DIGBY WELLS ENVIRONMENTAL

Environmental Impact Assessment for Sibanye Gold Limited

Air Quality Impact Assessment Report

Project Number:

GOL2376

Prepared for:

Sibanye Gold Limited

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This is undertaken under oath with respect to:

(i) the correctness of the information provided in the report;
(ii) the inclusion of comments and inputs from stakeholders and I&APs;
(iii) the inclusion of inputs and recommendations from other specialist reports, where relevant; and
(iv) any information provided by the EAP to interested and affected parties and any responses by the EAP to comments or inputs made by interested or affected parties

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EXECUTIVE SUMMARY

Digby Wells Environmental (hereafter Digby Wells) was requested by Sibanye Gold Limited (Pty) Ltd (hereafter Sibanye Gold) to conduct an Environmental Impact Assessment (EIA) and provide an Environmental Management Plan (EMP) for the proposed West Rand Tailings Retreatment Project (WRTRP), Gauteng Province. The study encompasses several specialist studies of which Air Quality Impact Assessment (AQIA) forms an integral component.

The Air Quality Impact Assessment (AQIA) study was undertaken to establish the impact(s) anticipated from the proposed WRTRP on ambient atmosphere of the area. Assessment of baseline scenarios was conducted using available ambient air quality data, i.e. dust deposition data from existing networks in the following Mining Right Areas: Kloof, Drienfontein, Cooke and Ezulwini and Driefontein PM_{10} data. This was followed by a detailed impact assessment to predict what the anticipated impacts are as a result of the WRTRP. In the impact assessment, emissions inventory of all potential areas and point sources of pollution were evaluated. This was followed by air dispersion model simulations to predict ground level concentrations and pollutant spread across the landscape.

Model predictions for the various pollutants assessed in this AQIA study confirmed particulate and gaseous emissions signature associated with the proposed Project on current ambient air quality of the area. The main findings of this AQIA study are summarised as follows:

- The maximum ground level concentrations of PM_{10} daily and annual concentrations from the various historical TSFs are predicted and compared against the current standard of 75 µg/m³. Although the maximum ground level concentrations predicted for Kloof TSF, Driefontein 3 TSF, Driefontein 5 TSF, Cooke TSF and Ezulwini TSF are higher than the current PM_{10} standard of 75 µg/m³, these are mostly confined to the centre of each TSF, with levels at selected sensitive receptors all within the limit. Model predictions of the worst case scenario (full footprint at maximum capacity) show PM_{10} daily from the Regional Tailings Storage Facility (RTSF) is higher than the current standard without mitigation (worst case scenario), with exceedances observed in the north-western area outside the RTSF boundary. The predicted annual levels were not in violation of the current PM_{10} standard of 40 µg/m³. The combined PM_{10} contributions from all sources at the CPP were within limit and not in exceedance of the daily and annual standards.
- Model prediction of $PM_{2.5}$ daily and annual concentrations from the various TSFs assessed were all within the current limits of 40 µg/m³ and 20 µg/m³ respectively, except for the RTSF (without mitigation)
- The dust deposition rates simulated by the model were all within the residential and non-residential limits of 600 mg/m^2/day and 1 200 mg/m^2/day respectively. The dispersion model shows that impacts are higher within the TSF areas.

The SO_2, NO_2 and CO emissions from the Central Processing Plant (CPP) showed ground level concentrations within the regulatory limits, with major contributions from the coal fired boiler.

The impact assessment ratings conducted are mainly negligible (negative) for various activities of the WRTRP. Impacts are especially higher during the operation phase of the CPP and the RTSF with a rating moderate (negative). However, the project brings about some positive impacts as the reclamation process will remove the perennial sources of pollution at the historical TSF sites as they are rehabilitated. Resulting tailings will be consolidated in a single RTSF that will be easier to manage, freeing up rehabilitated land for alternative land uses.

The main outcome of this study is that the Project will comply with the relevant ambient air quality standards. Although the maximum ground level concentrations for some pollutants are higher than the recommended standard, they were limited to facility's boundary or immediate vicinity. With suitable monitoring and mitigation measures, it will be possible to manage these impacts and for them to fall within current and future air quality standards.

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LIST OF ACRONYMS, ABBREVIATIONS AND TERMS

Abbreviation	Description
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
APPA	Atmospheric Pollution Prevention Act
AQG	Air Quality Guidelines
AQIA	Air Quality Impact Assessment
ASTM	American Society for Testing and Materials
AWTF	Advanced Water Treatment Facility
BWSF	Bulk Water Storage Facility
C4S	Cooke 4 South TSF
CA	Competent Authority
CPP	Central Processing Plant
CTSF	Central Tailings Storage Facility (Expanded from the Doornpoort TSF)
DEA	Department of Environmental Affairs
Digby Wells	Digby Wells Environmental
EIA	Environmental Impact Assessment
EMP	Environmental Management Programme
ESIA	Environmental and Social Impact Assessment
Ezulwini	Ezulwini Mining Company Limited is abbreviated to Ezulwini.
ha	Hectare
km	Kilometre
km^2	Kilometre squared
LoM	Life of Mine
m	Metre
m^2	Metre squared
mg	Milligram
mm	Millimetre
MM5	Mesoscale model – fifth generation
NDCR	National Dust Control Regulation
NEM:AQA	National Environmental Management: Air Quality Act

Abbreviation	Description
NEMA	National Environmental Management Act
PM_{10}	Particulate Matter 10 micrometres in diameter
$PM_{2.5}$	Particulate Matter 2.5 micrometres in diameter
PSU/NCAR	Pennsylvania State University / National Center for Atmospheric Research
Rand Uranium	Rand Uranium Limited is abbreviated to Rand Uranium.
ROM	Run of Mine
RTSF	Regional Tailings Storage Facility
SANS	South African National Standards
SGL	Sibanye Gold Limited
SO_4	Sulfate
TSF	Tailings Storage Facility
TSP	Total Suspended Particulates
WBT	West Block Thickener
WHO	World Health Organisation
WRTRP	West Rand Tailings Retreatment Project
WRTRP	It is “the WRTRP”

1 Introduction

There is a long history of gold and uranium mining in the broader West Rand area with an estimated 1.3 billion tonnes of tailings, containing in excess of 170 million pounds of uranium and 11 million ounces of gold. Sibanye Gold Limited (SGL) currently owns the majority of the tonnage and its gold and uranium content. SGL plans to ultimately exploit all these resources to develop a strong, long life and high yield surface business. Key to the successful execution of this development strategy is the West Rand Tailings Retreatment Project (WRTRP). The concept of the WRTRP is well understood with an 8 year history of extensive metallurgical test work, feasibility studies and design by a number of major mining houses. A pre-feasibility study (PFS) completed during 2013 for the WRTRP has confirmed that there is a significant opportunity to extract value from the SGL surface resources in a cost effective sequence.

The ultimate WRTRP involves the construction of a large-scale Central Processing Plant (CPP) for the recovery of gold, uranium and sulfur from the available resources. The CPP, centrally located to the West Rand resources, will be developed in phases to eventually treat up to 4mt/month of tailings inclusive of current arisings. Tailings will emanate from the hydraulic re-mining of a number of TSFs in a phased manner. The resultant tailings will be deposited on a modern tailings storage facility (TSF) called the regional TSF (RTSF).

Digby Wells Environmental (hereafter Digby Wells) was requested by Sibanye Gold Limited (Pty) Ltd (hereafter SGL) to conduct an Environmental Impact Assessment (EIA) and provide an Environmental Management Plan (EMP) for the proposed West Rand Tailings Retreatment Project (WRTRP), Gauteng Province. The study encompasses several specialist studies of which Air Quality Impact Assessment (AQIA) forms an integral component.

1.1 The West Rand Tailings Retreatment Project

Simplistically, SGL's historical TSF holdings in the West Rand can be divided into three blocks; the Northern, Southern and Western Blocks. Each of these blocks contains a number of historical TSFs. Each of the blocks will be reclaimed in a phased approach. Initially the Driefontein 3 TSF (Western Block) together with the Cooke TSF (Northern Block) will be reclaimed first. Driefontein 3 TSF, Driefontein 5 TSF (Western Block) and Cooke 4 Dam south (C4S) (Southern Block) will be reclaimed sequentially. However, hydraulic reclamation at Cooke Dump will commence same time as Driefontein 3 and will eventually run concurrently to all 3 TSFs.

- Western Block comprises: Driefontein 1, 2, 3, 4 and 5 TSF, and Libanon TSF. Once the Driefontein 3 TSF and Driefontein 5 TSFs have been depleted the remainder of the Driefontein TSFs, namely Driefontein 1, 2 and 4 and the Libanon TSF, will be processed through the CPP; and
- Northern Block comprises: Cooke TSF, Venterspost North TSF, Venterspost South TSF and Millsite Complex (38, 39 and 40/41 and Valley). Venterspost North and

South TSFs and Millsite Complex (38, 39 and 40/41 and Valley) will be processed with the concurrent construction of Module 2 float and gold plants.

- Southern Block comprises: Kloof 1 TSF, Kloof 2 TSF, South Shaft TSF (future), Twin Shaft TSF (future), Leeudoorn TSF and C4S TSF. Following completion of the Module 3 float and gold plants, Kloof 1 and 2 TSFs, South Shaft TSF (future), Twin Shaft TSF (future) and Leeudoorn TSF will be reclaimed.

Once commissioned the project will initially reclaim and treat the TSFs at a rate of 1.5 Mt/m (1Mt/m from Driefontein 3 TSF (followed sequentially by Driefontein 5 TSF and C4S TSFs) and 0.5 Mt/m from Cooke TSF). Reclamation and processing capacity will ultimately ramp up to 4 Mt/m over an anticipated period of 8 years. At the 4Mt/m tailings retreatment capacity, each of the blocks will be reclaimed and processed simultaneously.

The tailings material will be centrally treated in a CPP. In addition to gold and uranium extraction, sulfur will be extracted to produce sulphuric acid, an important reagent required for uranium leaching.

To minimise the upfront capital required for the WRTRP, only essential infrastructure will be developed during initial implementation. Use of existing and available infrastructure may be used to process gold and uranium until the volumetric increase in tonnage necessitates the need to expand the CPP.

The authorisation, construction and operation of a new deposition site for the residue from the CPP will be located in an area that has been extensively studied as part of the original West Wits Project (WWP) and Cooke Uranium Project (CUP). The “deposition area” on which the project is focussing, has been termed the RTSF and is anticipated to accommodate the entire tonnage from the district. The RTSF if proved viable will be one large facility as opposed to the two independent deposition facilities proposed by the WWP and CUP respectively.

Note: Amendments to various MWPs and EMPs will be applied for in due course pending the inclusion of additional TSFs as the WRTRP grows to process 4 Mt/m. The RTSF will be assessed for the complete footprint to ensure that the site is suitable for all future deposition requirements.

1.2 Initial implementation

Due to capital constraints in developing a project of this magnitude, it needs to be implemented over time. The initial investment and development will be focused on those assets that will put the project in a position to partially fund the remaining development.

This entails the design and construction of the CPP (gold module, floatation plant, uranium plant, acid plant and a roaster), to retreat up to 1.4 Mt/m from the Driefontein 3 TSF and Driefontein 5 TSF , C4S TSF and the Cooke TSF. Driefontein 3 TSF, Driefontein 5 TSF and C4S TSF will be mined sequentially over 11 years, whilst the Cooke TSF will be mined concurrent to these for a period of 16 years. The resultant tailings will be deposited onto the new RTSF.

1.3 Terms of Reference

Tasks associated with the air quality study scope of work are outlined below:

- Screening assessment for the different Mining Right Areas;
- Baseline assessment;
  - Evaluation of site specific meteorology;
  - Evaluation of background ambient air quality data;
  - Review of possible health and environmental implications of potential pollutants;
- Emissions inventory compilation;
- Dispersion modelling;
- Impact assessment; and
- Recommendation of mitigation measures incorporating Best Practicable Environmental Option.

2 Details of the Specialist

Matthew Ojelede completed his BSc (Hons) degree at the University of Benin, Edo State, Nigeria; an MSc in Environmental Science (Wits University) and a PhD in Environmental Management from the University of Johannesburg. He has been in the Atmospheric Research field since 2005 and now actively involved in air pollution research, associated impacts and application of regulatory requirements. Authored and co-authored research articles in peer Reviewed Journals and Dispersion Modelling Impact Assessments Reports. He has attended specialised courses in atmospheric dispersion modelling (AERMOD and CALPUFF).

3 Aims and Objectives

The aim of the Air Quality Impact Assessment (AQIA) study was to establish the impact(s) the proposed WRTRP would have on the ambient air quality of the area. To achieve this aim, several objectives were set out and they include:

- Screening assessment to determine possible fatal flaws for the ultimate project;
- Detailed assessment of the baseline air quality scenario;
- Conduct a comprehensive impact assessment study;
- Evaluation of predicted pollutants impact to the applicable standards;
- Recommendations and management of associated impacts.

4 Methodology

4.1 Gap Analysis

Due to the long history of the project a gap analysis was undertaken to determine the level of information that is currently available and usable.

It was established that the PM_{10} and $PM_{2.5}$ monitoring is limited making it difficult to establish reliable diurnal, monthly, seasonal and annual levels of these pollutants. Although Airshed Planning Professionals reported on PM_{10} sampling conducted by DD Science, the results were insufficient. The PM_{10} data should be updated and monitoring needs to be done on a continuous basis.

In the documents reviewed, no mention was made of site specific meteorological data. Meteorological data can be sourced from the South African Weather Service, however, this will be at a regional level. Should there be a site specific meteorological station it will yield data that are readily verifiable and site specific.

4.1.1 Environmental Impact Report: Proposed Gold Fields West Wits Project

In the Air Quality Impact Assessment Report compiled by SSI Engineering and Environmental (March 2010) for the Doornpoort Tailings Storage Facility, the air quality component was insufficient to appraise the background dust deposition rates, PM_{10} and $PM_{2.5}$. The report only mentioned proposed dust monitoring sites that have been identified with no mention of PM_{10}, $PM_{2.5}$ and gaseous pollutant monitoring. For the proposed project, particulate matter pollution will be a significant concern. Therefore, continuous assessments of PM_{10} levels at selected sensitive receptor and commissioning of a dust deposition network is required.

4.1.2 Amendment to Rand Uranium's Environmental Management Programme for the proposed Millsite Tailings Storage Facility as part of the interim disposal component of the Cooke Uranium Project (Mining Right GP 30/5/1/2/2 (173)

In the report titled *Air quality impact assessment for the Proposed Rand Uranium Millsite interim tailings Disposal near Randfontein (permit 3)*, prepared by Airshed Planning Professionals for Golder Associates Africa (Pty) Ltd, intermittent background measurements of PM_{10} conducted by DD Science and dust fallout monitoring were reported. DD Science conducted air quality monitoring around the Cooke Gold Plant area. Monitoring included dust deposition and PM_{10} monitoring and was conducted over three sampling campaigns. The first campaign was conducted from December 2008 to January 2009, and the second campaign from February 2009 to March 2009. The third campaign was from August 2009 to September 2009. Appraisal of relevant pollutants was limited to generated plots from dispersion modelling. PM_{10} and $PM_{2.5}$ are regulated and monitoring should be performed on a continuous basis with hourly and 24 hour averaging periods. The intermittent monitoring of PM_{10} has resulted in a gap in the monitoring data.

4.1.3 Cooke 4 Shaft – Environmental Impact Assessment and Environmental Management Programme

In the EIA and EMP report prepared by Shangoni Management Services (Pty) Ltd for Ezulwini Mining Company (Pty) Ltd operating as Cooke 4 Shaft, measured dust deposition data were presented for 2011 and 2012 respectively.

The latter was the only data presented for air quality and no mention was made to continuous monitoring of particulate matter - PM_{10}. The report also lacked adequate description of the meteorology of the area relevant to dust suspension and re-deposition.

4.1.4 Environmental Impact Assessment (EIA) For the Proposed Uranium Plant and Cooke Dump Reprocessing Infrastructure (Mining Right Mr 09/2008)

In the final EIA complied by Golder Associates and submitted to DMR and GDARD, the air quality component is the same as the report discussed in Section 4.1.2 and will not be discussed further.

4.2 Baseline Characterisation and Assessment

Specific tasks need to be completed in line with the requirements of the environmental and air quality legislation and guidelines. The methodology that was followed will include a literature review and assessment of the existing background information, processed data and collation into a consolidated impact report. Meteorological data obtained from Lakes Environmental Software was processed and used to determine local prevailing weather conditions.

The AQIA study relied solely on available background data: dust fallout measurements and PM_{10} data, supplemented where necessary with appropriate modelled data. Compilation of the specialist impact assessment report addressed the following:

- Identification of sensitive receptors;
- Identification of potential environmental risks;
- Review of required South African Legislations;
- Detailed assessment of available ambient air quality data; and
- Literature review of the health implications of anticipated pollutants from the operational phase of the Project.

4.3 Fieldwork and Seasonal Influence

4.3.1 Dust Fallout Monitoring

Monitoring of dust deposition rates is often conducted to establish background levels in an area, to which future perturbations will be compared. With Sibanye Gold, extensive dust monitoring networks were already in place, at the Kloof, Driefontein, Cooke and Ezulwini Mining Right Areas, hence use was made of the historical data provided – which dates back to 2002. From experience, the dust deposition rates vary with the seasonal fluctuations in wind speed regime. The deposition rates have been observed to be higher during spring and less in winter. The reason for the increase in spring is associated with the higher occurrence of wind speed greater than 5 m/s. This signature was seen in the historical data provided by SGL.

4.3.2 Monitoring of Particulate Matter (PM_{10})

SGL has already installed a continuous particulate monitoring instrument at the Driefontein site to measure PM_{10} at Libanon Business Park, coordinates: S26°21´23.50" and E27°36´33.21". The site has been in operation since January 2013. With the availability of this background data a site visit was not conducted.

4.4 Emission Inventory

Establishment of an emissions inventory based on the proposed project and associated activities was conducted to provide input parameters for the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) dispersion modelling.

Emission factors published by the US-EPA in its AP-42 document “Compilation of Air Pollution Emission Factors” and Australian National Pollutant Inventory (NPI) “Emission Estimation Technique (EET)” manuals have been used. The derived emission factors served as input data for our dispersion model, to predict the ground level concentrations and pollutant spread across the landscape.

There are various sources of emissions anticipated from the construction, operational and decommissioning phases. Envisaged emissions from the proposed WRTRP include pollutants, such as:

- Inhalable fraction of particulate matter (airborne material that enters the nose and mouth during breathing, which can be deposited anywhere in the respiratory tract - aerodynamic diameters less than or equal to 10 µm), while the respirable fraction encompasses the airborne material that penetrates the lower gas exchange region of the lungs (aerodynamic diameters less than or equal to 2.5 µm);
- Dustfall; and

- Gaseous emissions: oxides of nitrogen (NO and NO_2, jointly known as NO_x), sulfur dioxide (SO_2) and carbon monoxide (CO) from point sources i.e. boiler, roster/acid plant, uranium plants and gold plants.

The emissions inventory also catered for anticipated emissions associated with the construction of the Central Processing Plant (CPP), and wind erosion from the proposed Regional Tailings Storage Facility and the reclamation of tailings storage facilities – Driefontein 3 TSF, Drienfontein 5 TSF, Cooke TSF and C4S TSF. The Australian National Pollutant Inventory (NPI) "Emission Estimation Technique (EET) for Combustion in Boilers version 3.6 for Black Coal (Cyclone furnace) was used to quantify emission from the coal boiler. Stack parameters and emission factors for the Acid Plant and Uranium Plant were adopted from a previous study (Reich and Burger, 2009). To appraise emissions from the Gold Plant, stack parameters were also adopted from similar operation as these were not available. Emission factors were also taken from a previous study (uMoya Nilu – No. uMNo45-2614). Activities associated with the WRTRP are highlighted (Table 4-1). The detailed layout drawing of the ultimate CPP confirmed a single coal fired boiler on site, one acid plant, two roasters and two uranium plants and three gold plants. The use of the boiler will be limited to starting up the uranium plant and during acid plant shut down during maintenance. In addition, as the production of acid in the plant will be an exothermic reaction, the heat generated as a by-product will be used to heat the uranium plant, thus obviating the use of the boiler under ongoing operational conditions.

Table 4-1: Initial Activities of the WRTRP

Category	**Activity**
Kloof Mining Right area	
Infrastructure	Pipeline Routes (residual tailings).
	Central processing Plant (CPP) incorporating Module 1 float and gold plants and uranium, roaster and acid plants.
	The Regional Tailings Storage Facility (RTSF), RTSF Return Water Dam (RWD) and the Advanced Water Treatment Facility (AWTF). Collectively known as the RTSF complex.
Processes	Abstraction of water from K10 shaft
	Disposal of the residue from the AWTF.
	Gold, uranium and sulfur extraction at the CPP (tailings to RTSF)
	Water distribution at the AWTF for discharge.
Pumping	Pumping of up to 1.4 Mt/m of tailings to the RTSF.
	Pumping water from the RTSF return water dams to the AWTF.
	Discharging treated water to the Leeuspruit.

Category	Activity
Electricity supply	Power supply from Kloof 1 substation to the CPP.
	Power supply from Kloof 4 substation to the RTSF and AWTF.
Driefontein Mining Right area	
Infrastructure	Pipeline Routes (water, slurry and thickened tailings).
	West block Thickener (WBT) and Bulk Water Storage Facility (BWSF) complex.
	Collection sumps and pump stations at the Driefontein 3 and 5 TSFs
Processes	Hydraulic reclamation of the Driefontein 3 and 5 TSFs.
Pumping	Pumping water from K10 to the BWSF located next to the WBT.
	Pumping water from the BWSF to the Driefontein TSFs that will be reclaimed.(Dri3 & 5 TSFs)
	Pumping slurry from the TSF sump to the WBT (for Driefontein 3 and 5 TSFs).
	Pumping the thickened slurry from the WBT to the CPP.
Electricity supply	Power supply from West Driefontein 6 substation to Driefontein 3 TSF.
	Power supply from West Driefontein Gold substation to Driefontein 5 TSF.
	Power supply from East Driefontein Shaft substation to WBT and BWSF.
Cooke Mining Right area	
Infrastructure	Pipeline Routes (water, slurry and thickened tailings).
	Cooke thickener and BWSF.
	Collection sumps and pump stations at the Cooke TSF.
Processes	Abstraction of water from Cooke 1 shaft.
	Hydraulic reclamation of the Cooke TSF (which include temporary storage of the slurry in a sump).
Pumping	Pumping 5400 kt/m of tailings from the Cooke TSF to the Cooke thickener.
	Pumping from the Cooke thickener to the CPP via Ezulwini Booster station
Electricity supply	Power supply from the Cooke substation to the Cooke thickener.
	Power supply from the Cooke Plant to the Cooke TSF
Ezulwini Mining Right area	
Processes	Uranium extraction at Ezulwini (tailings to Ezulwini North Dump).
	Abstraction of water from Cooke shaft.
Pumping	Pumping water from Cooke 4 Shaft to the C4S TSF for reclamation.
	Pumping slurry from the TSF sump to the CPP.

