus considered reliable for use in this assessment (**Table 5-1**). However, rainfall data was unavailable for the period January – December 2012 due to technical problems. Site-specific modelled MM5 meteorological data was also obtained for the period January 2012 to December 2014 to provide an understanding of surface and upper air dispersion characteristics. The USEPA AERMET is a meteorological model that generates diagnostic wind field and boundary layer data using MM5 (Penn State/NCAR Mesoscale Model) wind fields as part of an objective analysis procedure. For the purposes of this study, an AERMET-ready MM5 dataset was purchased from Lakes Environmental Consultants. The data coverage stretches over Tubatse Chrome (anemometer height of 13 m) with a grid cell dimension of 12 km x 12 km over a 50 km x 50 km domain.

Table 5-1: Meteorological data recovery from the on-site weather station for the period January 2012 to December 2014.

Parameter	Data Recovery (%)
Wind speed	93.1
Wind direction	83.3
Temperature	89.2
Humidity	88.9

5.3.1 *LOCAL WIND FIELD*

Wind roses are a useful tool in illustrating prevailing meteorological conditions for an area, indicating wind speeds and frequency of distribution. In the following wind roses, the colour of the bar indicates the wind speed while the length of the bar represents the frequency of winds blowing from a certain direction (as a percentage). **Figure 5-3** presents the wind field characteristics for Tubatse Chrome (on-site) and surrounding Steelpoort (MM5) area for the period January 2012 to December 2014.

For Tubatse Chrome (on-site), easterly winds predominate, accompanied by strong winds occurring within the north and north-easterly sectors. Tubatse Chrome is located within a valley and as such, wind speeds are generally low over the monitoring period. Calm conditions, which are defined as wind speeds less than 1 m/s, occur frequently (22.25 % of the time). In comparison, the modelled (MM5) meteorological data shows dominant south-easterly winds. Wind speeds are moderate to fast, with calm conditions occurring 2.63 % of the time.

Diurnal variations in winds shown by the Tubatse Chrome on-site station and the modelled meteorological data are depicted in **Figure 5-4.** During the evening (18:00 – 24:00) and early morning hours (00:00 – 06:00), winds recorded at the Tubatse Chrome station originate predominately from the east, flowing through the valley. However, a shift to dominant northerly winds is observed during the late morning (06:00 – 12:00) and afternoon hours (12:00 – 18:00). Modelled meteorological data shows strong south-easterly winds dominating during the evening, early morning and late morning hours, with a shift to dominant moderate northerly winds in the afternoon.

Seasonal variations in winds over Tubatse Chrome (on-site) and modelled meteorological data are depicted in **Figure 5-5**. During summer (December - February), autumn (April – May) and winter (June – August), winds over Tubatse Chrome originate predominantly from the east, with a shift to dominant northerly winds during spring (September – November). Modelled meteorological data shows predominant east-south-easterly during the spring and summer months, while south-easterly winds prevail during autumn and winter. Winds are generally low to moderate for Tubatse Chrome (on-site) and moderate to high over the general Steelpoort area (MM5).

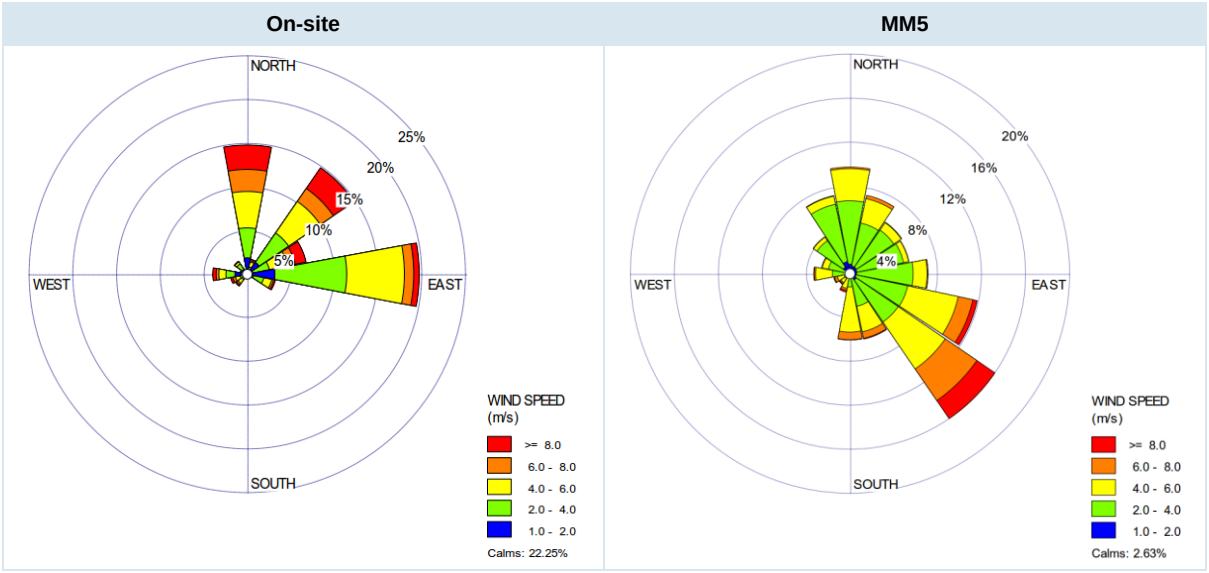


Figure 5-3: Period wind rose for Tubatse Chrome (on-site) and Steelpoort (MM5) for the period January 2012 to December 2014.

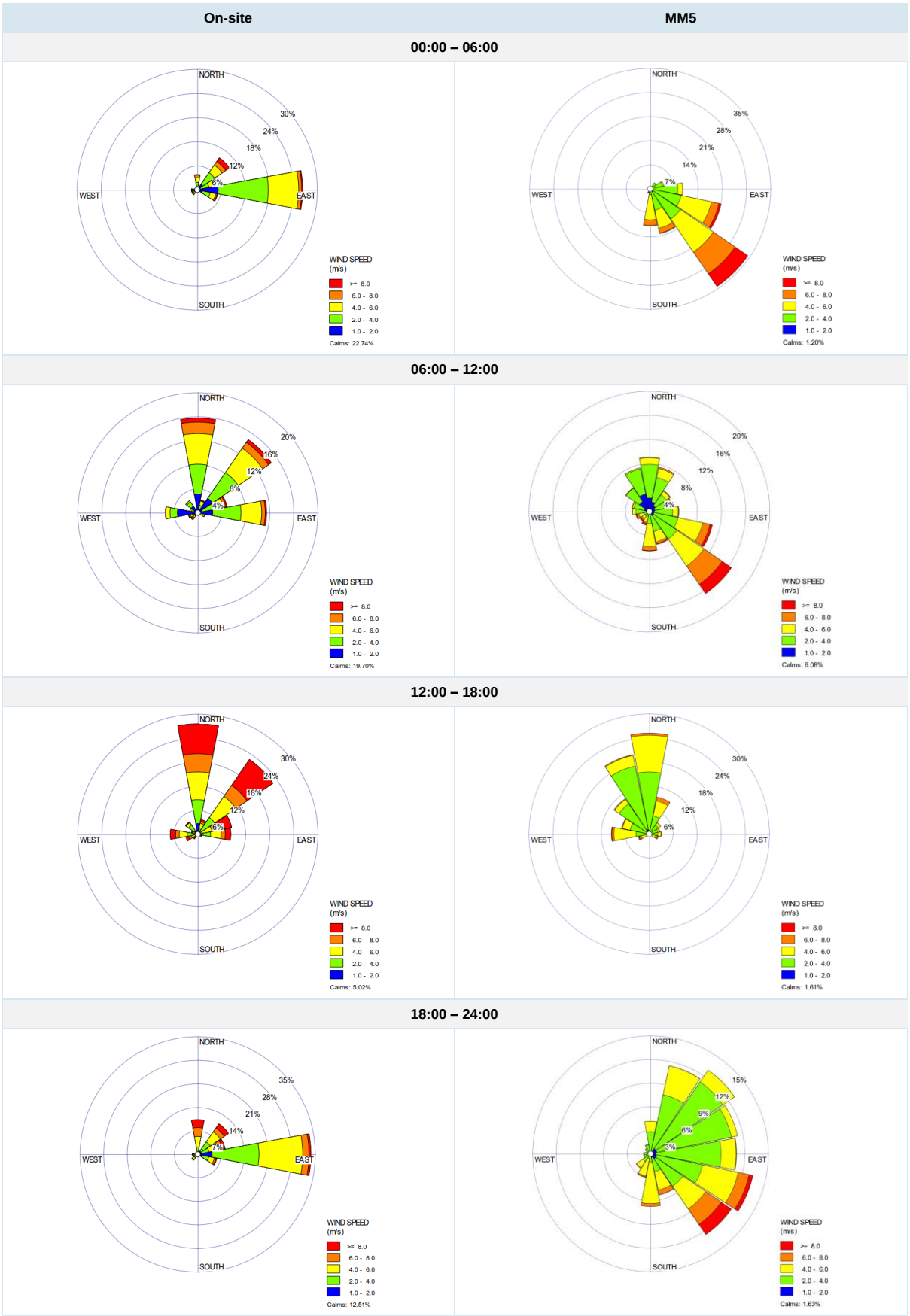


Figure 5-4: Diurnal wind roses for Tubatse Chrome (on-site) and Steelpoort (MM5) for the period January 2012 to December 2014.

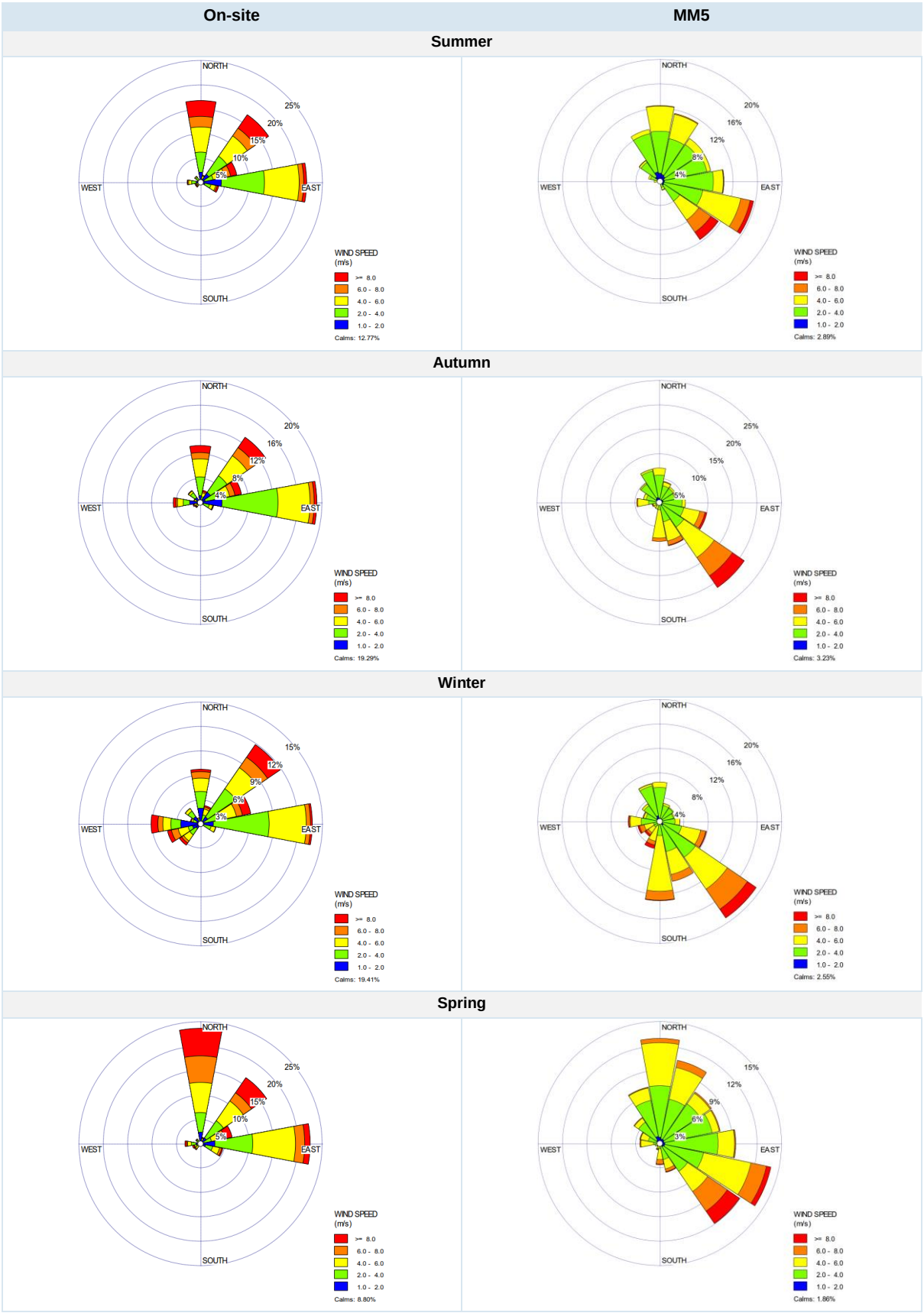


Figure 5-5: Seasonal wind roses for Tubatse Chrome (on-site) AND Steelpoort (MM5) for the period January 2012 - December 2014.

5.3.2 *TEMPERATURE*

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

For the period 2012 to 2014, average temperatures were relatively stable, with an average summer temperature of approximately 26.80 °C and an average winter temperature of around 18.11 °C (**Table 5-2** and **Figure 5-6**).

Table 5-2: Average temperatures (°C) at Tubatse Chrome (on-site) for the period of January 2012 to December 2014.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	26.6	28.2	26.1	21.9	19.7	16.7	17.3	20.1	22.4	24.1	25.4	26.3
2013	27.0	27.1	25.3	22.2	19.1	17.1	17.4	19.1	24.4	23.9	26.1	25.1
2014	27.2	27.2	25.1	22.5	20.3	17.5	17.1	20.8	24.1	24.3	25.5	26.5

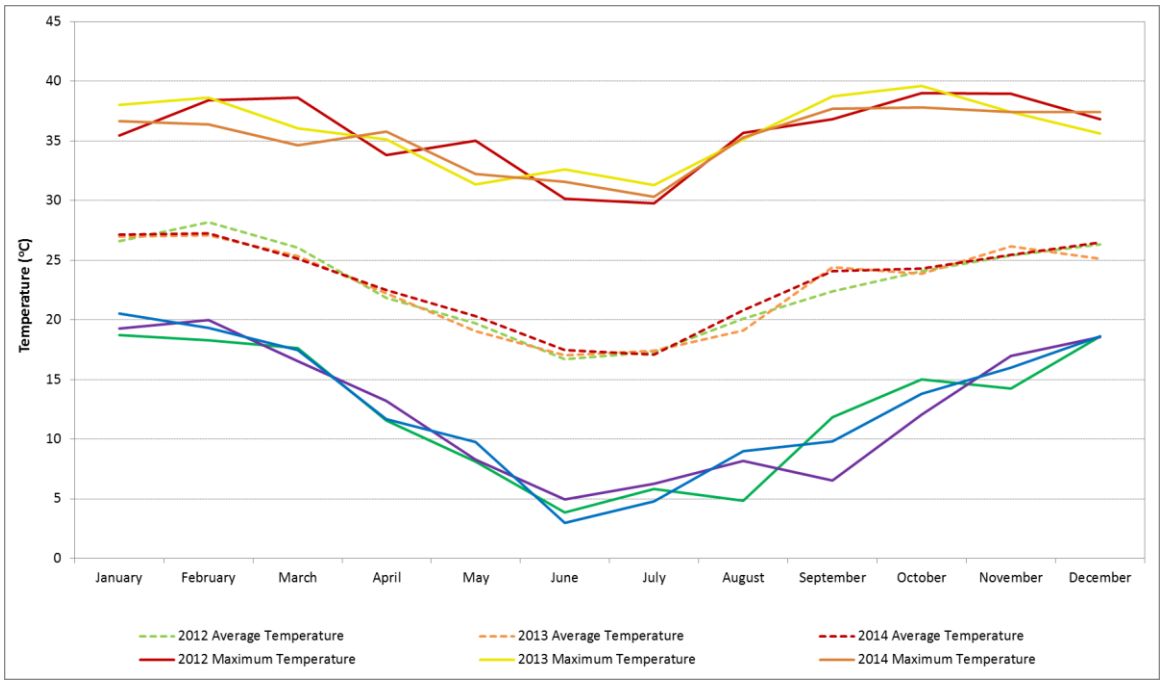


Figure 5-6: Average, maximum and minimum temperatures (°C) at Tubatse Chrome (on-site) for the period of January 2012 to December 2014

5.3.3 *RAINFALL*

Rainfall requires consideration as it represents an effective removal mechanism of atmospheric pollutants, thereby improving the air quality situation in high rainfall areas. Monthly rainfall (for the period January 2010 to December 2012) and humidity (for the period January 2012 to December 2014) is illustrated in **Table 5-3**.

