POLOKWANE SMELTER SO2 ABATEMENT AIR QUALITY IMPACT ASSESSMENT

POLOKWANE, LIMPOPO

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WSP | PARSONS BRINCKERHOFF

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POLOKWANE, LIMPOPO

Anglo American Platinum Ltd

Final Report

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ABBREVIATIONS

AAP	Anglo American Platinum Ltd
AP42	Air Pollutant Emission Factors
AQIA	Air Quality Impact Assessment
C_6H_6	Benzene
CO	Carbon monoxide
EF	Emission Factor
GNR	Government Notice Regulations
MES	Minimum Emission Standards
NAAQS	National Ambient Air Quality Standards
NEMAQA	National Environmental Management: Air Quality Act (Act 39 of 2004)
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NPI	National Pollutant Inventory
O_3	Ozone
PM	Particulate matter
$PM_{2.5}$	Particulate matter smaller than 2.5 µm in diameter
PM_{10}	Particulate matter smaller than 10 µm in diameter
SO_2	Sulphur dioxide
TSP	Total Suspended Particulates
VKT	Vehicle Kilometres Travelled
US EPA	United States Environmental Protection Agency
WHO	World Health Organisation
WSP	WSP Environmental (Pty) Ltd

EXECUTIVE SUMMARY

Anglo American Platinum Limited (AAP) proposes to install sulphur dioxide (SO_2) abatement equipment at their Polokwane Smelter. Polokwane Smelter is located south of Polokwane in the Limpopo Province. The installation of an efficient SO_2 removal system is required to ensure compliance with the National Environmental Management Air Quality Act (No. 39 of 2004) (NEM:AQA) Minimum Emission Standards (MES). As such, WSP Environmental (Pty) Ltd (WSP) was appointed to undertake an Air Quality Impact Assessment (AQIA) to assess the potential impacts associated with the existing activities at Polokwane Smelter and the construction and operation of the proposed SO_2 abatement plant. Airshed Planning Professionals (Pty) Ltd (Airshed) was contracted to use the CALPUFF dispersion model to simulate ground level SO_2 concentrations, in line with previous modelling studies for the operation. As such, Airshed assessed the potential impacts of SO_2 associated with the proposed project (full report in **Appendix D**), while WSP assessed that of particulates (PM_{10} and $PM_{2.5}$).

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 were obtained from the on-site weather station for the period January 2014 to December 2016. Additionally, site-specific modelled MM5 data was sourced for the period January 2014 – December 2016. Ambient PM_{10} concentrations were obtained from Polokwane Smelter's ambient air quality monitoring network for the period January 2014 to December 2016. Airshed provided a baseline assessment of ambient SO_2 concentrations monitored from the same monitoring network at Polokwane Smelter, over the same period.

The potential impact of emissions from Polokwane Smelter were evaluated with the following scenarios;

- Scenario 1: Existing Activities;
- Scenario 2a: Construction Phase of Proposed Development (without mitigation);
- Scenario 2b: Construction Phase of Proposed Development (with mitigation);
- Scenario 3: Operational Phase of Proposed Development (proposed 80 m stack height);
- Scenario 4: Cumulative Assessment;
- Scenario 5: Operational Phase of Proposed Development (proposed 60 m stack height); and
- Scenario 6: Cumulative Assessment with proposed increase in throughput following the WSA Plant.

Impacts were quantified through the compilation of a detailed emissions inventory and subsequent dispersion modelling simulations using a Level 2 dispersion model, AERMOD (for PM_{10} and $PM_{2.5}$) and a Level 3 dispersion model, CALPUFF (for SO_2). Emission rates were provided for point sources, while fugitive particulate 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. Predicted ambient concentrations were compared against the National Ambient Air Quality Standards (NAAQS) to determine the potential for human health impacts.

BASELINE ASSESSMENT

- Meteorological data recorded by the on-site station for the period January 2014 to December 2016 had an average data recovery above 80% and is considered to be representative of the site. The period wind rose showed dominant north-easterly winds with generally moderate to fast wind speed and calm conditions of approximately 5%;

- Ambient PM_{10} concentrations were compliant with the previous daily average standard (120 µg/m^3) at all monitoring stations for the 2014 monitoring period. During 2015, daily average PM_{10} concentrations were non-compliant at the Game Farm and South Farm stations, while all other stations were compliant. All stations were compliant with the current daily average standard for 2016. Annual average PM_{10} concentrations were compliant with both the previous and current standards (50 and 40 µg/m^3, respectively) where applicable, over the monitoring period.

IMPACT ASSESSMENT

Findings of the study are presented below.

- Ambient PM_{10} concentrations are predicted to be compliant with the daily and annual average standards less than 150 m and 40 m beyond the site boundary and at all sensitive receptors for Scenarios 1, 2a, 2b, 4 and 6. Predicted PM_{10} concentrations are compliant at all receptors for Scenarios 3 and 5. Cumulative PM_{10} concentrations (Scenario 4 + measured background concentrations and Scenario 6 + measured background concentrations) are compliant with the daily and average standard at all sensitive receptors;
- Ambient $PM_{2.5}$ concentrations are predicted to be compliant with the daily and annual average standards less than 40 m and 20 m beyond the site boundary and at all sensitive receptors for Scenarios 1, 2a, 2b, 4 and 6. Predicted $PM_{2.5}$ concentrations are compliant at all receptors for Scenarios 3 and 5. Cumulative $PM_{2.5}$ concentrations could not be assessed as ambient $PM_{2.5}$ concentrations were not available.
- Ambient SO_2 concentrations are predicted to be non-compliant with the hourly and daily average standards at Farmstead 2 and Farmstead 12, although all other sensitive receptors are compliant for Scenario 1. Annual average SO_2 concentrations for Scenario 1 are compliant at all receptor locations. Predicted SO_2 concentrations are compliant with their respective standards at all sensitive receptors and over the modelling domain for all incremental (Scenarios 3 and 5) and cumulative (Scenarios 4 and 6) scenarios.

Impacts associated with the proposed plant are low, with negligible change predicted with the installation of the WSA plant and proposed increase in throughput. Cumulative particulate concentrations are deemed to be of medium impact. However, it is noted that the existing background concentrations result in double accounting for PM_{10} concentrations as existing ambient concentrations resulting from Polokwane Smelter (and other sources) are summed with model predicted concentrations.

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 PM_{10} and dust fallout monitoring is continued to assess ambient concentrations and dust fallout levels.

Air Quality Consultant

Amber Sunderland is an Environmental Consultant 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. Amber is registered as a Professional Natural Scientist with the Southern African Council for Natural Scientific Professions (SACNASP). 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 SACNASP and has over 9 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:

1 INTRODUCTION

Anglo American Platinum Limited (AAP) proposes to install sulphur dioxide (SO_2) abatement equipment at their Polokwane Smelter. Polokwane Smelter is located south of Polokwane in the Limpopo Province. The installation of an efficient SO_2 removal system is required to ensure compliance with the National Environmental Management Air Quality Act (No. 39 of 2004) (NEM:AQA) Minimum Emission Standards (MES). As such, WSP Environmental (Pty) Ltd (WSP) was appointed to undertake an Air Quality Impact Assessment (AQIA) to assess the potential impacts associated with the existing activities at Polokwane Smelter and the construction and operation of the proposed SO_2 abatement plant. Airshed Planning Professionals (Pty) Ltd (Airshed) was contracted to use the CALPUFF dispersion model to simulate ground level SO_2 concentrations, in line with previous modelling studies for the operation. As such, Airshed assessed the potential impacts of SO_2 associated with the proposed project (full report in **Appendix D**), while WSP assessed that of particulates (PM_{10} and $PM_{2.5}$).

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 were obtained from the on-site weather station for the period January 2014 to December 2016. Additionally, site-specific modelled MM5 data was sourced for the period January 2014 – December 2016. Ambient PM_{10} concentrations were obtained from Polokwane Smelter's ambient air quality monitoring network for the period January 2014 to December 2016. Airshed provided a baseline assessment of ambient SO_2 concentrations monitored from the same monitoring network at Polokwane Smelter, over the same period.

Impacts were quantified through the compilation of a detailed emissions inventory and subsequent dispersion modelling simulations using a Level 2 dispersion model, CALPUFF (for PM_{10} and $PM_{2.5}$) and a Level 3 dispersion model, CALPUFF (for SO_2). Emission rates were provided for 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. Predicted ambient concentrations were compared against the National Ambient Air Quality Standards (NAAQS) to determine the potential for human health impacts.

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**

- Compilation of an emissions inventory for identified sources of emissions;
- Dispersion modelling simulations to assess ambient, ground-level particulate and gaseous concentrations for the existing and proposed facility; and

- Comparison of predicted concentrations to applicable National standards to assess the potential for human health effects.

2 PROJECT BACKGROUND

2.1 RATIONALE

The National Environmental Management: Air Quality Act (No. 39 of 2004) requires that furnaces at metallurgical industries be operated with efficient SO_2 removal abatement systems by 01 April 2015, however Polokwane Smelter was given an extension until 01 April 2020. In order to comply with this legislation and the more stringent associated emission standards, an SO_2 abatement system needs to be installed at the Polokwane Smelter. Currently, furnace off-gas is de-dusted by a baghouse and emitted from the main furnace stack. The concentration of SO_2 gas emitted from the furnace stack is approximately 2% volume of total off-gas. Since gas scrubbing technologies are only considered viable for off-gas containing 0.2% SO_2 concentration, more suitable abatement techniques were investigated. The proposed strategy to reduce SO_2 and achieve compliance with the Minimum Emission Standards at Polokwane Smelter is the installation of a Wet Gas Sulphuric Acid (WSA) Plant. The proposed WSA plant will convert SO_2 from the furnace off-gas into commercial-grade concentrated sulphuric acid. Subsequently, the exhaust emissions from the WSA plant (containing ~ 98% reduced SO_2 concentrations) will vent to atmosphere, while commercial-grade sulphuric acid will be temporarily stored before dispatch into the commercial market. **Figure 2-1** and **Figure 2-2** illustrate the site layout of the existing and proposed facility, respectively.

Figure 2-1: Site layout of existing operations at Polokwane Smelter.

Figure 2-2: Site layout of proposed operations at Polokwane Smelter.

2.2 PROCESS DESCRIPTION

The Polokwane Smelter is an existing metallurgical industrial furnace where sulphide concentrates are smelted. Wet concentrate is received and dried in a flash drier. The dry concentrate is smelted in an electric furnace, resulting in the recovery of platinum group metals (PGMs) and other base metals. The furnace matte is then tapped, cast and crushed. The resulting furnace slag is stockpiled at a dedicated slag storage facility. The furnace off-gas is currently cooled in a forced draft cooler before entering a bag-house to remove dust from the off-gas. The off-gas is then vented into the atmosphere via a 150m tall stack. Secondary emissions are captured around the furnace matte tapping and casting area and emitted from a separate flue within the same stack structure as the primary furnace off-gas (**Figure 2-3**).

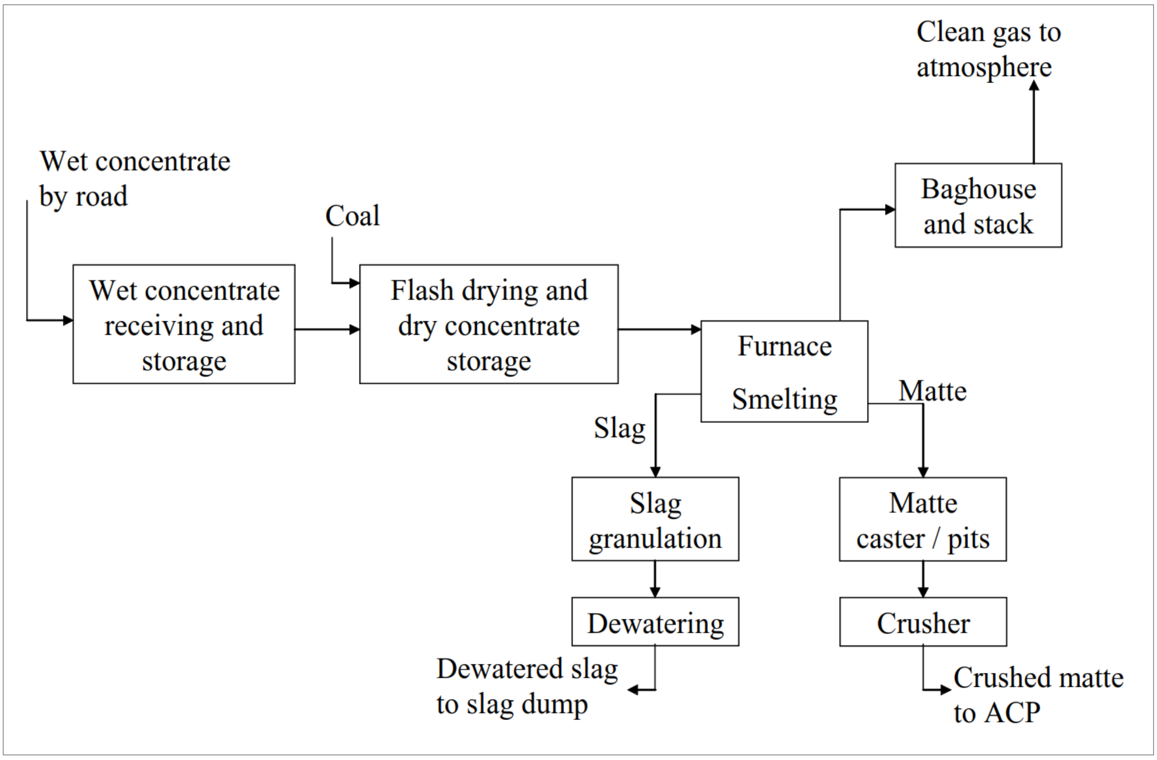

Figure 2-3: Process flow diagram of current operations at Polokwane Smelter (Hundermark and de Villiers, 2006).

3 AIR QUALITY LEGISLATION

The National Environmental Management: Air Quality Act 39 of 2004 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 NEM:AQA 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;
- GNR 486 on 29 June 2012 (Government Gazette 35463) National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter less than 2.5 micron meters (PM2.5); 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. This List of Activities has since been revised and promulgated on 22 November 2013 and forms part of GNR 893.

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 EMISSIONS CONTROL OF LISTED ACTIVITIES (POINT SOURCES)

In terms of the amended Listed Activities, Polokwane Smelter falls under Subcategory 4.1: Drying and Calcining (**Table 3-1**) and Subcategory 4.16: Smelting and Converting of Sulphide Ores (**Table 3-2**). The Minimum Emission Standards (MES) under Subcategory 4.1 has been updated (from those formerly applicable under Category 4) to account for oxides of nitrogen (NO_x) emissions. The MES under Subcategory 4.16 have not changed (from those formerly applicable under Category 4); however, the description has been updated to exclude inorganic chemicals-related activities regulated under Category 7.

Table 3-1: Subcategory 4.1 - Drying and Calcining (Government Gazette 37054, 2013).

Description:	Drying and calcining of mineral solids including ore.		
Application:	Facilities with capacity of more than 100 tons/month product.		
Substance or mixture of substances		**Plant status**	**mg/Nm³ under normal conditions of 273 Kelvin and 101.3 kPa.**
Common name	**Chemical symbol**		
Particulate matter	N/A	New	50
		Existing	100
Sulphur dioxide	SO_2	New	1000
		Existing	1000
Oxides of nitrogen	NO_X expressed as NO_2	New	500
		Existing	1200

Table 3-2: Subcategory 4.16 - Smelting and Converting of Sulphide Ores (Government Gazette 37054, 2013).

Description:	Processes in which sulphide ores are smelted, roasted calcined or converted (Excluding Inorganic Chemicals-related activities regulated under Category 7).		
Application:	All installations.		
Substance or mixture of substances		**Plant status**	**mg/Nm³ under normal conditions of 273 Kelvin and 101.3 kPa.**
Common name	**Chemical symbol**		
Particulate matter	N/A	New	50
		Existing	100
Oxides of nitrogen	NO_X expressed as NO_2	New	350
		Existing	2000
Sulphur dioxide (feed SO_2 <5% SO_2)	SO_2	New	1200
		Existing	3500
Sulphur dioxide (feed SO_2 >5% SO_2)	SO_2	New	1200
		Existing	2500

(a) The following special arrangements shall apply –
All facilities must install apparatus for the treatment of the sulphur content of the off-gasses.

3.2 AMBIENT AIR QUALITY STANDARDS

Ambient air quality standards and guidelines are specified in the NEM:AQA, SANS 69:2004 as well as SANS 1929:2005. 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 Polokwane Smelter are presented in **Table 3-3.**

Table 3-3: National Ambient Air Quality Standards.

Pollutant	Averaging Period	Concentration ($\mu g/m^3$)	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

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 or smelting of sulphur rich concentrates. 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).

5 BASELINE ASSESSMENT

5.1 LOCALITY AND STUDY AREA

Polokwane Smelter is located at the Palmietfontein site, approximately 12 km south of Polokwane, off Burgersfort Road (**Figure 5-1**). The Smelter is situated in the Limpopo Province and falls within the Lepelle-Nkumpi Local Municipality, which forms part of the greater Capricorn District Municipality.

The site falls within a rural area, with the surrounding land-use being predominantly agricultural. Small-holdings/farmsteads are located mainly to the north and south of the smelter, consisting of grass and shrub land, farming, and low-income residential areas (**Figure 5-2**).

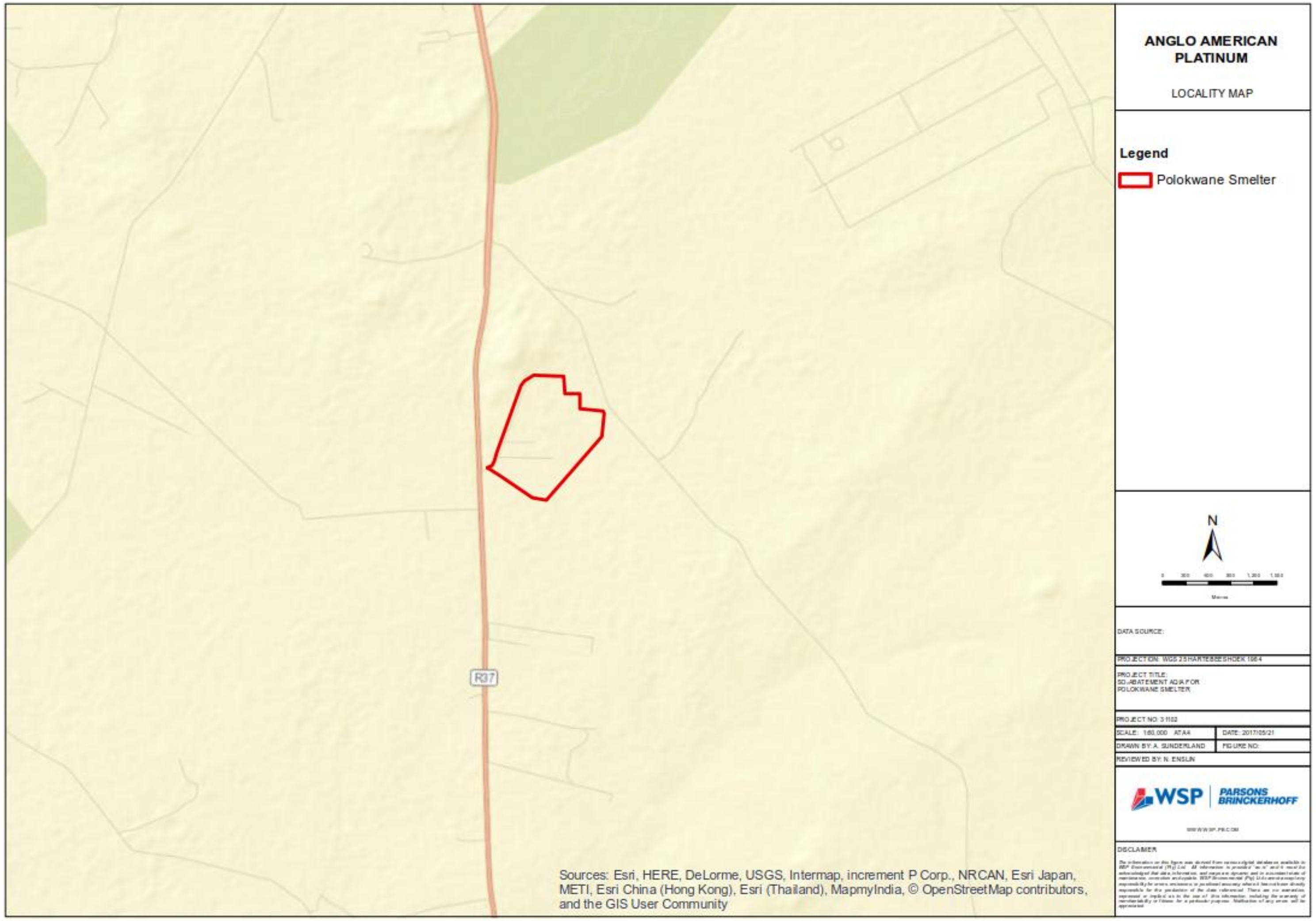

Figure 5-1: Locality map of Polokwane Smelter.

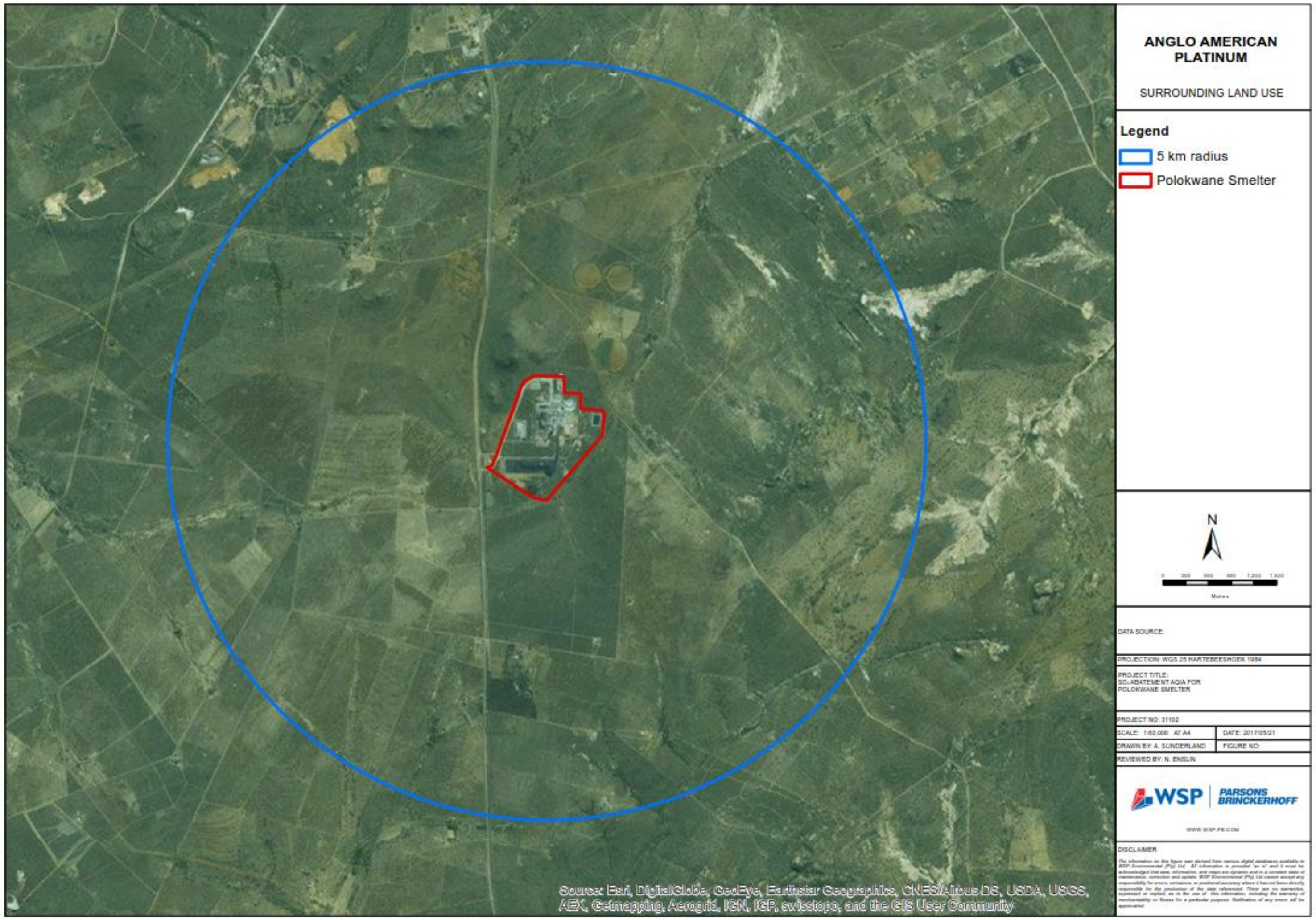

Figure 5-2: Surrounding land-use at Polokwane Smelter within a 5 km radius.

5.2 METEOROLOGICAL OVERVIEW

Meteorological variables including; wind speed, wind direction, ambient temperature and humidity, were sourced from the Polokwane Smelter on-site weather station for the period January 2014 – December 2016. This site is located on-site, and as such, is considered representative of the meteorological conditions for the area. Data recovery for meteorological variables is provided in **Table 5-1**. Site-specific modelled MM5 meteorological data was also obtained from Lakes Environmental for the period January 2014 to December 2016. The data coverage is centred over Polokwane Smelter (anemometer height of 14 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 2014 to December 2016.

Parameter	Data Recovery (%)
Wind speed	95.0
Wind direction	95.0
Temperature	81.2
Humidity	81.1

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 Polokwane Smelter on-site monitoring data for the period January 2014 to December 2016 and modelled meteorological data for the period January 2014 to December 2016. The on-site meteorological data shows dominant north-easterly winds. Wind speeds were generally moderate to fast, reaching speeds above 8 m/s. Calm conditions, which are defined as wind speeds less than 1 m/s, occur quite frequently (4.67 % of the time). For the modelled (MM5) meteorological data, dominant north-north-easterly winds occur, with frequent northerly winds also observed. Wind speeds are also moderate to fast, with calm conditions occurring 8.28 % of the time.

Diurnal variations in winds are depicted in **Figure 5-4**. On-site data shows dominant north-easterly winds occurring at all hours of the day. MM5 data shows dominant northerly winds during the early-morning and afternoon hours (00:00 – 18:00), accompanied by frequent north-north-easterly winds. However, a shift to dominant north-north-easterly winds is noted during the evening hours (18:00 – 24:00). Both datasets show moderate to fast winds, with lower wind speeds observed during the evening and early morning hours.

Seasonal variations in winds over Polokwane Smelter are depicted in **Figure 5-5**. On-site meteorological data shows that dominant north-easterly winds are maintained throughout the year. According to the MM5 data, north-north-easterly winds prevail during the spring and summer months (November – February), with a shift to dominant northerly winds during the autumn and winter months (March – August). Wind speeds are generally moderate to fast throughout the year.

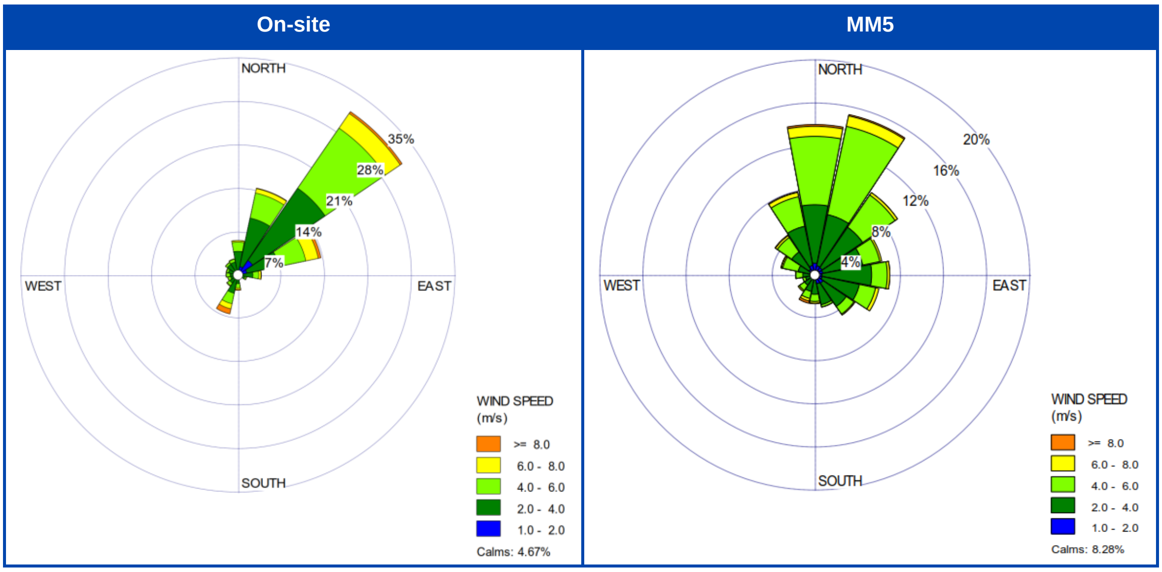

Figure 5-3: Period wind rose for Polokwane Smelter for the period January 2014 to December 2016.

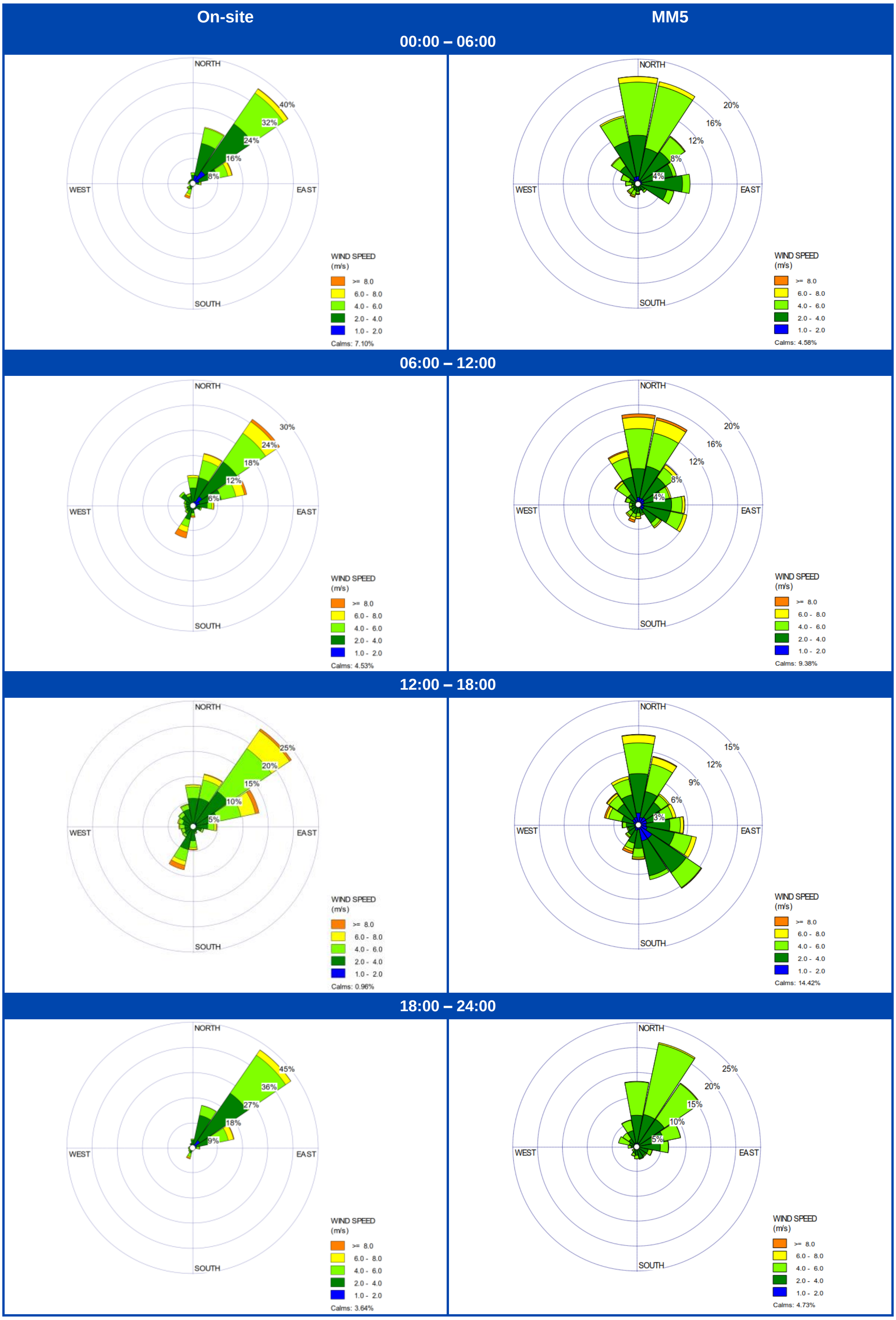

Figure 5-4: Diurnal wind roses for Polokwane Smelter for the period January 2014 to December 2016.

