APPENDIX H: AIR QUALITY ASSESSMENT

Air Quality Impact Assessment for the for the Gamsberg Smelter Project

Project done on behalf of **SLR Consulting (South Africa) (Pty) Ltd**

Project Compiled by:

R von Gruenewaldt

Address: 480 Smuts Drive, Halfway Gardens | **Postal:** P O Box 5260, Halfway House, 1685
Tel: +27 (0)11 805 1940 | **Fax:** +27 (0)11 805 7010

Report Details

Status	Revision 0.6
Report Title	Air Quality Impact Assessment for the for the Gamsberg Smelter Project
Report Number	18SLR10A
Date	June 2020
Client	SLR Consulting (South Africa) (Pty) Ltd
Prepared by	Renee von Gruenewaldt, (Pr. Sci. Nat.), MSc (University of Pretoria)
Reviewed by	Terri Bird, (Pr. Sci. Nat.), PhD (University of Witwatersrand)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.
Copyright Warning	Unless otherwise noted, the copyright in all text and other matter (including the manner of presentation) is the exclusive property of Airshed Planning Professionals (Pty) Ltd. It is a criminal offence to reproduce and/or use, without written consent, any matter, technical procedure and/or technique contained in this document.

Revision Record

Revision Number	**Date**	**Reason for Revision**
Rev 0	March 2020	For client review
Rev 0.1	May 2020	Incorporation on client's comments
Rev 0.2	May 2020	Incorporation on client's comments
Rev 0.3	June 2020	Incorporation on client's comments
Rev 0.4	June 2020	Incorporation on client's comments
Rev 0.5	June 2020	Incorporation of plots provided for the biodiversity specialist study
Rev 0.6	August 2020	Incorporation on client's comments

EXECUTIVE SUMMARY

Introduction

Black Mountain Mining (Pty) Ltd, part of Vedanta Zinc International, owns and operates the Gamsberg Zinc Mine. An EIA process was completed in 2013 (and approved on 12 August 2013 – Permit 43/2013) and amended on 2 December 2014 (Permit 43/2013 Amendment 2) (Ref: NC/EIA/NAM/KHA/AGG/2012), a Waste Management Licence (Ref: 12/9/11/L955/8); and Water Use Licence (Ref:14/D82C/ABCGI/2654)) for their open pit mining activities and concentrator plant have also been issued. The Gamsberg Zinc Mine has been in operation since June 2016 and is currently mining up to 4 million tonnes per annum (Mtpa) and producing up to 250 000 tonnes per annum (tpa) of zinc concentrate for export. Phase 2 will expand the mining capacity to 10 Mtpa and include the construction of the second concentrator plant. The Gamsberg Zinc Mine is located in the Northern Cape Province of South Africa, approximately 14 km east of the town of Aggeneys and 120 km east of Springbok along the N14.

Black Mountain Mining (Pty) Ltd is now proposing to construct a new zinc smelter and associated infrastructure to produce 300 000 tpa special high-grade zinc metal by processing 680 000 tpa of zinc concentrate (Gamsberg Smelter Project). As a by-product 450 000 tpa of pure sulphuric acid will be produced for both export and consumption within South Africa.

Black Mountain Mining (Pty) Ltd is proposing the following:

- A smelter complex using the Roast-Leach-Electrowinning (R-L-E) process with Jarosite precipitation and Jarofix conversion process;
- The development of a secured landfill facility for the disposal of the Jarofix;
- A new 7 km water pipeline from Horseshoe reservoir to the smelter complex;
- A laydown area and business partner camp for the construction phase; and
- Associated new roads and transmission line upgrades.

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by SLR Consulting (South Africa) (Pty) Ltd (SLR) to undertake an air quality impact assessment for the Gamsberg Smelter Project (hereafter referred to as the project).

The aim of the investigation was to quantify the possible impacts resulting from the project activities on human health (via the inhalation pathway). Nuisance impact on human receptors from dust fallout for residential and non-residential areas was also assessed. To achieve this, a good understanding of the local dispersion potential of the site was necessary and subsequently an understanding of existing sources of air pollution in the region and the resulting air quality (existing baseline). The baseline air quality formed the basis against which the smelter impacts were assessed and for determining potential ecological impacts. The latter is discussed in more detail in the Ecological Impact Assessment.

Study Approach and Methodology

The investigation followed the methodology required for a specialist report as prescribed in the Environmental Impact Assessment (EIA) Regulations (Government Regulation Notice 982 of 2014, as amended in 2017).

Baseline Assessment

The baseline study encompassed the analysis of air quality sensitive receptors, atmospheric dispersion potential and ambient air quality within the region.

Air quality sensitive receptors were identified from available satellite imagery and verified during the site visit conducted on the 9th September 2019.

The dispersion potential was assessed by means of the Weather Research and Forecasting mesoscale model (known as WRF) for the period 2016 to 2018.

The available ambient air quality data provided for the assessment consisted of the following:

- PM_{10} (inhalable particulates less than 10 µm in diameter) sampling undertaken during 2018 and 2019 at 5 sites;
- Dust fallout sampling at 14 sites for the period January 2018 to April 2019.
- Nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) sampling for the period June to September 2009.

Impact Assessment Criteria

Pollutants of concern due to project activities include, particulates (specifically PM_{10} and $PM_{2.5}$ (thoracic particulates less than 2.5 µm in diameter)), SO_2, NO_2 and lead (Pb). These pollutants are classified as criteria pollutants, with National Ambient Air Quality Standards having been established in South Africa to regulate ambient concentrations. For the current study, the impacts were assessed against published NAAQS and National Dust Control Regulations (NDCR).

Other pollutants of concern consisted of zinc (Zn) and dioxins. These are non-criteria pollutants and were screened against internationally recognised health effect screening levels and potential cancer risk respectively.

Emissions Inventory

Emissions inventories provide the source input required for the simulation of ambient air concentrations. Fugitive source emissions from vehicle entrainment, materials handling, and wind erosion from stockpiles were quantified by means of the United States Environmental Protection Agency (US EPA) and the Australian National Pollutant Inventory (NPI) emission factors. Emissions from the stacks were based on Minimum Emission Standards (MES) and emissions provided by SLR.

Impact Prediction Study

Gaseous concentrations and dustfall rates due to the proposed operations were simulated using the United States Environmental Protection Agency (US-EPA) approved AERMET/AERMOD dispersion modelling suite. Ambient concentrations were simulated to ascertain highest hourly, daily and annual averaging levels occurring as a result of the project operations. These were then compared to NAAQS and NDCR (legal limits for criteria pollutants) and health effect screening levels (for non-criteria pollutants).

Assumptions, Exclusions and Limitations

- Meteorological data: use was made of the WRF – modelled data for the period 2016 to 2018.
- Ambient data:
  - Dustfall data sampled during 2018 and 2019 was provided by Black Mountain Mining (Pty) Ltd.
  - PM_{10} and $PM_{2.5}$ concentrations were sampled during 2018 and 2019 and the data was provided by Black Mountain Mining (Pty) Ltd for the assessment.
  - NO_2 and SO_2 was sampled during 2009 and was assessed. This information was obtained from the Preliminary Climate and Air Quality Baseline Report completed for the Gamsberg Zinc Project in 2010 (SRK Consulting, 2010).
  - No survey for heavy metals, to the authors knowledge, has been conducted at the study area. Baseline levels for Zn and Pb could therefore not be ascertained.
- Emissions:
  - The baseline emissions inventory was limited to airborne particulates, including PM_{10}, $PM_{2.5}$, and TSP (total suspended particulates).
  - Information required for the calculation of emissions from fugitive dust sources for the proposed project operations was provided by the client. The assumption was made that this information was accurate.
  - Emissions for point sources was obtained from the legislated MES and information provided by the client.
  - Routine emissions from the proposed project operations were estimated and modelled. Atmospheric releases occurring as a result of non-routine operations or accidents were not accounted for.
- Impact assessment:
  - The simulated impacts are screened against health effect screening levels, NAAQS and NDCR and is not a health risk assessment.
  - The impact assessment is confined to the quantification of impacts on human health due to exposures via the inhalation pathway only and not through the ingestion and dermal absorption pathways for humans.
  - Simulated ground level concentrations for annual averaging periods and dust deposition levels for various pollutants were provided to the biodiversity specialists for assessment of potential impacts on plants in the study area. This analysis is provided in the biodiversity specialist assessment.
  - The construction and closure phases were assessed qualitatively due to the temporary nature of these operations, whilst the operational phase was assessed quantitatively.

Findings

The main findings from the baseline assessment, which are the main parameters informing the baseline conditions, were as follows:

- The main sources likely to contribute to cumulative particulate impacts are mining operations at Gamsberg (including Phase II).
- The area is dominated by winds from the south.
- The closest residential development to the proposed project is Aggeneys (~10 km west-southwest) of the site. The closest individual homestead to the proposed project is ~3.7 km west-southwest.
- Measured ambient daily PM_{10} ground level concentrations in the study area during 2018, ranged between 7.4 µg/m³ to 39 µg/m³ (99th percentile). This is below the NAAQS of 75 µg/m³.

- Measured ambient hourly NO_2 (maximum concentration of 0.4 µg/m³) and daily SO_2 (maximum concentration of 6.8 µg/m³) ground level concentrations in the vicinity of the project, during a 2009 survey, were well below the NAAQS of 200 µg/m³ (hourly NO_2) and 125 µg/m³ (daily SO_2).
- Dustfall rates were below non-residential NDCR at all sampling sites during the period period January 2018 to April 2019.

The simulated findings due to Gamsberg mining operations (including Phase II) were as follows:

- The $PM_{2.5}$ and PM_{10} ground level concentrations at off-site sensitive receptors were within NAAQS for all averaging periods.
- Simulated daily dust deposition, as a result of the current mining operations were found to be in compliance with NDCR for residential areas at all identified sensitive receptors within the study area.

The main findings from the impact assessment due to the proposed project operations were as follows:

- The simulated $PM_{2.5}$ and PM_{10} impacts due to baseline and project operations (PM_{10} and $PM_{2.5}$ NAAQS extends for an area of 17 322 528 m² and 2 557 345 m² respectively) are similar to impacts due to baseline operations only (PM_{10} and $PM_{2.5}$ NAAQS extends for an area of 17 035 090 m² and 2 533 821 m² respectively) and are well below NAAQS at sensitive receptors within the study area.
- The highest simulated Pb, NO_2 and SO_2 concentrations due to project operations were in compliance with NAAQS at all sensitive receptors within the study area only (Pb, NO_2 and SO_2 NAAQS extends for an area of 852 m² , 71 590 m² and 298 235 m² respectively).
- Maximum daily dust deposition due to project operations were well within the NDCR at all sensitive receptors within the study area and is similar in magnitude to baseline levels.
- The simulated zinc ground level concentrations were below the most stringent health effect screening levels at all identified sensitive receptors.
- The potential cancer risk due to dioxins and furans is "very low".

Recommendations

It is of the author's opinion that the project be authorised provided that the following recommendations are followed:

- Due to the sensitivity of the vegetation in the area, it is recommended that mitigation measures as recommended in Section 4.2.3 be implemented.
- Baseline monitoring should be undertaken for a minimum of 24 months prior to commissioning of the smelter to collect ambient air quality data. The ambient monitoring should as a minimum include daily concentrations of PM_{10}, $PM_{2.5}$ and monthly dust deposition. The ambient monitoring of hourly SO_2 and NO_2 concentrations as well as the metal analysis of the particulate matter would also provide value to the understanding of impacts on the vegetation. The ambient monitoring is recommended to continue once the smelter is operational in order to understand the impacts of the smelter on the vegetation.
- Emission monitoring should be undertaken according to the Air Emissions Licence requirements, once issued.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND SYMBOLS

AEL	Atmospheric Emission License
APCS	Air pollution control systems
AQA	Air Quality Act
ATSDR	US Federal Agency for Toxic Substances and Disease Registry
BMM	Black Mountain Mining (Pty) Ltd.
°C	Degrees Celsius
CO	Carbon monoxide
CO_2	Carbon dioxide
CALEPA	California Environmental Protection Agency
CEPA	Canadian Environmental Protection Agency
DEFF	Department of Environment, Forestry and Fisheries
EIA	Environmental Impact Assessment
HC	Hydrocarbon
I&AP	Interested and affected parties
IRIS	Integrated Risk Information System
km	Kilometre
LMo	Monin-Obukhov length
LPG	Liquefied Petroleum Gas
m^3	Cubic metre
m^2	Square metre
MES	Minimum Emission Standards
mg	Milligram
m/s	Meters per second
NAAQS	National Ambient Air Quality Standards
NACA	National Association for Clean Air
NAEIS	National Atmospheric Emission Inventory System
NDCR	National Dust Control Regulations
NEMA	National Environmental Management Act 1998
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
O_3	Ozone
OEHHA	Californian Office of Environmental Health Hazard Assessment
Pb	Lead
PM	Particulate matter
PM_{10}	Particulate Matter with an aerodynamic diameter of less than 10μm
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter of less than 2.5μm
RELs	Reference exposure levels
ROM	Run of Mine
SA	South Africa
SAAQIS	South African Air Quality Information System
SACNASP	South African Council for Natural Scientific Professions
SANS	South African National Standards
SLR	SLR Consulting (South Africa) (Pty) Ltd
SO_2	Sulfur Dioxide
TARA	Texas Natural Resource Conservation Commission Toxicology and Risk Assessment Division
TSF	Tailings Storage Facility
TSP	Total Suspended Particles
URF	Unit Risk Factor

US EPA	United States Environmental Protection Agency
VOC	Volatile organic compound
WHO	World Health Organisation
WRF	Weather Research and Forecasting mesoscale model
Zn	Zinc
µg	microgram

Note:

1. The spelling of “sulfur” has been standardised to the American spelling throughout the report. The International Union of Pure and Applied Chemistry, the international professional organisation of chemists that operates under the umbrella of UNESCO, in 1990 published a list of standard names for all chemical elements. It was decided that element 16 should be spelled “sulfur”. This compromise was to ensure that in future searchable databases would not be complicated by spelling variants. (IUPAC. Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"). Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications, Oxford (1997). XML on-line corrected version: http://goldbook.iupac.org (2006) created by M. Nic, J. Jirat, B. Kosata; updates compiled by A. Jenkins. ISBN 0-9678550-9-8.doi: 10.1351/goldbook)"

Air Quality Impact Assessment for the Gamsberg Smelter Project

1 INTRODUCTION

1.1 Purpose/ Objectives

Black Mountain Mining (Pty) Ltd, part of Vedanta Zinc International, owns and operates the Gamsberg Zinc Mine. An EIA process was completed in 2013 (and approved on 12 August 2013 – Permit 43/2013) and amended on 2 December 2014 (Permit 43/2013 Amendment 2) (Ref: NC/EIA/NAM/KHA/AGG/2012), a Waste Management Licence (Ref: 12/9/11/L955/8); and Water Use Licence (Ref:14/D82C/ABCGI/2654)) for their open pit mining activities and concentrator plant have also been issued. The Gamsberg Zinc Mine has been in operation since June 2016 and is currently mining up to 4 million tonnes per annum (Mtpa) and producing up to 250 000 tonnes per annum (tpa) of zinc concentrate for export. Phase 2 will expand the mining capacity to 10 Mtpa and include the construction of the second concentrator plant. The Gamsberg Zinc Mine is located in the Northern Cape Province of South Africa, approximately 14 km east of the town of Aggeneys and 120 km east of Springbok along the N14.

Black Mountain Mining (Pty) Ltd is now proposing to construct a new zinc smelter and associated infrastructure to produce 300 000 tpa special high-grade zinc metal by processing 680 000 tpa of zinc concentrate (Gamsberg Smelter Project). As a by-product 450 000 tpa of pure sulphuric acid will be produced for both export and consumption within South Africa.

Black Mountain Mining (Pty) Ltd is proposing the following:

- A smelter complex using the Roast-Leach-Electrowinning (R-L-E) process with Jarosite precipitation and Jarofix conversion process;
- The development of a secured landfill facility for the disposal of the Jarofix;
- A new 7 km water pipeline from Horseshoe reservoir to the smelter complex;
- A laydown area and business partner camp for the construction phase; and
- Associated new roads and transmission line upgrades.

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by SLR Consulting (South Africa) (Pty) Ltd (SLR) to undertake an air quality impact assessment for the Gamsberg Smelter Project (hereafter referred to as the project).

The location of the project is provided in Figure 1-1 and Figure 1-2.

The main objective of this study is to determine the significance of the predicted impacts from the project operations on the surrounding environment and on human health.

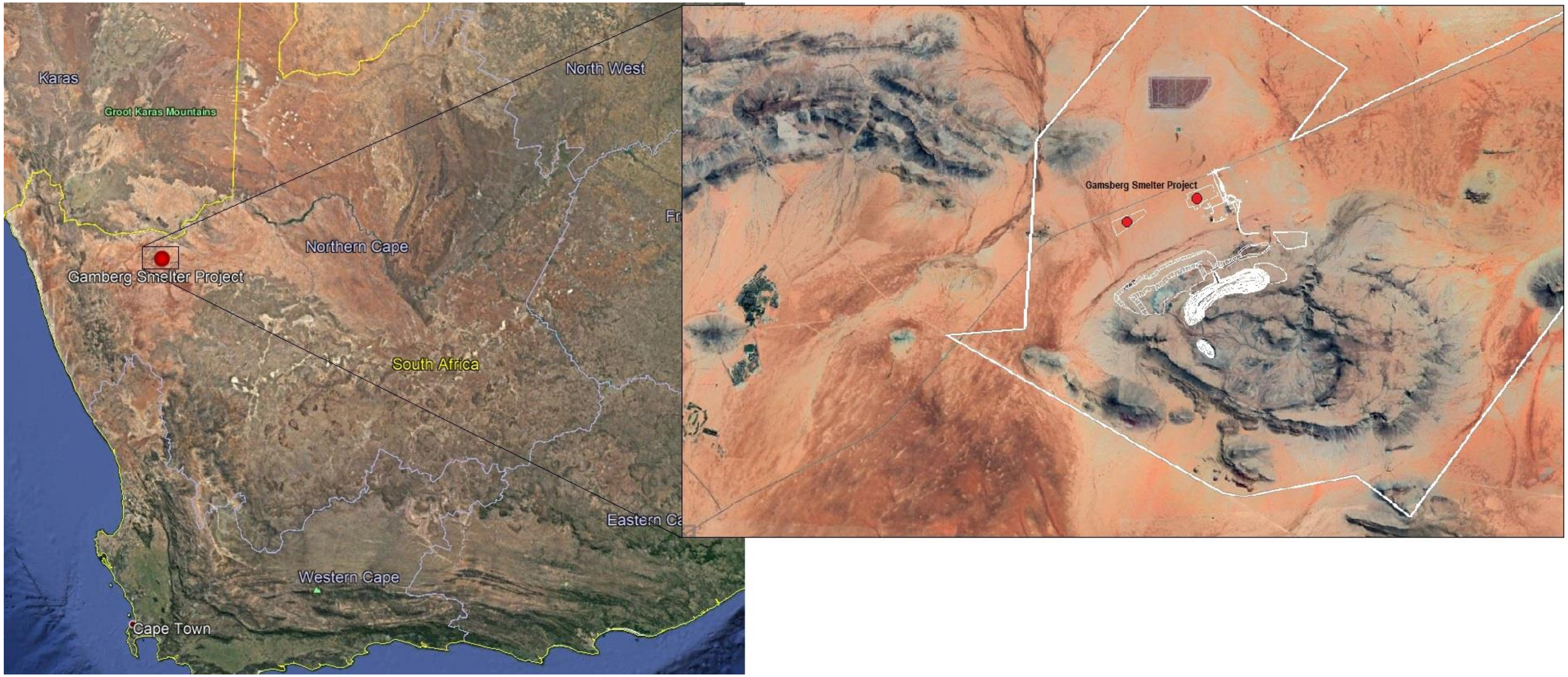

Figure 1-1: Location of the proposed project

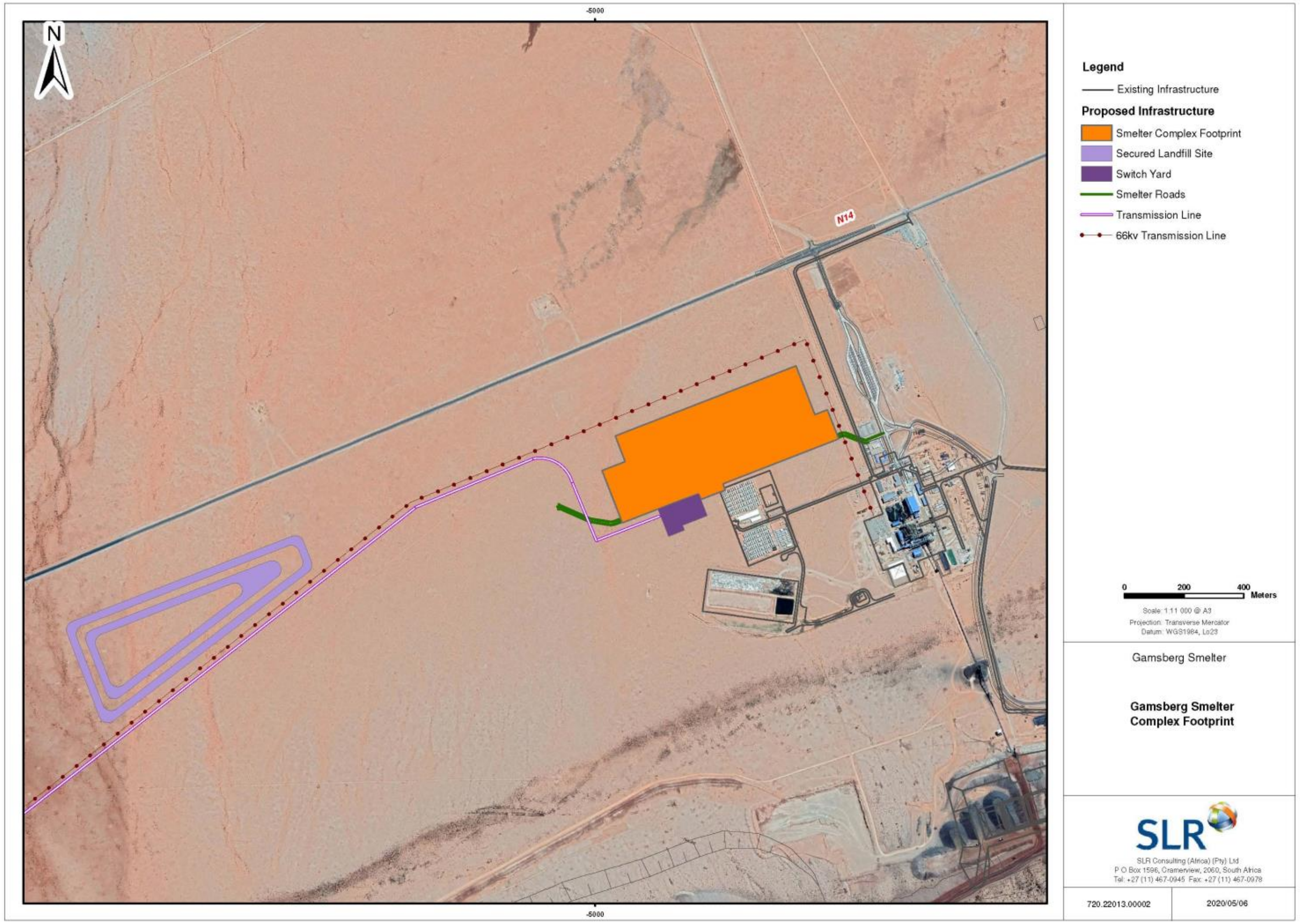

Figure 1-2: Project footprint

1.2 Terms of Reference/Scope of Work

The terms of reference for the assessment are as follows:

1. **Baseline**
   - Identification of existing air pollution sources;
   - Identification of air quality-sensitive receptors, including any nearby residential dwellings in the vicinity of the project;
   - Collection of local weather conditions from the closest meteorological monitoring station or calculated data;
     - Preparation of three years of raw meteorological data. The required meteorological data includes hourly average wind speed, wind direction and temperature data.
     - Simulation of wind field, mixing depth and atmospheric stability.
   - Description of the legislative and regulatory context, including ambient air quality standards.
   - Assessment of baseline air pollutant measurements (from available information).

2. **Impact Assessment**
   - Quantification of all sources of atmospheric emissions associated with the project.
   - Formatting of meteorological data for input to the dispersion model.
   - Dispersion simulations of ground level pollutants, due to routine emissions from the project, reflecting highest daily and annual average concentrations. The United States Environmental Protection Agency (US-EPA) approved AERMOD model to be used.
   - Analysis of dispersion modelling results.
   - Evaluation of potential for human health and environmental impacts, the latter providing an assessment of the dust fallout from the project.

In addition to the terms of reference, simulated ground level concentrations and deposition levels were provided to the biodiversity specialists for assessment of the potential impacts on plants in the study area. The detail of these impacts is discussed in more detail in the biodiversity impact assessment.

1.3 Deliverables

The final deliverable is an air quality impact assessment based on the simulated ground level air concentrations and total deposition rates that are then compared to the NAAQS, NDCR and internationally recognised health effect screening levels that may result in an unacceptable impact on the human sensitive receptors in the area.

1.4 Specialist Details

1.4.1 Statement of Independence

Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.

1.4.2 Competency Profiles

1.4.2.1 RG von Gruenewaldt (MSc (Meteorology), BSc, Pr. Sci Nat.)

Reneé von Gruenewaldt is a Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP) and a member of the National Association for Clean Air (NACA).

Following the completion of her bachelor's degree in atmospheric sciences in 2000 and honours degree (with distinction) with specialisation in Environmental Analysis and Management in 2001 at the University of Pretoria, her experience in air pollution started when she joined Environmental Management Services (now Airshed Planning Professionals) in 2002. Reneé von Gruenewaldt later completed her master's degree (with distinction) in Meteorology at the University of Pretoria in 2009.

Reneé von Gruenewaldt became partner of Airshed Planning Professionals in September 2006. Airshed Planning Professionals is a technical and scientific consultancy providing scientific, engineering and strategic air pollution impact assessment and management services and policy support to assist clients in addressing a wide variety of air pollution related risks and air quality management challenges.

She has extensive experience on the various components of air quality management including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. Reneé has been the principal air quality specialist and manager on several Air Quality Impact Assessment projects between 2006 to present and her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality.

A comprehensive curriculum vitae of Reneé von Gruenewaldt is provided in Appendix A.

The declaration of independence for Reneé von Gruenewaldt is provided in Appendix B.

1.5 Approach and Methodology

The methodology followed in the assessment to quantify the air quality impacts associated with the proposed project is discussed below. The general tasks included:

- The establishment of the baseline air quality (based on available information);
- Quantification of air emissions from the project;
- Obtaining and discussing meteorological parameters required to establish the atmospheric dispersion potential;
- Simulation of the ambient air concentrations for the pollutants of concern and dust fallout using a suitable atmospheric dispersion model;
- Assessment of the significance of the impacts through the comparison of simulated air concentrations (and fallout rates) with local standards (for legal compliance);
- Recommendations for mitigation and monitoring.

1.5.1 Potential Air Emissions from the Proposed Project

The air pollution associated with the proposed project activities includes the air emissions emitted from materials handling activities, windblown dust from storage piles, vehicle entrainment and stacks.

1.5.2 Regulatory Requirements and Assessment Criteria

In the evaluation of air emissions and ambient air quality impacts reference is made to National Ambient Air Quality Standards (NAAQS). These standards apply only to a number of common air pollutants, collectively known as criteria pollutants. Criteria pollutants include sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), inhalable particulate matter (including thoracic particulate matter with an aerodynamic diameter of equal to or less than 10 µm or PM_{10} and inhalable particulate matter with an aerodynamic diameter equal to or less than 2.5 µm or $PM_{2.5}$), benzene, ozone and lead. For non-criteria pollutants (i.e. Zinc (Zn)), reference is made to internationally recognised health effect screening levels. For dust fallout, impacts were assessed against published National Dust Control Regulations (NDCR).

1.5.3 Description of the Baseline Environment

The baseline study encompassed the analysis of air quality sensitive receptors, atmospheric dispersion potential and ambient air quality within the study area.

Air quality sensitive receptors were identified from available satellite imagery and verified during the site visit conducted on the 9th September 2019.

The dispersion potential was assessed by means of the Weather Research and Forecasting mesoscale model (known as WRF) for the period 2016 to 2018.

The available ambient air quality data provided by Black Mountain Mining (Pty) Ltd for the assessment consisted of the following:

- PM_{10} (inhalable particulates less than 10 µm in diameter) sampling undertaken during 2018 and 2019 at 5 sites;
- Dust fallout sampling at 14 sites for the period January 2018 to April 2019.
- Nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) sampling for the period June to September 2009.