Tubatse Chrome falls within a summer rainfall region, receiving most of its rainfall during the summer months. The lowest rainfall levels are experienced during the winter months (June – August) (**Figure 5-7**). Relative humidity is generally low to moderate, with an average of 41% during winter and 58% during summer.

Table 5-3: Total monthly rainfall (mm) for Tubatse Chrome (on-site) for the period January 2010 to December 2012.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	122.8	15.0	23.0	73.2	7.6	0.2	0.0	0.0	0.0	14.0	102.2	105.6
2011	119.4	19.0	22.0	76.8	9.4	0.6	1.4	4.0	6.0	49.0	2.4	141.8
2012	145.4	7.4	46.4	18.8	0.0	0.2	0.0	0.0	56.6	63.0	42.0	75.0

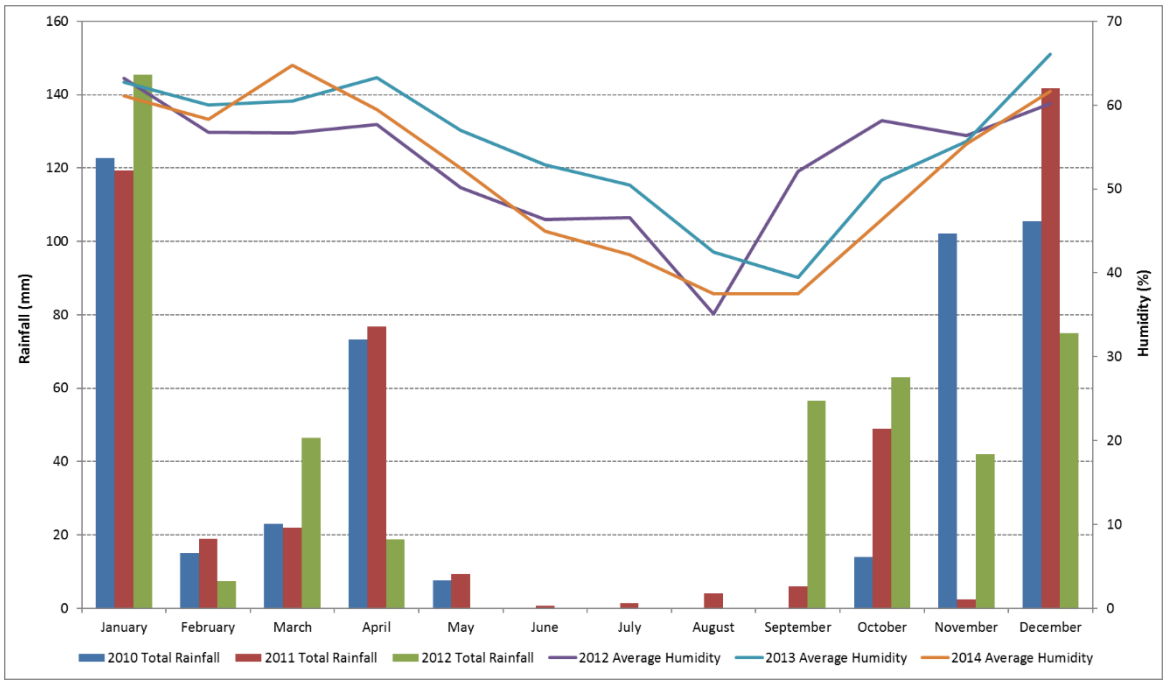


Figure 5-7: Monthly rainfall (mm) for the period January 2010 to December 2012 and average humidity (%) for the period January 2012 to December 2014 at Tubatse Chrome (on-site).

5.4 EXISTING AMBIENT AIR QUALITY

Steelpoort is a rural area with industrial and agricultural operations likely to contribute to ambient dust in the area. It is also likely that domestic fuel burning will contribute to ambient NO_2, SO_2, CO and PM concentrations in the area, given the proximity of low income areas to the plant.

5.4.1 *PM_{10} CONCENTRATIONS*

Tubatse Chrome operates five continuous monitoring stations that record ambient PM_{10} concentrations at different locations: Brine Dam 2 (on-site), Golela (on-site), Ngululu Carriers (off-site), Palaneng (off-site), Steelpoort Town (off-site). Ambient PM_{10} monitoring data was obtained for the period May 2013 – May 2015 and is illustrated in **Figure 5-8 - Figure 5-10**. It is noted that PM_{10} concentrations were provided as monthly averages. In the absence of a monthly average PM_{10} standard, comparison of the data was conservatively made with the previous and current annual average PM_{10} standard of 50 µg/m^{3}and 40 µg/m^3, respectively (where applicable).

Figure 5-8 illustrates the monthly average PM_{10} concentrations for the period May – December 2013 for each of the five monitoring stations. Monthly average PM_{10} concentrations fell below the previous annual average PM_{10} standard at all sites over the monitoring period. **Table 5-4** presents annual average PM_{10} concentrations recorded over the monitoring period. Annual average PM_{10} concentrations were compliant with the previous annual average standard although it should be noted that the dataset is not representative of a full calendar year. As such,

comparison of the annual average concentration with the previous annual average standard should be viewed with caution.

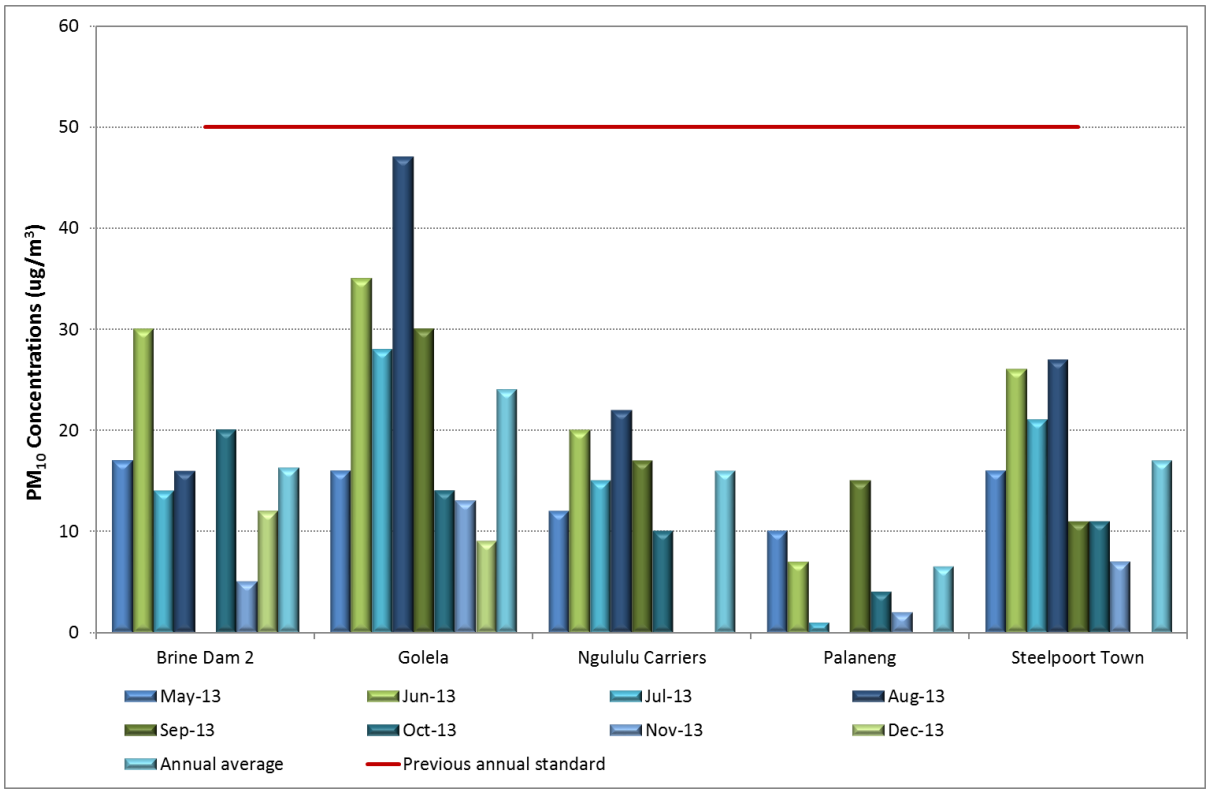


Figure 5-8: Monthly average PM_{10} concentrations at Tubatse Chrome for the period May - December 2013.

Figure 5-9 illustrates the monthly average PM_{10} concentrations for the period January – December 2014 for each of the five monitoring stations. Monthly average PM_{10} concentrations exceeded the previous annual average standard at Brine Dam 2, Golela and Steelpoort town during the monitoring period. **Table 5-4** presents annual average PM_{10} concentrations recorded over the period. Annual average PM_{10} concentrations fell below the previous annual average standard over the monitoring period. However, it is noted that each station had various months of missing data due to technical difficulties during the monitoring period. As such, the annual average PM_{10} concentration should be viewed with caution.

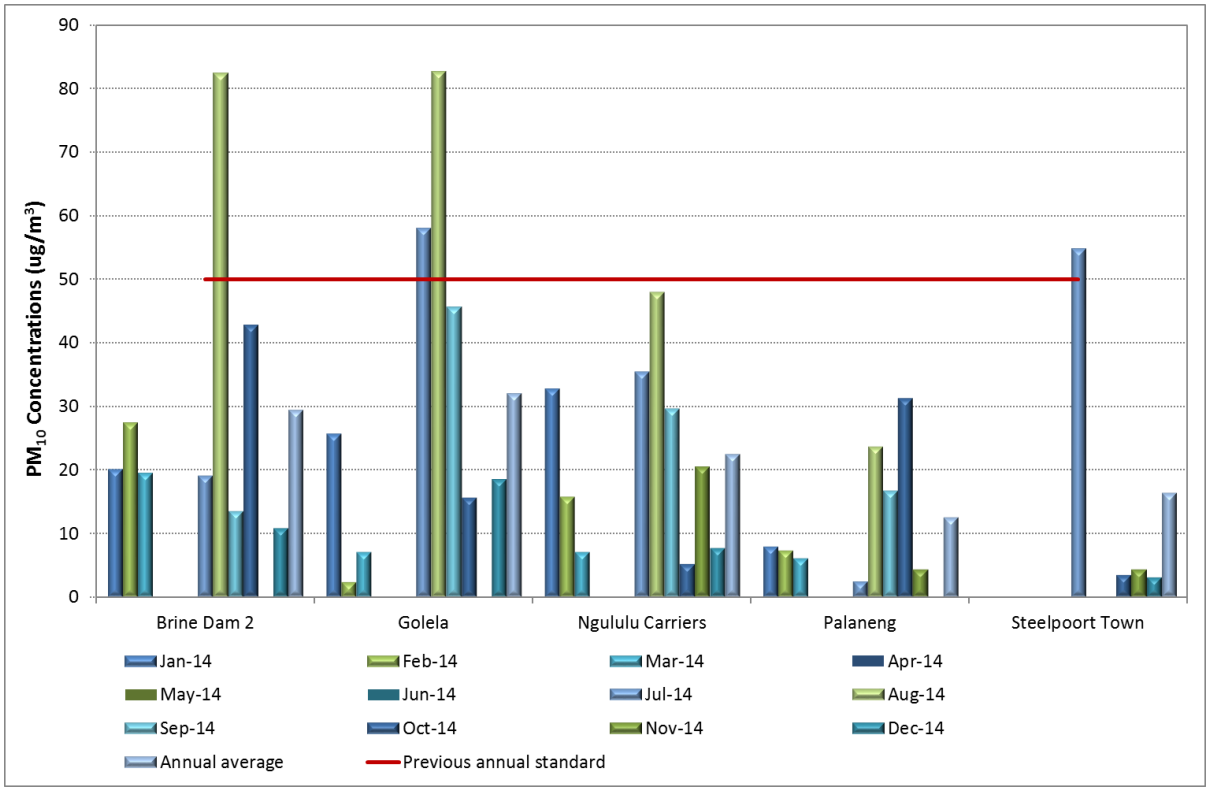


Figure 5-9: Monthly average PM_{10} concentrations monitored at Tubatse Chrome for the period January - December 2014.

Figure 5-10 illustrates the monthly average PM_{10} concentrations for each month over the period January – May 2015 for each of the five monitoring stations. Monthly average PM_{10} concentrations exceeded the current annual average standard at Golela and Ngululu Carriers in the months of January and April 2015. **Table 5-4** presents annual average PM_{10} concentrations recorded over the period. Annual average PM_{10} concentrations were compliant with the current annual average standard over the monitoring period although it is noted that the dataset is not representative of a full calendar year. Furthermore, stations located at Brine Dam 2, Palaneng and Steelpoort Town had various months of missing data due to technical difficulties during the monitoring period. As such, the recorded annual average should be viewed with caution.

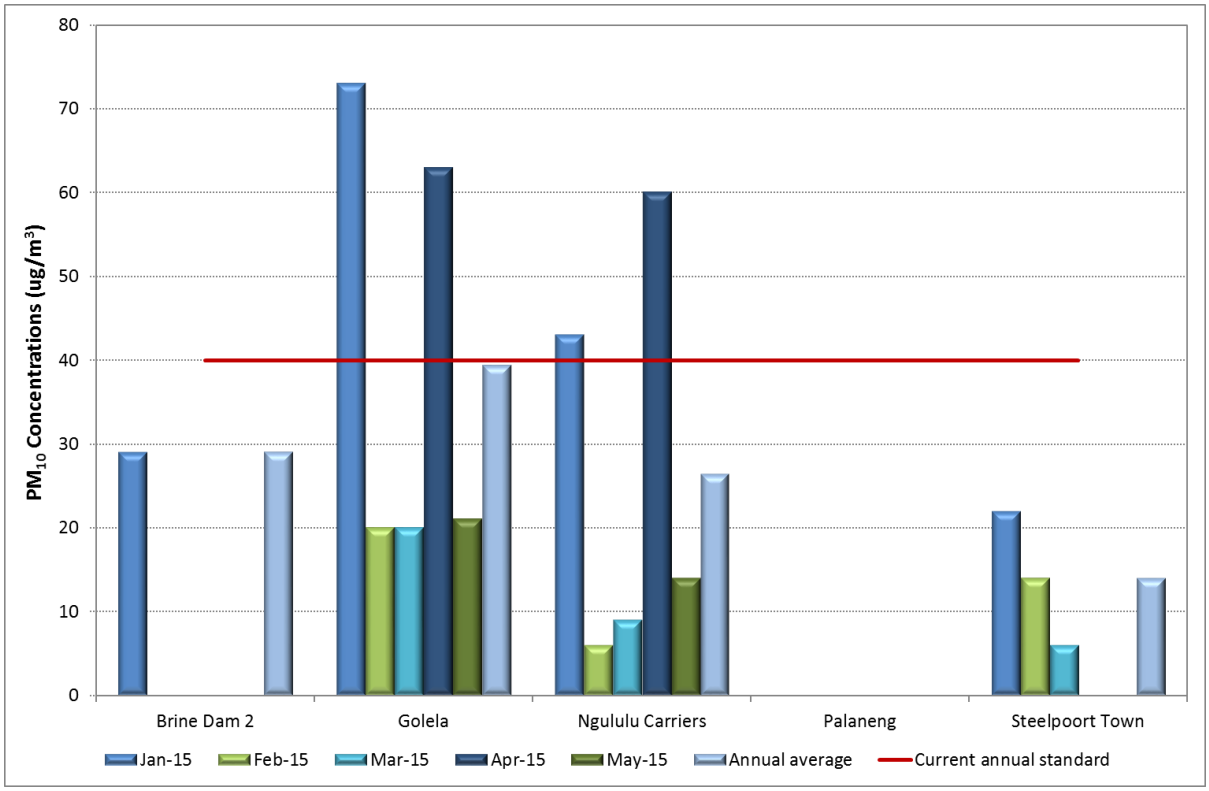


Figure 5-10: Monthly average PM_{10} concentrations monitored at Tubatse Chrome for the period January - May 2015.

Table 5-4: Annual average PM_{10} concentrations recorded at Tubatse Chrome for the period May 2013 - May 2015.