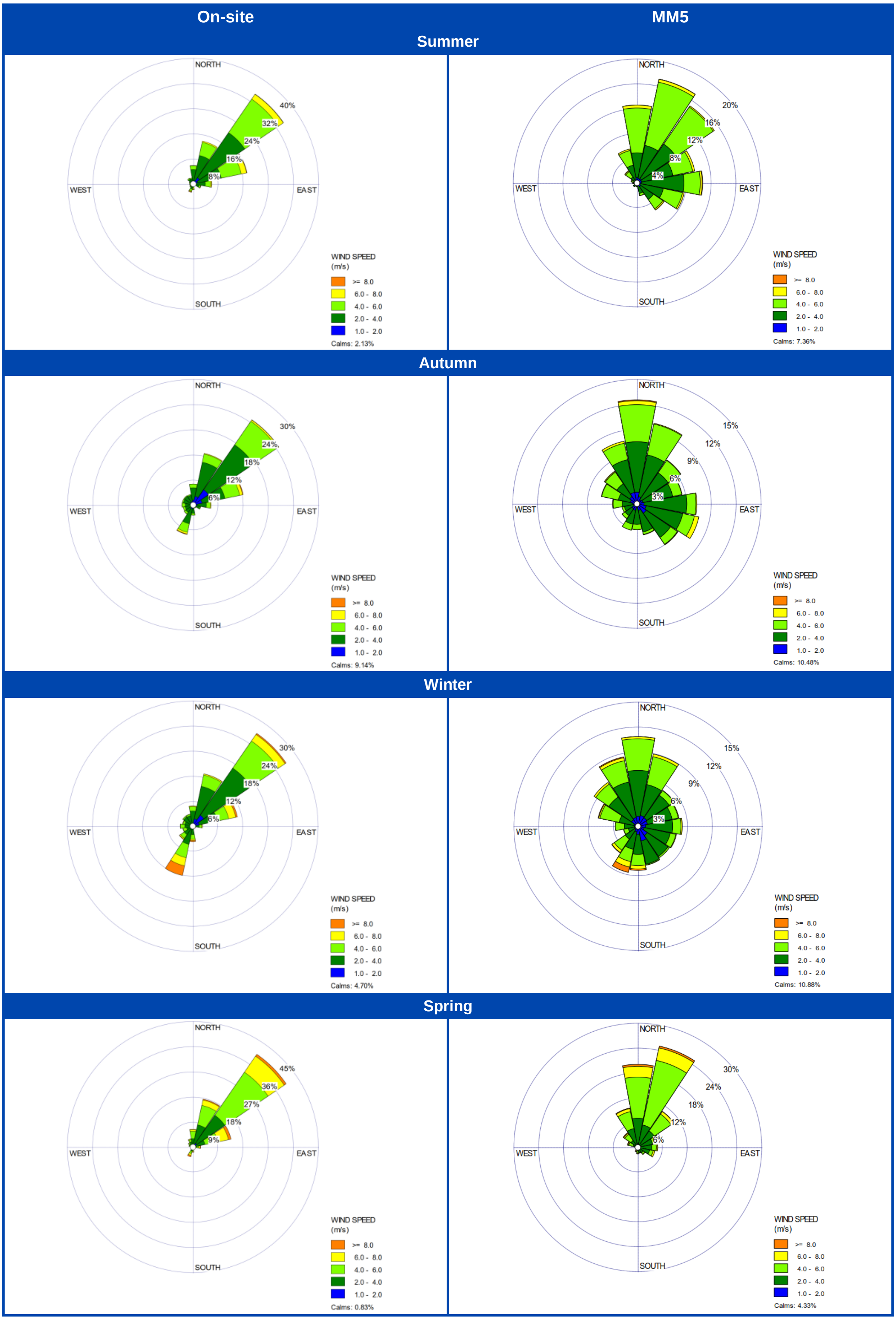

Figure 5-5: Seasonal wind roses for Polokwane Smelter for the period January 2014 to December 2016.

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 January 2014 to December 2016, average temperatures were relatively stable, with an average summer temperature of approximately 19.1 °C and an average winter temperature of around 12.5 °C (**Figure 5-6** and **Table 5-2**).

Table 5-2: Average temperatures (°C) at Polokwane Smelter (on-site) for the period January 2014 to December 2016.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	18.5	---	---	18.4	---	---	---	12.9	16.0	15.9	17.1	18.0
2015	18.6	19.3	17.1	15.7	16.1	11.2	11.9	14.8	16.0	18.8	18.7	20.8
2016	19.3	19.9	19.1	17.5	12.8	12.0	10.9	13.7	16.5	18.1	18.2	18.6

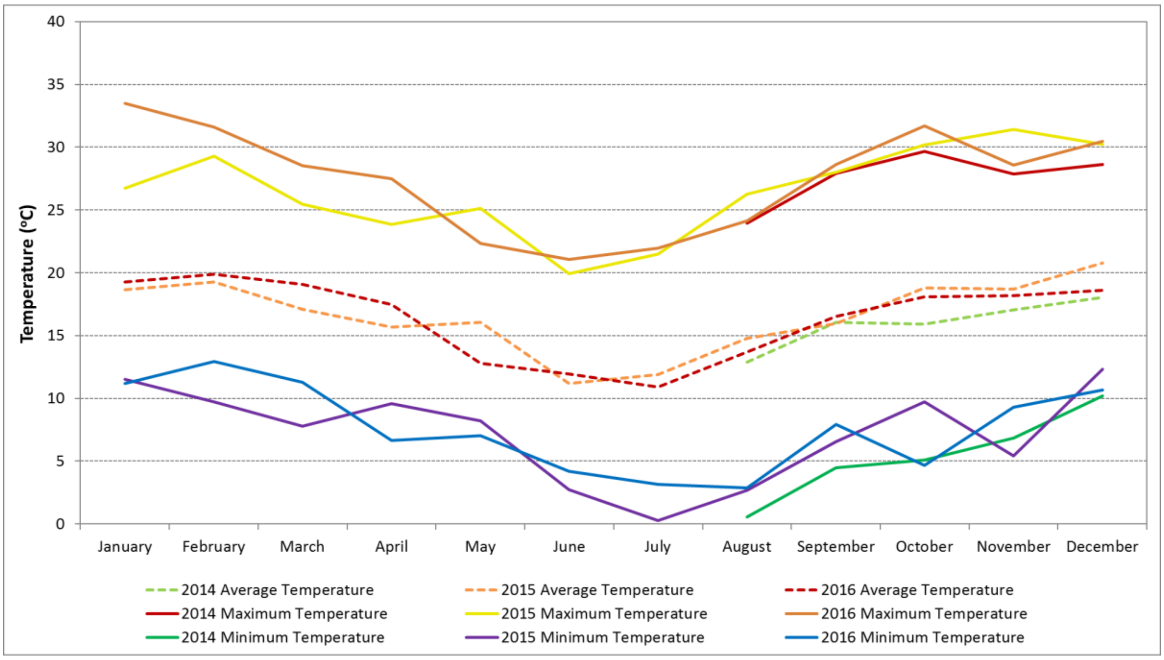

Figure 5-6: Average, maximum and minimum temperatures (°C) at Polokwane Smelter (on-site) for the period January 2014 to December 2016.

RAINFALL

Rainfall requires consideration as it represents an effective removal mechanism of atmospheric pollutants, thereby improving the air quality situation in high rainfall areas. Total monthly rainfall and average monthly humidity is illustrated in **Figure 5-7**, for the period January 2014 to December 2016.

Polokwane Smelter 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) (**Table 5-3**). Relative humidity is generally low to moderate, with an average of 48% during winter and 66% during summer.

Table 5-3: Total monthly rainfall (mm) for Polokwane Smelter for the period January 2014 to December 2016.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	70.2	52.0	200.8	54.0	1.2	0.0	0.0	0.0	0.0	37.2	77.0	523.6
2015	229.8	125.6	13.4	93.2	7.8	7.2	6.0	5.0	29.8	77.8	71.8	135.8
2016	115.2	87.4	311.2	33.2	22.2	2.0	24.8	0.0	1.6	31.8	190.2	200.2

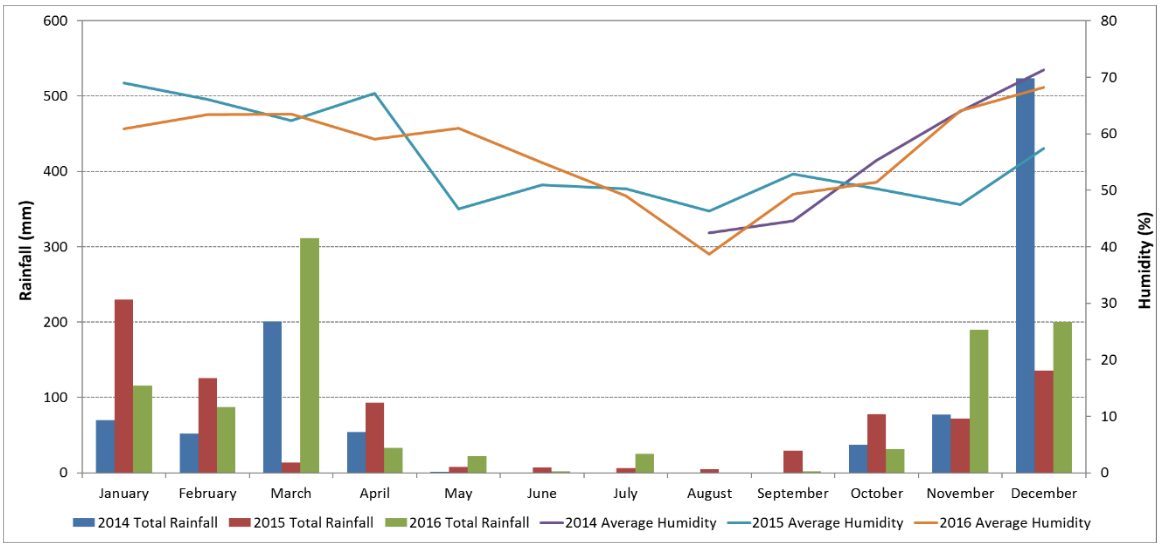

Figure 5-7: Total monthly rainfall (mm) and average monthly humidity (%) at Polokwane Smelter for the period January 2014 to December 2016.

5.3 EXISTING AMBIENT AIR QUALITY

Polokwane Smelter operates six continuous monitoring stations that record ambient PM_{10} concentrations, namely: Game Farm, North Farm, South Farm, School, Deelkraal and Kuschke. Ambient monitoring data was obtained for the period January 2014 – December 2016 and is illustrated in **Figure 5-8**.

Figure 5-8 illustrates the daily average PM_{10} concentrations for the period January 2014 to December 2016 for each of the six monitoring stations. Ambient PM_{10} concentrations were compliant with the daily average standard prescribed for the period up to 31 December 2014 (120 µg/m^3) in 2014, with less than four exceedences recorded at each of the stations. Daily average PM_{10} concentrations were non-compliant with the daily average standard prescribed as of 01 January 2015 (75 µg/m^3) at the Game Farm and North Farm monitoring stations for 2015, though compliant at all other stations for 2015 and 2016. **Table 5-4** presents the daily maximum (5th highest) and annual average PM_{10} concentrations recorded over the period, for compliance assessment. Annual average PM_{10} concentrations fell below both the annual average standards prescribed for; the period up to 31 December 2014 (previous); and as of 01 January 2015 (current) (where applicable) annual average standards of 50 and 40 µg/m^3 respectively, over the monitoring period.

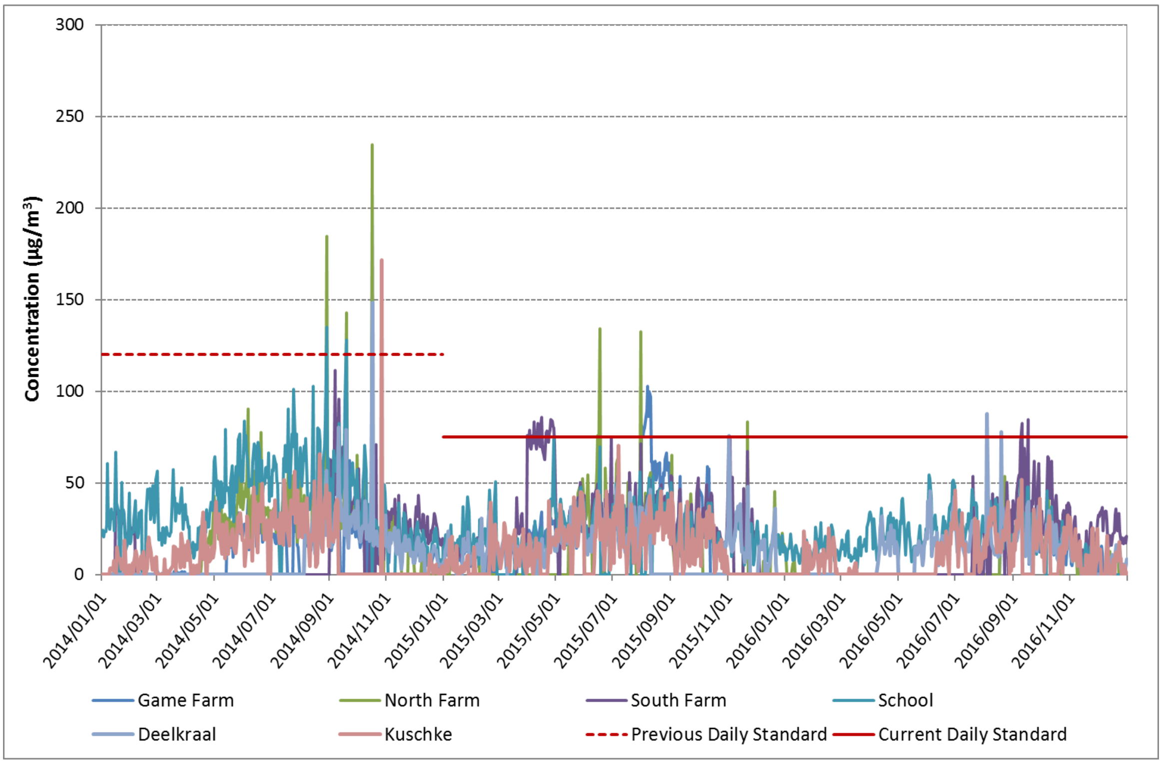

Figure 5-8: Daily average PM_{10} concentrations monitored at Polokwane Smelter for the period January 2014 – December 2016.

Table 5-4: Ambient PM_{10} concentrations at Polokwane Smelter for the period January 2014 – December 2016. Values highlighted in blue bold exceed their respective standards.

Monitoring Station	PM 10 Concentration (µg/m³)					
	Daily Maximum (5th Highest)			Annual Average		
	2014(1)	2015(2)	2016(2)	2014(1)	2015(2)	2016(2)
Game Farm	54.9 (1)	**86.4 (10)**	35.6 (0)	19.4	25.7	17.2
North Farm	77.5 (3)	65.3 (4)	45.7 (0)	32.9	29.8	20.8
South Farm	71.0 (0)	**82.7 (17)**	64.5 (2)	24.3	32.9	30.5
School	95.8 (2)	53.6 (0)	51.6 (0)	39.5	24.9	21.4
Deelkraal	46.5 (1)	46.5 (1)	42.5 (2)	22.9	19.7	18.2
Kuschke	50.9 (1)	45.3 (0)	41.0 (0)	18.9	19.5	15.2

Notes:

(1) As compared against the National standards and allowable frequency of exceedence prescribed for the period up to 31 December 2014

(2) As compared against the National standards and allowable frequency of exceedence prescribed as of 01 January 2015

(3) Number of exceedences of the daily average standard provided in brackets

Ambient SO_2 concentrations for the period January 2014 to December 2015 were obtained from the Airshed report, *Dispersion Modelling Scenarios for Polokwane Metallurgical Complex* (Reference Number: 17AAP01-02) (**Table 5-5)**. Measured SO_2 concentrations are compliant with the hourly (350 µg/m³), daily (125 µg/m³) and annual (50 µg/m³) average standards over the monitoring period.

Table 5-5: Ambient SO_2 concentrations at Polokwane Smelter for the period January 2014 – December 2015 (Airshed, 2017).

Pollutant	SO_2 Concentration (µg/m³)		
	Hourly Maximum	Daily Maximum	Annual Average
Game Farm	579 (3 & 8)	88 (0 & 0)	11
North Farm	834 (28 & 38)	152 (0 & 1)	11
South Farm	967 (46 & 83)	194 (0 & 4)	29
School	546 (1 & 1)	38 (0 & 0)	5
Deelkraal	849 (10 & 19)	111 (0 & 0)	13
Kuschke	685 (4 & 3)	82 (0 & 0)	5

Notes:

Number of exceedences of the hourly and daily average standards for 2015 and 2016 provided in brackets

6 IMPACT ASSESSMENT

6.1 EMISSIONS INVENTORY

A complete and representative 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 Polokwane Smelter 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 Polokwane Smelter were based on the following USEPA AP-42 sections: 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; 13.2.3: Heavy Construction Operations; 13.2.4: Aggregate Handling and Storage Piles; and 13.2.5: Industrial Wind Erosion. The NPI emissions estimation technique manual for Combustion Engines was used to calculate tailpipe emissions from vehicles at Polokwane Smelter. Calculations were applied to individual processes to obtain an emission to air estimate, based on information provided by the Client.

It is noted that the proposed development includes the installation of two sealed 1000 m^3 storage tanks (with vacuum vent only) for storing and exporting commercial grade sulphuric acid. Since the USEPA TANKS 4.09 Model is unable to estimate emissions for inorganic compounds, potential impacts of the proposed tanks were not quantitatively assessed.

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:

- **Scenario 1: Existing Activities (Status Quo)**
  - Contributions from the existing facility including emissions from four point sources, vehicle emissions and fugitive emissions from crushing, materials handling and storage, paved roads and wind erosion.
- **Scenario 2a: Construction Phase of Proposed Development (without mitigation)**
  - Combined assessment of existing activities together with the construction of the proposed site development.

→ **Scenario 2b: Construction Phase of Proposed Development (with mitigation)**

- Combined assessment of existing activities, as well as construction of the proposed site using wet suppression.

→ **Scenario 3: Operational Phase of Proposed Activities (80m Stack Height)**

- Incremental contributions from the proposed activities, including emissions from one point source of 80 m stack height, vehicle emissions and fugitive emissions from paved roads.

→ **Scenario 4: Cumulative Assessment (Existing + Proposed Activities)**

- Total contributions from the proposed plant including emissions from two point sources, vehicle emissions and fugitive emissions from crushing, materials handling and storage, paved roads and wind erosion.

→ **Scenario 5: Operational Phase of Proposed Activities (60m Stack Height)**

- Incremental contributions from the proposed activities, including emissions from one point source of 60 m stack height, vehicle emissions and fugitive emissions from paved roads.

→ **Scenario 6: Cumulative Assessment (Existing + Proposed Activities) with increased throughput of raw materials**

- Total contributions from the proposed plant following the WSA development and increased throughput of raw materials. Emission sources include; two point sources, vehicle emissions and fugitive emissions from crushing, materials handling and storage, paved roads and wind erosion.

WSP assessed particulate emissions for Scenarios 1 to 6, while Airshed assessed SO_2 emissions for Scenarios 1, 3, 4, 5 and 6.

CONSTRUCTION

Heavy construction is a source of dust emissions that can have a substantial temporary impact on the local air quality situation. Emissions during construction are associated with land clearing, drilling and blasting, ground excavation and cut and fill operations. Due to the absence of detailed information regarding specific construction activities during the construction phase, emissions were conservatively assumed to result from all of the above activities associated with construction. Dust emissions often vary substantially on a daily basis, depending on the level of activity, the specific operations and the prevailing meteorological conditions. A large portion of the emissions results from equipment traffic over temporary roads at the construction site (US EPA, 1995).

Construction consists of a series of different operations, each with its own duration and potential for dust generation. Construction operations are of a temporary nature, with a definable beginning and end. Dust emissions vary substantially over different phases of the construction process (US EPA, 1995).

It is expected that fugitive dust emissions will result from the construction of new infrastructure associated with the proposed project. Fugitive dust emissions were estimated using the US EPA emission factor for heavy construction activities, for Scenarios 2a and 2b. The emission factor for construction operations is given as:

$$E = 2.69\ Mg/Ha/month\ of\ activity$$

The PM_{10} fraction was conservatively assumed to be 50% of Total Suspended Particulates (TSP), while $PM_{2.5}$ was assumed to comprise 75% of PM_{10}. The emission factor is most applicable to construction operations with (i) medium activity levels, (ii) moderate silt contents and (iii) semi-arid climates. Construction activities were assumed to take place over a period of 24 months for nine hours per day and seven days per week. While mitigation measures were not applied in Scenario

2a, dust emissions were assumed to have a control efficiency of 50% (for water sprays) in Scenario 2b (NPI, 2012). The estimated source parameters and emission rates are provided in **Table 6-1** and **Table 6-2**. Only the construction of the WSA plant area was quantitatively assessed (**Figure 6-1**).

Table 6-1: Source parameters for construction activities at Polokwane Smelter.

Source Parameter	Construction Area
Area (m^2)	21,000
Operational hours per day	9
Control efficiency (%)	50*

*Scenario 2b only

Table 6-2: Emission rates for construction activities at Polokwane Smelter.

Source Parameters	Emission rate (g/s)	
	PM_{10}	$PM_{2.5}$
Scenario 2a – Construction Phase of Proposed Development without mitigation		
WSA construction area	2.86	2.13
Scenario 2b – Construction Phase of Proposed Development with mitigation		
WSA construction area	1.43	1.07

Figure 6-1: Proposed construction area at Polokwane Smelter.

STACK EMISSIONS

Point sources were assessed in terms of the following scenarios:

- Scenario 1: Assessed existing impacts from the existing main furnace stack (MF), secondary furnace stack (SF), flash dryer stack 1 (FD1) and flash dryer stack 2 (FD2);
- Scenario 3: Assessed the incremental point source contributions from the proposed WSA stack with a height of 80 m;
- Scenario 4: Assessed cumulative point source emissions from the SF, FD1, FD2 and WSA stacks for the proposed plant;
- Scenario 5: Assessed the incremental contributions from the proposed WSA stack with a height of 60 m rather than 80 m (as originally proposed); and
- Scenario 6: Assessed cumulative point source emissions from the SF, FD1, FD2 and WSA stacks for the proposed plant, following a 15% increase in raw material throughput.

Physical characteristics and emission rates for all point sources were provided by the Client, obtained from the stack emissions test report (SGS, 2012), and the Atmospheric Emissions License (AEL) (**Table 6-3** and **Table 6-4**). Particulate and SO_2 emissions were assumed to equal the MES for Subcategory 4.16: Smelting and Converting of Sulphide Ores (Government Gazette 893, 2013) for the proposed WSA stack. PM_{10} emissions were assumed to comprise 100% of total particulate emissions, while $PM_{2.5}$ emissions were assumed to be 60% of total particulates, for all point sources (Ehrlich *et al.*, 2007). Airshed (2017) made use of the SO_2 emission rates provided in **Table 6-5** to assess each of the applicable scenarios using the CALPUFF model.

Table 6-3: Source parameters for point sources.

Source	X (UTM 35S)	Y (UTM 35S)	Stack height (m)	Stack diameter (m)	Gas exit velocity (m/s)	Gas temperature (°C)
Scenario 1, 2a and 2b						
MF	751080	7340358	155	1.8	12.6	152
Scenario 1, 2a, 2b, 4 and 6						
SF	751078	7340366	155	2.4	27.2	24.4
FD1	750972	7340584	50	2	16.4	110
FD2	750932	7340584	50	2	15.1	110
Scenario 3, 4 and 6						
WSA Stack	751259	7340390	80	1.6	7.1	80
Scenario 5						
WSA Stack	751259	7340390	60	1.6	7.1	80

Table 6-4: Particulate emission rates for point sources.

Source	Emission rate (g/s)	
	PM_{10}	$PM_{2.5}$
Scenario 1, 2a and 2b		
MF	4.1	2.5
Scenario 1, 2a, 2b, 4 and 6		
SF	5.3 (6.0)	3.2 (3.6)
FD1	0.9 (1.0)	0.5 (0.6)
FD2	1.8 (2.1)	1.1 (1.2)
Scenario 3, 4, 5 and 6		
WSA Stack	0.7	0.4

*Increased emission rate associated with Scenario 6

Table 6-5: SO_2 emission rates for point sources (Airshed, 2017).

Source	Emission rate (g/s) SO_2
Scenario 1	
MF	395.8
Scenario 1 and 4	
SF	0.1
FD1	26.6
FD2	19.7
Scenario 3, 4 and 5	
WSA Stack	17.0
Scenario 6	
WSA Stack	17.0 15% increase in flash drier and secondary stack emissions

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:

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

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

Where:
E = particulate emission factor (g/VKT)
sL = road surface silt loading
W = average weight

The layout of the roads is shown in **Figure 6-2** with the source parameters for the existing and proposed paved roads at Polokwane Smelter given in **Table 6-6**. All vehicles pass in and out of the plant through the delivery road. Coal and concentrate are delivered via the delivery road and deposited at the coal bunker and concentrate pad, respectively. Crushed matte is exported by truck via the matte road. Lime is to be delivered, and sulphuric acid exported, via the proposed acid and lime road. Following the development of the proposed WSA plant, vehicle kilometres travelled (VKT) along the delivery road will increase due to the transfer of lime and acid on and off site. As such, the proposed delivery road accounts for the increase in VKT following the proposed development (**Figure 6-2**).

Scenarios 1, 2a and 2b assessed the impacts associated with existing roads on-site. Scenarios 3 and 5 assessed incremental contributions from the proposed acid and lime road, and proposed delivery road. Scenarios 4 and 6 assessed the cumulative contributions from the proposed delivery road in place of the existing delivery road, all other existing roads, and the proposed acid and lime road. Fugitive emissions from paved roads were assumed to remain constant for Scenario 6.

Potential fugitive emissions along paved roads were calculated using the above equation and are provided in **Table 6-7**. Emissions along the existing paved roads were assumed to be continuous, while the proposed acid and lime road was assumed to be utilised daily between the hours of 08:00 – 17:00. The number of vehicles travelling per day was provided by the Client. The loaded vehicle weights (for each material delivery truck) were assumed to be the same as those for Polokwane Smelter, as this data was unavailable. Proposed acid and lime trucks were given a loaded weight of 32 tonnes, with two acid trucks and one lime truck travelling on-site per day (as provided by the Client). The default USEPA road surface silt content of 8.2 g/m^2 (for a quarry) (USEPA, 2011) was applied. Since fugitive emissions along paved roads are mitigated with sweepers, emissions were assumed to be controlled with an efficiency of 40% (Chang-Tang *et al.*, 2012).

Figure 6-2: Layout of roads at Polokwane Smelter.

Table 6-6: Source parameters for paved roads.

Source	Scenarios 1, 2a and 2b	Scenarios 1, 2a, 2b, 4 and 6		Scenarios 3, 4, 5 and 6	
	Delivery Road	Coal and Concentrate Road	Matte Road	Proposed Acid and Lime Road	Proposed Delivery Road
Width (m)	10	10	10	10	10
Length (m)	1,818	187	346	838	1,818
Area (m^2)	18,177	1,866	3,455	8,376	18,177
Silt (g/m^2)	8.2	8.2	8.2	8.2	8.2
Average loaded vehicle weight (T)	50	53	46	32	50 (32)*
VKT/day	345	12	10	5	356 (11)*
Operational hours per annum	8,760	8,760	8,760	3,285	8,760
Control efficiency (%)	40	40	40	40	40

*Incremental Weight/VKT for proposed delivery road (three lime and acid trucks) for Scenarios 3 and 5.

Table 6-7: Emission rates for wheel entrainment on paved roads.

Pollutant	Emission Rate (g/s)	
	PM_{10}	$PM_{2.5}$
Scenarios 1, 2a and 2b		
Delivery Road	0.900	0.218
Scenarios 1, 2a, 2b, 4 and 6		
Coal and Concentrate Road	0.033	0.008
Matte Road	0.025	0.006
Scenarios 3, 4, 5 and 6		
Proposed Delivery Road	0.938 (0.018)*	0.227 (0.004)*
Proposed Acid and Lime Road	0.022	0.005

*Incremental contributions from proposed delivery road (three lime and acid trucks) for Scenarios 3 and 5.

VEHICULAR 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 6-8**). The above equation was used to calculate vehicle exhaust emissions from trucks travelling along roads on-site for all scenarios. Physical parameters of each of the roads are provided in **Table 6-6** and **Table 6-7**. 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).

Table 6-8: Emission rates for vehicle tailpipe emissions.

Source	Emission Rate (g/s)	
	PM_{10}	$PM_{2.5}$
Scenarios 1, 2a and 2b		
Delivery Road	1.9E-03	1.8E-03
Scenarios 1, 2a, 2b, 4 and 6		
Coal and Concentrate Road	6.6E-05	6.1E-05
Matte Road	5.8E-05	5.3E-05
Scenario 3, 4, 5 and 6		
Proposed Delivery Road	2.0E-03 (6.1E-05)*	1.8E-03 (5.6E-05)*
Proposed Acid and Lime Road	7.4E-05	6.8E-05

*Incremental contributions from proposed delivery road (three lime and acid trucks) for Scenarios 3 and 5.

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. Since point source parameters of the crusher baghouse stack were unknown, crushers were modelled as a volume source (**Figure 6-3**).

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 6-9**). The crushers are equipped with a baghouse of approximately 99% control efficiency (USEPA, 1982). Emissions from the primary and secondary crushers were assessed in Scenarios 1, 2a, 2b, 4 and 6 for baseline and cumulative impacts. Source characteristics are provided in **Table 6-10** with emission rates in **Table 6-11**.

Table 6-9: Emission factors for crushing and screening activities (kg/Ton of material processed).

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

Table 6-10: Source characteristics for primary and secondary crusher.

Parameter	Primary and Secondary Crusher
X – coordinate (UTM 35S)	750858
Y – coordinate (UTM 35S)	7340517
Height at release (m)	3
Length (m)	3
Width (m)	3
Operational hours per annum	4,380
Annual throughput (T)	52,560 (57,000)*
Emissions control	Baghouse
Abatement efficiency (%)	99

*Increased throughput for Scenario 6

Table 6-11: Emission rates for crushers.

Source	Emission Rate (g/s)	
	PM_{10}	$PM_{2.5}$
Scenarios 1, 2a, 2b, and 4		
Primary Crusher	0.00067	0.00004
Secondary Crusher	0.00004	0.00004
Scenario 6		
Primary Crusher	0.00072	0.00004
Secondary Crusher	0.00004	0.00004

Figure 6-3: Location of fugitive sources at Polokwane Smelter.

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 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, because 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:

$$E_{TSP} = 0.74 \times 0.0016 \times \left(\frac{U}{2.2}\right)^{1.3} \times \left(\frac{M}{2}\right)^{-1.4} kg/ton$$

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

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

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

The particle size multiplier varies with aerodynamic particle sizes and is given as a fraction of TSP. For PM_{30} the fraction is 74%, with 35% of TSP given to be equal to PM_{10}, and the $PM_{2.5}$ fraction is 11% of TSP (USEPA, 2006). Moisture contents of 15, 2.8 and 2.5% were given to concentrate aggregate, coal and matte respectively. A mean wind speed of 3.72 m/s (calculated from on-site meteorological data for 2016) was applied.

Physical parameters and calculated emission rates for materials handling are given in **Table 6-12**. Scenario 1, 2a, 2b and 4 assessed fugitive emissions from all existing sources, while Scenario 6 assessed fugitive emissions from all existing sources with the proposed 15% increase in throughput. Since all materials handling and storage associated with the proposed WSA plant is entirely pneumatic and enclosed, fugitive emissions associated with the WSA plant were not assessed further. Currently, concentrate aggregate is deposited on the concentrate pad before transferred via front-end-loader (FEL) to the blending warehouse. Though surplus concentrate stockpiles are stored on-site, this is temporary storage and not part of normal operating conditions. At the blending warehouse, concentrate is blended and dropped to the underground conveyor for transfer to the storage silos. Thereafter, concentrate is pneumatically transferred to the dryers, storage silos and furnace. Coal is deposited at the coal bunker, where it drops to the underground conveyor. The coal passes through a screening process and is conveyed to an enclosed storage silo. Coal is then pneumatically transferred from the storage silo to the dryers. Furnace slag undergoes a wet granulation process and is conveyed to a silo before transported to the slag dump via FEL. Since the slag is wet throughout this process, material transfer of slag was not assessed further. Finally, crushed matte is pneumatically transferred to a sealed storage silo, where it is dispensed into export trucks for sales.

Control measures are taken for most of the materials handling and storage activities mentioned above. Source details are provided in **Table 6-12**, while locations for each of the volume sources are provided in **Figure 6-3**.

