8.3 Visual Assessment

SOUTH32 SA COAL HOLDINGS (PTY) LTD

VANDYKSDRIFT CENTRAL MINING: INFRASTRUCTURE DEVELOPMENT
VISUAL ASSESSMENT
IMPACT ASSESSMENT REPORT

Report No.: JW201/18/G535-06 - Rev 4

July 2019

Jones & Wagener
Engineering & Environmental Consultants
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24 July 2019	Rev 3	Updated Final Impact Assessment Report	Tolmay Hopkins	Electronic	1
30 Sep 2019	Rev 4	Updated Final Impact Assessment Report	Tolmay Hopkins	Electronic	1

SYNOPSIS

South32 SA Coal Holdings (Pty) Ltd (South32), is the holder of an amended mining right for coal, granted by the Minister of Mineral Resources, in terms of the Mineral and Petroleum Resources Development Act (MPRDA) and notarially executed on the 21st of May 2015 under DMR reference MP30/5/1/2/2/379MR, in respect of its Wolvekrans Colliery. Wolvekrans Colliery comprises of the following sections:

- Ifalethu Colliery (previously referred to as Wolvekrans North Section[1]) consisting of the Hartbeestfontein, Bankfontein (mining now ceased), Goedehoop, Klipfontein sections and the North Processing Plant; and
- Wolvekrans Colliery (previously referred to as the Wolvekrans South Section) consisting of the Wolvekrans, Vlaklaagte (mining ceased), Driefontein, Boschmanskrans, Vandyksdrift, Albion and Steenkoolspruit sections, as well as the South Processing Plants (Eskom and Export). Some of these areas were previously known as Douglas Colliery.

The Vandyksdrift Central (VDDC) area falls within the footprint of historic underground mining operations at the old Douglas Colliery. In 2007, an amendment of the Environmental Management Programme Report (EMPR) for the Douglas Colliery operations was approved, to allow pillar mining (opencast) of the area previously mined by underground bord and pillar mining. Authorisation of the VDDC mining project included the following:

- Opencast operation on the farm Kleinkopje 15 IS and Steenkoolspruit 18 IS;
- Pillar extraction operation on the farm Vandyksdrift 19 IS;
- Reclamation of existing slurry ponds; and
- Rewashing of existing discard dumps (PHD, 2006).

The water uses associated with the opencast mining has been authorised in terms of water use licence number 24084535 dated 10 October 2008, issued to Douglas Colliery Services Limited.

The No. 2 seam workings are flooded with water and must be dewatered to enable the open pit development to proceed. A dewatering strategy has therefore been developed and an application for Environmental Authorisation (EA) of the dewatering activities was submitted to the Department of Mineral Resources (DMR) (Jaco-K Consulting, 2016(a)); a decision in this regard is pending. The water use activities associated with this upfront dewatering strategy have been authorised by WUL number 06/B11F/GCIJ/7943 dated 19 July 2018.

The 2007 approved EMPR Amendment included limited additional infrastructure in support of the opencast mining operations, as it was assumed at that stage that existing infrastructure will be used. In addition, the applications for authorisation of the activities associated with the dewatering strategy, were limited to the infrastructure to facilitate dewatering (i.e. dewatering boreholes, pumps, pipelines, storage tanks, mechanical evaporators, roads and power lines).

A pre-feasibility investigation has since been conducted, and the need to develop additional infrastructure to support the proposed opencast mining was identified. The additional infrastructure includes the following:

- Storm water management structures (drains and berms);
- Water management measures for the management of mine impacted water;

[1] This was previously referred to as Middelburg Colliery

- Overburden dumps;
- ROM coal stockpile areas;
- Mixed ROM coal and slurry stockpile areas;
- Topsoil stockpiles following clearance of vegetation;
- Pipelines for the conveyance of water;
- Hard park area and brake test ramp; and
- Haul roads and service roads.

The proposed VDDC opencast pit boundary as determined through the pre-feasibility investigation also differs from the mining area approved in the 2007 EMPR amendment. An area of approximately 196 hectares in the latest mine lay-out was not included in the previous mine lay-out and is therefore not approved to be opencast mined.

Jones & Wagener (Pty) Ltd Engineering & Environmental Consultants (J&W) has been appointed to undertake the EA, WUL and WML application process for the abovementioned project. As part of the process, specialist studies need to be undertaken. This report details the methods, analysis and findings of the Visual impact assessment undertaken for the proposed VDDC Infrastructure Development Project.