Monitoring station	Annual average PM_{10} Concentration ($\mu g/m^3$)		
	2013 (1)	2014 (1)	2015 (2)
Brine Dam 2	16	29	29
Golela	24	32	39
Ngululu Carriers	16	22	26
Palaneng	7	12	-
Steelpoort Town	17	16	14

Notes:

(1) Concentrations are compared against the previous (and more lenient) annual average PM_{10} standard

(2) Concentrations are compared against the current annual average PM_{10} standard

5.4.2 *DUST FALLOUT*

Tubatse Chrome operates a dust fallout monitoring network of 11 monitoring units (eight non-residential and three residential **Table 5-5** and **Figure 5-11**). Data was provided for the period January 2014 – May 2015 and is presented in **Figure 5-12** and **Figure 5-13** for non-residential and residential monitoring locations, respectively.

Table 5-5: Location of dust fallout units owned by Tubatse Chrome.

Dust Fallout Unit	Classification	X (UTM 35S)	Y (UTM 35S)
FOD1	Non-residential	215191.75	7260584.36
FOD2	Non-residential	218004.23	7260019.94
FOD3	Residential	217085.92	7261747.19
FOD4	Non-residential	216862.69	7260012.02
FOD5	Non-residential	217539.41	7260749.50
FOD6	Non-residential	215547.55	7260924.25
FOD7	Non-residential	217054.59	7259566.35
FOD8	Non-residential	217631.24	7260659.00
FOD9	Non-residential	215837.04	7260111.08
FOD10	Residential	215448.07	7258788.17
FOD11	Residential	214427.63	7260953.53

Figure 5-11: Location of dust fallout unites operated by Tubatse Chrome.

Figure 5-12 presents the average dust fallout rates at each non-residential location for the period January 2014 – May 2015. Dust fallout monitoring unit FDO8 was non-compliant throughout the monitoring period, having eight exceedences of the non-residential standard in 2014, and two (sequential) exceedences in 2015. **Figure 5-13** presents the average dust fallout rates at each residential location for the period January 2014 – May 2015. All monitoring locations were compliant for the period January – December 2014, despite two exceedences at FD03 (non-sequential) and one exceedence at FOD10 in 2015.

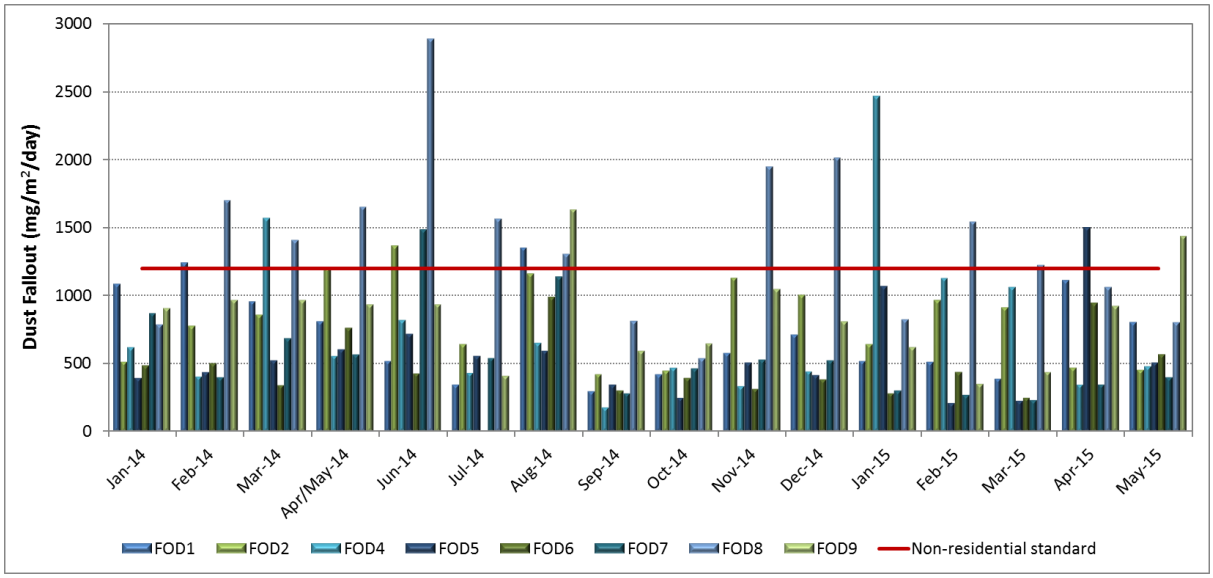


Figure 5-12: Dust fallout measured at non-residential locations for the period January 2014 - May 2015.

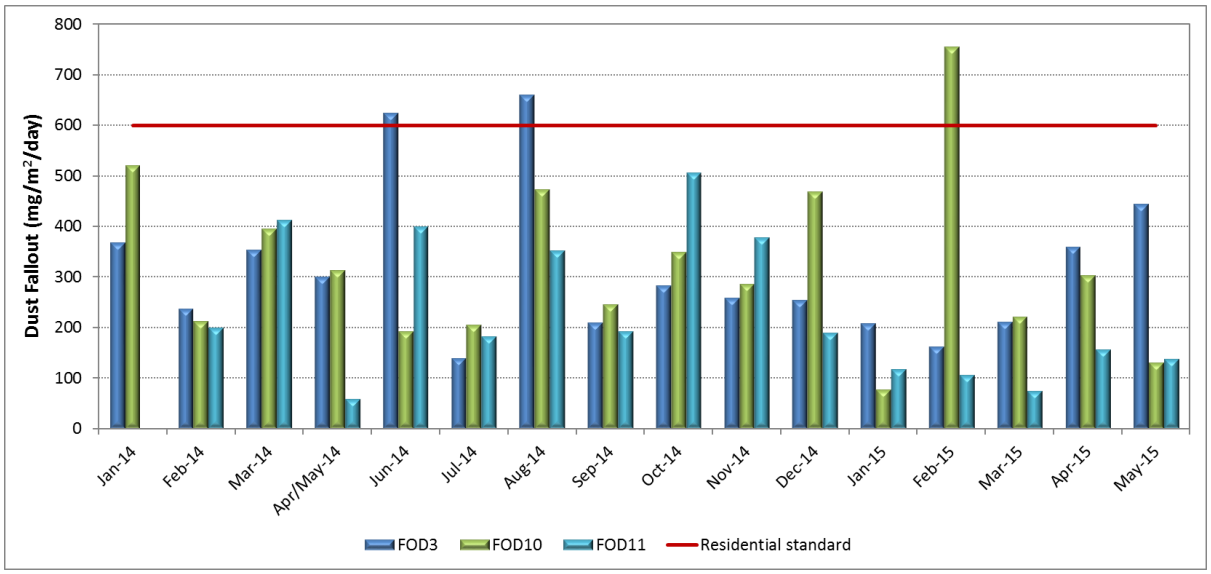


Figure 5-13: Dust fallout measured at residential locations for the period January 2014 - May 2015.

6 IMPACT ASSESSMENT

6.1 CONSTRUCTION AND DECOMISSIONNING PHASE

Emissions associated with construction activities for the proposed plant, and potential decommissioning was qualitatively assessed. Pollutants associated with construction and decommissioning activities are typically TSP, PM_{10} and $PM_{2.5}$. Heavy construction is a source of dust emissions that can have a substantial, temporary impact on the local air quality situation.

6.1.1 *CONSTRUCTION PHASE*

The quantity of dust emissions from construction operations is proportional to the area of land being worked and to the level of construction activity. Due to the size of the construction area and the nature of development, emissions from construction activities associated with the proposed boiler expansion are likely to be low. Though, a large portion of the emissions may result from heavy vehicle traffic over temporary roads at the construction or remediation site (USEPA, 1995), these fugitive emissions are often localised with low impacts on surrounding receptors. Furthermore, dust emissions are limited to the duration of the construction period.

6.1.2 *DECOMMISSIONING PHASE*

Emissions during construction are associated with land clearing, drilling and blasting, ground excavation, cut and fill operations and heavy vehicle traffic on temporary roads. Similar activities can be expected for the potential decommissioning phase. Since the quantity of dust emissions from construction operations is proportional to the area of land being worked, the remediation process should take place over smaller sections at a time. However, as mentioned above, fugitive dust emissions are generally localised with minimal impacts, and are limited to the period of remediation.

Overall impacts associated with the construction and decommissioning phases are likely to be low. Should there be reason for concern, emissions can be effectively reduced with the use of wet suppression and wind speed reduction mitigation techniques.

6.2 OPERATIONAL PHASE

6.2.1 *EMISSIONS INVENTORY*

A complete and accurate emission inventory is imperative for representative model outputs. Various methods exist to calculate emissions, with the approach dependent of the availability of data, time, skill and funds. Methods include continuous monitoring at source, data extrapolation from short-term source emissions testing, and the combination of published emission factors with known activity levels. Emission rates for activities at Tubatse Chrome were calculated using the United States Environmental Protection Agency (USEPA) AP-42 and Australian Government National Pollutant Inventory (NPI) emission factors. An emission factor is a value representing the relationship between an activity and the rate of emissions of a specified pollutant. These emission factors have been developed based on test data, material mass balance studies and engineering estimates.

Emission factors are always expressed as a function of the weight, volume, distance or duration of the activity emitting the pollutant. The general equation used for the estimation of emissions is:

$$E = A \times EF \times \left(1 - \frac{ER}{100}\right)$$

Where:

E = emission rate

A = activity rate

EF = emission factor

ER = overall emission reduction efficiency (%)

Emission estimates for Tubatse Chrome were based on the following USEPA AP-42 sections: 11.9: Western Surface Coal Mining; 11.19.2 Crushed Stone Processing and Pulverised Mineral Processing; 11.24 Metallic Minerals Processing; 12.5: Iron and Steel Production; 13.2.1 Paved Roads; 13.2.2: Unpaved Roads; 13.2.4: Aggregate Handling and Storage Piles; and 13.2.5: Industrial Wind Erosion. Calculations were applied to individual processes to obtain an emission to air estimate, based on information provided by Tubatse Chrome. The emission calculations and resultant emission rates are discussed in the section below.

Emissions were calculated with respect to each of the seven modelling scenarios (**Figure 6-1**):

- **Scenario 1: Existing Plant**
  - Contributions from the existing facility including vehicle emissions, emissions from six point sources and fugitive emissions from materials handling and storage, paved and unpaved roads and wind erosion
- **Scenario 2: Site alternative 1**
  - Proposed boilers and associated materials handling emissions.
- **Scenario 3: Site Alternative 2**
  - Proposed boilers and associated materials handling emissions.
- **Scenario 4: Site Alternative 3**
  - Proposed boilers and associated materials handling emissions
- **Scenario 5: Proposed Plant with Site Alternative 1**
  - Total contributions from the existing facility including vehicle emissions, emissions from seven point sources and fugitive emissions from materials handling and storage, paved and unpaved roads and wind erosion.
- **Scenario 6: Proposed Plant with Site Alternative 2**
  - Total contributions from the existing facility including vehicle emissions, emissions from seven point sources and fugitive emissions from materials handling and storage, paved and unpaved roads and wind erosion.
- **Scenario 7: Proposed Plant with Site Alternative 3**
  - Total contributions from the existing facility including vehicle emissions, emissions from seven point sources and fugitive emissions from materials handling and storage, paved and unpaved roads and wind erosion.

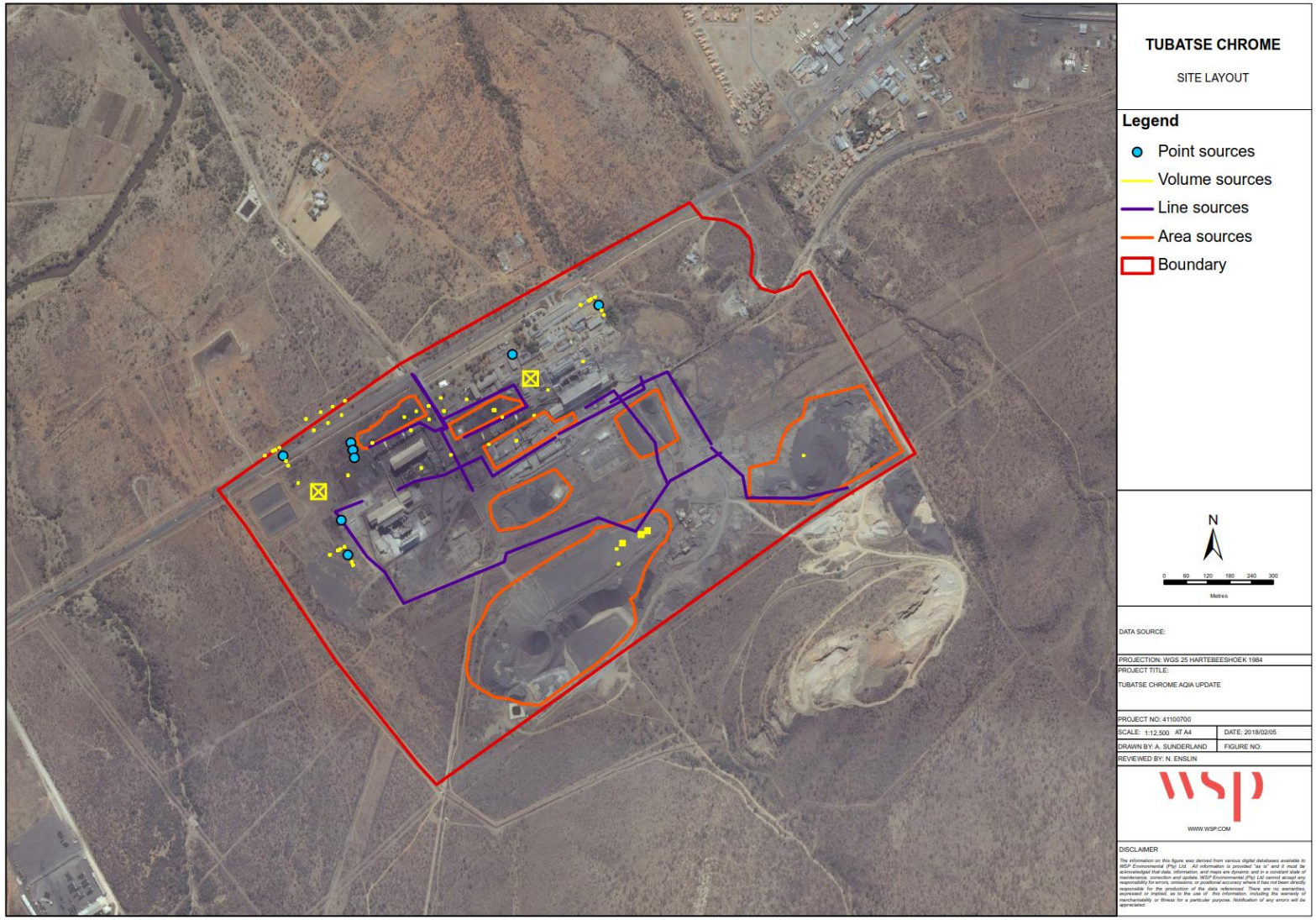


Figure 6-1: Emission sources at Tubatse Chrome including proposed sources at each of three site alternatives.

STACK EMISSIONS

For Scenario 1, Tubatse Chrome point source contributions were assessed for two furnace plant baghouses (EPBH and WPBG) and four PSP stacks (PSP M, PSP S, PSP DDS1 and PSP DDS2). Scenarios 2, 3 and 4 assessed the incremental impacts associated with the proposed CGBs BADD at each of the three site alternatives, respectively. Combined point source emissions were assessed by including existing stacks with the proposed boilers at each of the three site alternatives in Scenarios 5, 6 and 7 respectively. Physical characteristics and emission rates for each existing stack were obtained from the stack emissions test report (Levego, 2014) and the Atmospheric Emissions License (AEL) (**Table 6-1** and **Table 6-2**). Physical parameters and emissions rates associated with the proposed BADD stack were provided by the client. $PM_{2.5}$ emissions emitted from the proposed BADD were assumed to comprise 60% of PM_{10} emissions.

Table 6-1: Input parameters for point sources.

Source	X (UTM 35S)	Y (UTM 35S)	Stack height (m)	Stack diameter (m)	Gas exit velocity (m/s)	Gas exit temperature (ºC)
Scenario 1 (5, 6 and 7)						
EPBH	216488	7260911	26	4	3	200
WPBH	216018	7260455	22	27	2	190
PSP M	216045	7260668	55	1	11	38
PSP S	216054	7260627	60	1	12	26
PSP DDS1	216049	7260648	25	3	5	146
PSP DDS2	216049	7260648	40	2	21	69
Scenarios 2, 3, 4 (5, 6 and 7)						
Proposed BADD (site 1)	215871	7260606	40	3	2.95	160
Proposed BADD (site 2)	216023	7260356				
Proposed BADD (site 3)	216678	7261031				

Table 6-2: Emission rates for point sources.