1.5.4 Emissions Inventory

The establishment of a comprehensive emissions inventory formed the basis for the assessment of the air quality impacts from proposed operations. Proposed project operations result in point source emissions and fugitive emissions. Fugitive emissions refer to emissions that are spatially distributed over a wide area and not confined to a specific discharge point as would be the case for process related (or point source) emissions (IFC, 2007). In the quantification of fugitive dust, use was made of emission factors which link the quantity of a pollutant to the activity associated with the release of that pollutant. For point sources, emissions were obtained from Minimum Emission Standards (MES) or were provided by Black Mountain Mining (Pty) Ltd.

1.5.5 Atmospheric Dispersion Modelling

In the calculation of ambient air pollutant concentrations and dustfall rates for the project, use was made of the US EPA AERMOD atmospheric dispersion modelling suite. AERMOD is a Gaussian plume model best used for near-field applications where the steady-state meteorology assumption is most likely to apply. AERMOD is a model developed with the support of the AMS/EPA Regulatory Model Improvement Committee (AERMIC), whose objective has been to include state-of the-art science in regulatory models (Hanna, Egan, Purdum, & Wagler, 1999). AERMOD is a dispersion modelling system with three components, namely: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

The dispersion of SO_2, NO_2, Zinc (Zn), lead (Pb), dioxins and furans, PM_{10}, $PM_{2.5}$ and total suspended particulates (TSP) was modelled for an area covering 13.5 km (north-south) by 23.8 km (east-west). These areas were divided into a grid with a resolution of 50 m (north-south) by 50 m (east-west) for the modelling of concentrations. The grid resolution for the modelling of deposition was divided into a grid with a resolution of 150 m (north-south) by 200 m (east-west). AERMOD simulates ground-level concentrations for each of the receptor grid points. AERMOD version 18081 was used for the assessment.

1.6 Management of Uncertainties

The main assumptions, exclusions and limitations are summarised below:

- Meteorological data: use was made of the WRF – modelled data for the period 2016 to 2018.
- Ambient data:
  - Dustfall data sampled during 2018 and 2019 was provided by Black Mountain Mining (Pty) Ltd.
  - PM_{10} and $PM_{2.5}$ concentrations were sampled during 2018 and 2019 and the data was provided by Black Mountain Mining (Pty) Ltd for the assessment.
  - NO_2 and SO_2 was sampled during 2009 and was assessed. This information was obtained from the Preliminary Climate and Air Quality Baseline Report completed for the Gamsberg Zinc Project in 2010 (SRK Consulting, 2010).
  - No survey for heavy metals, to the authors knowledge, has been conducted at the study area. Baseline levels for Zn and Pb could therefore not be ascertained.
- Emissions:
  - The baseline emission inventory was limited to airborne particulates, including PM_{10}, $PM_{2.5}$ and TSP (total suspended particulates).
  - Information required for the calculation of emissions from fugitive dust sources for the proposed project operations was provided by the client. The assumption was made that this information was accurate.
  - Emissions for point sources was obtained from the legislated MES and information provided by the client.
  - Routine emissions from the proposed project operations were estimated and modelled. Atmospheric releases occurring as a result of non-routine operations or accidents were not accounted for.
- Impact assessment:
  - The simulated impacts are screened against health effect screening levels, NAAQS and NDCR and is not a health risk assessment.
  - The impact assessment is confined to the quantification of impacts on human health due to exposures via the inhalation pathway only and not through the ingestion and dermal absorption pathways for humans.

- Simulated ground level concentrations for annual averaging periods and dust deposition levels for various pollutants were provided to the biodiversity specialists for assessment of potential impacts on plants in the study area. This analysis is provided in the biodiversity specialist assessment.
- The construction and closure phases were assessed qualitatively due to the temporary nature of these operations, whilst the operational phase was assessed quantitatively.

1.7 Outline of Report

Assessment criteria applicable to the proposed project are presented in Section 2. The study area, atmospheric dispersion potential and the existing air quality for the area are discussed in Section 3. Dispersion model results are presented, and the main findings of the air quality impact assessments documented in Section 4. The significance ranking for the proposed project is provided in Section 5. Findings and recommendations are provided in Section 6.

2 REGULATORY REQUIREMENTS AND ASSESSMENT CRITERIA

The environmental regulations and guidelines governing the emissions and impact of the proposed project need to be considered prior to potential impacts and sensitive receptors being identified.

Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality standards are intended to indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality guidelines and standards are normally given for specific averaging periods. These averaging periods refer to the timespan over which the air concentration of the pollutant was monitored at a location. Generally, five averaging periods are applicable, namely an instantaneous peak, 1-hour average, 24-hour average, 1-month average, and annual average.

2.1 Minimum Emission Standards

The project will trigger MES. The MES of concern for the project is provided in the current Section (Table 2-1 to Table 2-3). The casting and smelting triggers MES Subcategory 4.14 which will release PM, SO_2, NO_2 and dioxins through the casting stack.

The wet gas has a mercury (Hg) removal stage. Hg is removed through a slurry, thus no Hg emission will be released through the stack. Roasting and acid plant activities will trigger MES Subcategory 4.16 releasing PM, SO_2 and NO_2 though the acid plant stack. The gas cleaning plant will trigger MES Subcategory 7.4 which will release PM through the acid plant stack.

Table 2-1: Subcategory 4.14 – Production and Processing of Zinc, Nickel and Cadmium

Description:	The extraction, processing and production of zinc, nickel or cadmium by the application of heat excluding		
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
Sulfur dioxide	SO_2	New	500
		Existing	500
Oxides of nitrogen	NO_x expressed as NO_2	New	500
		Existing	500
Mercury	Hg	New	0.2
		Existing	1
Dioxins	PCDD/PCDF	New	0.1 ngTEQ
		Existing	No standards proposed

Table 2-2: Subcategory 4.16 – Smelting and Converting of Sulphide Ores

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
Sulfur dioxide (feed SO_2 <5% SO_2)	SO_2	New	1200
		Existing	3500
Sulfur dioxide (feed SO_2 >5% SO_2)	SO_2	New	1200
		Existing	2500

Table 2-3: Subcategory 7.4: Production, Use in Production or Recovery of Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Mercury, and or Selenium, by the Application of Heat

Description:	Production, use or recovery of antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, mercury, selenium, thallium and their salts not covered elsewhere, excluding their use as catalyst.		
Application:	All installations producing or using more than 1 ton per month.		
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	10
		Existing	25

2.2 Applying for an Atmospheric Emission Licence

The applicant (Black Mountain Mining (Pty) Ltd) will be required to apply for a new Atmospheric Emission Licence (AEL). An AEL must include all sources of emission, not only those considered listed activities. In terms of the AEL application, the **applicant** should take into account the following sections of NEM:AQA:

37. Application for atmospheric emission licences:

(1) A person must apply for an AEL by lodging with the licensing authority of the area in which the listed activity is to be carried out, an application in the form required.

(2) An application for an AEL must be accompanied by –

(a) The prescribed processing fee; and

(b) Such documentation and information as may be required by the licensing authority.

38. Procedure for licence applications:

(1) The licensing authority –

(a) May, to the extent that is reasonable to do so, require the applicant, at the applicant's expense, to obtain and provide it by a given date with other information contained in or submitted in connection with the application;

> (b) *May conduct its own investigation on the likely effect of the proposed license on air quality;*
> (c) *May invite written comments from any organ of state which has an interest in the matter; and*
> (d) *Must afford the applicant an opportunity to make representations on any adverse statements or objections to the application.*

(2) *Section 24 of the NEMA and section 22 of the Environmental Conservation Act apply to all applications for atmospheric emission licenses, and both an applicant and the licensing authority must comply with those sections and any applicable notice issued or regulations made in relation to those sections.*

(3) –

> (a) *An applicant must take appropriate steps to bring the application to the attention of relevant organs of state, interested persons and the public.*
> (b) *Such steps must include the publication of a notice in at least two newspapers circulating the area in which the listed activity is applied for is or is to be carried out and must-*
>> (i) *Describe the nature and purpose of the license applied for;*
>> (ii) *Give particulars of the listed activity, including the place where it is to be carried out;*
>> (iii) *State a reasonable period within which written representations on or objections to the application may be submitted and the address or place where it must be submitted; and*
>> (iv) *Contain such other particulars as the licensing authority may require.*

2.3 Reporting of Atmospheric Emissions

The National Atmospheric Emission Reporting Regulations (Government Gazette No. 38633) came into effect on 2 April 2015. The purpose of the regulations is to regulate the reporting of data and information from identified points, non-point and mobile sources of atmospheric emissions to an internet-based National Atmospheric Emissions Inventory System (NAEIS). The NAEIS is a component of the South African Air Quality Information System (SAAQIS). Its objective is to provide all stakeholders with relevant, up to date and accurate information on South Africa's emissions profile for informed decision making.

Emission sources and data providers are classified according to groups. The project would be classified under Group A ("Listed activity published in terms of section 21(1) of the Act"). Emission reports from Group A must be made in the format required for NAEIS and should be in accordance with the AEL or provisional AEL.

As per the regulation, the applicant and/or their data provider should register on the NAEIS. Data providers must inform the relevant authority of changes if there are any:

- Change in registration details;
- Transfer of ownership; or
- Activities being discontinued.

A data provider must submit the required information for the preceding calendar year to the NAEIS by 31 March of each year. Records of data submitted must be kept for a period of 5 years and must be made available for inspection by the relevant authority.

The relevant authority must request a data provider, in writing, to verify the information submitted if the information is incomplete or incorrect. The data provider then has 60 days to verify the information. If the verified information is incorrect or incomplete the relevant authority must instruct a data provider, in writing, to submit supporting documentation prepared by an independent person. The relevant authority cannot be held liable for the cost of the verification of data. A person guilty of an offence in terms of section 13 of these regulations is liable for penalties.

2.4 National Ambient Air Quality Standards

National Ambient Air Quality Standards (NAAQS) are available for inhalable particulate matter less than 10 µm in diameter (PM_{10}), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), lead (Pb) and benzene gazetted on 24 December 2009. Inhalable particulate matter less than 2.5 µm in diameter ($PM_{2.5}$) was included in the NAAQS on 29 June 2012 (Gazette no. 35463).

The applicable pollutants of concern for the current assessment are highlighted in blue in Table 2-4.

Table 2-4: South African National Ambient Air Quality Standards

Substance	Molecular formula / notation	Averaging period	Concentration limit (µg/m³)	Frequency of exceedance	Compliance date
Sulfur dioxide	SO_2	10 minutes	500	526	Immediate
		1 hour	350	88	Immediate
		24 hours	125	4	Immediate
		1 year	50	0	Immediate
Nitrogen dioxide	NO_2	1 hour	200	88	Immediate
		1 year	40	0	Immediate
Particulate matter	PM_{10}	24 hour	75	4	Immediate
		1 year	40	0	Immediate
Fine particulate matter	$PM_{2.5}$	24 hour	40	4	1 Jan 2016 – 31 Dec 2029
			25	4	1 Jan 2030
		1 year	20	0	1 Jan 2016 – 31 Dec 2029
			15	0	1 Jan 2030
Ozone	O_3	8 hours (running)	120	11	Immediate
Benzene	C_6H_6	1 year	5	0	1 Jan 2015
Lead	Pb	1 year	0.5	0	Immediate
Carbon monoxide	CO	1 hour	30 000	88	Immediate
		8 hour (calculated on 1 hour averages)	10 000	11	Immediate

2.5 National Regulations for Dust Deposition

South Africa's Draft National Dust Control Regulations were published on 27 May 2011 with the dust fallout standards passed and subsequently published on the 1st of November 2013 (Government Gazette No. 36974). These are called the National Dust Control Regulations (NDCR). The purpose of the regulations is to prescribe general measures for the control of dust in all areas including residential and light commercial areas. SA NDCRs were published on 1 of November 2013. Acceptable dustfall rates according to the regulation are summarised in Table 2-5.

Table 2-5: Acceptable dustfall rates

Restriction Area	Dustfall rate (D) (mg m^{-2} day^{-1}, 30-day average)	Permitted frequency of exceeding dust fall rate
Residential	D < 600	Two within a year, not sequential months.
Non-residential	600 < D < 1 200	Two within a year, not sequential months

The regulation also specifies that the method to be used for measuring dustfall and the guideline for locating sampling points shall be ASTM D1739 (1970), or equivalent method approved by any internationally recognized body. It is important to note that dustfall is assessed for nuisance impact and not inhalation health impact (which is addressed in the NAAQS).

A revised Draft National Dust Control Regulations were published on 25 March 2018 (Government Gazette No. 41650) which references the same acceptable dustfall rates but refers to the latest version of the ASTM D1739 method to be used for sampling.

2.6 Screening Criteria for Non-Criteria Pollutants

Air quality screening levels for non-criteria pollutants are published by various sources. These sources include:

- World Health Organization (WHO) guideline values for non-carcinogens and unit risk factor guidelines for carcinogens,
- Chronic and sub-chronic inhalation reference concentrations and cancer unit risk factors published by the US-EPA in its Integrated Risk Information System (IRIS),
- Reference exposure levels (RELs) published by the Californian Office of Environmental Health Hazard Assessment (OEHHA),
- Minimal risk levels issued by the US Federal Agency for Toxic Substances and Disease Registry (ATSDR), and
- Acute, sub-acute and chronic effect screening levels published by the Texas Natural Resource Conservation Commission Toxicology and Risk Assessment Division (TARA).

The most stringent non-carcinogenic exposure thresholds for pollutants of interest for the proposed project are given in Table 2-6.

Table 2-6: Proposed non-carcinogenic exposure thresholds for pollutants of interest in the current study

Pollutant	Averaging Period	Selected Criteria	Source
Zinc	Acute (µg/m³)	50	TARA
	Chronic (µg/m³)	5	TARA

2.7 Non-Criteria Pollutants – Carcinogenic Effects

Unit risk factors (URFs) are applied in the calculation of carcinogenic risks. These factors are defined as the estimated probability of a person (60-70 kg) contracting cancer as a result of constant exposure to an ambient concentration of 1 µg/m³ over a 70-year lifetime. In the generic health risk assessment undertaken as part of the current study, maximum possible exposures (24-hours a day over a 70-year lifetime) are assumed for all areas beyond the boundary of the proposed development site. Unit risk factors were obtained from the WHO (2000) and from the US EPA IRIS database. The most stringent URFs (obtained from the WHO, IRIS and California EPA (CALEPA) databases) for compounds of interest in the current study are given in Table 2-7. The New York Department of Health have a qualitative ranking of cancer risk estimates, from very low to very high (Table 2-8).

Table 2-7: Proposed unit risk factors for pollutants of interest in the current assessment

Compound	Selected Criteria $(\mu g/m^3)^{-1}$	Source
Dioxins	33	CALEPA

Table 2-8: Excess Lifetime Cancer Risk (New York Department of Health)

Risk Ratio	Qualitative Descriptor
Equal to or less than one in a million	Very low
Greater than one in a million to less than one in ten thousand	Low
One in ten thousand to less than one in a thousand	Moderate
One in a thousand to less than one in ten	High
Equal to or greater than one in ten	Very high

2.8 Threshold Guidelines for Sensitive Vegetation

The guidelines used for the assessment of ground level concentrations and deposition levels on sensitive vegetation is discussed in the Ecological Impact Assessment.

2.9 Regulations Regarding Air Dispersion Modelling

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

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

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

- The distribution of pollutants concentrations and depositions are required in time and space.
- Pollutant dispersion can be reasonably treated by a straight-line, steady-state, Gaussian plume model with first order chemical transformation. The model specifically to be used in the air quality impact assessment of the proposed operation is AERMOD.
- Emissions are from sources where the greatest impacts are in the order of a few kilometres (less than 50 km) downwind.

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

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

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

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

For proposed facilities, proposed emissions rates must be used, based in Section 21. For a facility with superior control pollution measures (hence emission rates more stringent than Section 21 emission standards), the modelled emission rates must be based on the emission rates to be stipulated in the licence.

Chapter 4 of the Regulations prescribe meteorological data input from onsite observations to simulated meteorological data. The chapter also gives information on how missing data and calm conditions are to be treated in modelling applications. Meteorology is fundamental for the dispersion of pollutants because it is the primary factor determining the diluting effect of the atmosphere. Therefore, it is important that meteorology is carefully considered when modelling.

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

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

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

Chapter 7 of the Regulations outline how the plan of study and modelling assessment reports are to be presented to authorities.

2.10 Regulations Regarding Report Writing

This report complies with the requirements of the National Environmental Management Act, 1998 (NEMA, No 107 of 1998) and the environmental impact assessment (EIA) regulations (GNR 982 of 2014), as amended in 2017. The table below provides a summary of the requirements, with cross references to the report sections where these requirements have been addressed.

Table 2-9: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (2014), as amended in 2017

A specialist report prepared in terms of the Environmental Impact Regulations of 2014 (as amended in 2017) must contain:	Relevant section in report
Details of the specialist who prepared the report	Section 1.4
The expertise of that person to compile a specialist report including a curriculum vitae	Section 1.4.2 Appendix A
A declaration that the person is independent in a form as may be specified by the competent authority	Section 1.4.1 Appendix B
An indication of the scope of, and the purpose for which, the report was prepared	Section 1.2
An indication of the quality and age of base data used for the specialist report;	Section 3.2 Section 3.3
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 4
The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 3.2 Section 4.2
A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 1.5

A specialist report prepared in terms of the Environmental Impact Regulations of 2014 (as amended in 2017) must contain:	Relevant section in report
Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternative;	Section 3.1
An identification of any areas to be avoided, including buffers	Section 3.1
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 4.2
A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.6
A description of the findings and potential implications of such findings on the impact of the proposed activity or activities	Section 4.2
Any mitigation measures for inclusion in the EMPr	Section 4.1.2 Section 4.2.3
Any conditions for inclusion in the environmental authorisation	Section 6.2
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 6.2
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 7.2
Regarding the acceptability of the proposed activity or activities; and	Section 4.2
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Section 4.1.2 Section 4.2.3 Section 6.2
A description of any consultation process that was undertaken during the course of carrying out the study	Not applicable
A summary and copies if any comments that were received during any consultation process	None received
Any other information requested by the competent authority.	Not applicable

3 RECEIVING ENVIRONMENT

3.1 Air Quality Sensitive Receptors

Potential sensitive receptors within the project area (indicated in Figure 3-1), include individual homesteads, residential areas (i.e. Aggeneys), areas of industrial activities and recreational areas. Sensitive vegetation in the area has been considered under a separate study.

3.2 Climate and Atmospheric Dispersion Potential

Meteorological mechanisms direct the dispersion, transformation and eventual removal of pollutants from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. This dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction, and the variability in wind direction, determines the general path pollutants will follow, and the extent of crosswind spreading. The pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field (Tiwary and Colls, 2010).

The spatial variations, and diurnal and seasonal changes, in the wind field and stability regime are functions of atmospheric processes operating at various temporal and spatial scales (Goldreich and Tyson, 1988). The atmospheric processes at macro- and meso-scales need therefore be taken into account in order to accurately parameterise the atmospheric dispersion potential of a particular area. A qualitative description of the synoptic systems determining the macro-ventilation potential of the region may be provided based on the review of pertinent literature. These meso-scale systems may be investigated through the analysis of meteorological data observed for the region.

WRF data for the period 2016 to 2018 was used for the assessment.

3.2.1 Local Wind Field

The vertical dispersion of pollution is largely a function of the wind field. The wind speed determines both the distance of downward transport and the rate of dilution of pollutants. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness (Tiwary and Colls, 2010).

The wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below, reflect the different categories of wind speeds; the yellow area, for example, representing winds in between 4 and 5 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated.

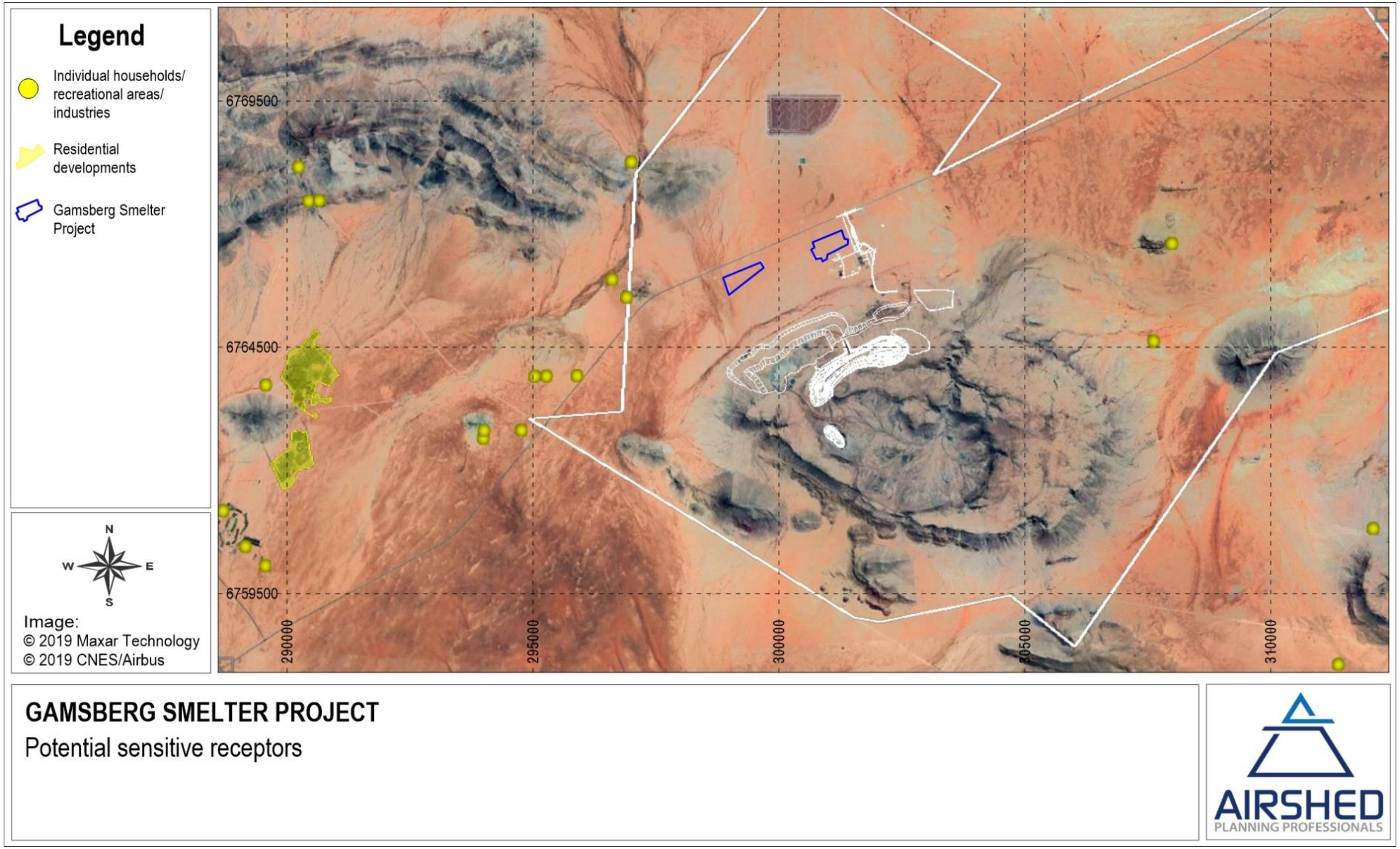

Figure 3-1: Location of potentially sensitive receptors within the study area

The period wind field and diurnal variability in the wind field are shown in Figure 3-2. The wind regime for the area is dominated by southerly flow fields. Calm conditions (wind speeds of less than 1 m/s) occurred 1.46 % of the period summarised.

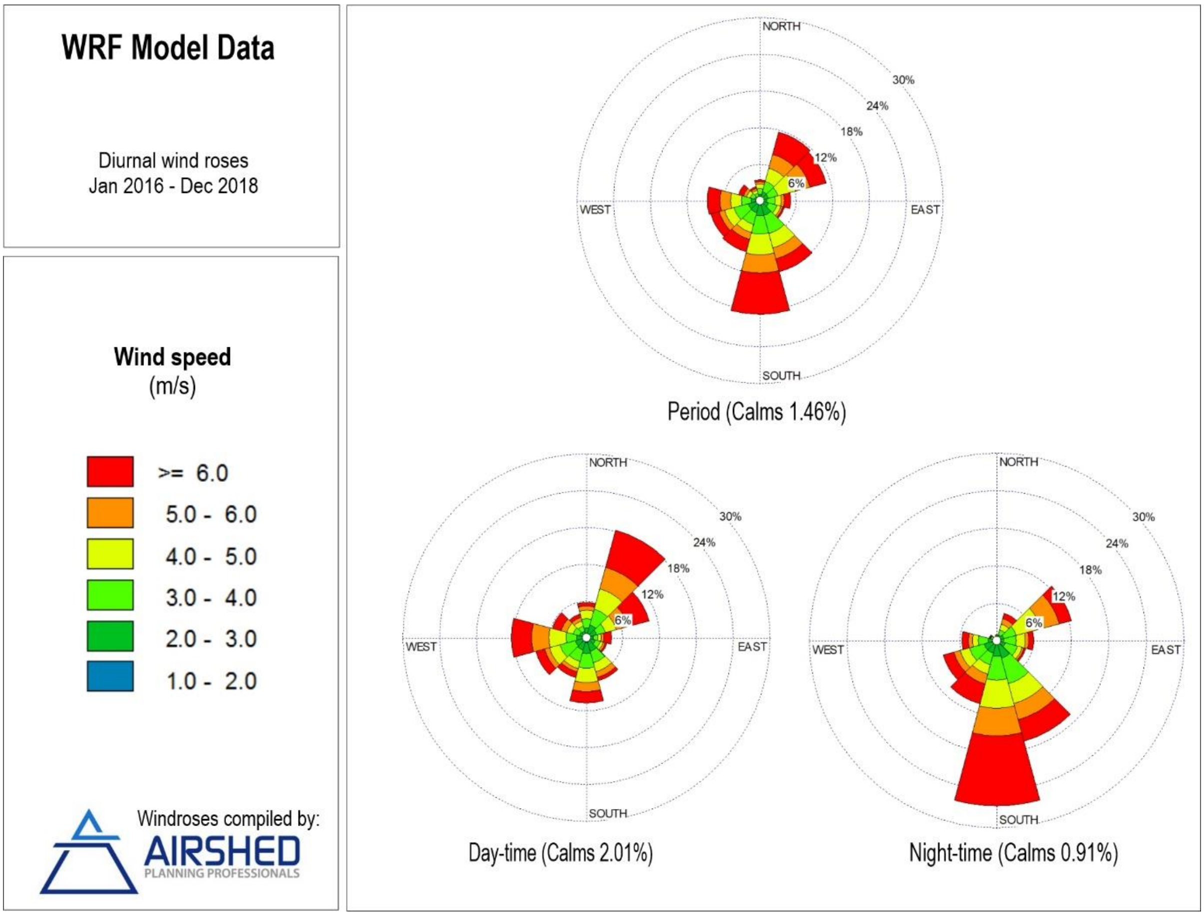

Figure 3-2: Period, day-, and night-time wind roses (WRF data, January 2016 to December 2018)

3.2.2 Ambient Temperature

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

Monthly mean, maximum and minimum temperatures are given in Table 3-1. Diurnal temperature variability is presented in Figure 3-3. Average monthly temperatures ranged between 11.8°C and 25.6°C. During the day, temperatures increase to reach maximum at about 15:00 in the late afternoon. Ambient air temperature decreases to reach a minimum at between 06:00 and 07:00.