The topography associated with the proposed new mining area is gently undulating mine and farmlands at an elevation of between 1520 mamsl and 1590 mamsl. The Olifants River runs parallel to the western boundary of the proposed mining area, where the topography is frequently steeper due to the presence of sandstone outcrops and depicts scenic cliffs and bends in the river.

The VDDC South32 Project area is situated within the grassland biome. This biome is centrally located in southern Africa, and adjoins all except the desert, fynbos and succulent Karoo biomes (Mucina & Rutherford, 2006). The project area is situated predominantly within one vegetation type; namely the Eastern Highveld Grassland (GM12) vegetation type.

The grassland found within the study area is very short with intermittent trees close to farmsteads and settlements. In the eastern parts of the site maize is planted and harvested annually, resulting in open fields without cover during the winter months. The vegetation therefore provides little visual cover for structures.

Some visual screening has been planted at the SKS workshops to the north of the mining area. The screening is effective for a section of the R544, but does not eliminate the visual impact, especially since the proposed new structures will be constructed outside of the area that is screened.

Most of the infrastructure present in the greater study area stems from mining activities (South32 Wolvekrans, Middelburg, Glencore Impunzi and Anglo Goedehoop). Some other industrial development is concentrated around the towns of eMalahleni and Middelburg. The main road in the area is the N12/N4 Highway, connecting Gauteng with Mpumalanga. In addition, the Duvha and Komati power stations provide further industrial impact. These activities have an industrial visual character and result in a more pronounced impact on the natural character of the landscape. Additionally, prominent Eskom powerlines cross the landscape to and from the two power stations.

Visually there are no sensitive features or no-go areas on the site itself. In the surrounding area the following are considered to be visually sensitive:

- Topographic Features
    - None
- Surrounding homesteads
    - The area around the site has several settlements overlooking the proposed mining area as well as along the infrastructure routes.
- Towns/urban areas
    - The towns of eMalahleni and Middelburg are located to the north of the project area.
    - The proposed infrastructure should not affect any towns/urban areas.
- Roads
    - The proposed project will be located west of the R544 from eMalahleni.

The viewshed from the proposed infrastructures extends some 10-12km to the north and south. The elevated views from the Ogies dyke in the north is offset by the flat terrain around the Olifants River floodplain, where the site is located. Views to the east and west are somewhat blocked due to topography, with a few isolated exceptions. The results from the impact assessment are summarised below.

Table 1: Impact Summary

Activity	Impact	Project Rating	Cumulative rating	Rating post mitigation
Construction: **Site/ stockpile preparation and construction**	**NEGATIVE IMPACT:** Clearing of vegetation and soil will result in visual impact. Vehicle movement and construction activities also visible.	LOW	HIGH	LOW
Operations **Operation and increase in visibility of mining, stockpiles, storing of wastes on sites**	**NEGATIVE IMPACT:** Stockpiling will increase visual impact over time, dust from operations and blasting will be visible.	HIGH	HIGH	HIGH
Closure **Rehabilitation of VDDC infrastructure project sites and mine.**	**POSITIVE IMPACT** Rehabilitation of stockpiles and bringing back a form of landscape that can support an alternative end use	LOW POSITIVE	HIGH	LOW POSITIVE

The Vandyksdrift Central mining project will utilise available mineral resources. These resources have been undermined previously, and several impacts have already occurred. Furthermore, the mining area is surrounded by other opencast operations, resulting in a landscape dominated by mining and its associated impacts.

The additional impact of the proposed VDDC infrastructure project is mostly located on existing impacted land. However, the areas that are not previously impacted by mining, will be highly impacted by the project.

It is the opinion of this specialist that the development should proceed. Rehabilitation and closure requirements must be enforced with the final end land use as the objective.