Source	Emission Rate (g/s)			
	NO_2	SO_2	PM_{10}	$PM_{2.5}$
Scenario 1 (and 7)				
EPBH	14.50	47.93	2.31	1.38
WPBH	14.80	13.68	7.81	4.69
PSP M	10.68	9.29	1.75	1.05
PSP S	0.0218	0.0008	0.0173	0.0104
PSP DDS1	-	-	0.56	0.34
PSP DDS2	-	-	0.11	0.07
Scenarios 4, 5, 6 (and 7)				
Proposed BADD	8.33	10.42	1.04	0.63

VEHICLE WHEEL ENTRAINMENT ON PAVED ROADS

Particulate emissions from paved roads are due to direct emissions from vehicles in the form of exhaust, brake wear, tire wear emissions and the re-suspension of loose material on the road surface. Dust emissions from paved roads vary with the silt loading present on the road surface. In addition, the average weight and speed of vehicles travelling on the road influences road dust emissions (USEPA, 2011).

The emission factor for particulate emissions generated by wheel entrainment on paved roads is estimated using the following equations:

$$E_{PM10} = 0.62 \times (\text{sL})^{0.91} \times (\text{W})^{1.02}$$

$$E_{PM2.5} = 0.15 \times (\text{sL})^{0.91} \times (\text{W})^{1.02}$$

Where:

E = particulate emission factor (g/VKT)

sL = road surface silt loading

W = average weight

Table 6-3 provides the source parameters, including the vehicle kilometres travelled (VKT) per day, for paved roads at Tubatse Chrome. The access road, which provides entrance to the site, is paved and approximately 150 m in length. All vehicles pass in and out of the plant through the paved access road. After crossing the weigh bridge, the paved access road splits to the east and the west, leading to the unpaved West Plant (WP) and East Plant (EP) raw materials roads respectively, or becomes the paved Tippler road when continuing straight (**Figure 6-2**). The Tippler road is approximately 360 m in length and is used by delivery trucks to transport concentrate ore to the tippler station (drops down to underground conveyor system that transfers ore to bunkers). Once concentrate ore and raw materials are delivered, trucks exit the plant along the same three roads and out the access road. Fugitive emissions were calculated for raw material delivery trucks travelling along the access road toward the Tippler road and WP and EP raw material roads, as well as delivery trucks along the Tippler road using the tippler station, with the above equation (**Figure 6-2**). Delivery trucks were assumed to travel along the access and Tippler roads for two hours per day; 08:00 – 09:00 and 17:00 – 18:00 every day of the year. The loaded vehicle weight of delivery trucks is 57 tons (as provided by the Client). The vehicle capacity of 35 tons was used to calculate the number of vehicles on-site using the material throughput per annum. The road surface silt content applied was the default USEPA value of 1.1 g/m^2 for iron and steel production (USEPA, 2011). Since fugitive emissions along paved roads are mitigated with sweepers, emissions were assumed to be controlled with an efficiency of 40% (Schreffler, 2006).

Figure 6-2: Layout of roads at Tubatse Chrome.

Table 6-3: Source parameters for paved roads.

Parameter	Access Road	Tippler Road
Scenarios 1, 5, 6 and 7		
Width (m)	6	6
Length (m)	147	359
Area (m^2)	884	2153
Silt (g/m^2)	1.1	1.1
Vehicle weight (tons)	22	22
Vehicle capacity (tons)	35	35
VKT/day	14	108
Operational hours per annum	730	730
Control efficiency (%)	40	40

Table 6-4: Emission rates for wheel entrainment on paved roads.

Source	Emission Rate (g/s)	
	PM_{10}	$PM_{2.5}$
Scenarios 1, 5, 6 and 7		
Access road	0.028	0.007
Tippler road	0.216	0.052

VEHICLE WHEEL ENTRAINMENT ON UNPAVED ROADS

Resuspended particulate emissions from unpaved roads originate from, and result in the depletion of, the loose material on the road surface (i.e. the surface loading). In turn, that surface loading is continually replenished by other sources. At industrial sites, surface loading is replenished by the spillage of material and trackout from unpaved roads and staging areas.

The emission factor for particulate emissions generated by wheel entrainment on unpaved roads is estimated using the following equations:

$$E_{PM10} = \left(1.5\left(\frac{s}{12}\right)^{0.9}\left(\frac{W}{3}\right)^{0.45}\right)(281.9)\ \ g/VKT$$

$$E_{PM2.5} = \left(0.15\left(\frac{s}{12}\right)^{0.9}\left(\frac{W}{3}\right)^{0.45}\right)(281.9)\ \ g/VKT$$

Where:

E = size specific emission factor (g/VKT)

s = surface material silt content (%)

W = mean vehicle weight (tons)

Table 6-5 and **Table 6-6** provide the source parameters and emission rates for unpaved roads at Tubatse Chrome. Fugitive emissions were calculated for wheel entrainment on all unpaved roads using the above equations. Delivery trucks use the unpaved EP and WP raw materials roads to drop materials into bunkers and stockpiles at the eastern and western plant storage areas. The raw material vehicles have a weight of 57 tons and operate for two hours per day (as mentioned above). Slag/metal carriers transport ferrochrome from furnaces along the EP and WP metal roads to the final product crushers, ferrochrome slag along the CRP road to the CRP crushers, and slag along the WP and EP slag road, which join the main slag road to the slag dump (**Figure 6-2**). The average

weight of the slag/metal carriers is 32 tons with a capacity of 35 tons. The vehicle capacity was used to calculate the number of slag/metal carriers on-site together with the annual throughput of ferrochrome and ferrochrome slag. Slag/metal carriers operate 24 hours per day, every day of the year. The road surface silt content applied for all unpaved roads was the USEPA default value of 0.2% for iron and steel production (USEPA, 2006). Since fugitive emissions along roads are mitigated with wet suppression, emissions were assumed to be controlled with an efficiency of 75% (USEPA, 2006).

Table 6-5: Source parameters for unpaved roads.

Parameter	WP raw material road	EP raw material road	WP Metal Road	EP Metal Road	WP Slag Road	EP Slag Road	Slag Road	CRP Road
Scenario 1, 5, 6 and 7								
Width (m)	10	10	10	10	10	10	10	10
Length (m)	233	487	510	299	1423	410	457	392
Area (m^2)	2330	4870	5104	2989	14226	4100	4569	3918
Silt (%)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Vehicle weight (tons)	22	22	32	32	32	32	32	32
Vehicle capacity (tons)	35	35	35	35	35	35	35	35
VKT/day	7	31	13	15	187	109	182	6
Operational hours/annum	730	730	8760	8760	8760	8760	8760	8760
Control efficiency (%)	75	75	75	75	75	75	75	75

Table 6-6: Emission rates for wheel entrainment on unpaved roads.

Source	Emission Rate (g/s)	
	PM_{10}	$PM_{2.5}$
Scenario 1, 5, 6 and 7		
WP raw material road	0.092	0.009
EP raw material road	0.391	0.039
WP Metal Road	0.162	0.016
EP Metal Road	0.193	0.019
WP Slag Road	2.381	0.238
EP Slag Road	1.393	0.139
Slag Road	2.318	0.232
CRP Road	0.075	0.008

VEHICLE TAILPIPE EMISSIONS

Atmospheric pollutants emitted from vehicles include hydrocarbons, CO, CO_2, NO_x, SO_2 and particulates. These pollutants are emitted from the tailpipe, from the engine and fuel supply system, and from brake linings, clutch plates and tyres. Hydrocarbon emissions, such as benzene, result from the incomplete combustion of fuel molecules in the engine. Carbon monoxide is a product of incomplete combustion and occurs when carbon in the fuel is only partially oxidized to carbon dioxide. Nitrogen oxides are formed by the reaction of nitrogen and oxygen under high pressure and temperature conditions in the engine. Sulphur dioxide is emitted due to the high sulphur content of the fuel. Particulates such as lead originate from the combustion process as well as from brake and clutch linings wear (Samaras and Sorensen, 1999).

Use was made of the Australian NPI emission factors for combustion engines:

$$Ei = LY \times EFi$$

Where:
E = emission of substance (kg/y)
LY = distance travelled in reporting year (km/y)
Efi = emission factor of substance (kg/km)
i = substance

Emission factors for vehicle tailpipe emissions were sourced from the NPI for very heavy goods vehicles (**Table 6-7**). The above equation was used to calculate vehicle exhaust emissions from trucks travelling along these roads. Physical parameters of each of the roads are provided in **Table 6-3** and **Table 6-5**. These details were used to calculate the kilometres travelled per year (LY), while the vehicle fuel consumption was assumed to be 0.04 m^3/100km (Fengchun and Hongwen, 2011). Since NPI emission factors were not available for NO_2 and as such, NO_x emissions were conservatively assumed.

Table 6-7: Emission rates for vehicle tailpipe emissions.

Source	Emission Rate (g/s)			
	NO_2	SO_2	PM_{10}	$PM_{2.5}$
Scenarios 1, 5, 6 and 7				
Access and Tippler Road	1.32E-01	1.00E-04	7.20E-03	6.60E-03
WP Raw Material Road	1.44E-02	1.00E-05	8.00E-04	7.00E-04
EP Raw Material Road	4.84E-02	4.00E-05	2.60E-03	2.40E-03
WP Metal Road	1.30E-03	1.00E-06	7.00E-05	6.00E-05
EP Metal Road	1.50E-03	1.00E-06	8.00E-05	8.00E-05
WP Slag Road	1.90E-02	1.00E-05	1.00E-03	1.00E-03
EP Slag Road	1.11E-02	9.00E-06	6.00E-04	6.00E-04
Slag Road	1.85E-02	1.00E-05	1.00E-03	9.00E-04
CRP Road	6.00E-04	5.00E-07	3.00E-05	3.00E-05

CRUSHING

Emissions from metallic minerals crushing include TSP, PM_{10} and $PM_{2.5}$. These can be either process source emissions, amendable to capture and subsequent control, or fugitive emissions, re-entrained by wind or vehicle/machinery movement. According to the USEPA AP-42 emission factors for Crushed Stone Processing and Pulverised Mineral Processing (2004), emissions from process sources should be classified as fugitive, unless emissions are extracted through an air vent or stack. As such, crushers were modelled as volume sources of fugitive emissions.

Emissions were calculated using emission factors from the USEPA AP-42 emission factors for Metallic Minerals Processing and Crushed Stone Processing and Pulverised Mineral Processing (**Table 6-8**). The final product primary crusher and CRP primary, secondary and tertiary crushers were assessed for Scenarios 1, 5, 6 and 7. These crushers are equipped with wet suppression, and as such, a control efficiency of 70% was applied to the calculated emission rates. Emissions for the proposed secondary and tertiary limestone crushers were calculated for Scenarios 2, 3, 4, 5, 6 and 7 and were assumed to be uncontrolled. Source characteristics are provided in **Table 6-9** with emission rates in **Table 6-10**.

Table 6-8: Emission factors for crushing and screening activities (kg/ton of material processed).

Source	Emission Factor (kg/ton)	
	PM_{10}	$PM_{2.5}$
Crushed Stone Processing and Pulverised Mineral Processing		
Primary Crushing	0.0200	0.0024
Secondary Crushing	0.0024	0.0024
Tertiary Crushing	0.0800	0.0024
Metallic Minerals Processing		
Secondary Crushing	0.0012	0.0012
Tertiary Crushing	0.0012	0.0012

Table 6-9: Source characteristics for primary and secondary crushers.

Parameter	Final Product Primary Crusher	CRP Primary Crusher	CRP Secondary Crusher	CRP Tertiary Crusher
Scenario 1, 5, 6, and 7				
Height at release (m)	3	6	6	6
Length (m)	2	2	2	2
Width (m)	2	2	2	2
Operational hours per annum	8,760	8,760	8,760	8,760
Annual throughput (T)	482,312	2,544,480	2,544,480	2,544,480
Emissions control	Wet suppression	Wet suppression	Wet suppression	Wet suppression
Abatement efficiency (%)	70	70	70	70

Table 6-10: Emission rates for crushers.

Source	Emission Rate (g/s)	
	PM_{10}	$PM_{2.5}$
Scenario 1, 5, 6 and 7		
Final Product Primary Crusher	0.0918	0.0110
CRP Primary Crusher	0.4841	0.0581
CRP Secondary Crusher	0.0581	0.0581
CRP Tertiary Crusher	1.9364	0.0581

AGGREGATE HANDLING AND STORAGE PILES

Materials handling operations predicted to result in fugitive dust emissions include the transfer of material by means of tipping, loading and offloading. The quantity of dust which will be generated from such loading and off-loading operations will depend on various climatic parameters, such as wind speed and precipitation, in addition to non-climatic parameters such as the nature (moisture content) and volume of the material handled. Fine particulates are more readily disaggregated and released to the atmosphere during the material transfer process, as a result of exposure to strong winds. Increase in the moisture content of the material being transferred would decrease the potential for dust emission, since moisture promotes the aggregation and cementation of fines to the surfaces of larger particles (USEPA, 2006).

The following equations were used to calculate particulate emissions respectively:

$$E_{PM10} = 0.35 \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \times \left(\frac{M}{2}\right)^{-1.4} \quad kg/ton$$

$$E_{PM2.5} = 0.053 \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \times \left(\frac{M}{2}\right)^{-1.4} \quad kg/ton$$

Where:
U = mean wind speed (m/s)
M = material moisture content (%)

The USEPA minimum default moisture content (2.5%) was used as a conservative estimate in calculating existing emissions, while a moisture content of 7.1% was used to calculate emissions resulting from the proposed activities (as provided by the client). The mean wind speed (1.79 m/s) was calculated based on site specific data.

Physical parameters and calculated emission rates for materials handling are given in **Table 6-11** and **Table 6-12**. Scenario 1 assessed fugitive emissions from all sources excluding those associated with the boiler expansion. All raw materials are stored at the WP and EP raw material bunkers and stockpiles. It is assumed that approximately 33% of all raw materials are delivered to the WP storage area, while the remaining 67% is deposited to the EP storage area. Ore concentrate is dropped into the tippler station and transferred to storage bunkers via conveyors. It was assumed that 90% of ore delivered consisted of fine concentrate dispensed at the tippler station. Fine ore concentrate is conveyed to the pelletizing plant before it can be used in the furnaces. Heavy dust from materials that could not be pelletized is dispensed into a bunker by the pelletizing plant conveyor for recirculation. It was assumed that the deposited heavy dust comprised 5% of total ore received. Ferrochrome and ferrochrome slag is released from the furnaces during the tapping process. It is assumed that 33% of ferrochrome and ferrochrome slag is tipped and broken at the WP metal and slag areas and 67% at the EP metal and slag areas. Ferrochrome slag is collected from the WP and EP areas and temporarily stockpiled near the CRP. From there, the ferrochrome slag is dispensed via a FEL into the crusher. CRP waste is disposed of at the slag dump while final product is stored in bunkers near the final product primary crusher. Final product is then dropped into the primary crusher via FEL and the crushed material is stored in bunkers before it is exported by rail.

Scenarios 2, 3 and 4 assessed fugitive emissions associated with materials handling. As part of the new design, limestone is no longer to be crushed onsite. Limestone is to be transferred via pneumatic processes and stored within a sealed silo. As such, potential impacts from limestone handling and storage were not assessed further. It is assumed that additional coal will be dispensed and stored in a bunker near the proposed boiler at one of the site alternatives. Coal will be collected from the bunker and transferred to the proposed boiler. Ash from the boiler will be collected and stored in the proposed ash silo. Ash will then be deposited directly into sales trucks via a hopper and taken off-site. Scenarios 5, 6 and 7 assessed the cumulative fugitive emissions associated with materials handling and storage from the existing plant (Scenario 1) combined with each of the possible site alternatives (Scenarios 2, 3 and 4).

Table 6-11: Source parameters for materials handling and storage.