Table 6-12: Source parameters for materials handling

Source	Material	X (UTM 35S)	Y (UTM 35S)	Length x Width	Height	Control efficiency (%)	Throughput (Tons/annum)
Scenarios 1, 2a, 2b, and 4							
Delivery to & from concentrate pad	Concentrate	751297	7340725	3 x 3	3	-	700,800
Blending warehouse	Concentrate	751287	7340678	33 x 33	5	Enclosure (90%)	700,800
Transfer to underground conveyor	Concentrate	751287	7340678	3 x 3	3	Enclosure (90%)	700,800
Transfer to storage silo	Concentrate	750961	7340680	3 x 3	3	Enclosure (90%)	700,800
Coal bunker	Coal	751129	7340703	3 x 3	3	Enclosure (90%)	35,000
Screening and conveying	Coal	751050	7340705	3 x 3	3	Enclosure (90%)	35,000
Transfer to storage silo	Coal	751057	7340560	3 x 3	3	Enclosure (90%)	35,000
Crushed matte to truck (export)	Matte	750904	7340533	3 x 3	3	Enclosure (90%)	120,000
Scenario 6							
Delivery to & from concentrate pad	Concentrate	751297	7340725	3 x 3	3	-	760,000
Blending warehouse	Concentrate	751287	7340678	33 x 33	5	Enclosure (90%)	760,000
Transfer to underground conveyor	Concentrate	751287	7340678	3 x 3	3	Enclosure (90%)	760,000
Transfer to storage silo	Concentrate	750961	7340680	3 x 3	3	Enclosure (90%)	760,000
Coal bunker	Coal	751129	7340703	3 x 3	3	Enclosure (90%)	40,250
Screening and conveying	Coal	751050	7340705	3 x 3	3	Enclosure (90%)	40,250
Transfer to storage silo	Coal	751057	7340560	3 x 3	3	Enclosure (90%)	40,250
Crushed matte to truck (export)	Matte	750904	7340533	3 x 3	3	Enclosure (90%)	138,000

Table 6-13: Emission rates for materials handling

Source	Material	Emission Rate (g/s)	
		PM_{10}	$PM_{2.5}$
Scenarios 1, 2a, 2b and 4			
Delivery to & from concentrate pad	Concentrate	9.8E-04	1.5E-04
Blending warehouse	Concentrate	2.9E-04	4.4E-05
Transfer to underground conveyor	Concentrate	2.9E-04	4.4E-05
Transfer to storage silo	Concentrate	1.5E-04	2.2E-05
Coal bunker	Coal	7.7E-05	1.2E-05
Screening and conveying	Coal	7.7E-05	1.2E-05
Transfer to storage silo	Coal	7.7E-05	1.2E-05
Crushed matte to truck (export)	Matte	3.1E-04	4.7E-05
Scenario 6			
Delivery to & from concentrate pad	Concentrate	3.2E-03	4.8E-04
Blending warehouse	Concentrate	3.2E-04	4.8E-05
Transfer to underground conveyor	Concentrate	3.2E-04	4.8E-05
Transfer to storage silo	Concentrate	1.6E-04	2.4E-05
Coal bunker	Coal	8.8E-05	1.3E-05
Screening and conveying	Coal	8.8E-05	1.3E-05
Transfer to storage silo	Coal	8.8E-05	1.3E-05
Crushed matte to truck (export)	Matte	3.6E-04	5.4E-05

FUGITIVE BUILDING EMISSIONS

Fugitive building emissions from casting and tapping were calculated for Scenarios 1, 2a, 2b and 4, using the USEPA AP-42 emission factors for Iron and Steel Production (**Table 6-14**) (**Figure 6-3**). Emission factors for Charging, Tapping and Slagging controlled by direct shell evacuation (0.0163 kg/t for PM_{10} and 0.0159 kg/t for $PM_{2.5}$) were used to calculate the mass (kg) of TSP per (tonne) of platinum concentrate smelted. Though developed for iron and steel production processes, the emission factors were assumed representative of platinum smelting operations in the absence of a specific platinum emission factor. A control efficiency of 90% was applied due to the enclosure of the warehouse limiting emissions (NPI, 2008).

Table 6-14: Fugitive building source parameters for Scenarios 1, 2a, 2b, 4 and 6.

Source Parameters	Furnace Building
X – coordinate (UTM 35S)	750945
Y – coordinate (UTM 35S)	7340440
Height (m)	8
Length (m)	45
Throughput (tonnes/annum)	700,800 (760,000)*
*increased throughput for Scenario 6	

Table 6-15: Fugitive building emission rates for Scenarios 1, 2a, 2b and 4.

Source	Emission Rate (g/s)	
	PM_{10}	$PM_{2.5}$
Scenario 1, 2a, 2b and 4		
Furnace Building	0.036	0.035
Scenario 6		
Furnace Building	0.039	0.038

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 that 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 equation (USEPA, 1998):

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

Emission rates were applied to the concentrate pad and slag dump for Scenarios 1, 2a, 2b and 4 (**Figure 6-4**). $PM_{2.5}$ emissions were assumed to equal 15% of PM_{10} (USEPA, 2006). Due to the high moisture content of platinum concentrate, and the wet granulation process of slagging, a 50% control efficiency for wet sprays was applied (NPI, 2012). Emission rates for wind erosion are provided in **Table 6-17**).

Table 6-16: Source parameters for open areas subject to wind erosion.

Source	Height (m)	Area (m^2)
Scenario 1, 2, 3 and 5		
Slag Dump	3	116,105
Concentrate pad	3	11,591

Table 6-17: Emission rates for wind erosion.

Source	Emission rate (g/s)	
	PM_{10}	$PM_{2.5}$
Scenario 1, 2, 3 and 5		
Slag dump	0.325	0.049
Concentrate pad	0.032	0.005

Figure 6-4: Sources of wind erosion at Polokwane Smelter.

SUMMARY OF EMISSIONS

A summary of percent contributions (calculated based on total emissions (tons/annum) for all identified sources associated with Scenario 1, 4 and 6 are illustrated in **Figure 6-5** - **Figure 6-7**. Point sources are the only source of SO_2 for each model scenario.

Point sources are currently the main source of PM_{10} and $PM_{2.5}$ emissions (**Figure 6-5**). Fugitive emissions from paved roads are the second highest contributors of PM_{10} and $PM_{2.5}$ emissions (7 and 3%, respectively), with wind erosion being the third highest contributor (3 and 0.7%, respectively). Particulate emissions associated with vehicles, crushing, aggregate handling and stockpiles are comparatively insignificant.

Following the proposed development (WSA plant), point sources continue to be the main source of PM_{10} and $PM_{2.5}$ emissions (**Figure 6-6**). Though fugitive PM_{10} and $PM_{2.5}$ contributions from fugitive paved roads (10 and 4%, respectively) and vehicles (0.02 and 0.04%, respectively) are slightly higher, the distribution remains similar to that of Scenario 1. Fugitive particulate emissions associated with vehicles, crushing, aggregate handling and stockpiles remain relatively insignificant. With the proposed increase in throughput of raw materials, there is a slight increase in emissions from crushing and materials handling, though this change is negligible (**Figure 6-7**)

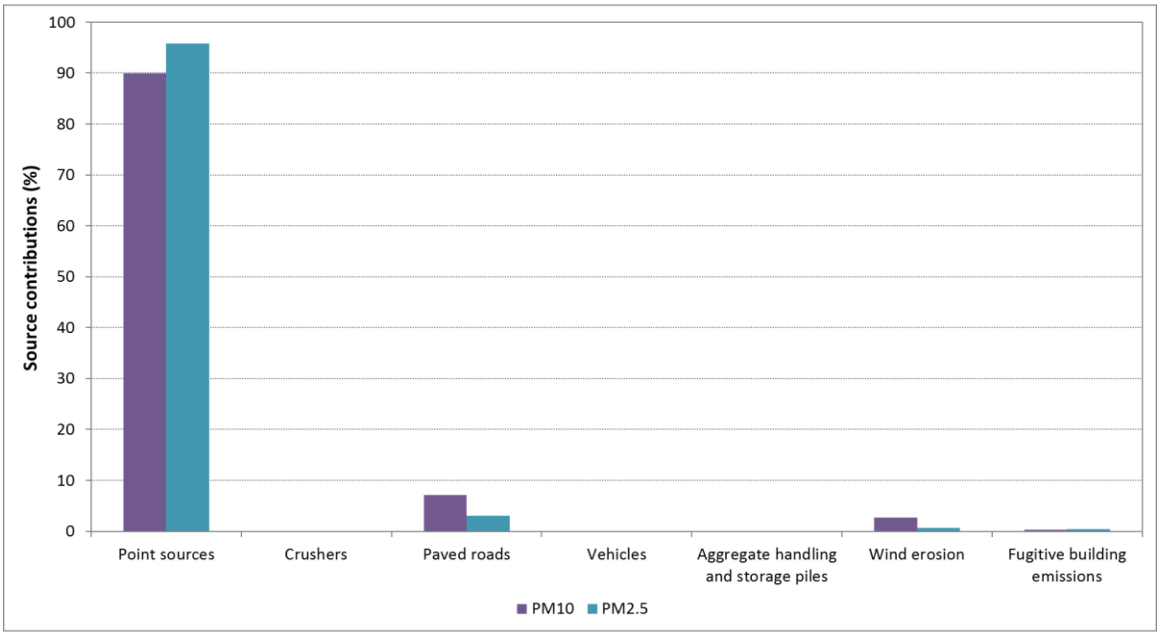

Figure 6-5: Source contributions (%) to total emissions for Scenario 1 - Existing Activities.

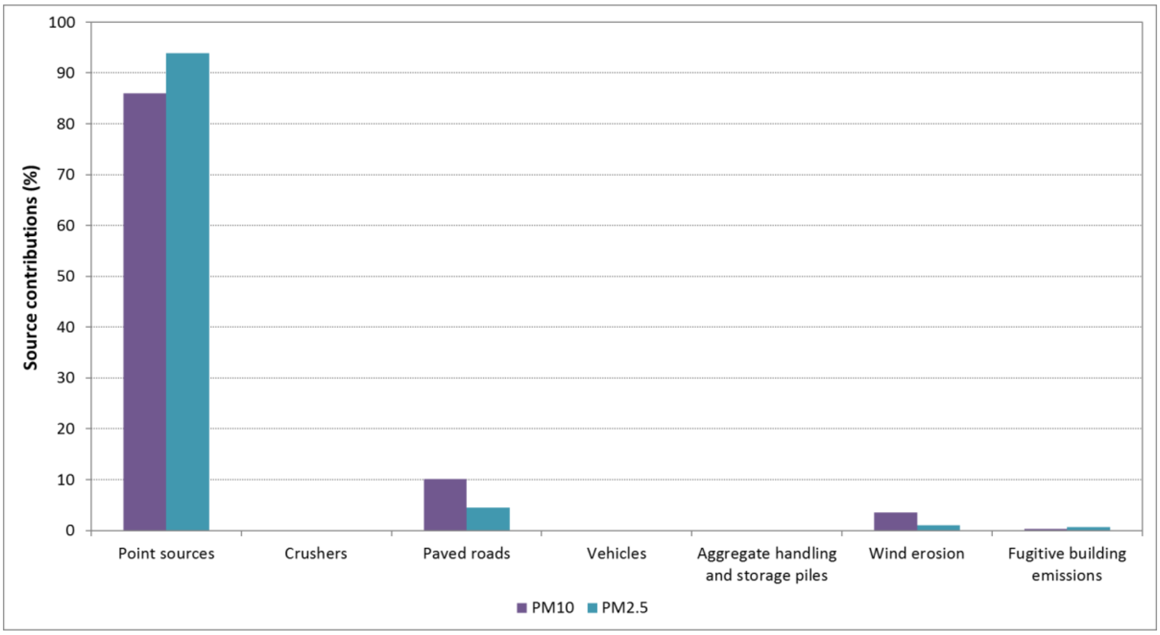

Figure 6-6: Source contributions (%) to total emissions for Scenario 4 – Cumulative Assessment of proposed plant.

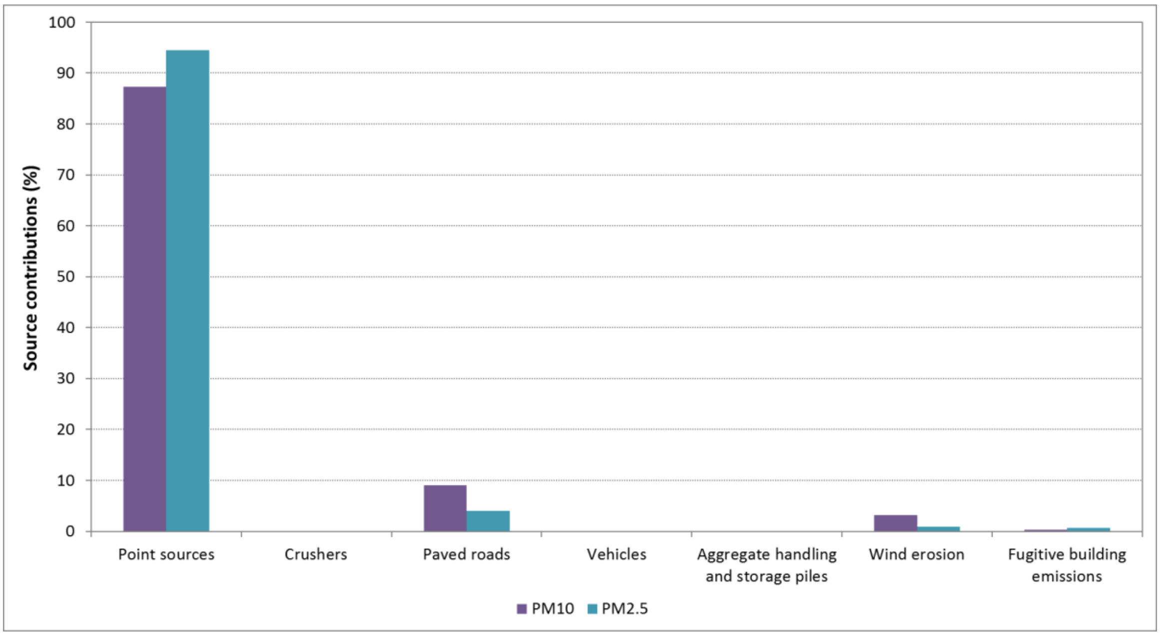

Figure 6-7: Source contributions (%) to total emissions for Scenario 6 – Cumulative Assessment of proposed plant (with increased throughput).

6.2 ASSUMPTIONS AND LIMITATIONS

The assumptions and limitations of this study are provided below:

- Modelled MM5 meteorological data was assumed to be representative of the study area;
- Due to the lack of appropriate emission factors, particulate stack emissions were assumed to have an increase of 15%, corresponding to the proposed increase in throughput for Scenario 6;
- Emission factors for charging, tapping and slagging from an electric arc furnace for iron and steel production were assumed to be applicable to Polokwane Smelter's production operations;
- PM_{10} emissions from point sources were assumed to comprise 100% TSP, while $PM_{2.5}$ emissions were assumed to be 60% TSP (Ehrlich *et al.*, 2007); and
- Cumulative impacts associated with $PM_{2.5}$ concentrations were not assessed as background concentrations were unavailable; and
- Cumulative impacts were assessed by summing predicted concentrations with background concentrations. This has the limitation of double accounting for ambient PM_{10} concentrations resulting from Polokwane Smelter, as existing ambient concentrations resulting from Polokwane Smelter (and other sources) are summed with model predicted concentrations.

6.3 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.

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 99^{th} percentile concentration for hourly and daily averaging periods (where applicable).

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 2014 – December 2016 (**Figure 6-8**). All meteorological data variables had a 100% data recovery for the monitoring period.

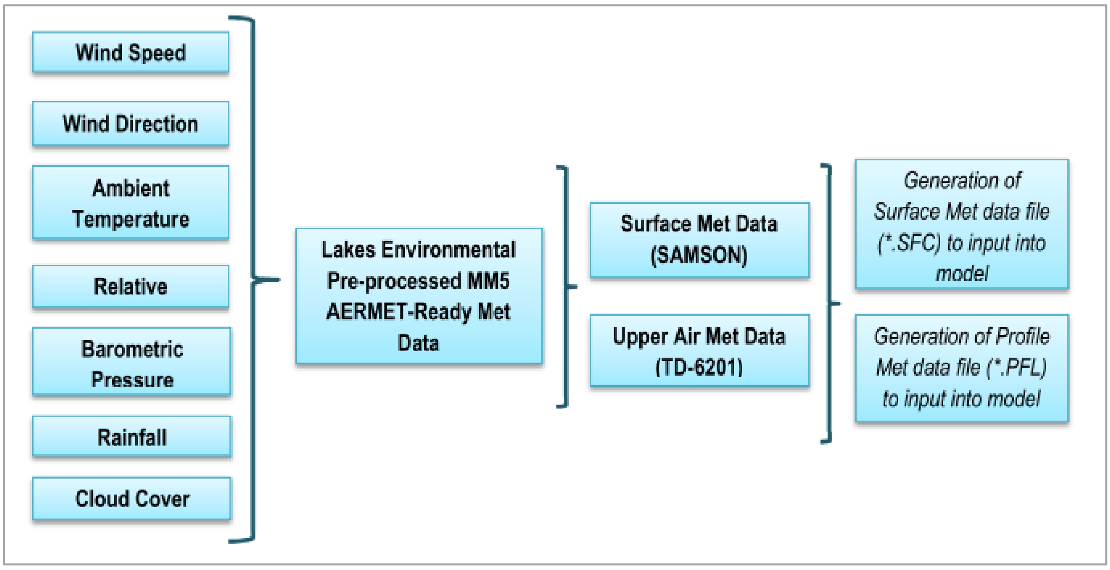

Figure 6-8: Meteorological data path.

MODEL DOMAIN

A modelling domain of 5 km × 5 km was used (**Table 6-18**), 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 site boundary.

Table 6-18: Model domain coordinates.

Domain Point	X (UTM 35S)	Y (UTM 35S)
North-eastern corner	756132	7345474
South-western corner	745534	7335210

SENSITIVE RECEPTORS

Receptors are identified as areas that may be impacted negatively due to emissions from Polokwane Smelter. 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 Polokwane Smelter are presented in **Table 6-19** and **Figure 6-9**. These areas are identified as small farmsteads or plots that are located in close proximity to the smelter.

Table 6-19: Location of receptors surrounding Polokwane Smelter.

Receptor	X (UTM 35S)	Y (UTM 35S)	Direction from Site Boundary	Distance from Site Boundary (km)
Farmstead 1	752192	7342051	NE	1.4
Farmstead 2	750961	7341652	N	0.6
Farmstead 3	750524	7342817	NNW	1.8
Farmstead 4	750717	7337503	S	1.9
Farmstead 5	750140	7337487	SSW	2.1
Farmstead 6	749457	7338834	SW	1.3
Farmstead 7	747681	7339104	SW	2.6
Farmstead 8	749367	7344349	NW	3.6
Farmstead 9	750192	7344492	NNW	3.5
Farmstead 10	752345	7336274	SSE	3.4
Farmstead 11	751608	7336334	SSE	3.1
Farmstead 12	751684	7341584	NNE	0.8
Farmstead 13	751601	7337592	SSE	1.9

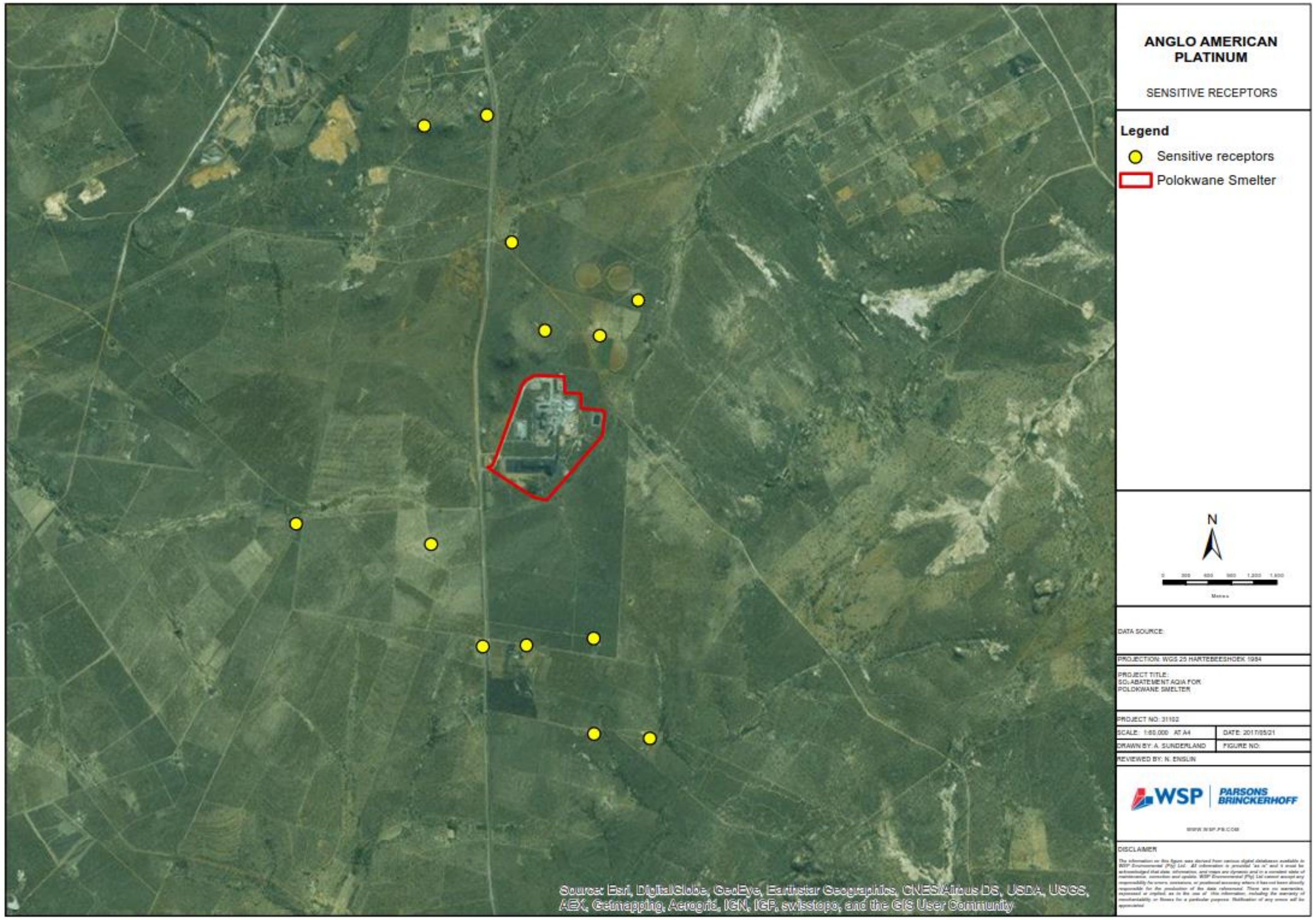

Figure 6-9: Location of sensitive receptors surrounding Polokwane Smelter.

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.

MODELLING SIMULATIONS

For the purpose of this study, dispersion modelling simulations were undertaken for;

- Scenario 1: Existing Activities;
- Scenario 2a: Construction Phase of Proposed Development (without mitigation);
- Scenario 2b: Construction Phase of Proposed Development (with mitigation);
- Scenario 3: Operational Phase of Proposed Development (proposed 80 m stack height);
- Scenario 4: Cumulative Assessment;
- Scenario 5: Operational Phase of Proposed Development (proposed 60 m stack height) and;
- Scenario 6: Cumulative Assessment following proposed increase in throughput.

WSP assessed the potential impacts of PM_{10} and $PM_{2.5}$ for each scenario using AERMOD, while Airshed assessed the potential impacts of SO_2 for Scenarios 1, 3, 4, 5 and 6 using CALPUFF.

Long-term scenarios were modelled 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 Polokwane Smelter. Short-term (daily or hourly) concentrations are also presented, assessed against the relevant National ambient air quality standards for compliance assessment purposes.

6.4 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}, $PM_{2.5}$ and SO_2 for all scenarios in **Appendix A**. It is noted that the SO_2 isopleth maps were provided by Airshed (2017) (Report: 17AAP01-02).

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

Predicted PM_{10} and $PM_{2.5}$ concentrations at sensitive receptors for all scenarios are given in **Table 6-20**. Ambient PM_{10} concentrations predicted for Scenarios 1, 2a, 2b, 4 and 6 exceeded the annual and daily standards less than 40 and 150 m from the site boundary, respectively. However, predicted concentrations were compliant at all sensitive receptors. Predicted PM_{10} concentrations were compliant with the annual and daily average standards at all receptor locations for Scenarios 3 and 5 (**Figure 8-1** – **Figure 8-14**).

$PM_{2.5}$ concentrations predicted for Scenarios 1, 2a, 2b, 4 and 6 exceeded the annual and daily standards less than 20 and 40 m from the site boundary, respectively. However, predicted concentrations were compliant at all sensitive receptors. Predicted $PM_{2.5}$ concentrations were compliant with the annual and daily average standards at all receptor locations for Scenario 3 and Scenario 5 (**Figure 8-15** – **Figure 8-28**).

Similar particulate concentrations are predicted for Scenario 1 (current plant) and Scenarios 4 and 6 (future plant) due to paved roads and vehicles being the main contributor to particulate concentrations. Scenarios 2a and 2b (construction phase with and without mitigation, respectively) showed notable variation in maximum predicted concentrations, as is expected. For Scenarios 3 and 5 (proposed activities), similar concentrations are predicted with a proposed stack height of 80 m and 60 m, respectively. Maximum predicted daily and annual average PM_{10} concentrations for Scenario 3 were 32.64 and 8.35 µg/m^3, respectively, while maximum predicted daily and annual average concentrations for Scenario 5 were 32.65 and 8.36 µg/m^3, respectively. Similar results are noted for $PM_{2.5}$ concentrations.

Table 6-20: Predicted ambient PM_{10} and $PM_{2.5}$ 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 Maximum	Annual Average	Daily Maximum
Scenario 1 – Existing Plant				
Farmstead 1	0.62	8.92	0.20	2.09
Farmstead 2	0.71	7.56	0.29	2.23
Farmstead 3	0.63	10.52	0.20	2.65
Farmstead 4	0.99	8.27	0.30	1.83
Farmstead 5	1.12	9.05	0.33	2.12
Farmstead 6	1.67	11.52	0.46	2.91
Farmstead 7	0.53	4.79	0.17	1.21
Farmstead 8	0.27	4.34	0.09	0.98
Farmstead 9	0.30	5.20	0.10	1.18
Farmstead 10	0.62	7.95	0.18	1.76
Farmstead 11	0.67	7.63	0.20	1.71
Farmstead 12	1.18	16.02	0.37	3.86
Farmstead 13	1.06	11.84	0.30	2.59
Max. boundary	**110.99**[1]	**483.86**[1]	**27.01**[1]	**118.50**[1]
Max. modelling domain	**409.18**[1]	**1607.64**[1]	**100.30**[1]	**392.81**[1]
Scenario 2a: Construction Phase of Proposed Development (without mitigation)				
Farmstead 1	0.74	9.55	0.29	2.97
Farmstead 2	0.87	9.80	0.41	3.60
Farmstead 3	0.78	12.67	0.32	3.59
Farmstead 4	1.07	8.47	0.36	2.11
Farmstead 5	1.19	9.79	0.39	2.30
Farmstead 6	1.75	13.67	0.52	3.56
Farmstead 7	0.56	5.03	0.19	1.32
Farmstead 8	0.32	4.58	0.13	1.39
Farmstead 9	0.36	7.11	0.15	1.74
Farmstead 10	0.66	8.10	0.21	1.85
Farmstead 11	0.71	7.92	0.23	2.11
Farmstead 12	1.47	21.59	0.58	4.99
Farmstead 13	1.13	11.84	0.35	2.85
Max. boundary	**111.17**[1]	**486.97**[1]	**27.15**[1]	**119.06**[1]
Max. modelling domain	**409.81**[1]	**1607.75**[1]	**116.08**[1]	**392.89**[1]
Scenario 2b: Construction Phase of Proposed Development (with mitigation)				
Farmstead 1	0.74	9.55	0.24	2.38

Receptor	PM_{10} Concentration (µg/m^3)		$PM_{2.5}$ Concentration (µg/m^3)	
	Annual Average	Daily Maximum	Annual Average	Daily Maximum
Farmstead 2	0.87	8.87	0.35	3.07
Farmstead 3	0.78	11.57	0.26	3.06
Farmstead 4	1.07	8.32	0.33	1.93
Farmstead 5	1.19	9.68	0.36	2.19
Farmstead 6	1.75	11.97	0.49	3.22
Farmstead 7	0.56	4.83	0.18	1.32
Farmstead 8	0.32	4.54	0.11	1.27
Farmstead 9	0.36	5.87	0.12	1.71
Farmstead 10	0.66	7.96	0.20	1.85
Farmstead 11	0.71	7.63	0.21	1.92
Farmstead 12	1.47	16.52	0.48	4.89
Farmstead 13	1.13	11.84	0.33	2.59
Max. boundary	**111.17**[1]	**486.76**[1]	**27.08**[1]	**118.90**[1]
Max. modelling domain	**409.81**[1]	**1607.70**[1]	**100.53**[1]	**392.85**[1]
Scenario 3 – Proposed Development (80 m stack height)				
Farmstead 1	0.02	0.17	0.01	0.06
Farmstead 2	0.03	0.25	0.02	0.11
Farmstead 3	0.02	0.21	0.01	0.07
Farmstead 4	0.03	0.13	0.01	0.07
Farmstead 5	0.03	0.15	0.02	0.08
Farmstead 6	0.03	0.19	0.01	0.06
Farmstead 7	0.01	0.09	0.01	0.03
Farmstead 8	0.01	0.08	0.004	0.03
Farmstead 9	0.01	0.08	0.004	0.03
Farmstead 10	0.02	0.10	0.008	0.05
Farmstead 11	0.02	0.11	0.008	0.05
Farmstead 12	0.04	0.31	0.02	0.14
Farmstead 13	0.03	0.16	0.01	0.07
Max. boundary	2.20	9.88	0.56	2.47
Max. modelling domain	8.35	32.64	2.08	8.07
Scenario 4 – Cumulative Assessment				
Farmstead 1	0.60	9.26	0.18	2.14
Farmstead 2	0.66	7.82	0.25	2.15
Farmstead 3	0.61	10.70	0.19	2.65
Farmstead 4	0.96	8.29	0.28	1.87
Farmstead 5	1.09	9.21	0.31	2.12
Farmstead 6	1.65	11.98	0.44	3.00
Farmstead 7	0.51	4.79	0.15	1.23
Farmstead 8	0.26	4.49	0.08	1.01
Farmstead 9	0.28	5.31	0.09	1.21
Farmstead 10	0.61	7.99	0.17	1.76
Farmstead 11	0.66	7.78	0.19	1.76
Farmstead 12	1.16	15.98	0.35	3.74
Farmstead 13	1.05	12.12	0.29	2.66

Receptor	PM10 Concentration (µg/m³)		PM2.5 Concentration (µg/m³)	
	Annual Average	Daily Maximum	Annual Average	Daily Maximum
Max. boundary	**115.52**[1]	**504.80**[1]	**28.06**[1]	**123.42**[1]
Max. modelling domain	**426.82**[1]	**1677.51**[1]	**104.46**[1]	**409.44**[1]
Scenario 5 – Proposed development (60 m stack height)				
Farmstead 1	0.02	0.18	0.01	0.07
Farmstead 2	0.03	0.26	0.02	0.12
Farmstead 3	0.02	0.21	0.01	0.07
Farmstead 4	0.04	0.23	0.02	0.14
Farmstead 5	0.05	0.24	0.03	0.14
Farmstead 6	0.04	0.22	0.02	0.09
Farmstead 7	0.02	0.10	0.01	0.05
Farmstead 8	0.01	0.09	0.004	0.03
Farmstead 9	0.01	0.09	0.004	0.04
Farmstead 10	0.02	0.15	0.01	0.08
Farmstead 11	0.02	0.16	0.01	0.09
Farmstead 12	0.04	0.34	0.02	0.16
Farmstead 13	0.03	0.21	0.02	0.11
Max. boundary	2.20	9.89	0.56	2.47
Max. modelling domain	8.36	32.65	2.09	8.07
Scenario 6 – Cumulative Assessment (with proposed increase in throughput)				
Farmstead 1	0.62	9.28	0.19	2.17
Farmstead 2	0.69	7.88	0.27	2.24
Farmstead 3	0.63	10.78	0.20	2.71
Farmstead 4	0.99	8.36	0.29	1.90
Farmstead 5	1.12	9.25	0.33	2.15
Farmstead 6	1.68	12.02	0.45	3.03
Farmstead 7	0.53	4.84	0.16	1.25
Farmstead 8	0.27	4.50	0.09	1.02
Farmstead 9	0.29	5.33	0.09	1.21
Farmstead 10	0.62	8.04	0.18	1.78
Farmstead 11	0.67	7.80	0.20	1.76
Farmstead 12	1.19	16.07	0.37	3.87
Farmstead 13	1.07	12.14	0.30	2.67
Max. boundary	**115.59**[1]	**504.94**[1]	**28.10**[1]	**123.50**[1]
Max. modelling domain	**426.93**[1]	**1677.61**[1]	**104.53**[1]	**409.50**[1]

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

SULPHUR DIOXIDE CONCENTRATIONS

Table 6-21 presents the predicted SO_2 concentrations at receptor locations for all scenarios, as provided by Airshed in their report, *Dispersion Modelling Scenarios for Polokwane Metallurgical Complex* (Reference Number: 17AAP01-02). Daily and hourly average SO_2 concentrations for Scenario 1 are predicted to exceed the daily and hourly average SO_2 standards at Farmstead 2 and Farmstead 12, although all other sensitive receptors are complaint. Annual average SO_2 concentrations for Scenario 1 are compliant at all receptor locations. Daily, hourly and annual average SO_2 concentrations are predicted to be compliant with their respective standards at all sensitive receptors and over the modelling domain for all incremental (Scenarios 3 and 5) and cumulative (Scenarios 4 and 6) scenarios (**Figure 8-29 – Figure 8-43**). For more detail, the full report completed by Airshed is included in **Appendix D**.

The percentage reduction in SO_2 concentrations for each future scenario (Scenarios 3 to 6) in comparison to the current (Scenario 1) is shown in **Table 6-22**. Concentrations predicted for all future scenarios show an average reduction of 87% in ground level SO_2 concentrations from the current (Scenario 1) concentrations at all sensitive receptor locations (Airshed, 2017).

Table 6-21: Predicted ambient SO_2 concentrations at surrounding receptors (Airshed, 2017).