NEMA Appendix 6 requirements

Regulation: GNR 982, December 2014, as amended		
Specialist Report		Section in the Report
Appendix 6 (a)	A specialist report prepared in terms of these Regulations must contain— details of— the specialist who prepared the report; and the expertise of that specialist to compile a specialist report including a curriculum vitae;	Section 1.8 & App A
Appendix 6 (b)	A declaration that the specialist is independent in a form as may be specified by the competent authority;	App B
Appendix 6 (c)	An indication of the scope of, and the purpose for which, the report was prepared;	Section 1.1
Appendix 6 (cA)	An indication of the quality and age of base data used for the specialist report;	Section 2.1
Appendix 6 (cB)	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 4
Appendix 6 (d)	The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 2.2
Appendix 6 (e)	A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 2.1
Appendix 6 (f)	Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a, site plan identifying site alternatives;	Section 4
Appendix 6 (g)	An identification of any areas to be avoided, including buffers;	Section 4
Appendix 6 (h)	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 4
Appendix 6 (i)	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 2
Appendix 6 (j)	A description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	Section 4
Appendix 6 (k)	Any mitigation measures for inclusion in the EMPr;	Section 4.4
Appendix 6 (l)	Any conditions for inclusion in the environmental authorisation;	Section 6.2
Appendix 6 (m)	Any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 5
Appendix 6 (n)	A reasoned opinion— i. whether the proposed activity, activities or portions thereof should be authorised; (iA) regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 6
Appendix 6 (o)	A description of any consultation process that was undertaken during the course of preparing the specialist report;	Refer main EIA
Appendix 6 (p)	A summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Refer main EIA
Appendix 6 (q)	Any other information requested by the competent authority.	Refer main EIA

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Acronyms and Abbreviations

DEA .... Department of Environmental Affairs
DMR .... Department of Mineral Resources
DWS .... Department of Water and Sanitation
EA .... Environmental Authorisation
EAP .... Environmental Assessment Practitioner
EE .... Employment Equity
EIA .... Environmental Impact Assessment
EIS .... Ecological Importance and Sensitivity
ELM .... Emalahleni Local Municipality
GDP .... Gross Domestic Product
IDP .... Integrated Development Plan
J&W .... Jones & Wagener (Pty) Ltd Engineering & Environmental Consultants
km .... kilometres
km^2 .... square kilometres
LED .... Local Economic Development
m .... metres
m^2 .... square metres
m^3 .... cubic metres
LOoP .... Life-of-Operation
MPRDA .... Mineral and Petroleum Resources Development Act (Act No 28 of 2002)
NEMA .... National Environmental Management Act (Act No 107 of 1998)
NEM: WA .... National Environmental Management Waste Act (Act No 59 of 2008)
NWA .... National Water Act (Act No 36 of 1998)
South32 .... South32 SA Coal Holdings (Pty) Ltd
SKS .... Steenkoolspruit
VDDC .... Vandyksdrift Central
WML .... Waste Management Licence
WUL .... Water Use Licence

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1. INTRODUCTION

South32 SA Coal Holdings (Pty) Ltd (South32), is the holder of an amended mining right for coal, granted by the Minister of Mineral Resources, in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002) (MPRDA) and notarially executed on the 21st of May 2015 under DMR reference MP30/5/1/2/2/379MR, in respect of its Wolvekrans – Ifalethu Colliery. This mining right comprises of the following areas:

- Ifalethu Colliery (previously referred to as Wolvekrans North Section[2]) consisting of the Hartbeestfontein, Bankfontein (mining now ceased), Goedehoop, Klipfontein sections and the North Processing Plant; and
- Wolvekrans Colliery (previously referred to as the Wolvekrans South Section) consisting of the Wolvekrans, Vlaklaagte (mining ceased), Driefontein, Boschmanskrans, Vandyksdrift, Albion and Steenkoolspruit sections, as well as the South Processing Plants (Eskom and Export). Some of these areas were previously known as Douglas Colliery.

The Vandyksdrift Central (VDDC) area falls within the footprint of historic underground mining operations at the old Douglas Colliery. In 2007, an amendment of the Environmental Management Programme Report (EMPR) for the Douglas Colliery operations was approved, to allow pillar mining (opencast) of the area previously mined by underground bord and pillar mining. Authorisation of the VDDC mining project included the following:

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The water uses associated with the opencast mining have been authorised in terms of Water Use Licence (WUL) number 24084535 dated 10 October 2008, issued to Douglas Colliery Services Limited.

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The 2007 approved EMPR Amendment included limited additional infrastructure in support of the opencast mining operations, as it was assumed at that stage that existing infrastructure will be used. In addition, the applications for authorisation of the activities associated with the dewatering strategy, were limited to the infrastructure to facilitate dewatering (i.e. dewatering boreholes, pumps, pipelines, storage tanks, mechanical evaporators, roads and power lines).

A pre-feasibility investigation has since been conducted, and the need to develop additional infrastructure to support the proposed opencast mining was identified. The additional infrastructure includes the following:

- Storm water management structures (drains and berms);
- Water management measures for the management of mine impacted water;
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- Haul roads and service roads.