Source	Material	X (UTM 35S)	Y (UTM 35S)	Length x Width	Height	Control efficiency (%)	Throughput (Tons/annum)
Scenarios 1, 5, 6 and 7							
WP raw materials storage	Lumpy ore	216018.00	7260744.67	3 x 3	3	Enclosure and chemical suppression (90%)	374,086
	Pellets	215980.39	7260723.91	3 x 3	3	Enclosure (90%)	204,600
	Limestone	215940.86	7260703.79	3 x 3	3	Enclosure (90%)	56,480
	Cokenuts	216026.92	7260783.64	3 x 3	3	Half stored in enclosure (90%)	24,918
	Coal	215993.14	7260768.55	3 x 3	3	Half stored in enclosure (90%)	21,935
	Anthracite	215960.62	7260752.83	3 x 3	3	Half stored in enclosure (90%)	21,935
	Gas coke	215919.82	7260733.96	3 x 3	3	Half stored in enclosure (90%)	24,918
EP raw materials storage	Lumpy ore	216360.99	7260788.13	3 x 3	3	Enclosure and chemical suppression (90%)	748,172
	Pellets	216299.15	7260756.05	3 x 3	3	Enclosure (90%)	415,400
	Limestone	216258.34	7260733.41	3 x 3	3	Enclosure (90%)	114,671
	Cokenuts	216190.13	7260739.05	3 x 3	3	Half stored in enclosure (90%)	49,837
	Coal	216223.27	7260755.40	3 x 3	3	Half stored in enclosure (90%)	44,534
	Anthracite	216256.43	7260769.88	3 x 3	3	Half stored in enclosure (90%)	44,534
	Gas coke	216290.22	7260791.88	3 x 3	3	Half stored in enclosure (90%)	49,837
Concentrate ore to tippler station	Ore	216236.48	7260599.57	3 x 3	3	Enclosure and chemical suppression (90%)	1,122,259
Heavy dust from pelletizing plant	Ore	216102.36	7260668.84	3 x 3	3	Enclosure (90%)	62,348
WP slag area	Slag	215898.41	7260558.43	3 x 3	3	-	839,678
EP slag area	Slag	216584.26	7260813.98	3 x 3	3	-	1,704,802
WP Metal area	Metal	216035.30	7260579.91	3 x 3	3	Enclosure (90%)	159,163
EP Metal area	Metal	216681.38	7260892.45	3 x 3	3	Enclosure (90%)	323,149
CRP stockpile of WP and EP furnace slag for crusher	Metal/slag	216778.50	7260336.09	3 x 3	3	-	2,544,480
Tipping to CRP crusher	Metal/slag	216773.38	7260377.62	3 x 3	3	Enclosure (90%)	2,544,480
CRP waste to Slag dump	Slag	216482.98	7260256.67	3 x 3	3	-	2,447,988

WP Final product stockpile for crusher	Metal	216317.87	7260635.60	3 x 3	3	Enclosure (90%)	159,163
EP Final product stockpile for crusher	Metal	216459.39	7260739.62	3 x 3	3	-	323,149
Final product area (CRP metal)	Metal	216546.80	7260744.19	3 x 3	3	Enclosure (90%)	96,492
Final product area (crushed metal)	Metal	216422.39	7260664.81	3 x 3	3	Enclosure (90%)	482,312
Final product – rail road	Metal	216497.78	7260674.86	3 x 3	3	Enclosure (90%)	578,804
WP fugitive casting and building emissions	Metal/slag	215954.35	7260534.46	3 x 3	20	Tap fume extraction and enclosure (90%)	159,163
EP fugitive casting and building emissions	Metal/slag	216536.35	7260845.20	3 x 3	20	Tap fume extraction and enclosure (90%)	323,149
Scenarios 2, 3, 4, 5, 6 and 7							
Coal to bunker	Coal	216208.32	7260703.86	3 x 3	3	-	86,600
Ash to silo	Ash Site 1	215864.75	7260618.94	3 x 3	3	Enclosure (90%)	2,880
	Ash Site 2	216045.80	7260341.47				
	Ash Site 3	216731.57	7261032.82				
Ash to sales truck	Ash Site 1	215871.04	7260605.68	3 x 3	3	Enclosure (90%)	2,880
	Ash Site 2	216049.29	7260333.09				
	Ash Site 3	216737.86	7261019.55				

Table 6-12: Emission rates for materials handling and storage.

Source	Material	Emission Rate (g/s)	
		PM_{10}	$PM_{2.5}$
Scenarios 1, 5, 6 and 7			
WP raw materials storage	Lumpy ore	3.72E-04	5.63E-05
	Pellets	2.03E-04	3.08E-05
	Limestone	5.61E-05	8.50E-06
	Cokenuts	2.72E-04	4.12E-05
	Coal	2.40E-04	3.63E-05
	Anthracite	2.40E-04	3.63E-05
	Gas coke	2.72E-04	4.12E-05
EP raw materials storage	Lumpy ore	7.43E-04	1.13E-04
	Pellets	4.13E-04	6.25E-05
	Limestone	1.14E-04	1.73E-05
	Cokenuts	5.45E-04	8.25E-05
	Coal	4.87E-04	7.37E-05
	Anthracite	4.87E-04	7.37E-05
	Gas coke	5.45E-04	8.25E-05
Concentrate ore to tippler station	Ore	1.12E-03	1.69E-04
Heavy dust from pelletizing plant	Ore	6.20E-04	9.38E-05
WP slag area	Slag	8.34E-03	1.26E-03
EP slag area	Slag	1.69E-02	2.57E-03
WP Metal area	Metal	1.58E-04	2.40E-05
EP Metal area	Metal	3.21E-04	4.86E-05
CRP stockpile of WP and EP furnace slag for crusher	Metal/slag	5.06E-02	7.66E-03
Tipping to CRP crusher	Metal/slag	2.53E-03	3.83E-04
CRP waste to Slag dump	Slag	2.43E-02	3.68E-03
WP Final product stockpile for crusher	Metal	3.16E-04	4.79E-05
EP Final product stockpile for crusher	Metal	6.42E-03	9.73E-04
Final product area (CRP metal)	Metal	1.92E-04	2.90E-05
Final product area (crushed metal)	Metal	9.59E-04	1.45E-04
Final product – rail road	Metal	5.75E-04	8.71E-04
Scenario 2, 3, 4, 5, 6 and 7			
Coal to bunker	Coal	2.00E-04	3.02E-05
Ash to silo	Ash	6.64E-07	1.01E-07
Ash to sales truck	Ash	6.64E-07	1.01E-07

FUGITIVE BUILDING EMISSIONS

Fugitive building emissions associated with each furnace were assessed for Scenarios 1, 5, 6 and 7 (**Table 6-13** and **Table 6-14**). Emissions from tapping were calculated using the USEPA AP-42 emission factors for Iron and Steel Production. The emission factor for Melting, Refining, Charging, Tapping and Slagging controlled by direct shell evacuation (0.0215 kg/ton) was used to calculate the mass (kg) of total particulate emissions (TSP) per ton of ferrochrome produced. Though developed for iron and steel production processes, the emission factor was assumed to be representative of ferrochrome production operations. As a conservative estimate, the calculated

TSP emission rate was assumed to remain the same for PM_{10} and $PM_{2.5}$ for each of the applicable scenarios. A control efficiency of 90% was applied due to the enclosure of the warehouse limiting emissions (NPI, 2008).

Table 6-13: Fugitive building source parameters.

Parameter	WP (Furnaces 5 – 6)	EP (Furnaces 1 – 4)
Scenario 1, 5, 6 and 7		
Height (m)	20	20
Length (m)	3	3
Width (m)	3	3
Ferrochrome casting (tons/annum)	159163	323149

Table 6-14: Fugitive building emissions.

Source	Emission rate (g/s)	
	PM_{10}	$PM_{2.5}$
Scenario 1, 5, 6 and 7		
WP fugitive building emissions	1.09E-02	1.09E-02
EP fugitive building emissions	2.20E-02	2.20E-02

WIND EROSION

Dust emissions due to the erosion of open storage piles and exposed areas occur when the threshold wind speed is exceeded (Cowherd *et al*., 1988; EPA, 1995). The threshold wind speed is dependent on the erosion potential of the exposed surface, which is expressed in terms of the availability of erodible material per unit area (mass/area). Any factor which binds the erodible material or otherwise reduces the availability of erodible material on the surface, thus decreases the erosion potential of the surface. Studies have shown that when the threshold wind speeds are exceeded, particulate emission rates tend to decay rapidly due to the reduced availability of erodible material (Cowherd *et al*., 1988).

The default emission factors for wind erosion over open areas are calculated using the below equations (USEPA, 1998):

$$E_{TSP} = 0.4 \text{ kg}/ha/hour$$

$$E_{PM10} = 0.2 \text{ kg}/ha/hour$$

Emission rates were applied to the WP and EP raw materials storage areas, two excess stockpiles, cokenuts stockpile and ore stockpile, the old slag dump and current slag dump and the final product storage area (**Figure 6-3**) (before crushing) for Scenarios 1, 5, 6 and 7 (**Table 6-15** and **Table 6-16**). It was conservatively assumed that wind erosion from all open areas is uncontrolled.

Table 6-15: Source parameters for open areas subject to wind erosion.

Source	Height (m)	Area (m^2)
Scenarios 1, 5, 6 and 7		
WP raw materials area	2	10327
EP raw materials area	2	9081
Excess cokenuts stockpile	2	18909
Excess ore stockpile	2	21842
Old slag dump	2	160933
Current slag dump	2	79557
Final product storage	2	15148

Table 6-16: Emission rates for wind erosion.

Source	Emission rate (g/s)	
	PM_{10}	$PM_{2.5}$
Scenarios 1, 5, 6 and 7		
WP raw materials area	0.057	0.009
EP raw materials area	0.050	0.008
Excess cokenuts stockpile	0.105	0.016
Excess ore stockpile	0.121	0.018
Old slag dump	0.892	0.134
Current slag dump	0.441	0.066
Final product storage	0.084	0.013

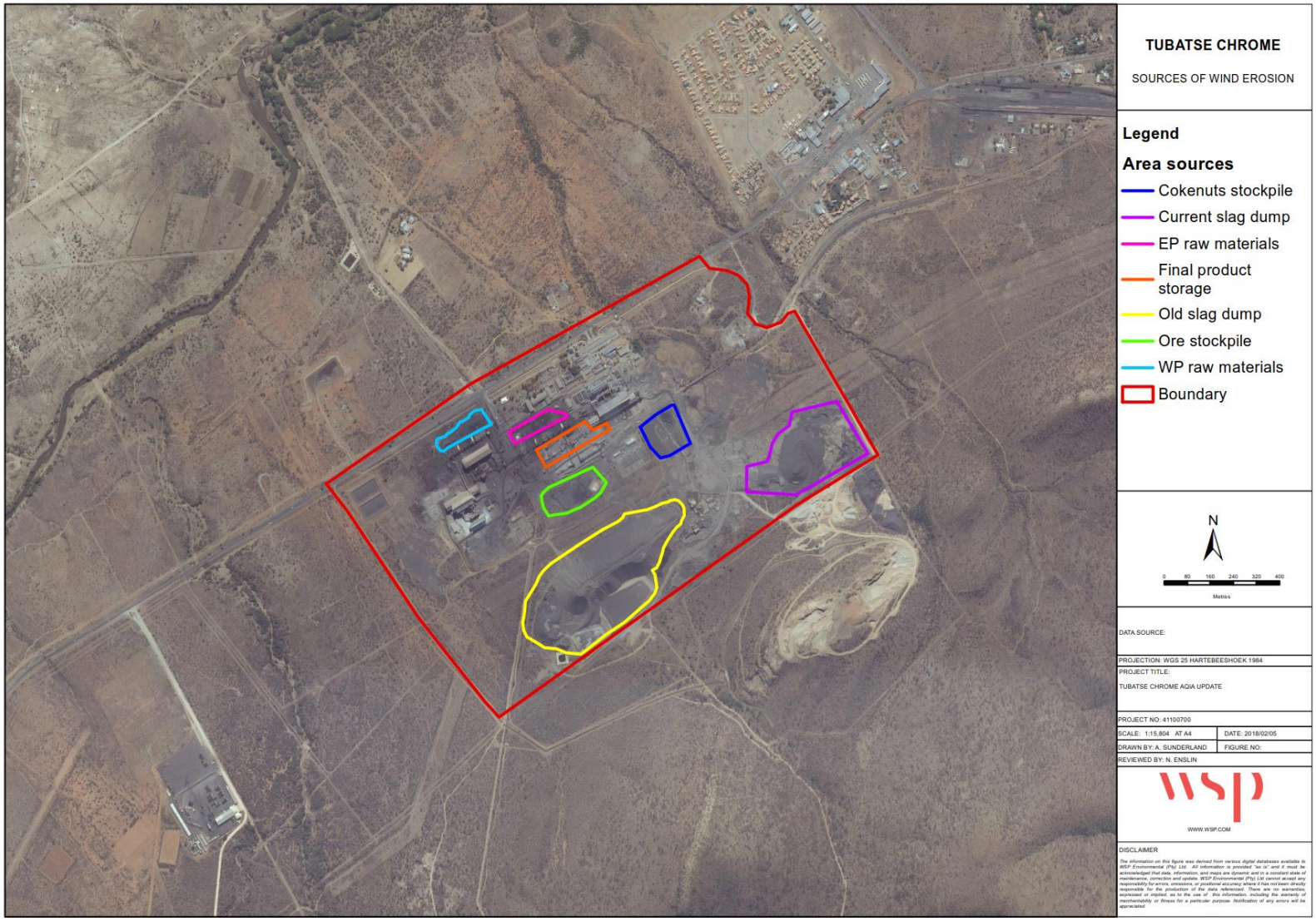


Figure 6-3: Sources of wind erosion at Tubatse Chrome.

6.2.2 *SUMMARY OF EMISSIONS*

A summary of percent contributions (calculated based on total emissions (tons/annum)) for all identified sources associated with the existing and proposed cumulative scenarios (scenarios 1, 5, 6 and 7) are illustrated in **Figure 6-4 - Figure 6-5**.

- **Scenario 1: Existing Plant**
  - Point sources are the main source of NO_2, SO_2, PM_{10} and $PM_{2.5}$ emissions (**Figure 6-4**). Currently, wind erosion (17%) and crushers (13%) are the second and third highest contributors to PM_{10} emissions, while all other fugitive sources have negligible contributions.
- **Scenarios 5, 6 and 7: Proposed plant (with either site alternative 1, 2 or 3)**
  - Following the proposed expansion, point sources are still predicted to be the main source of NO_2 and SO_2 contributions, with an increase in percent PM_{10} and $PM_{2.5}$ emissions (**Figure 6-5**). Following the expansion, crushers (13%) become the second highest contributors to PM_{10}, while wind erosion emissions decrease to 9%. All other fugitive sources have negligible contributions.

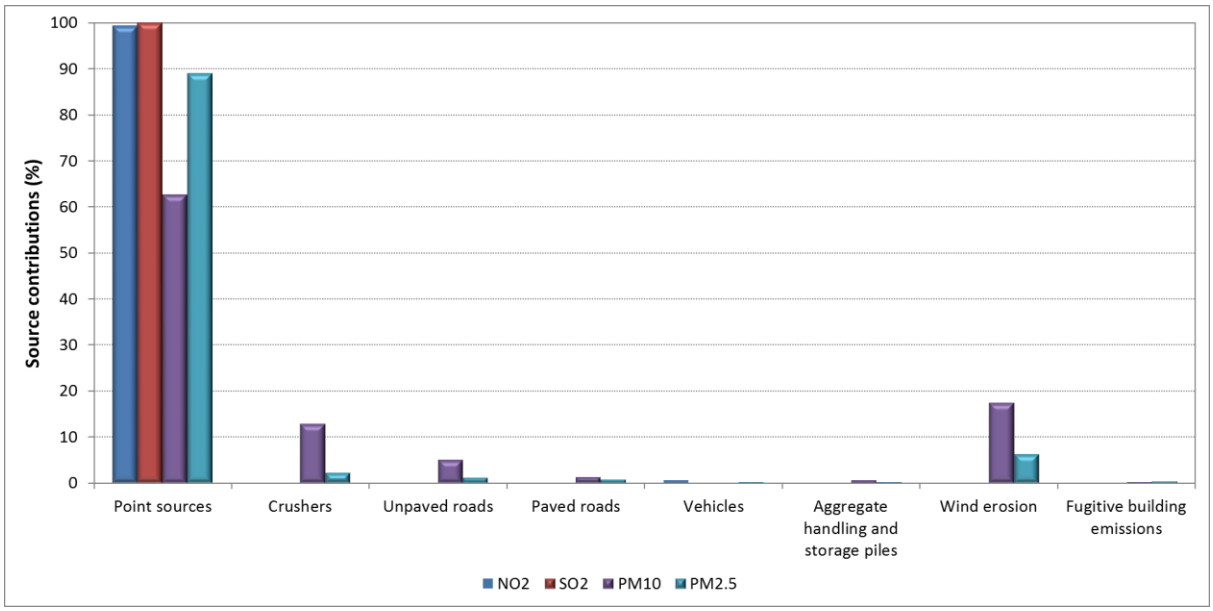


Figure 6-4: Source contributions (%) to total emissions for the existing plant.