Category	Activity
Electricity supply	Power supply from Ezulwini plant to the C4S TSF

4.4.1 Construction Phase

4.4.1.1 Construction Equipment (Dust Emissions)

The preparation of the area prior to the commencement of hydraulic reclamation activities was categorised under the construction phase operation. However, the area to be impacted is small and activities on site will be short term before hydraulic reclamation commences at each of the reclamation sites (hence considered negligible). During the construction phase, emissions from clearing of vegetation at the CPP and RTSF areas, loading of topsoil onto trucks or stockpiles will occur, accompanied by erosion, suspension and resuspension of loose dust particulate matter from vehicle wheels. Although this phase will be short-term, fugitive emissions from open areas was quantified from the United States Environmental Protection Agency (US EPA) AP-42, 2006. The dust emissions from construction operations are proportional to the area of land being worked.For this activity, 10 working hours per day were assumed for the construction works. Emission factors from AP-42 for construction activity operations of 2.69 Mg/hectare/year was used. A summary of the emission contribution from construction work is presented in Table 4-2.

Table 4-2: Summary of Particulate Matter associated with the Construction Process

Pollutant	Emissions (t/y) CPP	Emissions (t/y) RTSF
$PM_{2.5}$	2.4	78.6
PM_{10}	11.3	374.3
TSP	22.6	748.6

In the calculation of erosion from cleared areas, it is assumed that the entire surface area for the CPP and the RTSF will not be cleared all at the same time; hence 50% of the area was used in the estimate.

4.4.2 Operational Phase

Emissions associated with the operational phase encompass those from a variety of sources: Erosion of existing tailings storage facilities designated for reclamation – Driefontein 3 TSF, Driefontein 5 TSF, Cooke TSF, and C4S TSF. Erosion of dust from the new RTSF alongside emissions from point sources at the CPP (Boiler stack, Roaster/Acid Plant stack, Gold Plant stacks and Uranium Plant stacks) will add to the pollutants load. To quantify emissions, the specification of the stacks (point sources) and dimension of the various area sources, the meteorology of the area and emission factors are required as input parameters. Gaseous emissions from the mine fleet of vehicles and other mine machineries were not appraised as these were considered negligible.

Wind erosion from the RTSF was modelled in two phases – the initial lower compartment and then the lower and upper compartment. Since TSFs will be reclaimed sequentially, they were modelled separately. The model runs were set up to account for 50% mitigation (the reason being that reclamation is taking place hydraulically coupled with the fact that the existing TSFs have vegetation cover). The following are the dimensions of the TSFs used in assessing wind erosion (Table 4-3). The TSF heights for Driefontein 3 TSF, Driefontein 5 TSF were calculated, while the heights for Cooke TSF and C4S TSF were assumed. For the RTSF, a height of 100 m was assumed for the life of the Project.

Table 4-3: Parameters for the TSFs Considered

Source	Height (m)	Area (m^2)	X length (m)	Y length (m)	Moisture content (%)
Driefontein 3	42	135	1500	900	6.9
Driefontein 5	60	118	1300	910	6.9
Cooke TSF	40	177	1650	1070	6.9
C4S	30	158	1250	1260	6.9
RTSF	100	1382	3590	3850	6.9

For the fine dust component of particulate emissions from industrial wind erosion, a $PM_{2.5}/PM_{10}$ ratio of 0.15 is commonly used. However, a ratio of 0.21 was used in our estimate based on (Cowherd et al 2010; USEPA, 2006; Watson et al, 1996). Dust emissions due to the erosion of open storage piles and exposed areas occur when the threshold wind speed is exceeded (Cowherd *et al.*, 1988; USEPA, 1995). The parameters used in the calculations of the emissions associated with wind erosion are given below (Table 4-4). The emission factors were with mitigation, as most of these tailings already have well established vegetation and hard crust on the surface, and the RTSF will be rehabilitated concurrently.

Table 4-4: Derived Emission Factors for Wind Erosion from TSF (with Mitigation)

Activity	Unit	TSP emission factors	PM_{10} emission factors	$PM_{2.5}$ emission factors
Tailings storage facility	$g/m^2/s$	8.2E-08	2.7E-08	5.73E-09

Table 4-5 gives PSD as adopted from a similar gold reclamation TSF operation used as input parameters for estimating dust deposition rates. Table 4-6 gives an overview of annual emissions from the TSFs due to wind erosion.

Table 4-5: Particle Size Distribution for TSF Material

Source	Particle Size Fraction (%)			
	75 µm	30 µm	10 µm	2.5 µm
Tailings storage facility	0.26	0.30	0.24	0.20

Table 4-6: Estimated Annual Emissions for the Wind Erosion Sources

Activity	Annual emissions (t/y)		
	TSP	PM_{10}	$PM_{2.5}$
Driefontein 3	5.81	2.90	0.61
Driefontein 5	5.09	2.55	0.53
Cooke TSF	7.60	3.80	0.80
C4S	6.78	3.39	0.71
RTSF (Lower Compartment)	27.46	13.73	2.88
RTSF (Lower and Upper Compartments)	59.48	29.74	6.25
Total emissions	**112.22**	**56.11**	**11.78**

4.4.2.1 Emissions from Dirt Roads

Road suspended particulate emissions result from the dust entrainment by vehicle wheels. The usual hauling of ore and waste is not part of the project activity and hence was not considered. Since existing TSFs will be hydraulic reclaimed, emissions from use of dirt roads by workers will be minimal and adjudged negligible.

4.4.2.2 Screens

There will be screening of wet slurry to remove unwanted materials i.e. rocks, metals and biological materials for ease of processing. In most cases where dry grinding is employed, significant emissions of fugitive dust occur. The screening will be a wet process, hence dust emissions from this source are considered negligible.

4.4.2.3 Stack Emission Sources

Stack emissions will be released from the following ultimate infrastructure at the CPP:

- Three Gold Plants;
- Two Uranium Plants;
- Two Roasters;
- One Acid Plant; and
- One boiler.

Table 4-7 below shows the stack parameters used in the dispersion model. The stack parameters for the boiler, acid plant and uranium plants were taken from a previous report by Airshed Planning Professional (Pty) Ltd (Reich and Burger, 2009). In the dispersion model, emission rates for SO_2 and particulates (50 mg/Nm3) from the above report were used. Pollutants associated with the boiler were quantified using the default emission factors from the Australian National Pollutant Inventory (NPI) “Emission Estimation Technique (EET) for Combustion in Boilers version 3.6.

To assess the gold plant and roaster (Kiln), the stack parameters assumed are indicted in Table 4-7 below. However, emission factors from a previous report by uMoya-NILU (uMN045, 2014), for the gold plant and kiln for SO_2, NO_2 and particulate matter were used.

NOTE: These emission factors were used to quantify pollutants from with the CPP sources, the reason being that at the time of compiling this report data associated with the CCP plant stacks and associated emissions were not available. Hence, stack parameters and emission factors from similar operations were adopted.

Table 4-7: Stack Parameters, Gaseous and Particulate Emission Rates for Point Sources

Point Source	Boilers	Acid Plant Stack	Uranium Plant Stack	Gold Plant Stack	Gold kiln (Roaster)
No of Units	1	1	2	3	2
Stack diameter (m)	0.8	1.02	1.02	0.94	0.8
Stack Height (m)	25	36	36	20	25
Temp (K)	473	353	353	295	530
Flow rate (m^3/s)	10.1	10.6	10.6	10.4	0.3
Velocity (m/s)	20	13	13	10	0.5
Emission Rates PM_{10} (g/s)	4.11E-03	0.531	0.531	5.93E-05	1.05E-05
Emission Rates NOx(g/s)	3.03E-02			2.54E-06	6.34E-07
Emission Rates SO_2 (g/s)	2.05E+00	3.47		1.90E-06	6.34E-07
Emission Rates SO_3 (g/s)		0.27			
Emission Rates CO (g/s)	4.58E-02				

4.5 Air Quality Dispersion Modelling

Dispersion models compute ambient concentrations as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations due to emissions from various sources. All emission scenarios were simulated using the United States Environmental Protection Agency's Preferred/Recommended Models: AERMOD modelling system (a regulatory model approved by the Department of Environmental Affairs (DEA) for use in EIAs (DEA, 2012). The latter uses MM5 modelled meteorological data set obtained from Lakes Environmental in Canada. This dataset consists of surface data, as well as upper air meteorological data that is required to run the dispersion model.

All relevant averaging periods were modelled for pollutants of concern. In all instances, the worst-case scenario has been presented to demonstrate the highest predicted impact. It is important to note that highest period-averages (i.e. highest hourly-average and highest 24-hour-average) presented in the maps are indicative of the highest expected concentrations for the period-average for the modelled year at each position in the modelled domain, and must not be interpreted as being representative of general conditions. The intention of the predicted ground level concentrations is to present the worst-case scenario for those averaging periods.

The daily average concentrations were calculated as 99th percentile. Annual averages were shown as the highest values (100th percentile) according to the NEM: AQA Air Dispersion Regulation (2012). Isopleth plots of ground level concentrations for the different pollutants associated with the proposed WRTRP operations were generated.

4.6 Legal Context

The prevailing legislation in the Republic of South Africa with regards to the Air Quality field is the National Environment Management: Air Quality Act, 2004 (Act No. 39 of 2004) (NEM: AQA). The NEM: AQA repealed the Atmospheric Pollution Prevention Act, 1965 (45 of 1965) (APPA) and various other laws dealing with air pollution.

According to the NEM: AQA, the provincial environmental departments, local authorities (district and local municipalities) are separately and jointly responsible for the implementation and enforcement of various aspects of the Act. Each of these spheres of government is obliged to appoint an air quality officer and to co-operate with each other and co-ordinate their activities through mechanisms provided for in the National Environmental Management Act, 1998 (Act No 107 of 1998) (NEMA).

The purpose of NEM: AQA is to set norms and standards that relate to:

- Institutional frameworks, roles and responsibilities;
- Air quality management planning;
- Air quality monitoring and information management;
- Air quality management measures; and
- General compliance and enforcement.

Amongst other things, it is intended that the setting of norms and standards will achieve the following:

- The protection, restoration and enhancement of air quality in South Africa;
- Increased public participation in the protection of air quality and improved public access to relevant and meaningful information about air quality; and
- The reduction of risks to human health and the prevention of the degradation of air quality.

The Department of Environmental Affairs (DEA) has published the National Dust Control Regulations on November 1, 2013. In the New National Dust Control Regulations, terms such as target, action and alert thresholds were omitted. Another notable observation was the reduction of the permissible frequency from three to two incidences within a year. The standard actually adopted a more stringent approach than previously, and would require dedicated mitigation measures now that it is in force.

The National Dust Fallout standard is given in the Table 4-8 below.

Table 4-8: National Dust Fallout Standards (using ASTM D1739:1970 or equivalent)

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

Also, DEA has established National Ambient Air Quality Standards for PM_{10} (Table 4-9) and particulate matter of aerodynamic diameter less than 2.5 micron metres since June 2012 (GN486: 2012) as depicted in

Table 4-10.

Table 4-9: National Ambient Air Quality Standards as of 24 December 2009

National Ambient Air Quality Standards for Sulphur Dioxide (SO_2)				
AVERAGING PERIOD	LIMIT VALUE ($\mu g/m^3$)	LIMIT VALUE (ppb)	FREQUENCY OF EXCEEDANCE	COMPLIANCE DATE
10 Minutes	500	191	526	Immediate
1 hour	350	134	88	Immediate
24 hours	125	48	4	Immediate
1 year	50	19	0	Immediate
The reference method for the analysis of SO_2 shall be ISO 6767.				

National Ambient Air Quality Standards for Nitrogen Dioxide (NO_2)

AVERAGING PERIOD	LIMIT VALUE ($\mu g/m^3$)	LIMIT VALUE (ppb)	FREQUENCY OF EXCEEDANCE	COMPLIANCE DATE
1 hour	200	106	88	Immediate
1 year	40	21	0	Immediate

The reference method for the analysis of NO_2 shall be ISO 7996.

National Ambient Air Quality Standards for Particulate Matter (PM_{10})

AVERAGING PERIOD	LIMIT VALUE ($\mu g/m^3$)	FREQUENCY OF EXCEEDANCE	COMPLIANCE DATE
24 hour	75	4	1 January 2015
1 year	40	0	1 January 2015

The reference method for the determination of the PM_{10} fraction of suspended particulate matter shall be EN 12341.

National Ambient Air Quality Standards for Ozone (O_3)

AVERAGING PERIOD	LIMIT VALUE ($\mu g/m^3$)	LIMIT VALUE (ppb)	FREQUENCY OF EXCEEDANCE	COMPLIANCE DATE
8 hours (running)	120	61	11	Immediate

The reference method for the analysis of ozone shall be the UV photometric method as described in SANS 13964.

National Ambient Air Quality Standards for Benzene (C_6H_6)

AVERAGING PERIOD	LIMIT VALUE ($\mu g/m^3$)	LIMIT VALUE (ppb)	FREQUENCY OF EXCEEDANCE	COMPLIANCE DATE
1 year	5	1.6	0	1 January 2015

The reference methods for the sampling and analysis of benzene shall either be EPA Compendium method TO-14 A or method TO-17.

National Ambient Air Quality Standard for Lead (Pb)

AVERAGING PERIOD	LIMIT VALUE ($\mu g/m^3$)	LIMIT VALUE (ppb)	FREQUENCY OF EXCEEDANCE	COMPLIANCE DATE
1 year	0.5		0	Immediate

The reference method for the analysis of lead shall be ISO 9855.

National Ambient Air Quality Standards for Carbon Monoxide (CO)

AVERAGING PERIOD	LIMIT VALUE (mg/m^3)	LIMIT VALUE	FREQUENCY OF	COMPLIANCE DATE

		(ppm)	EXCEEDANCE	
1 hour	30	26	88	Immediate
8 hour (calculated on 1 hourly averages)	10	8.7	11	Immediate
The reference method for analysis of CO shall be ISO 4224.				

Table 4-10: National Ambient Air Quality Standards for Particulate Matter ($PM_{2.5}$)

National Ambient Air Quality Standards for Particulate Matter ($PM_{2.5}$)			
AVERAGING PERIOD	**LIMIT VALUE (µg/m^3)**	**FREQUENCY OF EXCEEDANCE**	**COMPLIANCE DATE**
24 hours	65	0	Immediate – 31 December 2015
24 hours	40	0	1 January 2016 – 31 December 2029
24 hours	25	0	01 January 2030
1 year	25	0	Immediate – 31 December 2015
1 year	20	0	1 January 2016 – 31 December 2029
1 year	15	0	01 January 2030
The reference method for the determination of PM2.5 fraction of suspended particulate matter shall be EN 14907.			

5 Assumptions and Limitations

The following assumptions and limitations were identified:

- Modelled data will be used if site-specific meteorological data is not available for the impact assessment study of the Project area;
- Data input into the model will be based on all documentation provided by the Client; and
- Stack parameters and some emission factors were adopted from previous reports as the exact specifications of onsite stacks were not available.

6 Screening Assessment

The screening exercise focused on the Kloof, Driefontein, Cooke and Ezulwini Mining Right Areas. Erosion of tailings facilities can lead to ambient particulate loading and poor air quality (Aube *et al.*, 1999, Ojelede *et al*, 2012). The different mining areas are assessed separately.

This air quality site screening assessment considered the prevailing meteorology in the area i.e. wind speed intensities from the different sectors, coupled with the potential implication(s) of wind erosion from existing TSFs on the ambient air quality of the surrounding receptors. This was done as a desktop assessment to inform the decision making process.

Three years' worth of hourly weather data from Lakes Environmental was analysed and used to generate wind rose plots for the Project area. The impact of winds blowing from a sector and sweeping through the identified TSFs in each Mining Right Area will depend on several factors: the intensity of the wind speed, size of the TSF, presence of erodible material amenable to wind erosion and the distance to nearby receptors. The intensity of the wind speeds are illustrated in Figure 7-1 (wind rose for the entire period i.e. 2012 - 2014). The air quality criteria used in the screening exercise are presented in Table 6-1 below.

Table 6-1: Air Quality Criteria

No.	Air Quality Criteria
1	Proximity of TSF to receptor(s)
2	Receptor located downwind
3	Population density of identified receptor(s)

6.1 Kloof Mining Right Area

The wind speed patterns explained below are also applicable to the TSFs in the Kloof Mining Right Area. In the screening exercise the current potential of the TSFs in the Kloof Mining Right Areas as a source of dust was assessed, with the following conclusions reached: The vegetation cover on Kloof 1 is well established and not likely to pose significant dust impact on the surrounding atmosphere. Residential developments are far away from the TSF at four compass points, Kloof 2 on the other hand has a well-established vegetation cover on the sides, but the top is bare and prone to wind erosion. However, the site has a buffer of around 800 m from any residential area and farms. Impacts associated with storm event(s) will be minimal due to the vegetation cover on the sides and the existing buffer between the TSF and the nearest residential area, downwind. The Leeudoorn TSF also has a well-established vegetation cover by the sides but the top is bare and prone to wind erosion. Although the quality of air will be reduced if the latter occurs, there will be minimal impact as the area around consists mainly of open veldt (no residential area) with few farm holdings (limited impacts, i.e. minimal destruction of productive grazing and crop lands, smothering of crops or soiling of grazing land).

However, once reclamation of the TSFs in this MRA commences, impacts on ambient air quality is considered minimal since the tailings will be reclaimed hydraulically (mining will be a wet process). There are no fatal flaws and impacts on nearby communities are not likely to be exacerbated.

6.2 Driefontein Mining Right Area

The screening process tries to assess what the current impacts of the TSFs in the Drienfontein Mining Right Area based on the criteria specified in Table 6-1. The TSFs that make up the Driefontein Mining Right Areas (Driefontein 1 TSF, Driefontein 2 TSF, Driefontein 3 TSF, Driefontein 4 TSF and Driefontein 5 TSF and Libanon) are all within 200 m from existing residential developments. The majority of these developments are down wind and likely to be impacted. For Driefontein 1 TSF and Driefontein 2 TSF, there are communities south that are likely to be impacted by airborne dust from these TSFs. The top of both TSFs do not have vegetation cover but the sides are well vegetated. Driefontein 3 TSF will have minimal impact as the top and side slopes have well established vegetation cover. Driefontein 4 TSF has well established vegetation cover on the side slopes but the top is bare and seems to have formed a hard crust that is not amenable to wind erosion. Hence, this will have less impact on ambient air quality. Driefontein 5 TSF and Libanon, both in the vicinity of residential communities, will pose less impact due the vegetation cover at the top of these TSFs and side slopes.

The reclamation of the TSFs in Driefontein Mining Right Area does not pose any fatal flaw and will not worsen the current air quality scenario of the neighbouring communities such Carletonville. Impacts are considered minimal, as mining will take place by hydraulic reclamation.

6.3 Cooke Mining Right Area

Current scenario is assessed based on the criteria in Table 6-1. The dominant wind directions are from the NNE and N (**Error! Reference source not found.**). From an air quality point of view, winds blowing from the NNE and N will sweep through the Millsite Complex resulting in an increase of dust levels for residents in the Randfontein area, about 1.4 km down wind. In the vicinity of Venterspost TSFs, surrounding land is largely undeveloped. An assessment of the Venterpost 1 and Venterspost 2 show they are covered with vegetation. Hence, the ambient air quality impact on residential development west of the TSFs will be minimal. The Cooke TSF is covered with vegetation on the sides only, and the top surface seems to have been stabilised by the hard crust. For the Cooke TSF, it is anticipated that the barracks less than 1 km from the southern edge will receive minimal impact during storm episode(s). The reason being that there is enough buffer between the Cooke TSF and the nearest residential area.

For C4S TSF, the surrounding area is mainly veldt vegetation with no residential area downwind of the TSF. It is worth mentioning that the TSF is covered with vegetation and only a small section of the top area is bare, but seem to have formed a hard crust which can withstand wind erosion. Impacts anticipated during reclamation will be minimal, owing to the hydraulic reclamation process. No fatal flaw observed during the screening process

6.4 Ezulwini Mining Right Area

In the Ezulwini Mining Right Area, there will be the construction of a pipeline which will have a negligible impact on ambient air quality. No TSF in this area was designated for reclamation. In the course of the screening process, no significant fatal flaw was identified in terms of air quality.

7 Baseline Environment

7.1 Regional Climate and Factors Influencing Air Dispersion

7.1.1 Regional Climate

South Africa is located in the sub-tropics where high pressures and subsidence dominate. However, the southern part of the continent can also serve as a source of hot air that intrudes sub-tropics, and that sometimes lead to convective movement of air masses. On average, a low pressure system will develop over the southern part of the continent, while the normal high pressures will remain over the surrounding oceans. These high pressures are known as Indian High Pressure Cell and Atlantic High Pressure Cell. The intrusion of continents will allow for the development of circulation patterns that will draw moisture (rain) from either tropics (hot air masses over equator) or from the mid-latitude and temperate latitudes.

Southern Africa is influenced by the two major high pressure cells, in addition to various circulation systems prevailing in the adjacent tropical and temperate latitudes. The mean circulation of the atmosphere over Southern Africa is anticyclonic throughout the year (except near the surface) due to the dominance of the three high pressure cells, namely South Atlantic High Pressure, off the west coast, the South Indian High Pressure off the east coast and the Continental High Pressure over the interior.

It is these climatic conditions and circulation movements that are responsible for the distribution and dispersion of air pollutants in the vicinity of the proposed operations and disposal facility site and associated pipeline and between neighbouring provinces and countries bordering South Africa.