The proposed VDDC opencast pit boundary as determined through the pre-feasibility investigation also differs from the mining area approved in the 2007 EMPR amendment. An area of approximately 196 hectares in the latest mine lay-out was not included in the previous mine lay-out and is therefore not approved to be opencast mined.

1.1 Scope and Purpose

Jones & Wagener Engineering and Environmental Consultants (J&W) has been appointed by South32 as an independent Environmental Assessment Practitioner (EAP) to undertake an Integrated Regulatory Process (IRP) to obtain the required approvals/authorisations for the required infrastructure development to enable South32 to continue with opencast mining at VDDC.

The environmental applications foreseen include:

- Application for Environmental Authorisation through a Scoping and Environmental Impact Assessment Report (S&EIAR) process and the compilation of an Environmental Management Programme (EMPr) in terms of the National Environmental Management Act, 1998 (Act 107 of 1998; NEMA) and its Regulations;
- Waste Management Licence Application (WMLA) in terms of the National Environmental Management: Waste Act, 2008 (Act 59 of 2008; NEM:WA); and

- Integrated Water Use Licence Application (IWULA) in terms of the National Water Act, 1998 (Act 36 of 1998; NWA), including an Integrated Water and Waste Management Plan (IWWMP).

A Heritage Impact Assessment in terms of the National Heritage Resources Act, 1999 (Act 25 of 1999, NHRA) will also be undertaken.

This report details the methods, analysis and findings of the Visual impact assessment undertaken for the proposed project.

The objectives of the study are to:

- Provide a consolidated baseline assessment for the entire VDDC site in terms of visual impact;
- Assess the potential impact from the propose mining operations and associated infrastructure on the baseline visual environment;
- Where relevant, suggest mitigation measures or alternatives that reduce potential significant impacts to acceptable levels; and
- Provide a concise report that captures the findings and recommendations mentioned above.

To achieve the objectives listed above, the scope of work for this study includes the following:

South32 has indicated that there is a number of specialist studies that have been completed for each of the various sections of the site. These however were specific to the project at the time. Thus, J&W would like to approach the project in a phased approach as follows:

1) Baseline Assessment: (review of existing Visual reports, ground truthing and gap analysis)

2) Impact Assessment: (once the infrastructure layout plans and drawings are available undertake a Visual impact assessment).

1.2 Site Location

The VDDC infrastructure development project is a brownfields project within the greater Wolvekrans Colliery mining rights area. Wolvekrans Colliery is located between the towns of eMalahleni and Kriel, within the jurisdictional area of the eMalahleni Local Municipality (ELM) and the Nkangala District Municipality (NDM) of the Mpumalanga Province. The mine is situated approximately 30 km south-east of the town of eMalahleni, in close proximity to the Duvha Power Station (refer to **Figure 1-1**).

VDDC is located on the western boundary of Wolvekrans Colliery. The Olifants River determine the southern boundary. The proposed infrastructure development will take place on the farms Kleinkopje 15 IS, VanDyksdrift 19 IS, Wolvekrans 17 IS and Steenkoolspruit 18 IS.

1.3 Project Description

The infrastructure development forms part of the VDDC mining project. The construction phase will commence after authorisation for the infrastructure components has been obtained and is expected to commence in 2020. The construction period is expected to be 18 – 24 months. The operational phase is expected to commence 2022.