Receptor	SO_2 Concentration (µg/m³)		
	Annual Average	Daily Maximum	Hourly Maximum
Scenario 1 – Existing Plant			
Farmstead 1	5.8	92	676 (4)
Farmstead 2	16.8	**189 (10)**	**1103 (120)**
Farmstead 3	5.3	84	631 (7)
Farmstead 4	10.4	104	699 (24)
Farmstead 5	11.2	97	639 (21)
Farmstead 6	16.6	120 (3)	617 (57)
Farmstead 7	11.4	90	514 (10)
Farmstead 8	2.3	37	363 (1)
Farmstead 9	2.7	53	425 (1)
Farmstead 10	4.8	65	424 (3)
Farmstead 11	5.6	73	487 (6)
Farmstead 12	13.6	**188 (8)**	**963 (89)**
Farmstead 13	8.7	105	661 (20)
Scenario 3 – Proposed Development (80 m stack height)			
Farmstead 1	0.3	4	45
Farmstead 2	1.1	9	75
Farmstead 3	0.2	2	26
Farmstead 4	0.7	5	57
Farmstead 5	0.9	7	59
Farmstead 6	1.3	8	57
Farmstead 7	1.0	7	51
Farmstead 8	0.1	1	10
Farmstead 9	0.1	1	15
Farmstead 10	0.3	2	24
Farmstead 11	0.3	2	30
Farmstead 12	1.1	10	81
Farmstead 13	0.5	4	45
Scenario 4 – Cumulative Assessment			
Farmstead 1	0.6	11	82
Farmstead 2	2.3	30	152
Farmstead 3	0.5	8	85
Farmstead 4	1.3	14	75
Farmstead 5	1.6	16	71
Farmstead 6	2.5	16	72
Farmstead 7	1.9	17	69

Receptor	SO_2 Concentration (µg/m³)		
	Annual Average	Daily Maximum	Hourly Maximum
Farmstead 8	0.2	4	58
Farmstead 9	0.3	5	73
Farmstead 10	0.5	6	56
Farmstead 11	0.6	8	60
Farmstead 12	1.9	27	137
Farmstead 13	0.9	10	73
Scenario 5 – Proposed development (60 m stack height)			
Farmstead 1	0.4	4	60
Farmstead 2	1.5	13	96
Farmstead 3	0.3	3	32
Farmstead 4	1.0	8	78
Farmstead 5	1.3	10	83
Farmstead 6	1.9	12	77
Farmstead 7	1.4	9	65
Farmstead 8	0.1	1	15
Farmstead 9	0.2	1	17
Farmstead 10	0.3	2	30
Farmstead 11	0.4	3	36
Farmstead 12	1.4	13	104
Farmstead 13	0.6	5	55
Scenario 6 – Cumulative Assessment (with proposed increase in throughput)			
Farmstead 1	0.7	13	94
Farmstead 2	2.7	33	173
Farmstead 3	0.6	10	98
Farmstead 4	1.5	16	86
Farmstead 5	1.8	18	82
Farmstead 6	2.8	19	82
Farmstead 7	2.2	20	80
Farmstead 8	0.2	5	66
Farmstead 9	0.3	6	83
Farmstead 10	0.6	7	64
Farmstead 11	0.7	9	69
Farmstead 12	2.1	31	157
Farmstead 13	1.1	11	84

Table 6-22: Reduction in SO_2 concentrations from Scenario 1 to Scenario 4 (Airshed, 2017).

Receptors	Reduction in SO_2 concentrations (%)		
	Annual	Daily	Hourly
Farmstead 1	89	88	88
Farmstead 2	86	84	86
Farmstead 3	90	90	86
Farmstead 4	88	87	89
Farmstead 5	86	84	89
Farmstead 6	85	86	88
Farmstead 7	83	81	87
Farmstead 8	91	89	84
Farmstead 9	90	91	83
Farmstead 10	90	91	87
Farmstead 11	90	89	88
Farmstead 12	86	85	86
Farmstead 13	90	90	89

6.5 CUMULATIVE IMPACTS

The National Framework for Air Quality Management in the Republic of South Africa (Government Gazette 37078) calls for air quality assessment in terms of cumulative impacts rather than the contributions from an individual facility. Compliance with NAAQS is to be determined by taking into account all local and regional contributions to background concentrations. For each averaging time, the sum of the model predicted concentration (C_P) and the background concentration (C_B) must be compared with the National Ambient Air Quality Standards. The background concentrations C_B, must be the sum of contributions from non-modelled local sources and regional background air quality. If the sum of background and predicted concentrations (C_B +C_P) is more than the National Ambient Air Quality Standards, the design of the facility must be reviewed (including pollution control equipment) to ensure compliance with National Ambient Air Quality Standards. For the different facility locations and averaging times, the comparison with the National Ambient Air Quality Standards must be based on recommendations in **Table 6-23**.

Table 6-23: Recommended procedures for assessing compliance with the National Ambient Air Quality Standards.

Facility Location	Annual NAAQS	Short-Term NAAQS (24 hours or less)
Isolated facility not influenced by other sources, C_B insignificant*.	Highest C_P must be less than the NAAQS, no exceedances allowed.	99th percentile concentrations must be less than the NAAQS. Wherever one year is modelled, the highest concentrations shall be considered.
Facilities influenced by background sources e.g., in urban areas and priority areas.	Sum of the highest C_P and background concentrations must be less that the NAAQS, no exceedences allowed.	Sum of the 99th percentile concentrations and background C_B must be less than the NAAQS. Wherever one year is modelled, the highest concentrations shall be considered.
Isolated facility not influenced by other sources, C_B insignificant*.	Highest C_P must be less than the NAAQS, no exceedances allowed.	99th percentile concentrations must be less than the NAAQS. Wherever one year is modelled, the highest concentrations shall be considered.

*For an isolated facility influenced by regional background pollution C_B must be considered.

In determining the cumulative impacts, predicted incremental annual, daily and hourly average (where applicable) PM_{10} and SO_2 concentrations at sensitive receptors have been added to the measured background concentrations at Game Farm, North Farm, South Farm, School, Deelkraal and Kuschke monitoring stations. Background PM_{10} concentrations were averaged across all six monitoring stations to calculate a short-term maximum (based on the 5th (daily) and 89th (hourly) highest values) and long-term annual average value for the period January 2014 to December 2016. These values were combined with Scenario 4 and 6 predictions of PM_{10} at sensitive receptors for a cumulative assessment. However, it is noted that this conservatively assumes that short-term maximum and long-term average values remain constant across the model domain. Ambient $PM_{2.5}$ concentrations were not assessed cumulatively due to unavailable background data. Cumulative impacts of SO_2 concentrations at the sensitive receptor locations for Scenario 4 and Scenario 6 were summed with the average of concentrations sampled at all six monitoring locations during the period 15 September 2014 to 02 October 2014 when the Polokwane Metallurgical Complex was in shut-down (Airshed, 2017). SO_2 concentration measured during this period is assumed to be representative of other background (excluding Polokwane Smelter) sources (Airshed, 2017).

CUMULATIVE PM_{10} CONCENTRATIONS

Cumulative PM_{10} concentrations exceed the daily average standard beyond the site boundary for both Scenarios 4 and 6. However, concentrations remain compliant at all sensitive receptors (**Table 6-24** and **Table 6-25**).

Table 6-24: Scenario 4 - Cumulative Assessment including background concentrations. Values highlighted in blue bold exceed their respective standards.

Receptor	PM_{10} Concentration (µg/m^3)	
	Annual Average	Daily Maximum
Background concentrations		
All receptors	24.1	58.7
Scenario 4 – Cumulative Assessment (predicted concentrations)		
Farmstead 1	0.60	9.26
Farmstead 2	0.66	7.82
Farmstead 3	0.61	10.70
Farmstead 4	0.96	8.29
Farmstead 5	1.09	9.21
Farmstead 6	1.65	11.98
Farmstead 7	0.51	4.79
Farmstead 8	0.26	4.49
Farmstead 9	0.28	5.31
Farmstead 10	0.61	7.99
Farmstead 11	0.66	7.78
Farmstead 12	1.16	15.98
Farmstead 13	1.05	12.12
Max. boundary	**115.52**[1]	**504.80**[1]
Max. modelling domain	**426.82**[1]	**1677.51**[1]
Scenario 4 – Cumulative Assessment (including background concentrations)		
Farmstead 1	24.69	68.00
Farmstead 2	24.75	66.56
Farmstead 3	24.70	69.44
Farmstead 4	25.05	67.03
Farmstead 5	25.18	67.95

Receptor	PM10 Concentration (µg/m³)	
	Annual Average	Daily Maximum
Farmstead 6	25.74	70.72
Farmstead 7	24.60	63.53
Farmstead 8	24.35	63.23
Farmstead 9	24.37	64.05
Farmstead 10	24.70	66.73
Farmstead 11	24.75	66.52
Farmstead 12	25.25	74.72
Farmstead 13	25.14	70.86
Max. boundary	**139.61**[1]	**563.54**[1]
Max. modelling domain	**450.91**[1]	**1736.25**[1]

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

Table 6-25: Scenario 6 - Cumulative Assessment (with increased throughput) including background concentrations. Values highlighted in blue bold exceed their respective standards.

Receptor	PM_{10} Concentration (µg/m³)	
	Annual Average	Daily Maximum
Background concentrations		
All receptors	24.1	58.7
Scenario 6 – Cumulative Assessment with proposed increase in throughput (predicted concentrations)		
Farmstead 1	0.62	9.28
Farmstead 2	0.69	7.88
Farmstead 3	0.63	10.78
Farmstead 4	0.99	8.36
Farmstead 5	1.12	9.25
Farmstead 6	1.68	12.02
Farmstead 7	0.53	4.84
Farmstead 8	0.27	4.50
Farmstead 9	0.29	5.33
Farmstead 10	0.62	8.04
Farmstead 11	0.67	7.80
Farmstead 12	1.19	16.07
Farmstead 13	1.07	12.14
Max. boundary	**115.59**[1]	**504.94**[1]
Max. modelling domain	**426.93**[1]	**1677.61**[1]
Scenario 6 – Cumulative Assessment with proposed increase in throughput (including background concentrations)		
Farmstead 1	24.71	68.02
Farmstead 2	24.78	66.62
Farmstead 3	24.72	69.52
Farmstead 4	25.08	67.10
Farmstead 5	25.21	67.99
Farmstead 6	25.77	70.76
Farmstead 7	24.62	63.58
Farmstead 8	24.36	63.24

Receptor	PM_{10} Concentration (µg/m³)	
	Annual Average	Daily Maximum
Farmstead 9	24.38	64.07
Farmstead 10	24.71	66.78
Farmstead 11	24.76	66.54
Farmstead 12	25.28	74.81
Farmstead 13	25.16	70.88
Max. boundary	**139.68**[1]	**563.68**[1]
Max. modelling domain	**451.02**[1]	**1736.35**[1]

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

CUMULATIVE SO_2 CONCENTRATIONS

Cumulative SO_2 concentrations are compliant with their respective hourly, daily and annual average SO_2 standards at all sensitive receptors (**Table 6-26** and **Table 6-27**) (Airshed, 2017).

Table 6-26: Scenario 4 - Cumulative Assessment including background concentrations.

Receptor	SO_2 Concentration (µg/m³)		
	Annual Average	Daily Maximum	Hourly Maximum
Scenario 4 – Cumulative Assessment (predicted concentrations)			
Farmstead 1	0.6	11	82
Farmstead 2	2.3	30	152
Farmstead 3	0.5	8	85
Farmstead 4	1.3	14	75
Farmstead 5	1.6	16	71
Farmstead 6	2.5	16	72
Farmstead 7	1.9	17	69
Farmstead 8	0.2	4	58
Farmstead 9	0.3	5	73
Farmstead 10	0.5	6	56
Farmstead 11	0.6	8	60
Farmstead 12	1.9	27	137
Farmstead 13	0.9	10	73
Scenario 4 – Cumulative Assessment (including background concentrations)			
Farmstead 1	5	26	127
Farmstead 2	7	44	197
Farmstead 3	5	23	130
Farmstead 4	6	28	120
Farmstead 5	6	30	116
Farmstead 6	7	31	117
Farmstead 7	6	32	114
Farmstead 8	5	19	103
Farmstead 9	5	19	118
Farmstead 10	5	21	101
Farmstead 11	5	22	105
Farmstead 12	6	42	182
Farmstead 13	5	25	118

Table 6-27: Scenario 6 - Cumulative Assessment (with increased throughput) including background concentrations.

Receptor	SO_2 Concentration (µg/m³)		
	Annual Average	Daily Maximum	Hourly Maximum
Scenario 6 – Cumulative Assessment with proposed increase in throughput (predicted concentrations)			
Farmstead 1	0.7	13	94
Farmstead 2	2.7	33	173
Farmstead 3	0.6	10	98
Farmstead 4	1.5	16	86
Farmstead 5	1.8	18	82
Farmstead 6	2.8	19	82
Farmstead 7	2.2	20	80
Farmstead 8	0.2	5	66
Farmstead 9	0.3	6	83
Farmstead 10	0.6	7	64
Farmstead 11	0.7	9	69
Farmstead 12	2.1	31	157
Farmstead 13	1.1	11	84
Scenario 6 – Cumulative Assessment with proposed increase in throughput (including background concentrations)			
Farmstead 1	5	27	139
Farmstead 2	7	48	218
Farmstead 3	5	24	143
Farmstead 4	6	30	131
Farmstead 5	6	33	127
Farmstead 6	7	33	127
Farmstead 7	7	35	125
Farmstead 8	5	19	111
Farmstead 9	5	20	128
Farmstead 10	5	22	109
Farmstead 11	5	23	114
Farmstead 12	6	46	202
Farmstead 13	5	26	129

6.6 IMPACT RATING

The purpose of this AQIA is to identify the potential impacts of the construction and operation of the proposed WSA plant within the area. The outcomes of the impact assessment provide a basis to make informed decisions to ensure that there is not unacceptable social or environmental impact of the proposed facility. The impact assessment was evaluated using a risk matrix. A detailed description of the impact assessment methodology is provided in **Appendix B**.

During the construction and decommissioning phases, the resultant environmental impacts on the surrounding residential receptors are deemed “medium” with no mitigation in place and “low” with the implementation of the mitigation measures described in **Section 6.6**. The impacts associated with the operational phase are deemed “medium” for SO_2 and particulate concentrations with no mitigation in place and “low” with possible mitigation. Cumulative PM_{10} impacts are considered "medium", while cumulative SO_2 impacts (following the proposed WSA plant) are considered "low". For the detailed impact assessment results, please see **Appendix C**.

6.7 RECOMMENDATIONS

CONSTRUCTION AND DECOMMISSIONING PHASE

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 6-28**.

Table 6-28: 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.

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 PM_{10} and dust fallout monitoring is continued to assess ambient concentrations and dust fallout levels.

7 CONCLUSIONS

The potential impact of emissions from Polokwane Smelter was evaluated with the following scenarios:

- **Scenario 1: Existing Activities**
  - Contributions from the existing facility including emissions from two point sources, vehicle emissions and fugitive emissions from crushing, materials handling and storage, paved and unpaved roads and wind erosion.
- **Scenario 2a: Construction Phase of Proposed Development (without mitigation)**
  - Combined assessment of existing activities together with the construction of the proposed site development.
- **Scenario 2b: Construction Phase of Proposed Development (with mitigation)**
  - Combined assessment of existing activities, as well as construction of the proposed site using wet suppression for dust emissions control.
- **Scenario 3: Operational Phase of Proposed Development (80 m stack height)**
  - Incremental contributions from the proposed activities, including emissions from one point source of 80 m stack height, vehicle emissions and fugitive emissions from paved roads.
- **Scenario 4: Cumulative Assessment**
  - Total contributions from the proposed plant including emissions from two point sources, vehicle emissions and fugitive emissions from crushing, materials handling and storage, paved and unpaved roads and wind erosion.
- **Scenario 5: Operational Phase of Proposed Development (60 m stack height)**
  - Incremental contributions from the proposed activities, including emissions from one point source of 60 m stack height, vehicle emissions and fugitive emissions from paved roads.
- **Scenario 6: Cumulative Assessment (Existing + Proposed Activities) with increased throughput**
  - Total contributions from the proposed plant following the WSA development and increased throughput of raw materials. Emission sources include; two point sources, vehicle emissions and fugitive emissions from crushing, materials handling and storage, paved roads and wind erosion.

Emission sources included point source emissions from furnace and dryer stacks, and fugitive emissions from construction, 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} and $PM_{2.5}$.

Findings of the study are presented below.

- Ambient PM_{10} concentrations are predicted to be compliant with the daily and annual average standards less than 150 and 40 m beyond the site boundary and at all sensitive receptors for Scenarios 1, 2a, 2b, 4 and 6. Predicted PM_{10} concentrations are compliant at all receptors for Scenarios 3 and 5. Cumulative PM_{10} concentrations (Scenario 4 + measured background concentrations and Scenario 6 + measured background concentrations), are compliant with the daily and average standard at all sensitive receptors;
- Ambient $PM_{2.5}$ concentrations are predicted to be compliant with the daily and annual average standards less than 40 and 20 m beyond the site boundary and at all sensitive receptors for

Scenarios 1, 2a, 2b, 4 and 6. Predicted $PM_{2.5}$ concentrations are compliant at all receptors for Scenarios 3 and 5. Cumulative $PM_{2.5}$ concentrations could not be assessed as ambient $PM_{2.5}$ concentrations were not available;

- Ambient SO_2 concentrations are predicted to be non-compliant with the hourly and daily average standards at Farmstead 2 and Farmstead 12, although all other sensitive receptors are compliant for Scenario 1. Annual average SO_2 concentrations for Scenario 1 are compliant at all receptor locations. Predicted SO_2 concentrations are compliant with their respective standards at all sensitive receptors and over the modelling domain for all incremental (Scenarios 3 and 5) and cumulative (Scenarios 4 and 6) scenarios.

Impacts associated with the proposed plant are low, with negligible change predicted with the installation of the WSA plant and proposed increase in throughput. Cumulative particulate concentrations are deemed to be of medium impact. However, it should be noted that the existing background concentrations result in double accounting for PM_{10} concentrations as existing ambient concentrations resulting from Polokwane Smelter (and other sources) are summed with model predicted concentrations.

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. Continued PM_{10} and dust fallout monitoring is recommended in order to manage ambient concentrations and fallout levels.

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Appendix A

DISPERSION MAPS

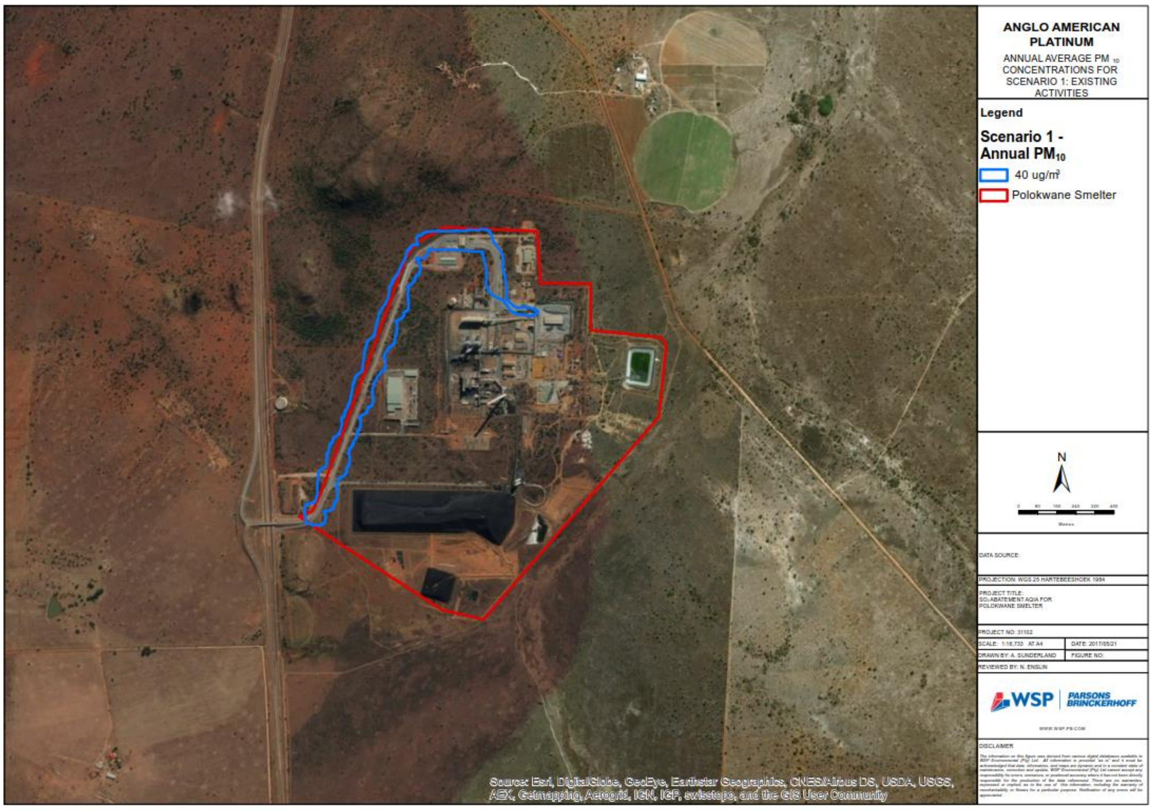

Figure 8-1: Scenario 1 - Annual average PM_{10} concentrations.

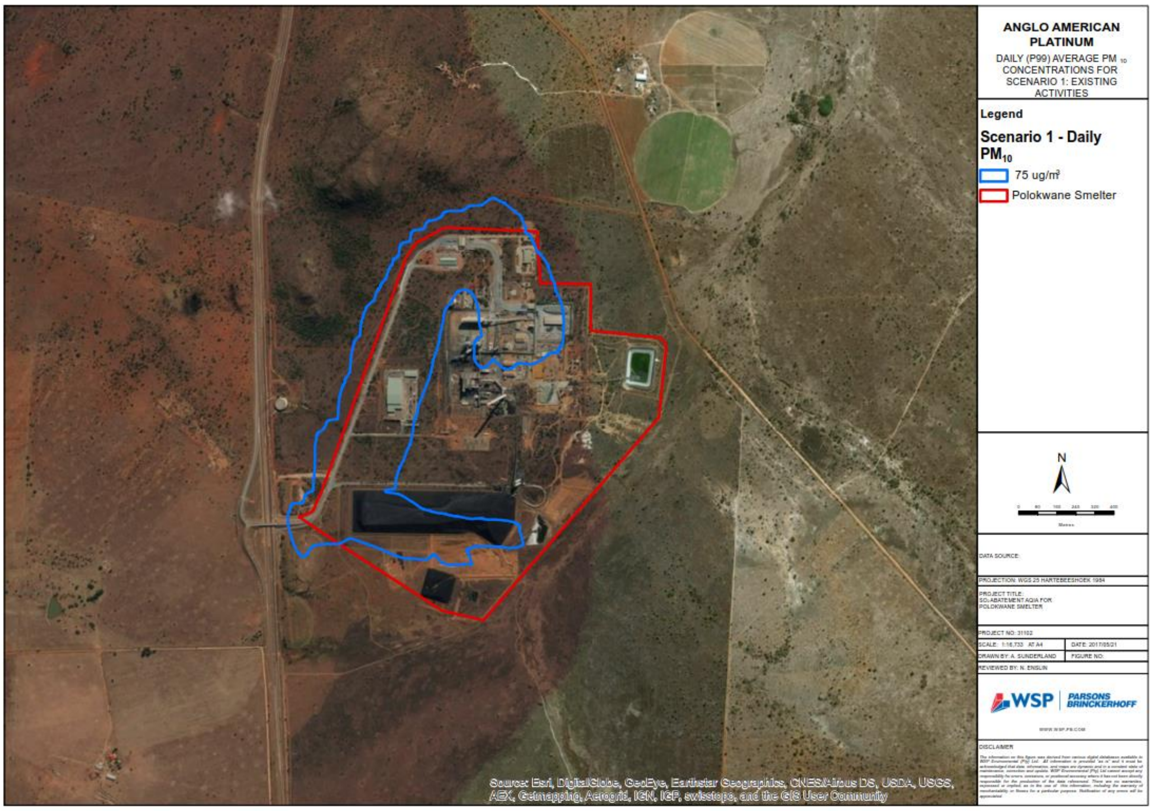

Figure 8-2: Scenario 1 - Daily average PM_{10} concentrations.

Figure 8-3: Scenario 2a – Annual average PM_{10} concentrations.

Figure 8-4: Scenario 2a – Daily average PM_{10} concentrations.

Figure 8-5: Scenario 2b – Annual average PM_{10} concentrations.

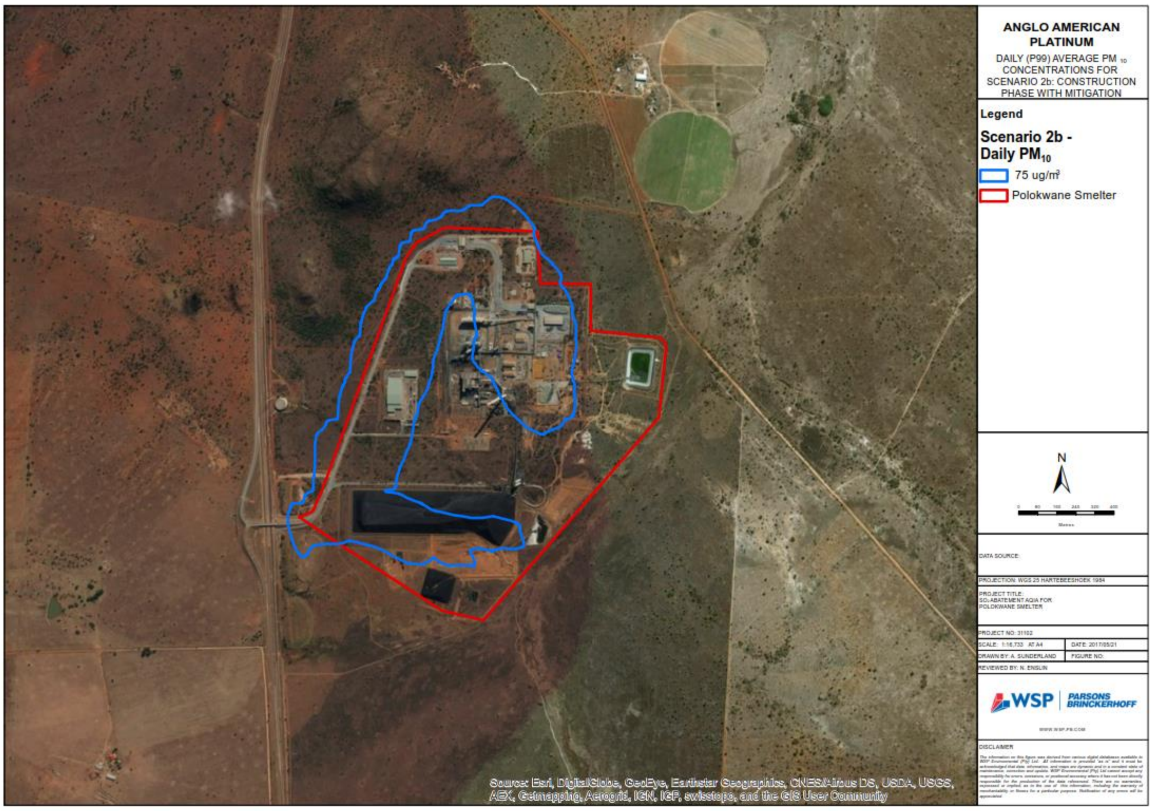

Figure 8-6: Scenario 2b – Daily average PM_{10} concentrations.

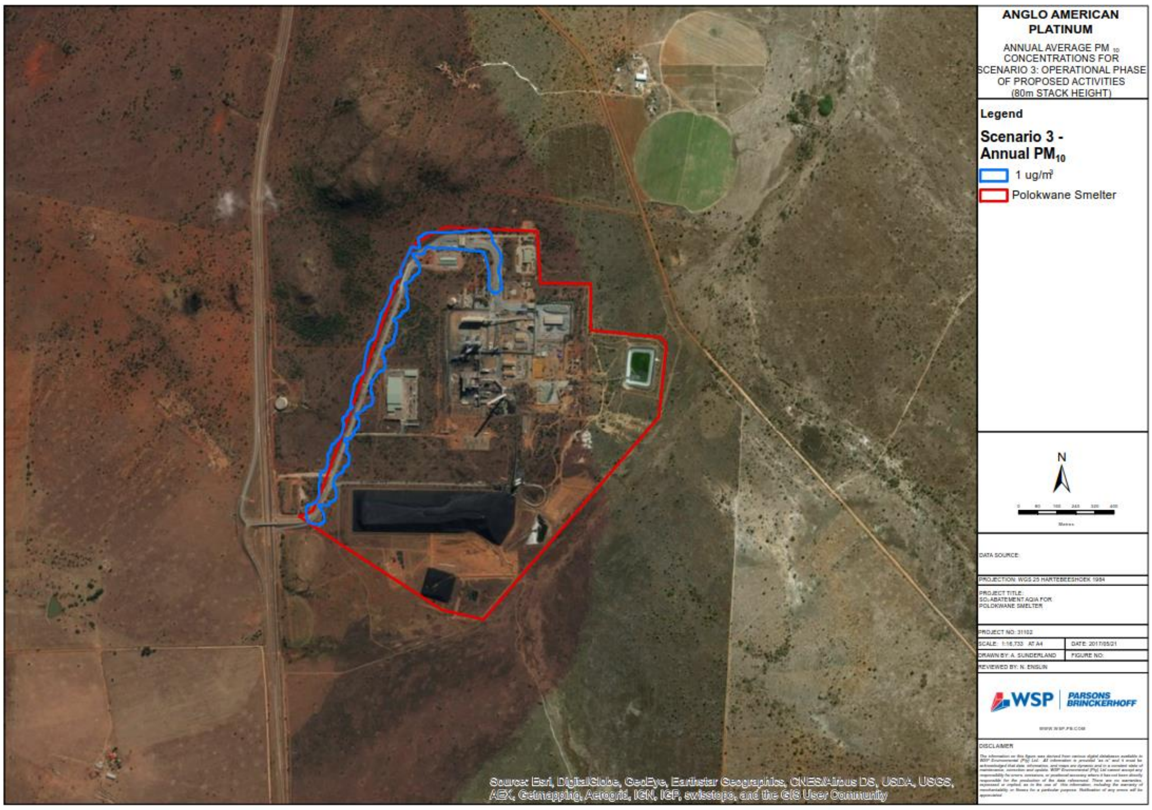

Figure 8-7: Scenario 3 – Annual average PM_{10} concentrations.

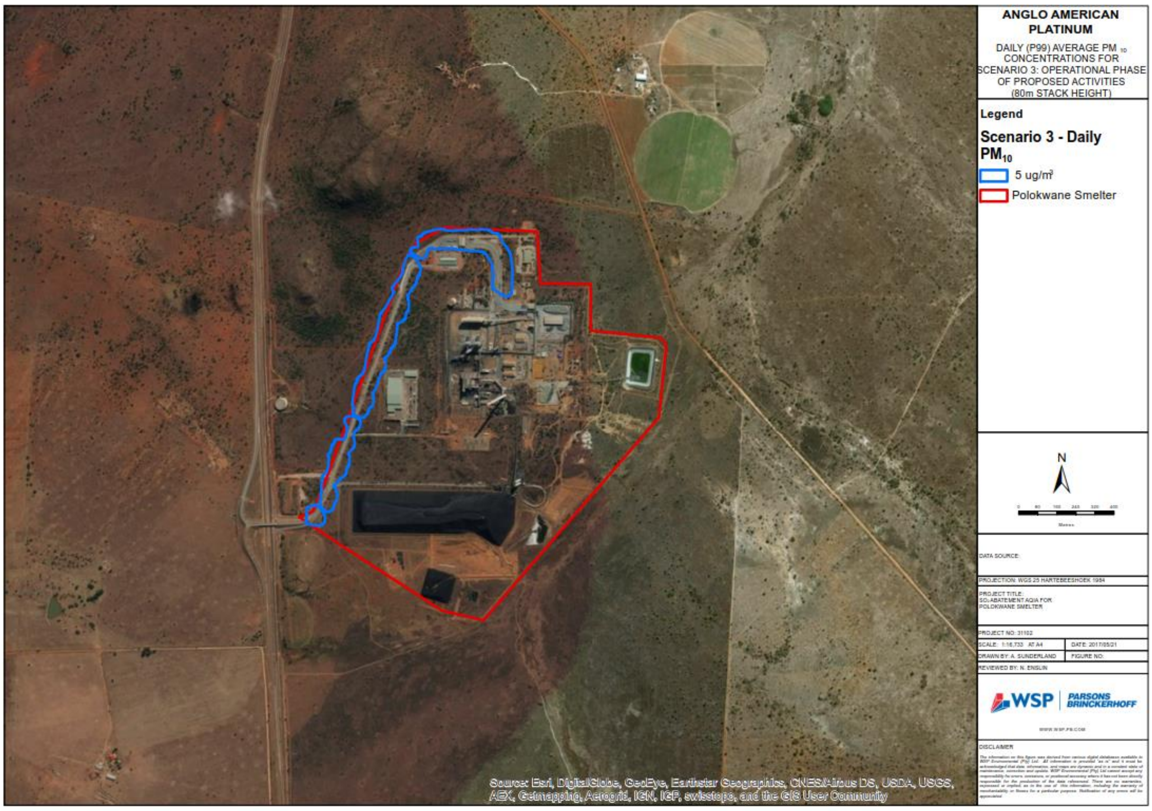

Figure 8-8: Scenario 3 – Daily average PM_{10} concentrations.