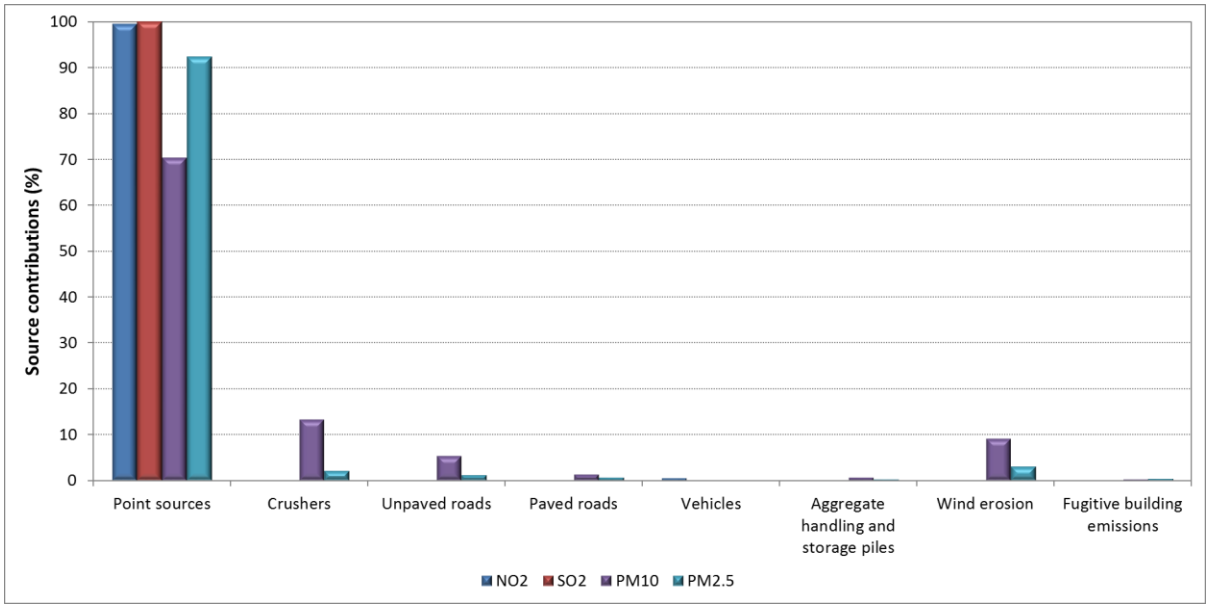


Figure 6-5: Source contributions (%) to total emissions for the proposed plant.

6.3 ASSUMPTIONS AND LIMITATIONS

The assumptions and limitations of this study are provided below:

- AERMET MM5 meteorological data was assumed to be representative of the study area;
- All NO_x emissions were assumed to comprise totally of NO_2;
- The WP raw materials storage area was assumed to receive 33% of total raw materials, while the EP receives 67%;
- Emission factors for melting, refining, charging, tapping and slagging from an electric arc furnace for iron and steel production were assumed to be applicable to Tubatse Chrome production operations;
- Ambient PM_{10} concentrations were provided in monthly average concentrations and conservatively compared against the annual average standard; and
- Only ambient PM_{10} concentrations were provided for the study as other pollutant concentrations are unavailable. Furthermore, PM_{10} concentrations are representative of the period 2013 – 2015 as more recent data was not provided.

6.4 DISPERSION MODELLING

Atmospheric dispersion modelling mathematically simulates the transport and fate of pollutants emitted from a source into the atmosphere. Sophisticated software with algorithms that incorporate source quantification, surface contours and topography, as well as meteorology can reliably predict the downwind concentrations of these pollutants.

AERMOD is a recommended Level 2 model in *The Regulations Regarding Air Dispersion Modelling* (the Modelling Regulations) (Government Gazette 37804). AERMOD is a new generation air dispersion model designed for short-range dispersion of airborne pollutants in steady state plumes that uses hourly sequential meteorological files with pre-processors to generate flow and stability regimes for each hour, that produces output maps of plume spread with key isopleths for visual interpretation and enables, through its statistical output, direct comparisons with the latest National and international ambient air quality standards for compliance testing.

The AERMOD atmospheric dispersion modelling system is an integrated system that includes three modules:

- A steady-state dispersion model designed for short-range (up to 50 km) dispersion of air pollutant emissions from stationary industrial sources.
- A meteorological data pre-processor (AERMET) that accepts surface meteorological data, upper air soundings, and optionally, data from on-site instrument towers. It then calculates atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux.
- A terrain pre-processor (AERMAP) whose main purpose is to provide a physical relationship between terrain features and the behaviour of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

6.4.1 *MODELLING STATISTICAL OUTPUTS*

For the purposes of this investigation, various statistical outputs were generated, as described below:

- **Long-term scenario**

  The long-term scenario refers to an annual average concentration, which is calculated by averaging all hourly concentrations. The calculation is conducted for each grid point within the modelling domain. The long-term concentration for each receptor point is presented in a results table.

- **Short-term scenario**

  The short-term scenario refers to the 99th percentile concentration. The 99th percentile concentrations are recommended for short-term assessment with the available ambient air quality standards since the highest predicted ground level concentrations can be considered outliers due to complex variability of meteorological

processes. This might cause exceptionally high concentrations that the facility may never actually exceed in its lifetime. The 99th percentile results (1-hour or 24-hours) are graphically presented as concentration isopleths, indicating the short-term concentrations at each grid point.

6.4.2 *MODELLING INPUT*

METEOROLOGICAL DATA

Data input into the model includes modelled MM5 surface and upper air meteorological data with wind speed, wind direction, temperature, pressure, precipitation, cloud cover and ceiling height for January 2012 – December 2014 (**Figure 6-6**).

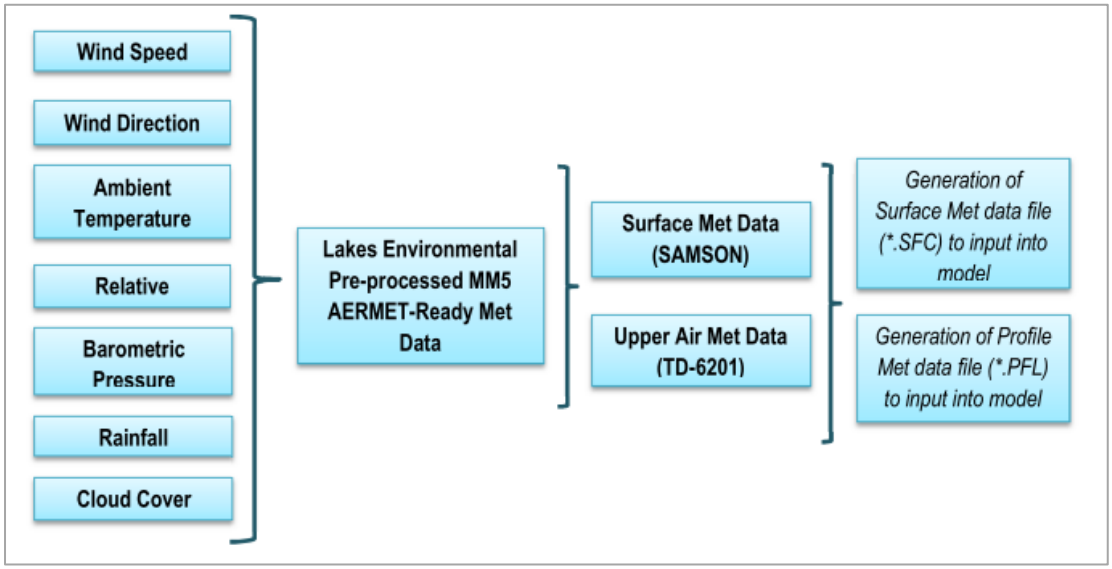


Figure 6-6: Meteorological data path.

MODEL DOMAIN

A modelling domain of 5 km × 5 km was used (**Table 6-17**), with multi-tier Cartesian grid receptor spacing's of 50 and 100 m as recommended in the Modelling Regulations. A receptor spacing of 50 m was also located along the plant boundary.

Table 6-17: Model domain coordinates.

Domain Point	X (UTM 35S)	Y (UTM 35S)
North-eastern corner	221433	7265537
South-western corner	211433	7255537

SENSITIVE RECEPTORS

Receptors are identified as areas that may be impacted negatively due to emissions from Tubatse Chrome. Examples of receptors include, but are not limited to, schools, shopping centres, hospitals, office blocks and residential areas. The sensitive receptors identified in the area surrounding Tubatse are presented in **Table 6-18** and **Figure 6-7**.

Table 6-18: Location of receptors surrounding Tubatse Chrome.

Receptor	X (UTM 35S)	Y (UTM 35S)	Direction from Site Boundary	Distance from Site Boundary (m)
Steelpoort	217233	7261341	NNW	60
Farm	215748	7261378	NNE	565
Excelsus Combined School	217213	7262307	NNW	960
Laerskool	217112	7262599	NNW	1200

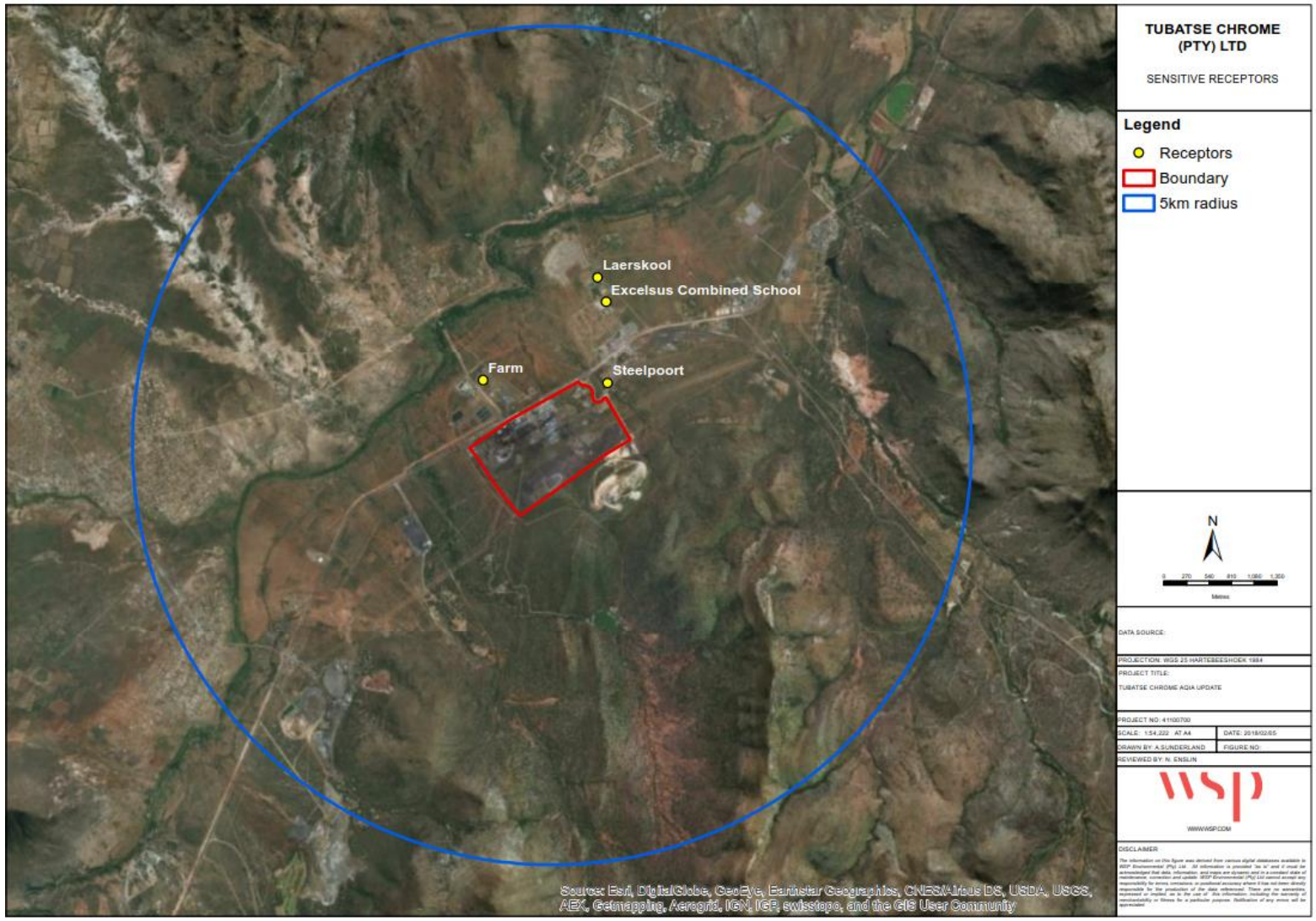


Figure 6-7: Location of sensitive receptors surrounding Tubatse Chrome.

As defined in the Modelling Regulations, ambient air quality objectives are applied to areas where there is public access outside the facility fenceline (i.e. beyond the facility boundary). Within the facility boundary, environmental conditions are prescribed by occupational health and safety criteria. The facility boundary is defined based on these criteria:

- The facility fenceline or the perimeter where public access is restricted;
- If the facility is located within another larger facility boundary, the facility boundary is the boundary of the encompassing facility;

If a public access road passes through the facility, the facility boundary is the perimeter along the road allowance.

6.4.3 *MODELLING SIMULATIONS*

For the purpose of this study, dispersion modelling simulations were undertaken for the a) existing plant (Scenario 1), b) incremental impacts of the proposed boiler and associated activities and three site alternatives (scenarios 2, 3 and 4) and c) cumulative assessment of the proposed plant with each of the three site alternatives (scenarios 5, 6 and 7). PM_{10}, $PM_{2.5}$, SO_2 and NO_2 emissions were assessed for each scenario.

Long-term scenarios were run to predict the annual average concentrations of criteria pollutants, as health risks are primarily based on long-term exposure to pollutants. The model plots therefore present the 'average' or 'day-to-day' situation experienced as a result of emissions from Tubatse Chrome. Short-term (daily or hourly) concentrations are also presented, assessed against the relevant National ambient air quality standards for compliance assessment purposes.

6.4.4 *DISPERSION MODELLING RESULTS*

Predicted ambient pollutant concentrations are discussed below for each pollutant and each respective scenario. Dispersion model isopleths maps are provided for PM_{10} and SO_2 for all scenarios in **Appendix A**, while the findings of the AQIA competed in 2016 are provided in **Appendix B**.

PM_{10} AND $PM_{2.5}$ CONCENTRATIONS

Table 6-19 provides the predicted PM_{10} and $PM_{2.5}$ concentrations at receptor locations for all scenarios. Maximum PM_{10} and $PM_{2.5}$ concentrations are provided for each scenario in **Table 6-20** and **Table 6-21**, respectively.

Ambient PM_{10} concentrations are predicted to be non-compliant (having more than 4 exceedences per annum) with the daily average standard approximately 120 m beyond the site boundary for Scenarios 1, 5, 6 and 7. However, daily average PM_{10} concentrations are predicted to be compliant at all sensitive receptor locations. Annual average PM_{10} concentrations are compliant with the annual average standard at all sensitive receptors and across the study area for Scenarios 1, 5, 6 and 7. For the remaining scenarios (2, 3 and 4), predicted PM_{10} concentrations are compliant with the daily and annual average standard at all receptors and across the study area (**Figure 8-1 – Figure 8-4)**.

Daily and annual average $PM_{2.5}$ concentrations are predicted to be compliant at all sensitive receptor locations and across the study area, for all scenarios.

Particulate emissions associated with the crusher appear to be the main contributor to ambient concentrations, with fugitive emissions from materials handling and storage having the second highest contribution. Overall, particulate concentrations associated with proposed CGBs and BADD are lower than those estimated in the original AQIA (WSP, 2016) including the (then proposed) coal-fired boiler.

Table 6-19: Predicted ambient PM_{10} and PM_{25} concentrations at surrounding receptors. Values highlighted in blue bold exceed their respective standards.