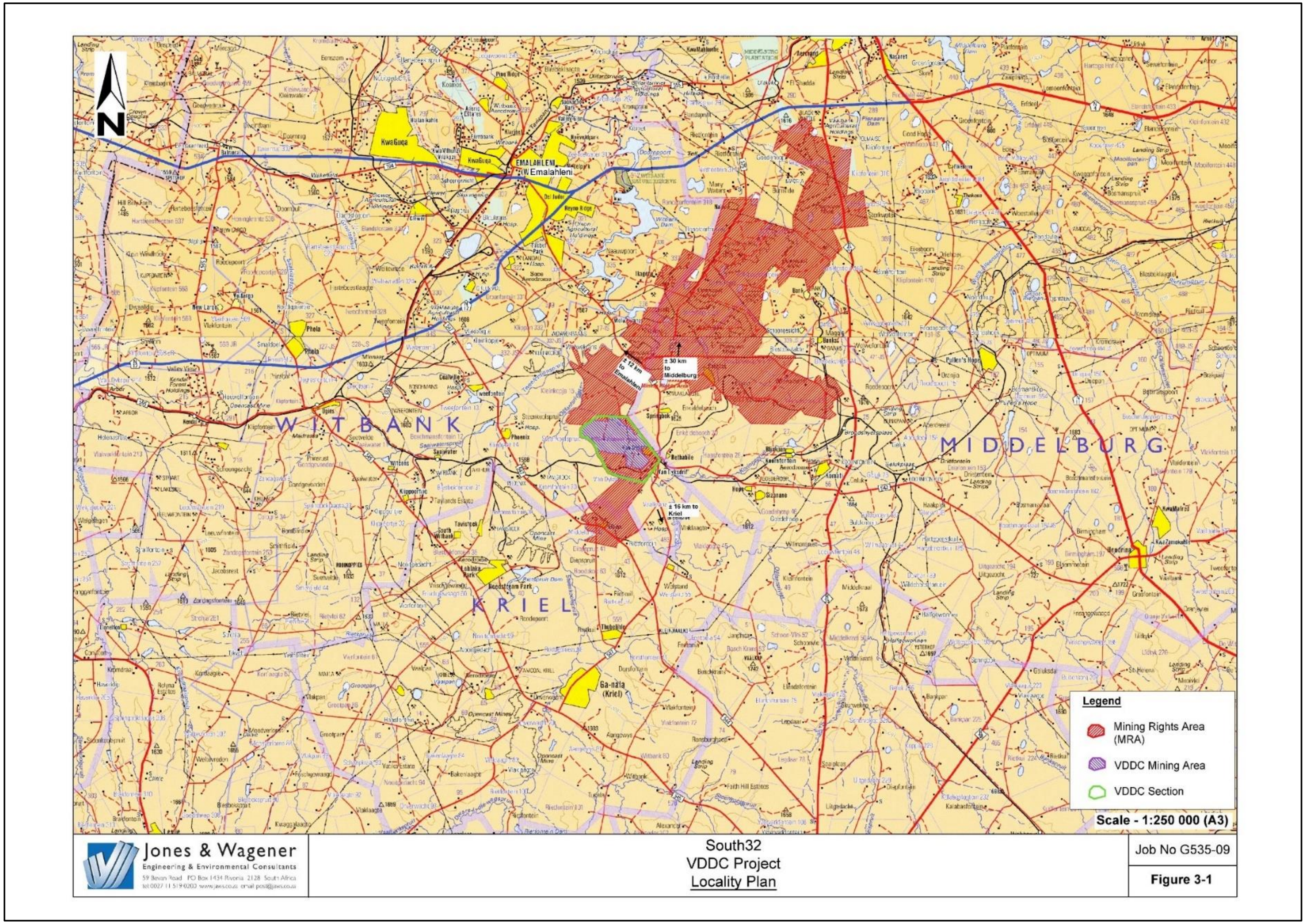

Figure 1-1: Locality of the project

1.4 Coal reserves

The VDDC area has been identified as the most likely coal source to replace the Steenkoolspruit (SKS) operations, and to fulfil the current contracts and market obligations of the mining complex (South32, 2017a).

Coal produced will be mainly exported through the Richards Bay coal terminal.

Limited opencast mining was done before 1990 in the top shallower No. 5 seam. The No. 4L, No. 2, No. 2A and No. 1 coal seams were exploited in the past by means of underground mining. All underground operations were terminated during October 2008. The No. 2 Seam is the principal seam in the project area and its thickness can exceed 9 m, but only the lower select horizon of higher quality 2.5 m – 4.5 m was previously extracted. The targeted mineable seams are the No. 5, No. S4UA, No. S4L, No. S2RP, No. S2A and No. S1 seams respectively (South32, 2017a).

As a result of the previous mining of the No. 2 Seam horizon by bord and pillar means, the following has resulted:

- The majority of the underground No. 2 seam workings are flooded because of water ingress from both surface and underground aquifers. A dewatering programme will be implemented before opencast mining operations commence.
- An area of the No. 2 Seam was historically used for placement of slurry from the processing plant. It is believed to be contained in the southeast portion of the deposit by underground seals and barrier.

1.5 Existing infrastructure

Existing infrastructure in the VDDC area is shown on **Figure 1-2** and described below.

1.5.1 Access, transport and logistics

Access to the VDDC project area is via one of three existing approaches, depending on the size of the transport, namely:

- Current SKS main entrance;
- Current Wolvekrans main entrance (via BMK workshops); and
- Current VDD main entrance (opposite Springbok village).