Table 3-1: Monthly temperature summary (WRF data, January 2016 to December 2018)

Month	Temperature (°C)		
	Minimum	Maximum	Average
Jan	9.3	39.8	25.6
Feb	8.3	38.9	25.2
Mar	6.9	37.1	22.9

Month	Temperature (°C)		
	Minimum	Maximum	Average
Apr	5.2	33.3	20.8
May	3.6	29.9	16.5
Jun	1.0	27.5	12.9
Jul	-1.5	26.7	11.8
Aug	-2.2	32.2	12.6
Sep	-1.5	36.0	15.9
Oct	2.9	36.8	19.5
Nov	2.8	36.0	22.0
Dec	7.3	37.9	23.9

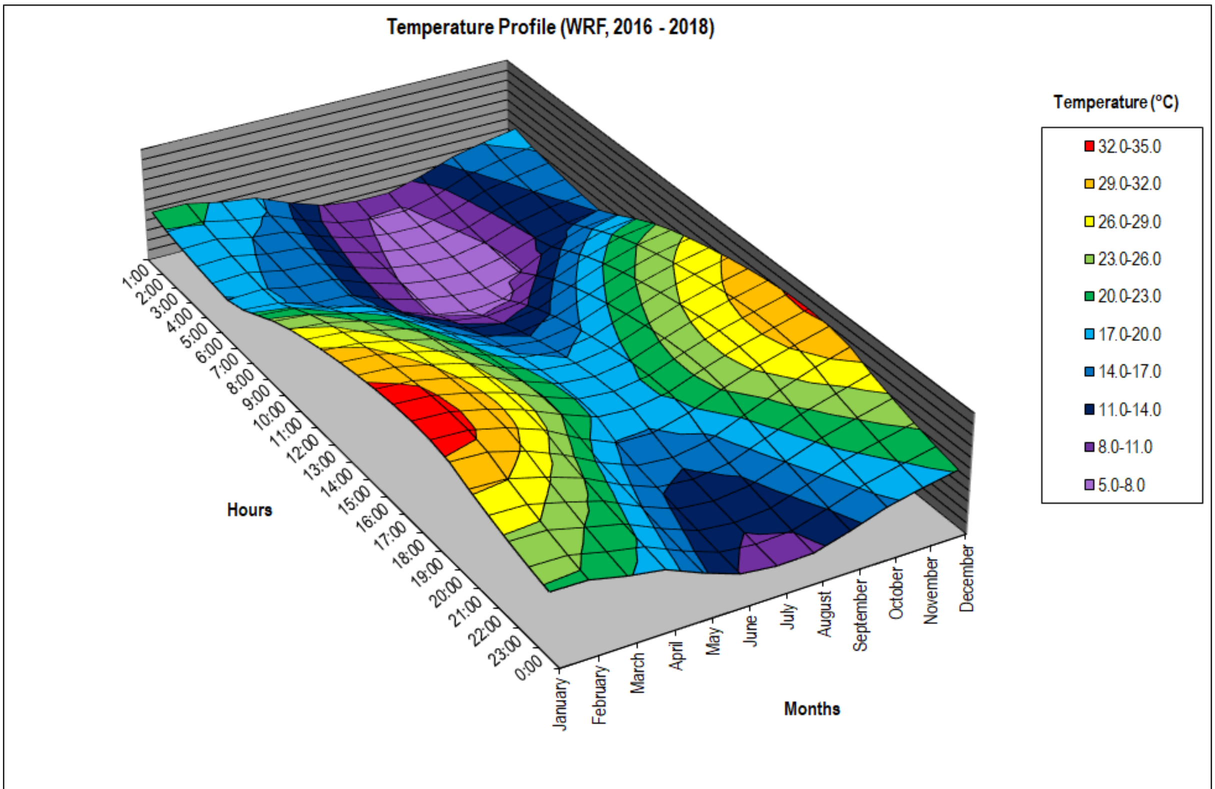

Figure 3-3: Diurnal temperature profile (WRF data, January 2016 to December 2018)

3.2.3 Atmospheric Stability and Mixing Depth

The new generation air dispersion models differ from the models traditionally used in a number of aspects, the most important of which are the description of atmospheric stability as a continuum rather than discrete classes. The atmospheric boundary layer properties are therefore described by two parameters: the boundary layer depth and the Monin-Obukhov length, rather than in terms of the single parameter Pasquill Class. The Monin-Obukhov length (LMo) provides a measure of the importance of buoyancy generated by the heating of the ground and mechanical mixing generated by the frictional effect of the earth's surface. Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC, 2004). The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface. Night times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds and less dilution potential. During windy and/or cloudy conditions, the atmosphere is normally neutral. For low level releases, the highest ground level concentrations would occur during weak wind speeds and stable (night-time) atmospheric conditions. The atmospheric stability for the site is provided in Figure 3-4.

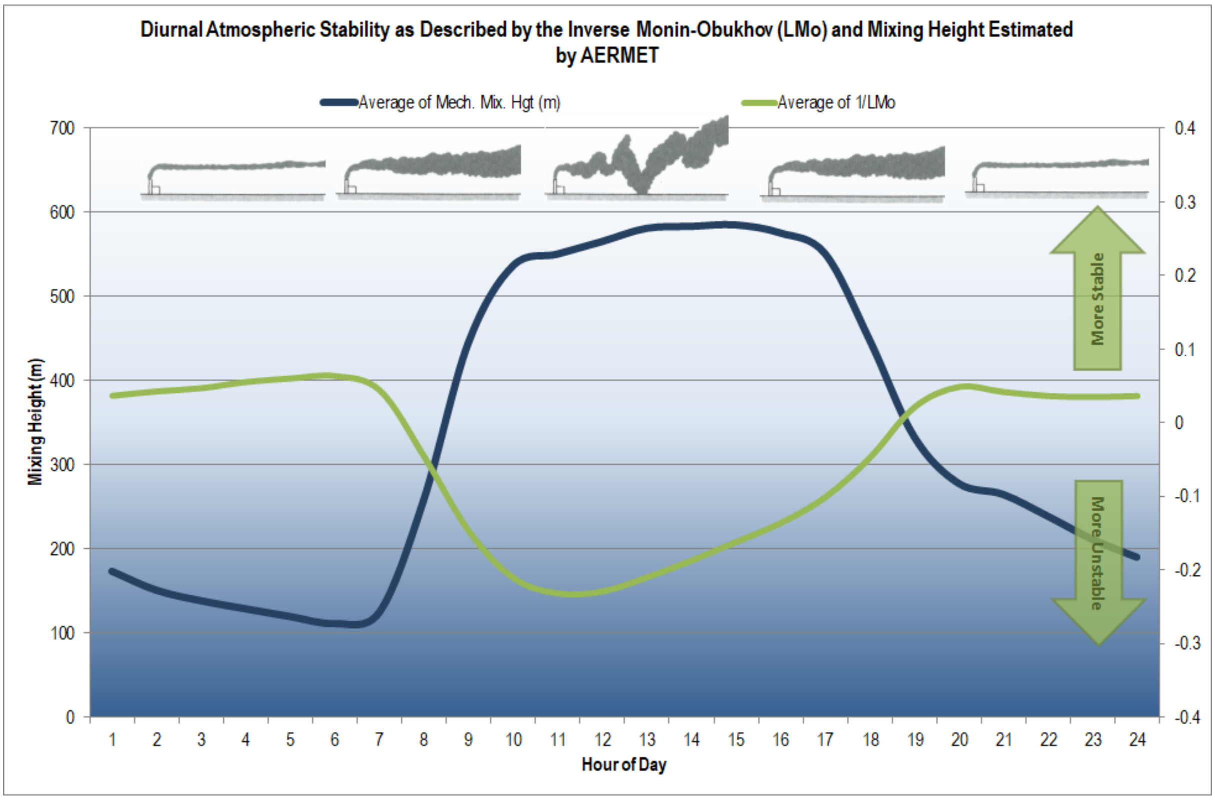

Figure 3-4: The diurnal atmospheric stability for the site as estimated with AERMET

3.3 Ambient Air Quality within the Region

3.3.1 Ambient Particulate Concentrations

Ambient PM_{10} sampling was undertaken at the site during 2018 and 2019. The location of the PM_{10} sampling points is provided in Figure 3-5. A summary of ambient PM_{10} concentrations measured at the GB Mining Offices, GB South Access, Aggeneys High School, GB Camp and GB NW is provided in Table 3-2.

The GB NW site could be classified as a background site (representative of natural desert windblown dust). The daily PM_{10} concentrations were 21 µg/m³ (99th percentile). It should be noted that the daily PM_{10} NAAQS at this site was exceeded 3 times during the sampling period and the data availability was only 58%.

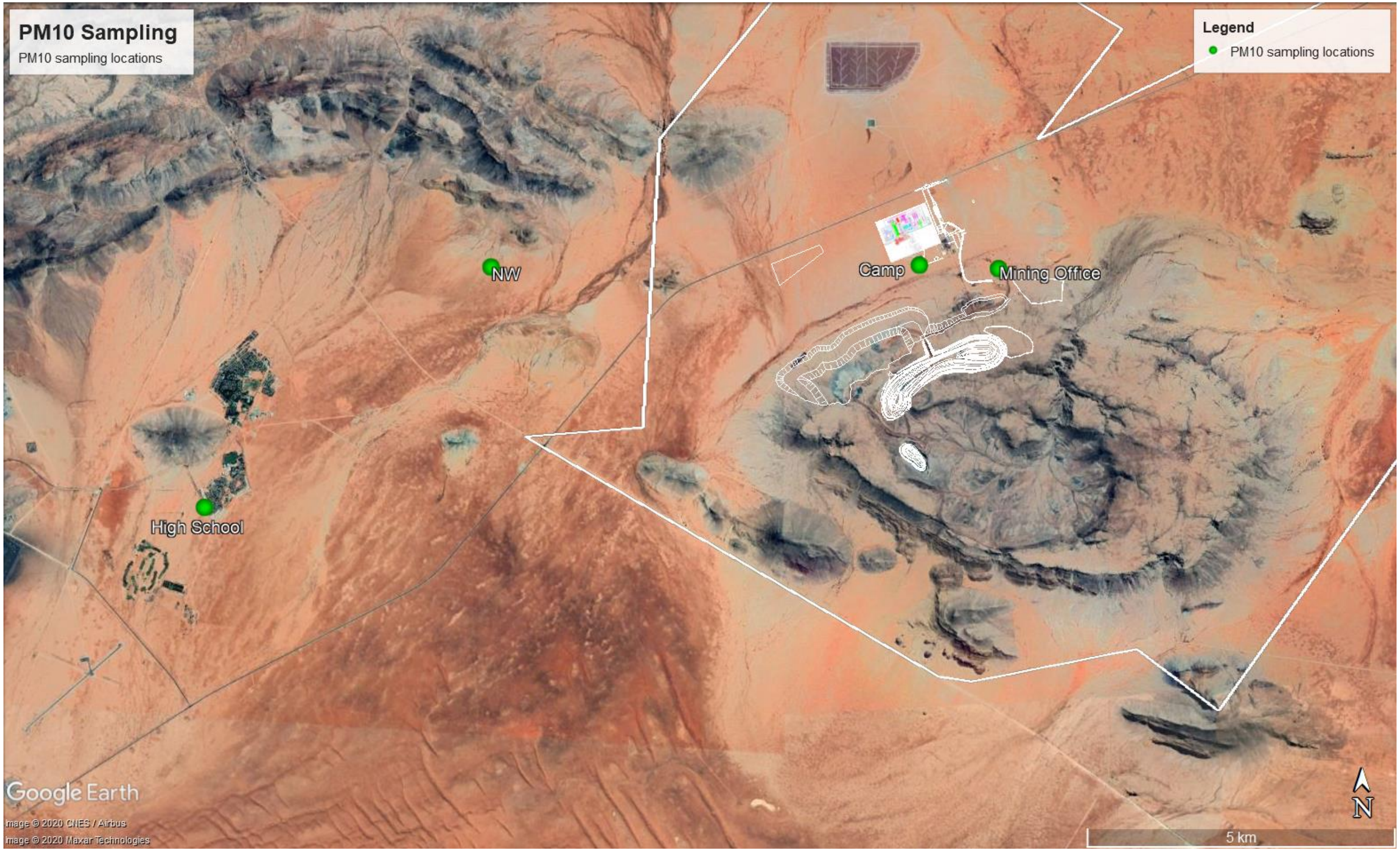

Figure 3-5: PM_{10} sampling locations

Table 3-2: Summary of the ambient particulate measurements within the study area (units: µg/m3)

Pollutant	Availability (%)	Daily				No of recorded exceedances
		Max	99th Percentile	90th Percentile	50th Percentile	
GB Mining Offices (January - May 2018)						
PM_{10}	100	273.5	39.0	11.3	2.2	12
GB South Access (January - June 2018)						
PM_{10}	96	50.6	7.4	2.1	0.3	0
Aggeneys High School, South Village (January - September 2019)						
PM_{10}	97	564.5	23.0	9.0	2.7	5
GB Camp (January - September 2019)						
PM_{10}	98	337.0	27.8	11.5	3.5	7
GB NW (January - September 2019)						
PM_{10}	58	498.0	21.0	8.5	0.0	3

Time variation plots of ambient concentrations measured at GB Mining Offices (Figure 3-6), GB South Access (Figure 3-7), Aggeneys High School, South Village (Figure 3-8), GB Camp(Figure 3-9) and GB NW (Figure 3-10) show the variation of PM_{10} ground level concentrations over daily, weekly and annual cycles.

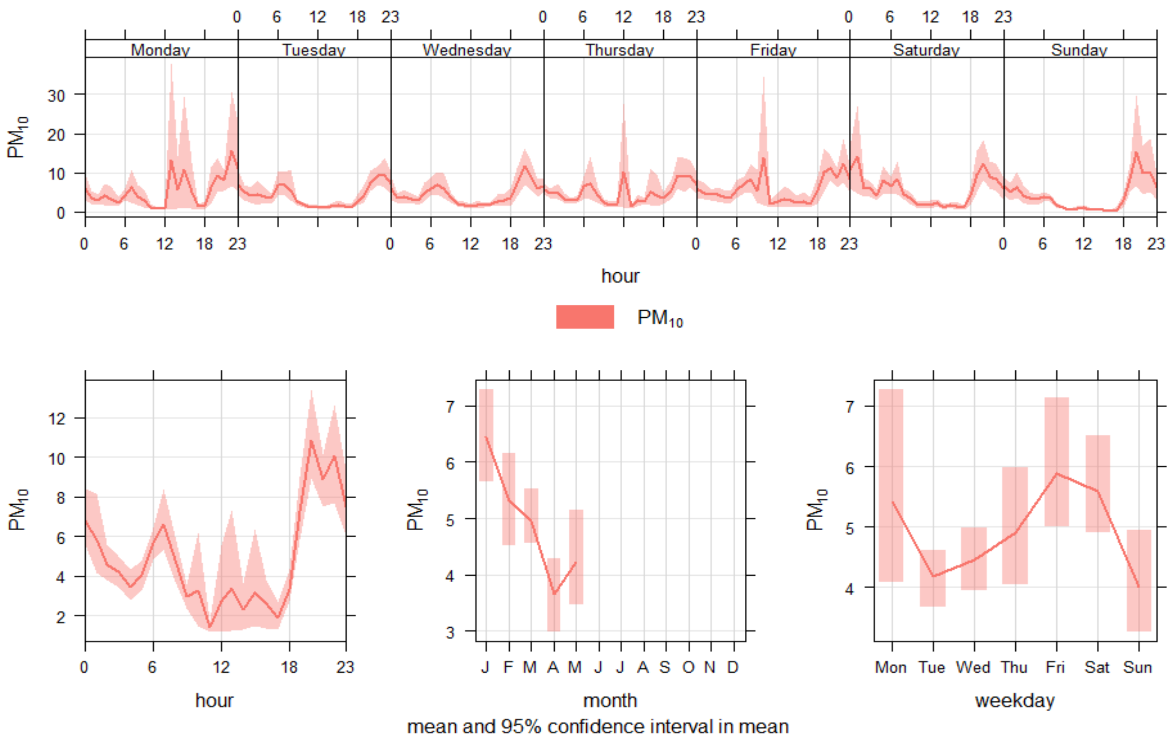

Figure 3-6: Time variation summary of measured ambient PM_{10} concentrations GB Mining Offices (January - May 2018)

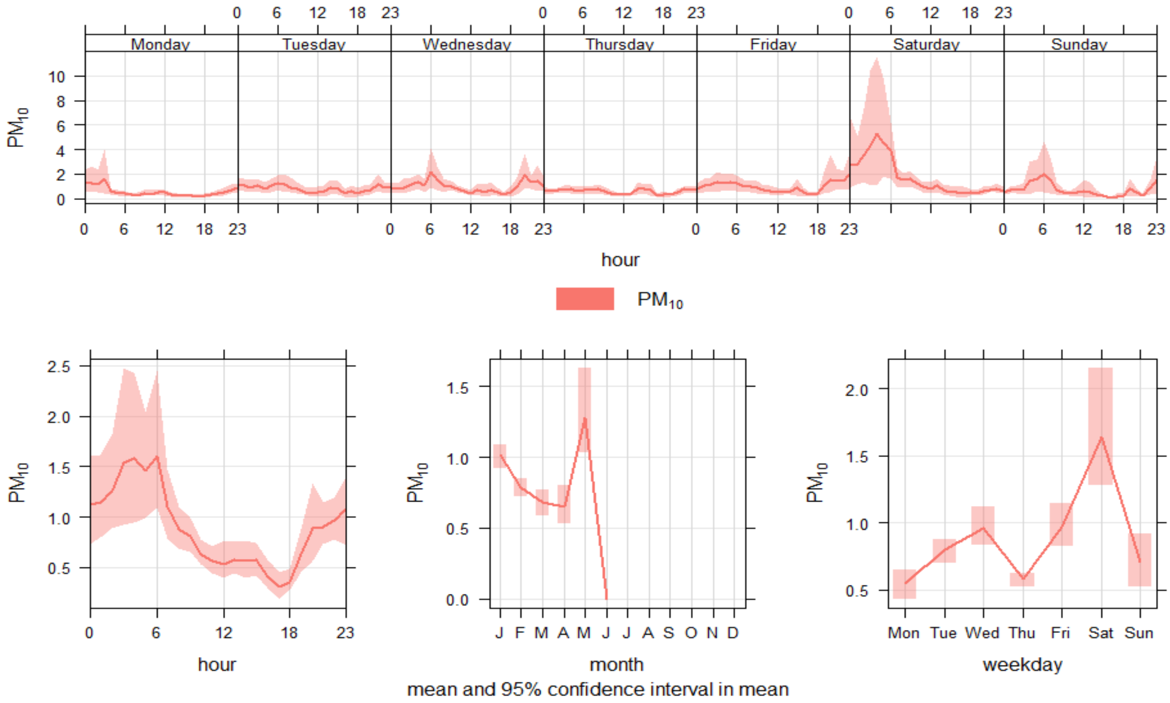

Figure 3-7: Time variation summary of measured ambient PM_{10} concentrations from GB South Access (January - June 2018)

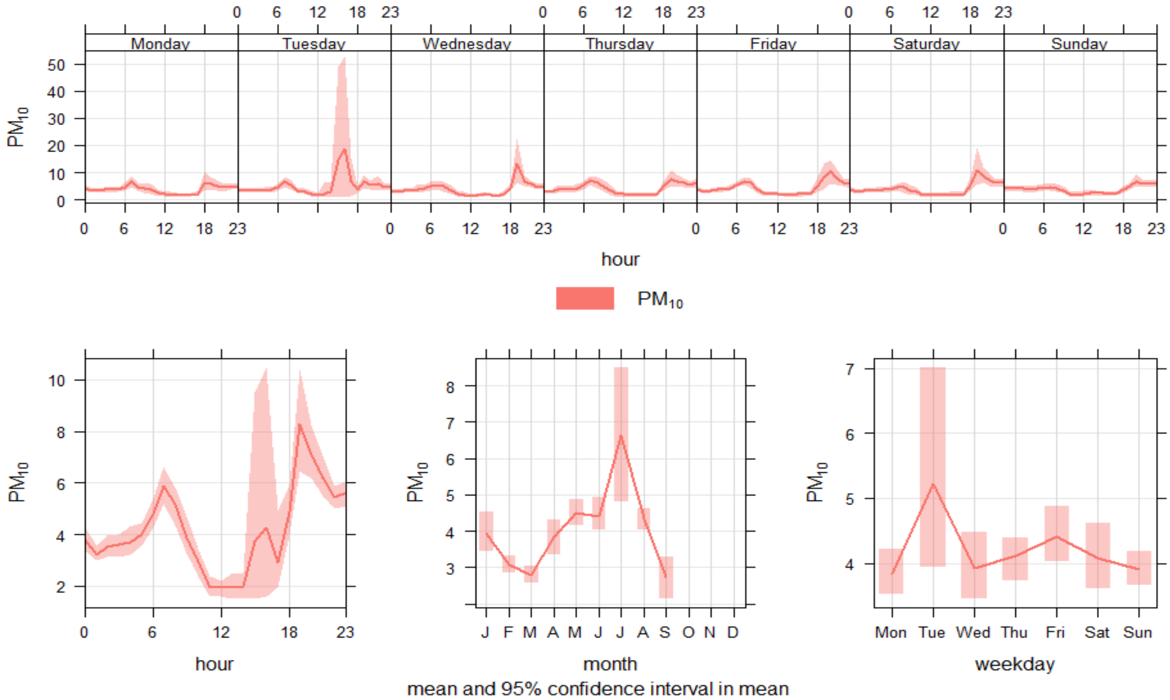

Figure 3-8: Time variation summary of measured ambient PM_{10} concentrations from Aggeneys Highschool, South Village (January - September 2019)

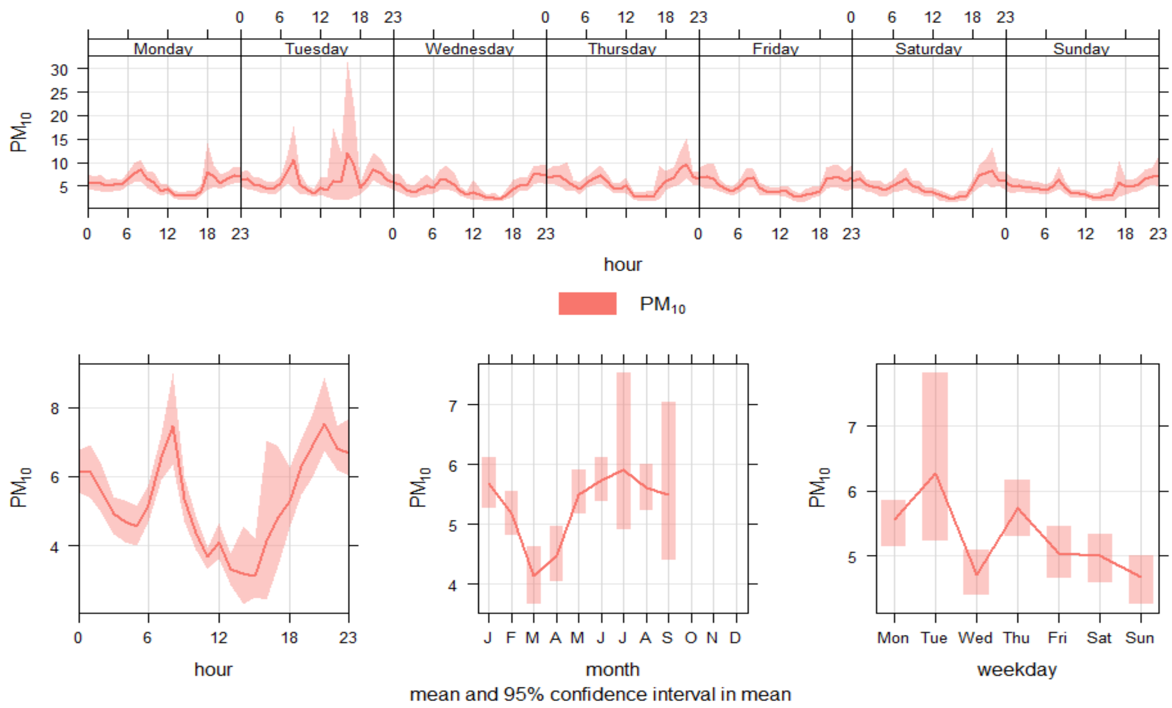

Figure 3-9: Time variation summary of measured ambient PM_{10} concentrations from the GB Camp (January - September 2019)

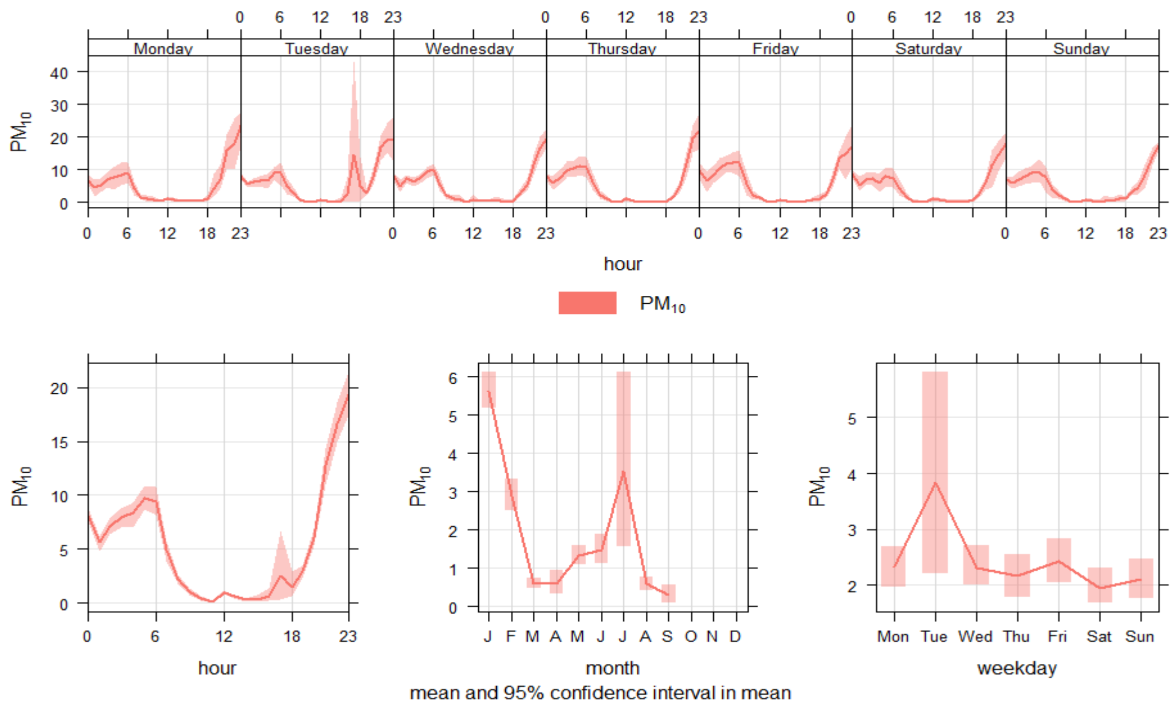

Figure 3-10: Time variation summary of measured ambient PM_{10} concentrations from GB NW (January - September 2019)

The source contribution of ambient PM_{10} is more visually understood through polar plots (Figure 3-11 to Figure 3-15). These polar plots (Carslaw and Ropkins, 2012; Carslaw, 2013) provide an indication of the directional contribution as well as the dependence of concentrations on wind speed.

The highest mean PM_{10} ground level concentrations at the GB Mining Offices monitoring station were observed with winds from the south east at wind speeds of about 7 m/s (Figure 3-11).

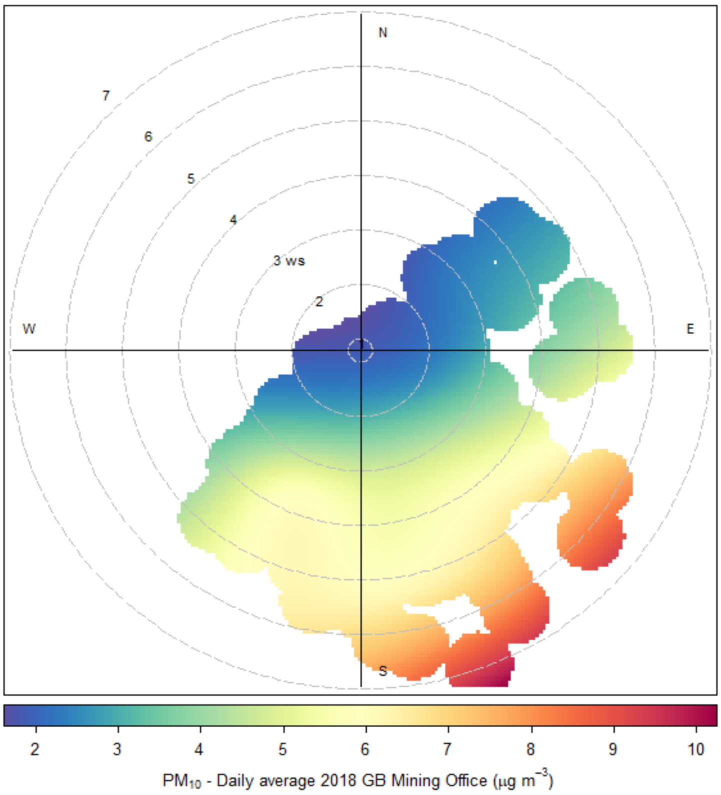

Figure 3-11: Polar plot of daily PM_{10} concentration observations GB Mining Offices (January - May 2018)

The highest mean PM_{10} GB South Access monitoring station was observed with winds from the south west at wind speeds of about 12 m/s (Figure 3-12).

At the GB Aggeneys Highschool, the highest mean PM_{10} concentrations were observed from the south west with wind speeds of about 3.25 m/s (Figure 3-13).

The highest mean PM_{10} ground level concentrations at the GB Camp monitoring station were observed with winds from the south west at wind speeds of about 4.5 m/s (Figure 3-14).

The highest mean PM_{10} GB BW monitoring station was observed with winds from the west at wind speeds of about 8 m/s (Figure 3-15).