7.1.2 Local Climate and Meteorological Overview

Ambient air quality in this region of South Africa is strongly influenced by regional atmospheric movements, together with local climatic and meteorological conditions. The most important of these atmospheric movement routes are the direct transport towards the Indian Ocean and the recirculation over the sub-continents.

The country experiences distinct weather patterns in summer and winter that affect the dispersal of pollutants in the atmosphere. In summer, unstable atmospheric conditions result in mixing of the atmosphere and rapid dispersion of pollutants. Summer rainfall also aids in removing pollutants through wet deposition. In contrast, winter is characterised by atmospheric stability caused by a persistent high pressure system over South Africa. This dominant high pressure system results in subsidence, causing clear skies and a pronounced temperature inversion over the Highveld. This inversion layer traps the pollutants in the lower atmosphere, which results in reduced dispersion and a poorer ambient air quality. Preston-Whyte and Tyson (1988) describe the atmospheric conditions in the winter months as highly unfavourable for the dispersion of atmospheric pollutants.

Modelled meteorological data for the period January 2012 to December 2014 was obtained for a point in the proposed project area near Westonaria (26.317775 S, 27.650683 E). The 2015 data is not available currently. This will be released from January 2016. The spatial and annual variability in the wind field for the proposed project area calculated from the modelled data is clearly evident in **Error! Reference source not found.**. The predominant winds come from the north northeast and north, accounting for 18.9% and 16.7% and winds from the NE sector dominated the wind regime. Wind speeds greater that ≥ 5.4 m/s occurred for about 17.3% throughout the period. Secondary winds were also observed from the north northwest (10%) and northeast (8%). The average wind speed was 3.86 m/s. Wind class frequency distribution per sector is given in **Error! Reference source not found.** and **Error! Reference source not found.**. The patterns during the night, morning and evening hours were somehow similar, with the dominant winds coming from the north, north northeast and north northwest (**Error! Reference source not found.**).

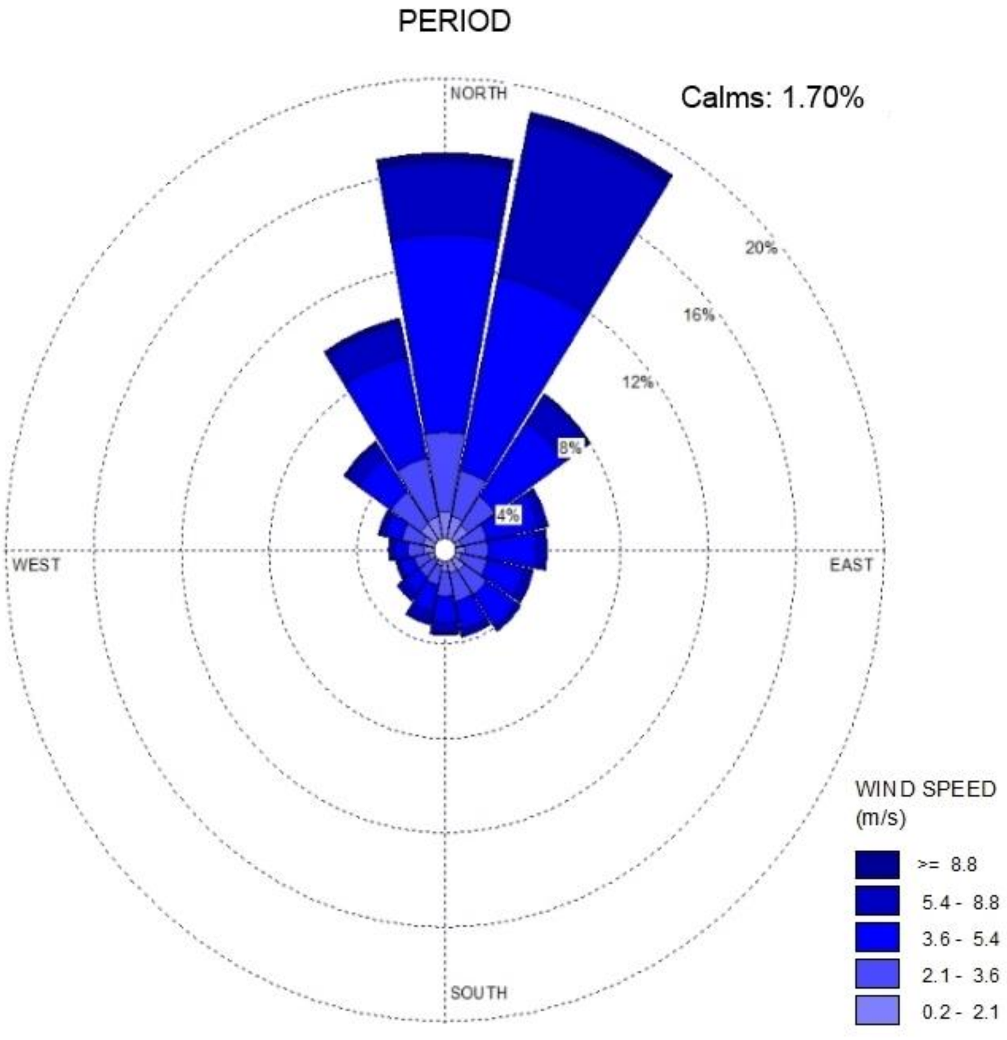


Figure 7-1: Surface Wind Rose for the Sibanye Project Area

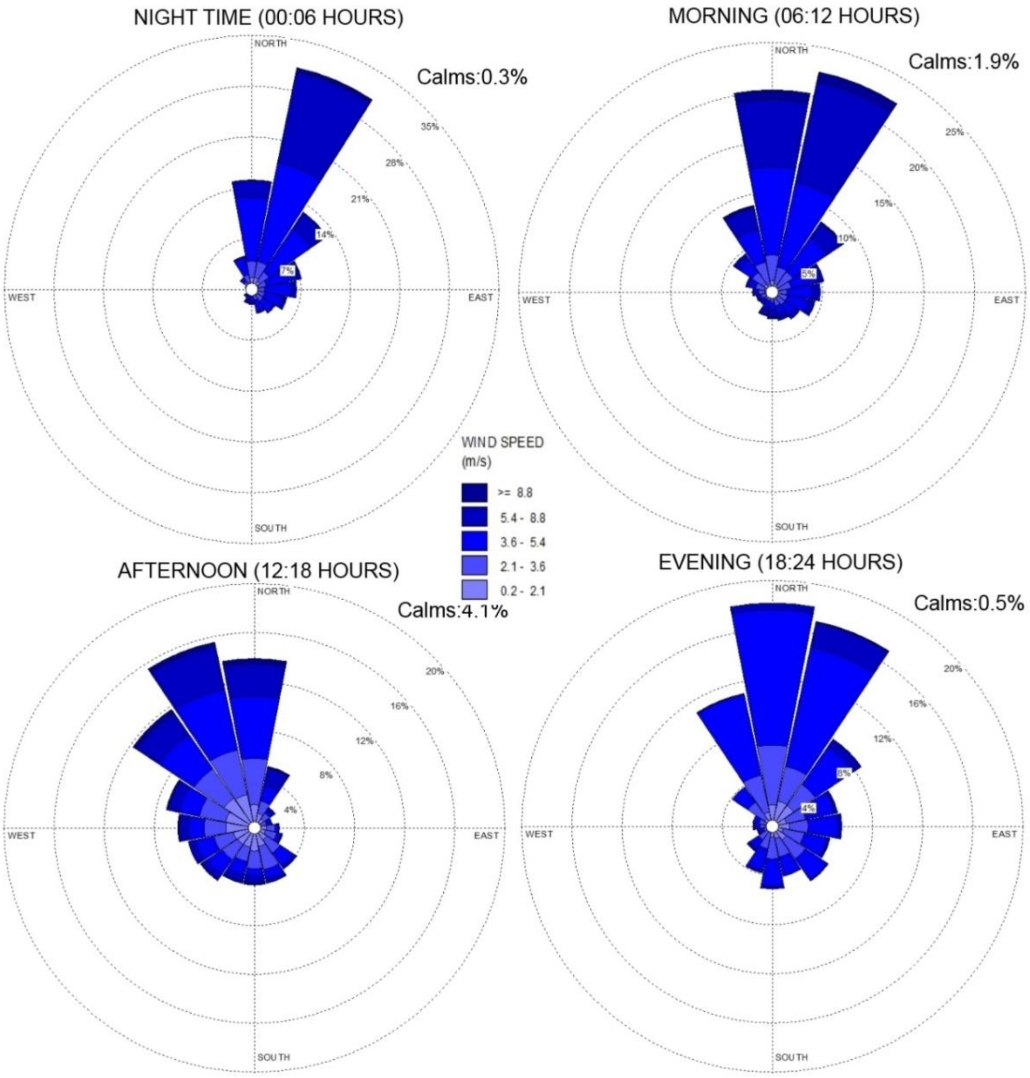


Figure 7-2: Diurnal variation of winds at night 00:00 – 06:00 (top right), morning 06:00 – 12:00 (top left), afternoon 12:00 – 18:00 (bottom left) and evening 18:00 – 24:00 (bottom right)

Error! Reference source not found. shows that the different seasons and the dominant wind patterns observed. In autumn, the north northeast dominated (15%) and winds >5.4m/s occurred for 9.5% of the time. Spring was dominated by winds from north northeast (22%), with wind speed greater than 5.4 m/s occurring for 27.8% of the time. In summer and winter, the dominant winds were observed from north (11.7%) and (~20%) respectively.

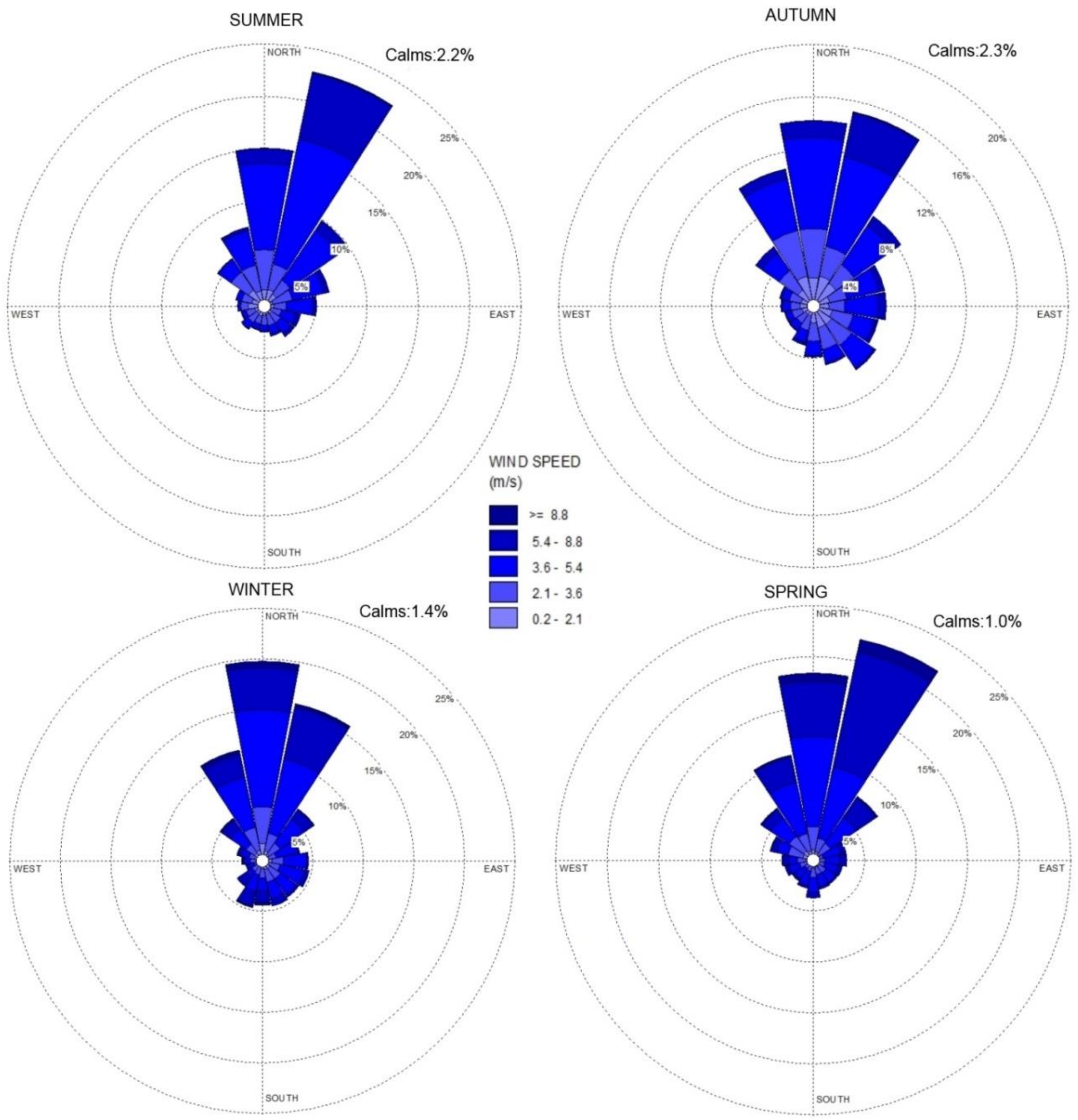


Figure 7-3: Seasonal variation of winds in summer (Dec – Feb), autumn (March – May), winter (Jun – Aug) and spring (Sep – Nov)

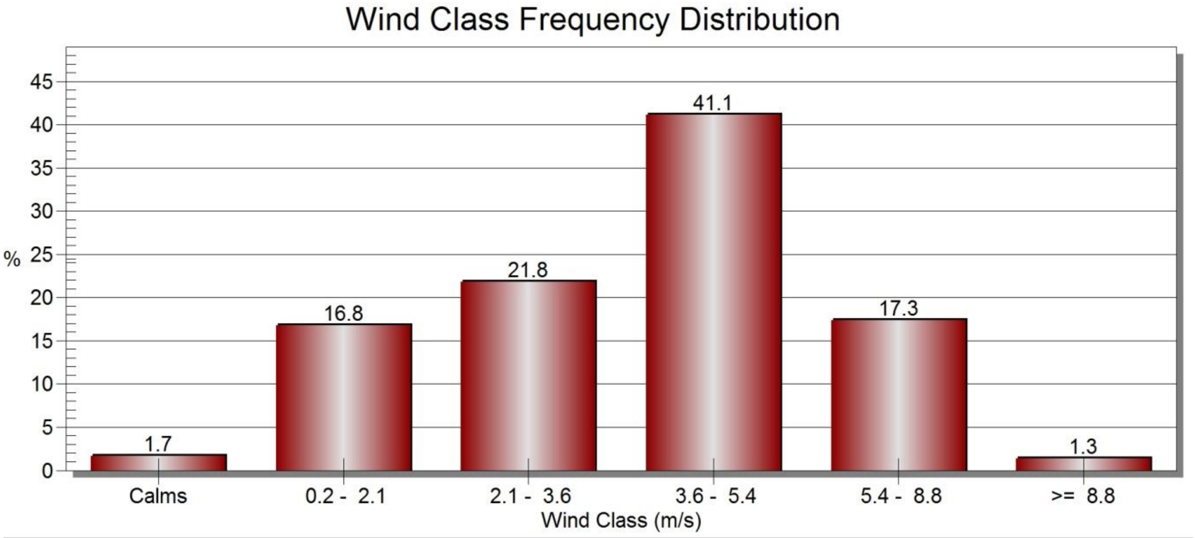


Figure 7-4: Wind class frequency distribution

Table 7-1: Wind class frequency distribution per direction

No.	Directions	0.2 -2.1	2.1 -3.6	3.6 -5.4	5.4 -8.8	>= 8.8	Total (%)
1	N	1.6	3.4	8.4	3.1	0.4	16.8
2	NNE	1.5	2.0	8.4	6.6	0.4	18.9
3	NE	1.3	1.5	3.8	1.4	0.1	8.0
4	ENE	0.8	1.2	2.4	0.4	0.0	4.8
5	E	0.9	1.0	2.2	0.5	0.0	4.7
6	ESE	0.8	1.2	1.7	0.4	0.0	4.1
7	SE	1.1	1.2	1.6	0.3	0.0	4.2
8	SSE	1.0	1.2	1.2	0.3	0.0	3.8
9	S	0.9	1.0	1.1	0.5	0.1	3.6
10	SSW	0.7	0.8	1.2	0.5	0.0	3.2
11	SW	0.6	0.8	0.8	0.4	0.0	2.6
12	WSW	0.8	0.7	0.6	0.2	0.0	2.3
13	W	1.0	0.7	0.6	0.2	0.0	2.6
14	WNW	1.0	1.0	0.8	0.3	0.0	3.1
15	NW	1.3	1.6	1.8	0.7	0.1	5.6
16	NNW	1.5	2.5	4.4	1.5	0.2	10.0
Sub-Total		**16.8**	**21.8**	**41.1**	**17.3**	**1.3**	**98.3**
	Calms						1.7
	Missing/Incomplete						0
Total							**100**

7.1.3 Topography

The area has a number of significant topographical features like high ridgelines and valleys that are prominent in the landscapes. The Project areas elevation ranges from 1465 m to 1751 mamsl.

7.1.4 Temperature

The monthly temperature maximum and average for the project area are given in Table 7-2. The monthly maximum temperatures range from 8.8°C in July to 18.2°C in January, with monthly average ranging from 2.4°C in July to 13.2°C in January (Figure 7-5). Annual mean temperature for the area is given as 15.23°C.

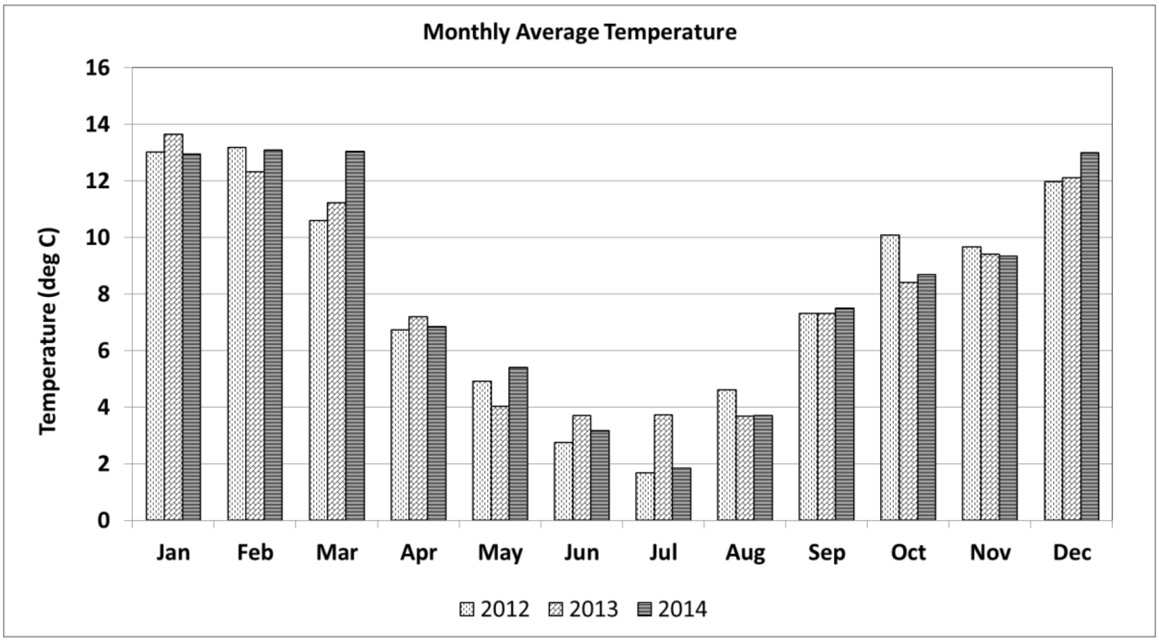


Figure 7-5: Monthly Average Temperature

Table 7-2: Monthly Average Temperature Values

Temp(°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	18.2	18.2	17.9	14.9	13.5	11.4	8.8	14.1	15.3	16.0	17.2	17.3	15.2
Monthly Mean	13.2	12.8	11.6	6.9	4.8	3.2	2.4	4.0	7.4	9.1	9.5	12.4	8.1

7.1.5 Relative Humidity

The data in Table 7-3 is representative of the relative humidity for the proposed WRTRP area. The annual maximum, minimum and average relative humidity is given as 66.4 %, 61.6 % and 63.8 % respectively. The daily maximum relative humidity remains above 60 % for most of the year, and range from 57.9 % in November to 74.2 % in March. The daily minimum relative humidity on the other hand is above 56 % for the whole year, with the highest minimum (67.2 %) observed in June and the lowest (55.6 %) occurring in November.

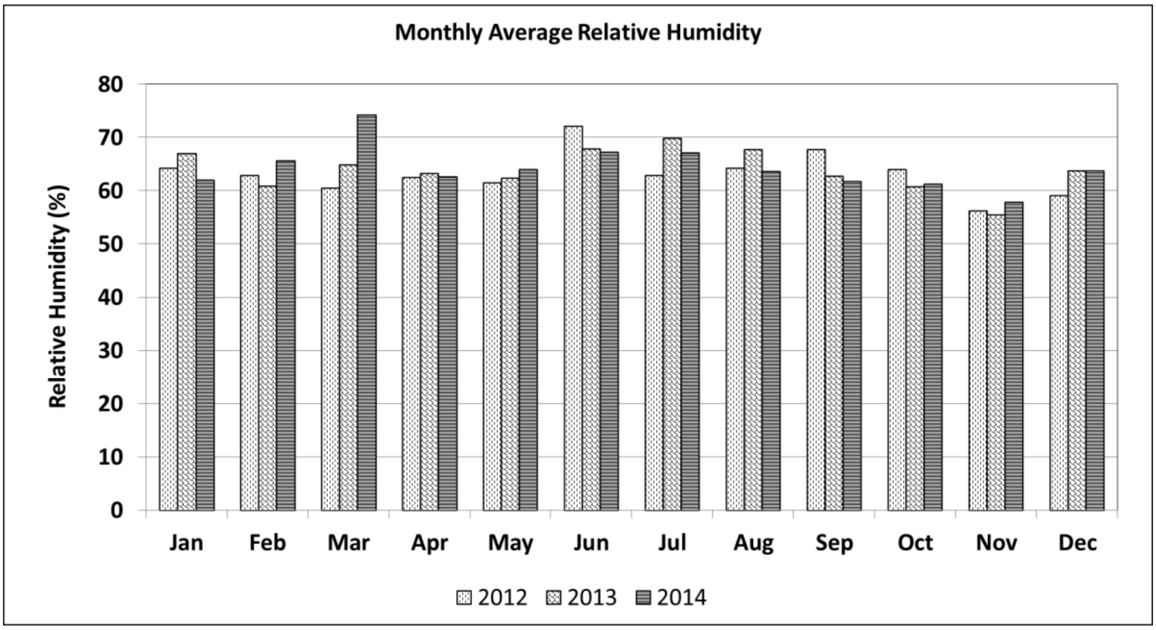


Figure 7-6: Monthly Average Relative Humidity

Table 7-3: Monthly Average Relative Humidity Values

Relative Humidity (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	67.1	65.6	74.2	63.3	64.0	72.2	69.9	67.7	67.7	64.0	57.9	63.8	66.4
Monthly Min.	62.1	60.9	60.6	62.5	61.5	67.2	63.0	63.6	61.8	60.8	55.6	59.1	61.6
Monthly Ave.	64.5	63.1	66.5	62.8	62.6	69.1	66.7	65.2	64.1	62.0	56.5	62.2	63.8

7.1.6 Precipitation

As shown in Table 7-4, for the three years data considered, the total monthly rainfall (max) and average total monthly rainfall are reported. The annual totals and average of 1065 mm and 591 mm, respectively, are reported.