All personnel transport and light delivery vehicles will enter the site via the current SKS main entrance. Personal vehicles will park in the existing personnel vehicle parking, whilst busses will drop personnel off at the existing bus turnaround.

Light delivery vehicles and heavy delivery vehicles up to 10 t single body trucks will also enter via the existing SKS main entrance and deliver to the required location, or to the existing store facilities (South32, 2017b).

The heavy delivery vehicles and lowbeds will access the site via either the WVK main entrance or the VDD main entrance, depending on the destination within the VDDC Project area (South32, 2017b).

A number of existing haul roads have been developed within the mining area (refer to **Figure 1-2**).

1.5.2 Steenkoolspruit (SKS) facilities

Existing facilities at the SKS operations include the ROM tip and the overland conveyor system to the South Export Plant, the SKS complex offices, warehouse, change houses, workshops, wash bays, laydown areas, a sewage treatment plant and fuelling facilities.

The southern SKS facilities currently in use by the Vandyksdrift North (VDDN) operation include contractors' offices, laydown areas, as well as a fuel, lube, air and coolant (FLAC) station.

1.5.3 Topsoil dump

An existing topsoil dump is located on the north-eastern boundary of the VDDC section.

1.5.4 Surface dumps

Surface discard dumps exist on the southern portion of the VDDC resource area, namely the PSS and LAC dumps. These dumps are in the process of being reclaimed and it is expected that approximately 40% of the material will be recovered. Final rejects from the reclamation process is disposed of on the southern portion of the PSS dump. This Final Rejects Dump will remain in future and the VDDC mining area has been changed to exclude this footprint from the mine plan.

1.5.5 Storm water management measures

A number of clean and dirty water management berms and canals have been constructed to ensure that runoff is managed. This includes a clean water diversion dam which contains clean runoff from the undisturbed areas to the north-east.

A number of dirty water canals drain dirty runoff to dirty water facilities. The Vleishaft Dam is an existing Pollution Control Dam (PCD) with a capacity of 600 000 m^3, that has been authorised for the disposal of mine impacted water in terms of WULs issued to the mine.

Dirty runoff from the discard reclamation and processing plant drains to the Bob Henry dam and silt paddocks.

Existing water management measures at the PSS dump comprises of a clean water canal which collects clean water west of the PSS Dump Extension, as well as a system of unlined canals which collects dirty runoff from the PSS Dump and conveys the water to four PCD's. Excess water from the PCD's is pumped to the underground workings via a borehole. Water is abstracted from the workings via boreholes for re-use in the processing plant.

1.5.6 ROM coal stockpiles

Two Run-of-mine (ROM) coal stockpiles have been developed:

- A ROM coal pad located between the SKS void and the haul road, from where it is taken to the South Export Processing Plant via conveyors from the SKS crushing plant;
- A ROM stockpile area to the south of the Vleishaft Dam, of which a portion is currently used as a hard park area.