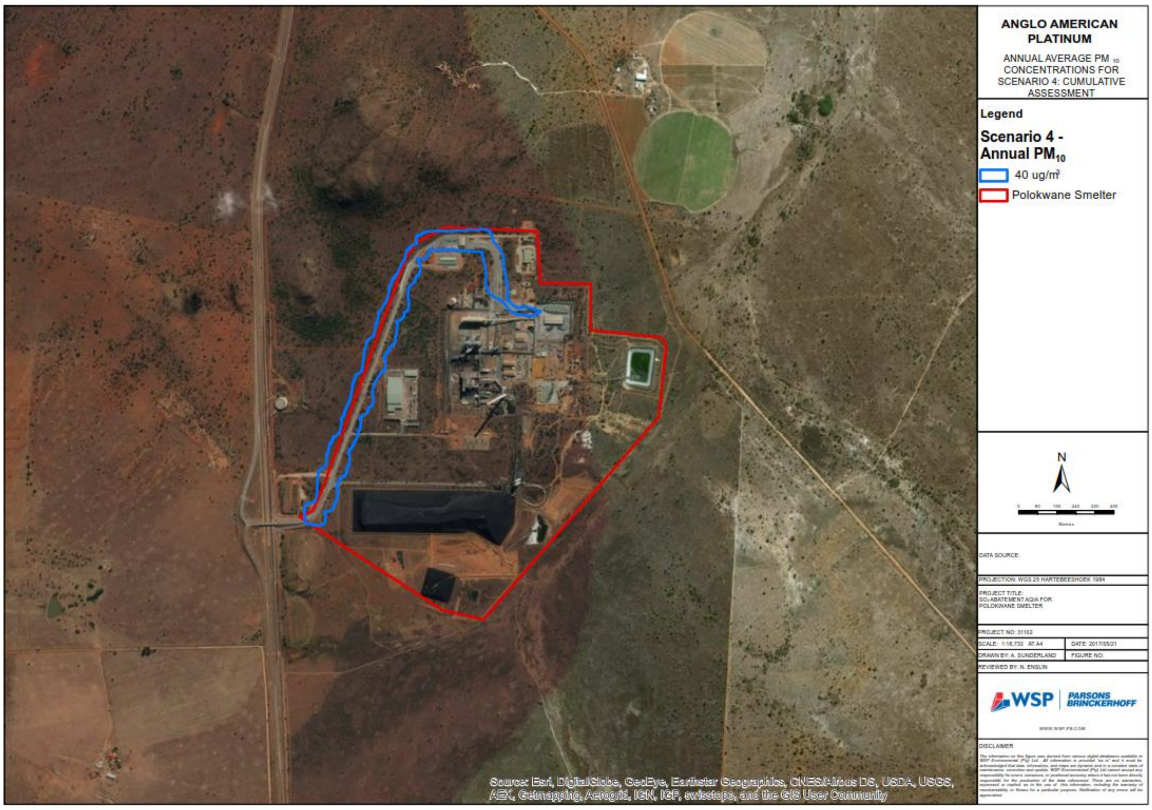

Figure 8-9: Scenario 4 – Annual average PM_{10} concentrations.

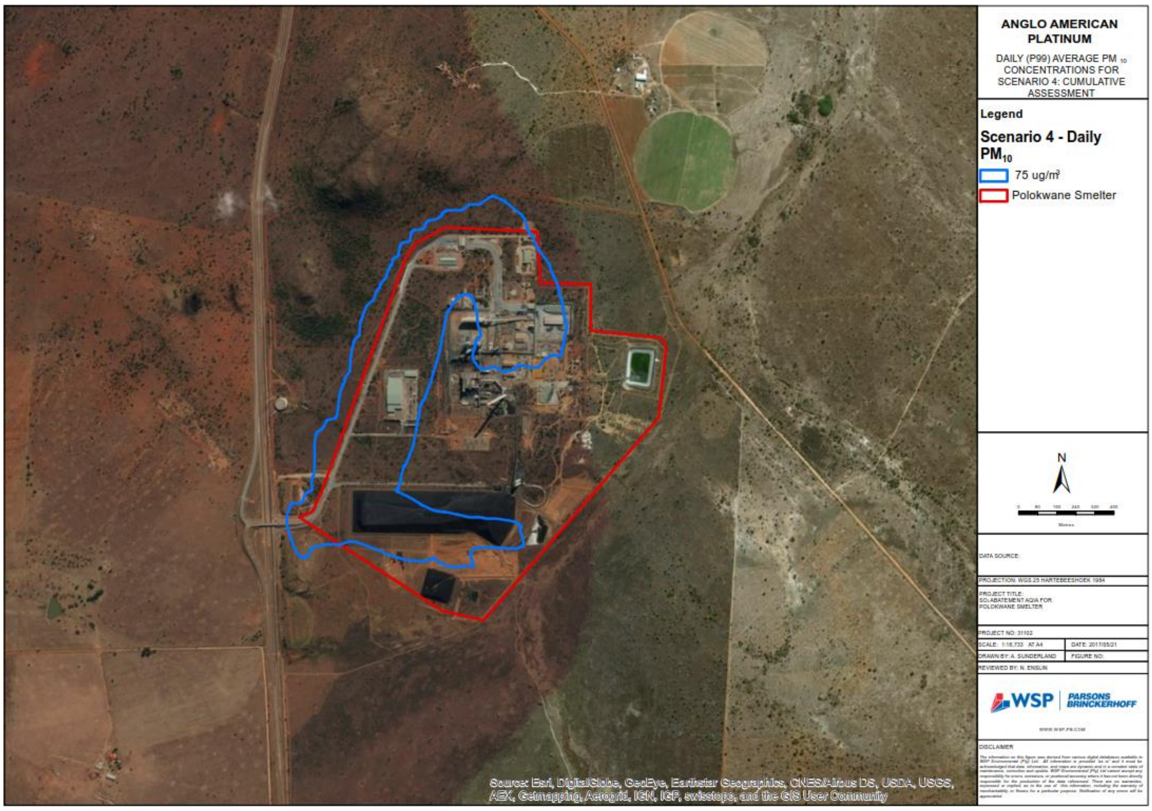

Figure 8-10: Scenario 4 – Daily average PM_{10} concentrations.

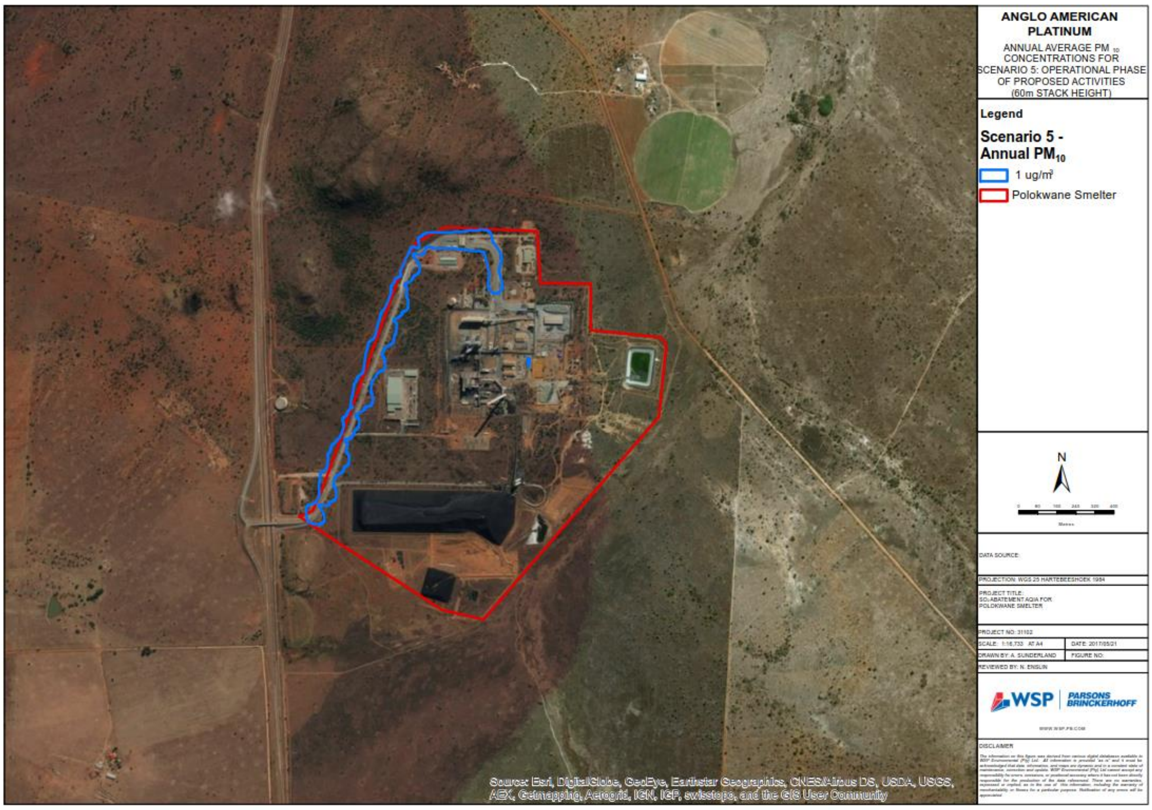

Figure 8-11: Scenario 5 – Annual average PM_{10} concentrations.

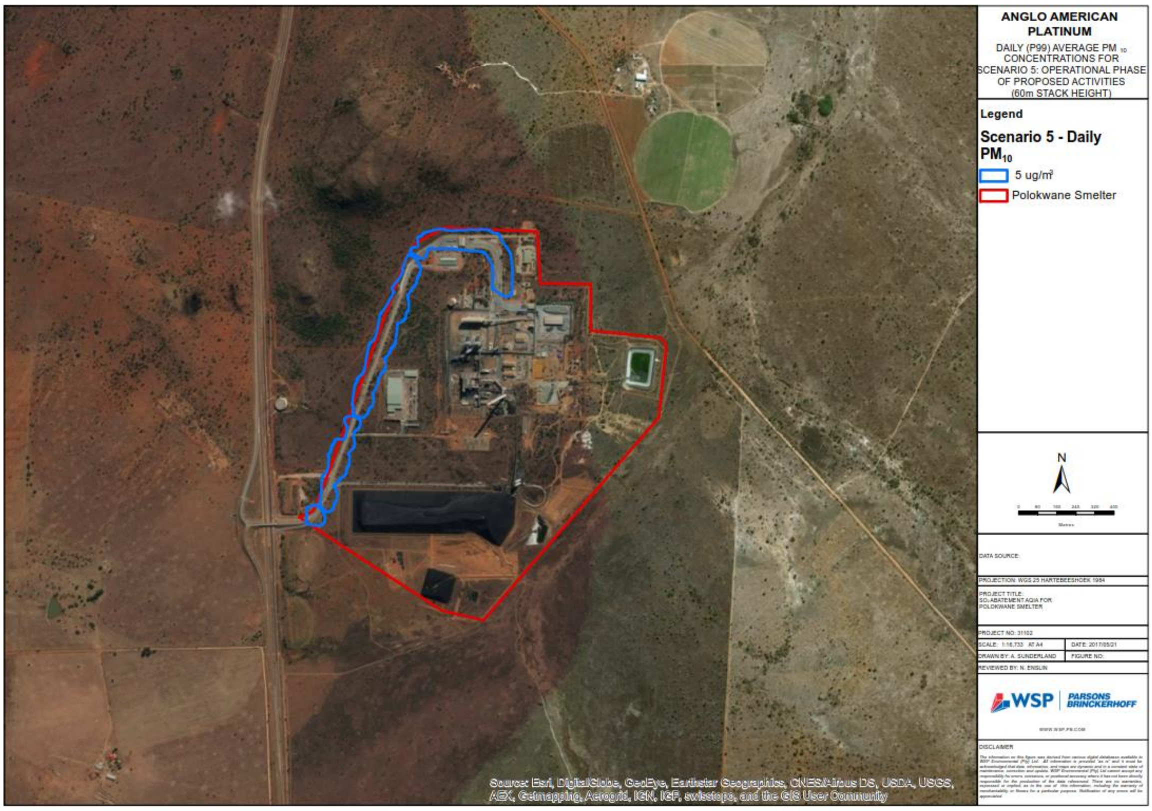

Figure 8-12: Scenario 5 – Daily average PM_{10} concentrations.

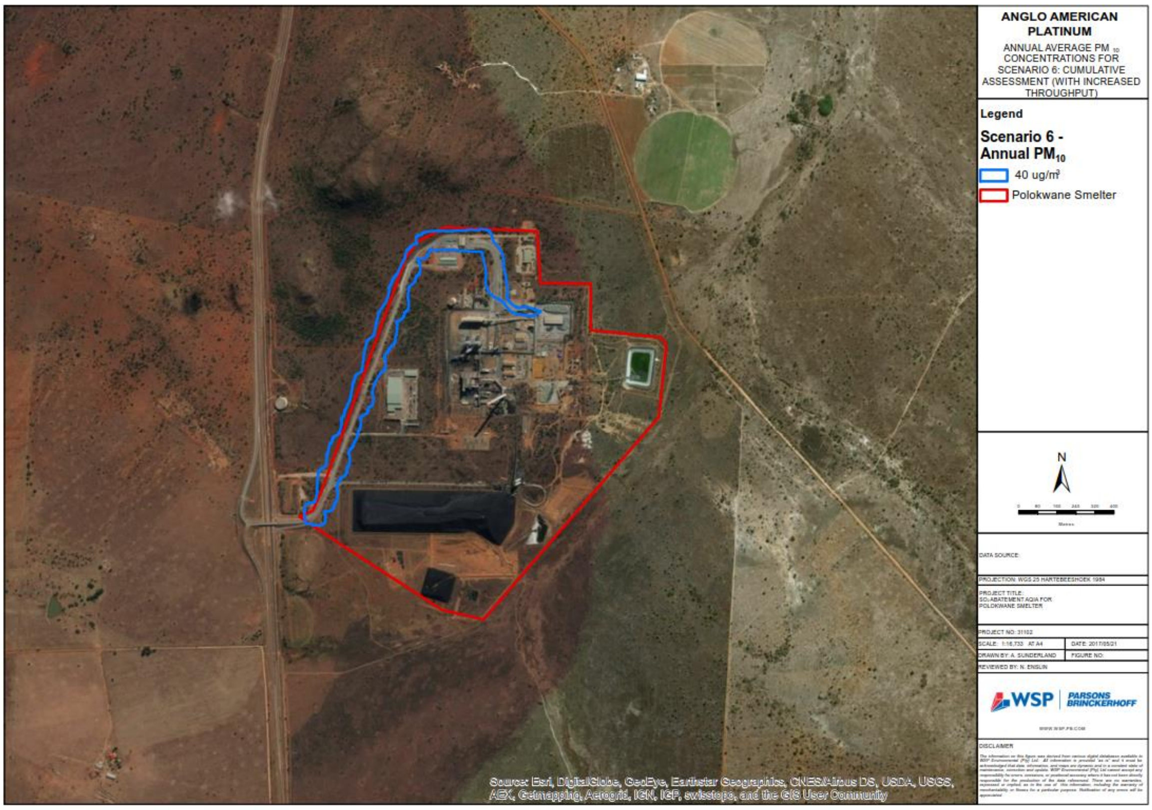

Figure 8-13: Scenario 6 – Annual average PM_{10} concentrations.

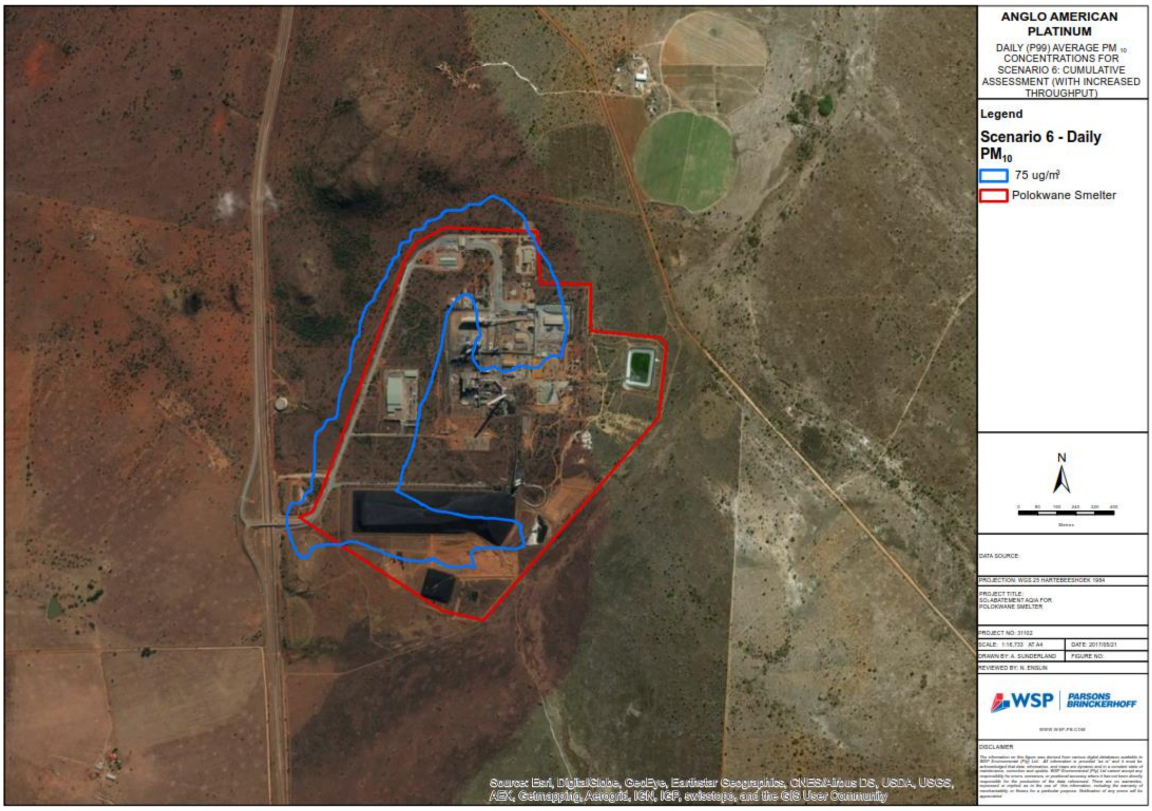

Figure 8-14: Scenario 6 – Daily average PM_{10} concentrations.

Figure 8-15: Scenario 1 – Annual average $PM_{2.5}$ concentrations.

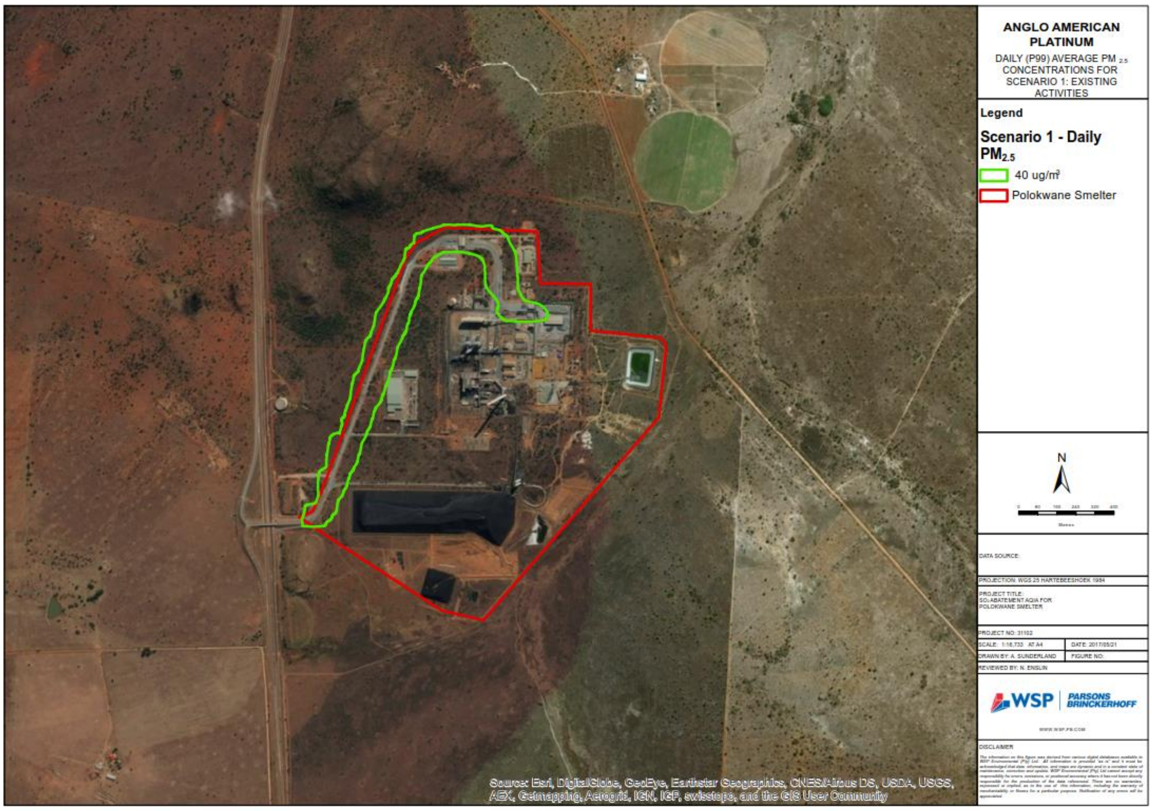

Figure 8-16: Scenario 1 – Daily average $PM_{2.5}$ concentrations.

Figure 8-17: Scenario 2a – Annual average $PM_{2.5}$ concentrations.

Figure 8-18: Scenario 2a – Daily average $PM_{2.5}$ concentrations.

Figure 8-19: Scenario 2b – Annual average $PM_{2.5}$ concentrations.

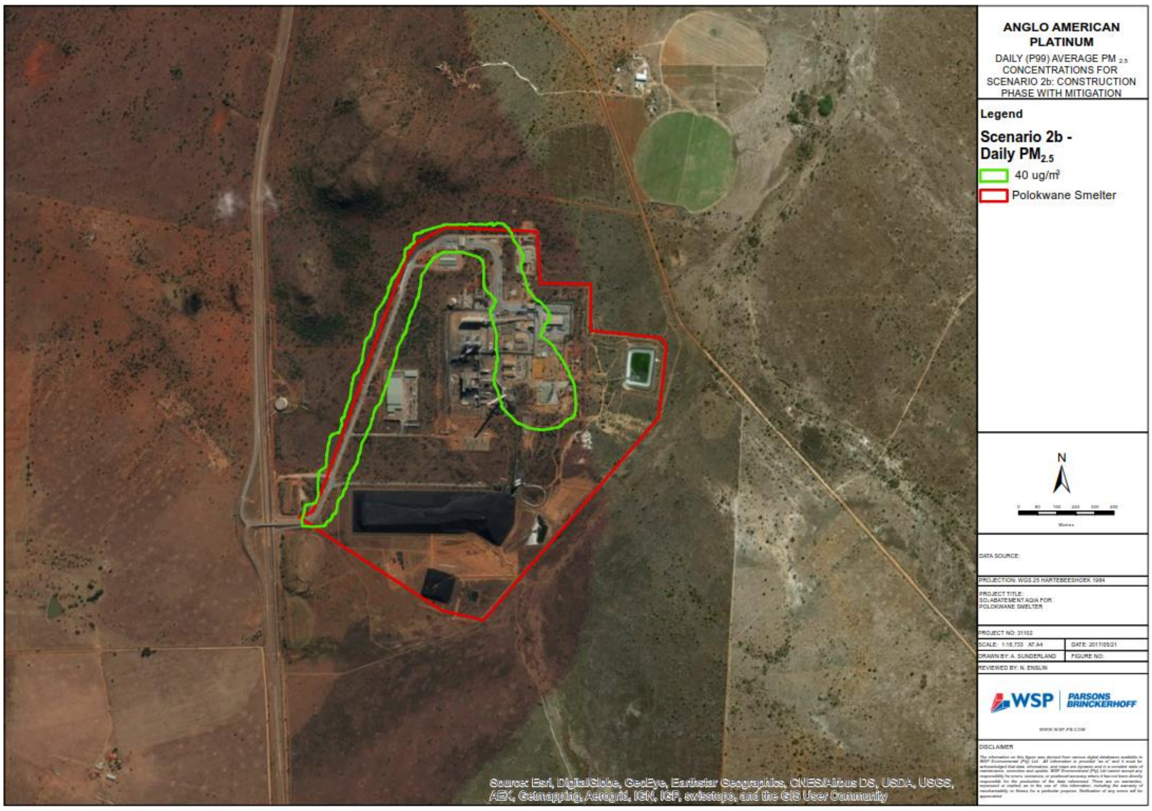

Figure 8-20: Scenario 2b – Daily average $PM_{2.5}$ concentrations.

Figure 8-21: Scenario 3 – Annual average $PM_{2.5}$ concentrations.

Figure 8-22: Scenario 3 – Daily average $PM_{2.5}$ concentrations.

Figure 8-23: Scenario 4 – Annual average $PM_{2.5}$ concentrations.

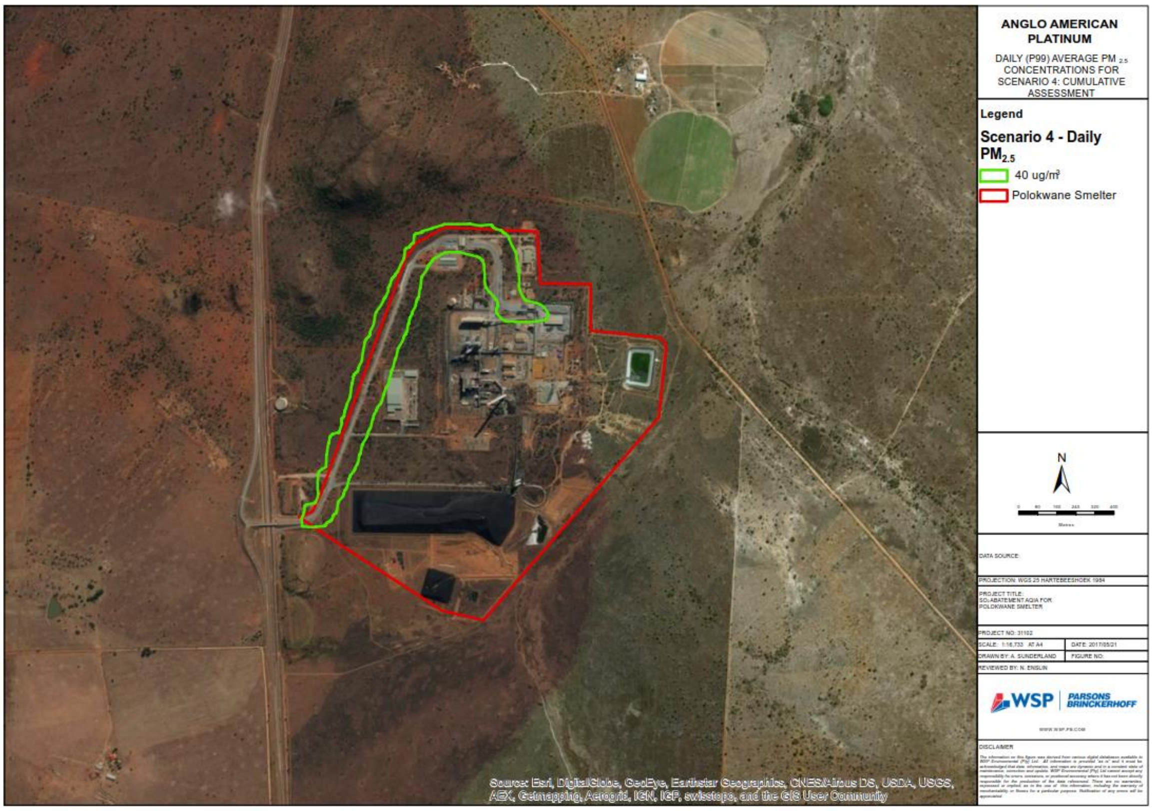

Figure 8-24: Scenario 4 – Daily average $PM_{2.5}$ concentrations.

Figure 8-25: Scenario 5 – Annual average $PM_{2.5}$ concentrations.

Figure 8-26: Scenario 5 – Daily average $PM_{2.5}$ concentrations.

Figure 8-27: Scenario 6 – Annual average $PM_{2.5}$ concentrations.

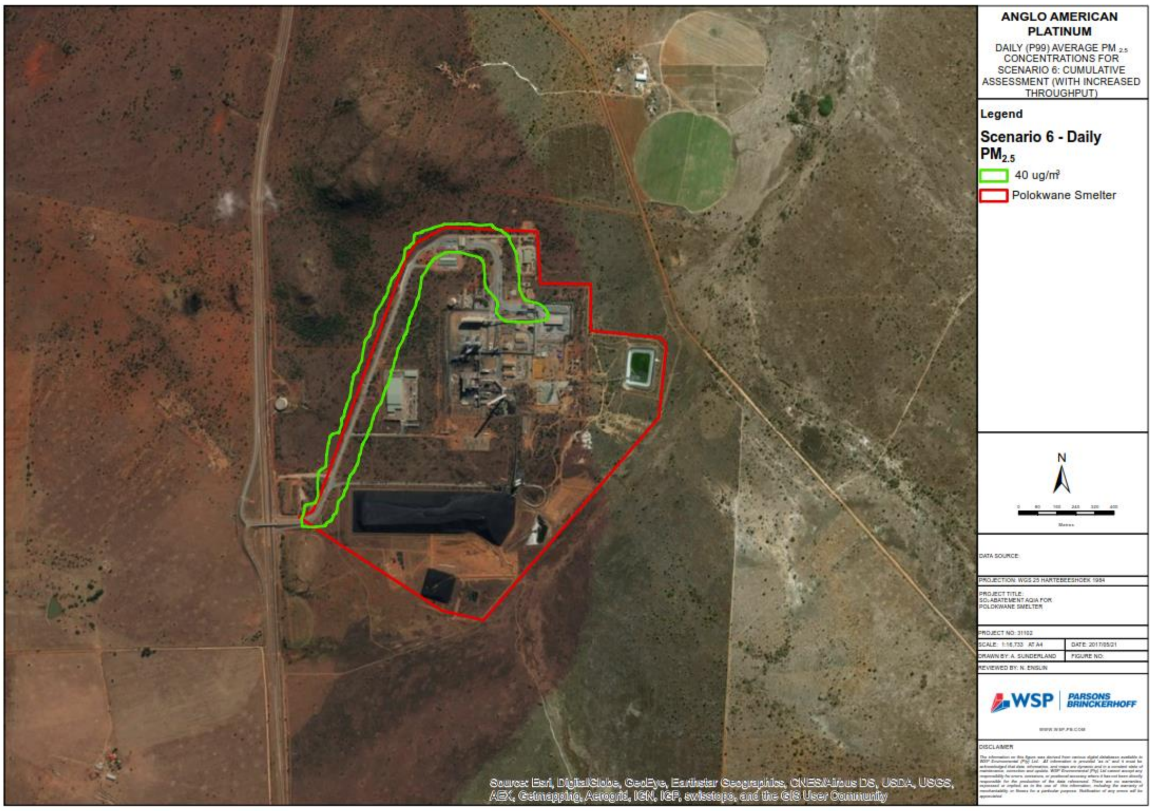

Figure 8-28: Scenario 6 – Daily average $PM_{2.5}$ concentrations.

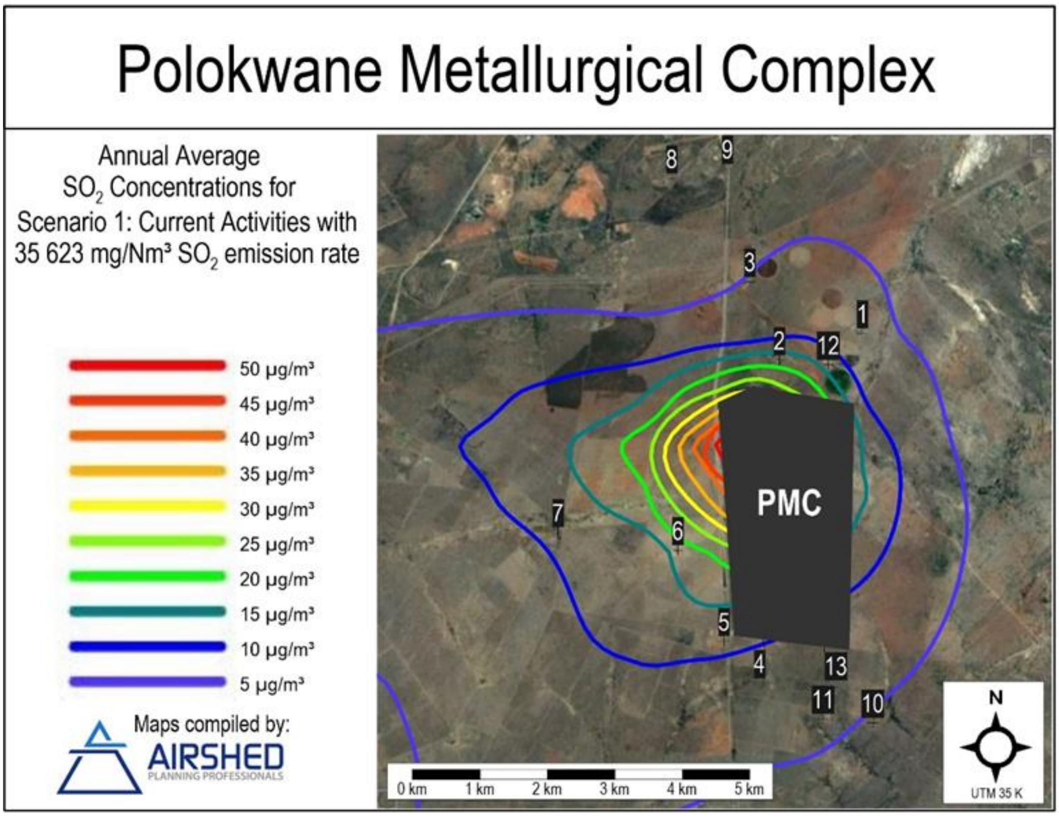

Figure 8-29: Scenario 1 – Annual average SO_2 concentrations.