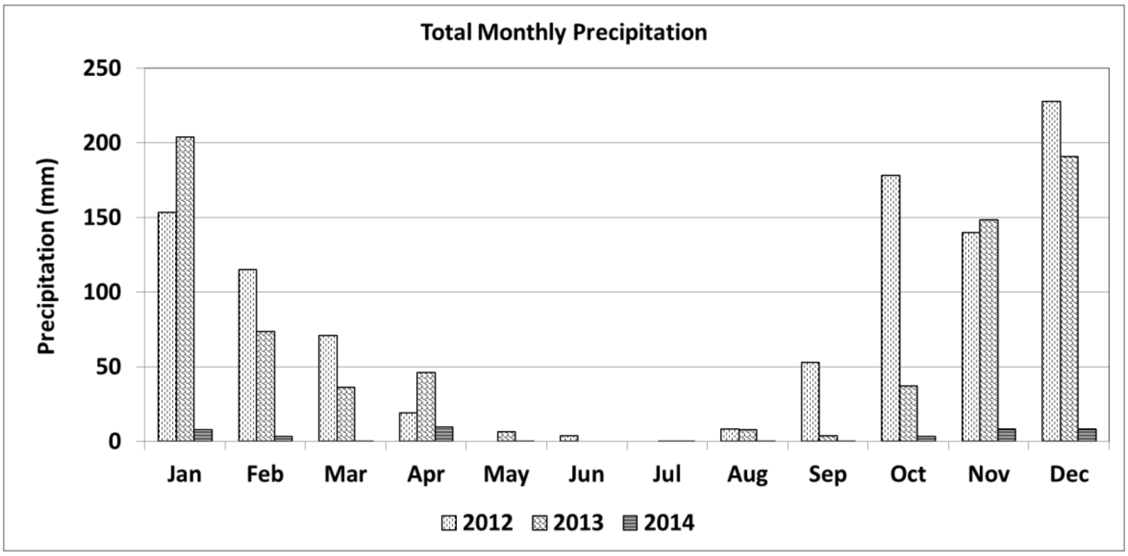


Figure 7-7: Total Monthly Precipitation

Table 7-4: Total Monthly and Average Precipitation Values

Precipitation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Total Monthly Rainfall (Max).	204.2	115.1	70.9	46.2	6.9	4.1	0.5	8.6	53.1	178.3	148.6	228.1	1065
Average Total Monthly Rainfall	122.0	64.1	35.8	25.1	2.6	1.4	0.3	5.8	19.2	72.9	99.1	142.5	591

7.1.7 Evaporation

As shown in Table 7-5, the maximum, minimum and mean monthly evaporation rates as measured in the Westonaria area for the period 1957-1987 are 263 mm, 113 mm and 178 mm, respectively. The South African Weather Service has stopped collecting evaporation data, hence the use of archived records. The highest monthly maximum evaporation (322 mm) occurred in October and the lowest of 68 mm in April. The monthly minimum evaporation ranges between 68 mm (April) and 180 mm in October. The average monthly evaporation is presented in Figure 7-8.

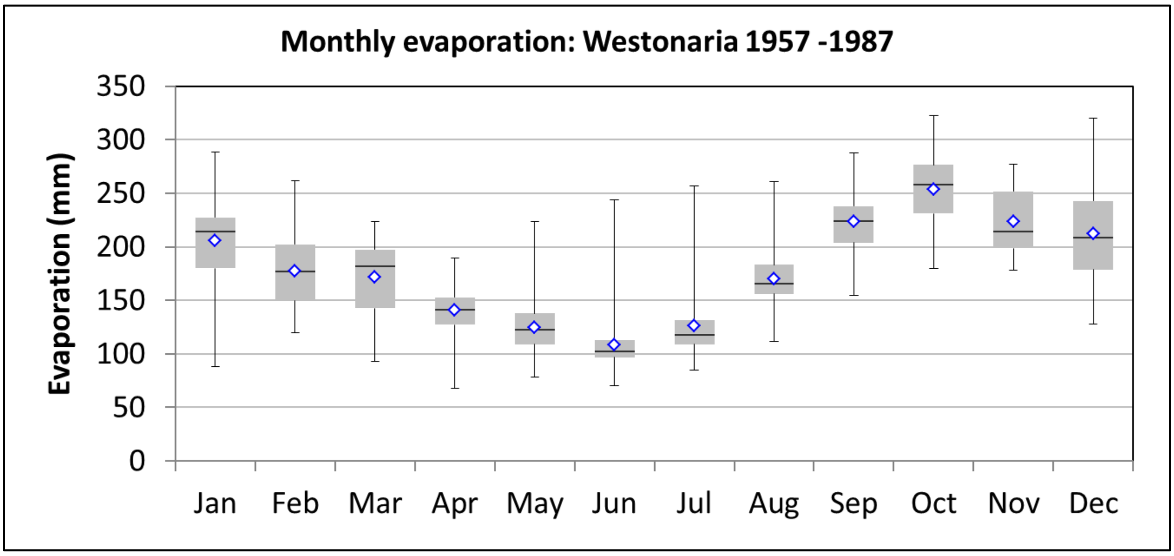


Figure 7-8: Monthly evaporation for Westonaria S-Pan Evaporation Station (1957 – 1987) (Source: South African Weather Service)

Table 7-5: Monthly Evaporation Rates for Westonaria

Evaporation (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Monthly Max.	289	262	224	190	223	244	257	261	288	322	277	320	263
Monthly Min.	88	120	93	68	79	70	85	111	155	180	178	128	113
Monthly Mean	206	177	171	141	124	109	126	170	224	253	224	212	178

7.1.8 Boundary Layer Properties and Atmospheric Stability

The region of the atmosphere governing transport and dispersion of the majority of the pollutants is the planetary boundary layer. This layer is defined as the layer where the wind structure is influenced by the surface of the Earth (Preston-Whyte and Tyson (1988)).

The height of the planetary boundary layer varies with the atmospheric stability and this is important for the concentrations of pollutants in the air because the majority of the pollutant mass typically is confined within this layer. During night-time when conditions in most cases are stable, the planetary boundary layer is shallow, down to 20-50 metres and the surface concentration of pollutants can therefore be quite high, especially close to emission sources that are active during the night. Under unstable conditions the planetary boundary layer can be as high as 2 kilometres and pollutants are in this case distributed in the air column mainly by convective turbulence.

The atmospheric conditions may be divided into three broad classes in terms of stability: neutral, stable and unstable conditions. These major three categories are characterised by the following:

- *Neutral* conditions where the temperature is homogeneous throughout the boundary layer. This situation typically occurs in the transition from day to night and is characterised by strong winds and clouds and large amounts of mechanical turbulence.

- *Stable* conditions where the temperature is lowest close to the surface and increases towards the top of the boundary layer. This situation typically occurs during night-time or in winter situations and is characterised by little turbulence and a strong stratification of the planetary boundary layer which is quite shallow. This class can be further divided into stable and very stable classes.
- *Unstable* conditions where the temperature of the air closest to the surface is higher than the temperature of the air above it. This situation typically occurs during daytime at summer when the sun is shining and it is characterised by large amounts of convective turbulence usually resulting in the formation of cumulus clouds during the day. This class can be further divided into very unstable, moderately unstable and unstable classes.

The refined classes of atmospheric stability classes are further defined in the Table 7-6 and Table 7-7.

Table 7-6: Atmospheric Stability Classes

Designation	Stability Class	Atmospheric Condition
A	Very unstable	Calm wind, clear skies, hot daytime conditions
B	Moderately unstable	Clear skies, daytime conditions
C	Unstable	Moderate wind, slightly overcast daytime conditions
D	Neutral	High winds or cloudy days and nights
E	Stable	Moderate wind, slightly overcast night-time conditions
F	Very stable	Low winds, clear skies, cold night-time conditions

Table 7-7: Meteorological Conditions that define the Pasquill Stability Classes

Surface wind speed	Daytime incoming solar radiation			Night time cloud cover	
m/s	Strong	Moderate	Slight	> 50%	< 50%
< 2	A	A – B	B	E	F
2 – 3	A – B	B	C	E	F
3 – 5	B	B – C	C	D	E
5 – 6	C	C – D	D	D	D
> 6	C	D	D	D	D

*Note: Class D applies to heavily overcast skies, at any wind speed day or night.

7.2 Particulate Matter

Major atmospheric pollutants in the proposed Project area will be influenced by existing local and regional sources in the area, which includes mainly:

- Precious Metals Refinery;
- Tailings Storage Facilities; and
- Agricultural activities in the area.

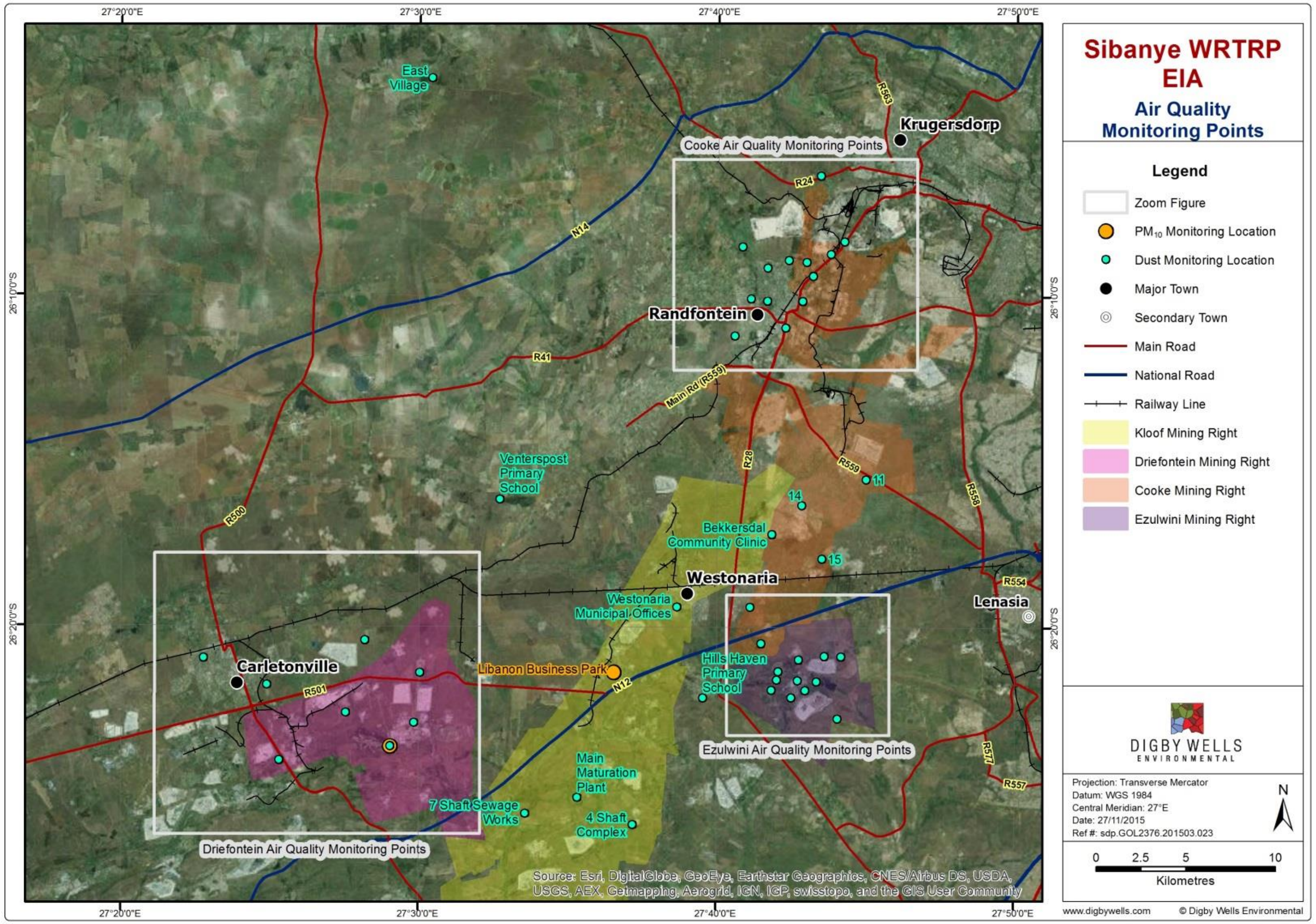
In terms of Air Quality, the baseline can be established with available dust deposition data and particulate matter – PM_{10} and $PM_{2.5}$ and Gaseous pollutants (if available). Data provided by SGL was used to assess the Air Quality background of the project site, and this is discussed in details below.

7.2.1 Dust Fallout Baseline

Dust deposition data is crucial as it shows monthly, seasonal, and inter-annual variability in dust fallout rates – pre and during the operational phase of an activity. The amount of dust collected at any given time is a function of the rate of deposition, which may vary widely depending on the meteorological factors described previously, such as wind speed intensity, direction and variations in the background dust concentrations. The dust fallout sampling, analyses, and interpretation is conducted according to the recommended SANS 1929:2011 (adapted from ASTM1739-98) expressed in the units of mg/m^2/day averaged over a 30-day period.

SGL has provided dust deposition data for the WRTRP area dating back to 2006 for analysis and interpretation. Several networks are currently operational at the Kloof, Driefontein, Cooke, Ezulwini Mining Right Area. The different monitoring networks currently in operation and their relative position to each other are depicted in Figure 7-9.

In terms of dust deposition standards for this study, the NDCR 2013 standard which classified two areas: residential and non-residential was applicable in the assessment phase. With regards to the graphs, the green line represents the limit which the dust fallout levels are permissible for residential areas, and the red line represents the limit which the dust fallout levels are permissible for non-residential areas. For residential and non-residential limits, the current margin of tolerance is two exceedances within a year, and no two sequential months (NDCR, 2013).



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 7-9: Air Quality Monitoring Points at the different MRAs

7.2.1.1 Kloof Mining Right Area

The Kloof Dust Watch (Community Initiative) results confirm that dust collected at the different sites is imported from the four compass points north, south, east and west. Figure 7-10 (Bekkersdal Community Clinic) and Figure 7-11 (Manyano Shaft) the two worst cases are used to depict the deposition rates observed. However, results from the other sites in the network are discussed below and not represented graphically.

7.2.1.1.1 Venterspost Primary

Exceedances were observed in August and September of 2010, with imports from the east and north dominating the results. In 2011, an exceedance was observed in August with import from the south and east dominating. Deposition rates in 2012 were all below the recommended standard of 600 mg/m2/day. In 2013, the month of December exceeded the residential limit with equal contribution from all directions. In 2014, 75% of the months exceeded 400 mg/m^2/day. The months of August and September were worse with deposition rates above the industrial limit of 1200 mg/m^2/day.

7.2.1.1.2 Bekkersdal Community Clinic

Through 2010 – 2013, deposition rates were within the residential and non-residential limits, although the rates were higher in August and September. In 2014, the dust deposition rate was intense, with 58% of the months exceeding the non-residential limit of 1200 mg/m^2/day.

7.2.1.1.3 Manyano Shaft

As in other sites, the dusts collected are imports from north, south, east and west. Often; the months of August and September are highest. In 2010, deposition rates exceeded the industrial limit with imports from north and south dominating. Deposition rates for half of the year exceeded the non-residential limit of 1200 mg/m^2/day.

7.2.1.1.4 Ikamva Shaft

For the period 2010 – 2013, deposition rates were within the residential and non-residential limits, except in August and September of 2010 (both month exceeded the non-residential limit). In 2014, deposition rates were intense with 9 months exceeding the non-residential limit of 1200 mg/m^2/day.

7.2.1.1.5 KLF BMD

The dust deposition rates measured were imports from all compass points, with imports from the west and east dominating. Dust deposition rates were all below the residential limit of 600 mg/m^2/day.

7.2.1.1.6 Hills Haven Primary

September and December 2010 were in exceedance of the residential limit. In year 2014, January, August and November exceeded the residential limit. September and October exceeded non-residential limit.

7.2.1.1.7 Thuthukane Shaft

August and September 2010, August 2011 were in exceedance of the residential limit. In 2014, the residential limit was also exceeded in January and April. The months of September and October 2014 exceeded the non-residential limit. The dust deposition rates recorded on site were imports from the four compass points.

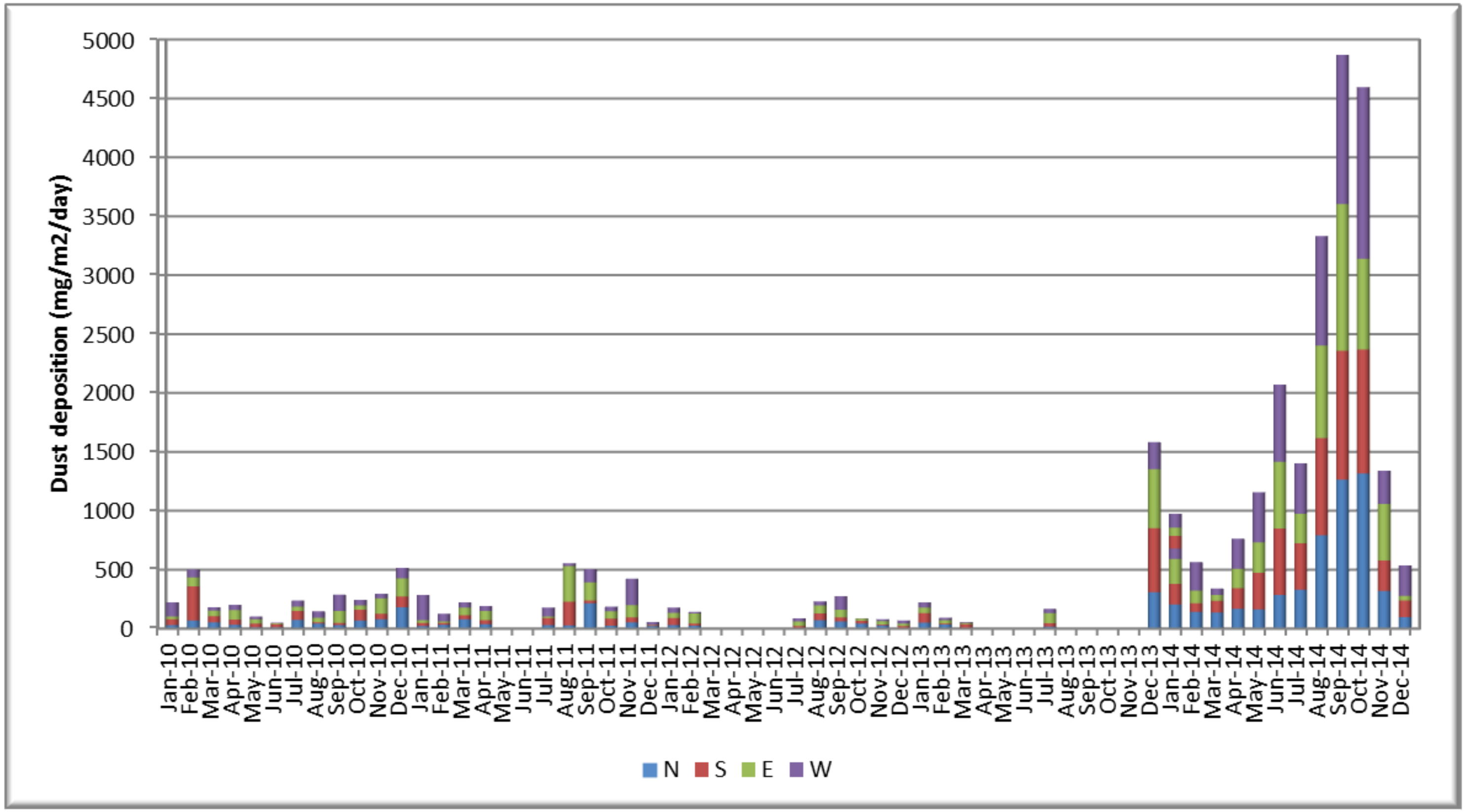


Figure 7-10: Kloof Dust Watch – Bekkersdal Community Clinic

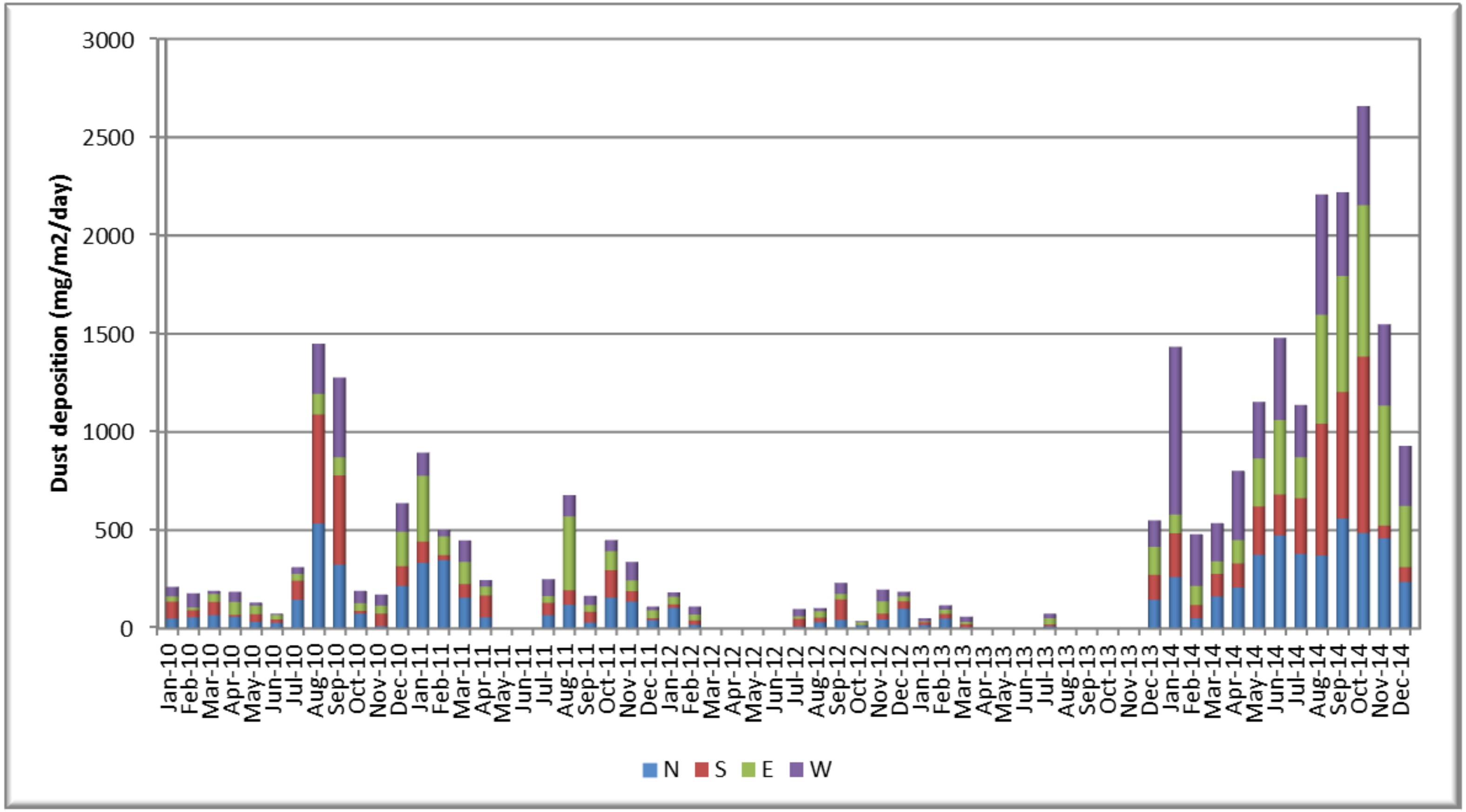


Figure 7-11: Kloof Dust Watch – Manyano Shaft

7.2.1.2 Driefontein Mining Right Area

Dust deposition rates for Driefontein dust watch sites are shown below (Figure 7-12 and Figure 7-13). It is however worth mentioning that several exceedances of the residential limit and non-residential limits were observed for the period 2010-2014. Often, the exceedances occur around August through to November.