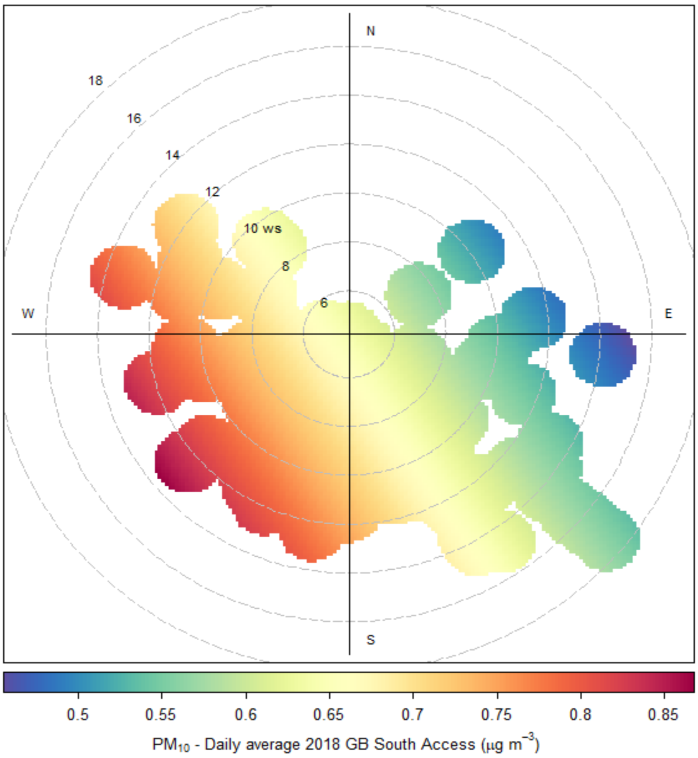

Figure 3-12: Polar plot of daily PM_{10} concentration observations GB South Access (January - June 2018)

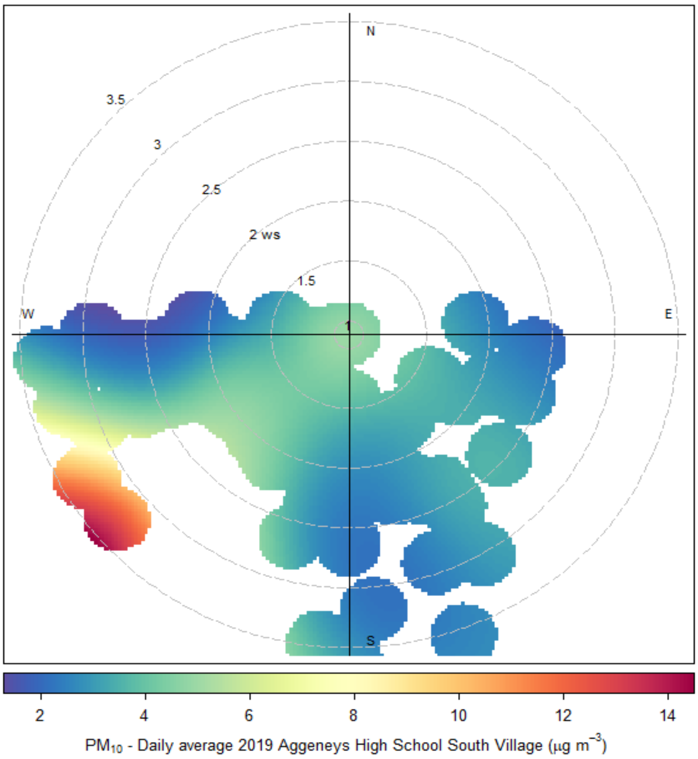

Figure 3-13: Polar plot of daily PM_{10} concentration observations at Aggeneys HS SV (January - September 2019)

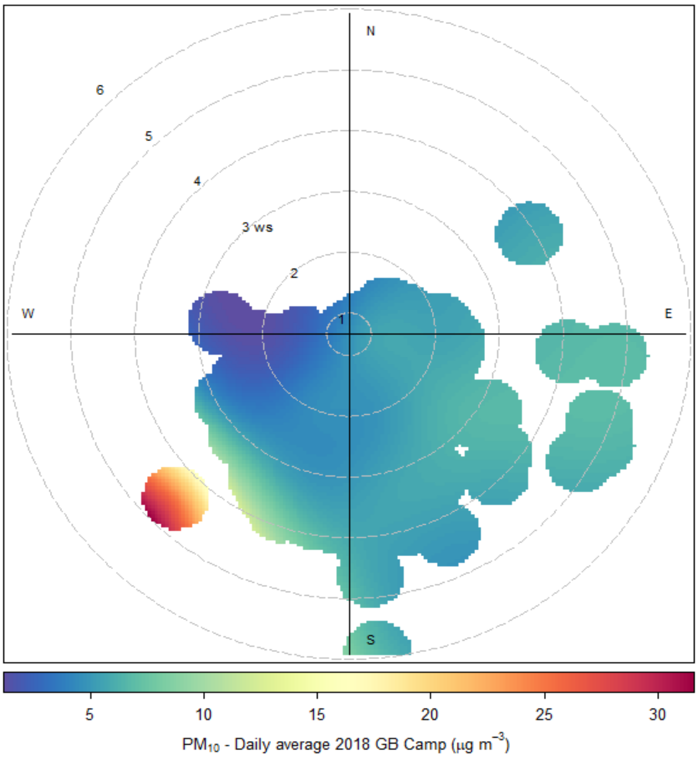

Figure 3-14: Polar plot of daily PM_{10} concentration observations at GB Camp (January - September 2019)

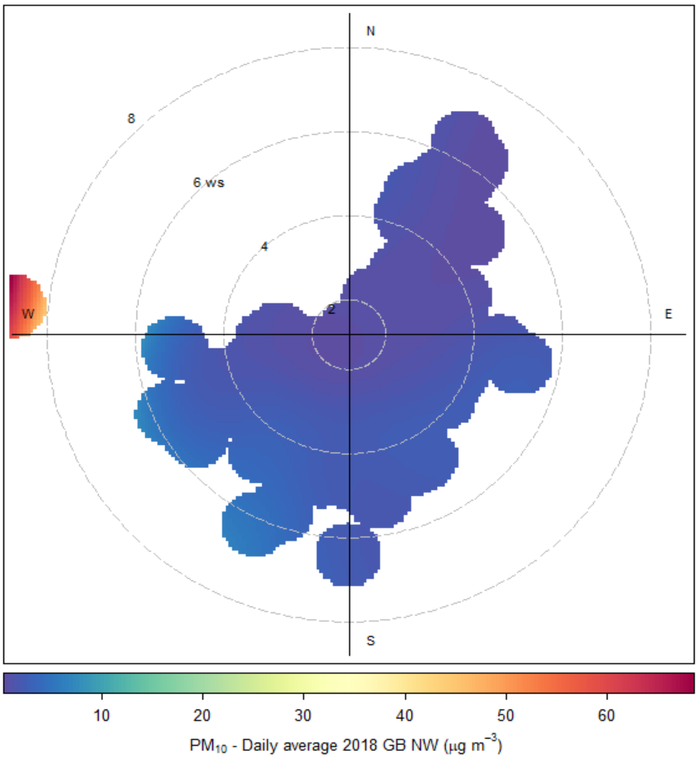

Figure 3-15: Polar plot of daily PM_{10} concentration observations GB NW (January - September 2019)

3.3.2 Dust Fallout

Sampled dust fallout data for 14 single dust buckets were provided for the current assessment. The co-ordinates for three sites, provided as decimal degrees, were available. The dustfall classification and location (where available) as provided is given in Table 3-3 and Figure 3-16. The measured dust fallout for the period January 2018 to April 2019 is provided in Figure 3-17 and Table 3-4.

Table 3-3: Location of the dust fallout buckets

Sample Location	Classification	Latitude	Longitude
Single Dust Bucket			
Kykgat 1	Non-residential	29.34292°S	19.06166°E
Kykgat 2	Non-residential	29.33943°S	19.06474°E
GAMS - SU1	Non-residential	29.246°S	18.96117°S
GAMS - SU2	Non-residential	29.24892°S	18.96835°S
GAMS - SU3	Non-residential	29.26135°S	18.96803°S
Achab (House)	Non-residential		
Achab (Gams)	Non-residential	29.24738°S	19.04404°E
BMM TRC	NA		
Gams Bloem	Non-residential		
Achab House New	Non-residential		
Achab Gams New	Non-residential		
Gams Ramp (Not Sprayed)	Non-residential		
Gams Ramp (Sprayed)	Non-residential		
SND	NA		

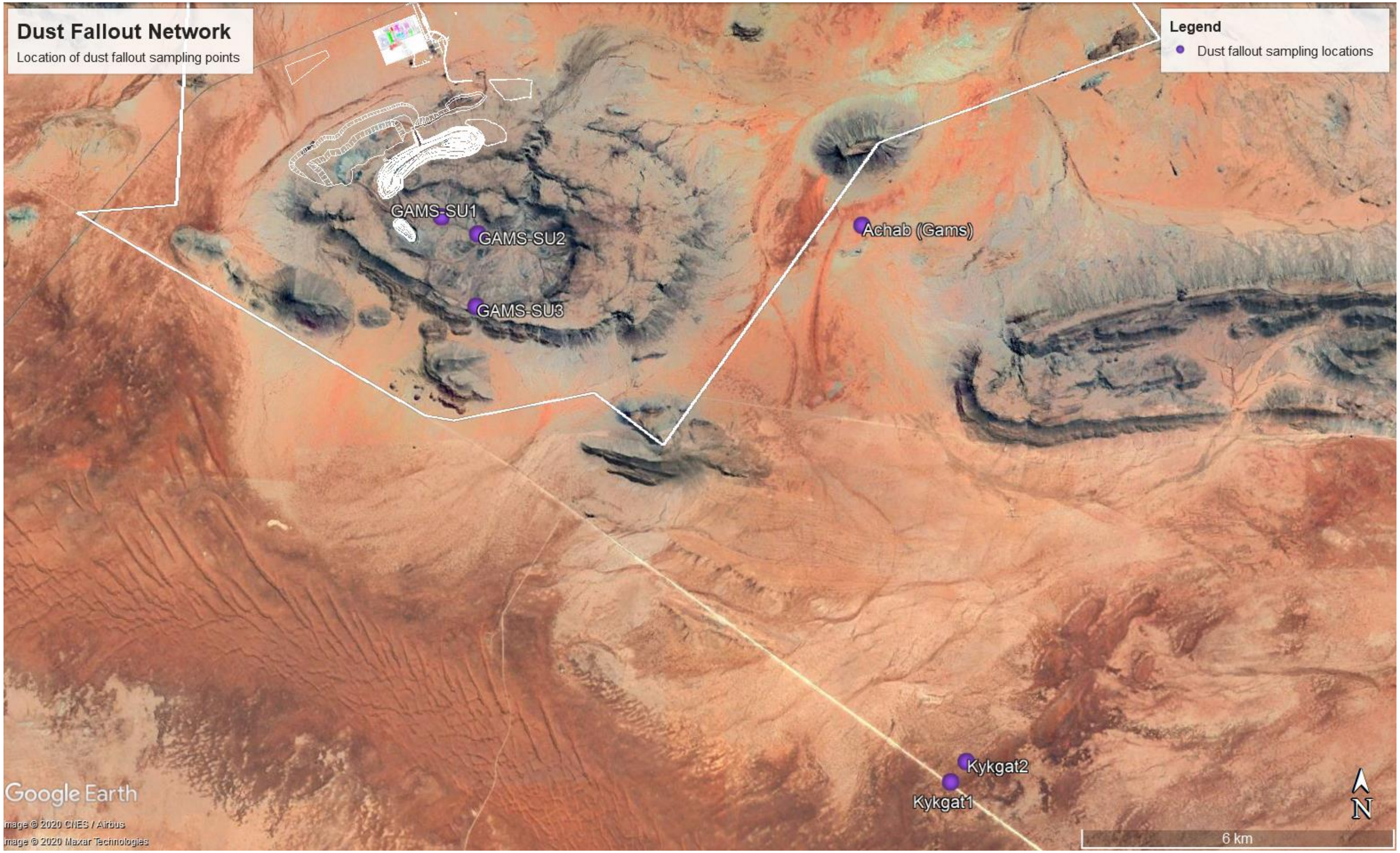

Figure 3-16: The location of dust fallout sampling points

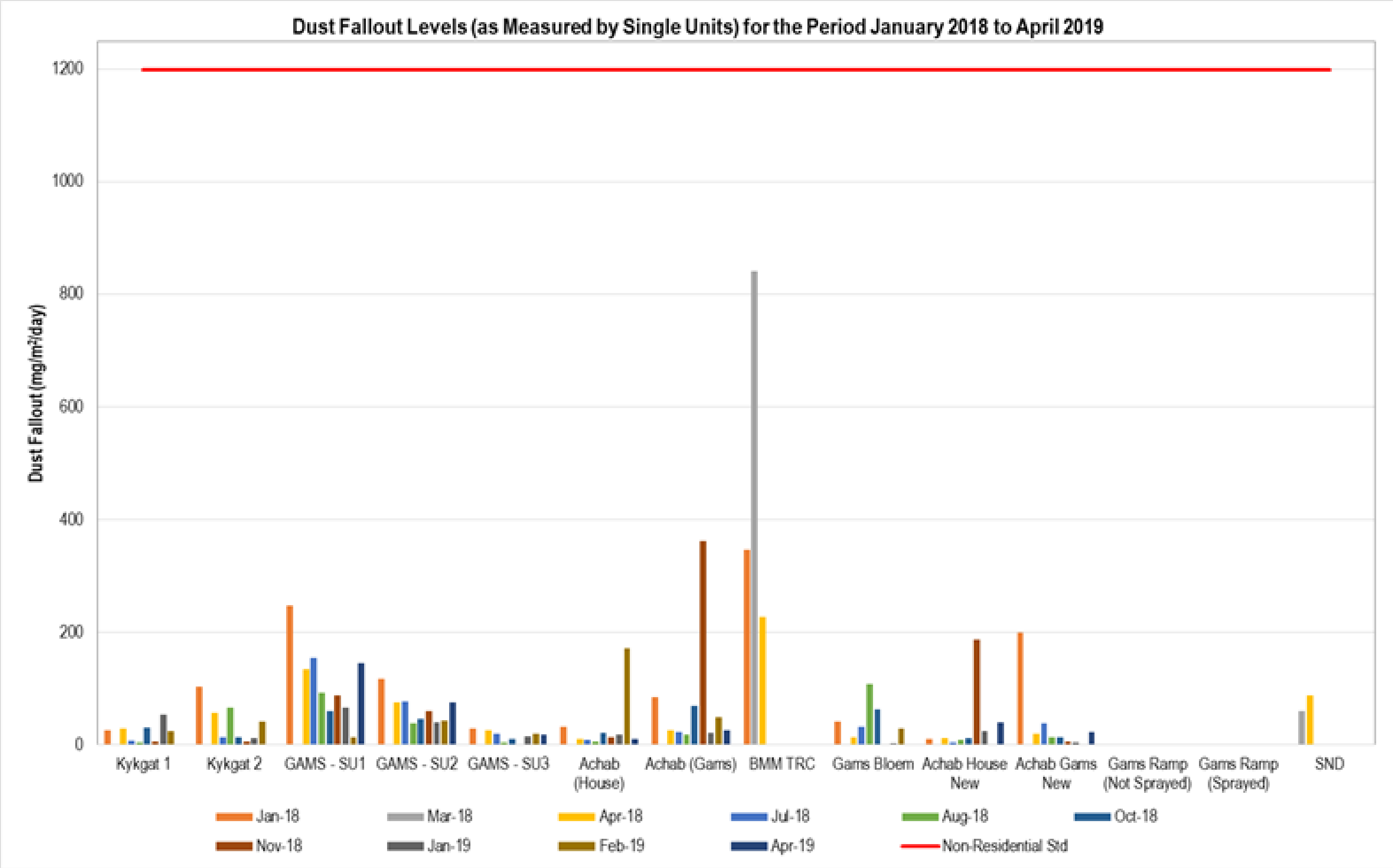

Figure 3-17: The measured dust fallout rates from the single buckets for the period January 2018 to April 2019

Table 3-4: The measured dust fallout rates for the period January 2018 to April 2019

Sample Location	Non-Residential Std	Dust Fallout (mg/m²/day)									
		Jan-18	Mar-18	Apr-18	Jul-18	Aug-18	Oct-18	Nov-18	Jan-19	Feb-19	Apr-19
Kykgat 1	1200	26		29	7	4	30	5	54	25	
Kykgat 2	1200	104		57	14	66	13	6	12	42	
GAMS - SU1	1200	248		135	154	92	59	88	66	13	145
GAMS - SU2	1200	118		75	78	39	46	60	41	44	76
GAMS - SU3	1200	29		25	20	5	11		15	19	18
Achab (House)	1200	32		10	8	6	21	14	18	172	11
Achab (Gams)	1200	85		25	23	18	69	363	21	49	25
BMM TRC	1200	347	842	228							
Gams Bloem	1200	41		13	32	107	63		2	28	
Achab House New	1200	11		11	4	9	12	187	25		39
Achab Gams New	1200	200		19	38	13	14	6	4		23
Gams Ramp (Not Sprayed)	1200										
Gams Ramp (Sprayed)	1200										
SND	1200		59	88							

3.3.3 Gaseous Concentrations

In 2009, NO_2 and SO_2 were sampled during the months of June and September at 10 locations (SRK Consulting, 2010). The location of the sampling points is provided in Figure 3-18. In the absence of a more recent data, this information was incorporated in the following section.

Sampled SO_2 concentrations for June and September 2009 were well below the daily NAAQS of 125 µg/m³ for all sampling points. Results received for the month of June were below detection limit for 8 sites with two sites GAM A9 and GAM A10 having SO_2 concentrations of 0.47 µg/m³ and 0.36 µg/m³ respectively. During September 2009, SO_2 concentrations had increased when compared to June, but the measured levels remained below the daily SO_2 NAAQS (SRK Consulting, 2010).

NO_2 concentrations were below the hourly NAAQS of 200 µg/m³ for both the June and September 2009 sampling periods. All sampled concentrations were recalculated from 24-hours to 1-hr values, for comparison to hourly NAAQS values.

Table 3-5: Sampled SO_2 and NO_2 ground level concentrations during a 2009 survey

Sample ID	Daily SO_2 Concentrations (µg/m³)		Hourly NO_2 Concentrations (µg/m³)	
	Jun-09	Sep-09	Jun-09	Sep-09
GAM A1	BDL	3.64	BDL	0.32
GAM A2	BDL	0.6	BDL	BDL
GAM A3	BDL	0.32	BDL	0.32
GAM A4	BDL	6.78	BDL	BDL
GAM A5	BDL	0.1	BDL	BDL
GAM A6	BDL	0.1	BDL	0.19
GAM A7	BDL	BDL	BDL	BDL
GAM A8	BDL	0.48	0.09	0.12
GAM A9	0.47	0.62	0.33	BDL
GAM A10	0.36	0.1	0.001	0.42
NAAQS (99th percentile)	125		200	

BDL: Below detection limit

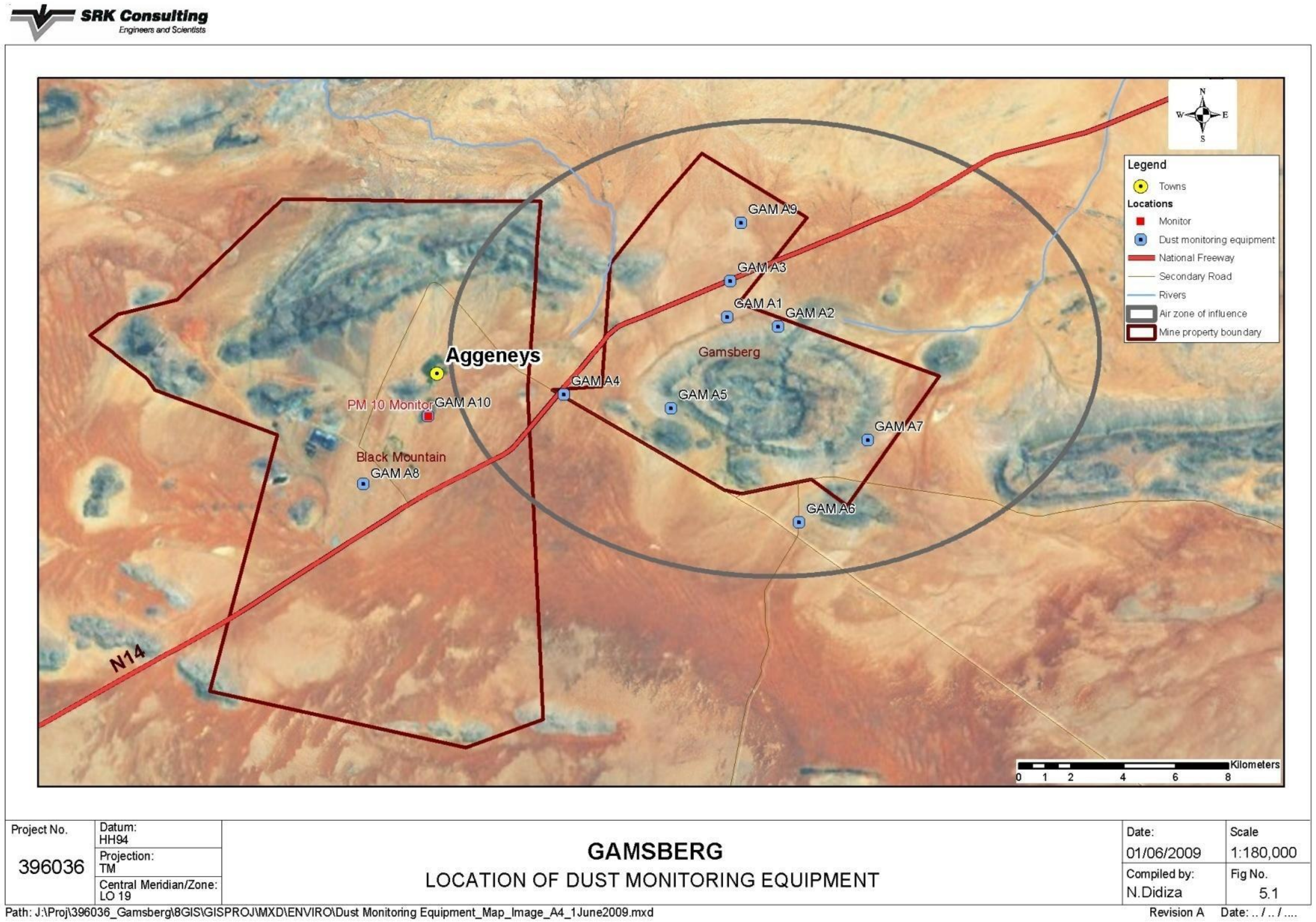

Figure 3-18: Location of sampling points during the 2009 survey

3.4 Existing Sources of Emissions near the Proposed Project

3.4.1 *Mining Activities*

Mining activities to the south (Gamsberg Zinc Mine) and west (Black Mountain Mine) of the project site would add to the PM emissions and ground level concentrations in the airshed. Emission sources would include materials handling activities, vehicle entrainment and windblown dust from storage piles and tailings storage facilities.

3.4.2 *Vehicle Exhaust Emissions*

Air pollution from vehicle emissions may be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly into the atmosphere, and secondary, those pollutants formed in the atmosphere as a result of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. The significant primary pollutants emitted by motor vehicles include carbon dioxide (CO_2), CO, hydrocarbon compounds (HC), SO_2, oxides of nitrogen (NO_x) and particulate matter (PM). Secondary pollutants include NO_2, photochemical oxidants (e.g. ozone), hydrocarbons (HC), sulfuric acid, sulfates, nitric acid and nitrate aerosols.

3.4.3 *Other Fugitive Dust Sources*

Fugitive dust emissions may occur as a result of vehicle-entrained dust from local paved and unpaved roads and wind erosion from open areas. The extent of particulate emissions from the main roads will depend on the number of vehicles using the roads and on the silt loading on the roadways.

Windblown dust generates from natural and anthropogenic sources. For wind erosion to occur, the wind speed needs to exceed a certain threshold, called the threshold velocity. This relates to gravity and the inter-particle cohesion that resists removal. Surface properties such as soil texture, soil moisture and vegetation cover influence the removal potential. Conversely, the friction velocity or wind shear at the surface is related to atmospheric flow conditions and surface aerodynamic properties. Thus, for particles to become airborne, its erosion potential has to be restored; that is, the wind shear at the surface must exceed the gravitational and cohesive forces acting upon them, called the threshold friction velocity. Every time a surface is disturbed, its erosion potential is restored (US EPA, 2004).

4 IMPACTS FROM THE PROPOSED PROJECT ON THE RECEIVING ENVIRONMENT

4.1 Planning/Design and Construction Phase

4.1.1 Identification of Environmental Aspects

The construction phase will comprise a series of different activities including land clearing, topsoil removal, material loading and hauling, stockpiling, grading, bulldozing, compaction, (etc.). Each of these operations has its own duration and potential for dust generation. It is anticipated therefore that the extent of dust emissions would vary substantially from day to day depending on the level of activity, the specific activities, and the prevailing meteorological conditions. This is in contrast to most other fugitive dust sources where emissions are either relatively steady or follow a discernible annual cycle.

A list of all the potential dust generation activities expected during the construction phase is provided in Table 4-1. Unmitigated construction activities provide the potential for impacts on local communities, primarily due to nuisance and aesthetic impacts associated with fugitive dust emissions, and impacts on the sensitive vegetation. On-site dustfall may also represent a nuisance to employees.

The construction phase was assessed qualitatively due to the short-term duration. Table 4-1: Typical sources of fugitive particulate emission associated with construction

Impact	Source	Activity
Gaseous	Vehicle tailpipe	Transport and general construction activities
PM_{10} and $PM_{2.5}$	Stockpile areas and open areas	Clearing of groundcover
		Levelling of area
		Wind erosion from open areas
		Materials handling
	Transport infrastructure	Clearing of vegetation and topsoil
		Levelling of areas

4.1.2 Mitigation Measures Recommended

Incremental PM_{10} and $PM_{2.5}$ concentrations and deposition rates due to the construction phase of the proposed project will be of relatively short-term and of local impact. The implementation of effective controls, however, during this phase would also serve to set the precedent for mitigation during the operational phase.

Dust control measures which should be implemented during the construction phase are outlined in Table 4-2. Control techniques for fugitive dust sources generally involve watering, chemical stabilization, and the reduction of surface wind speed though the use of windbreaks and source enclosures.

Table 4-2: Dust control measures that should be implemented during construction activities

Construction Activity	Recommended Control Measure(s)
Materials storage, handling and transfer operations	Wet or chemical suppression, where feasible, on stockpiles and materials handling activities
Open areas (windblown emissions)	Minimise extent of disturbed areas. Reduction of frequency of disturbance.
Vehicle movement	Limit vehicle speeds to 40 km/hr.

4.2 Operational Phase

4.2.1 Identification of Environmental Aspects

In terms of air quality, atmospheric emissions represent the environmental aspects of concern for the assessment of the proposed project. The sources of these emissions were determined by first identifying the inputs and outputs to the various processes and secondly considering the disturbance to the environment by the proposed operations. Possible aspects associated with the proposed operations of relevance in terms of air quality impacts are listed in Table 4-3.

Table 4-3: Potential air pollutants emitted from the proposed project

Operational phase		
Aspects	Source	Activities
Vehicle Entrainment		
Particulate emissions; fugitive dust	Vehicle activity on paved and unpaved roads	Transportation of raw materials Transportation of waste Transportation of product
Material handling		
Fugitive dust	Materials handling operations	Loading and offloading of waste material Offloading of raw material
Storage piles		
Fugitive dust	Wind erosion	Windblown dust from storage piles and waste facilities
Stacks		
Gaseous and particulate emissions	Acid Plant Stack Casting Stack Dross Treatment Stack Zinc Dust Plant Stack	Stack emissions.

4.2.2 Quantification of Environmental Aspects and Impact Classification

4.2.2.1 Emissions Inventory

The operation phase is assessed quantitatively with the emissions provided in the current section. In addition to the project, emissions for the baseline mining operations are quantified in order to assess the cumulative impacts due to proposed project operations. The emission factors and calculated emission rates for the fugitive sources are provided in Table 4-4. The stack parameters and emissions are provided in Table 4-5.

Table 4-4: Emission factors used to quantify the routine emissions from the operational phase for the project

<table>
<tr><th>Activity</th><th>Emission Equation</th><th>Source</th><th>Information assumed/provided</th></tr>
<tr><td>Vehicle entrainment on unpaved surfaces</td><td>$$E = k(s/12)^a(W/3)^b$$
Where,
E = size-specific emission factor (lb/VKT)
s = surface material silt content (%)
W = mean vehicle weight (tons)

The particle size multiplier (k) is given as 0.15 for $PM_{2.5}$, 1.5 for PM_{10}, and as 4.9 for TSP.
A is given as 0.9 for $PM_{2.5}$ and PM_{10} and 0.7 for TSP.
A is given as 0.45 for $PM_{2.5}$, PM_{10} and TSP.</td><td>US-EPA AP42 Section 13.2.2</td><td>In the absence of site-specific silt data, use was made of US EPA default mean silt loading of 8.4 % for haul roads.