Receptor	PM_{10} concentration (µg/m^3)		$PM_{2.5}$ concentration (µg/m^3)	
	Annual average	Daily average	Annual average	Daily average
Scenario 1				
Steelpoort	4.15	31.26	0.70	4.31
Farm	10.91	44.69	2.50	7.54
Excelsus	1.66	14.81	0.33	2.78
Laerskool	1.53	14.40	0.33	2.58
Max. fenceline	32.25	**116.42**[1]	6.63	21.14
Scenario 2				
Steelpoort	0.02	0.17	0.01	0.10
Farm	0.11	0.76	0.06	0.46
Excelsus	0.02	0.15	0.01	0.09
Laerskool	0.02	0.17	0.01	0.10
Max. fenceline	0.38	1.28	0.23	0.77
Scenario 3				
Steelpoort	0.02	0.16	0.01	0.09
Farm	0.08	0.54	0.05	0.33
Excelsus	0.02	0.17	0.01	0.10
Laerskool	0.02	0.18	0.01	0.11
Max. fenceline	0.43	2.04	0.26	1.22
Scenario 4				
Steelpoort	0.10	0.61	0.06	0.37
Farm	0.13	0.71	0.08	0.42
Excelsus	0.04	0.41	0.03	0.25
Laerskool	0.05	0.49	0.03	0.29
Max. fenceline	0.28	1.21	0.17	0.73
Scenario 5				
Steelpoort	4.18	31.28	0.72	4.34
Farm	11.02	44.85	2.56	7.66
Excelsus	1.67	14.95	0.34	2.80
Laerskool	1.55	14.44	0.34	2.67
Max. fenceline	32.41	**116.51**[1]	6.73	21.51
Scenario 6				
Steelpoort	4.18	31.28	0.72	4.33
Farm	11.00	44.78	2.55	7.60
Excelsus	1.67	15.05	0.34	2.81
Laerskool	1.55	14.45	0.34	2.68
Max. fenceline	32.37	**116.55**[1]	6.71	22.22
Scenario 7				
Steelpoort	4.25	31.33	0.76	4.42
Farm	11.05	44.79	2.58	7.55

Receptor	PM_{10} concentration (µg/m³)		$PM_{2.5}$ concentration (µg/m³)	
	Annual average	Daily average	Annual average	Daily average
Excelsus	1.70	15.35	0.35	2.82
Laerskool	1.58	14.48	0.36	2.73
Max. fenceline	32.35	116.50[1]	6.69	21.18

Notes:

[1]Predicted on-site where ambient air quality objectives do not apply

Table 6-20: Maximum PM_{10} concentrations recorded for each scenario.

Scenario	X (UTM 35S)	Y (UTM 35S)	Concentration (µg/m³)	Elevation (m)	Grid resolution (m)	Averaging period	Date	Hour
Scenario 1	216833	7260437	429.72	815.83	50	Annual	N/A	N/A
	216833	7260387	912.44	818.25	50	Daily	2012/01/23	24
Scenario 2	215883	7260387	0.60	786.99	50	Annual	N/A	N/A
	215533	7260887	2.17	762.18	50	Daily	2014/02/15	24
Scenario 3	216033	7260137	0.57	798.12	50	Annual	N/A	N/A
	215683	7260637	2.08	771.85	50	Daily	2014/02/15	24
Scenario 4	216683	7260787	0.59	796.59	50	Annual	N/A	N/A
	216333	7261337	2.19	773.95	50	Daily	2013/07/29	24
Scenario 5	216833	7260437	429.79	815.83	50	Annual	N/A	N/A
	216833	7260387	912.46	818.25	50	Daily	2012/01/23	24
Scenario 6	216833	7260437	429.81	815.83	50	Annual	N/A	N/A
	216833	7260387	912.47	818.25	50	Daily	2012/01/23	24
Scenario 7	216833	7260437	429.95	815.83	50	Annual	N/A	N/A
	216833	7260387	912.69	818.25	50	Daily	2012/01/23	24

Table 6-21: Maximum $PM_{2.5}$ concentrations recorded for each scenario.

Scenario	X (UTM 35S)	Y (UTM 35S)	Concentration (µg/m³)	Elevation (m)	Grid resolution (m)	Averaging period	Date	Hour
Scenario 1	216783	7260437	25.15	822.25	50	Annual	N/A	N/A
	216783	7260337	64.12	822.77	50	Daily	2014/12/01	24
Scenario 2	215883	7260387	0.36	786.99	50	Annual	N/A	N/A
	215533	7260887	1.30	762.18	50	Daily	2014/02/15	24
Scenario 3	216033	7260137	0.34	798.12	50	Annual	N/A	N/A

	215683	7260637	1.25	771.85	50	Daily	2014/02/15	24
Scenario 4	216683	7260787	0.35	796.59	50	Annual	N/A	N/A
	216333	7261337	1.31	773.95	50	Daily	2013/07/29	24
Scenario 5	216783	7260437	25.20	822.25	50	Annual	N/A	N/A
	216783	7260337	64.15	822.77	50	Daily	2014/12/01	24
Scenario 6	216783	7260437	25.21	822.25	50	Annual	N/A	N/A
	216783	7260337	64.16	822.77	50	Daily	2014/12/01	24
Scenario 7	216783	7260437	25.30	822.25	50	Annual	N/A	N/A
	216783	7260337	64.22	822.77	50	Daily	2014/12/01	24

SO_2 CONCENTRATIONS

Table 6-22 presents the predicted SO_2 concentrations at receptors locations for all scenarios with maximum SO_2 concentrations provided in **Table 6-23** for each scenario. Daily and hourly average SO_2 concentrations are predicted to be non-compliant with the daily and hourly average standards approximately 360 and 140 m beyond the site boundary, respectively, for scenarios 1, 5, 6 and 7. However, it is noted that daily and hourly average concentrations are compliant at each of the receptor locations for scenarios 1, 5, 6 and 7. For scenarios 2, 3 and 4, daily and hourly average concentrations are very low and thus compliant at all receptors and across the study area (**Figure 8-5 - Figure 8-8**). Annual average concentrations are predicted to be compliant at all receptor locations and across the study area for all scenarios (**Figure 8-9** and **Figure 8-10**).

Point sources are noted as the main contributor to ambient SO_2 concentrations, with negligible changes observed with the addition of the proposed boilers. Overall, SO_2 concentrations associated with proposed CGBs and BADD are lower than those estimated in the original AQIA (WSP, 2016) including the (then proposed) coal-fired boiler.

Table 6-22: Predicted ambient SO_2 concentrations at surrounding receptors. Values highlighted in blue bold exceed their respective standards.

Receptor	SO_2 Concentration (µg/m^3)		
	Annual Average	Daily Average	Hourly Average
Scenario 1			
Steelpoort	3.85	25.49	63.24
Farm	19.51	75.27	168.91
Excelsus	4.59	22.50	91.13
Laerskool	4.56	23.22	87.07
Max. fenceline	32.31	**182.52**[1]	**364.21**[1]
Scenario 2			
Steelpoort	0.24	1.75	4.43
Farm	1.05	7.62	19.94
Excelsus	0.16	1.52	3.26
Laerskool	0.17	1.67	3.45
Max. fenceline	3.78	12.79	35.23
Scenario 3			
Steelpoort	0.23	1.58	4.36
Farm	0.82	5.42	16.47
Excelsus	0.17	1.75	3.54

Receptor	SO_2 Concentration (µg/m^3)		
	Annual Average	Daily Average	Hourly Average
Laerskool	0.19	1.77	4.42
Max. fenceline	4.25	20.37	38.40
Scenario 4			
Steelpoort	0.95	6.13	15.72
Farm	1.31	7.08	17.59
Excelsus	0.42	4.15	9.83
Laerskool	0.51	4.90	13.08
Max. fenceline	2.84	12.14	35.28
Scenario 5			
Steelpoort	4.09	27.30	67.83
Farm	20.56	75.61	169.00
Excelsus	2.31	23.47	47.30
Laerskool	2.71	25.04	67.41
Max. fenceline	33.10	**183.45**	**364.43**
Scenario 6			
Steelpoort	4.08	26.67	67.14
Farm	20.33	75.55	169.02
Excelsus	2.32	23.69	48.59
Laerskool	2.74	25.47	69.22
Max. fenceline	33.07	**183.18**	**364.39**
Scenario 7			
Steelpoort	4.80	31.80	78.38
Farm	20.82	80.56	178.43
Excelsus	2.57	25.62	55.61
Laerskool	3.06	28.54	77.22
Max. fenceline	34.46	**186.63**	**365.64**

Notes:
[1]Predicted on-site where ambient air quality objectives do not apply

Table 6-23: Maximum SO_2 concentrations recorded for each scenario.

Scenario	X (UTM 35S)	Y (UTM 35S)	Concentration (µg/m^3)	Elevation (m)	Grid resolution (m)	Averaging period	Date	Hour
Scenario 1	216483	7260687	43.94	799.31	50	Annual	N/A	N/A
	216233	7261137	204.47	776.10	50	Daily	2013/07/29	24
	216283	7261087	397.99	779.30	50	Hourly	2012/09/25	02
Scenario 2	215883	7260387	6.03	786.99	50	Annual	N/A	N/A
	215533	7260887	21.72	762.18	50	Daily	2014/02/15	24
	215783	7260387	47.74	785.63	50	Hourly	2013/08/30	09

Scenario 3	216033	7260137	5.70	798.12	50	Annual	N/A	N/A
	215683	7260637	20.78	771.85	50	Daily	2014/02/15	24
	215933	7260137	45.60	792.08	50	Hourly	2013/01/26	09
Scenario 4	216683	7260787	5.91	796.59	50	Annual	N/A	N/A
	216333	7261337	21.86	773.95	50	Daily	2013/07/29	24
	216633	7260837	48.10	797.57	50	Hourly	2012/11/27	10
Scenario 5	216483	7260687	45.27	799.31	50	Annual	N/A	N/A
	216233	7261137	204.95	776.10	50	Daily	2013/07/29	24
	216283	7261087	398.27	779.30	50	Hourly	2013/09/22	04
Scenario 6	216483	7260687	44.95	799.31	50	Annual	N/A	N/A
	216233	7261137	204.78	776.10	50	Daily	2013/07/29	24
	216283	7261087	398.22	779.30	50	Hourly	2013/09/22	04
Scenario 7	216483	7260687	47.23	799.31	50	Annual	N/A	N/A
	216233	7261137	208.53	776.10	50	Daily	2013/07/29	24
	216283	7261087	398.35	779.30	50	Hourly	2013/09/22	04

NO_2 CONCENTRATIONS

Table 6-24 presents the predicted NO_2 concentrations at receptors locations for all scenarios with maximum NO_2 concentrations provided in **Table 6-25** for each scenario. Annual and hourly average NO_2 concentrations are predicted to be compliant at all receptor locations and across the study area, for all scenarios. Overall, NO_2 concentrations associated with proposed CGBs and BADD are lower than those estimated in the original AQIA (WSP, 2016) including the (then proposed) coal-fired boiler.

Table 6-24: Predicted ambient NO_2 concentrations at surrounding receptors.

Receptor	NO_2 Concentration (µg/m^3)	
	Annual Average	Hourly Average
Scenario 1		
Steelpoort	1.75	2.65
Farm	8.62	24.48
Excelsus	3.01	6.10
Laerskool	3.01	6.09
Max. fenceline	14.00	35.90
Scenario 2		
Steelpoort	0.19	0.25
Farm	0.84	1.08
Excelsus	0.13	0.14
Laerskool	0.13	0.13
Max. fenceline	3.02	7.55
Scenario 3		

Receptor	NO_2 Concentration (µg/m³)	
	Annual Average	Hourly Average
Steelpoort	0.18	0.26
Farm	0.66	0.66
Excelsus	0.14	0.14
Laerskool	0.15	0.12
Max. fenceline	3.40	8.40
Scenario 4		
Steelpoort	0.76	1.50
Farm	1.05	1.74
Excelsus	0.33	0.34
Laerskool	0.41	0.26
Max. fenceline	2.27	5.82
Scenario 5		
Steelpoort	1.95	2.93
Farm	9.46	26.65
Excelsus	1.17	1.21
Laerskool	1.31	1.06
Max. fenceline	15.99	41.19
Scenario 6		
Steelpoort	1.94	2.94
Farm	9.27	26.54
Excelsus	1.17	1.22
Laerskool	1.33	1.04
Max. fenceline	15.99	38.87
Scenario 7		
Steelpoort	2.52	4.15
Farm	9.67	28.23
Excelsus	1.37	1.41
Laerskool	1.59	1.20
Max. fenceline	14.43	39.55

Table 6-25: Maximum NO_2 concentrations recorded for each scenario.

Scenario	X (UTM 35S)	Y (UTM 35S)	Concentration (µg/m³)	Elevation (m)	Grid resolution (m)	Averaging period	Date	Hour
Scenario 1	216033	7260287	21.72	793.22	50	Annual	N/A	N/A
	216133	7260787	96.72	788.27	50	Hourly	2012/11/14	08
Scenario 2	215883	7260387	4.83	786.99	50	Annual	N/A	N/A
	215883	7260437	17.35	790.52	50	Hourly	2014/07/29	15
Scenario 3	216033	7260137	4.56	798.12	50	Annual	N/A	N/A

	216033	7260137	14.61	798.12	50	Hourly	2013/04/13	10
Scenario 4	216683	7260787	4.72	796.59	50	Annual	N/A	N/A
	216683	7260837	15.36	792.99	50	Hourly	2013/02/03	09
Scenario 5	216033	7260287	25.09	793.22	50	Annual	N/A	N/A
	216133	7260787	99.14	788.27	50	Hourly	2012/11/02	09
Scenario 6	216033	7260287	22.79	793.22	50	Annual	N/A	N/A
	216133	7260787	97.96	788.27	50	Hourly	2012/11/02	09
Scenario 7	216033	7260287	22.35	793.22	50	Annual	N/A	N/A
	216133	7260787	103.68	788.27	50	Hourly	2012/11/06	09

6.5 IMPACT RATING

Air quality impacts associated with the construction phase, operational phases and decommissioning phase are rated in the tables below. Since construction and decommissioning phases are associated with temporary emission sources, impacts are expected to be medium to low. Though potential impacts are likely to be localised, these may be effectively reduced with the use of wet suppression and wind speed reduction mitigation techniques. As such, impacts are expected to be low for the construction and decommissioning phases post mitigation (**Table 6-26** and **Table 6-27**). Incremental impacts associated with the proposed expansion at site alternatives 1, 2 and 3 only (Scenarios 2, 3 and 4), are expected to be low (**Table 6-28**). Cumulative NO_2 and $PM_{2.5}$ impacts associated with the proposed plant (Scenarios 5, 6 and 7) are predicted to be low. Cumulative SO_2 and PM_{10} impacts associated are expected to be medium beyond the site boundary and low at sensitive receptors (**Table 6-29**).

Table 6-26: Impact rating for activities associated with the construction phase.

Area of Impact	Pollutant	Prior to Mitigation								Post Mitigation							
		Severity	Extent	Duration	Consequence of Impact	Probability	Confidence	Status	Significance of Impact	Severity	Extent	Duration	Consequence of Impact	Probability	Confidence	Status	Significance of Impact
Impact beyond site boundary	TSP	Med	Med	Low	**Med**	Low	Low	Neutral	**Low**	Low	Med	Low	**Low**	Low	Low	Neutral	**Low**
	PM_{10}	Low	Med	Low	**Low**	Low	Low	Neutral	**Low**	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**
	$PM_{2.5}$	Low	Med	Low	**Low**	Low	Low	Neutral	**Low**	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**
Impact at sensitive receptors	TSP	Low	Med	Low	**Low**	Low	Low	Neutral	**Low**	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**
	PM_{10}	Low	Med	Low	**Low**	Low	Low	Neutral	**Low**	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**
	$PM_{2.5}$	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**

Table 6-27: Impact rating for activities associated with the decommissioning phase.

Area of Impact	Pollutant	Prior to Mitigation								Post Mitigation							
		Severity	Extent	Duration	Consequence of Impact	Probability	Confidence	Status	Significance of Impact	Severity	Extent	Duration	Consequence of Impact	Probability	Confidence	Status	Significance of Impact
Impact beyond site boundary	TSP	Med	Med	Low	**Med**	Low	Low	Neutral	**Low**	Low	Med	Low	**Low**	Low	Low	Neutral	**Low**
	PM_{10}	Low	Med	Low	**Low**	Low	Low	Neutral	**Low**	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**
	$PM_{2.5}$	Low	Med	Low	**Low**	Low	Low	Neutral	**Low**	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**
Impact at sensitive receptors	TSP	Low	Med	Low	**Low**	Low	Low	Neutral	**Low**	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**
	PM_{10}	Low	Med	Low	**Low**	Low	Low	Neutral	**Low**	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**
	$PM_{2.5}$	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**

Table 6-28: Impact rating for activities associated with operational phases of Scenarios 2, 3 and 4.

Area of Impact	Post Mitigation								
	Pollutant	Severity	Extent	Duration	Consequence of Impact	Probability	Confidence	Status	Significance of Impact
Impact beyond site boundary	All pollutants	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**
Impact at sensitive receptors	All pollutants	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**

Table 6-29: Impact rating for activities associated with operational phases of Scenario 1, 5, 6 and 7.