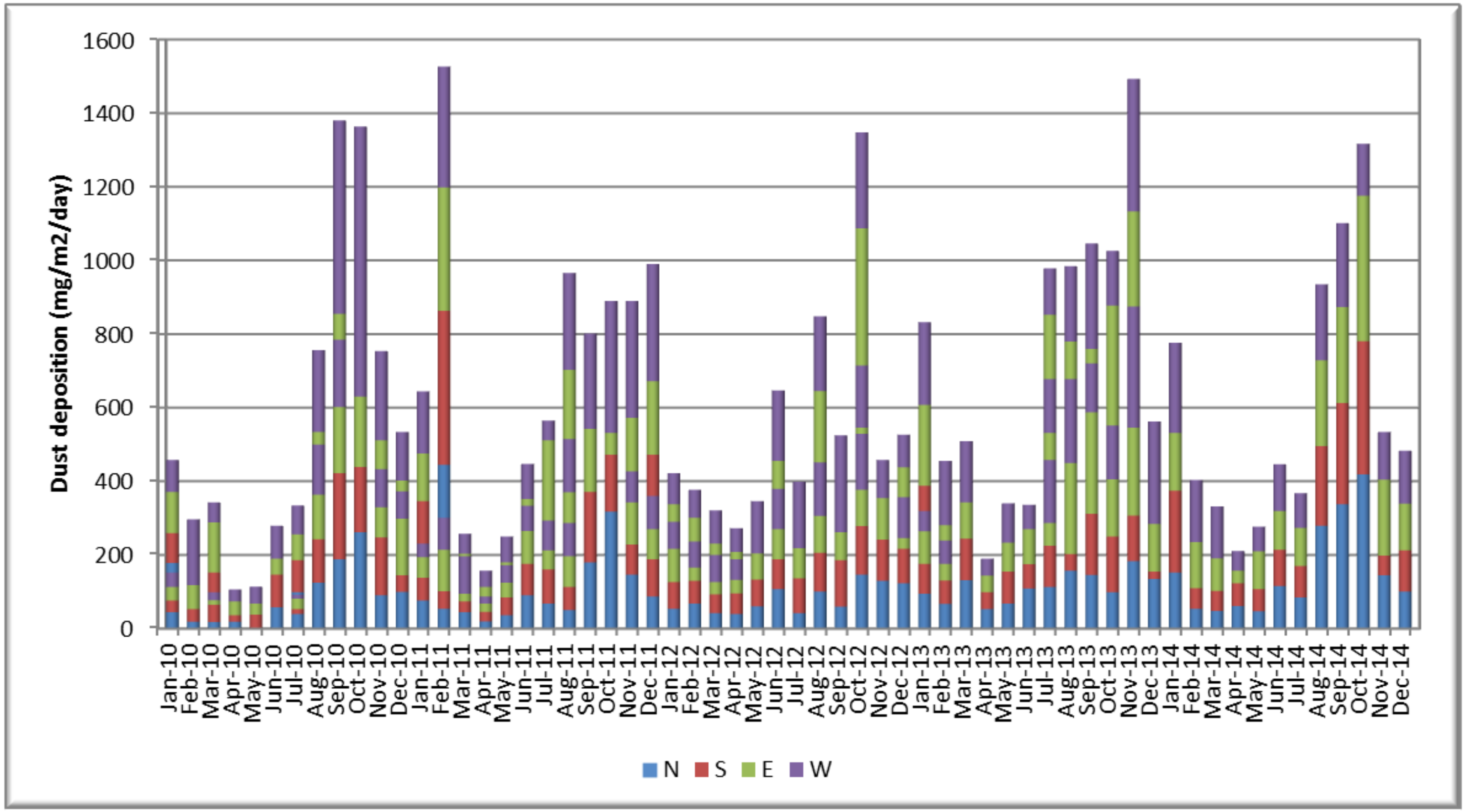


Figure 7-12: Driefontein Dust Watch – Carletonville 1

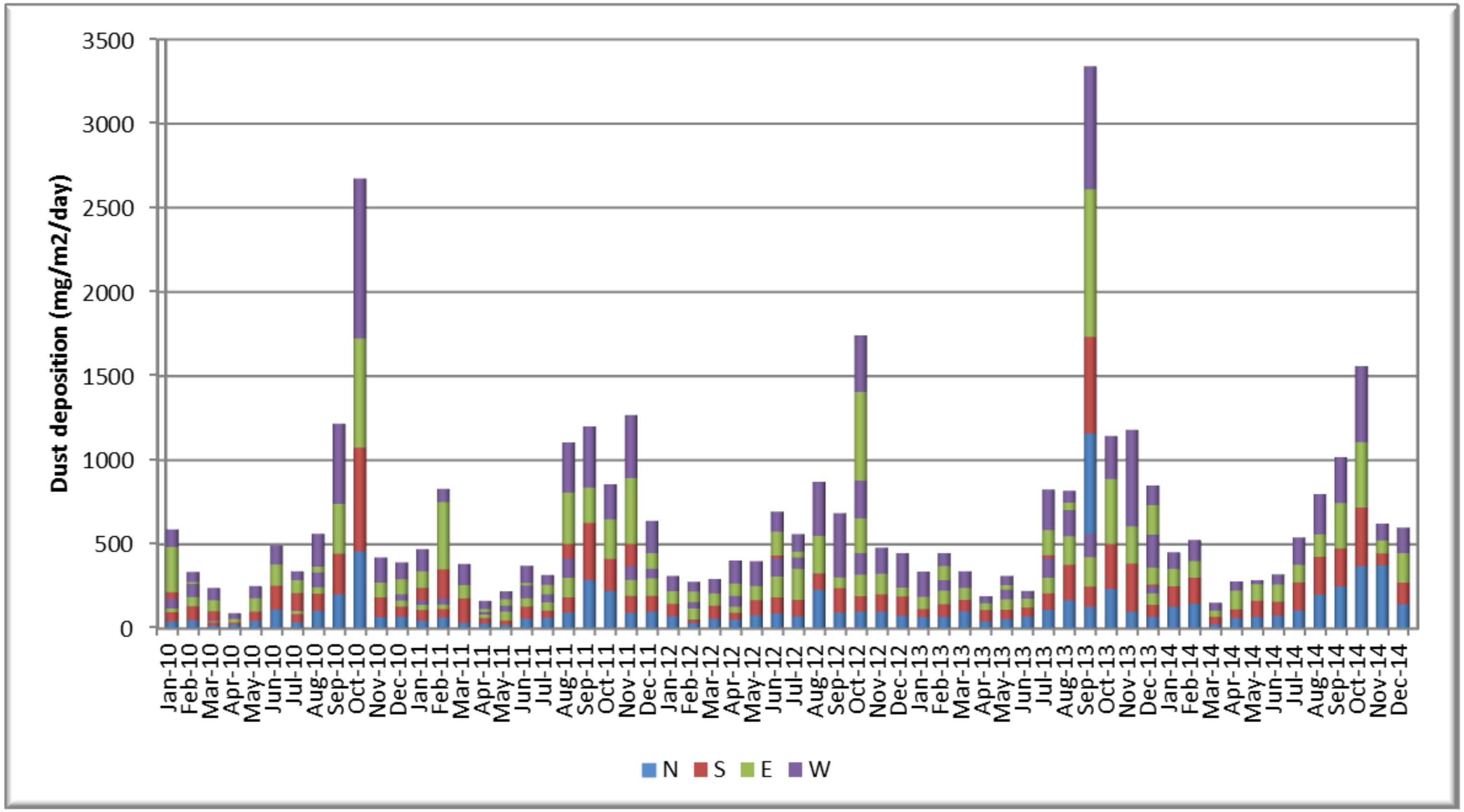


Figure 7-13: Driefontein Dust Watch – Carletonville 2

7.2.2 PM_{10} Baseline

Data from the current Driefontein particulate matter monitor is presented below. The particulate monitor is located at West Village (S 26 23.646', E 027 29.054'). Data for 2013 and 2014 were made available for analyses. The ambient concentrations observed in 2013 are below the current standard of 75 ug/m^3, which came into effect in January 2015. There were no exceedances observed throughout the period (Figure 7-14).

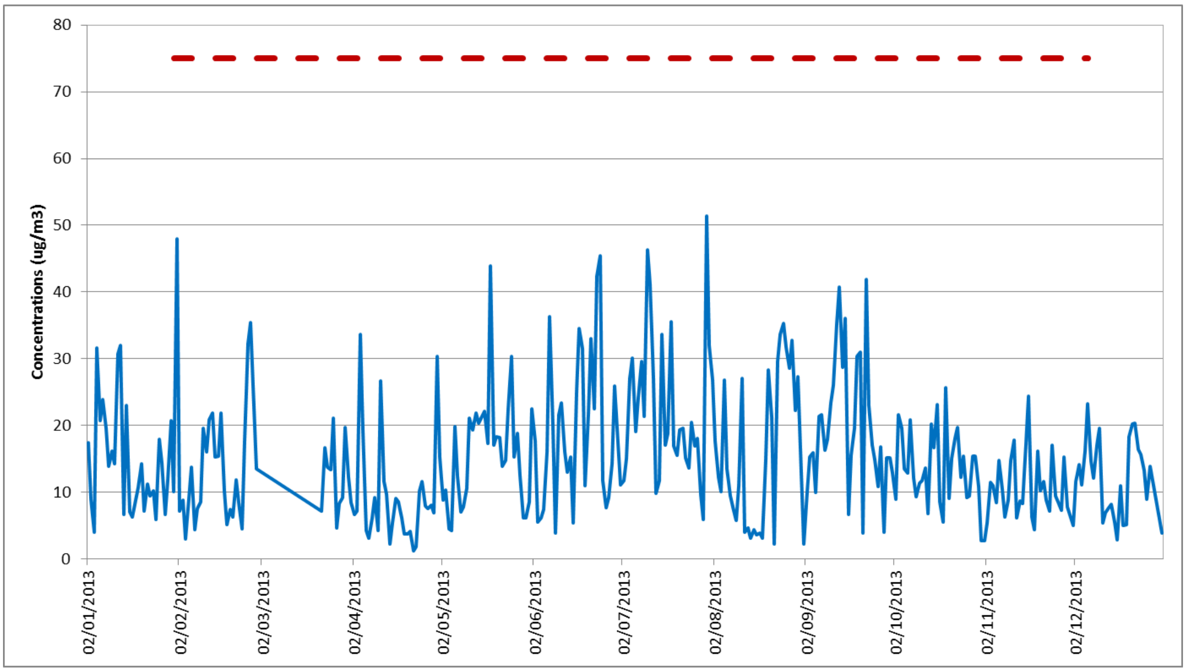


Figure 7-14: Driefontein – Ambient PM_{10} Concentrations (2013)

In 2014, the measured ambient concentrations of PM_{10} were below the standard until August, September and October when exceedances were observed. The exceedance can be attributed to dust storm episode which usually intensifies during these months. The NAAQS of 75 µg/m^3 was exceeded twice in August, twice in September and once in October (Figure 7-15).

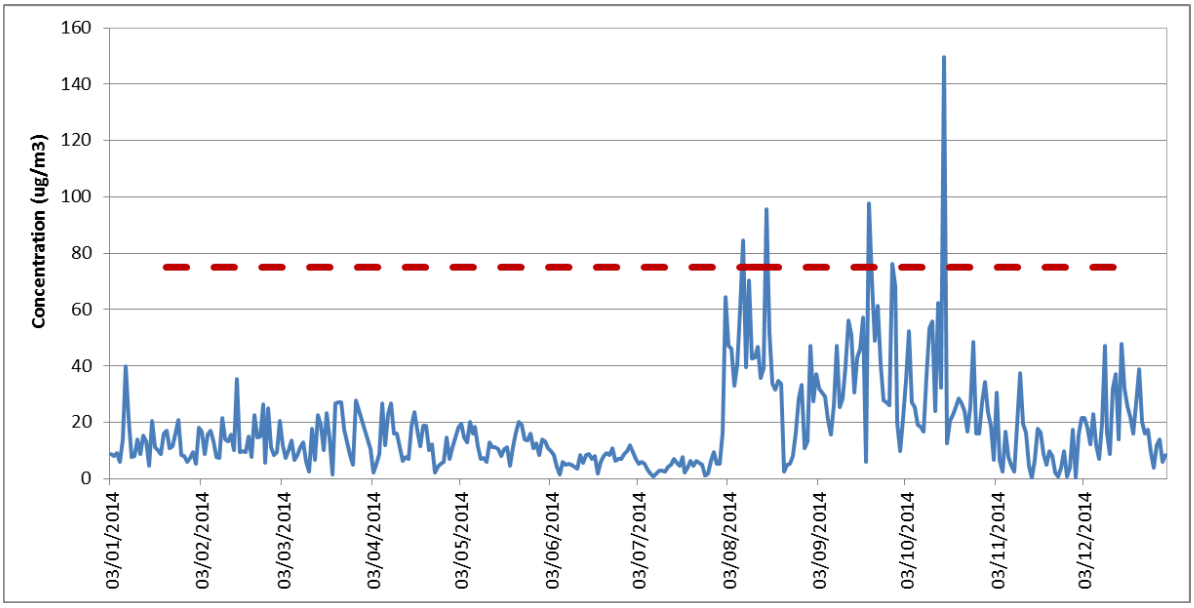
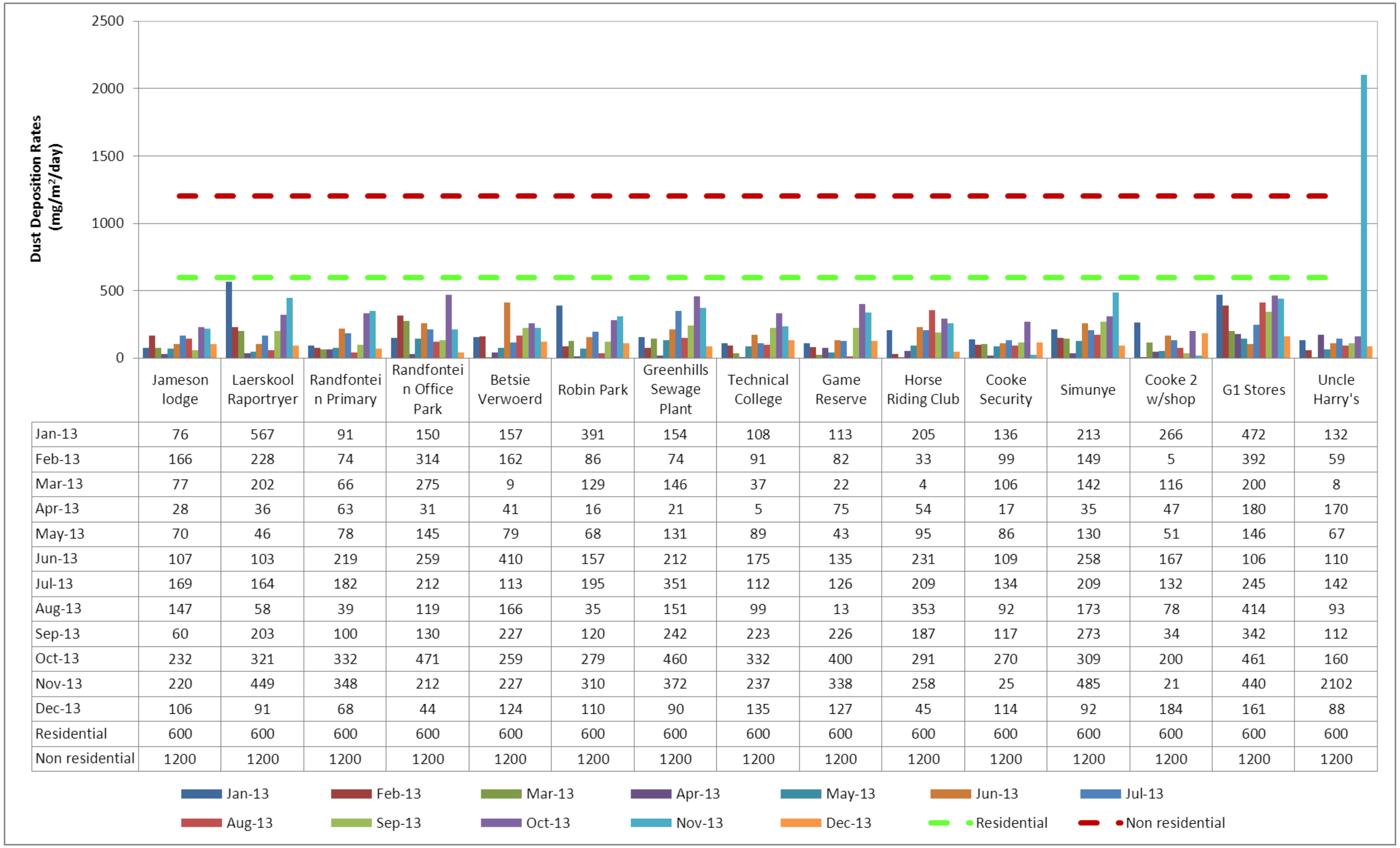


Figure 7-15: Driefontein – Ambient PM_{10} Concentrations (2014)

7.2.2.1 Cooke Mining Right Area

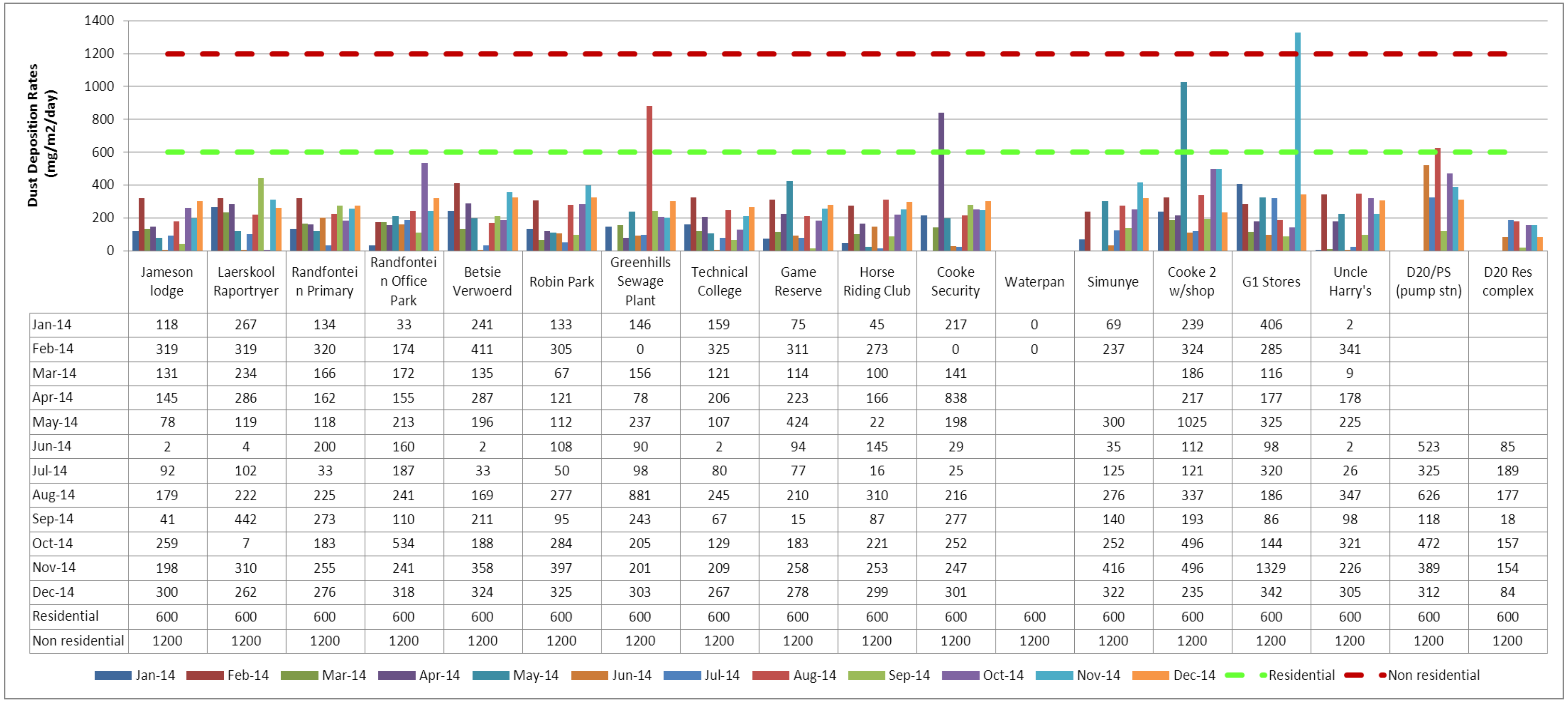
Data from Rand Uranium dust monitoring network are represented with dust fall rates measured in 2013 and 2014 (Figure 7-16 and Figure 7-17). In 2013 all sites were within the 600 mg/m^2/day recommended for residential areas, with the exception of December at sites Uncle Harry with deposition rate of 2 102 mg/m^2/day.