The capacity of the trucks to be used was given:
<table>
<tr><th>Material</th><th>Truck capacity (t)</th></tr>
<tr><td>ROM and Waste</td><td>135</td></tr>
<tr><td>Jarosite and other materials</td><td>30</td></tr>
</table>
The throughput of the material was provided for the baseline and proposed project operations:
<table>
<tr><th>Material</th><th>Throughput (tpa)</th></tr>
<tr><td>Ore mined</td><td>10 000 000</td></tr>
<tr><td>Waste mined</td><td>90 000 000</td></tr>
<tr><td>Jarosite and other materials</td><td>238 000</td></tr>
</table>
75% control efficiency were assumed on all unpaved roads.</td></tr>
<tr><td>Vehicle entrainment on paved surfaces</td><td>$$E = k(sL)^{0.91}(W)^{1.02}$$
Where,
E = size-specific emission factor (g/VKT)
sL = road surface silt loading (g/m²)
W = mean vehicle weight (tons)

The particle size multiplier (k) is given as 0.15 for $PM_{2.5}$, 0.62 for PM_{10}, and as 3.23 for TSP.</td><td>US-EPA AP42 Section 13.2.1</td><td>In the absence of site-specific silt loading data, use was made of US EPA default mean silt loading of 8.2 g/m².

The capacity of the trucks to be used was given:
<table>
<tr><th>Material</th><th>Truck capacity (t)</th></tr>
<tr><td>Concentrate</td><td>30</td></tr>
<tr><td>Zn Ingot</td><td>30</td></tr>
<tr><td>Sulphuric Acid</td><td>30</td></tr>
<tr><td>Store material</td><td>20</td></tr>
<tr><td>Jarosite and other materials</td><td>30</td></tr>
<tr><td>Mn Cake</td><td>30</td></tr>
<tr><td>Product (metal)</td><td>35</td></tr>
</table>
The throughput of the material was provided for the baseline and proposed project operations:
<table>
<tr><th>Material</th><th>Throughput (tpa)</th></tr>
<tr><td>Concentrate</td><td>520 000</td></tr>
<tr><td>Zn Ingots</td><td>250 000</td></tr>
<tr><td>Sulphuric Acid</td><td>400 000</td></tr>
<tr><td>Store material</td><td>30 000</td></tr>
<tr><td>Jarosite and other materials</td><td>238 000</td></tr>
<tr><td>Mn Cake</td><td>16 000</td></tr>
<tr><td>Product</td><td>300 000</td></tr>
</table></td></tr>
</table>

Activity	Emission Equation	Source	Information assumed/provided
Materials handling	$E = 0.0016 \frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$ Where, E = Emission factor (kg dust / t transferred) U = Mean wind speed (m/s) M = Material moisture content (%) The $PM_{2.5}$, PM_{10} and TSP fraction of the emission factor is 5.3%, 35% and 74% respectively.	US-EPA AP42 Section 13.2.4	An average wind speed of 4.6 m/s was used based on the modelled WRF data for the period 2016 to 2018. The throughput of the material was provided (see above).
Crushing and screening	Primary (for low moisture ore): $E_{TSP} = 0.2\ kg/t\ material\ processed$ $E_{PM10} = 0.02\ kg/t\ material\ processed$ $E_{PM2.5} = 0.0037\ kg/t\ material\ processed$ Fraction of $PM_{2.5}$ taken from US-EPA crushed stone emission factor ratio for tertiary crushing	NPI Section: Mining	*80% control efficiency was assumed for the mitigated scenario.*
Drilling	$E_{TSP} = 0.59\ kg\ of\ dust\ /drill\ hole$ PM_{10} is given as 52% of TSP emissions and $PM_{2.5}$ is assumed to be 3% of TSP emissions	NPI Section: Mining	148 drill holes per day was provided.
Blasting	$E_{TSP} = 0.00022\ x\ A^{1.5}$ Where, A = area blasted in m² PM_{10} is given as 52% of TSP emissions and $PM_{2.5}$ is assumed to be 3% of TSP emissions	NPI Section: Mining	A blast area was provided. *As blasting activities are intermittent and not a continuous operation, the emissions from this activity was quantified but not modelled.*
Wind Erosion	$E_{TSP} = 0.4\ kg/ha/hr$ $E_{PM10} = 0.2\ kg/ha/hr$ $E_{PM2.5} = 0.03\ kg/ha/hr$ Fraction of $PM_{2.5}$ taken from same ratio as PM_{10} to $PM_{2.5}$ for materials handling.	NPI Section: Mining	Layout of all storage piles were provided including the secured landfill facility to the west of the smelter. The Jarofix that will be disposed of on the secured landfill facility will have a moisture content of between 30% and 40% and is thus unlikely to result in any dust emissions during disposal. Additionally, it should solidify to a hard concrete-like substance thus also not adding to dust levels. The windblown dust levels, however, have been quantified from the secured landfill facility using the emission factors provided by the US-EPA. This should provide a conservative impact estimate from this source. Hourly emission rate file was calculated and simulated.

Table 4-5: Stack parameters and emission rates

Parameter	Normal Operations				Start up/ Upset conditions		Unit
	Acid Plant Stack	Casting Stack	Dross Treatment Stack	Zn Dust Plant Stack	Roaster Start Up Stack (40 hrs)	Acid Plant Stack (restart: 5-10min twice a year)	
Relevant MES Subcategory	Subcategory 4.16 Subcategory 7.4	Subcategory 4.14					
Height	70	30	20	20	30	70	m
Diameter	2.5	2	1	1	2	2.5	m
Velocity	20	7	5	5	10	20	m/s
Volumetric flow	98.2	22.0	3.9	3.9	31.4	98.2	m^3/s
	78.1	18.0	3.3	3.3	13.8	78.1	Nm^3/s
Temperature	70	60	50	50	350	70	°C
PM emissions	50	50	5	5	10	100	mg/Nm^3
	3.91	0.90	0.02	0.02	0.14	7.81	g/s
	123.21	28.43	0.52	0.52	0.02	0.01	tpa
Percentage of PM to total emissions through AP stack					0.02	0.01	%
SO_2 emissions	1200	500				52.352	mg/Nm^3
	93.77	9.01				4.09	g/s
	2 957.03	284.28				0.005	tpa
Percentage of SO_2 to total emissions through AP stack						0.0002	%
NO_2 emissions	350						mg/Nm^3
	27.35						g/s
	862.47						tpa
Dioxins and Furans		1.00E-07					mg/Nm^3
		1.80E-09					g/s
		5.69E-08					tpa
Zn emissions [(a)]	1.95	0.90	0.02	0.02			g/s
	61.60	28.43	0.52	0.52			tpa
Pb emissions [(a)]	0.20	0.90	0.02	0.02			g/s
	6.16	28.43	0.52	0.52			tpa

Notes:

(a) The Zn and Pb emissions are not defined in the minimum emission standards but were calculated based on fractions available for the concentrate (50% Zn content and 5% Pb content). These fractions were applied to the Acid Plant Stack. For the Casting Stack, Dross Treatment Stack and Zn Dust Plant Stack, the Zn and Pb content were conservatively assumed to be all particulate matter emissions.

Only routine stack activities were modelled for the current impact assessment.

4.2.2.2 *Synopsis of Particulate Emissions from Various Sources at the Project due to Proposed Project Operational Activities*

Particulate emissions calculated for various source types are given in Table 4-6. The baseline mining operations assumed 75% control efficiency on unpaved road surfaces and 80% control efficiency on crushing activities. Materials handling due to baseline mining operations represents the most significant source of particulate emissions (Figure 4-1).

Table 4-6: Particulate emissions due to routine baseline and project operations

ACTIVITY	Emissions (tpa)			% Contribution			Rank
	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP
Routine Operations: control efficiency of 75% applied to unpaved roads and 80% applied to crushing activities							
Vehicle entrainment (baseline)	846.50	241.29	24.13	5.48	3.36	1.99	2
Vehicle entrainment (project)	146.24	30.89	6.25	0.95	0.43	0.52	6
Materials handling (baseline)	13 465.99	6 369.05	964.46	87.18	88.82	79.73	1
Materials handling (project)	3.51	1.66	0.25	0.02	0.02	0.02	8
Crushing (baseline)	400.00	160.00	29.60	2.59	2.23	2.45	4
Wind erosion (baseline)	400.89	200.45	30.07	2.60	2.80	2.49	3
Wind erosion (project)	30.06	15.03	2.25	0.19	0.21	0.19	7
Stacks (project)	152.68	152.68	152.68	0.99	2.13	12.62	5
TOTAL	**15 445.87**	**7 171.05**	**1 209.69**	**100.00**	**100.00**	**100.00**	

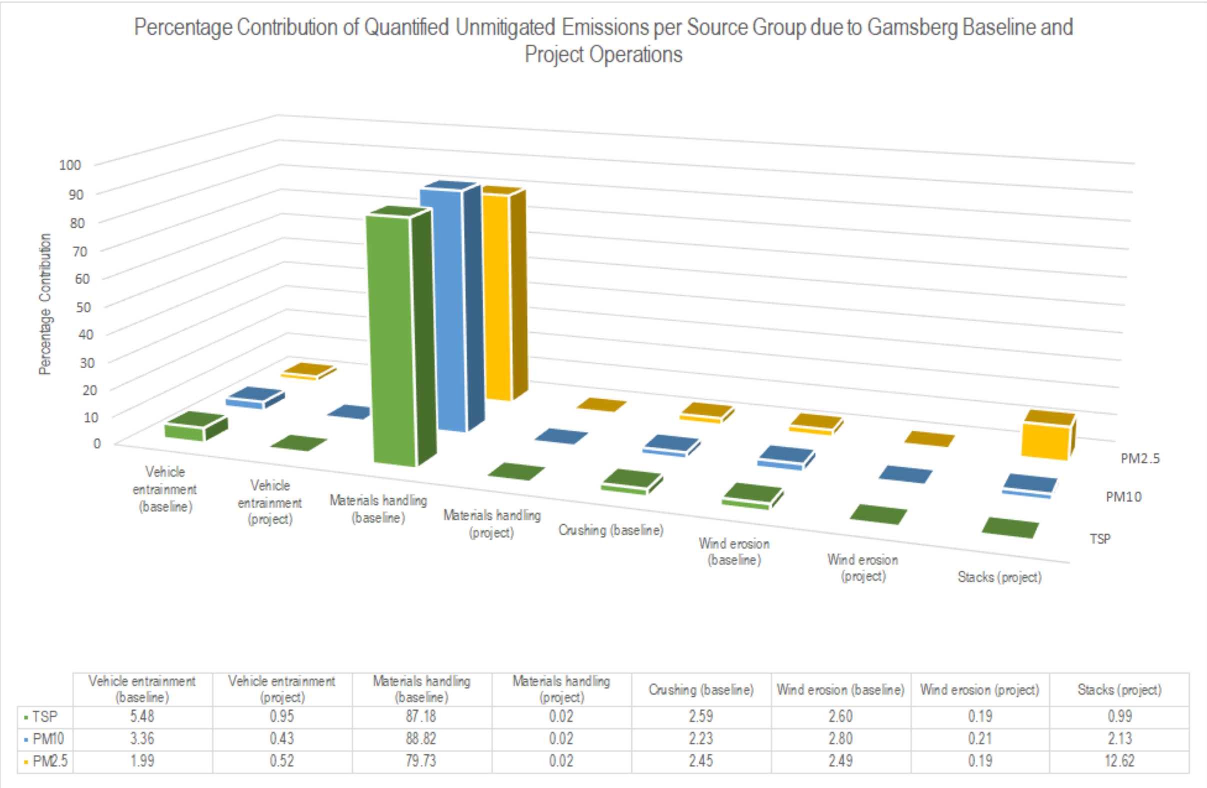

Figure 4-1: Percentage contribution of particulate emissions due to routine baseline and project operations

4.2.2.3 Dispersion Simulation Results and Compliance Assessment

Simulations were undertaken to determine particulate matter (PM_{10} and $PM_{2.5}$), NO_2, SO_2, Zn, Pb concentrations and total daily dust deposition from project activities. Two scenarios were simulated: (1) baseline mining operations (including Phase II), and (2) cumulative baseline and proposed project operations in order to understand the incremental increase in impacts due to the project. The difference between the modelling conducted in 2013 and the current assessment is listed in Appendix E.

For compliance, reference was made to NAAQS and NDCR. For non-criteria pollutants, impacts were screened against the most stringent health effect screening levels. The plots provided for the relevant pollutants of concern during the operational phase are given in Figure 4-7.

Table 4-7: Isopleth plots presented in the current section

Pollutant	Operations	Figure
$PM_{2.5}$	Baseline operations (mining operations only)	Figure 4-2
	Cumulative operations (mining and proposed project operations)	Figure 4-3
PM_{10}	Baseline operations (mining operations only)	Figure 4-4
	Cumulative operations (mining and proposed project operations)	Figure 4-5
TSP	Baseline operations (mining operations only)	Figure 4-6
	Cumulative operations (mining and proposed project operations)	Figure 4-7
	Project operations	Figure 4-8
SO_2	Project operations	Figure 4-9 to Figure 4-11
NO_2	Project operations	Figure 4-12 to Figure 4-13
Pb	Project operations	Figure 4-14
Zn	Project operations	Figure 4-15 to Figure 4-16

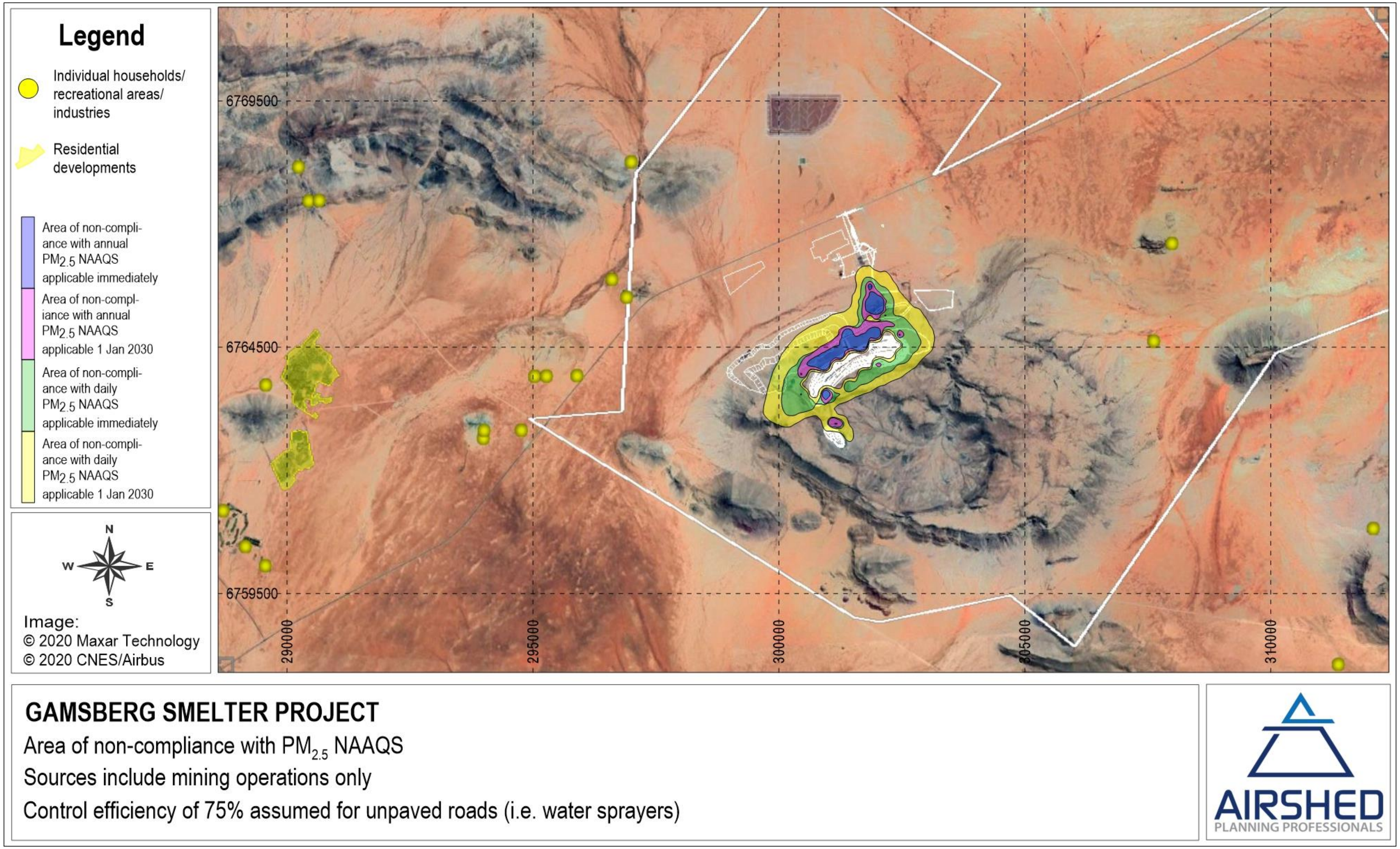

Figure 4-2: Area of non-compliance of $PM_{2.5}$ NAAQS due to baseline mining operations

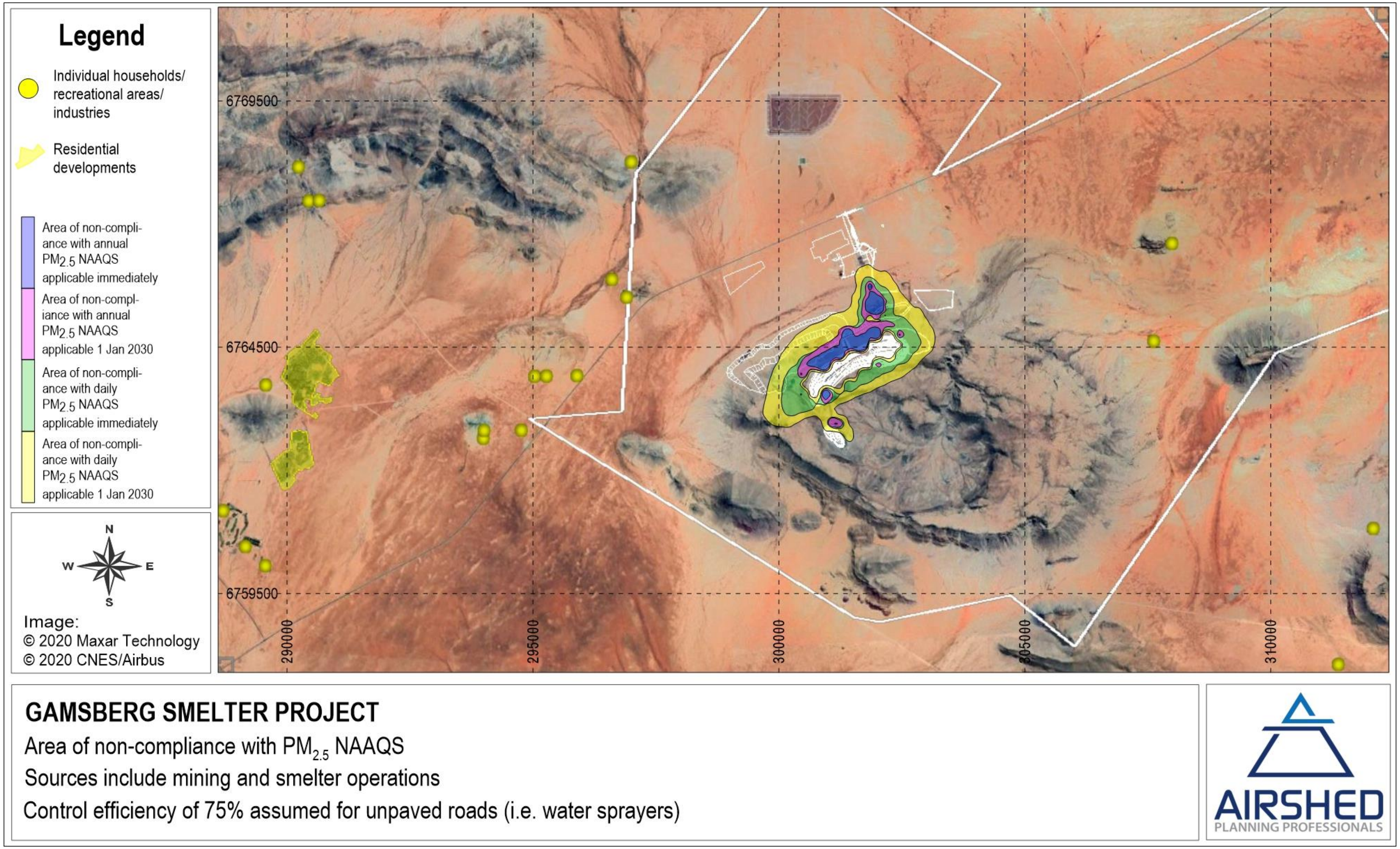

Figure 4-3: Area of non-compliance of $PM_{2.5}$ NAAQS due to baseline mining and proposed project operations

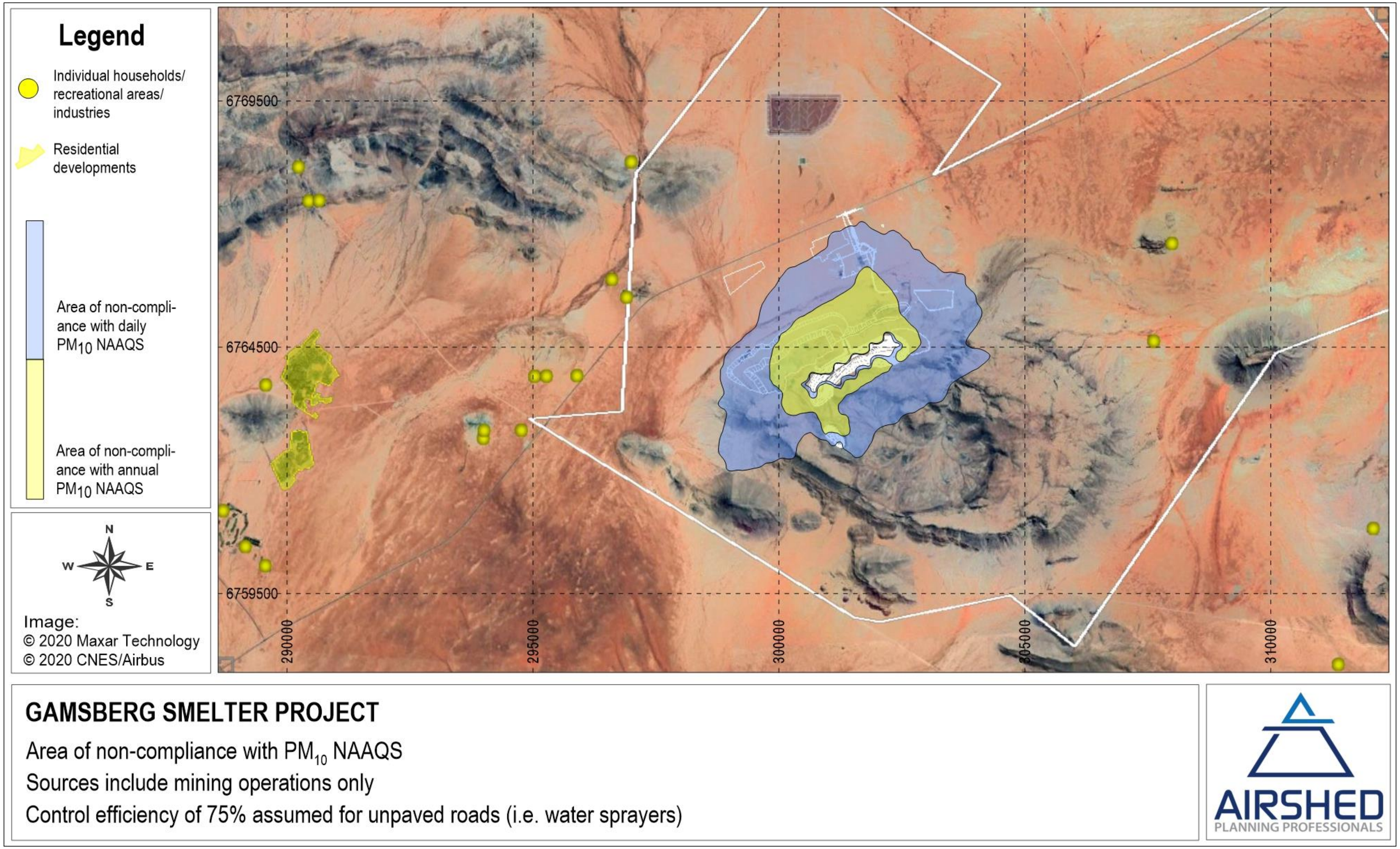

Figure 4-4: Area of non-compliance of PM_{10} NAAQS due to baseline mining operations

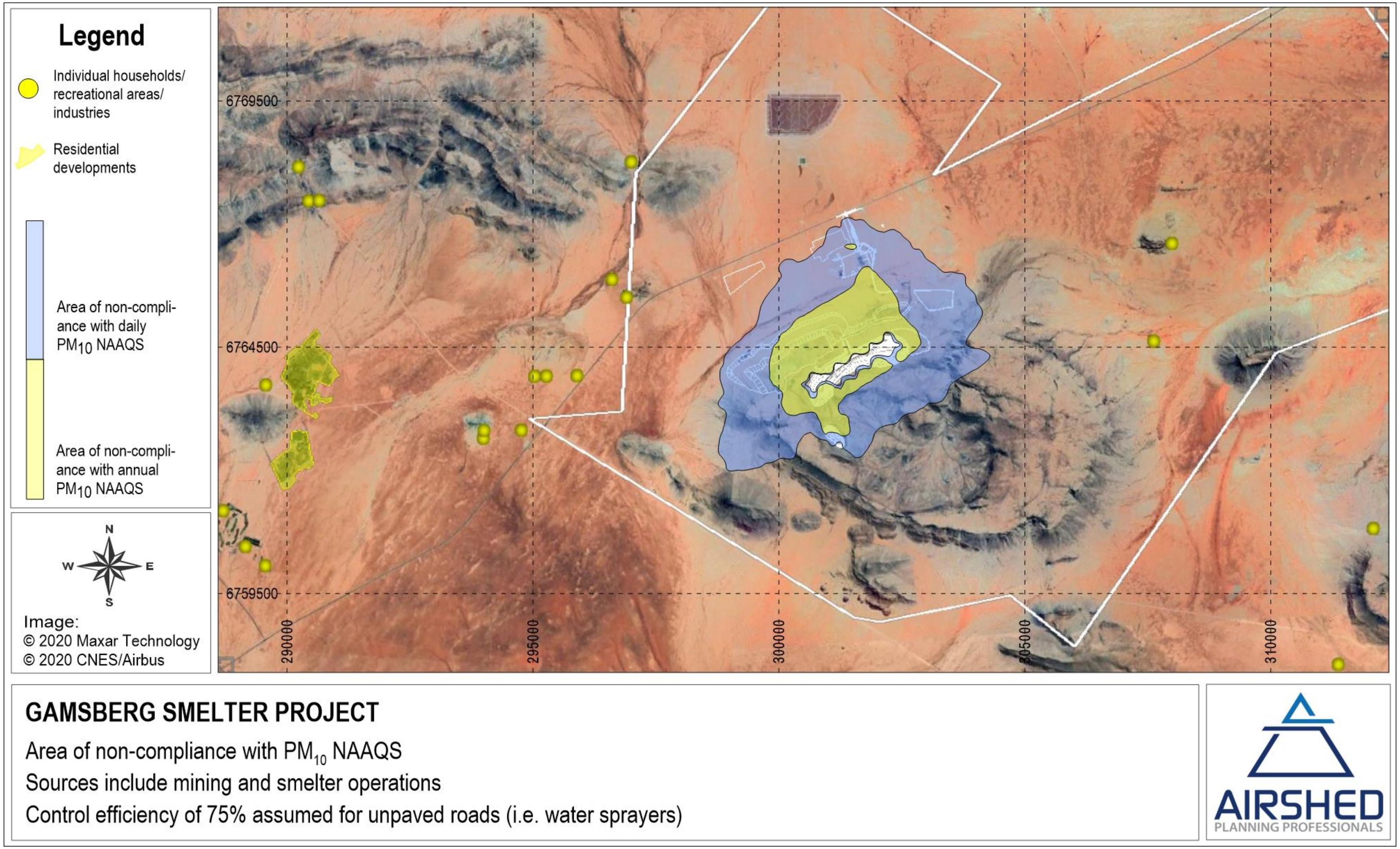

Figure 4-5: Area of non-compliance of PM_{10} NAAQS due to baseline mining and proposed project operations