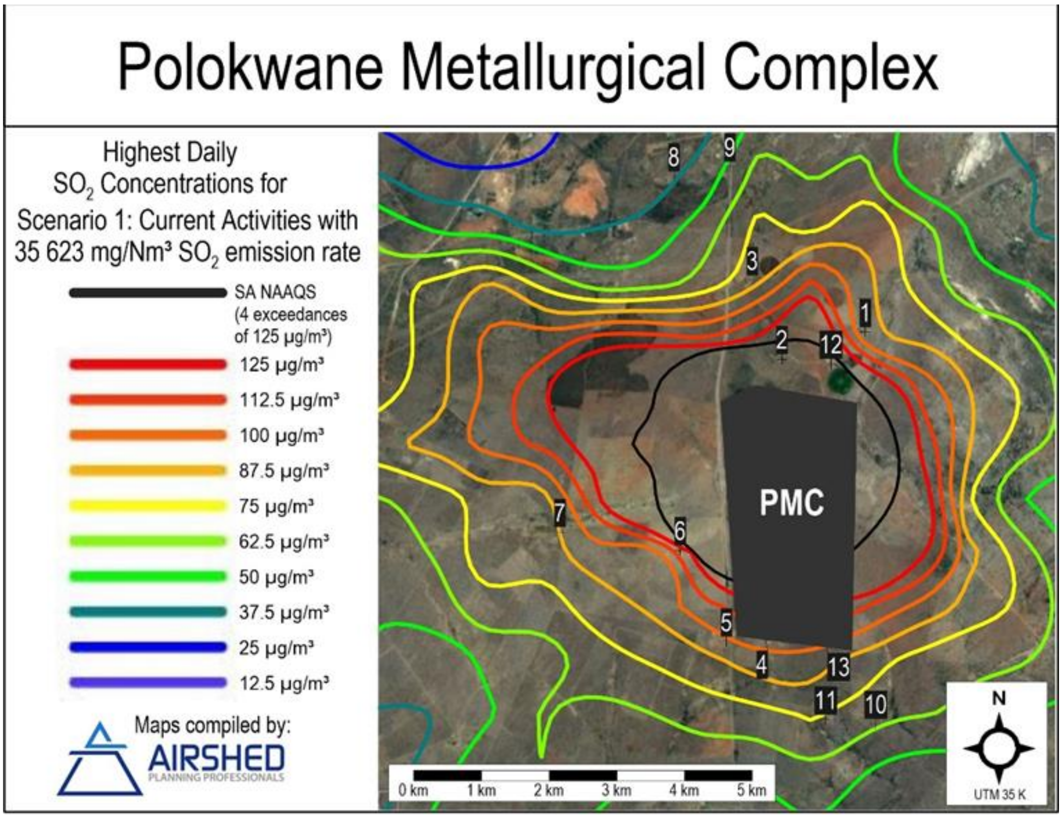

Figure 8-30: Scenario 1 – Daily average SO_2 concentrations.

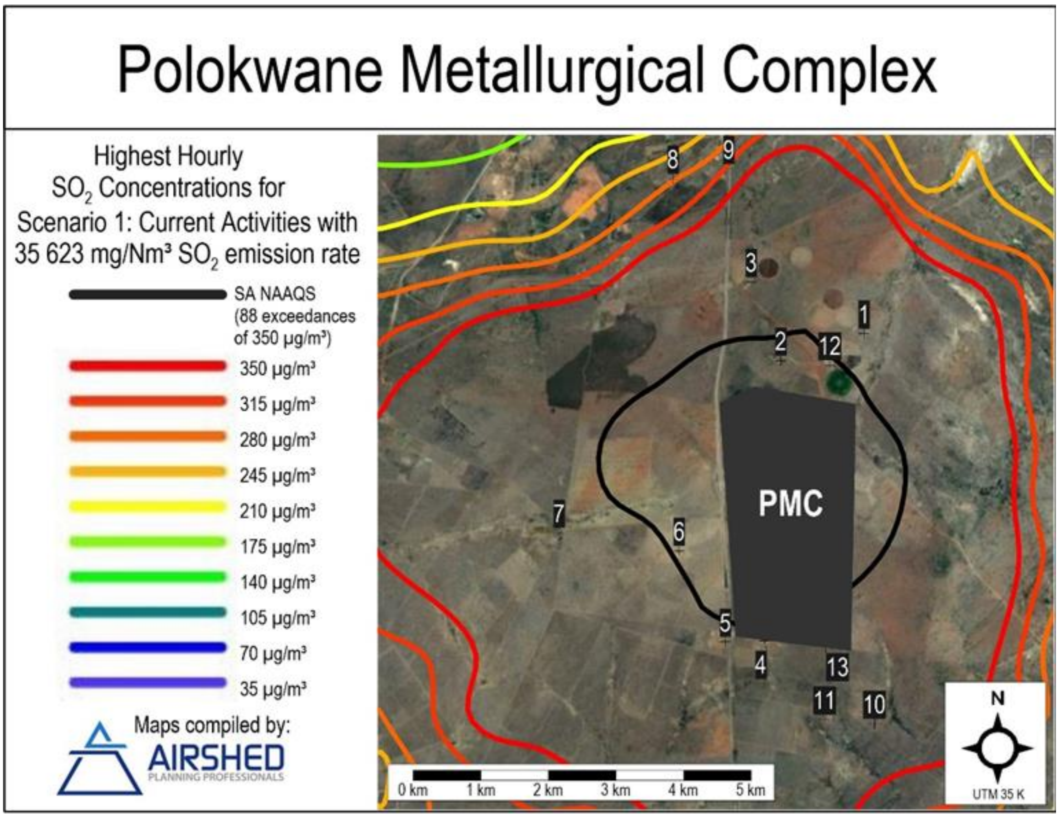

Figure 8-31: Scenario 1 – Hourly average SO_2 concentrations.

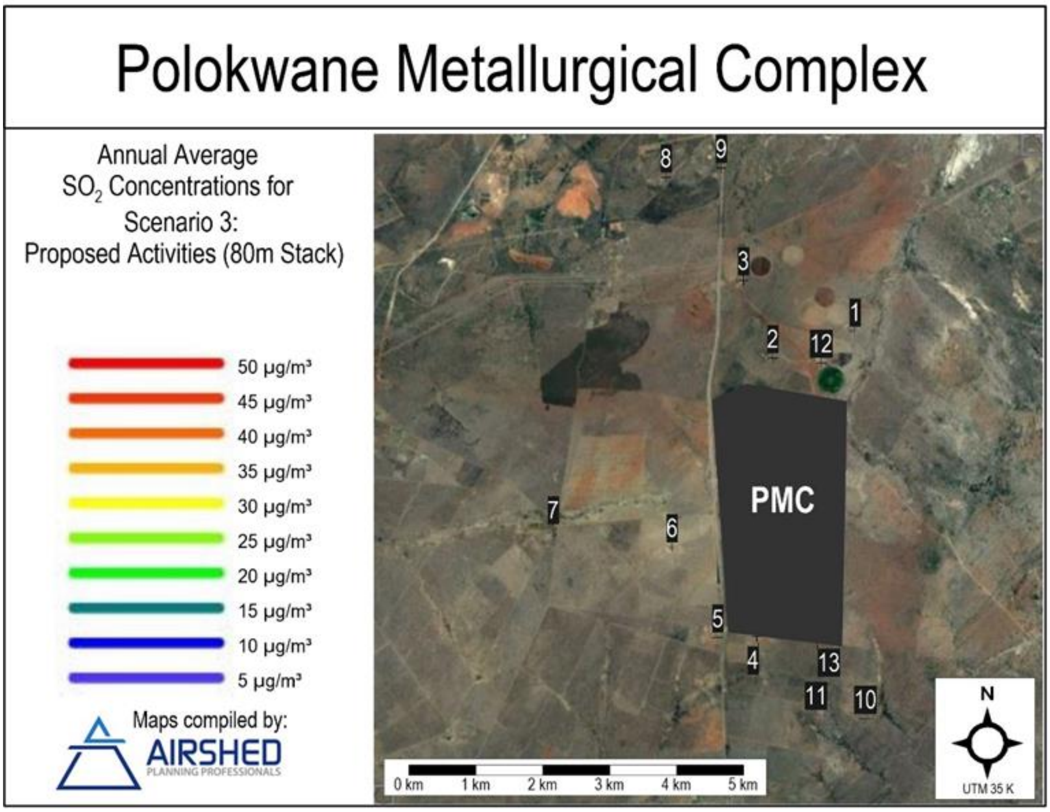

Figure 8-32: Scenario 3 – Annual average SO_2 concentrations.

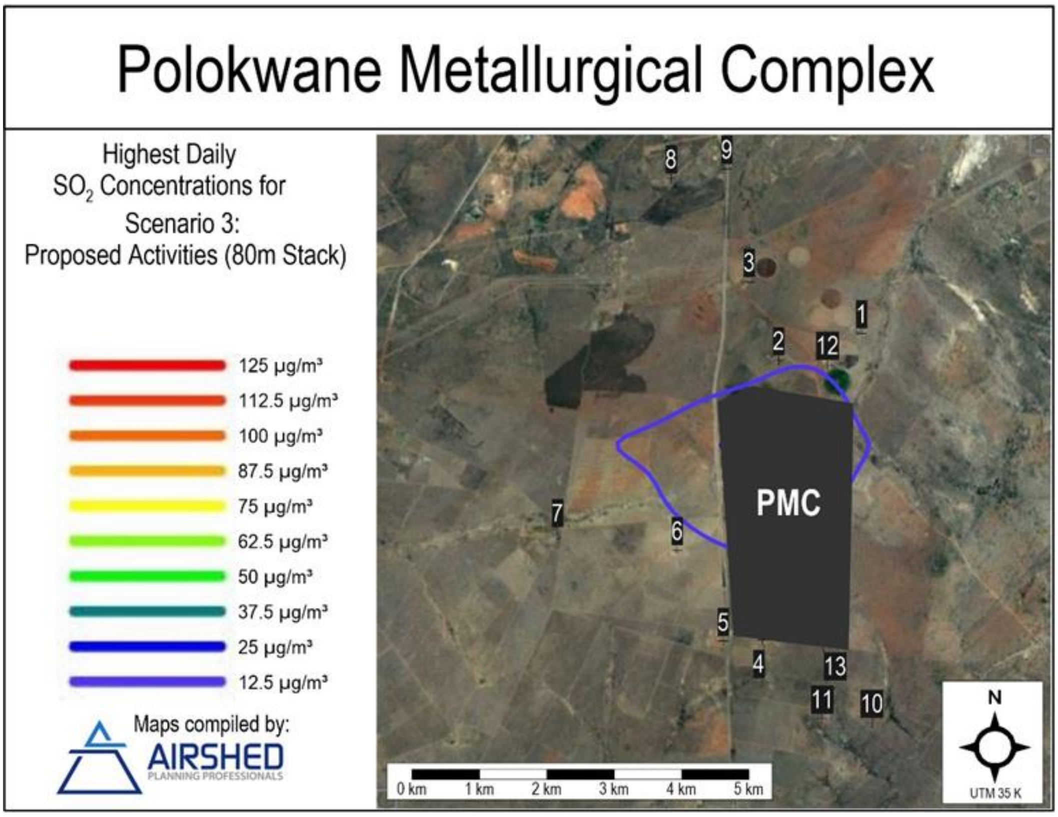

Figure 8-33: Scenario 3 – Daily average SO_2 concentrations.

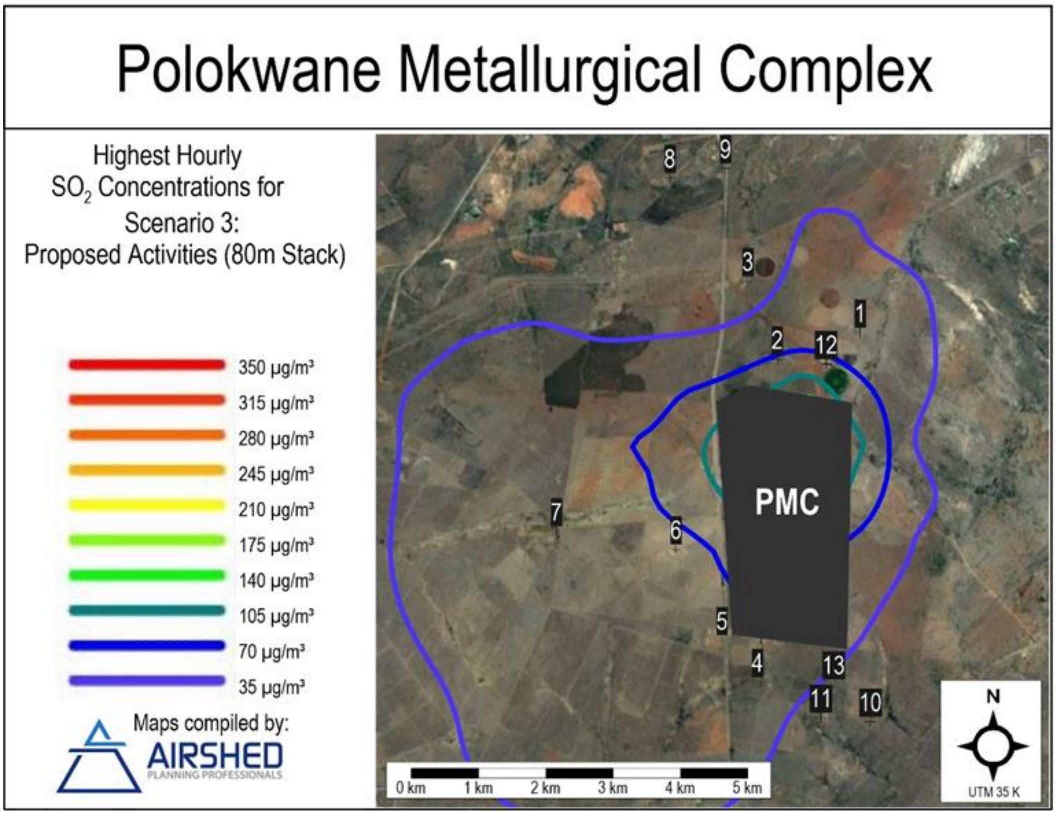

Figure 8-34: Scenario 3 – Hourly average SO_2 concentrations.

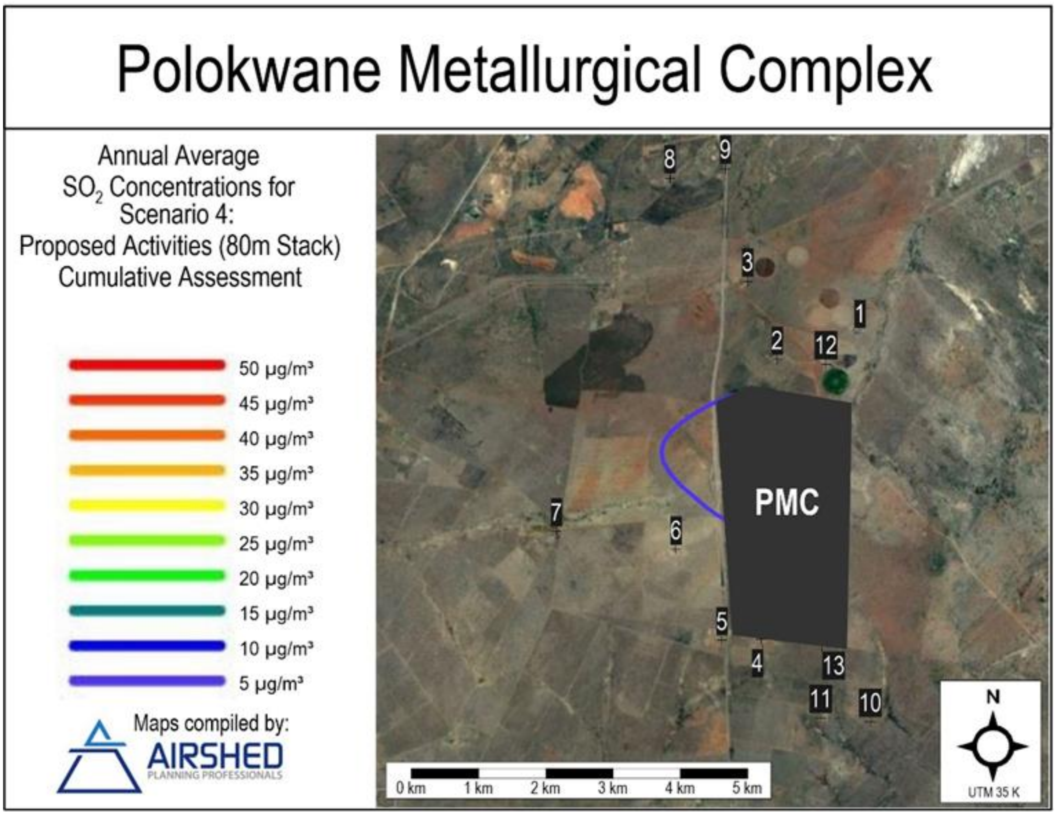

Figure 8-35: Scenario 4 – Annual average SO_2 concentrations.

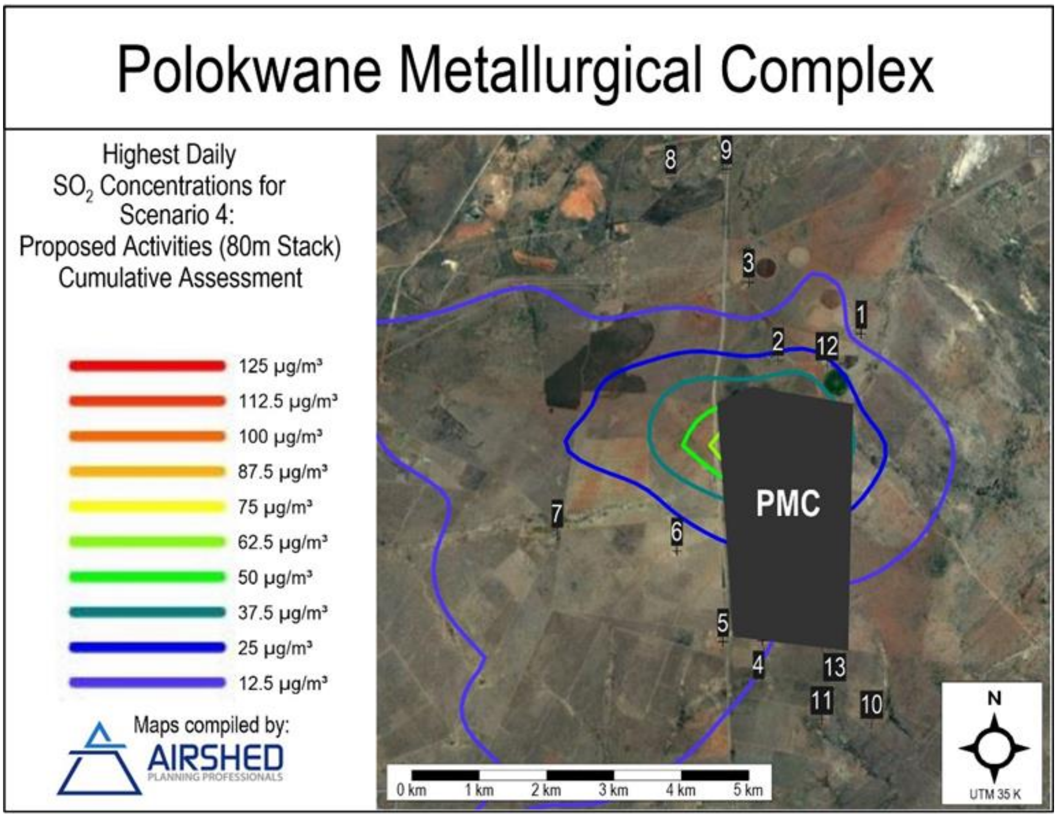

Figure 8-36: Scenario 4 – Daily average SO_2 concentrations.

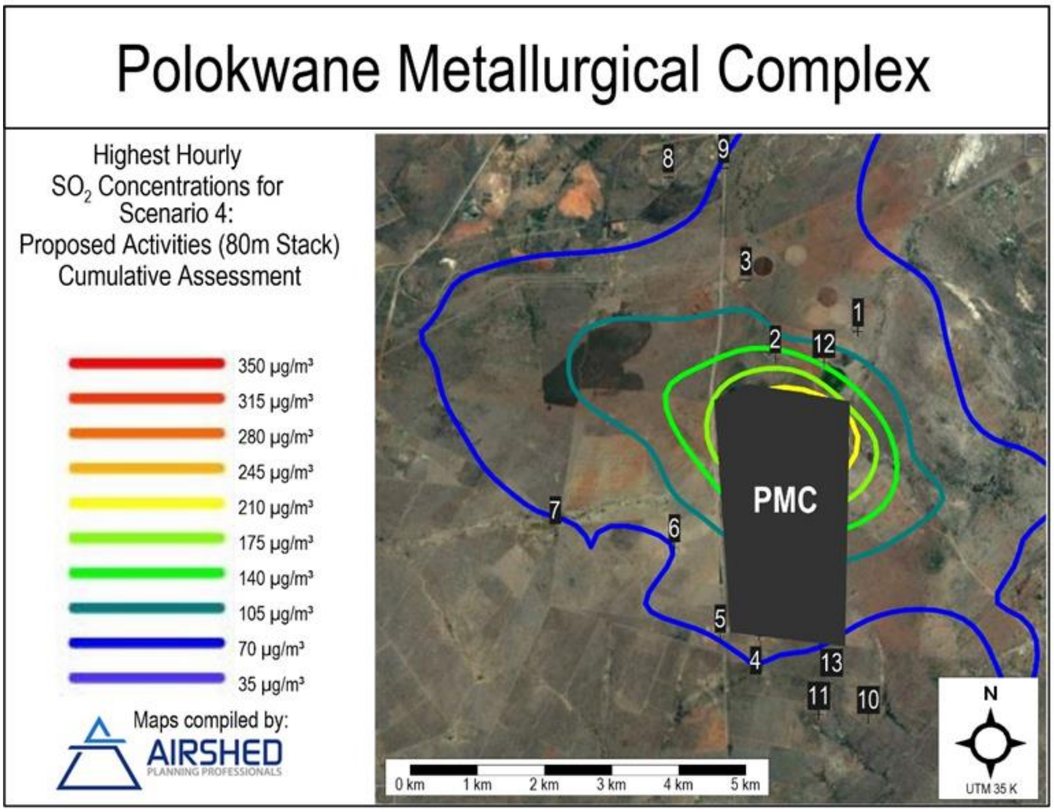

Figure 8-37: Scenario 4 – Hourly average SO_2 concentrations.

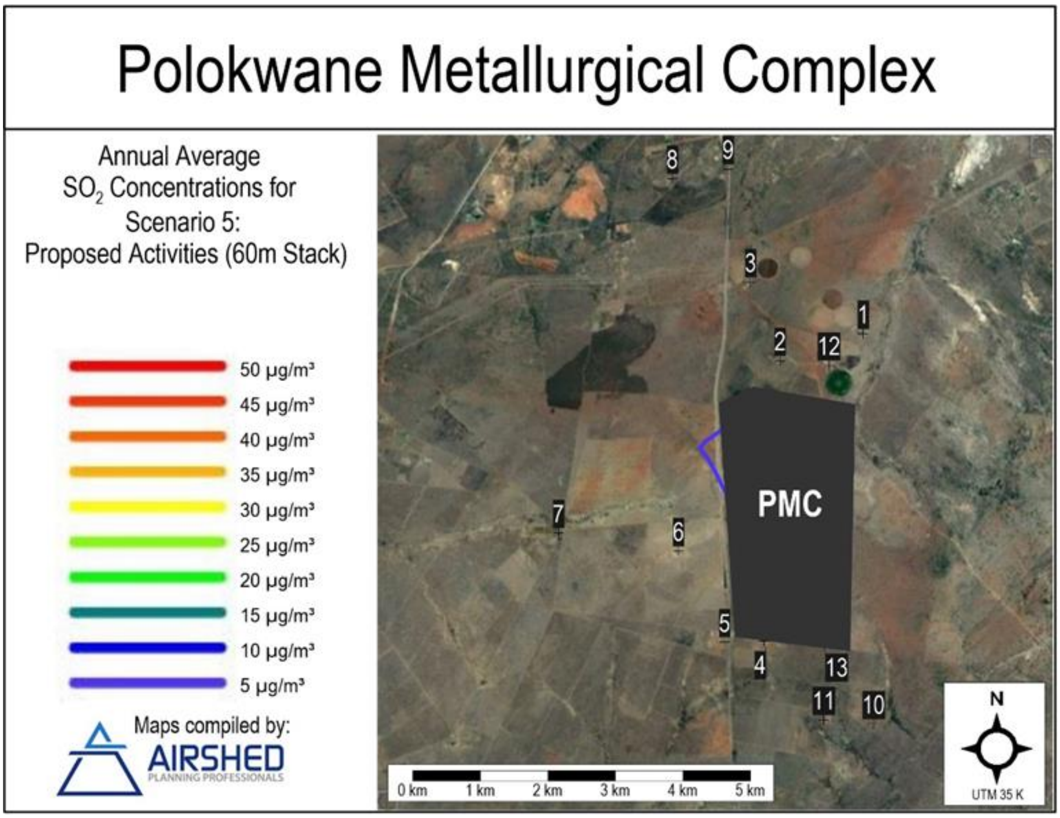

Figure 8-38: Scenario 5 – Annual average SO_2 concentrations.

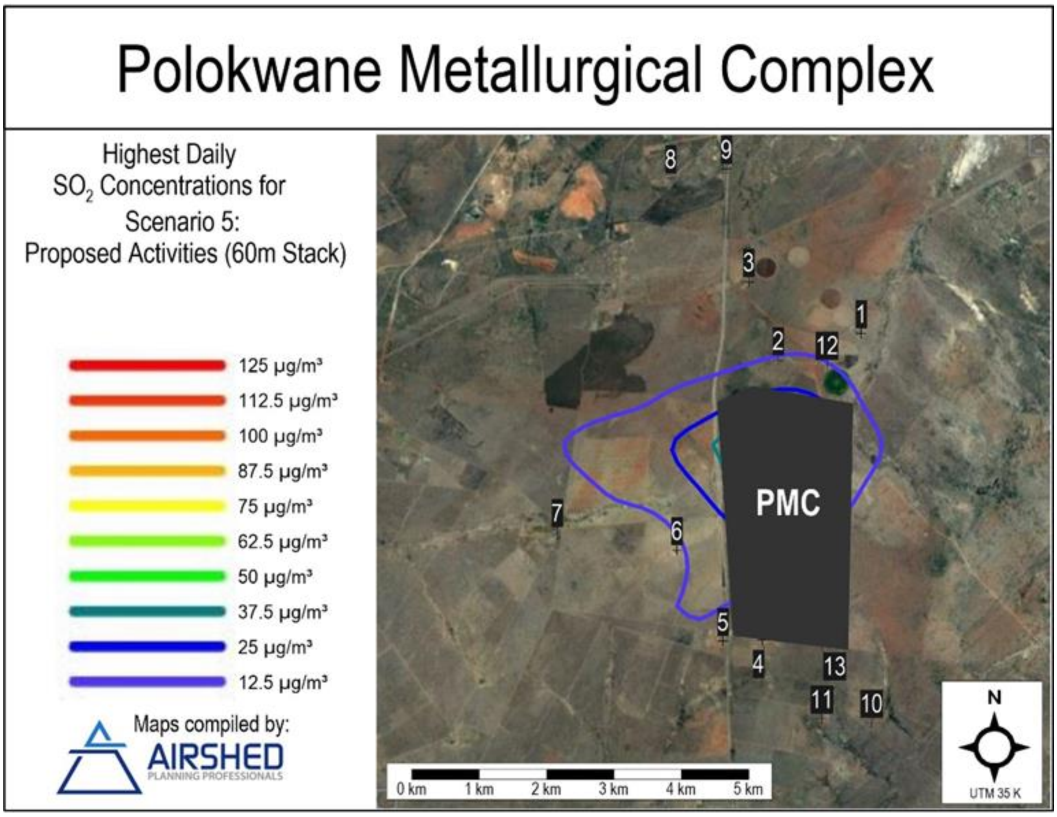

Figure 8-39: Scenario 5 – Daily average SO_2 concentrations.

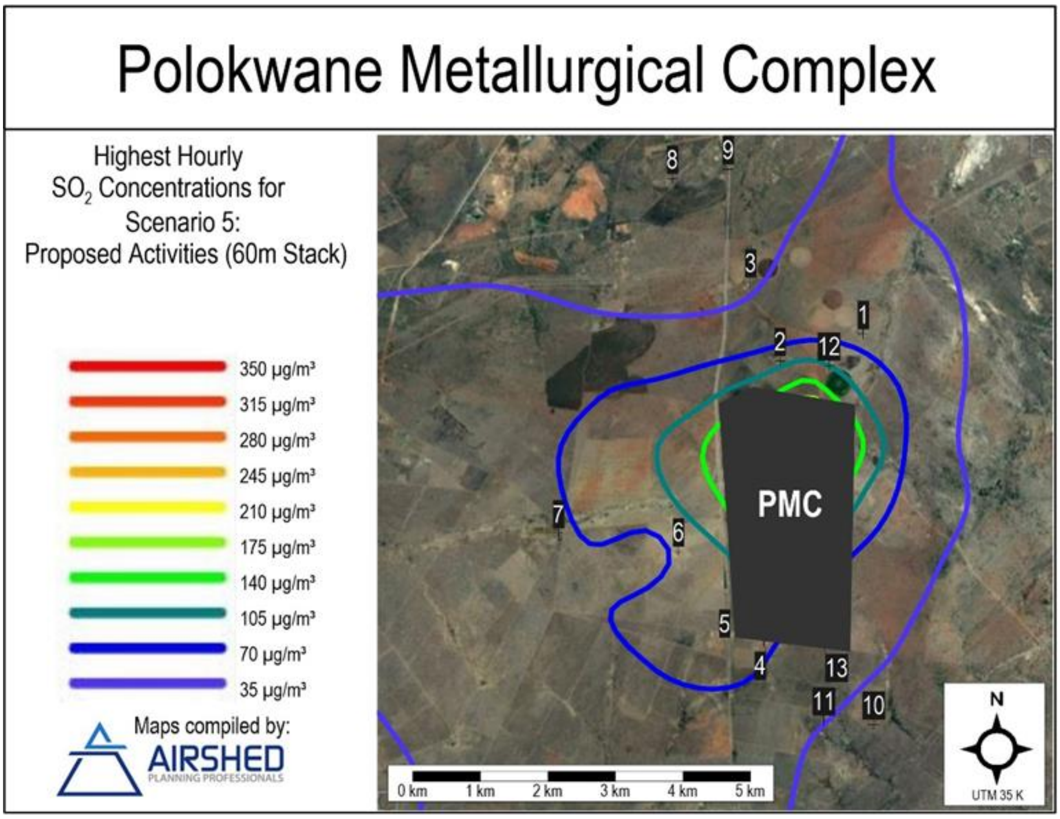

Figure 8-40: Scenario 5 – Hourly average SO_2 concentrations.

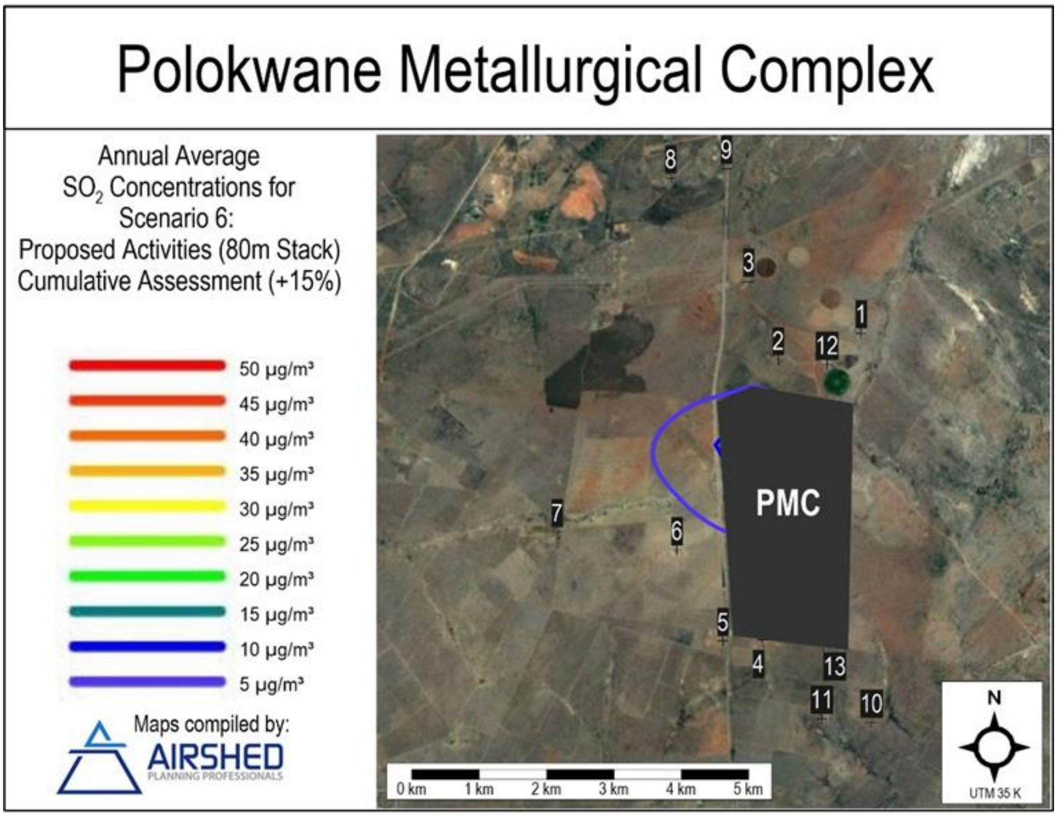

Figure 8-41: Scenario 6 – Annual average SO_2 concentrations.