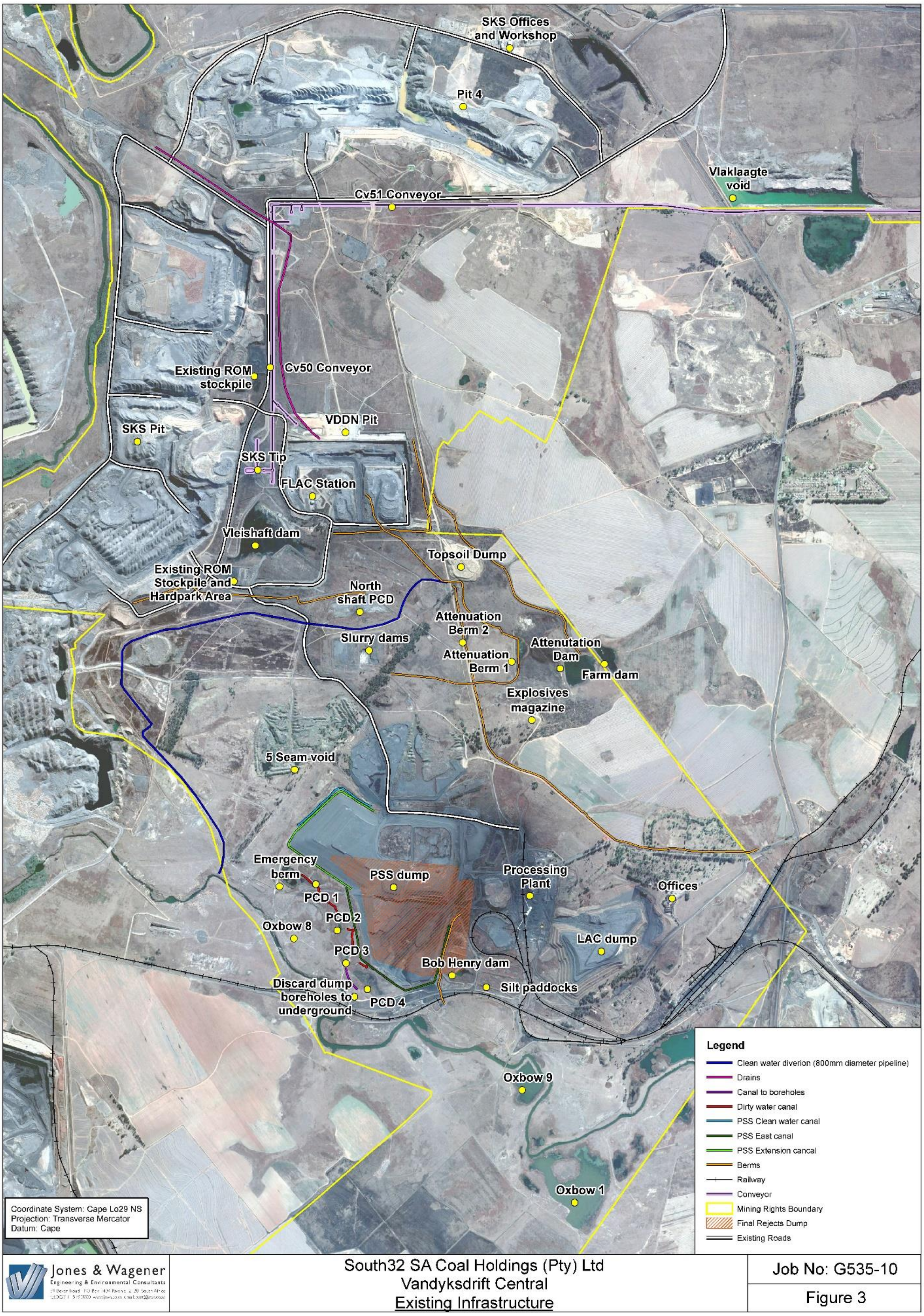

Figure 1-2: Existing infrastructure

1.5.7 Power supply

The VDDC section is supplied from Eskom's Klein 132 kV Substation, which feeds the DMO Klein Olifant 132 kV Substation. The voltage is stepped down to 22 kV via two 20 MVA power transformers feeding the 22 kV switchgear located in the Klein Olifant Substation (South32, 2017b).

The existing electricity infrastructure is shown on **Figure 1-3**.

A section of the Klein-Kromfontein 132 kV powerline must be relocated to allow opencast mining to proceed. This is the subject of a separate application that is undertaken by South32 in terms of a self-build agreement with Eskom. The EA for the powerline will be transferred to Eskom on completion of the construction phase.

1.6 Upfront dewatering infrastructure

In order to mine the VDDC reserve, the water contained in the underground workings must be removed prior to mining. This will be achieved by drilling a number of boreholes into the old underground workings and to abstract the water via these boreholes.

Water will be pumped from the boreholes accessing different underground compartments and will be transferred via borehole connector pipelines to the Vleishaft Dam and/or directly to the evaporation tanks that will be located at the evaporation sites where water will be evaporated using mechanical evaporators. Three evaporators sites have been identified, namely No. 5 Seam void, Vleishaft Dam and Vlaklaagte Void.

In addition, some water will be pumped and stored in the Steenkoolspruit Pit void (Jaco-K Consulting, 2016(b)).

The following evaporators systems have been installed:

- Eight evaporators at Vleishaft Dam (2 Mℓ);
- Twenty evaporators at Vlaklaagte void (2 Mℓ); and

An additional 12 new evaporators (3 Mℓ) will be installed at the No. 5 Seam void by the end of 2019.

1.7 Project description: Proposed new infrastructure

The new infrastructure to be developed (and which will be the subject of the IRP) is shown on a **Figure 1-4** and discussed below.