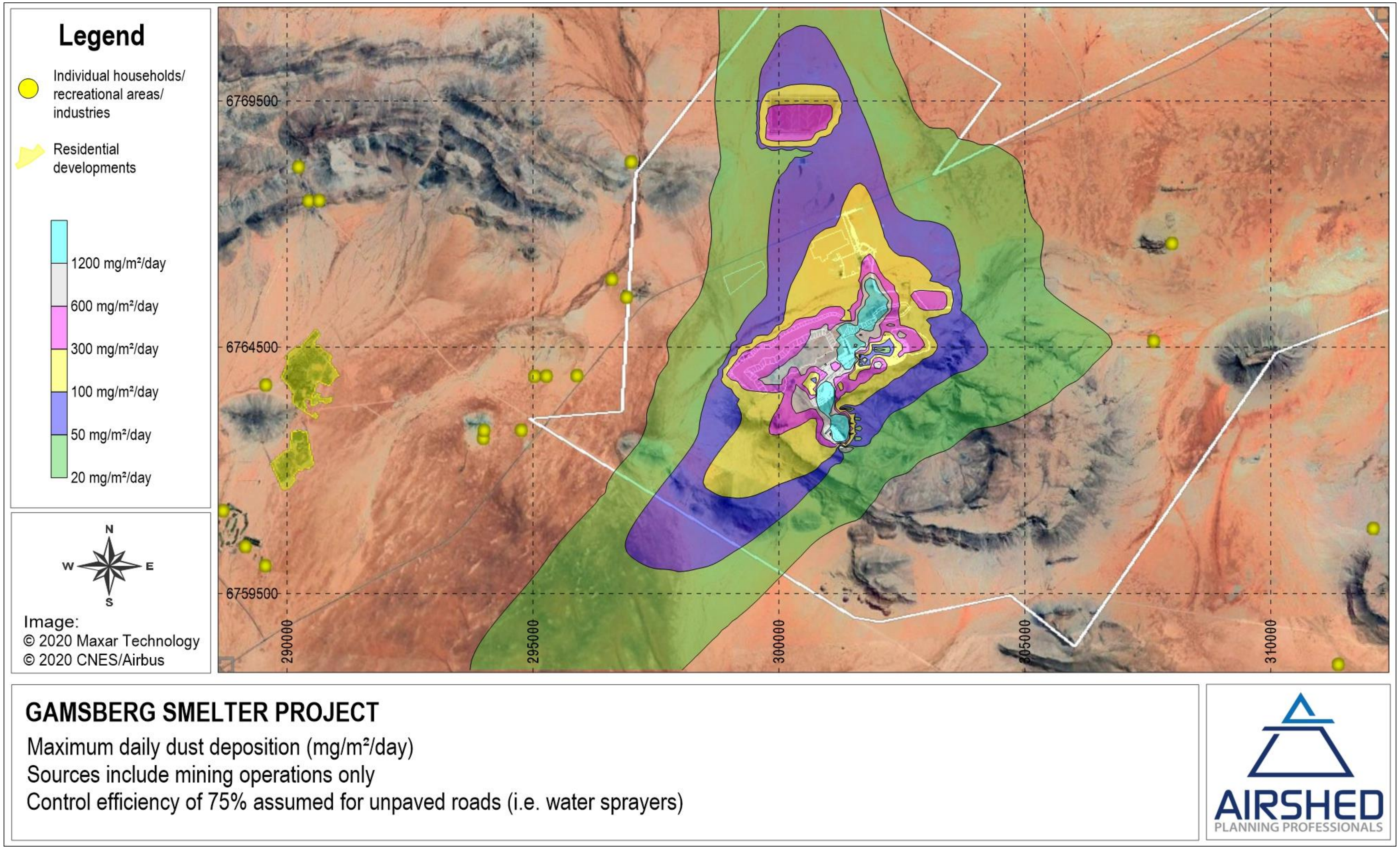

Figure 4-6: Total particulate deposition due to baseline mining operations

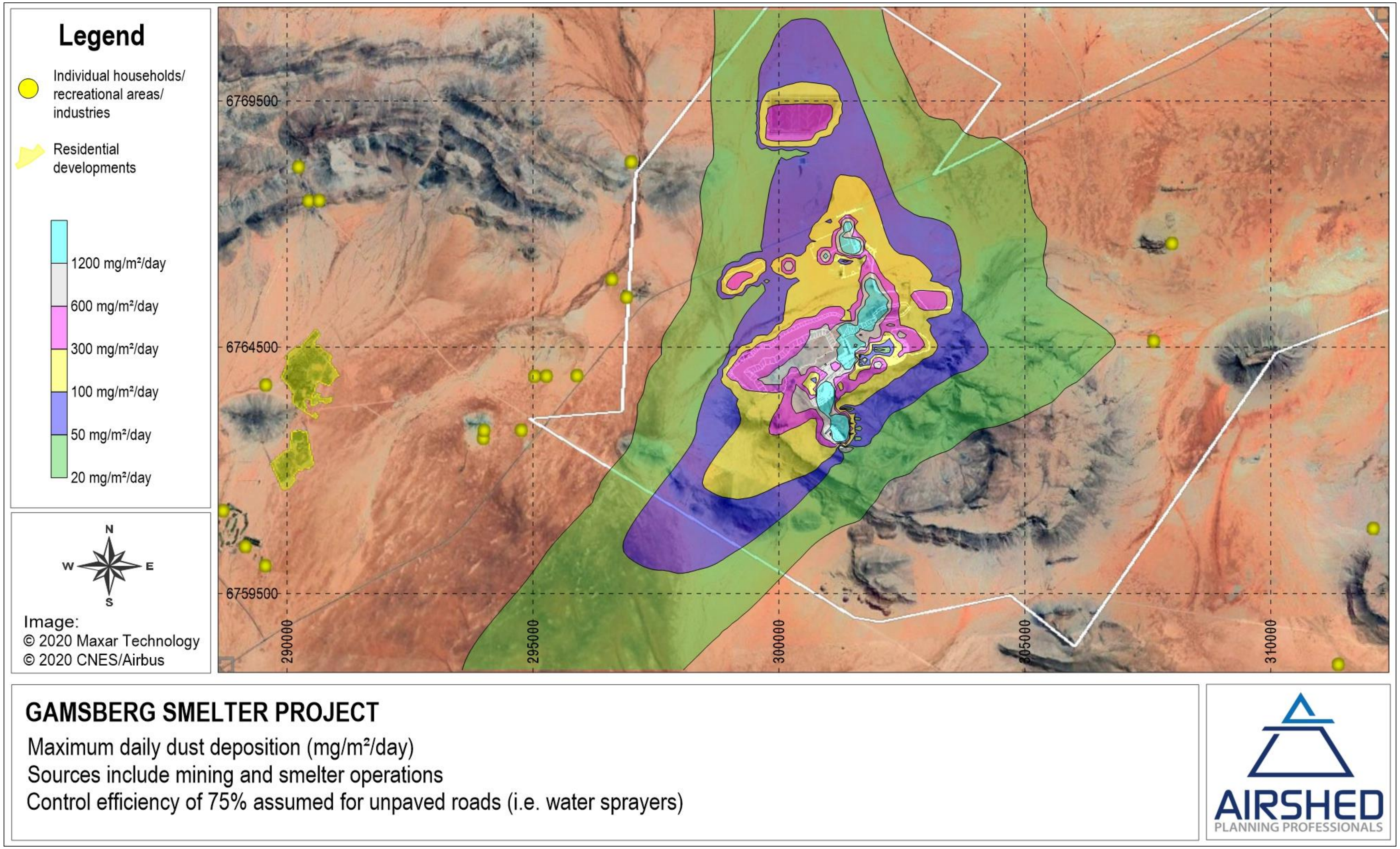

Figure 4-7: Total particulate deposition due to baseline mining and proposed project operations

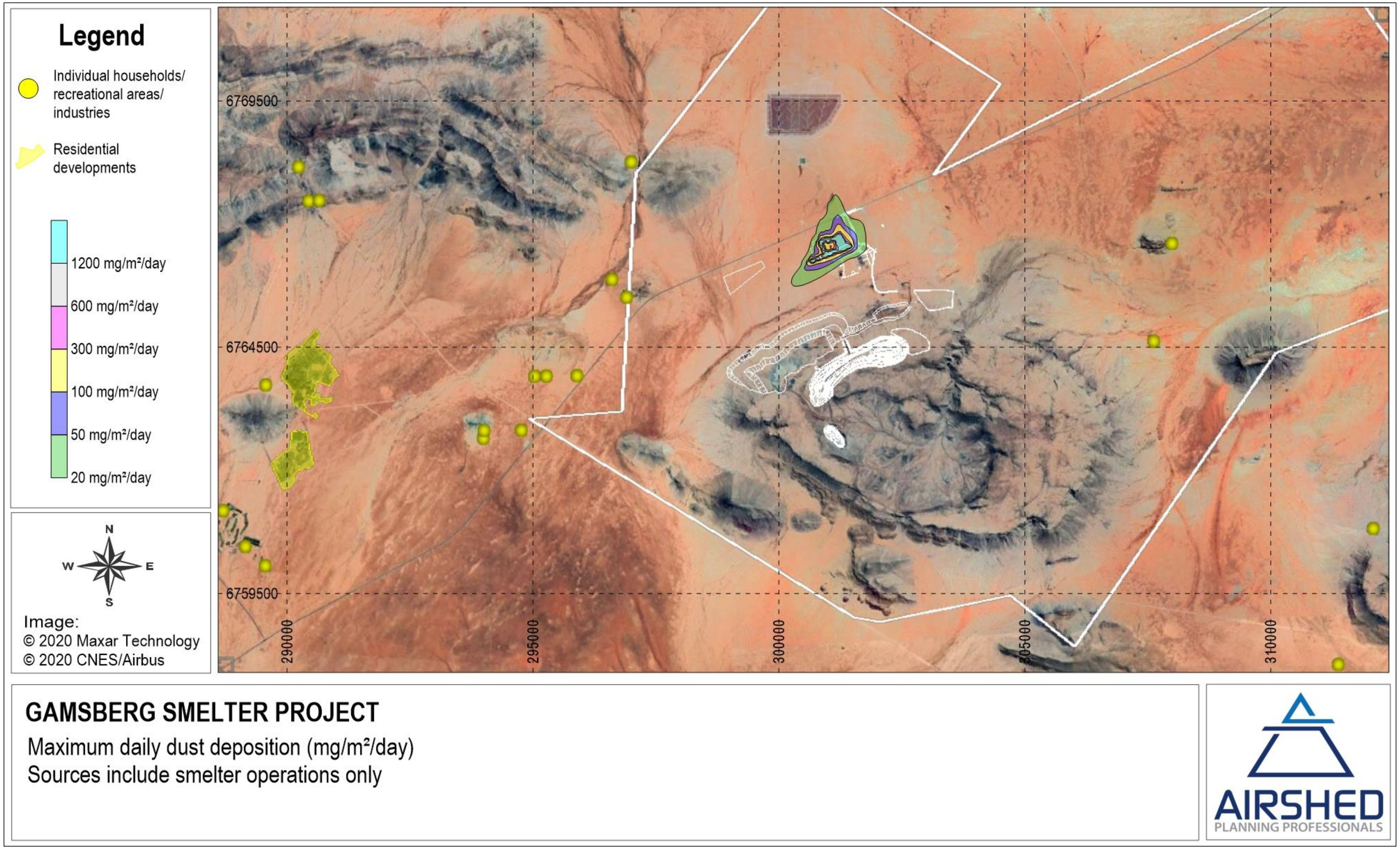

Figure 4-8: Total particulate deposition due to proposed project operations only

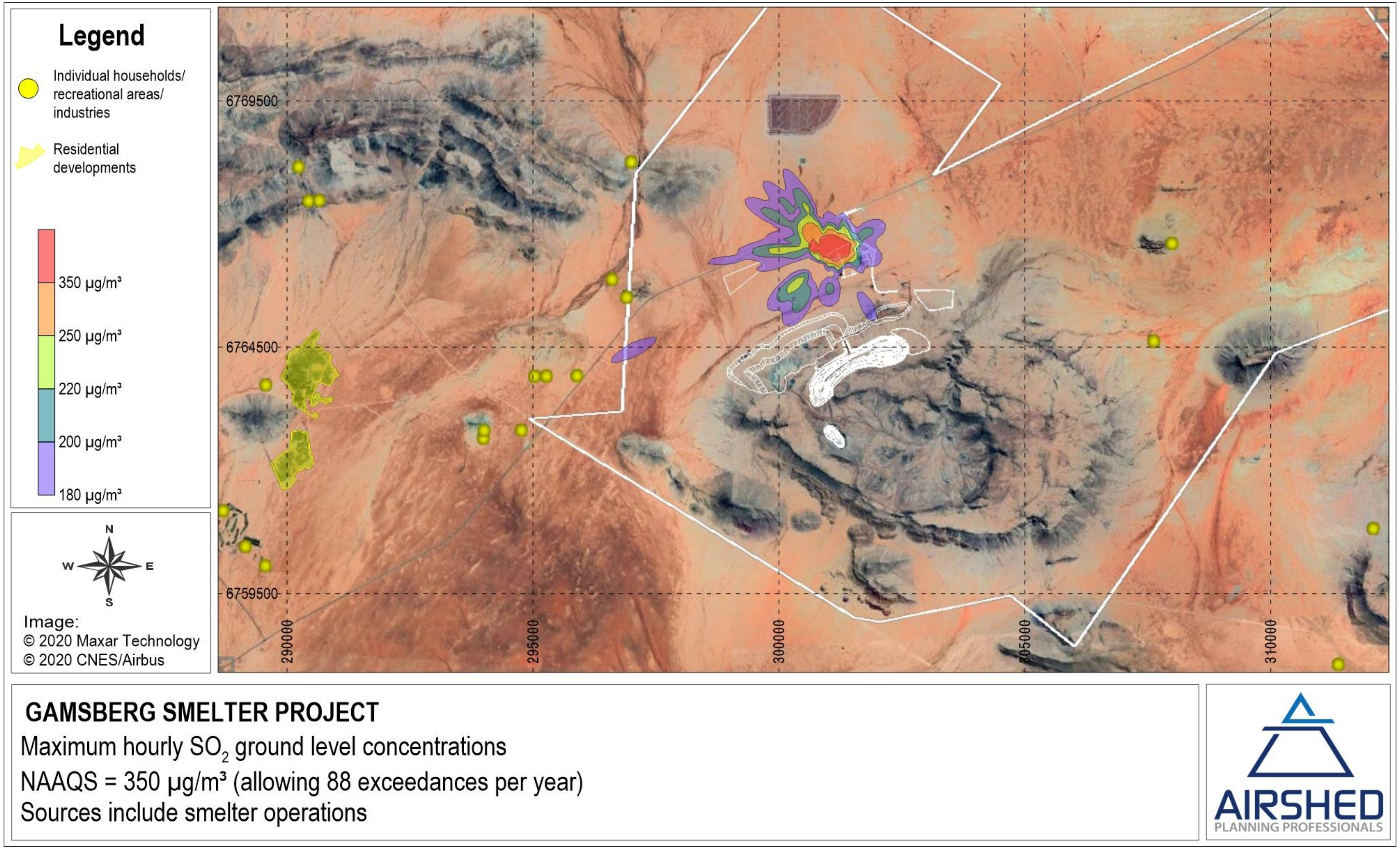

Figure 4-9: Highest hourly SO_2 ground level concentrations due to proposed project operations only

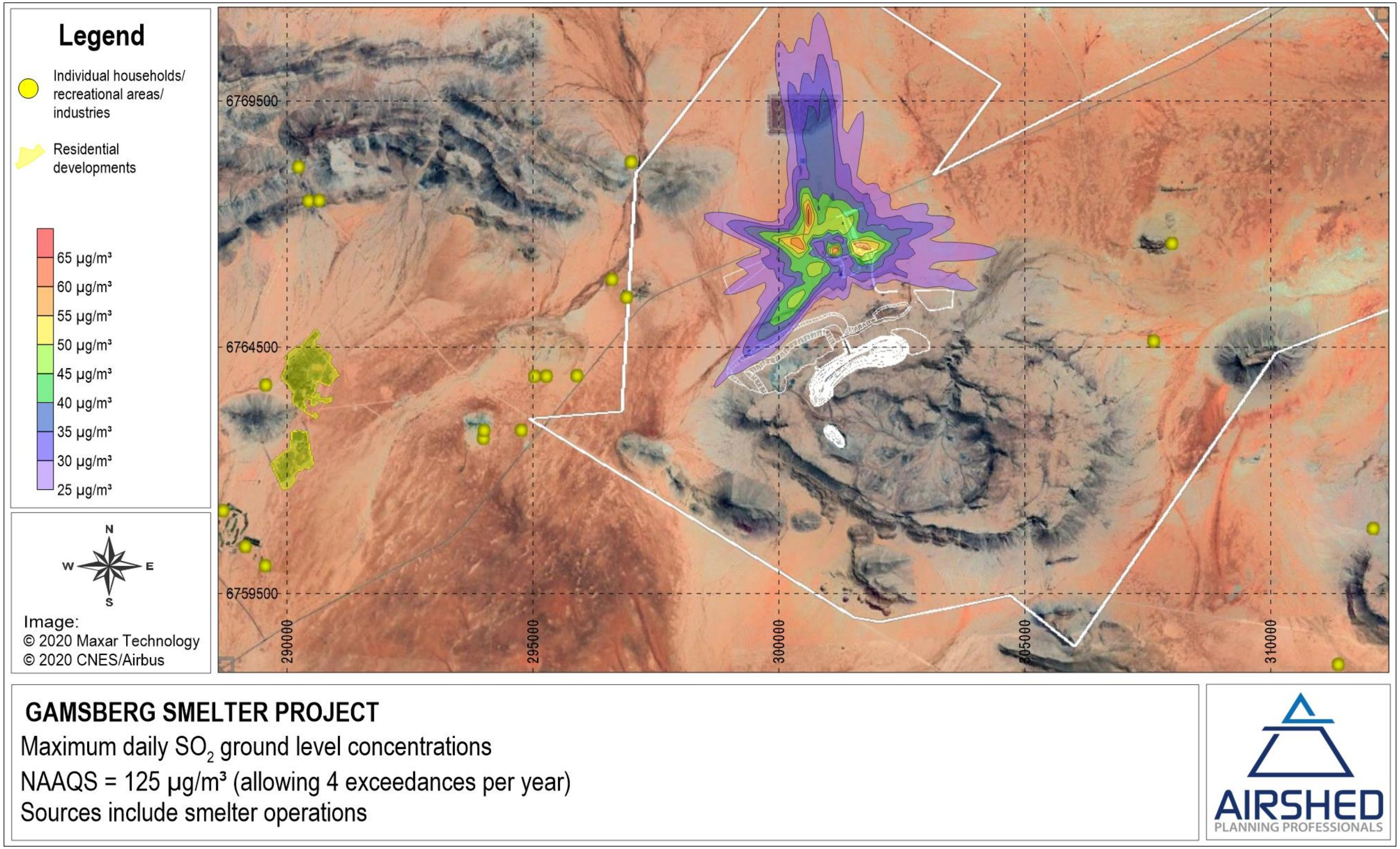

Figure 4-10: Highest daily SO_2 ground level concentrations due to proposed project operations only

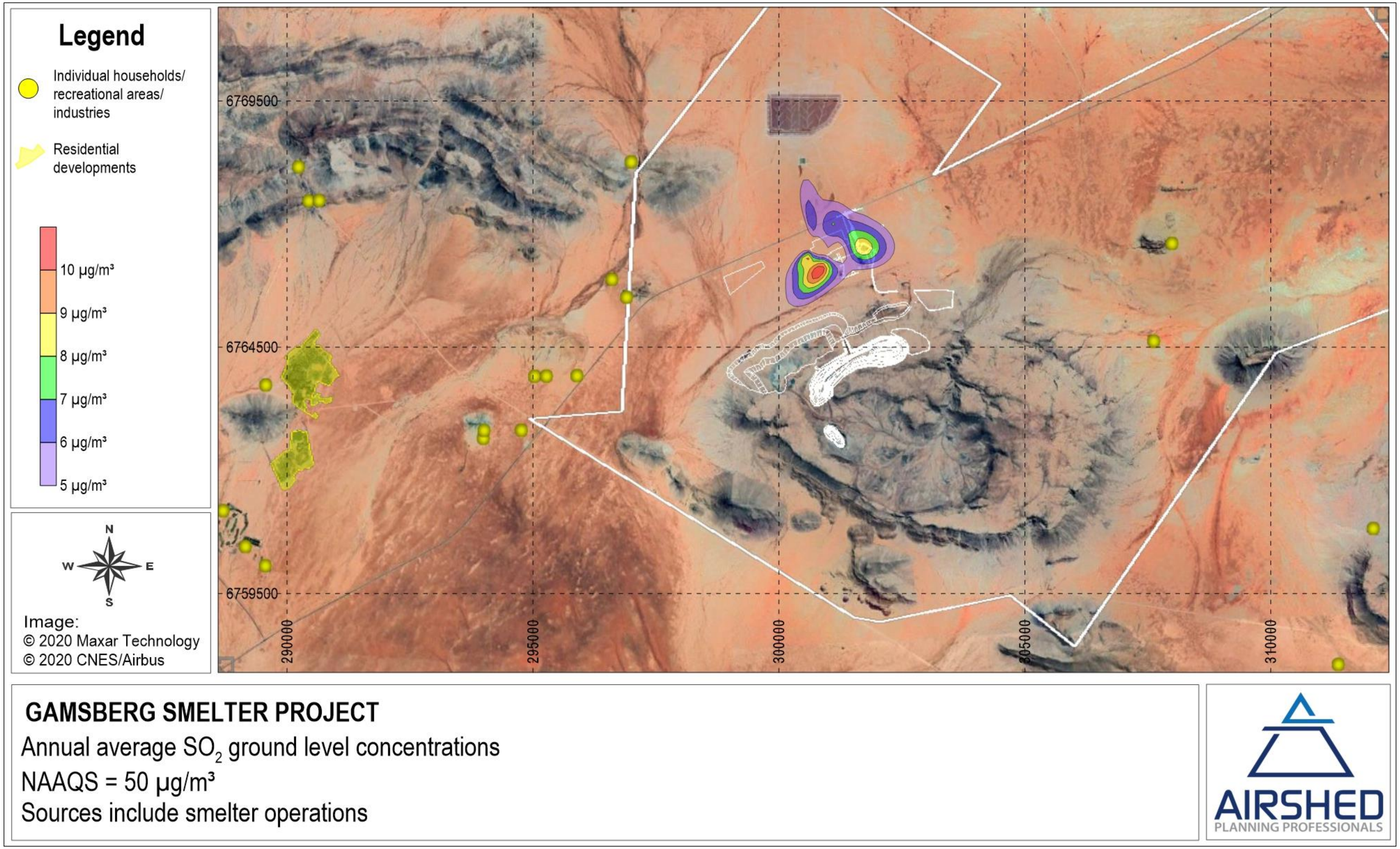

Figure 4-11: Annual average SO_2 ground level concentrations due to proposed project operations only

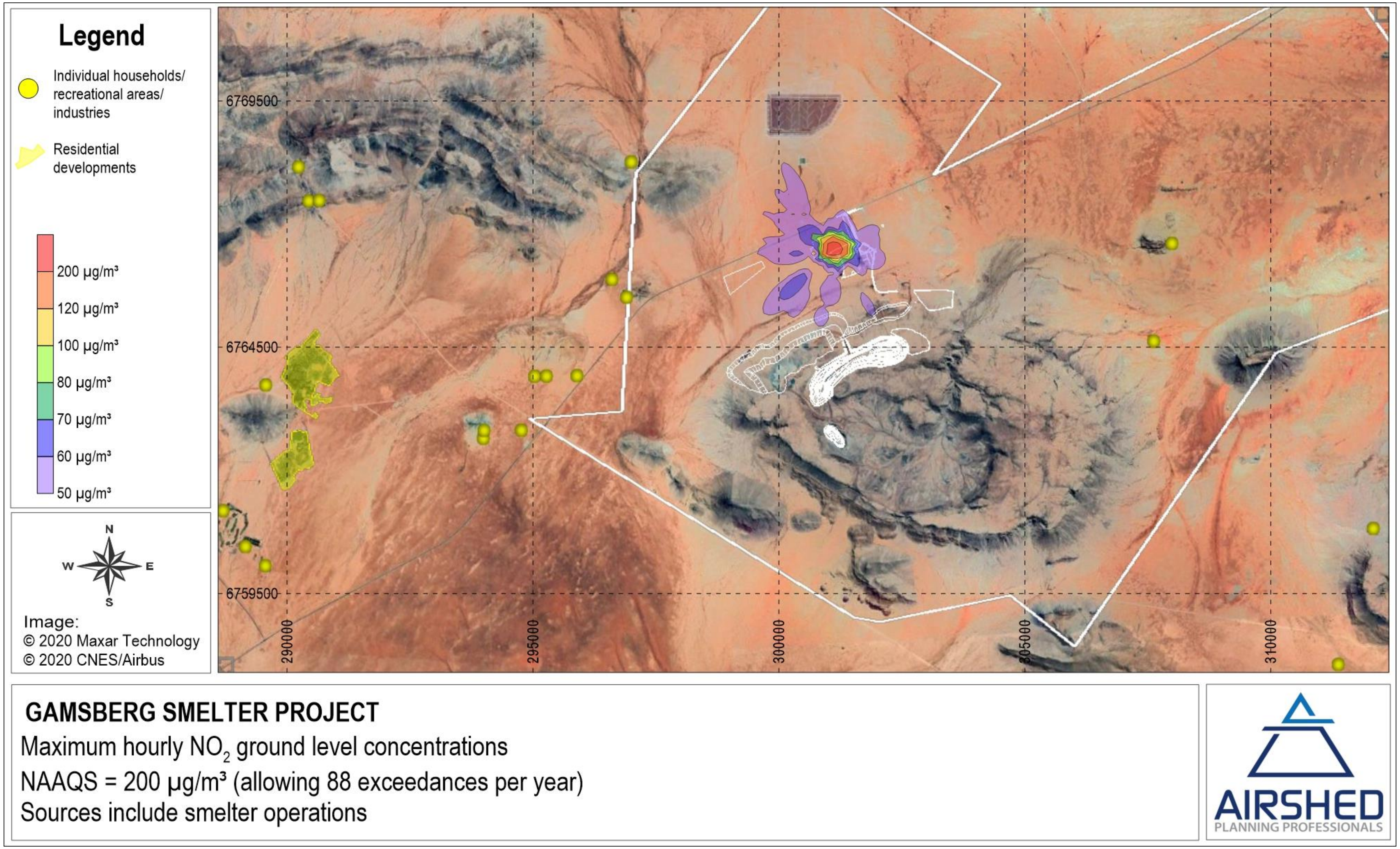

Figure 4-12: Highest hourly NO_2 ground level concentrations due to proposed project operations only