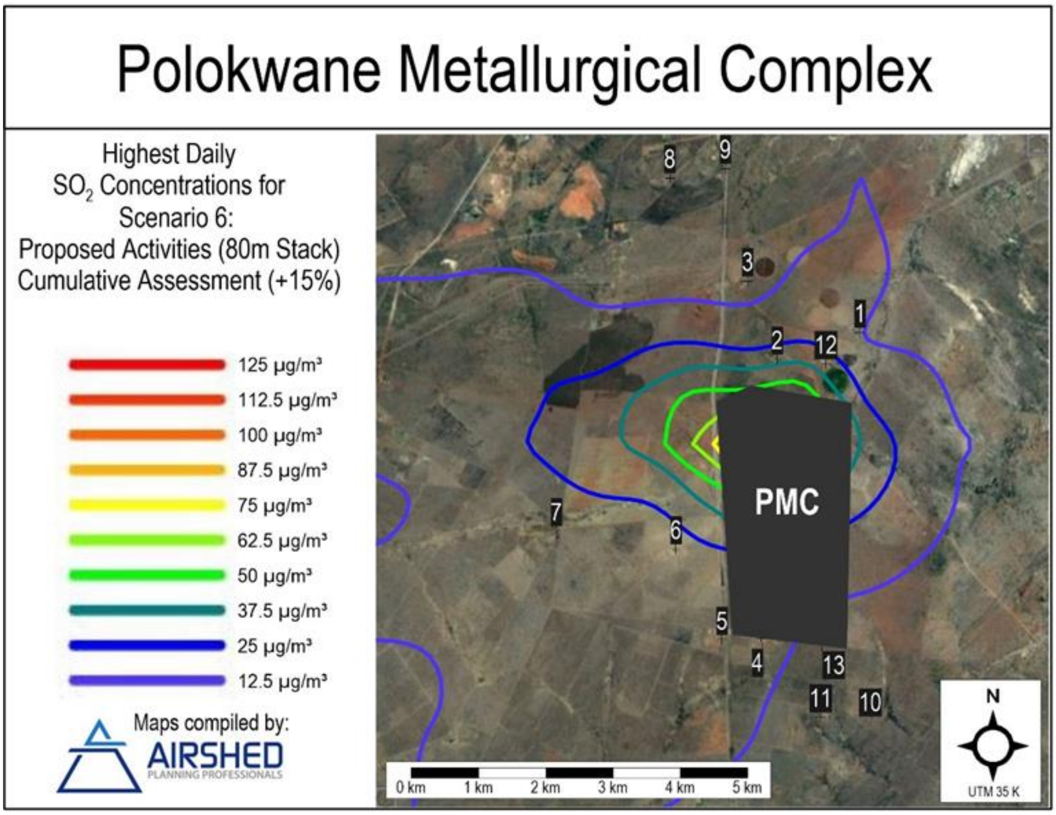

Figure 8-42: Scenario 6 – Daily average SO_2 concentrations.

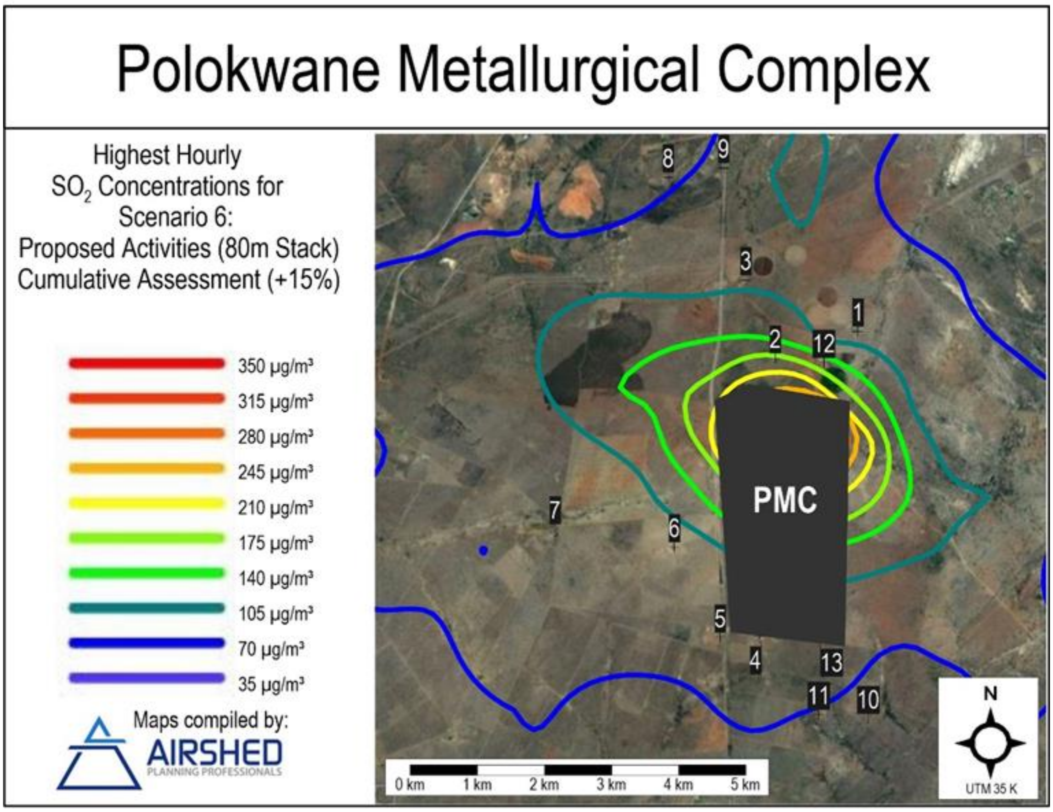

Figure 8-43: Scenario 6 – Hourly average SO_2 concentrations.

Appendix B

IMPACT ASSESSMENT METHODOLOGY

IMPACT ASSESSMENT METHODOLOGY

The EIA uses a methodological framework developed by WSP | Parsons Brinckerhoff to meet the combined requirements of international best practice and NEMA, Environmental Impact Assessment Regulations, 2014 (GN No. 982) (the “EIA Regulations”).

As required by the EIA Regulations (2014), the determination and assessment of impacts will be based on the following criteria:

- Nature of the Impact
- Significance of the Impact
- Consequence of the Impact
- Extent of the impact
- Duration of the Impact
- Probability if the impact
- Degree to which the impact:
  - can be reversed;
  - may cause irreplaceable loss of resources; and
  - can be avoided, managed or mitigated.

Following international best practice, additional criteria have been included to determine the significant effects. These include the consideration of the following:

- Magnitude: to what extent environmental resources are going to be affected;
- Sensitivity of the resource or receptor (rated as high, medium and low) by considering the importance of the receiving environment (international, national, regional, district and local), rarity of the receiving environment, benefits or services provided by the environmental resources and perception of the resource or receptor); and
- Severity of the impact, measured by the importance of the consequences of change (high, medium, low, negligible) by considering inter alia magnitude, duration, intensity, likelihood, frequency and reversibility of the change.

It should be noted that the definitions given are for guidance only, and not all the definitions will apply to all of the environmental receptors and resources being assessed. Impact significance was assessed with and without mitigation measures in place.

METHODOLOGY

Impacts are assessed in terms of the following criteria:

- The **nature**, a description of what causes the effect, what will be affected and how it will be affected

Nature or Type of Impact	Definition
Beneficial / Positive	An impact that is considered to represent an improvement on the baseline or introduces a positive change.

NATURE OR TYPE OF IMPACT	DEFINITION
Adverse / Negative	An impact that is considered to represent an adverse change from the baseline, or introduces a new undesirable factor.
Direct	Impacts that arise directly from activities that form an integral part of the Project (e.g. new infrastructure).
Indirect	Impacts that arise indirectly from activities not explicitly forming part of the Project (e.g. noise changes due to changes in road or rail traffic resulting from the operation of Project).
Secondary	Secondary or induced impacts caused by a change in the Project environment (e.g. employment opportunities created by the supply chain requirements).
Cumulative	Impacts are those impacts arising from the combination of multiple impacts from existing projects, the Project and/or future projects.

→ The physical **extent**, wherein it is indicated whether:

SCORE	DESCRIPTION
1	the impact will be limited to the site;
2	the impact will be limited to the local area;
3	the impact will be limited to the region;
4	the impact will be national; or
5	the impact will be international;

→ The **duration**, wherein it is indicated whether the lifetime of the impact will be:

SCORE	DESCRIPTION
1	of a very short duration (0 to 1 years)
2	of a short duration (2 to 5 years)

SCORE	DESCRIPTION
3	medium term (5–15 years)
4	long term (> 15 years)
5	permanent

- The **magnitude of impact on ecological processes**, quantified on a scale from 0-10, where a score is assigned:

SCORE	DESCRIPTION
0	small and will have no effect on the environment.
2	minor and will not result in an impact on processes.
4	low and will cause a slight impact on processes.
6	moderate and will result in processes continuing but in a modified way.
8	high (processes are altered to the extent that they temporarily cease).
10	very high and results in complete destruction of patterns and permanent cessation of processes.

- The **probability of occurrence**, which describes the likelihood of the impact actually occurring. Probability is estimated on a scale where:

SCORE	DESCRIPTION
1	very improbable (probably will not happen.
2	improbable (some possibility, but low likelihood).
3	probable (distinct possibility).
4	highly probable (most likely).

Score	Description
5	definite (impact will occur regardless of any prevention measures).

- the **significance**, which is determined through a synthesis of the characteristics described above (refer formula below) and can be assessed as low, medium or high;
- the **status**, which is described as either positive, negative or neutral;
- the degree to which the impact can be reversed;
- the degree to which the impact may cause irreplaceable loss of resources; and
- the *degree* to which the impact can be mitigated.

The **significance** is determined by combining the criteria in the following formula:

$$S = (E+D+M)*P$$

S = Significance weighting

E = Extent

D = Duration

M = Magnitude

P = Probability

The **significance weightings** for each potential impact are as follows:

Overall Score	Significance Rating	Description
< 30 points	Low	where this impact would not have a direct influence on the decision to develop in the area
31-60 points	Medium	where the impact could influence the decision to develop in the area unless it is effectively mitigated
> 60 points	High	where the impact must have an influence on the decision process to develop in the area

The impact significance without mitigation measures will be assessed with the design controls in place. Impacts without mitigation measures in place are not representative of the Project's actual extent of impact, and are included to facilitate understanding of how and why mitigation measures were identified. The residual impact is what remains following the application of mitigation and management measures, and is thus the final level of impact associated with the development of the Project. Residual impacts also serve as the focus of management and monitoring activities during Project implementation to verify that actual impacts are the same as those predicted in this EIA Report.

Appendix C

IMPACT ASSESSMENT RESULTS

Air Quality Impact Assessment

Significance Rating Table

Construction Phase (Scenarios 2a and 2b)									
Potential Impact		**Extent (E)**	**Duration (D)**	**Magnitude (M)**	**Probability (P)**	**Significance (S=(E+D+M)*P)**		**Status (+ve or -ve)**	**Confidence**
Impact of PM_{10} concentrations on Receptors	**Nature of impact:**	Direct							
	Without Mitigation	2	2	4	4	**32**	**Medium**	-	
	degree to which impact can be reversed:	High							
	degree of impact on irreplaceable resources:	Low							
	Mitigation Measures	Wet suppression							
	With Mitigation	2	2	2	3	**18**	**Low**		
Impact of $PM_{2.5}$ concentrations on Receptors	**Nature of impact:**	Direct							
	Without Mitigation	2	2	4	4	**32**	**Medium**	-	
	degree to which impact can be reversed:	High							
	degree of impact on irreplaceable resources:	Low							
	Mitigation Measures	Wet suppression							
	With Mitigation	2	2	2	3	**18**	**Low**	-	

Air Quality Impact Assessment

Significance Rating Table

Operational Phase (Scenarios 1, 3, 4 and 5)

Potential Impact		Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Impact of SO_2 concentrations on Receptors	Nature of impact:	Direct							
	Without Mitigation	2	5	6	3	39	Medium	-	
	degree to which impact can be reversed:	Low							
	degree of impact on irreplaceable resources:	Medium							
	Mitigation Measures	Wet Sulphuric Acid Process							
	With Mitigation	1	5	2	2	16	Low	+	
Impact of PM_{10} concentrations on Receptors	Nature of impact:	Direct							
	Without Mitigation	2	5	2	3	27	Low	-	
	degree to which impact can be reversed:	High							
	degree of impact on irreplaceable resources:	Low							
	Mitigation Measures	Not Applicable							
	With Mitigation	2	5	2	2	18	Low	-	
Impact of $PM_{2.5}$ concentrations on Receptors	Nature of impact:	Direct							
	Without Mitigation	2	5	2	2	18	Low	-	
	degree to which impact can be reversed:	High							
	degree of impact on irreplaceable resources:	Low							
	Mitigation Measures	Not Applicable							
	With Mitigation	1	5	2	1	8	Low	-	

Air Quality Impact Assessment

Significance Rating Table

Cumulative Impacts (Scenarios 4 and 6)									
Potential Impact		**Extent (E)**	**Duration (D)**	**Magnitude (M)**	**Probability (P)**	**Significance (S=(E+D+M)*P)**		**Status (+ve or -ve)**	**Confidence**
Impact of SO_2 concentrations on Receptors	**Nature of impact:**	Cumulative							
	Without Mitigation	1	5	0	1	**6**	**Low**	-	
	degree to which impact can be reversed:	High							
	degree of impact on irreplaceable resources:	Low							
	Mitigation Measures	Not Applicable							
	With Mitigation	1	5	0	1	**6**	**Low**	-	
Impact of PM_{10} concentrations on Receptors	**Nature of impact:**	Cumulative							
	Without Mitigation	2	5	4	3	**33**	**Medium**	-	
	degree to which impact can be reversed:	Medium							
	degree of impact on irreplaceable resources:	Low							
	Mitigation Measures	Not Applicable							
	With Mitigation	2	5	4	3	**33**	**Medium**	-	

Air Quality Impact Assessment

Significance Rating Table

Decommissioning Phase

Potential Impact		Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Impact of PM_{10} concentrations on receptors	Nature of impact:	Direct							
	Without Mitigation	2	2	4	4	32	Medium	-	
	degree to which impact can be reversed:	High							
	degree of impact on irreplaceable resources:	Low							
	Mitigation Measures	Wet Suppression and Wind speed Reduction							
	With Mitigation	2	2	2	3	18	Low	-	
Impact of $PM_{2.5}$ concentrations on receptors	Nature of impact:	Direct							
	Without Mitigation	2	2	4	4	32	Medium	-	
	degree to which impact can be reversed:	High							
	degree of impact on irreplaceable resources:	Low							
	Mitigation Measures	Wet Suppression and Wind speed Reduction							
	With Mitigation	2	2	2	3	18	Low	-	

Appendix D

AIRSHED REPORT

AIRSHED
PLANNING PROFESSIONALS

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19 June 2017

Anglo Platinum Limited – Rustenburg Operations
Waterval Smelter Complex
5th Street, Waterval Mine Village
Rustenburg

Dispersion Modelling Scenarios for Polokwane Metallurgical Complex

1. Introduction

As part of the Polokwane Metallurgical Complex SO_2 Abatement Air Quality Impact Assessment conducted by WSP Environmental (Pty) Ltd (WSP) Airshed was appointed by Anglo and WSP to use the CALPUFF dispersion model specifically for assessment of SO_2 emissions. The CALPUFF model was updated with recent (2014 – 2015) meteorological data to simulate ground level SO_2 concentrations from proposed activities to compare to baseline concentrations from current activities.

2. Dispersion Model and Modelling Domain

The CALMET/CALPUFF suite of models were used for dispersion modelling (CALMET v 6.334, CALPUFF v 6.42 and CALPOST v5.6394) The dispersion model was updated with modelled CALMET ready WRF (Weather Research and Forecasting Model) meteorological data for the period 1 January 2014 to 31 December 2015 for a 100km x 100km domain with a 12km resolution (the centre point being at the Polokwane Metallurgical Complex).

Elevation data used in the dispersion model was obtained from the Shuttle Radar Topography Mission (SRTM) dataset at horizontal resolution of three arc-seconds (90 m). Use was made of Lambert Azimuthal land use data for Africa.

Ground level concentrations were also simulated at thirteen sensitive receptor locations as identified by WSP (WSP, 2017).

Table 1: Discreet Receptor Locations with Coordinates

Receptor	X (UTM 35S)	Y (UTM 35S)
Farmstead 1	752192	7342051
Farmstead 2	750961	7341652
Farmstead 3	750524	7342817

Receptor	X (UTM 35S)	Y (UTM 35S)
Farmstead 4	750717	7337503
Farmstead 5	750140	7337487
Farmstead 6	749457	7338834
Farmstead 7	747681	7339104
Farmstead 8	749367	7344349
Farmstead 9	750192	7344492
Farmstead 10	752345	7336274
Farmstead 11	751608	7336334
Farmstead 12	751684	7341584
Farmstead 13	751601	7337592

3. Existing Ambient Air Quality

Anglo American Platinum operates six ambient air quality monitoring stations around the Polokwane Metallurgical Complex. Measured SO_2 concentrations for the period January 2014 to December 2015 are shown in Table 2. **Measured SO_2 concentrations at the six ambient air quality monitoring stations are in compliance with the SA NAAQS for all averaging periods for the 2014 to 2015 sampling period.**

Table 2: Measured SO_2 Concentrations (2014 – 2015)

Monitoring Station	Annual Average Concentration (SA NAAQS - 50 µg/m³)	Highest Daily Concentration	2014 & 2015 frequency of exceedance of daily NAAQS (4 exceedances of 125 µg/m³ allowed)	Highest Hourly Concentration	2014 & 2015 frequency of exceedance of hourly NAAQS (88 exceedances of 350 µg/m³ allowed)
School	5	38	0 & 0	546	1 & 1
GameFarm	11	88	0 & 0	579	3 & 8
NorthFarm	11	152	0 & 1	834	28 & 38
Kuschke	5	82	0 & 0	685	4 & 3
SouthFarm	29	194	0 & 4	967	46 & 83
Deelkraal	13	111	0 & 0	849	10 & 19

4. Emission Rates and Stack Parameters

Scenario 1 dispersion modelling was conducted using the average emission rate recorded from 2014 to 2016 (35 623 mg/Nm³) from the furnace primary stack. The maximum monthly average SO_2 emission rate during this period occurred in April 2015 when a monthly average SO_2 emission rate of 51 204 mg/Nm³ was recorded. The minimum monthly average SO_2 emission rate was recorded as 21 945 mg/Nm³ in July 2016.

Emissions for this scenario were calculated with a volumetric flow rate of 40 000 Nm³/hr resulting in a SO_2 emission rate of 395.8 g/s from the furnace primary stack. Parameters and emission rates describing the two flash dryer stacks and the furnace secondary stack were assumed to remain unchanged from the AEL on site. Scenario 2 represents construction phase impacts, and SO_2 concentrations were therefore not modelled for this scenario.

Stack parameters for the WSA stack for the future scenarios (scenarios 3, 4 and 5) were provided by WSP. Emissions rates were calculated using the Section 21 Subcategory 4.16 Minimum Emission Limit of 1 200 mg/Nm³ for which the project has been designed. A description of the Scenarios modelled and the parameters describing each scenario are shown in Table 3. No fugitive emissions from the PMC operations were quantified or included in the dispersion modelling. It is assumed that if measured and modelled ambient concentrations due to current PMC point sources without abatement equipment are in compliance with the SA NAAQS without accounting for fugitive emissions in the dispersion modelling then future concentrations will also be in compliance with the SA NAASQ when SO_2 abatement is applied to the most significant SO_2 source.

Table 3: Dispersion Modelling Scenarios

Existing Scenario	Description	Stack Height	SO_2 Emission Rate
1	Current Activities: 35 623 mg/Nm³ SO_2 Concentration	Primary Stack - 155 m	395.8 g/s
Future Scenarios	**Description**	**Stack Height**	**SO_2 Emission Rate**
3[(d)]	Incremental[(a)] Proposed (80m)	WSA Stack- 80 m	17.0 g/s
4	Cumulative[(b)] Proposed (80m)	WSA Stack- 80 m	17.0 g/s
5	Incremental[(a)] Proposed (60m)	WSA Stack- 60 m	17.0 g/s
6	Cumulative[(b)] Proposed (80m) (+15% increase in throughput[(c)])	WSA Stack- 80 m	WSA - 17.0 g/s 15% increase in flash drier and secondary stack emissions

(a)Incremental scenarios describe only the impact of the WSA stack, without other PMC or background sources.
(b)Cumulative scenarios describe the impact of the WSA stack cumulative with the impact from other PMC point sources.
(c)A 15% increase in emissions scenario is included to account for a proposed15% increase in concentration throughput
(d) Scenario 2 represents construction phase impacts, and SO_2 concentrations were therefore not modelled for this scenario.

5. Simulated Concentrations – Discreet Receptor Locations

Simulated ground level SO_2 concentrations at identified sensitive receptor locations are shown in Table 4. Where exceedances of the SA NAAQS limit values were simulated the number of exceedances are shown in parenthesis.

Simulated SO_2 concentrations due to existing activities (Scenario 1) are in exceedance of the SA daily NAAQS (4 exceedances of 125 µg/m³) and hourly NAAQS (88 exceedances of 350 µg/m³) at Farmstead 2 and Farmstead 12 and in compliance with the SA NAAQS at all other sensitive receptor locations. Measured SO_2 concentrations at the SouthFarm (Farmstead 6) and NorthFarm (Farmstead 12) monitoring stations during the period 2014 to 2015 show that ambient SO_2 concentrations at these two locations are in compliance with the SA NAAQS for all averaging periods. The CALPUFF model is intended for use on scales from tens of metres to hundreds of kilometres from a source, however, the model has a tendency to potentially over-predict in the near-field (US EPA 2005).

Simulated annual average SO_2 concentrations for Scenario 1 are in compliance with the SA NAAQS (50 µg/m³) at all sensitive receptor locations. Simulated SO_2 concentrations are in compliance with the SA NAAQS for all averaging periods for all incremental (Scenarios 3 and 5) and cumulative (Scenarios 4 and 6) future scenarios for the entire modelling domain.

Table 4: Simulated Ground level SO_2 Concentrations at Discreet Receptor Locations

Receptor	SO_2 Concentration (µg/m³)		
	Annual Average	Highest Daily	Highest Hourly
Scenario 1 - Existing Activities - 35 623 mg/Nm³ SO_2 Concentration			
Farmstead 1	5.8	92	676 (4)
Farmstead 2	16.8	**189 (10)**	**1103 (120)**
Farmstead 3	5.3	84	631 (7)
Farmstead 4	10.4	104	699 (24)
Farmstead 5	11.2	97	639 (21)
Farmstead 6	16.6	120 (3)	617 (57)
Farmstead 7	11.4	90	514 (10)
Farmstead 8	2.3	37	363 (1)
Farmstead 9	2.7	53	425 (1)
Farmstead 10	4.8	65	424 (3)
Farmstead 11	5.6	73	487 (6)
Farmstead 12	13.6	**188 (8)**	**963 (89)**

Receptor	SO_2 Concentration (µg/m³)		
	Annual Average	Highest Daily	Highest Hourly
Farmstead 13	8.7	105	661 (20)
Scenario 3 - Proposed Activities (80m Stack Height)			
Farmstead 1	0.3	4	45
Farmstead 2	1.1	9	75
Farmstead 3	0.2	2	26
Farmstead 4	0.7	5	57
Farmstead 5	0.9	7	59
Farmstead 6	1.3	8	57
Farmstead 7	1.0	7	51
Farmstead 8	0.1	1	10
Farmstead 9	0.1	1	15
Farmstead 10	0.3	2	24
Farmstead 11	0.3	2	30
Farmstead 12	1.1	10	81
Farmstead 13	0.5	4	45
Scenario 4 - Proposed Activities (80m Stack Height) - Cumulative Assessment			
Farmstead 1	0.6	11	82
Farmstead 2	2.3	30	152
Farmstead 3	0.5	8	85
Farmstead 4	1.3	14	75
Farmstead 5	1.6	16	71
Farmstead 6	2.5	16	72
Farmstead 7	1.9	17	69
Farmstead 8	0.2	4	58
Farmstead 9	0.3	5	73
Farmstead 10	0.5	6	56
Farmstead 11	0.6	8	60
Farmstead 12	1.9	27	137
Farmstead 13	0.9	10	73
Scenario 5 - Proposed Activities (60m Stack Height)			
Farmstead 1	0.4	4	60
Farmstead 2	1.5	13	96
Farmstead 3	0.3	3	32
Farmstead 4	1.0	8	78
Farmstead 5	1.3	10	83

Receptor	SO_2 Concentration (µg/m³)		
	Annual Average	Highest Daily	Highest Hourly
Farmstead 6	1.9	12	77
Farmstead 7	1.4	9	65
Farmstead 8	0.1	1	15
Farmstead 9	0.2	1	17
Farmstead 10	0.3	2	30
Farmstead 11	0.4	3	36
Farmstead 12	1.4	13	104
Farmstead 13	0.6	5	55
Scenario 6 - Proposed Activities (80m Stack Height) - Cumulative Assessment (+15%)			
Farmstead 1	0.7	13	94
Farmstead 2	2.7	33	173
Farmstead 3	0.6	10	98
Farmstead 4	1.5	16	86
Farmstead 5	1.8	18	82
Farmstead 6	2.8	19	82
Farmstead 7	2.2	20	80
Farmstead 8	0.2	5	66
Farmstead 9	0.3	6	83
Farmstead 10	0.6	7	64
Farmstead 11	0.7	9	69
Farmstead 12	2.1	31	157
Farmstead 13	1.1	11	84

The percentage reduction in SO_2 concentrations from current activities (Scenario 1) to cumulative future activities are shown in **Error! Not a valid bookmark self-reference.**. Simulated concentrations for future scenarios show an average reduction of 87% in ground level SO_2 concentrations from the current (Scenario 1) levels at sensitive receptor locations.

Table 5: Reduction in SO_2 concentrations from Scenario 1 to Scenario 4.

Receptor	Reduction in SO_2 Concentrations from Scenario 1 to Scenario 4		
	Annual	Daily	Hourly
Farmstead 1	89%	88%	88%
Farmstead 2	86%	84%	86%

Receptor	Reduction in SO_2 Concentrations from Scenario 1 to Scenario 4		
	Annual	Daily	Hourly
Farmstead 3	90%	90%	86%
Farmstead 4	88%	87%	89%
Farmstead 5	86%	84%	89%
Farmstead 6	85%	86%	88%
Farmstead 7	83%	81%	87%
Farmstead 8	91%	89%	84%
Farmstead 9	90%	91%	83%
Farmstead 10	90%	91%	87%
Farmstead 11	90%	89%	88%
Farmstead 12	86%	85%	86%
Farmstead 13	90%	90%	89%

6. Simulated Concentrations – Isopleth Plots

Simulated SO_2 concentrations for all scenarios are provided in this section as described in Table 6.

Table 6: Simulated SO_2 Isopleth Plots.

Scenario	Highest Hourly Isopleth	Highest Daily Isopleth	Annual Average Isopleth
1	Figure 1	Figure 6	Figure 11
3	Figure 2	Figure 7	Figure 12
4	Figure 3	Figure 8	Figure 13
5	Figure 4	Figure 9	Figure 14
6	Figure 5	Figure 10	Figure 15

Simulated ground level SO_2 concentrations are in compliance with the SA NAAQS over the entire study area for all future scenarios (Scenarios 3, 4, 5 and 6).

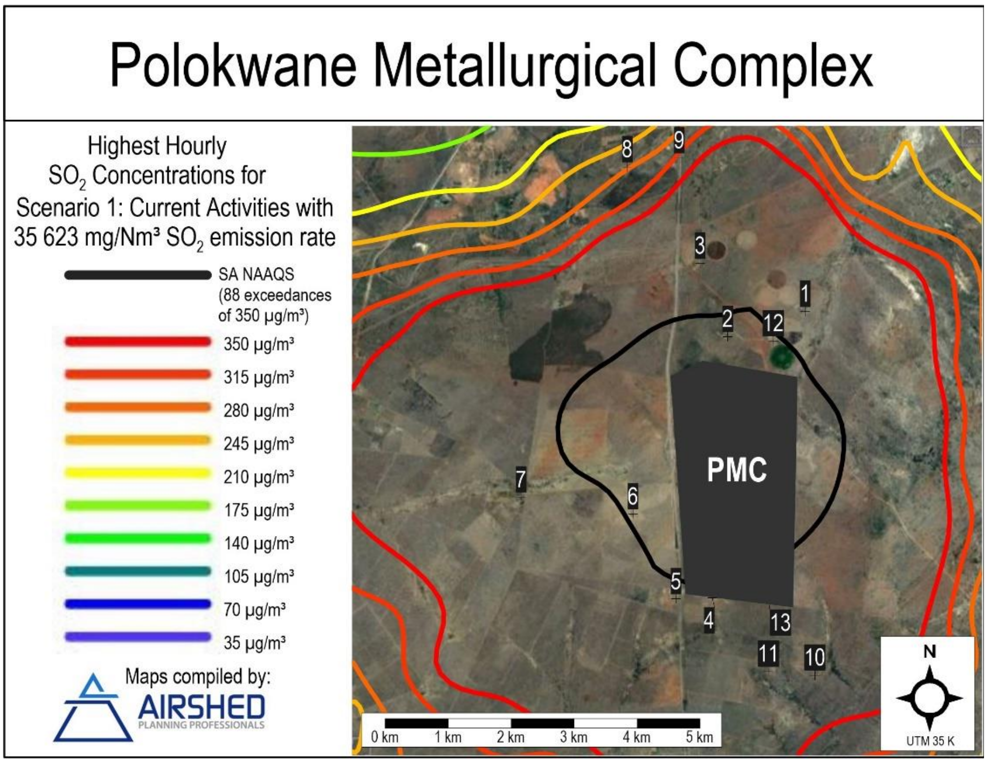

Figure 1: Highest hourly ground level SO_2 concentrations – Scenario 1

Measured SO_2 concentrations (Table 2) at the SouthFarm (Farmstead 6) and NorthFarm (Farmstead 12) monitoring stations during the period 2014 to 2015 show that ambient SO_2 concentrations due to current activities are in compliance with the SA NAAQS for all averaging periods at these two locations. The CALPUFF model is intended for use on scales from tens of metres to hundreds of kilometres from a source, however, the model has a tendency to potentially over-predict in the near-field (US EPA 2005).