Exceedances observed in 2014 were observed predominantly in July, with different sites exceeding the standard for residential areas - 600 mg/m2/day (NDCR 2013). There was no violation of the permissible frequency of exceedance. The current margin of tolerance is two exceedances within a year, no two sequential months (NDCR, 2013).



	Jameson lodge	Laerskool Raportryer	Randfontein Primary	Randfontein Office Park	Betsie Verwoerd	Robin Park	Greenhills Sewage Plant	Technical College	Game Reserve	Horse Riding Club	Cooke Security	Simunye	Cooke 2 w/shop	G1 Stores	Uncle Harry's
Jan-13	76	567	91	150	157	391	154	108	113	205	136	213	266	472	132
Feb-13	166	228	74	314	162	86	74	91	82	33	99	149	5	392	59
Mar-13	77	202	66	275	9	129	146	37	22	4	106	142	116	200	8
Apr-13	28	36	63	31	41	16	21	5	75	54	17	35	47	180	170
May-13	70	46	78	145	79	68	131	89	43	95	86	130	51	146	67
Jun-13	107	103	219	259	410	157	212	175	135	231	109	258	167	106	110
Jul-13	169	164	182	212	113	195	351	112	126	209	134	209	132	245	142
Aug-13	147	58	39	119	166	35	151	99	13	353	92	173	78	414	93
Sep-13	60	203	100	130	227	120	242	223	226	187	117	273	34	342	112
Oct-13	232	321	332	471	259	279	460	332	400	291	270	309	200	461	160
Nov-13	220	449	348	212	227	310	372	237	338	258	25	485	21	440	2102
Dec-13	106	91	68	44	124	110	90	135	127	45	114	92	184	161	88
Residential	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
Non residential	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200

Figure 7-16: Dust Deposition Record for RU Monitoring Network (2013)



	Jameson lodge	Laerskool Raportryer	Randfontein Primary	Randfontein Office Park	Betsie Verwoerd	Robin Park	Greenhills Sewage Plant	Technical College	Game Reserve	Horse Riding Club	Cooke Security	Waterpan	Simunye	Cooke 2 w/shop	G1 Stores	Uncle Harry's	D20/PS (pump stn)	D20 Res complex
Jan-14	118	267	134	33	241	133	146	159	75	45	217	0	69	239	406	2		
Feb-14	319	319	320	174	411	305	0	325	311	273	0	0	237	324	285	341		
Mar-14	131	234	166	172	135	67	156	121	114	100	141			186	116	9		
Apr-14	145	286	162	155	287	121	78	206	223	166	838			217	177	178		
May-14	78	119	118	213	196	112	237	107	424	22	198		300	1025	325	225		
Jun-14	2	4	200	160	2	108	90	2	94	145	29		35	112	98	2	523	85
Jul-14	92	102	33	187	33	50	98	80	77	16	25		125	121	320	26	325	189
Aug-14	179	222	225	241	169	277	881	245	210	310	216		276	337	186	347	626	177
Sep-14	41	442	273	110	211	95	243	67	15	87	277		140	193	86	98	118	18
Oct-14	259	7	183	534	188	284	205	129	183	221	252		252	496	144	321	472	157
Nov-14	198	310	255	241	358	397	201	209	258	253	247		416	496	1329	226	389	154
Dec-14	300	262	276	318	324	325	303	267	278	299	301		322	235	342	305	312	84
Residential	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
Non residential	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200

Figure 7-17: Dust Deposition Record for RU Monitoring Network (2014)

7.2.2.2 Ezulwini Mining Right Area

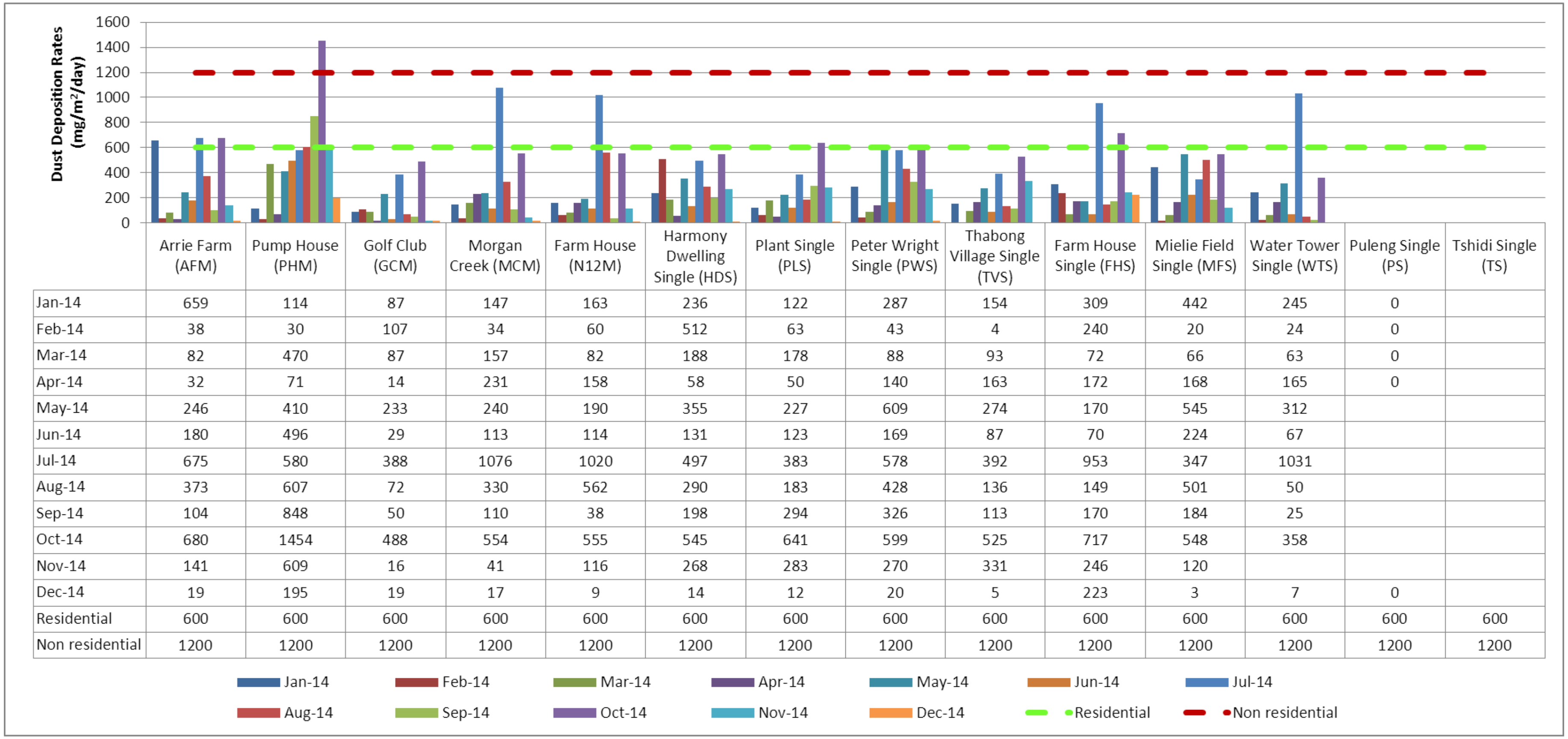
Figure 7-18 and Figure 7-19 represent the dust deposition measurements collected at the Ezulwini network.

In 2013, although sites such as N12M, HDS and PWS were in exceedance of the recommended 600 mg/m^2/day in the month of August, the only violation of the recommended standard was at site AFM. At site AFM the recommend residential limit was exceeded for four consecutive months in a row. Thus, in violation of the permissible margin of tolerance of two exceedances within a year, and no two sequential months (NDCR, 2013).

In 2014, the exceedances were observed predominantly in July at six different sites. The only violation observed was at site PHM with three consecutive months; August (607 mg/m^2/day), September (848 mg/m^2/day) and October (1454 mg/m^2/day).

	Arrie Farm (AFM)	Pump House (PHM)	Golf Club (GCM)	Morgan Creek (MCM)	Farm House (N12M)	Harmony Dwelling Single (HDS)	Plant Single (PLS)	Peter Wright Single (PWS)	Thabong Village Single (TVS)	Farm House Single (FHS)	Mielie Field Single (MFS)	Water Tower Single (WTS)	Puleng Single (PS)	Tshidi Single (TS)
Jan-13	186	160	77	85	196	106	49	44	58	437	128	90	0	
Feb-13	182	75	120	173	125	119	85	68	40	143	305	51	0	
Mar-13	315	29	52	29	51	68	68	17	17	10	6	24	0	
Apr-13	37	29	66	65	26	69	161	69	42	20	271	34	0	
May-13	349	37	73	58	66	18	56	59	82	116	77	62		
Jun-13	635	98	46	67	160	311	53	206	81	76	222	58		
Jul-13	668	137	95	69	224	368	54	300	123	117	239	76		
Aug-13	1159	654	251	290	733	624	294	879	266	296	310	232		
Sep-13	1170	661	195	171	454	278	216	558	153	252	268	178		
Oct-13	470	106	21	42	214	21	237	166	141	185	197	125		
Nov-13	318	282	149	201	264	278	240	355	295	343	310	281		
Dec-13	18	46	22	14	73	109	55	11	52	296	79	63	0	
Residential	600	600	600	600	600	600	600	600	600	600	600	600	600	600
Non residential	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200

Figure 7-18: The Dust Deposition Rates - Ezulwini Network (2013)



	Arrie Farm (AFM)	Pump House (PHM)	Golf Club (GCM)	Morgan Creek (MCM)	Farm House (N12M)	Harmony Dwelling Single (HDS)	Plant Single (PLS)	Peter Wright Single (PWS)	Thabong Village Single (TVS)	Farm House Single (FHS)	Mielie Field Single (MFS)	Water Tower Single (WTS)	Puleng Single (PS)	Tshidi Single (TS)
Jan-14	659	114	87	147	163	236	122	287	154	309	442	245	0	
Feb-14	38	30	107	34	60	512	63	43	4	240	20	24	0	
Mar-14	82	470	87	157	82	188	178	88	93	72	66	63	0	
Apr-14	32	71	14	231	158	58	50	140	163	172	168	165	0	
May-14	246	410	233	240	190	355	227	609	274	170	545	312		
Jun-14	180	496	29	113	114	131	123	169	87	70	224	67		
Jul-14	675	580	388	1076	1020	497	383	578	392	953	347	1031		
Aug-14	373	607	72	330	562	290	183	428	136	149	501	50		
Sep-14	104	848	50	110	38	198	294	326	113	170	184	25		
Oct-14	680	1454	488	554	555	545	641	599	525	717	548	358		
Nov-14	141	609	16	41	116	268	283	270	331	246	120			
Dec-14	19	195	19	17	9	14	12	20	5	223	3	7	0	
Residential	600	600	600	600	600	600	600	600	600	600	600	600	600	600
Non residential	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200

Figure 7-19: The Dust Deposition Rates – Ezulwini Network (2014)

7.3 Health Effects of the Potential Pollutants

7.3.1 Particulates

The pollutants of concern associated with the proposed construction and operational phases of the WRTRP will include particulate matter (whether in the form of dust fallout, PM_{10} or $PM_{2.5}$) and gases such NO_2, SO_2, CO_2 and CO

In terms of health effects, particulate air pollution is associated with complaints of the respiratory system (WHO, 2000). Particle size is important for health reasons because it controls where in the respiratory system a given particle deposits. Fine particles are thought to be more damaging to human health than coarse particles as larger particles are less respirable in that they do not penetrate deep into the lungs compared to smaller particles (Manahan, 1991). Larger particles are deposited into the extra-thoracic part of the respiratory tract while smaller particles are deposited into the smaller airways leading to the respiratory bronchioles (WHO, 2000).

Based on the existing evidence of adverse health effects at low levels of exposure, WHO revised its Air Quality Guidelines (AQG) for PM in 2005. For $PM_{2.5}$, the new AQG values are 10 µg/m^3 for the annual average and 25 µg/m^3 for the 24-hour mean (not to be exceeded for more than 3 days/year). The corresponding guidelines for PM_{10} were set as 20 µg/m^3 and 50 µg/m^3. Short-term and long-term health effects associated with exposure to these pollutants are presented in Table 7-8. SO_2 can react with other compounds in the atmosphere to form small particles. These can penetrate deeply into sensitive parts of the lungs resulting in respiratory diseases. The latter also applies to NO_2 in the environment.

7.3.2 Short-Term Exposure

Various studies undertaken during the 1980s and early 1990s have looked at the relationship between daily fluctuations in particulate matter and mortality at low levels of exposure. Pope *et al* (1992) studied daily mortality in relation to PM_{10} concentrations in Utah Valley during the period 1985 - 1989. A maximum daily average concentration of 365 µg/m^3 was recorded with effects on mortality observed at concentrations of < 100 µg/m^3. The increase in total daily mortality was 13% per 100 µg/m^3 increase in the 24 hour average. Studies by Schwartz (1993) in Birmingham recorded daily concentrations of 163 µg/m^3 and noted that an increase in daily mortality was experienced with an increase in PM_{10} concentrations. Relative risks for chronic lung disease and cardiovascular deaths were higher than deaths from other causes.

However, in the past, daily particulate concentrations were in the range 100 – 1000 µg/m^3 whereas in more recent times, daily concentrations are between 10 – 100 µg/m^3. Overall, exposure-response can be described as curvilinear, with small absolute changes in exposure at the low end of the curve having similar effects on mortality to large absolute changes at the high end (WHO, 2000). Short-term exposure to SO_2 can result in an array of adverse respiratory effects. The same can be said of NOx in the atmosphere.

7.3.3 Long-term exposure

Long-term exposure to low concentrations (~10 µg/m^3) of particulates is associated with mortality and other chronic effects such as increased rates of bronchitis and reduced lung function (WHO, 2000).

Studies have indicated an association between lung function and chronic respiratory disease and airborne particles. Older studies by Chestnut *et al* (1991) found that FVC (Forced Vital Capacity) decreases with increasing annual average particulate levels with an apparent threshold at 60 µg/m^3. Using chronic respiratory disease data, Schwartz (1993) determined that the risk of chronic bronchitis increased with increasing particulate concentrations, with no apparent threshold.

Table 7-8: Short-term and long-term health effects associated with exposure to PM (after WHO, 2004)

Pollutant	Short-term exposure	Long-term exposure
Particulate matter	▪ Lung inflammatory reactions ▪ Respiratory symptoms ▪ Adverse effects on the cardiovascular system ▪ Increase in medication usage ▪ Increase in hospital admissions ▪ Increase in mortality	▪ Increase in lower respiratory symptoms ▪ Reduction in lung function in children ▪ Increase in chronic obstructive pulmonary disease ▪ Reduction in lung function in adults ▪ Reduction in life expectancy ▪ Reduction in lung function development

8 Sensitivity Analysis and No-Go Areas

Based on a thorough assessment of TSFs and nearby residential receptors in the different Mining Right Areas, and considering the natures of the initial phase of the proposed WRTRP, associated infrastructure and background dust fall rates, it is unlikely that the proposed operation will make the area non-compliant to existing air quality standards. A sensitivity map showing the current dust baseline, monitoring points and nearby receptors are depicted below (Figure 8-1). There are no sensitive areas within the WRTRP domain because the areas have been impacted by previous/existing mining activities and pollution sources. The wet reclamation mining process will not exacerbate current air quality conditions. Coupled with the aforementioned, the proposed pipelines will follow existing servitudes. Hence, there are no “No-Go” areas that the proposed project will impact on in terms of air quality. This assertion is made considering that the tailings will be reclaimed hydraulically with most infrastructure within existing mining right areas.

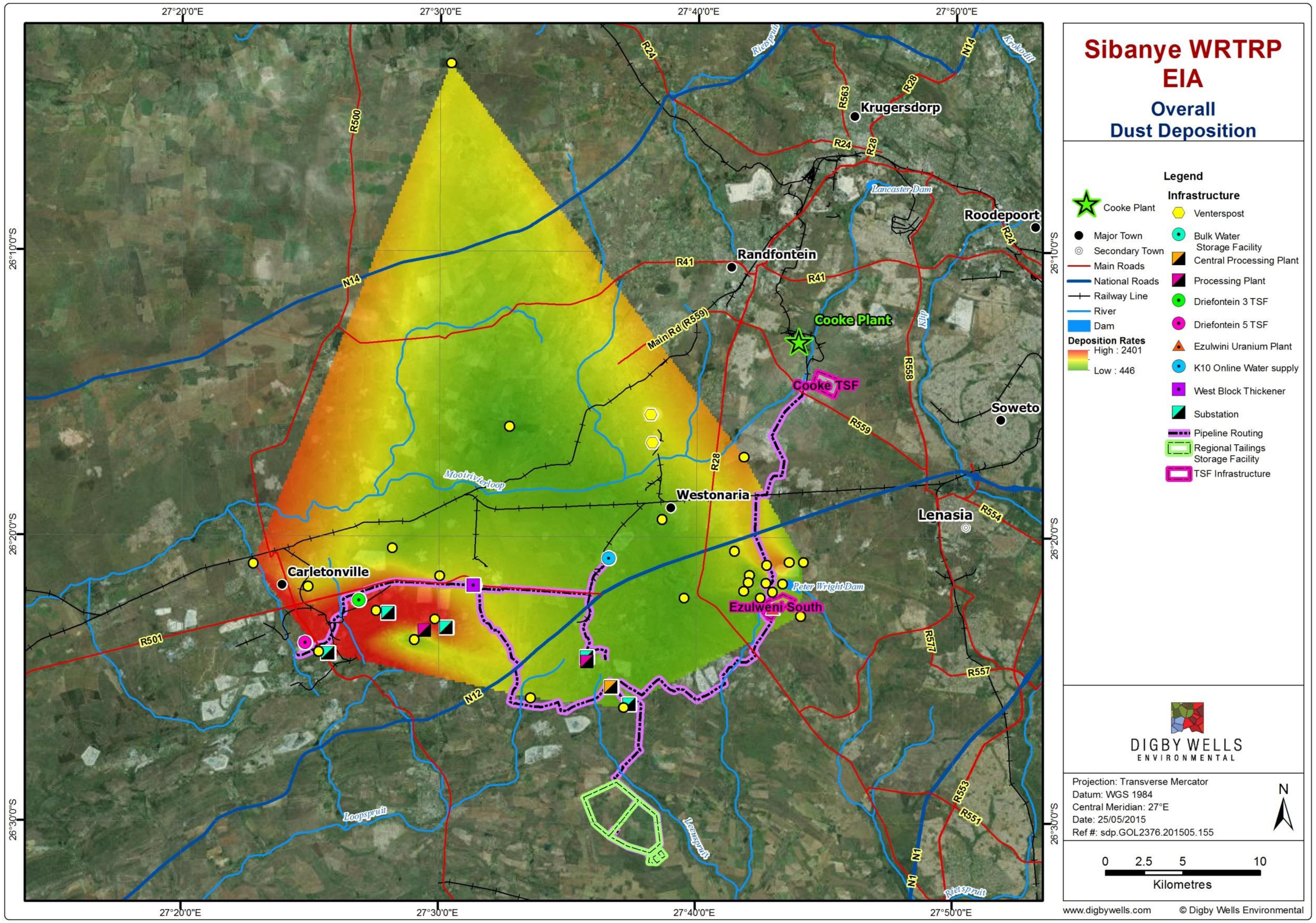


Figure 8-1: Sensitivity Map generated from Dust Deposition Records

8.1 Evaluation of Dispersion Modelling Results

Evaluation of the predicted pollutants levels was performed by comparing the maximum modelled impacts to the applicable standards. All the information necessary for this evaluation including: (a) source location map (b) complete modelling output isopleths and (c) graphic presentations of the modelling results for each pollutant, showing the magnitude and location of the maximum ambient impacts are presented in the sections below. Wind erosion from the existing TSFs was modelled with mitigation measures in place. The TSFs are vegetated on the side slopes and some have formed a hard on the surface overtime.

8.1.1 Kloof Mining Right Area

The project activities that will be assessed in the Kloof Mining Right Area are presented below. Those activities that can have potential air quality impacts are marked with asterisk.