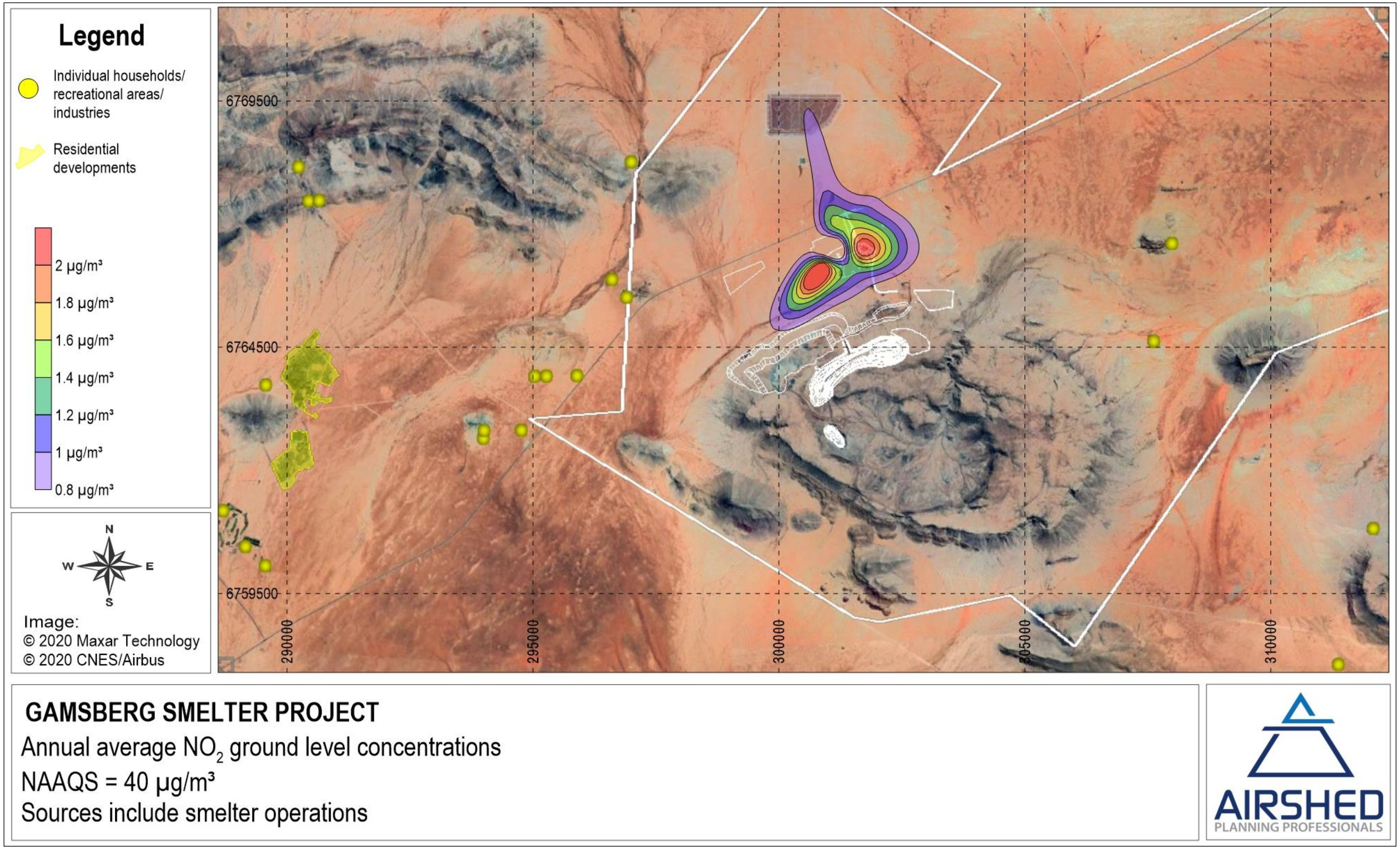

Figure 4-13: Annual average NO_2 ground level concentrations due to proposed project operations only

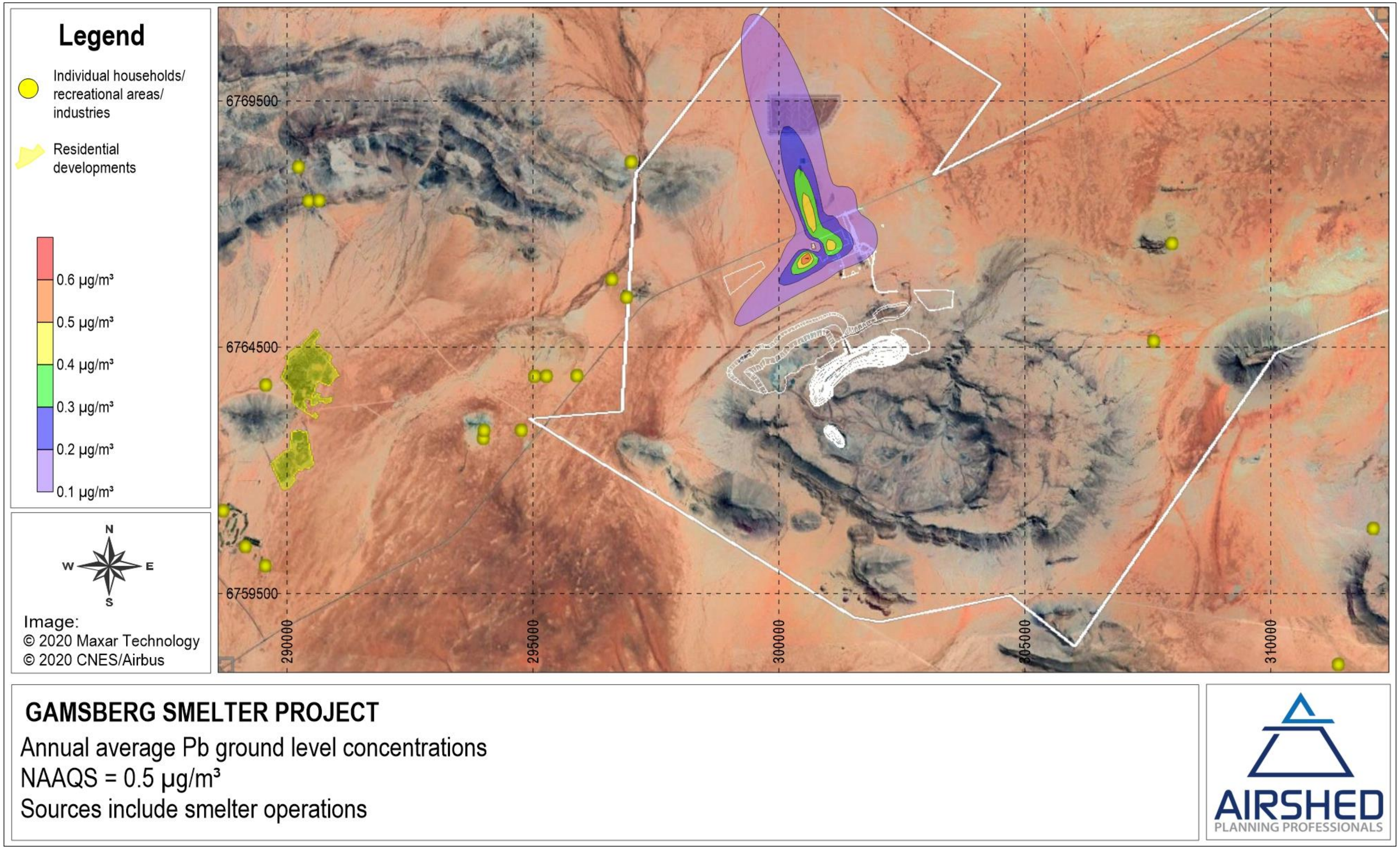

Figure 4-14: Annual average Pb ground level concentrations due to proposed project operations only

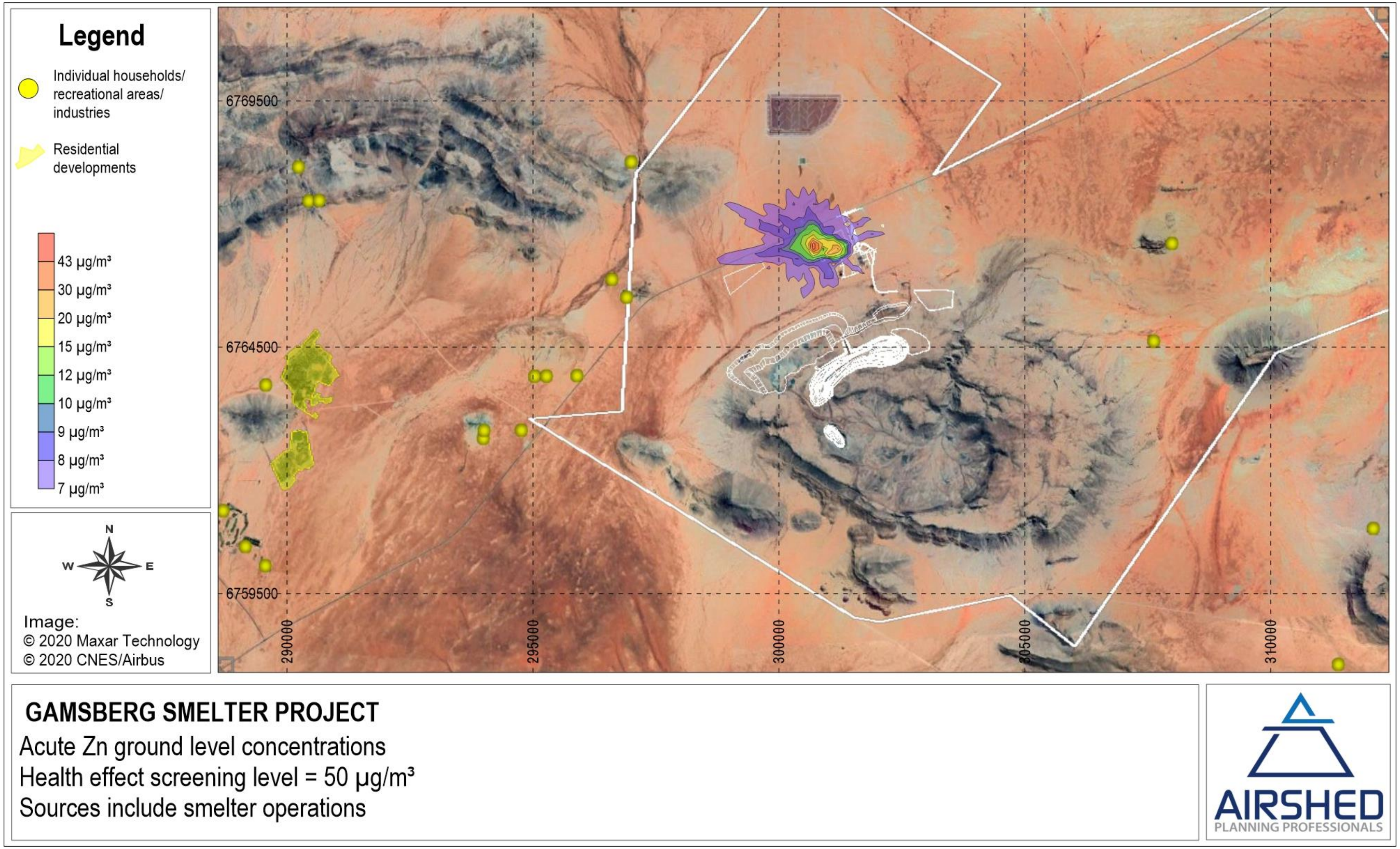

Figure 4-15: Acute Zn ground level concentrations due to proposed project operations only

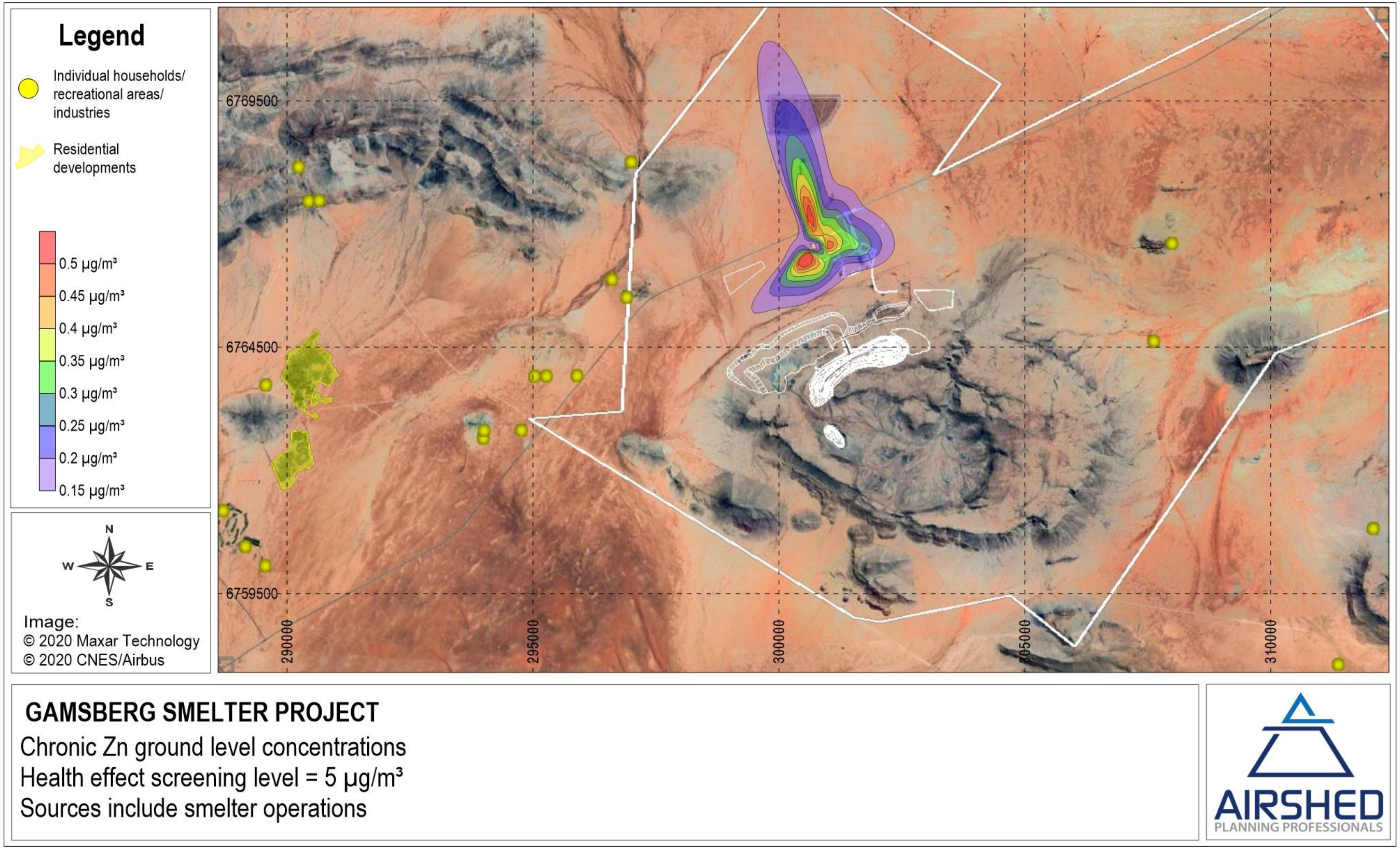

Figure 4-16: Chronic Zn ground level concentrations due to proposed project operations only

The incremental increase in simulated $PM_{2.5}$, PM_{10} concentrations and total dust deposition from baseline to proposed project operations is negligible.

The highest simulated $PM_{2.5}$ and PM_{10} concentrations due to baseline and project operations is in compliance with NAAQS at all human sensitive receptors within the study area for all averaging periods (Figure 4-2 to Figure 4-5).

Maximum daily dust deposition due to baseline and project operations are within the NDCR for residential areas at all sensitive offsite human receptors within the study area (Figure 4-6 to Figure 4-7).

Simulated Pb, NO_2 and SO_2 impacts due to project activities, are within the NAAQS at all offsite human sensitive receptors within the study area for all averaging periods (Figure 4-9 to Figure 4-14).

The screening of non-criteria pollutants against health effect screening levels due to project activities is provided in Table 4-8. The maximum simulated acute and chronic Zn ground level concentrations are below the most stringent health effect screening levels (Figure 4-15 to Figure 4-16).

Table 4-8: Screening of non-criteria pollutants against health risk guidelines

Metallic element	Acute exposure[a] [units: µg/m³]		Chronic exposure[b] [units: µg/m³]	
	Maximum concentration[c]	Strictest health effect screening level	Maximum concentration[c]	Strictest health effect screening level
Zn	43	50 [d]	0.7	5 [d]

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

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

(c) Maximum concentration simulated across the domain

(d) Effect screening levels published by the Texas Natural Resource Conservation Commission Toxicology and Risk Assessment Division (TARA)

The maximum annual ground level concentrations for dioxins due to the project is 1.2 E-09 µg/m³. Based on the unit risk factor available for dioxins ((33 µg/m³)$^{-1}$), the maximum potential cancer risk is 4 in 100 million. According to the qualitative description provided by the New York Department of Health (Section 2.7), the cancer risk due to project operations is "very low".

4.2.2.4 Predicted Impacts on Vegetation

No national ambient air quality standards or guidelines are available for the protection of vegetation. The simulated ground level concentrations for SO_2 and NO_2 and depositions for PM, Pb and Zn were provided to the biodiversity specialists in order to understand the potential area of impact on sensitive vegetation due to the proposed project and current mining activities. The plots for SO_2 and NO_2 concentrations and PM deposition is provided in Section 4.2.2.3. The plots for Pb and Zn deposition levels provided for the biodiversity assessment are included in Appendix D.

4.2.3 Mitigation Measures Recommended

The mitigation measures provided in the current section is based on the proposed project operations only and does not include the mitigation measures already detailed in the approved EMP for the current mining activities.

For the stacks, best available technology should be implemented in order to minimise the emissions from these sources. As part of the Atmospheric Emissions Licence, for sources that trigger MES, mitigation measures need to be selected in order to meet the stipulated emission limits.

For the road surface from the Smelter to the Jarosite dump, mitigation (such as sweeping) should be implemented to minimise the vehicle entrainment from this surface.

In the assessment, proposed project activities were simulated assuming 75% control efficiency for vehicle entrainment.

4.3 Decommissioning and Closure Phase

4.3.1 Identification of Environmental Aspects

It is assumed that all the operations will have ceased by the closure phase of the project. Aspects and activities associated with the decommissioning phase of the proposed operations are listed in Table 4-9.

The same mitigation measures for the construction phase can be implemented for the decommissioning phase. Simulations of the decommissioning and closure phases were not included in the current study due to its temporary impacting nature.

Table 4-9: Activities and aspects identified for the decommissioning phase

Impact	Source	Activity
Generation of $PM_{2.5}$ and PM_{10}	Open surfaces	Dust generated during rehabilitation activities
Generation of $PM_{2.5}$ and PM_{10}	Offices and buildings	Demolition of the structure
Gas emissions	Vehicles	Tailpipe emissions from vehicles utilised during the closure phase

5 SIGNIFICANCE RANKING

The significance of the potential air quality impacts due to the project activities was assessed according to the methodology adopted by SLR Consulting Africa (Pty) Ltd refer to Appendix C of this report for the methodology.

The significance of the air quality impacts due to project activities were found to be low (Table 5-1). Assuming the adoption of good engineering practice and mitigation measures as recommended, the significance of project air quality impacts may be reduced to very low (Table 5-1). The impacts due to construction and closure phases of the project were found to be very low.

Table 5-1: Significance rating for air quality impacts due to project activities

Project Activity	Impacts		Probability	Consequence				Significance Rating
Phase	Description	Impacts	Probability	Intensity	Duration	Extent	Conse-quence	Significance Rating
Construction	PM impacts due to vehicle entrainment, materials handling, windblown dust from open areas. Tailpipe emissions due to vehicle activity.	Air quality impacts on off-site human receptors	Without Mitigation					
			M	L	L	M	L	Very Low
			With Mitigation					
			L	L	L	L	L	Very Low
Project activities	Resulting Impact from Project Activities only (including vehicle entrainment, materials handling and stack emissions).		Without Mitigation					
			L	L	H	M	M	Low
			With Mitigation					
			L	VL	H	L	L	Very Low
Closure	PM impacts due to demolition, vehicle entrainment, materials handling, windblown dust from open areas. Tailpipe emissions due to vehicle activity.		Without Mitigation					
			M	L	L	M	L	Very Low
			With Mitigation					
			L	L	L	L	L	Very Low

6 FINDINGS AND RECOMMENDATIONS

6.1 Findings

An air quality impact assessment was conducted for the project operations. The main objective of this study was to determine the significance of the predicted impacts from the project operations on the surrounding environment and on human health. Emission rates were quantified for the project activities and dispersion modelling executed.

The main findings from the baseline assessment, which are the main parameters informing the baseline conditions, were as follows:

- The main sources likely to contribute to cumulative particulate impact are the mining operations at Gamsberg (including Phase II).
- The area is dominated by winds from the south.
- The closest residential development to the proposed project is Aggeneys (~10 km west-southwest) of the site. The closest individual homestead to the proposed project is ~3.7 km west-southwest.
- Measured ambient daily PM_{10} ground level concentrations in the study area during 2018, ranged between 7.4 µg/m³ to 39 µg/m³ (99th percentile). This is below the NAAQS of 75 µg/m³.
- Measured ambient hourly NO_2 (maximum concentration of 0.4 µg/m³) and daily SO_2 (maximum concentration of 6.8 µg/m³) ground level concentrations in the vicinity of the project, during a 2009 survey, were well below the NAAQS of 200 µg/m³ (hourly NO_2) and 125 µg/m³ (daily SO_2).
- Dustfall rates were below non-residential NDCR at all sampling sites during the period period January 2018 to April 2019.

The simulated findings due to Gamsberg mining operations (including Phase II) were as follows:

- The $PM_{2.5}$ and PM_{10} ground level concentrations at off-site sensitive receptors were within NAAQS for all averaging periods.
- Simulated daily dust deposition, as a result of the current mining operations were found to be in compliance with NDCR for residential areas at all identified sensitive receptors within the study area.

The main findings from the impact assessment due to the proposed project operations were as follows:

- The simulated $PM_{2.5}$ and PM_{10} impacts due to baseline and project operations (PM_{10} and $PM_{2.5}$ NAAQS extends for an area of 17 322 528 m² and 2 557 345 m² respectively) are similar to impacts due to baseline operations only (PM_{10} and $PM_{2.5}$ NAAQS extends for an area of 17 035 090 m² and 2 533 821 m² respectively) and are well below NAAQS at sensitive receptors within the study area.
- The highest simulated Pb, NO_2 and SO_2 concentrations due to project operations were in compliance with NAAQS at all sensitive receptors within the study area only (Pb, NO_2 and SO_2 NAAQS extends for an area of 852 m² , 71 590 m² and 298 235 m² respectively).
- Maximum daily dust deposition due to project operations were well within the NDCR at all sensitive receptors within the study area and is similar in magnitude to baseline levels.

- The simulated zinc ground level concentrations were below the most stringent health effect screening levels at all identified sensitive receptors.
- The potential cancer risk due to dioxins and furans is “very low”.

6.2 Recommendations

It is of the author’s opinion that the project be authorised provided that the following recommendations are followed:

- Due to the sensitivity of the vegetation in the area, it is recommended that mitigation measures as recommended in Section 4.2.3 be implemented.
- Baseline monitoring should be undertaken for a minimum of 24 months prior to commissioning of the smelter to collect ambient air quality data. The ambient monitoring should as a minimum include daily concentrations of PM_{10}, $PM_{2.5}$ and monthly dust deposition. The ambient monitoring of hourly SO_2 and NO_2 concentrations as well as the metal analysis of the particulate matter would also provide value to the understanding of impacts on the vegetation. The ambient monitoring is recommended to continue once the smelter is operational in order to understand the impacts of the smelter on the vegetation.
- Emission monitoring should be undertaken according to the Air Emissions Licence.

7 REFERENCES

APCD. (1995). *Colorado State Implementation Plan for Particulate Matter (PM10) - Denver Metropolitan Nonattainment Area Element.* Regional Air Quality Council and Colorado Department of Health, Air Pollution Control Division.

Carslaw, D. (2014). *The openair manual - open-source tools for analysing air pollution data.* King's College London.

Carslaw, D., & Ropkins, K. (2012). *openair - an R package for air quality data analysis.* Environmental Modelling and Software, 27-28, 52 - 61.

CERC. (2004). *ADMS Urban Training. Version 2. Unit A.*

Cowherd, C., Muleski, G., & Kinsey, J. (1988). *Control of Open Fugitive Dust Sources.* North Carolina: US Environmental Protection Agency.

DEFF. (2004). *The National Environmental Management: Air Quality Act (Act No. 39 of 2004), Standards and Regulations.* The Department of Environmental Affairs, Republic of South Africa.

DEFF. (2009, Dec 24). *National Ambient Air Quality Standards.* Department of Environmental Affairs, Government Gazette No. 32816, 24 December 2009.

DEFF. (2011, August 5). National dust control regulations. *Gazette No. 34493*.

DEFF. (2012, June 29). *National Ambient Air Quality Standard for Particulate Matter with Aerodynamic Diameter less than 2.5 micron metres (PM2.5).* Department of Environmental Affairs, Government Gazette No. 35463, 29 June 2012.

DEFF. (2014). *Regulations regarding Air Dispersion Modelling.* Department of Environmental Affairs, Government Gazette No. 37804, 11 July 2014.

Goldreich, Y., & Tyson, P. (1988). Diurnal and Inter-Diurnal Variations in Large-Scale Atmospheric Turbulence over Southern Africa. *South African Geographical Journal*, 48-56.

Hanna, S. R., Egan, B. A., Purdum, J., & Wagler, J. (1999). *Evaluation of ISC3, AERMOD, and ADMS Dispersion Models with Observations from Five Field Sites.*

IFC. (2007). *General Environmental, Health and Safety Guidelines.* World Bank Group.

MFE. (2001). *Good Practice Guide for assessing and managing the environmental effects of dust emissions.* New Zeeland Ministry for the Environment.

NPI. (2011). *Emission Estimation Technique Manual for Mining. Version 3.* Australian Government Department of Sustainability, Environment, Water, Population and Communities.

SRK Consulting. (2010). *Gamsberg Zinc Project Preliminary Climate and Air Quality Baseline Report.*

Tiwary, A., & Colls, J. (2010). *Air Pollution: Measurement, Modelling and Mitigation.*

U.S. Department of the Interior, U.S. Geological Survey. (2016, October 24). *Digital Elevation: SRTM 1 Arc-Second Global*. Retrieved from EarthExplorer: http://earthexplorer.usgs.gov

US EPA. (1995). *AP 42, 5th Edition, Volume I, Chapter 13: Miscellaneous Sources, 13.2.3 Heavy Construction Operations.* Retrieved from Technology Transfer Network .

APPENDIX A - COMPREHENSIVE CURRICULUM VITAE OF THE AUTHOUR OF THE CURRENT ASSESSMENT

CURRICULUM VITAE	RENÉ VON GRUENEWALDT

FULL CURRICULUM VITAE

Name of Firm	Airshed Planning Professionals (Pty) Ltd
Name of Staff	René von Gruenewaldt (*nee* Thomas)
Profession	Air Quality Scientist
Date of Birth	13 May 1978
Years with Firm	More than 15 years
Nationalities	South African

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP)
- Member of the National Association for Clean Air (NACA)

KEY QUALIFICATIONS

René von Gruenewaldt (Air Quality Scientist): René joined Airshed Planning Professionals (Pty) Ltd (previously known as Environmental Management Services cc) in 2002. She has, as a Specialist, attained over fifteen (15) years of experience in the Earth and Natural Sciences sector in the field of Air Quality and six (6) years of experience in the field of noise assessments. As an environmental practitioner, she has provided solutions to both large-scale and smaller projects within the mining, minerals, and process industries.

She has developed technical and specialist skills in various modelling packages including the AMS/EPA Regulatory Models (AERMOD and AERMET), UK Gaussian plume model (ADMS), EPA Regulatory puff based model (CALPUFF and CALMET), puff based HAWK model and line based models. Her experience with emission models includes Tanks 4.0 (for the quantification of tank emissions), WATER9 (for the quantification of waste water treatment works) and GasSim (for the quantification of landfill emissions). Noise propagation modelling proficiency includes CONCAWE, South African National Standards (SANS 10210) for calculating and predicting road traffic noise and CadnaA.

Having worked on projects throughout Africa (i.e. South Africa, Mozambique, Malawi, Kenya, Angola, Democratic Republic of Congo, Namibia, Madagascar and Egypt) René has developed a broad experience base. She has a good understanding of the laws and regulations associated with ambient air quality and emission limits in South Africa and various other African countries, as well as the World Bank Guidelines, European Community Limits and World Health Organisation.

RELEVANT EXPERIENCE

Mining and Ore Handling

René has undertaken numerous air quality impact assessments and management plans for coal, platinum, uranium, copper, cobalt, chromium, fluorspar, bauxite, manganese and mineral sands mines. These include: compilation of emissions databases for Landau and New Vaal coal collieries (SA), impact assessments and management plans for numerous mines over Mpumalanga (viz. Schoonoord, Belfast, Goedgevonden, Mbila, Evander South, Driefontein, Hartogshoop, Belfast, New Largo, Geluk, etc.), Mmamabula Coal Colliery (Botswana), Moatize Coal Colliery (Mozambique), Revuboe Coal Colliery (Mozambique), Toliera Sands Heavy Minerals Mine and Processing (Madagascar), Corridor Sands Heavy Minerals Mine monitoring assessment, El Burullus Heavy Minerals Mine and processing (Egypt), Namakwa Sands Heavy Minerals Mine (SA), Tenke Copper Mine and Processing Plant (DRC), Rössing Uranium (Namibia), Lonmin platinum mines including operations at Marikana, Baobab, Dwaalkop and Doornvlei (SA), Impala Platinum (SA), Pilannesburg Platinum (SA), Aquarius Platinum, Hoogland Platinum Mine (SA), Tamboti PGM Mine (SA), Sari Gunay Gold Mine (Iran), chrome mines in the Steelpoort Valley (SA), Mecklenburg Chrome Mine (SA), Naboom Chrome Mine (SA), Kinsenda Copper Mine (DRC), Kassinga Mine (Angola) and Nokeng Flourspar Mine (SA), etc.

Mining monitoring reviews have also been undertaken for Optimum Colliery's operations near Hendrina Power Station and Impunzi Coal Colliery with a detailed management plan undertaken for Morupule (Botswana) and Glencor (previously known as Xstrata Coal South Africa).