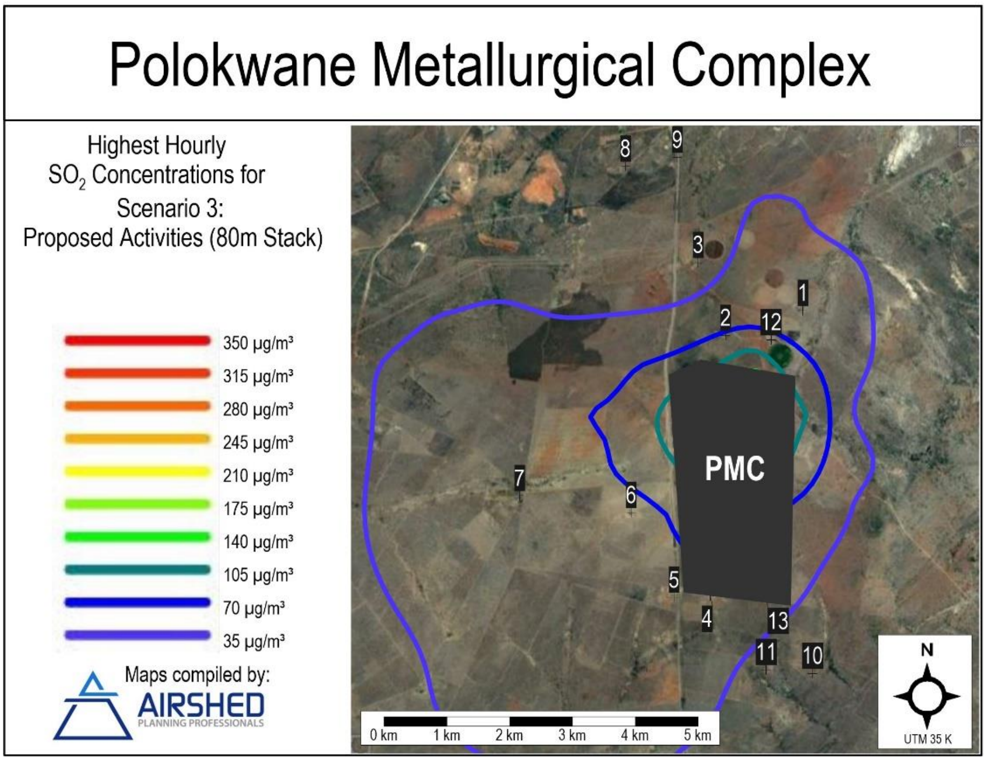

Figure 2: Highest hourly ground level SO_2 concentrations – Scenario 3

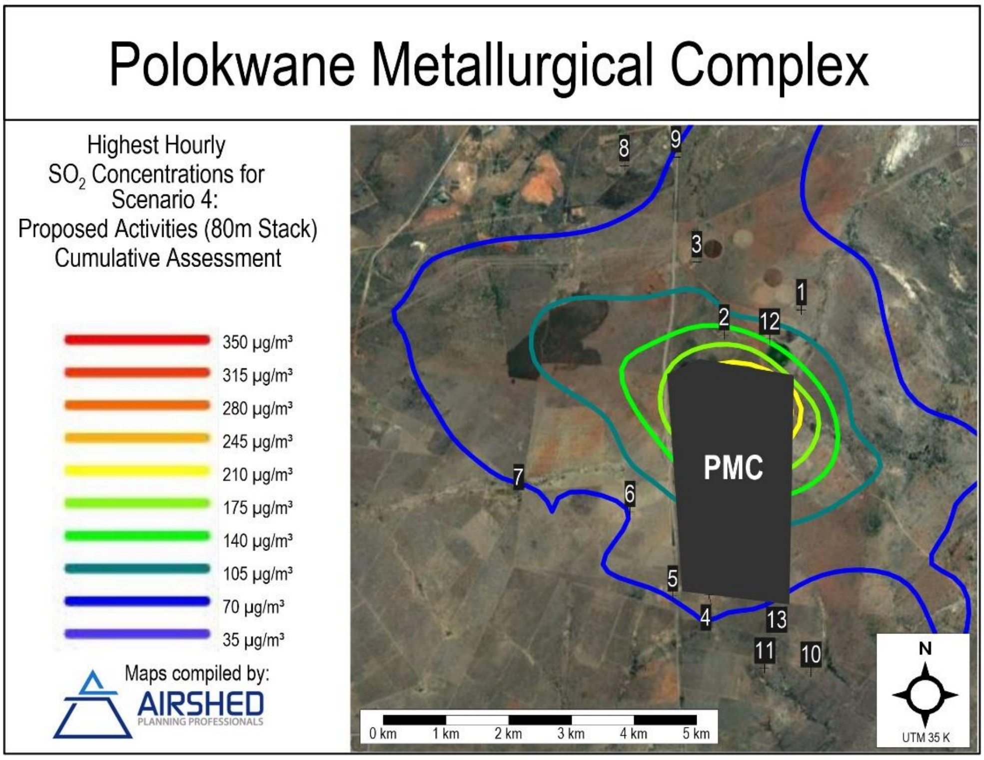

Figure 3: Highest hourly ground level SO_2 concentrations – Scenario 4

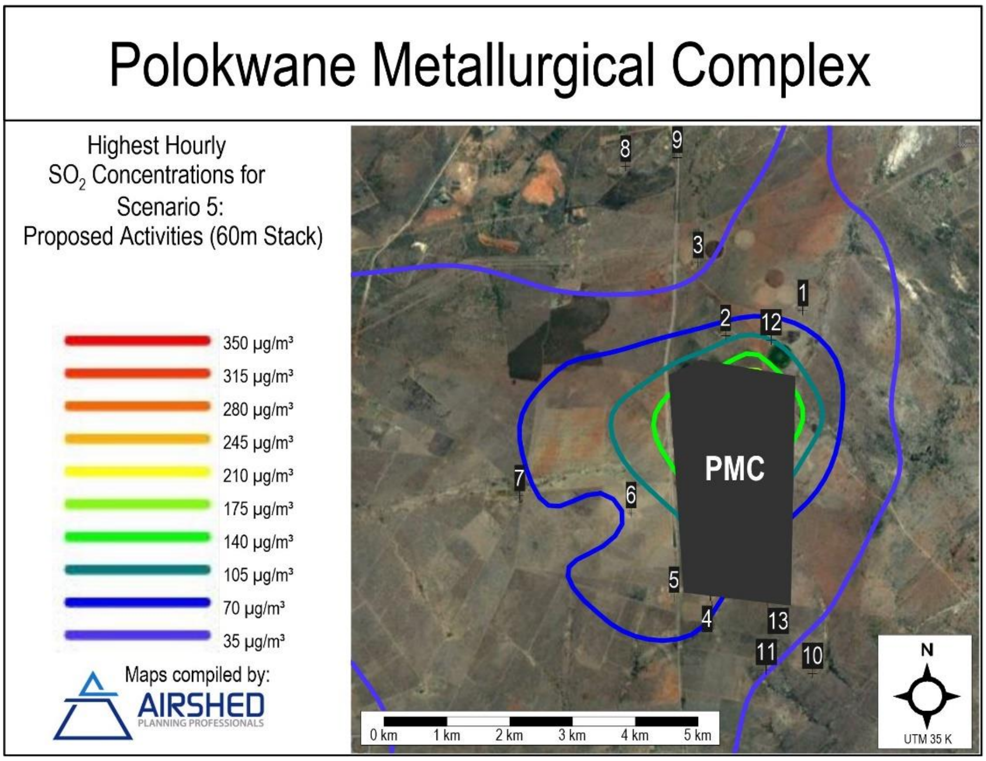

Figure 4: Highest hourly ground level SO_2 concentrations – Scenario 5

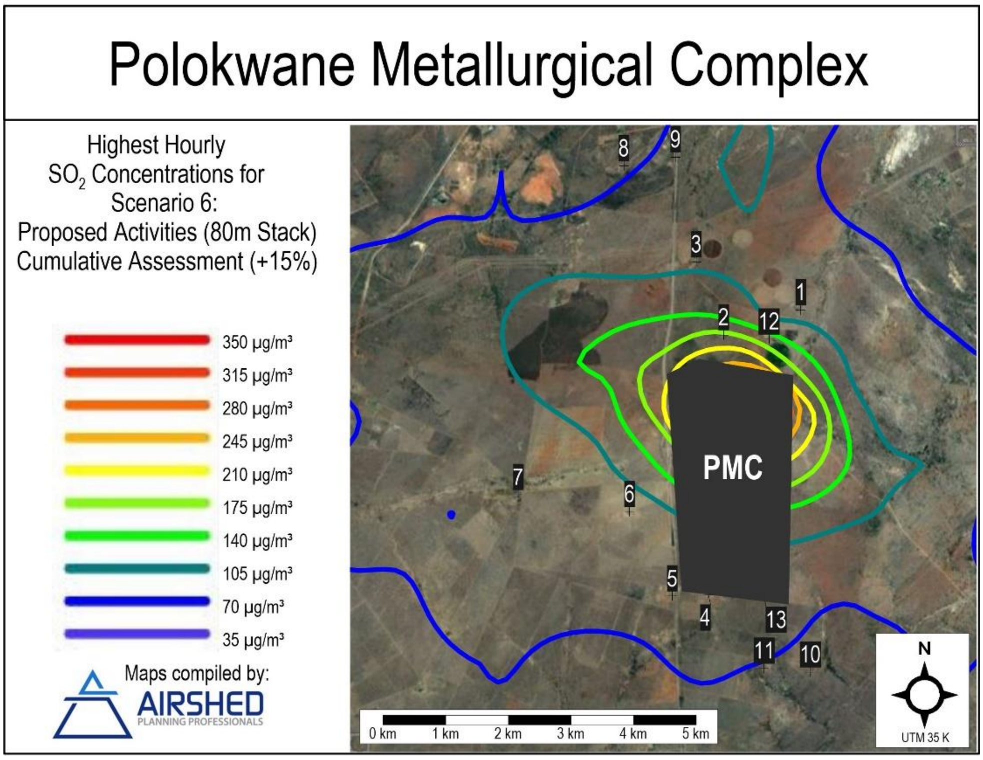

Figure 5: Highest hourly ground level SO_2 concentrations – Scenario 6

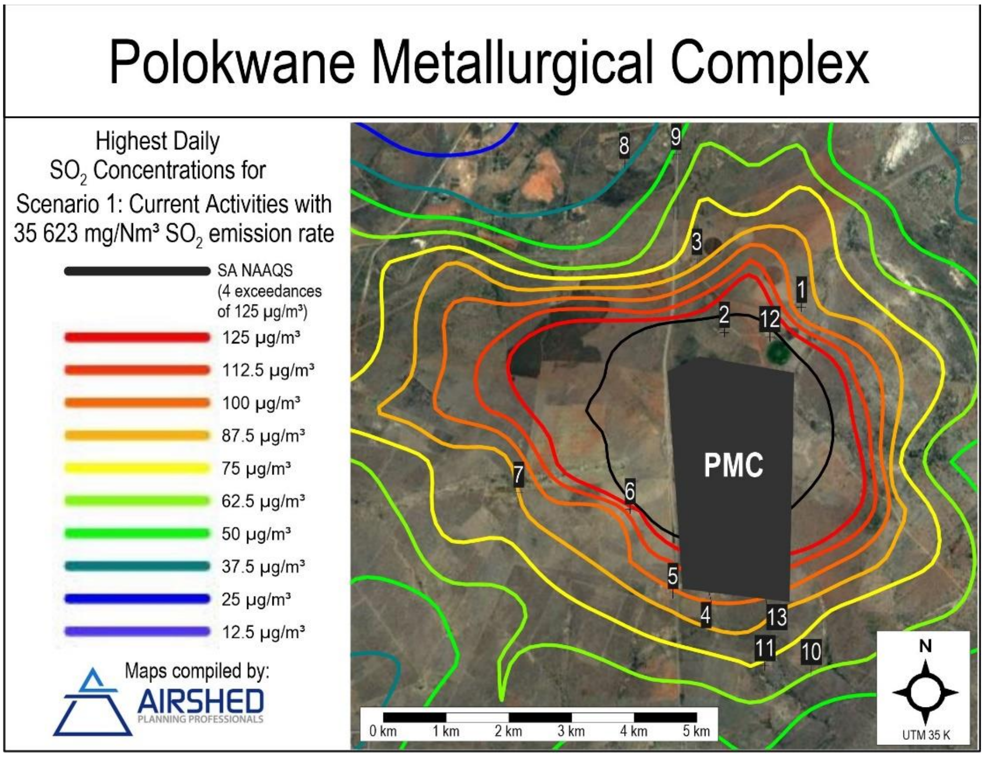

Figure 6: Highest daily ground level SO_2 concentrations – Scenario 1

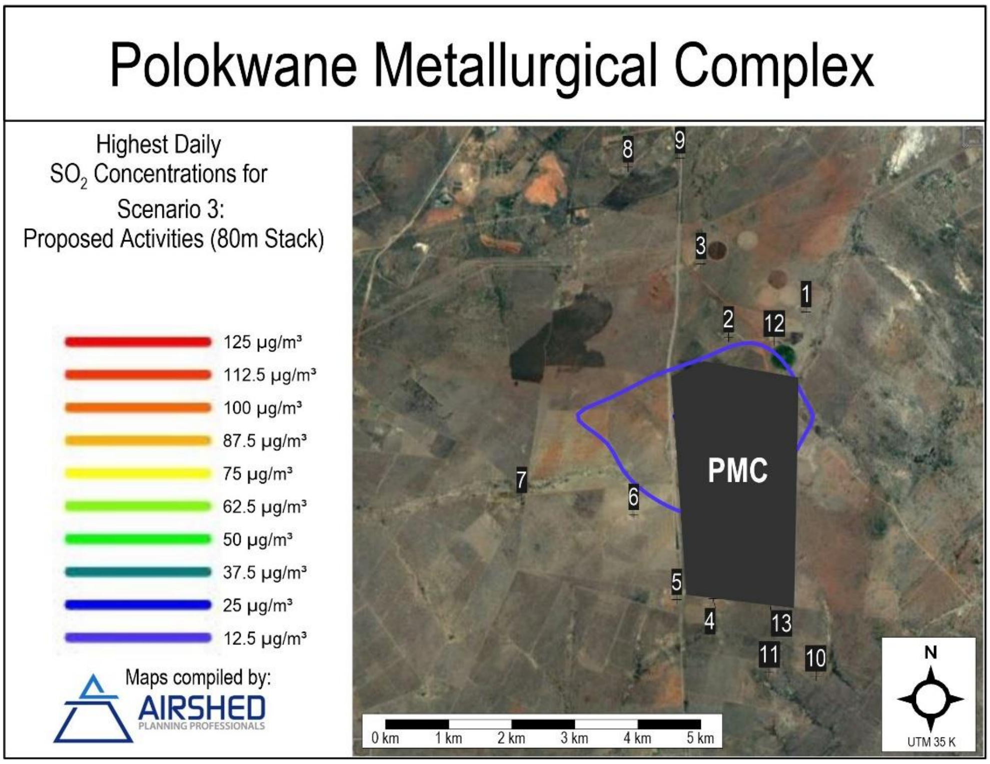

Figure 7: Highest daily ground level SO_2 concentrations – Scenario 3

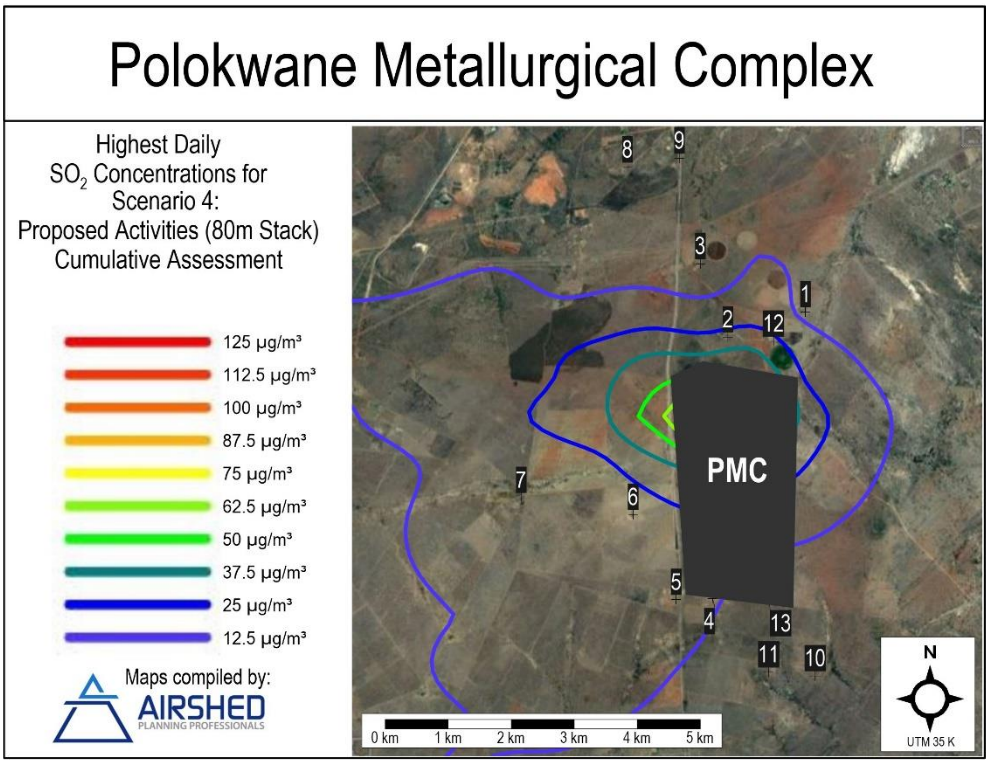

Figure 8: Highest daily ground level SO_2 concentrations – Scenario 4

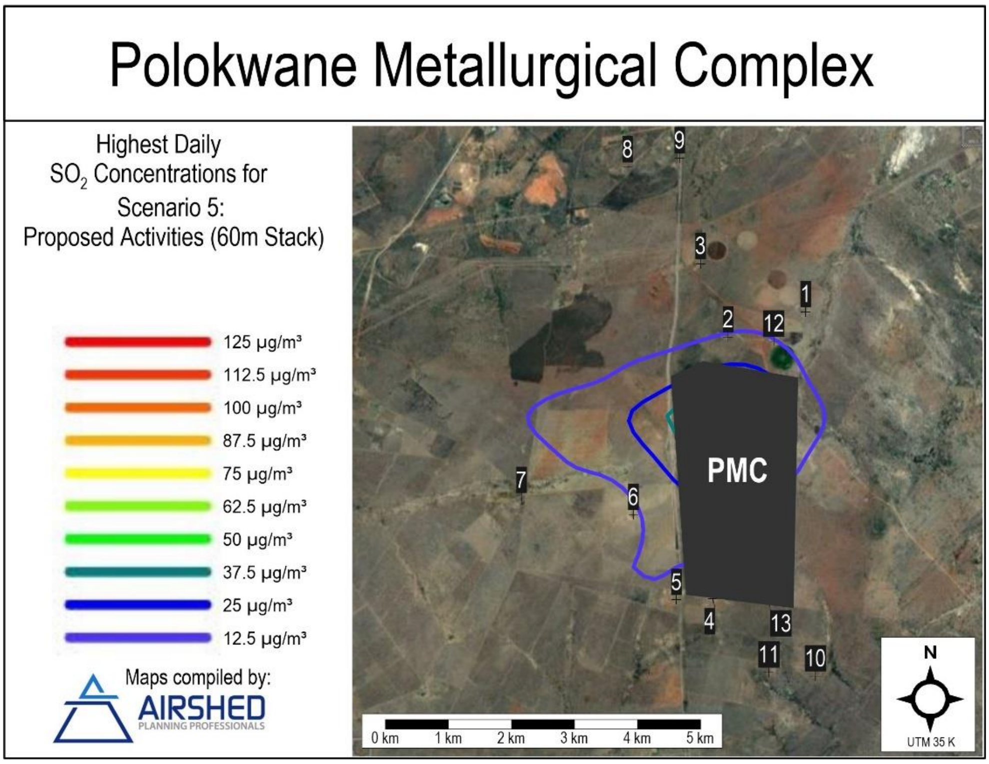

Figure 9: Highest daily ground level SO_2 concentrations – Scenario 5

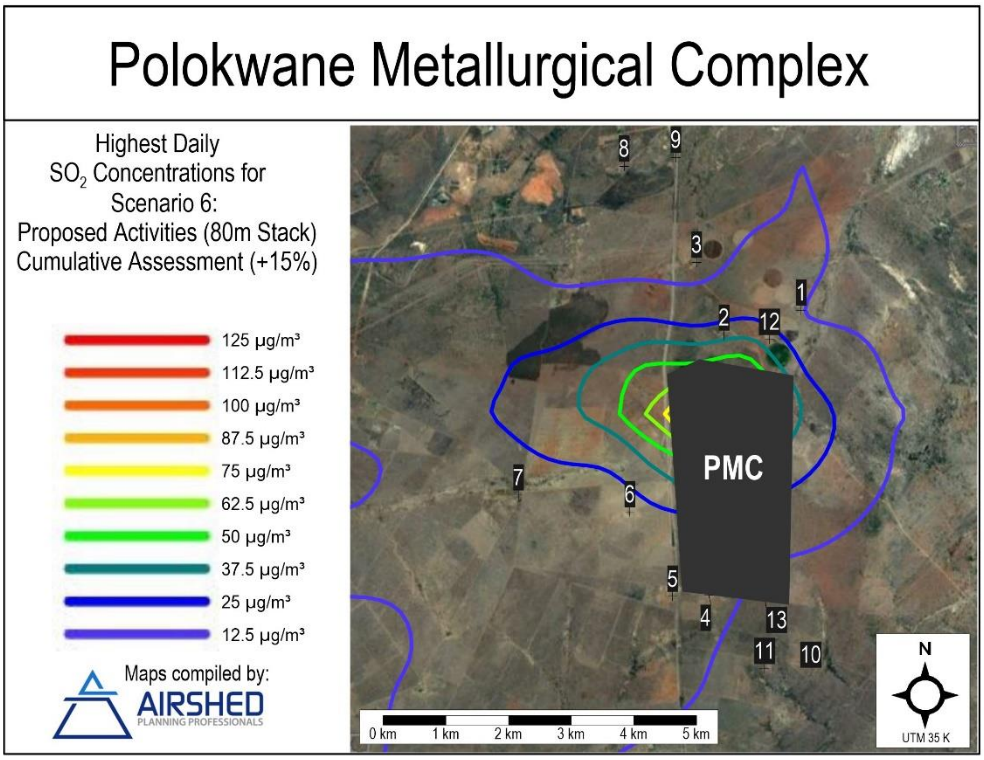

Figure 10: Highest daily ground level SO_2 concentrations – Scenario 6

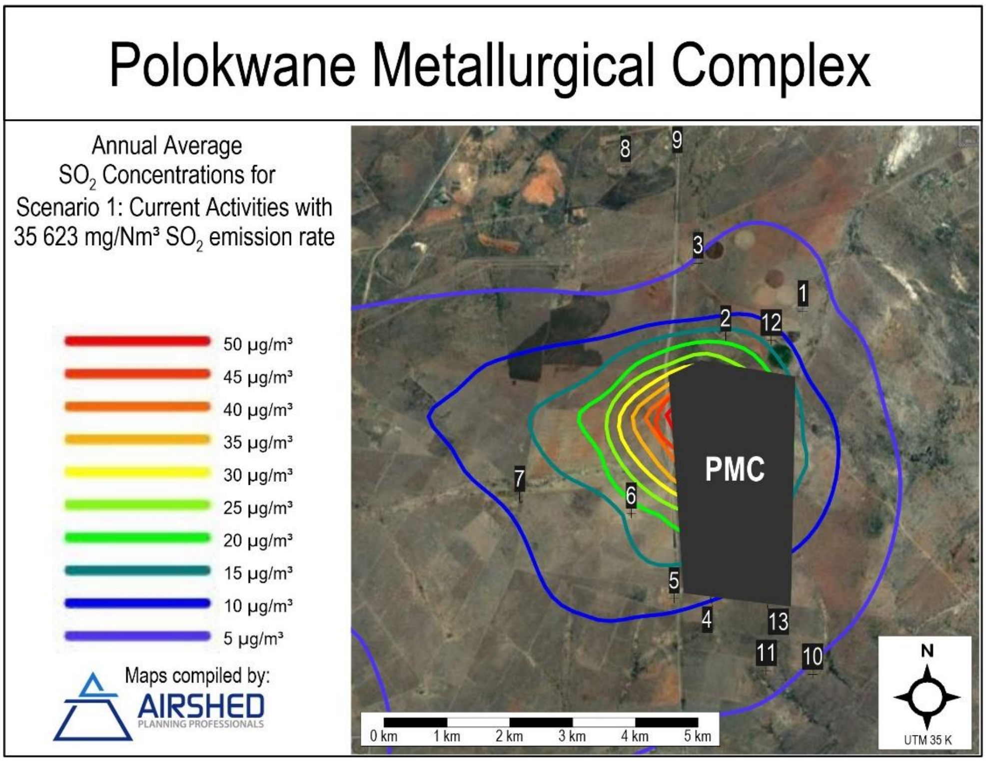

Figure 11: Annual average ground level SO_2 concentrations – Scenario 1

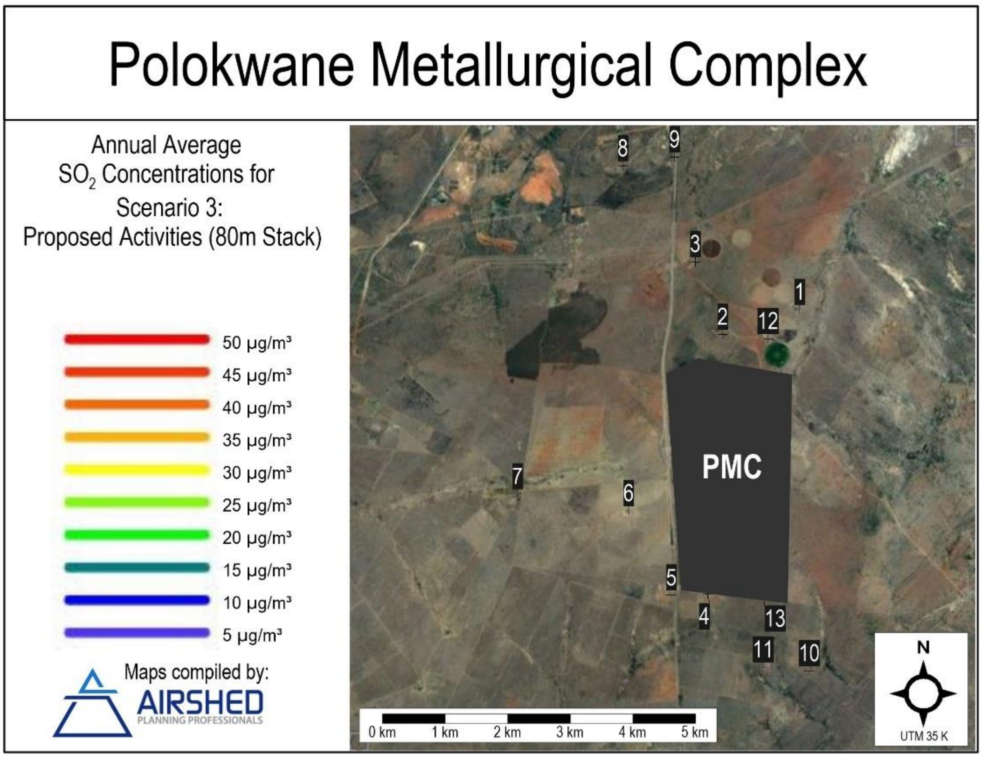

Figure 12: Annual average ground level SO_2 concentrations – Scenario 3

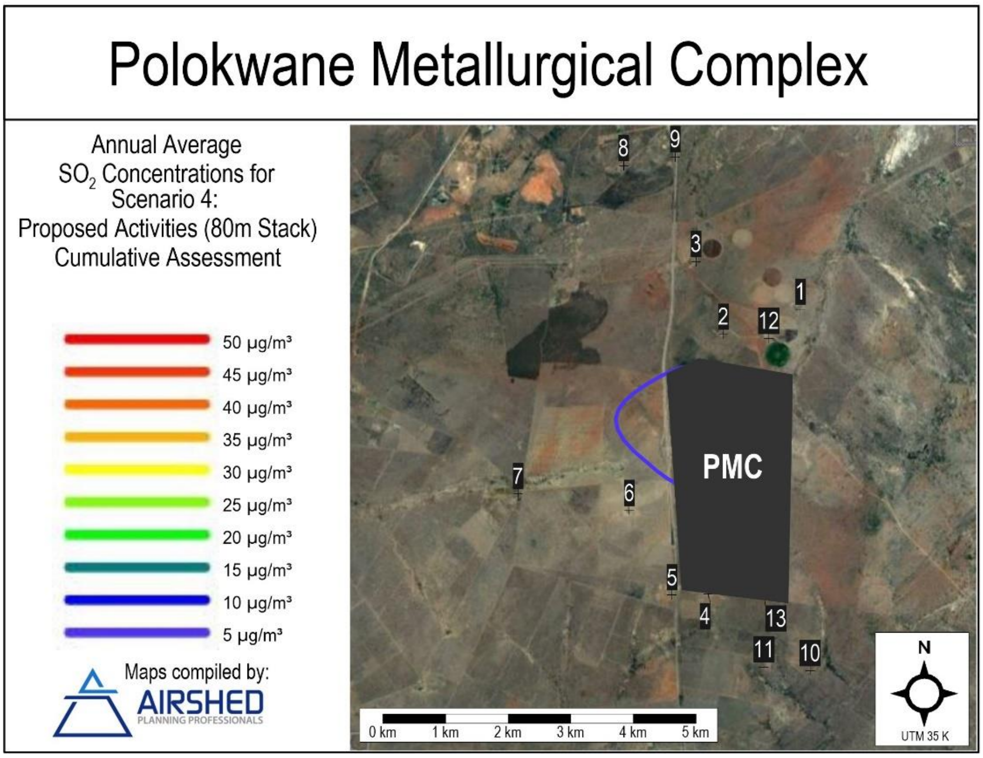

Figure 13: Annual average ground level SO_2 concentrations – Scenario 4

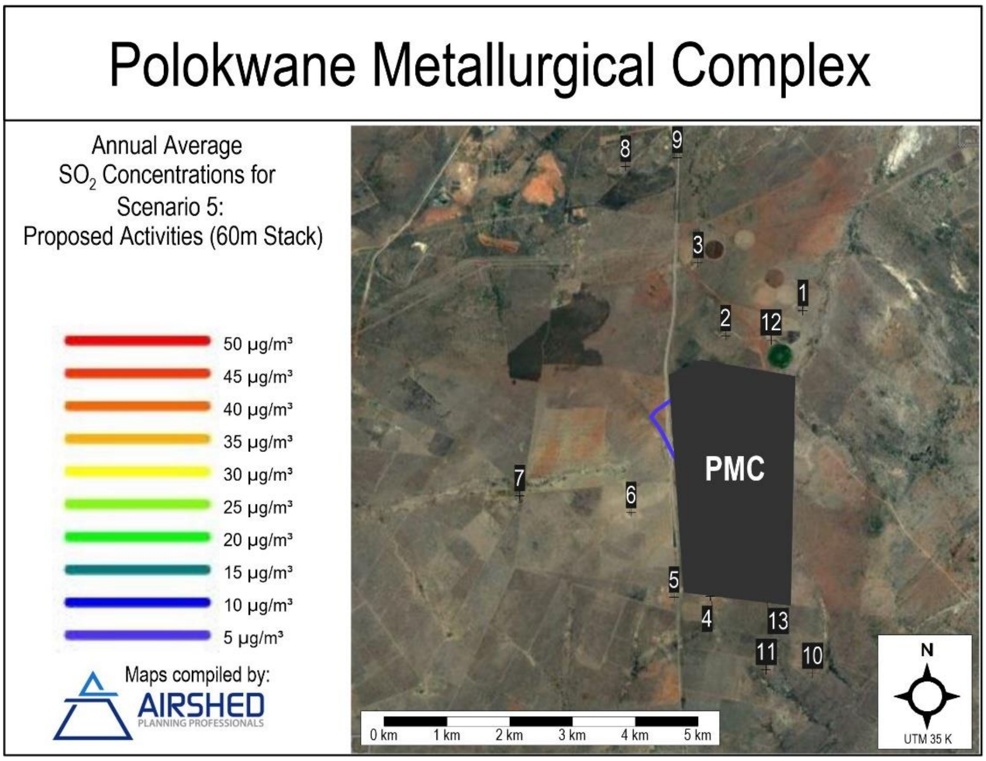

Figure 14: Annual average ground level SO_2 concentrations – Scenario 5

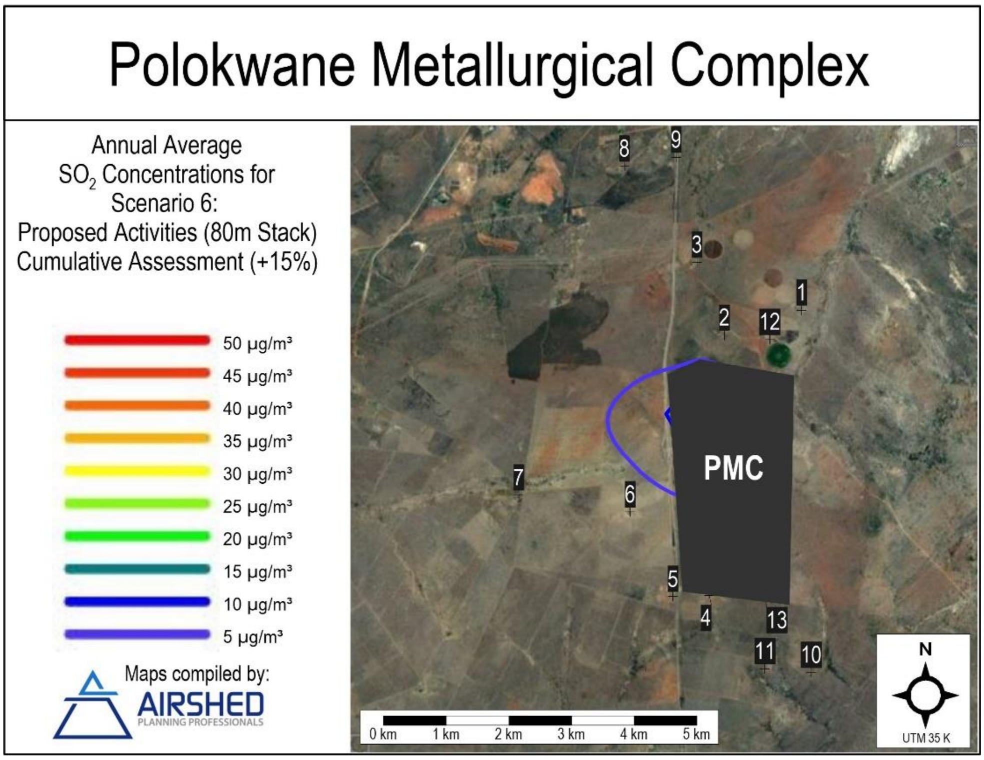

Figure 15: Annual average ground level SO_2 concentrations – Scenario 6

7. Cumulative Impact

Cumulative impacts (Table 7) were assessed by adding simulated SO_2 concentrations due to all PMC point sources at the sensitive receptor locations for Scenario 4 and Scenario 6 to the average of concentrations sampled at all six monitoring locations during the period 15 September 2014 to 2 October 2014 when the Polokwane Metallurgical Complex was in shut-down. SO_2 concentration measured during this period is assumed to be representative of other background (non-PMC) source. Cumulative SO_2 concentrations (Table 7) are in compliance with the SA NAAQS for all averaging periods.

Table 7: Cumulative Scenario 4 Concentrations

Receptor	SO_2 Concentration (µg/m³)		
	Annual Average	Highest Daily	Highest Hourly
Scenario 4 - Proposed Activities (80m Stack Height) - Cumulative Assessment + Background SO_2 Concentrations			
Farmstead 1	5	26	127
Farmstead 2	7	44	197
Farmstead 3	5	23	130
Farmstead 4	6	28	120
Farmstead 5	6	30	116
Farmstead 6	7	31	117
Farmstead 7	6	32	114
Farmstead 8	5	19	103
Farmstead 9	5	19	118
Farmstead 10	5	21	101
Farmstead 11	5	22	105
Farmstead 12	6	42	182
Farmstead 13	5	25	118
Scenario 6 - Proposed Activities (80m Stack Height) - Cumulative Assessment (+15%)+ Background SO_2 Concentrations			
Farmstead 1	5	27	139
Farmstead 2	7	48	218
Farmstead 3	5	24	143
Farmstead 4	6	30	131
Farmstead 5	6	33	127
Farmstead 6	7	33	127
Farmstead 7	7	35	125

Receptor	SO_2 Concentration (µg/m³)		
	Annual Average	Highest Daily	Highest Hourly
Farmstead 8	5	19	111
Farmstead 9	5	20	128
Farmstead 10	5	22	109
Farmstead 11	5	23	114
Farmstead 12	6	46	202
Farmstead 13	5	26	129

8. References

Grobler, N, Liebenberg-Enslin, H, Bird T (2013) *Atmospheric Impact Report: Application for Postponement of the Minimum Emissions Standards at the Polokwane Metallurgical Complex.* Airshed Planning Professionals Report No 13AAP01 Final v.3.

WSP (2017) *Polokwane Smelter SO_2 Abatement Air Quality Impact Assessment.* WSP Report Number 31102

US EPA, (2005). Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions. North Carolina, U.S. Environmental Protection Agency, 2005. Federal Register / Vol. 70, No. 216 / Rules and Regulations. Appendix W of 40 CRF Part 51.

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