Area of Impact	Post Mitigation								
	Pollutant	Severity	Extent	Duration	Consequence of Impact	Probability	Confidence	Status	Significance of Impact
Impact beyond site boundary	PM_{10}	Med	Low	Low	**Low**	Low	Low	Neutral	**Low**
	$PM_{2.5}$	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**
	NO_2	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**
	SO_2	Med	Low	Low	**Low**	Low	Low	Neutral	**Low**
Impact at sensitive receptors	PM_{10}	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**
	$PM_{2.5}$	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**
	NO_2	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**
	SO_2	Low	Low	Low	**Low**	Low	Low	Neutral	**Low**

6.6 RECOMMENDATIONS

6.6.1 *CONSTRUCTION AND DECOMMISSIONING PHASES*

Management procedures to ensure minimal disturbance can be employed during the construction and decommissioning phase to mitigate dust. Performing construction and remediation activities over separate portions will reduce wind erosion of open land. Wet suppression and wind speed reduction are common methods used to control open dust sources at construction sites, as a source of water and material for wind barriers tend to be readily available. General control methods for open dust sources, as recommended by the US EPA, are given in **Table 6-30**.

Table 6-30: Mitigation measures for general construction (US EPA, 1995).

Emission source	Recommended control method
Debris handling	Wind speed reduction
	Wet suppression[1]
Truck transport[2]	Wet suppression
	Paving
	Chemical stabilisation[3]
Bulldozers	Wet suppression[4]
Pan scrapers	Wet suppression
Cut/fill material handling	Wind speed reduction
	Wet suppression
Cut/fill haulage	Wet suppression
	Paving
	Chemical stabilisation
General construction	Wind speed reduction
	Wet suppression
	Early paving of permanent roads

Notes:

(1) Dust control plans should contain precautions against watering programs that confound trackout problems.

(2) Loads could be covered to avoid loss of material in transport, especially if material is transported offsite.

(3) Chemical stabilisation usually cost-effective for relatively long-term or semi-permanent unpaved roads

(4) Excavated materials may already be moist and may not require additional wetting.

6.6.2 *OPERATIONAL PHASE*

- It is recommended that existing and proposed mitigation techniques are maintained and that abatement machinery is regularly serviced according to supplier specifications; and
- It is recommended that dust fallout monitoring is continued to ensure compliance in the surrounding areas.

7 CONCLUSIONS

The AQIA included a qualitative assessment of impacts associated with the construction and decommissioning phases of the plant, as well as a quantitative assessment of the operational phase associated with seven scenarios:

- **Scenario 1: Existing Plant**
  - Contributions from the existing facility including vehicle emissions, emissions from six point sources and fugitive emissions from materials handling and storage, paved and unpaved roads and wind erosion
- **Scenario 2: Site alternative 1**
  - Proposed boilers and associated materials handling emissions.
- **Scenario 3: Site Alternative 2**
  - Proposed boilers and associated materials handling emissions.
- **Scenario 4: Site Alternative 3**
  - Proposed boilers and associated materials handling emissions
- **Scenario 5: Proposed Plant with Site Alternative 1**
  - Total contributions from the existing facility including vehicle emissions, emissions from seven point sources and fugitive emissions from materials handling and storage, paved and unpaved roads and wind erosion.
- **Scenario 6: Proposed Plant with Site Alternative 2**
  - Total contributions from the existing facility including vehicle emissions, emissions from seven point sources and fugitive emissions from materials handling and storage, paved and unpaved roads and wind erosion.
- **Scenario 7: Proposed Plant with Site Alternative 3**
  - Total contributions from the existing facility including vehicle emissions, emissions from seven point sources and fugitive emissions from materials handling and storage, paved and unpaved roads and wind erosion.

Emission sources included point source emissions from furnace stacks and a proposed boiler, and fugitive emissions from paved and unpaved roads, vehicle emissions, materials handling and storage, fugitive building emissions and wind erosion. The study assessed the following key pollutants; PM_{10}, $PM_{2.5}$, NO_2 and SO_2.

Findings of the study are presented below.

CONSTRUCTION AND DECOMMISSIONING PHASE

- Based on a qualitative assessment, impacts associated with the construction and decommissioning phases are likely to be low, as associated particulate emissions result in localised concentrations and are limited to the duration of the construction and remediation period.

OPERATIONAL PHASE

- Predicted annual average PM_{10} concentrations are compliant at all receptor locations and across the study area for all model scenarios. Daily average PM_{10} concentrations are predicted to be non-compliant approximately 120 m beyond the site boundary for Scenarios 1, 5, 6 and 7, although compliant at all sensitive receptor locations. For the remaining scenarios (2, 3 and 4), daily average PM_{10} concentrations are predicted to be compliant at all sensitive receptors and across the study area;
- Predicted $PM_{2.5}$ concentrations are compliant with both the daily and annual average standard at all receptors and across the study area for all scenarios;

- Predicted NO_2 concentrations are compliant with both the hourly and annual average standard at all sensitive receptor locations and across the study area for all scenarios, despite the conservative assumption that all NO_x emissions comprise totally of NO_2; and
- Predicted annual average SO_2 concentrations are compliant at all receptor locations and across the study area for all scenarios. Daily and hourly average concentrations for Scenarios 1, 5, 6 and 7 are non-compliant approximately 360 and 140 m beyond the site boundary, although compliant at all sensitive receptor locations. For the remaining scenarios (2, 3 and 4), predicted daily and hourly average SO_2 concentrations are compliant at all sensitive receptors and across the study area.

Based on the findings of the study, it is recommended that existing and proposed mitigation strategies are maintained and that mitigation equipment is serviced according to supplier specifications. It is recommended that dust fallout monitoring is continued to ensure compliance beyond the site boundary. It is further recommended that wet suppression and wind speed reduction mitigation strategies are employed during the construction and decommissioning phases of the project.

8 REFERENCES

- ATSDR (2008): Toxicological profile for chromium. Available online at: http://www.atsdr.cdc.gov/toxprofiles/tp7.pdf.
- Cowherd et al (1998). Control of Open Fugitive Dust Sources, EPA-450/3-88-008, United States Environmental Protection Agency, Research Triangle Park, North Carolina.
- Cosijn, C., and Tyson, P.D., (1996) Stable discontinuities in the atmosphere over South Africa. S. Afr. J. of Sci. 92 381-386.
- Department of Environmental Affairs (DEA), 2014: Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa, South Africa.
- Environmental Affairs, Department of - National Environmental Management: Air Quality Act, *Act 39 of 2004*: National Ambient Air Quality Standards, published under Government Notice 1210 in Government Gazette 32816 dated 24 December 2009.
- Environmental Affairs, Department of - *National Environmental Management: Air Quality Act, Act 39 of 2004*: List of Activities Which Result in Atmospheric Emissions Which Have or May Have a Significant Detrimental Effect on the Environment, Including Health, Social Conditions, Economic Conditions, Ecological Conditions or Cultural Heritage, published under Government Notice 248 in Government Gazette 33064 dated 31 March 2010.
- Environmental Affairs, Department of - *National Environmental Management: Air Quality Act, Act 39 of 2004*: National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter less than 2.5 Micron Metres ($PM_{2.5}$), published under Government Notice 486 in Government Gazette 35463 dated 29 June 2012.
- Environmental Affairs, Department of - *National Environmental Management: Air Quality Act, Act 39 of 2004*: National Dust Control Regulations, Published under Government Notice R827 in Government Gazette 36974 dated 1 November 2013.
- Environmental Affairs, Department of - *National Environmental Management: Air Quality Act, Act 39 of 2004*: List of Activities Which Result in Atmospheric Emissions Which Have or May Have a Significant Detrimental Effect on the Environment, Including Health, Social Conditions, Economic Conditions, Ecological Conditions or Cultural Heritage, published under Government Notice 893 in Government Gazette 37054 dated 22 November 2013.
- Freiman, M. T., and Piketh, S. J. (2003). Air transport into and out of the industrial Highveld region of South Africa. Journal of Applied Meteorology, 42(7), 994-1002.
- Garstang, M., Tyson, P.D., Swap, R., Edwards, M., Kållberg, P., and Lindesay, J.A. (1996) Horizontal and vertical transport of air over southern Africa. J. Geophys. Res. 101 (D19) 23721-23736.
- Tyson, P.D., Garstang, M., and Swap, R. (1996) Large-scale recirculation of air over southern Africa. J. Appl. Meteorol. 35 2218-2236.
- Tyson, P.D. and Preston-Whyte, R.A. (2000): The Weather and Climate of Southern Africa, Oxford University Press, Southern Africa.
- United States Environmental Protection Agency (USEPA) 2011: Health Effects of Pollution, available at http://www.epa.gov/region07/air/quality/health.htm (accessed July 2013).
- United States Environmental Protection Agency (USEPA), 2006: Aggregate Handling and Storage Piles, Compilation of Air Pollution Emission Factors.

United States Environmental Protection Agency (USEPA), 1996: Compilation of Air Pollution Emission Factors (AP-42), 6th Edition, Volume 1, as contained in the *AirCHIEF (AIR Clearinghouse for Inventories and Emission Factors) CD-ROM (compact disk read only memory)*, US Environmental Protection Agency, Research Triangle Park, North Carolina. Also available at URL: http://www.epa.gov/ttn/chief/ap42/

APPENDIX

A DISPERSION MAPS

APPENDIX

Figure 8-1: **Daily average PM_{10} concentrations for Scenarios 1, 5, 6 and 7.**

APPENDIX

Figure 8-2: **Daily average PM_{10} concentrations for Scenarios 2, 3 and 4.**

APPENDIX

Figure 8-3: **Annual average PM_{10} concentrations for Scenarios 1, 5, 6 and 7.**

Figure 8-4: **Annual average PM_{10} concentrations for Scenarios 2, 3 and 4.**

APPENDIX

Figure 8-5: Hourly average SO_2 concentrations for Scenarios 1, 5, 6 and 7.

APPENDIX

Figure 8-6: **Hourly average SO_2 concentrations for Scenarios 2, 3 and 4.**

APPENDIX

Figure 8-7: Daily average SO_2 concentrations for Scenarios 1, 5, 6 and 7.

Figure 8-8: **Daily average SO_2 concentrations for Scenarios 2, 3 and 4.**

Figure 8-9: **Annual average SO_2 concentrations for Scenarios 1, 5, 6 and 7.**

Figure 8-10: Annual average SO_2 concentrations for Scenarios 2, 3 and 4.

APPENDIX

B PREVIOUS AQIA RESULTS

APPENDIX

Table 8-1: Predicted ambient PM10 and PM25 concentrations at surrounding receptors. Values highlighted in bold exceed their respective standards (WSP, 2016).

Receptor	PM_{10} concentration ($\mu g/m^3$)		$PM_{2.5}$ concentration ($\mu g/m^3$)	
	Annual average	Daily average	Annual average	Daily average
Scenario 1				
Steelpoort	4.15	31.26	0.70	4.31
Farm	10.91	44.69	2.50	7.54
Excelsus	1.66	14.81	0.33	2.78
Laerskool	1.53	14.40	0.33	2.58
Max. fenceline	32.25	**116.42**[1]	6.63	21.14
Scenario 2				
Steelpoort	0.19	1.29	0.12	0.77
Farm	0.33	1.02	0.19	0.61
Excelsus	0.10	0.45	0.06	0.27
Laerskool	0.10	0.55	0.06	0.33
Max. fenceline	1.97	5.90	1.18	3.53
Scenario 3				
Steelpoort	0.17	0.82	0.10	0.49
Farm	0.23	0.87	0.14	0.52
Excelsus	0.10	0.58	0.06	0.35
Laerskool	0.10	0.75	0.06	0.45
Max. fenceline	2.08	5.73	1.25	3.43
Scenario 4				
Steelpoort	0.66	4.07	0.40	2.43
Farm	0.45	2.66	0.27	1.59
Excelsus	0.19	1.12	0.11	0.67
Laerskool	0.17	1.17	0.10	0.70
Max. fenceline	1.24	5.56	0.74	3.33
Scenario 5				
Steelpoort	4.35	31.43	0.82	4.60
Farm	11.24	45.75	2.69	7.68
Excelsus	1.76	14.95	0.39	2.98
Laerskool	1.63	14.58	0.39	2.80
Max. fenceline	32.97	**117.09**[1]	7.06	21.76
Scenario 6				
Steelpoort	4.32	31.43	0.80	4.50
Farm	11.14	45.34	2.64	7.70
Excelsus	1.76	15.38	0.39	3.09
Laerskool	1.63	14.64	0.39	2.86
Max. fenceline	32.70	**117.47**[1]	6.90	22.56

APPENDIX

Receptor	PM_{10} concentration ($\mu g/m^3$)		$PM_{2.5}$ concentration ($\mu g/m^3$)	
	Annual average	Daily average	Annual average	Daily average
Scenario 7				
Steelpoort	4.81	31.75	1.10	5.52
Farm	11.37	45.33	2.77	7.74
Excelsus	1.84	15.14	0.44	3.15
Laerskool	1.70	14.84	0.43	2.85
Max. fenceline	32.83	**117.13[1]**	6.98	21.48

Notes:
[1]Predicted on-site where ambient air quality objectives do not apply

Table 8-2: Predicted ambient SO_2 concentrations at surrounding receptors. Values highlighted in bold exceed their respective standards (WSP, 2016).

Receptor	SO_2 Concentration ($\mu g/m^3$)		
	Annual Average	Daily Average	Hourly Average
Scenario 1			
Steelpoort	3.85	25.49	63.24
Farm	19.51	75.27	168.91
Excelsus	4.59	22.50	91.13
Laerskool	4.56	23.22	87.07
Max. fenceline	32.31	**182.52[1]**	**364.21[1]**
Scenario 2			
Steelpoort	0.20	1.35	4.08
Farm	0.34	1.07	3.98
Excelsus	0.11	0.47	2.36
Laerskool	0.10	0.57	2.22
Max. fenceline	2.07	6.19	18.11
Scenario 3			
Steelpoort	0.18	0.86	3.53
Farm	0.24	0.91	3.75
Excelsus	0.10	0.61	2.29
Laerskool	0.10	0.79	2.28
Max. fenceline	2.18	6.01	18.67
Scenario 4			
Steelpoort	0.69	4.27	10.52
Farm	0.47	2.79	7.23
Excelsus	0.20	1.17	3.80
Laerskool	0.18	1.23	3.61
Max. fenceline	1.30	5.83	16.91
Scenario 5			
Steelpoort	4.05	26.99	67.30

APPENDIX

Receptor	SO_2 Concentration ($\mu g/m^3$)		
	Annual Average	Daily Average	Hourly Average
Farm	19.85	75.50	168.92
Excelsus	2.26	22.06	46.32
Laerskool	2.65	24.12	65.48
Max. fenceline	32.85	**183.26**[1]	**364.25**[1]
Scenario 6			
Steelpoort	4.02	26.42	66.08
Farm	19.75	75.41	168.92
Excelsus	2.26	22.40	47.57
Laerskool	2.65	24.33	65.29
Max. fenceline	32.69	**183.07**[1]	**364.27**[1]
Scenario 7			
Steelpoort	4.54	29.63	73.44
Farm	19.98	77.41	169.24
Excelsus	2.35	23.21	49.17
Laerskool	2.72	24.78	67.16
Max. fenceline	33.23	**184.38**[1]	**364.35**[1]

Notes:
[1]Predicted on-site where ambient air quality objectives do not apply

APPENDIX

Table 8-3: Predicted ambient NO_2 concentrations at surrounding receptors (WSP, 2016).

Receptor	NO_2 Concentration ($\mu g/m^3$)	
	Annual Average	Hourly Average
Scenario 1		
Steelpoort	1.75	2.65
Farm	8.62	24.48
Excelsus	3.01	6.10
Laerskool	3.01	6.09
Max. fenceline	14.00	35.90
Scenario 2		
Steelpoort	0.19	0.32
Farm	0.33	0.72
Excelsus	0.10	0.18
Laerskool	0.10	0.16
Max. fenceline	1.97	5.03
Scenario 3		
Steelpoort	0.17	0.33
Farm	0.23	0.43
Excelsus	0.10	0.17
Laerskool	0.10	0.15
Max. fenceline	2.08	5.34
Scenario 4		
Steelpoort	0.66	1.42
Farm	0.45	0.78
Excelsus	0.19	0.38
Laerskool	0.17	0.29
Max. fenceline	1.24	3.01
Scenario 5		
Steelpoort	1.95	2.98
Farm	8.94	25.41
Excelsus	1.14	1.22
Laerskool	1.28	1.02
Max. fenceline	14.64	39.50
Scenario 6		
Steelpoort	1.92	3.00
Farm	8.85	25.23
Excelsus	1.13	1.19
Laerskool	1.28	1.01

APPENDIX

Receptor	NO_2 Concentration ($\mu g/m^3$)	
	Annual Average	Hourly Average
Max. fenceline	14.67	38.04
Scenario 7		
Steelpoort	2.39	4.08
Farm	9.08	25.96
Excelsus	1.22	1.43
Laerskool	1.36	1.16
Max. fenceline	14.43	38.55