Air quality assessments have also been undertaken for mechanical appliances including the Durban Coal Terminal and Nacala Port (Mozambique) as well as rail transport assessments including BHP-Billiton Bauxite transport (Suriname), Nacala Rail Corridor (Mozambique and Malawi), Kusile Rail (SA) and WCL Rail (Liberia).

Metal Recovery

Air quality impact assessments have been carried out for Highveld Steel, Scaw Metals, Lonmin's Marikana Smelter operations, Saldanha Steel, Tata Steel, Afro Asia Steel and Exxaro's Manganese Pilot Plant Smelter (Pretoria).

Chemical Industry

Comprehensive air quality impact assessments have been completed for NCP (including Chloorkop Expansion Project, Contaminated soils recovery, C3 Project and the 200T Receiver Project), Revertex Chemicals (Durban), Stoppani Chromium Chemicals, Foskor (Richards Bay), Straits Chemicals (Coega), Tenke Acid Plant (DRC), and Omnia (Sasolburg).

Petrochemical Industry

Numerous air quality impact assessments have been completed for Sasol (including the postponement/exemption application for Synfuels, Infrachem, Natref, MIBK2 Project, Wax Project, GTL Project, re-commissioning of boilers at Sasol Sasolburg and Ekandustria), Engen Emission Inventory Functional Specification (Durban), Sapref refinery (Durban), Sasol (at Elrode) and Island View (in Durban) tanks quantification, Petro SA and Chevron (including the postponement/exemption application).

Pulp and Paper Industry

Air quality studies have been undertaken or the expansion of Mondi Richards Bay, Multi-Boiler Project for Mondi Merebank (Durban), impact assessments for Sappi Stanger, Sappi Enstra (Springs), Sappi Ngodwana (Nelspruit) and Pulp United (Richards Bay).

Power Generation

Air quality impact assessments have been completed for numerous Eskom coal fired power station studies including the ash expansion projects at Kusile, Kendal, Hendrina, Kriel and Arnot; Fabric Filter Plants at Komati, Grootvlei, Tutuka, Lethabo and Kriel Power Stations; the proposed Kusile, Medupi (including the impact assessment for the Flue Gas Desulphurization) and Vaal South Power Stations. René was also involved and the cumulative assessment of the existing and return to service Eskom power stations assessment and the optimization of Eskom's ambient air quality monitoring network over the Highveld.

In addition to Eskom's coal fired power stations, various Eskom nuclear power supply projects have been completed including the air quality assessment of Pebble Bed Modular Reactor and nuclear plants at Duynefontein, Bantamsklip and Thyspunt.

Apart from Eskom projects, power station assessments have also been completed in Kenya (Rabai Power Station) and Namibia (Paratus Power Plant).

Waste Disposal

Air quality impact assessments, including odour and carcinogenic and non-carcinogenic pollutants were undertaken for the Waste Water Treatment Works in Magaliesburg, proposed Waterval Landfill (near Rustenburg), Tutuka Landfill, Mogale General Waste Landfill (adjacent to the Leipardsvlei Landfill), Cape Winelands District Municipality Landfill and the Tsoeneng Landfill (Lesotho). Air quality impact assessments have also been completed for the BCL incinerator (Cape Town), the Ergo Rubber Incinerator and the Ecorevert Pyrolysis Plant.

Cement Manufacturing

Impact assessments for ambient air quality have been completed for the Holcim Alternative Fuels Project (which included the assessment of the cement manufacturing plants at Ulco and Dudfield as well as a proposed blending platform in Roodepoort).

Management Plans

René undertook the quantification of the baseline air quality for the first declared Vaal Triangle Airshed Priority Area. This included the establishment of a comprehensive air pollution emissions inventory, atmospheric dispersion modelling, focusing on impact area "hotspots" and quantifying emission reduction strategies. The management plan was published in 2009 (Government Gazette 32263).

René has also been involved in the Provincial Air Quality Management Plan for the Limpopo Province.

Other Experience (2001)

Research for B.Sc Honours degree was part of the "Highveld Boundary Layer Wind" research group and was based on the identification of faulty data from the Majuba Sodar. The project was THRIP funded and was a joint venture with the University of Pretoria, Eskom and Sasol (2001).

EDUCATION

M.Sc Earth Sciences	University of Pretoria, RSA, Cum Laude (2009) Title: *An Air Quality Baseline Assessment for the Vaal Airshed in South Africa*
B.Sc Hons. Earth Sciences	University of Pretoria, RSA, Cum Laude (2001) Environmental Management and Impact Assessments
B.Sc Earth Sciences	University of Pretoria, RSA, (2000) Atmospheric Sciences: Meteorology

ADDITIONAL COURSES

CALMET/CALPUFF	Presented by the University of Johannesburg, RSA (March 2008)
Air Quality Management	Presented by the University of Johannesburg, RSA (March 2006)
ARCINFO	GIMS, Course: Introduction to ARCINFO 7 (2001)

COUNTRIES OF WORK EXPERIENCE

South Africa, Mozambique, Malawi, Liberia, Kenya, Angola, Democratic Republic of Congo, Lesotho, Namibia, Madagascar, Egypt, Suriname and Iran.

EMPLOYMENT RECORD

January 2002 - Present

Airshed Planning Professionals (Pty) Ltd, (previously known as Environmental Management Services cc until March 2003), Principal Air Quality Scientist, Midrand, South Africa.

2001

University of Pretoria, Demi for the Geography and Geoinformatics department and a research assistant for the Atmospheric Science department, Pretoria, South Africa.

Department of Environmental Affairs and Tourism, assisted in the editing of the Agenda 21 document for the world summit (July 2001), Pretoria, South Africa.

1999 - 2000

The South African Weather Services, vacation work in the research department, Pretoria, South Africa.

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

- Understanding the Synoptic Systems that lead to Strong Easterly Wind Conditions and High Particulate Matter Concentrations on The West Coast of Namibia, H Liebenberg-Enslin, R von Gruenewaldt, H Rauntenbach and L Burger. National Association for Clean Air (NACA) conference, October 2017.
- Topographical Effects on Predicted Ground Level Concentrations using AERMOD, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2011.
- Emission Factor Performance Assessment for Blasting Operations, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2009.
- Vaal Triangle Priority Area Air Quality Management Plan – Baseline Characterisation, R.G. Thomas, H Liebenberg-Enslin, N Walton and M van Nierop. National Association for Clean Air (NACA) conference, October 2007.
- A High-Resolution Diagnostic Wind Field Model for Mesoscale Air Pollution Forecasting, R.G. Thomas, L.W. Burger, and H Rautenbach. National Association for Clean Air (NACA) conference, September 2005.
- Emissions Based Management Tool for Mining Operations, R.G. Thomas and L.W. Burger. National Association for Clean Air (NACA) conference, October 2004.
- An Investigation into the Accuracy of the Majuba Sodar Mixing Layer Heights, R.G. Thomas. Highveld Boundary Layer Wind Conference, November 2002.

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent
Afrikaans	Fair	Good	Good

CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications, and my experience.

______________________	06/08/2019
Signature of staff member	Date (Day / Month / Year)

Full name of staff member: René Georgeinna von Gruenewaldt

APPENDIX B - DECLARATION OF INDEPENDENCE

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: René von Gruenewaldt

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

Professional Registration No.: 400304/07

Declaration of independence and accuracy of information provided:

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

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

Signed at Midrand on this 12th of August 2020

SIGNATURE

Principal Air Quality Scientist

CAPACITY OF SIGNATORY

APPENDIX C – IMPACT SIGNIFICANCE RATING

The methodology used for assessing the significance of the impact was obtained from the SLR.

PART A: DEFINITIONS AND CRITERIA*		
Definition of SIGNIFICANCE		Significance = consequence x probability
Definition of CONSEQUENCE		Consequence is a function of intensity, spatial extent and duration
Criteria for ranking of the INTENSITY of environmental impacts	**VH**	Severe change, disturbance or degradation. Associated with severe consequences. May result in severe illness, injury or death. Targets, limits and thresholds of concern continually exceeded. Substantial intervention will be required. Vigorous/widespread community mobilization against project can be expected. May result in legal action if impact occurs.
	H	Prominent change, disturbance or degradation. Associated with real and substantial consequences. May result in illness or injury. Targets, limits and thresholds of concern regularly exceeded. Will definitely require intervention. Threats of community action. Regular complaints can be expected when the impact takes place.
	M	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional complaints can be expected.
	L	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.
	VL	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.
	VL+	Negligible change or improvement. Almost no benefits. Change not measurable/will remain in the current range.
	L+	Minor change or improvement. Minor benefits. Change not measurable/will remain in the current range. Few people will experience benefits.
	M+	Moderate change or improvement. Real but not substantial benefits. Will be within or marginally better than the current conditions. Small number of people will experience benefits.
	H+	Prominent change or improvement. Real and substantial benefits. Will be better than current conditions. Many people will experience benefits. General community support.
	VH+	Substantial, large-scale change or improvement. Considerable and widespread benefit. Will be much better than the current conditions. Favourable publicity and/or widespread support expected.
Criteria for ranking the DURATION of impacts	**VL**	Very short, always less than a year. Quickly reversible
	L	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.
	M	Medium-term, 5 to 10 years.
	H	Long term, between 10 and 20 years. (Likely to cease at the end of the operational life of the activity)
	VH	Very long, permanent, +20 years (Irreversible. Beyond closure)
Criteria for ranking the EXTENT of impacts	**VL**	A part of the site/property.
	L	Whole site.
	M	Beyond the site boundary, affecting immediate neighbours
	H	Local area, extending far beyond site boundary.
	VH	Regional/National

PART B: DETERMINING CONSEQUENCE							
INTENSITY = VL							
DURATION	Very long	VH	Low	Low	Medium	Medium	High
	Long term	H	Low	Low	Low	Medium	Medium
	Medium term	M	Very Low	Low	Low	Low	Medium
	Short term	L	Very low	Very Low	Low	Low	Low
	Very short	VL	Very low	Very Low	Very Low	Low	Low
INTENSITY = L							
DURATION	Very long	VH	Medium	Medium	Medium	High	High
	Long term	H	Low	Medium	Medium	Medium	High
	Medium term	M	Low	Low	Medium	Medium	Medium
	Short term	L	Low	Low	Low	Medium	Medium
	Very short	VL	Very low	Low	Low	Low	Medium
INTENSITY = M							
DURATION	Very long	VH	Medium	High	High	High	Very High
	Long term	H	Medium	Medium	Medium	High	High
	Medium term	M	Medium	Medium	Medium	High	High
	Short term	L	Low	Medium	Medium	Medium	High
	Very short	VL	Low	Low	Low	Medium	Medium
INTENSITY = H							
DURATION	Very long	VH	High	High	High	Very High	Very High
	Long term	H	Medium	High	High	High	Very High
	Medium term	M	Medium	Medium	High	High	High
	Short term	L	Medium	Medium	Medium	High	High
	Very short	VL	Low	Medium	Medium	Medium	High
INTENSITY = VH							
DURATION	Very long	VH	High	High	Very High	Very High	Very High
	Long term	H	High	High	High	Very High	Very High
	Medium term	M	Medium	High	High	High	Very High
	Short term	L	Medium	Medium	High	High	High
	Very short	VL	Low	Medium	Medium	High	High

VL	L	M	H	VH
A part of the site/ property	Whole site	Beyond the site, affecting neighbours	Extending far beyond site but localised	Regional/ National
		EXTENT		

PART C: DETERMINING SIGNIFICANCE							
PROBABILITY (of exposure to impacts)	Definite/ Continuous	VH	Very Low	Low	Medium	High	Very High
	Probable	H	Very Low	Low	Medium	High	Very High
	Possible/ frequent	M	Very Low	Very Low	Low	Medium	High
	Conceivable	L	Insignificant	Very Low	Low	Medium	High
	Unlikely/ improbable	VL	Insignificant	Insignificant	Very Low	Low	Medium
			VL	L	M	H	VVH
			CONSEQUENCE				

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	**Decision guideline**
Very High	Potential fatal flaw unless mitigated to lower significance.
High	It must have an influence on the decision. Substantial mitigation will be required.
Medium	It should have an influence on the decision. Mitigation will be required.
Low	Unlikely that it will have a real influence on the decision. Limited mitigation is likely required.
Very Low	It will not have an influence on the decision. Does not require any mitigation
Insignificant	Inconsequential, not requiring any consideration.

***VH = very high, H = high, M= medium, L= low and VL= very low and + denotes a positive impact.**

APPENDIX D – LEAD AND ZINC DEPOSITION LEVELS PROVIDED FOR THE BIODIVERSITY IMPACT ASSESSMENT

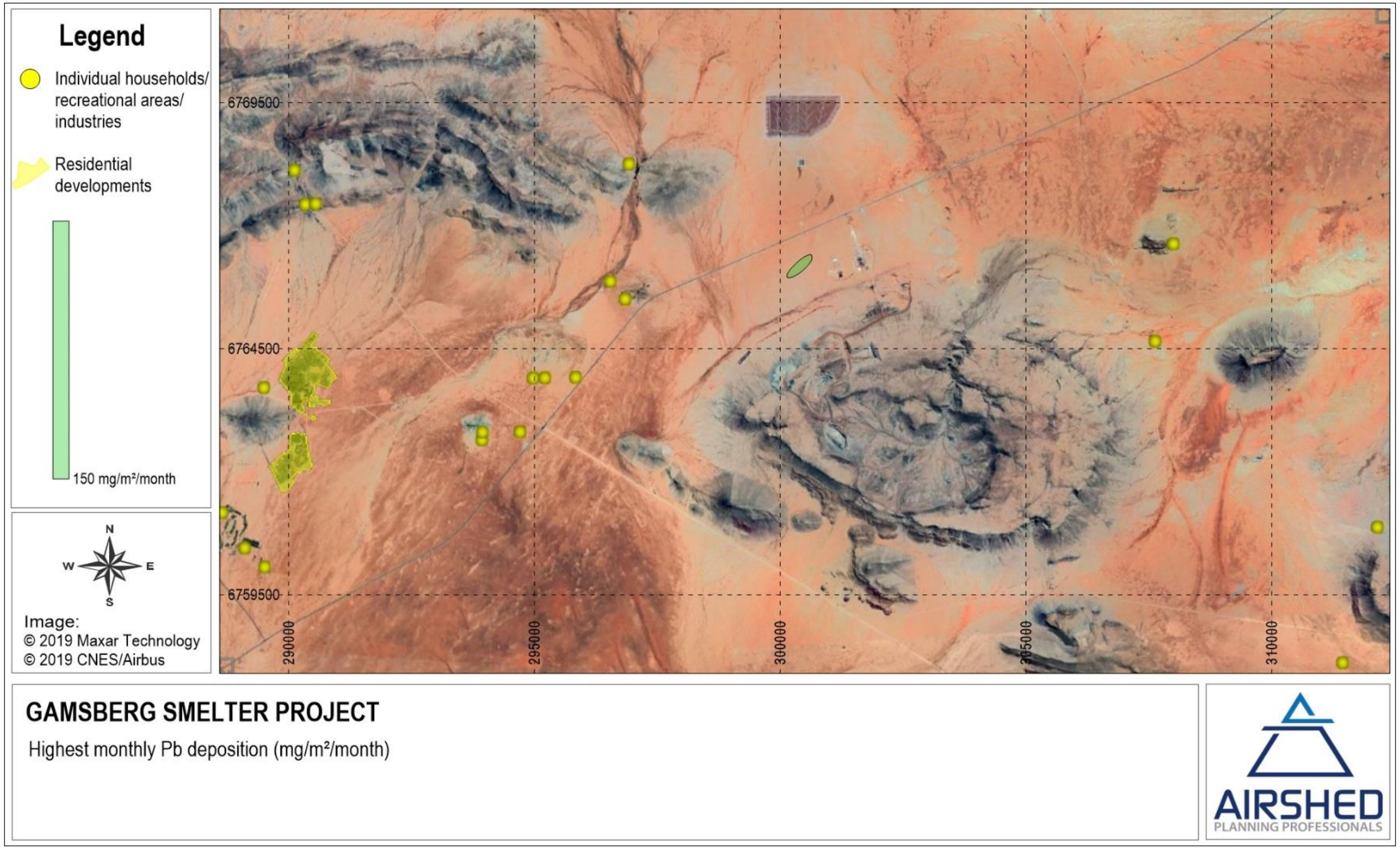

Figure D-1: Highest monthly lead deposition due to project operations

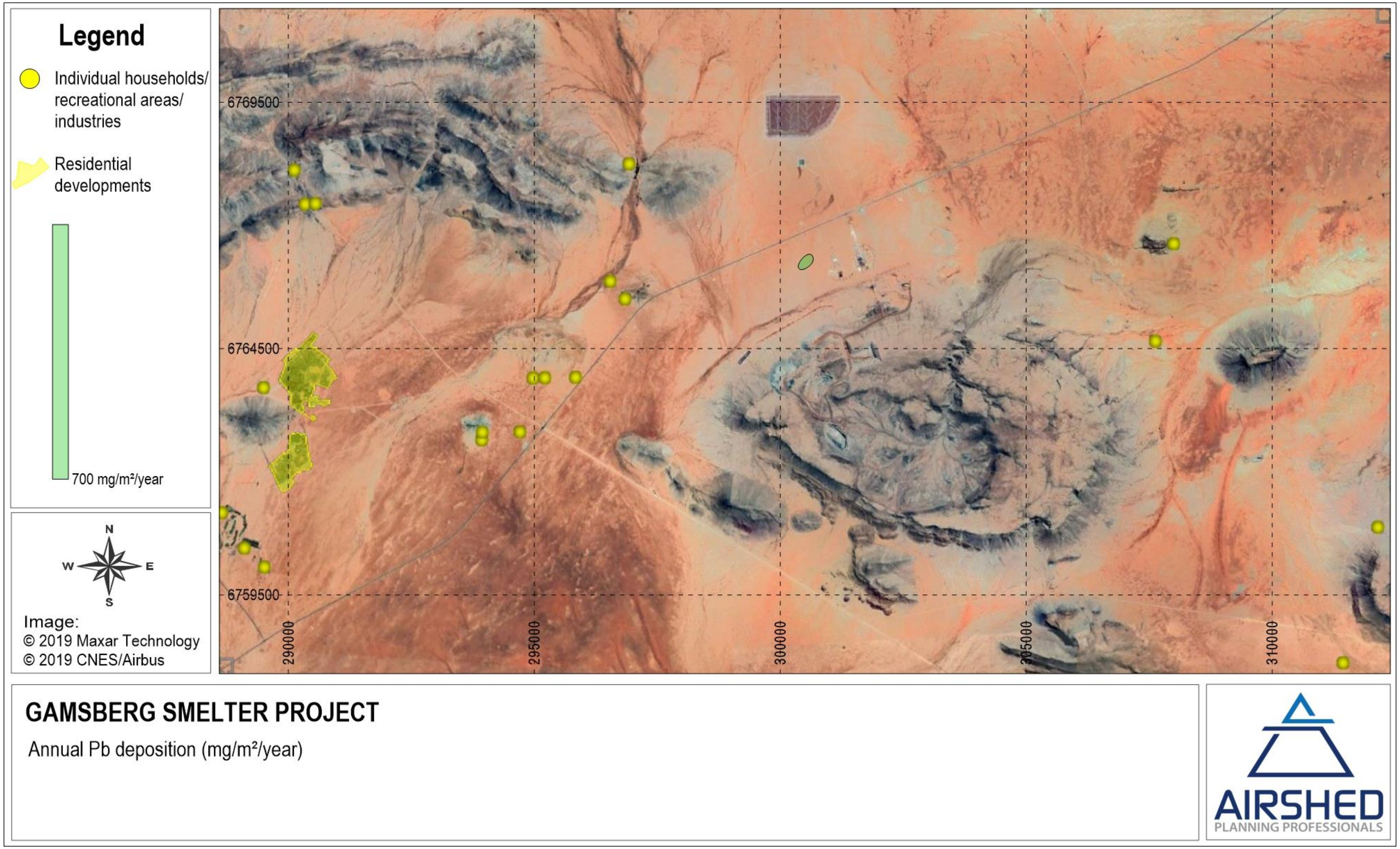

Figure D-2: Annual lead deposition due to project operations

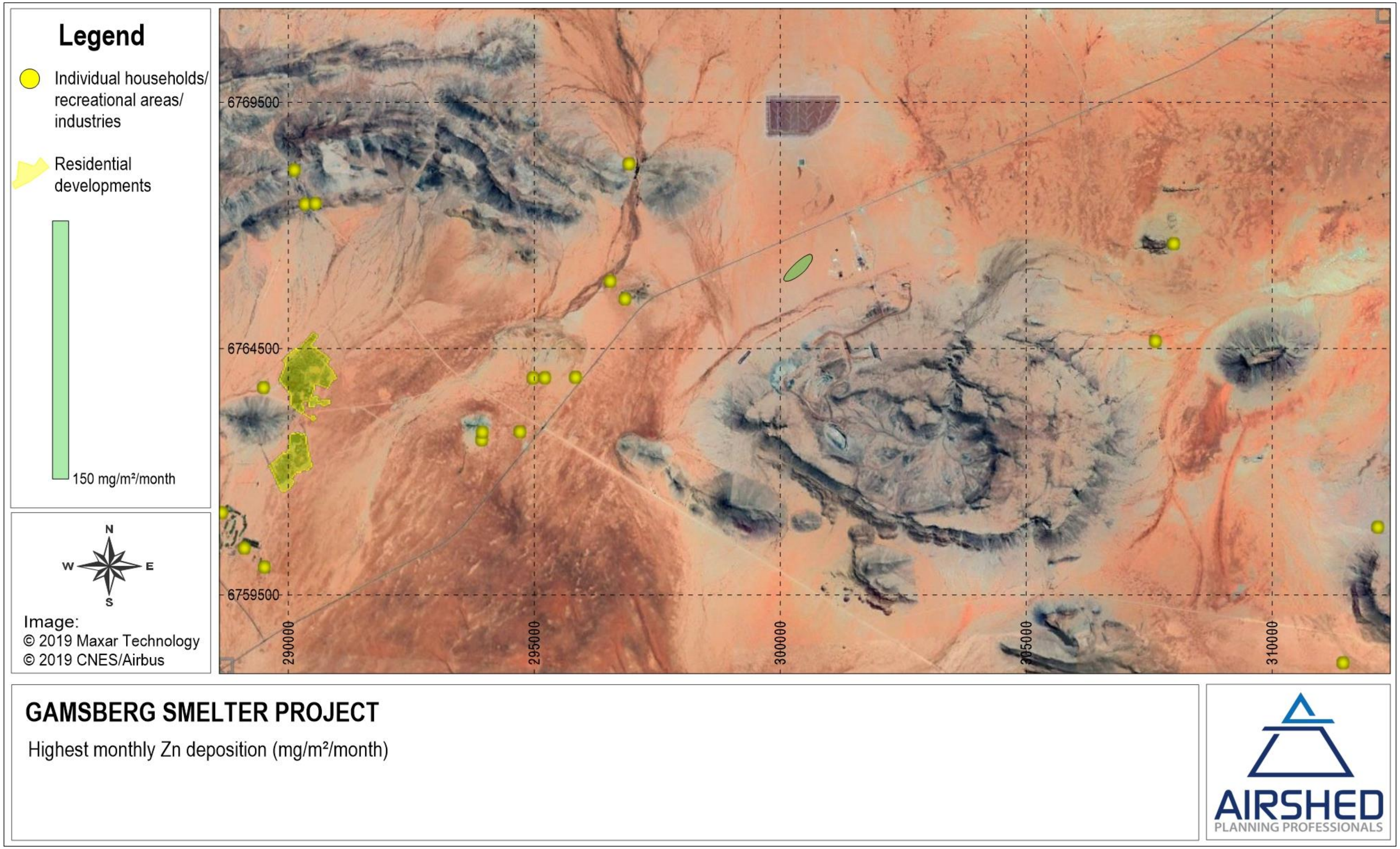

Figure D-3: Highest monthly zinc deposition due to project operations

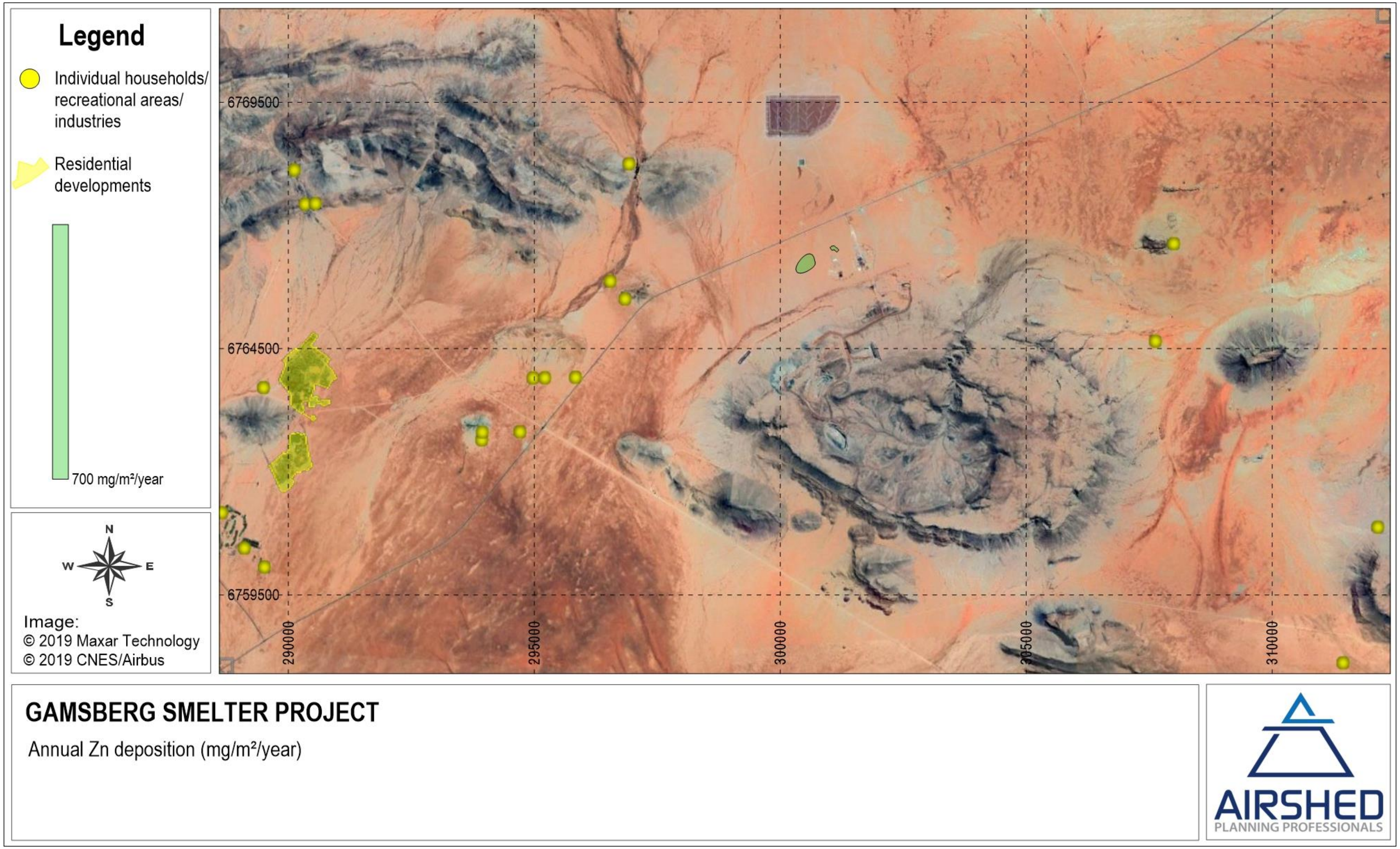

Figure D-4: Annual zinc deposition due to project operations

APPENDIX E – DIFFERENCES BETWEEN THE MODELLING CONDUCTED IN THE 2013 ASSESSMENT AND THE CURRENT ASSESSMENT

2013 AQIA	Current assessment
Meteorological data used: Pofadder for the period 2007-2009.	Meteorological data used: WRF data for a point extracted at site for the period 2016-2018.
High moisture ore (>4%) emission factor used for the quantification of emissions from the crusher.	More for the moisture provided as 0.4%. Low moisture ore (<4%) emission factor used for the quantification of crushing emissions.
50% control efficiency assumed on all transfer points.	Control efficiency for materials handling was only assumed at the crusher transfer point (50% for wetting and a further 30% for enclosure).
Mean weight of trucks assumed to be 320t and 32 trucks used to haul ore.	Provided that the trucks will be between 90t and 180t capacity. This equates to an average weight of between 120t and 240t and ~203 trips per day to move 10 Mtpa ore.
The silt content on the road was assumed to be 6.9%. this assumption was not qualified.	The silt content on the road was assumed to be 8.4% based on US EPA defaults.