Category	Activity
Kloof Mining Right area	
Infrastructure	Pipeline Routes (residual tailings).
	Central processing Plant (CPP) incorporating Module 1 float and gold plants and uranium, roaster and acid plants*.
	The Regional Tailings Storage Facility (RTSF), RTSF Return Water Dam (RWD) and the Advanced Water Treatment Facility (AWTF). Collectively known as the RTSF complex*.
Processes	Abstraction of water from K10 shaft
	Disposal of the residue from the AWTF.
	Gold, uranium and sulfur extraction at the CPP (tailings to RTSF)*
	Water distribution at the AWTF for discharge.
Pumping	Pumping of up to 1.5 Mt/m of tailings to the RTSF.
	Pumping water from the RTSF return water dams to the AWTF.
	Discharging treated water to the Leeuspruit.
Electricity supply	Power supply from Kloof 1 substation to the CPP.
	Power supply from Kloof 4 substation to the RTSF and AWTF.

8.1.1.1 RTSF TSF

8.1.1.1.1 Lower compartment

Model simulations of the lower compartment footprint at full capacity are presented below. Ground level concentrations of PM10, PM2.5 and deposition rates were generated (Figure 8-2, Figure 8-3, Figure 8-4, Figure 8-5 and Figure 8-11).

PM_{10} Predicted Impacts

The maximum predicted 24-hour daily concentration of PM_{10} attributed to this source as a result of erosion arrived at 191 µg/m³ (**Error! Reference source not found.**), which was in exceedance of the limit (75 µg/m³). In terms of spatial impact, much of the areas where these exceedances occurred are towards the northwest section of the RTSF (about 2 km from the edge of the TSF). The annual concentration was 5.5 µg/m³). This is below the annual limit of 40 µg/m³. Although the dominant wind is from the north northeast and north the ridge in the northern section which is above 1 750 m most likely served as a hindrance allowing the less infrequent winds from the south and southeast to dominate. Hence, pollutants are concentrated in the southern section of the ridge, north of the RTSF.

$PM_{2.5}$ Predicted Impacts

The 24-hour $PM_{2.5}$ concentration of 33 µg/m³ was within limit (40 µg/m³). Isopleth showing the pollutant spread is presented in Figure 8-9. The maximum predicted annual concentration of 1.6 µg/m³ is within the required standard of 20 µg/m³ (Figure 8-5).

Dust fallout Impacts

The maximum predicted dust deposition rate of 188 mg/m2/day attributed to the lower compartment of the RTSF from wind erosion is presented below (Figure 8-11). The predicted deposition rate is well within the residential and non-residential limits of 600 mg/m^2/day and 1 200 mg/m^2/day (NDCR 2013) respectively. A summary of the dispersion model results for the proposed lower compartment of RTSF are presented in Table 8-1.

Table 8-1: Summary of Dispersion Modelling Results - Lower Compartment (RTSF)

Air Contaminant	Averaging Period	Ambient Air Quality Standard (µg/m^3)	Maximum GLC (µg/m^3)
Inhalable Particulates (PM_{10})	24 hour	75	123
	Annual	40	5.5
Fine Particulate ($PM_{2.5}$)	24 hour	40	33
	Annual	20	1.6
Dust fall (mg/m^2/day)			
Dust Deposition	monthly	600	274

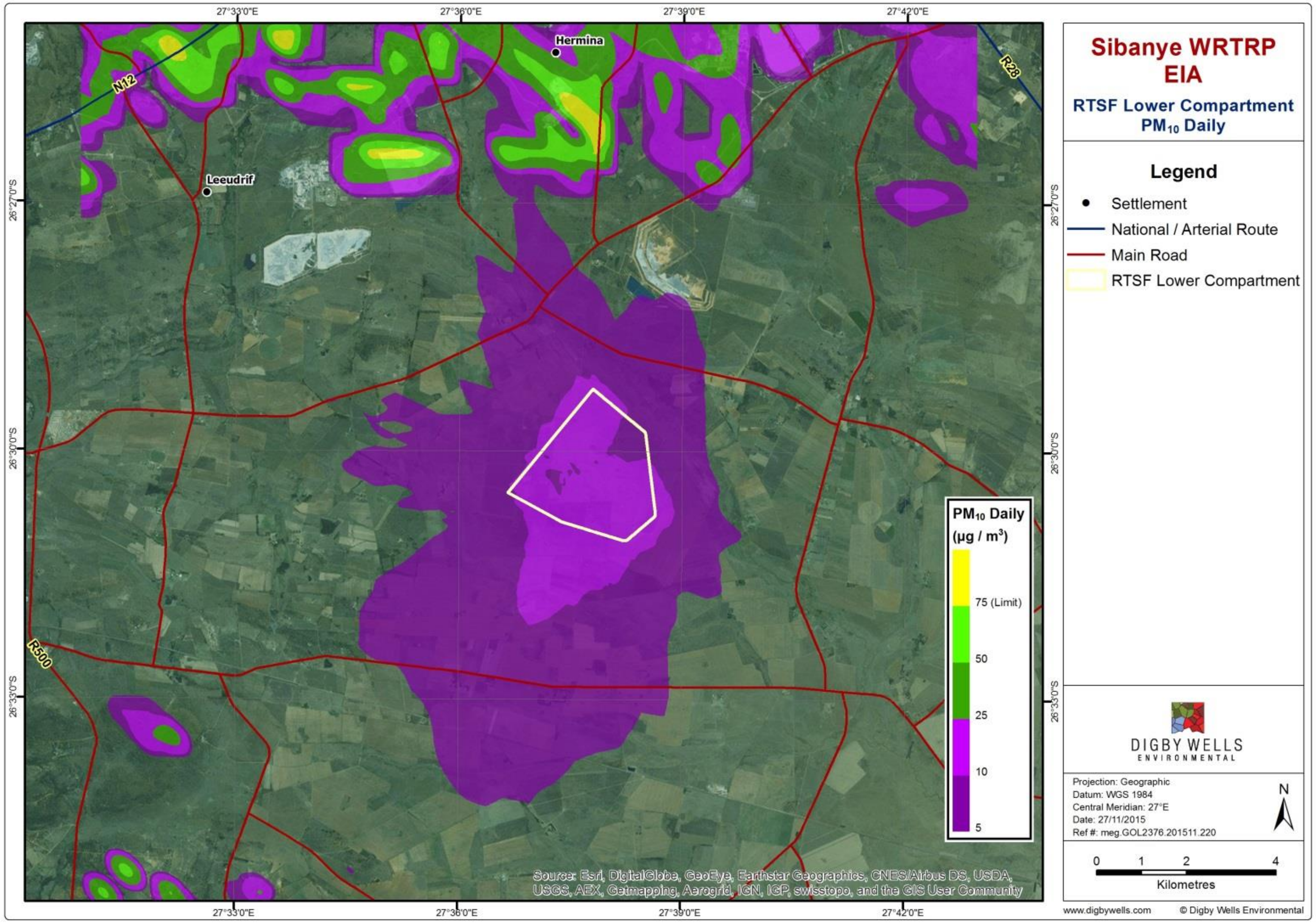


Figure 8-2: Predicted 24-Hour Average PM_{10} Concentrations, 99th Percentile (µg/m^3)

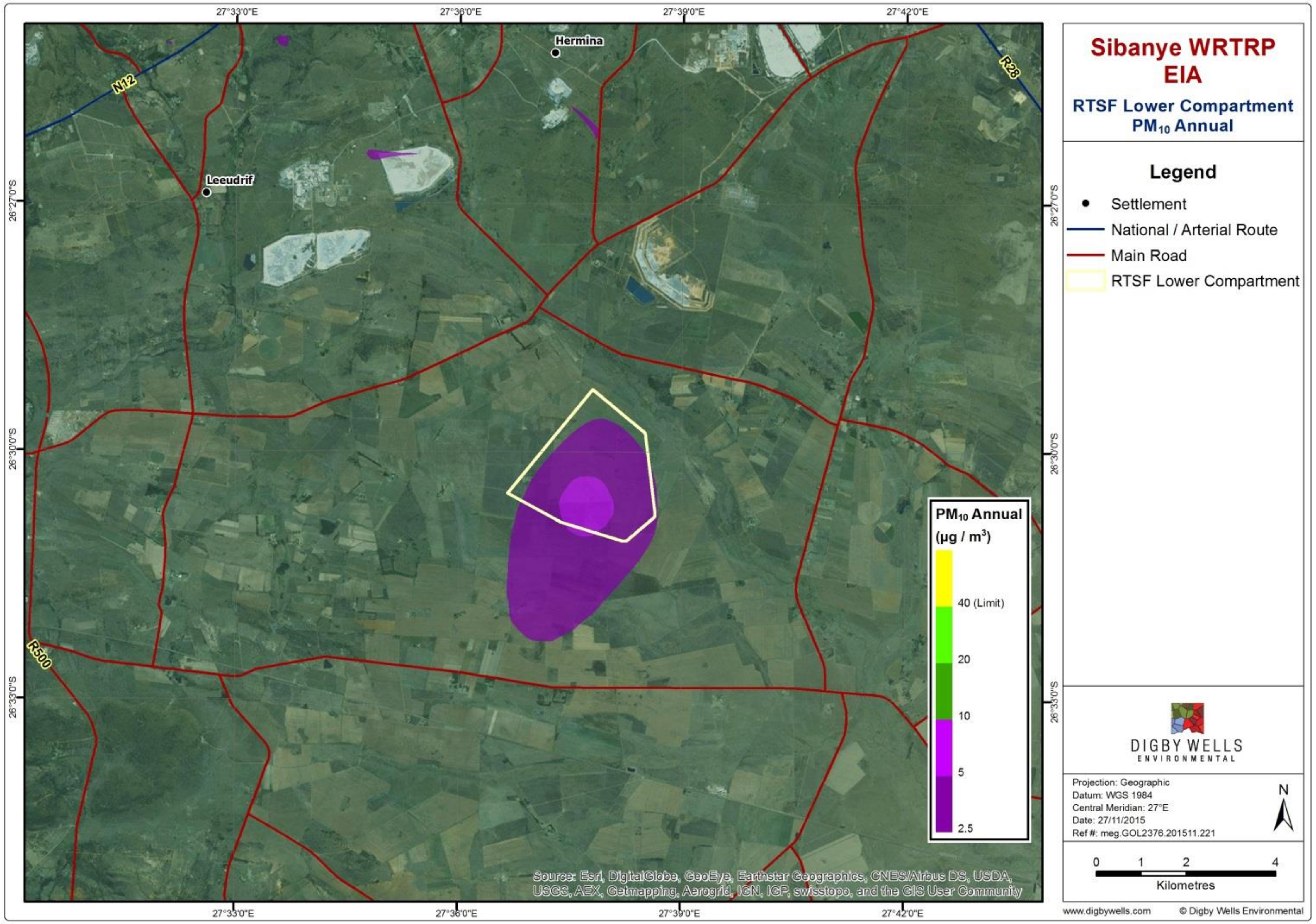


Figure 8-3: Predicted Annual Average PM_{10} Concentrations, 100th Percentile ($\mu g/m^3$)

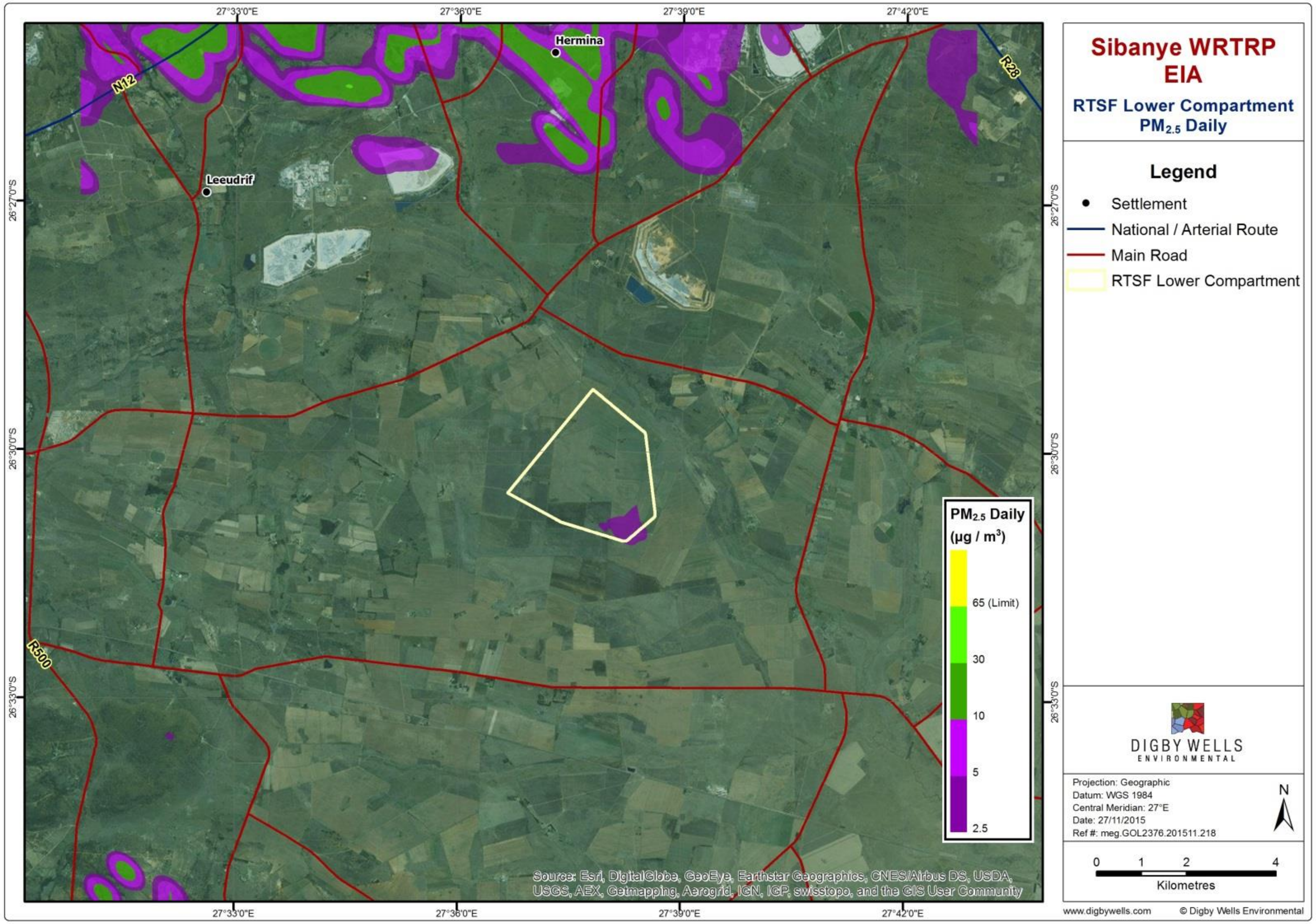


Figure 8-4: Predicted 24-Hour Average $PM_{2.5}$ Concentrations, 99th Percentile (µg/m^3)

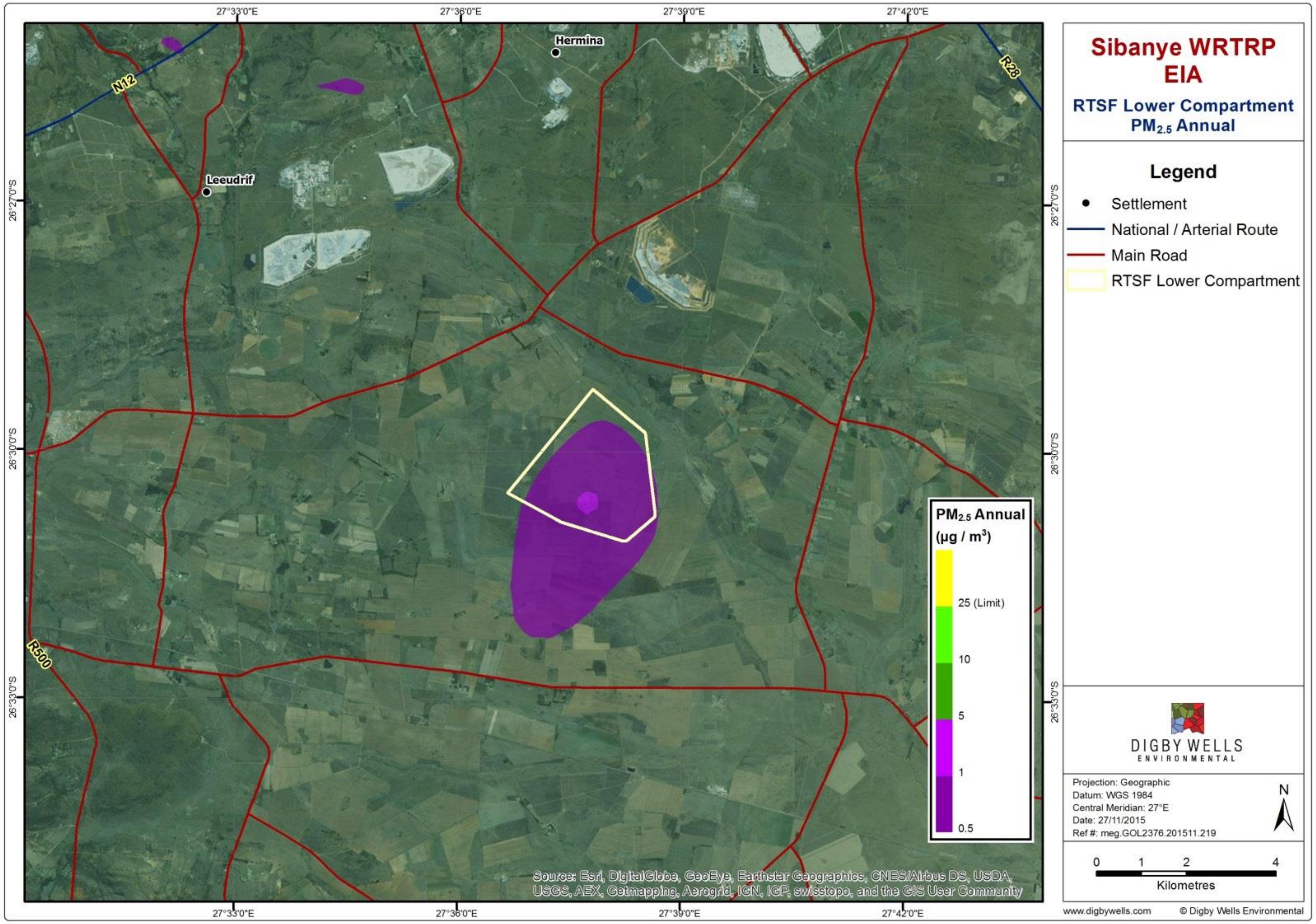


Figure 8-5: Predicted Annual Average $PM_{2.5}$ Concentrations, 100th Percentile (µg/m³)

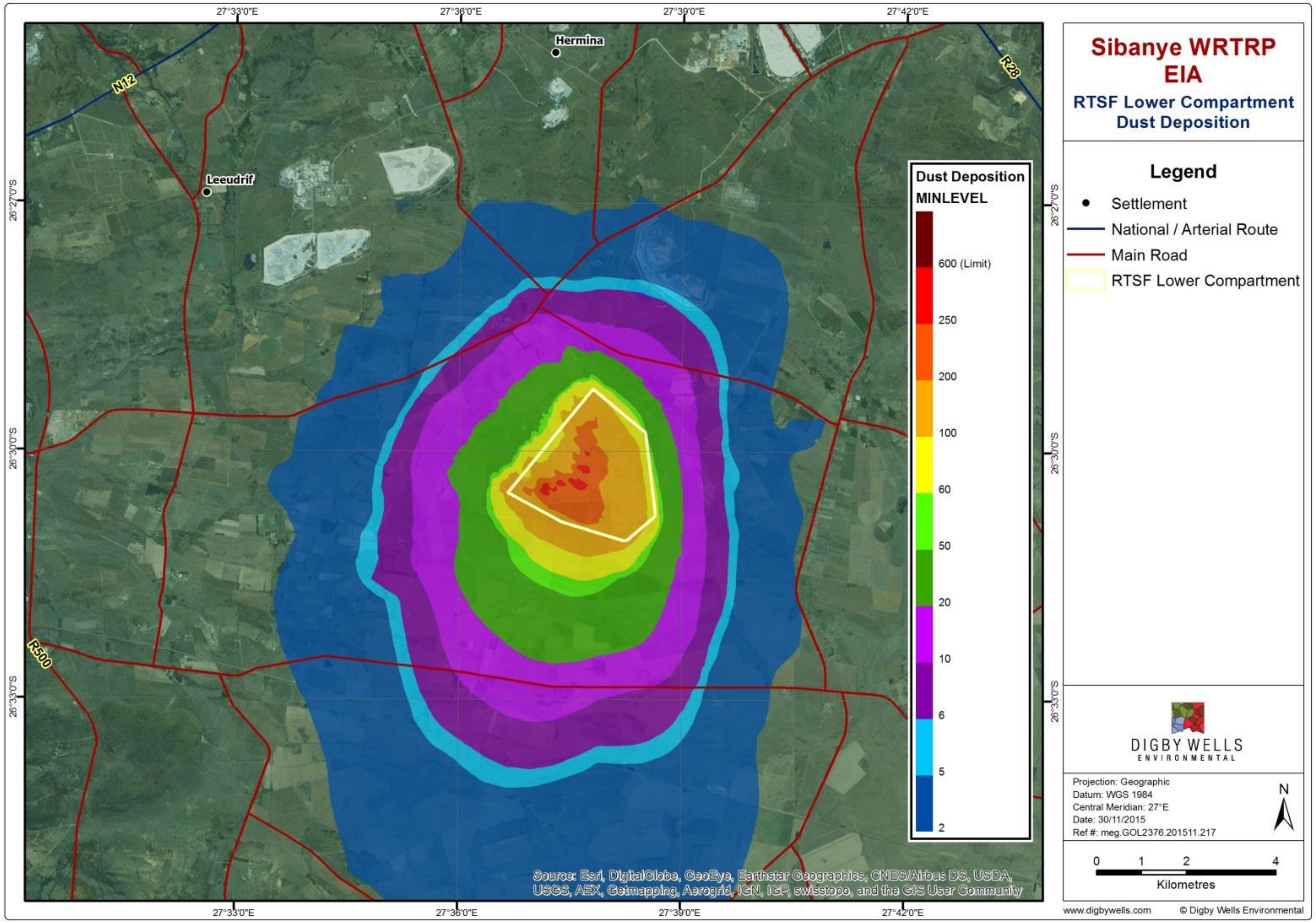


Figure 8-6: Predicted Maximum (100th percentile) Dust Deposition (mg/m2/day)

8.1.1.1.2 Lower and upper compartments

The assessment of the RTSF considered the first phase (lower compartment and full footprint) and the second phase (lower and the upper compartments at 105m high). The latter is considered as the worst case scenario, since impacts will not exceed predicted pollutant concentration.

Lower compartment .Construction of pipeline will occur in the Kloof MRA, however, this will have minimal impact on ambient air quality of the area.

Model predictions for the lower and upper compartments (worst case)

PM_{10} Predicted Impacts

The isopleth plot showing the predicted 99th percentile 24-hour daily concentration of PM_{10} attributed due to erosion of the proposed RTSF is presented (Figure 8-7). The maximum predicted ground level concentration of 278 µg/m³ was in exceedance of the limit (75 µg/m³). In terms of spatial impact, much of the area where these exceedances occurred is towards the northwest section of the RTSF. Although the dominant wind is from the north northeast and north the ridge in the northern section which is above 1 750 m most likely served as a hindrance allowing the less infrequent winds from the south and southeast to dominate. Hence concentration of pollutants are predicted in the southern section of the ridge north of the RTSF

The predicted PM_{10} level is attributed to the erosion of the proposed RTSF and not cumulative impact from all the existing sources in the area. The predicted maximum annual ground level PM_{10} concentration anticipated from the RTSF is presented in Figure 8-8. The annual highest ground level concentration of 13 µg/m³ falls within the regulatory standard of 40 µg/m³. The model predictions represent the worst case scenario with erosion from the lower and upper compartments.

$PM_{2.5}$ Predicted Impacts

The predicted highest 24-hour concentration of $PM_{2.5}$ from the proposed RTSF is presented in Figure 8-9. The maximum ground level concentration of 58 µg/m³ is higher than the current standard South African standard of 40 µg/m³ without mitigation.

The predicted highest annual concentration for $PM_{2.5}$ from the proposed RTSF is presented in Figure 8-10. The maximum ground level annual concentration predicted of 3 µg/m³ is within the required standard of 20 µg/m³.

Dust fallout Impacts

The predicted dust deposition rates attributed to the RTSF from wind erosion are presented below (Figure 8-11). The predicted maximum deposition rate is well within the residential and non-residential limits of 600 mg/m^2/day and 1 200 mg/m^2/day (NDCR 2013) respectively.

A summary of the dispersion model results for the proposed RTSF are presented in Table 8-2.

Table 8-2: Summary of Dispersion Modelling Results (RTSF)

Air Contaminant	Averaging Period	Ambient Air Quality Standard ($\mu g/m^3$)	Maximum GLC ($\mu g/m^3$)
Inhalable Particulates (PM_{10})	24 hour	75	278
	Annual	40	13
Fine Particulate ($PM_{2.5}$)	24 hour	40	58
	Annual	20	3
Dust fall ($mg/m^2/day$)			
Dust Deposition	monthly	600	244

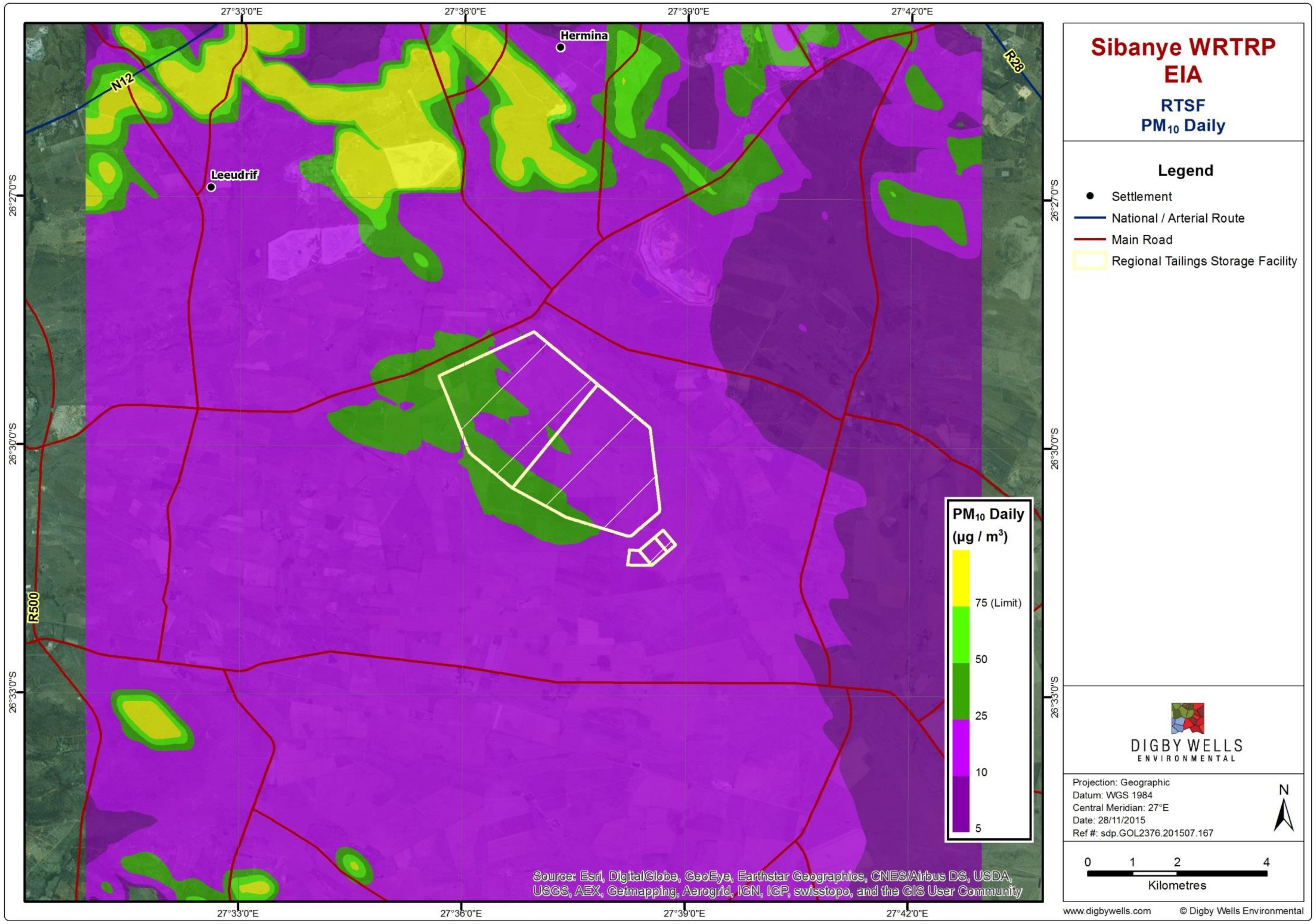


Figure 8-7: Predicted 24-Hour Average PM_{10} Concentrations, 99th Percentile ($\mu g/m^3$)

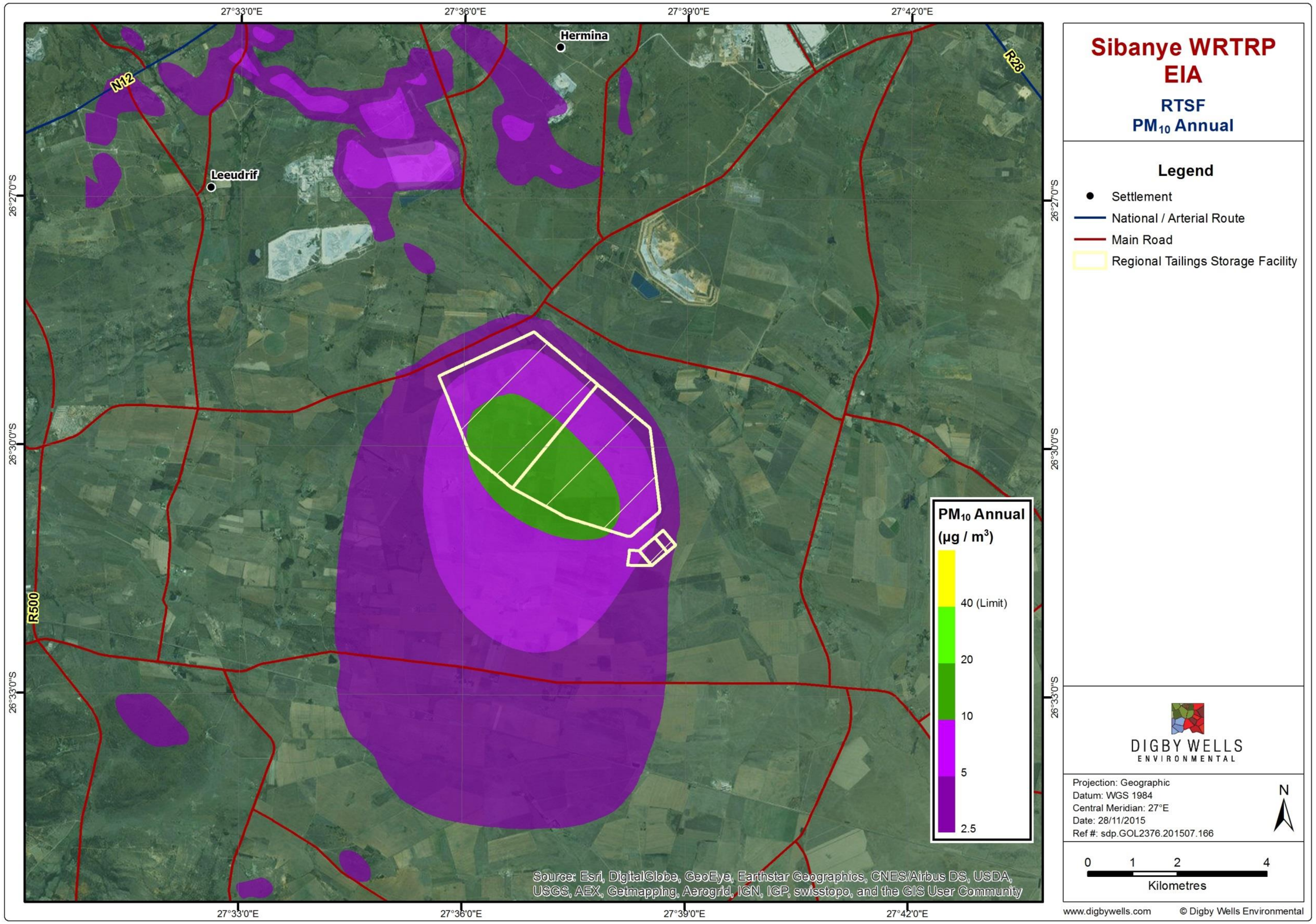


Figure 8-8: Predicted Annual Average PM_{10} Concentrations, 100th Percentile ($\mu g/m^3$)

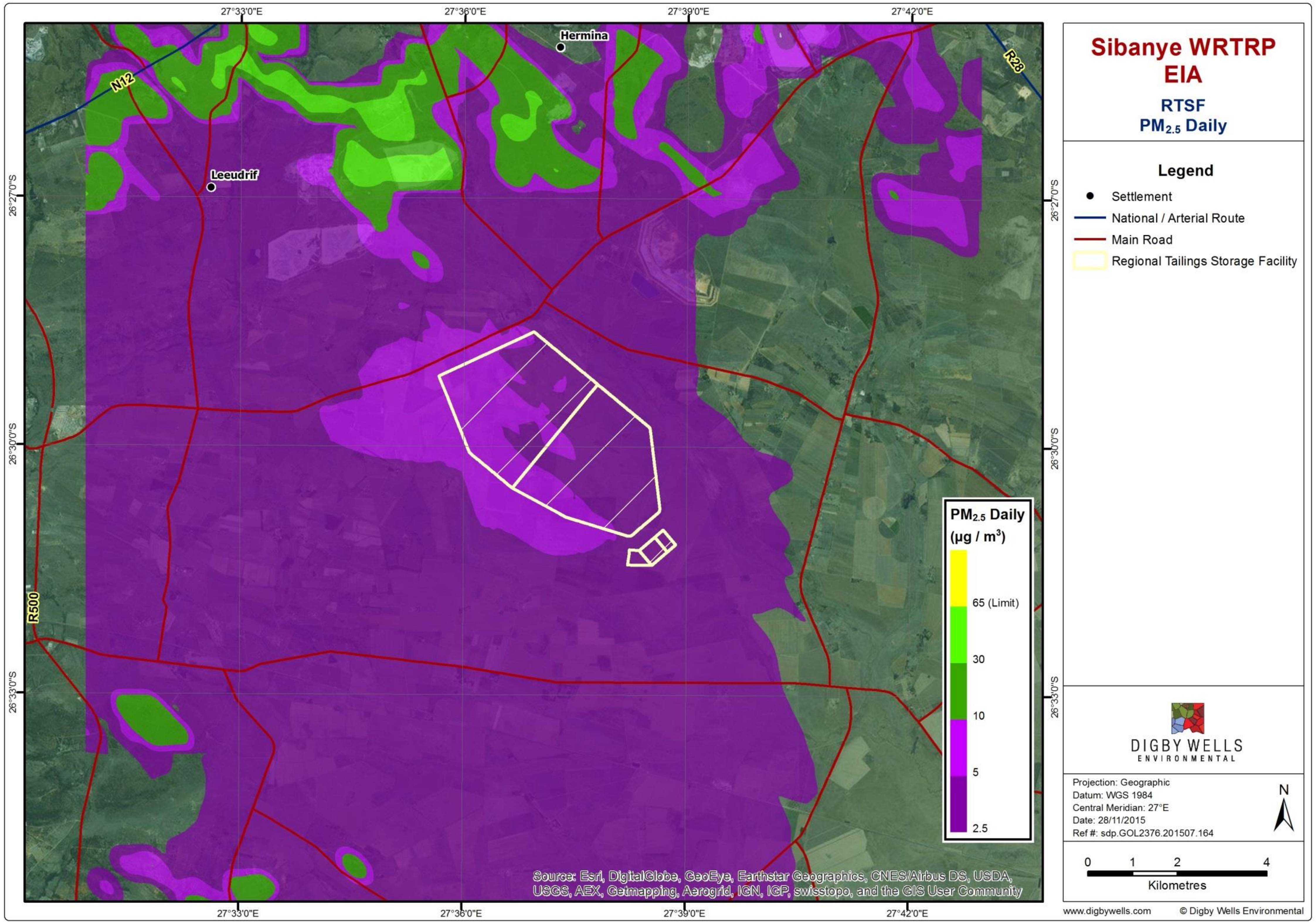


Figure 8-9: Predicted 24-Hour Average $PM_{2.5}$ Concentrations, 99th Percentile (µg/m^3)

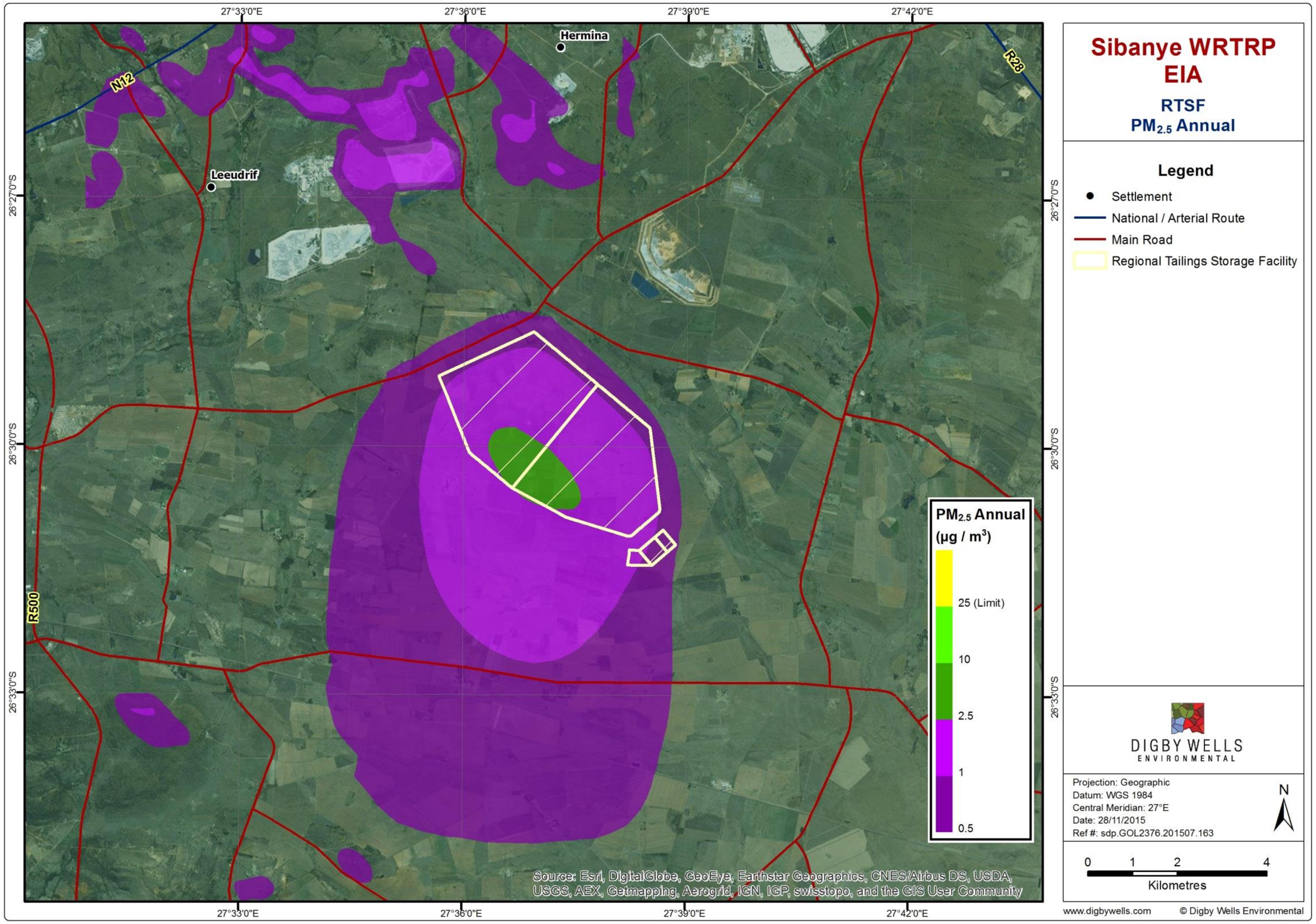


Figure 8-10: Predicted Annual Average $PM_{2.5}$ Concentrations, 100th Percentile (µg/m^3)

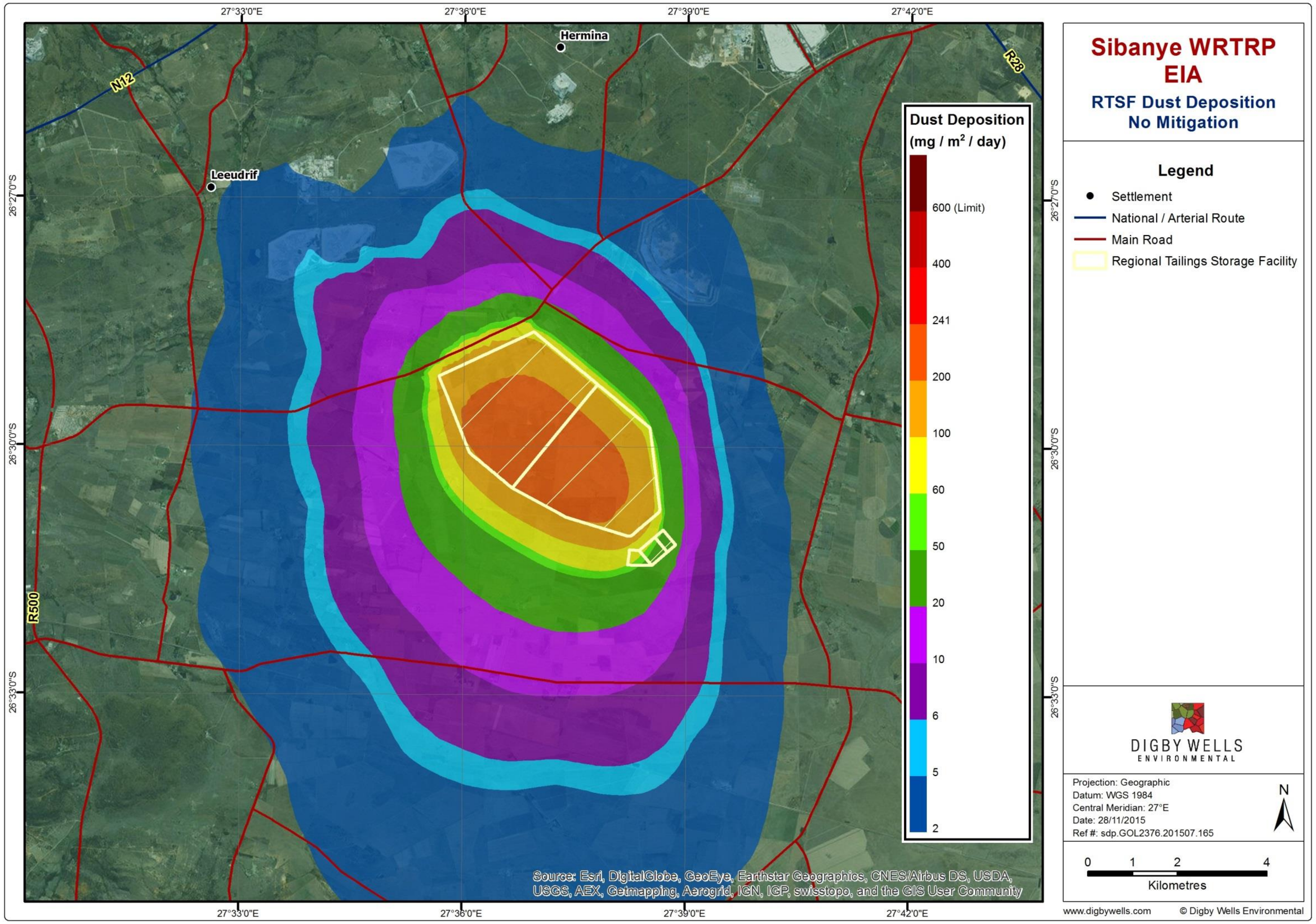


Figure 8-11: Predicted Maximum (100th percentile) Dust Deposition (mg/m^2/day)