1.7.1 Topsoil dumps

The topsoil excavated from the box cut areas and areas cleared for the development of infrastructure will be relocated to a topsoil stockpile area to be located adjacent to the existing topsoil stockpile in the east of the project area. In addition, provision has been made for a topsoil stockpile area in between the ramps.

The box cut topsoil will be stockpiled due to the lack of direct placement option at the start of the opencast mining operations.

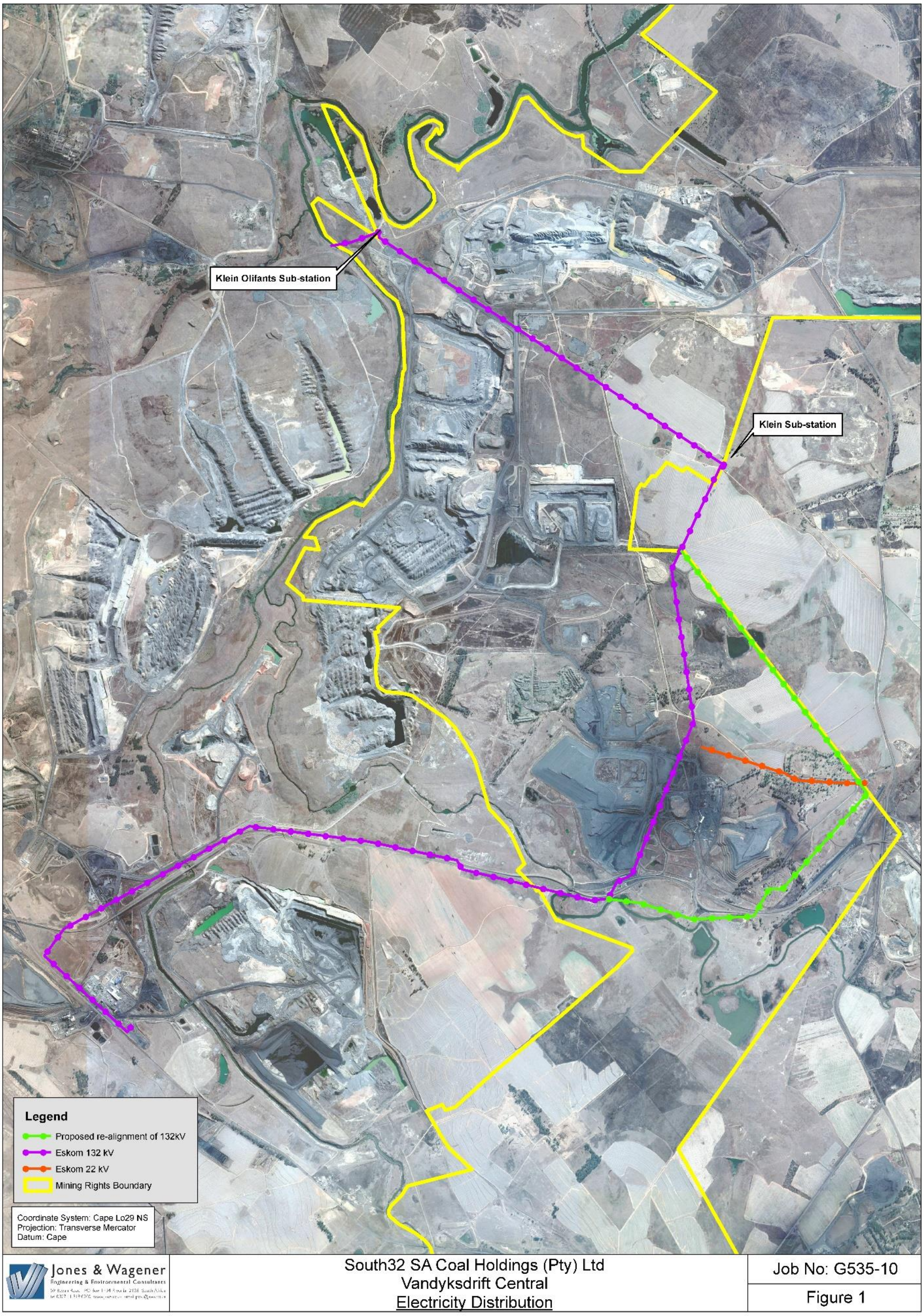

Figure 1-3: Existing electricity distribution network

1.7.2 Overburden dumps

The boxcut will be done using a combination of dragline and truck and shovel. Overburden from the boxcut will be placed on four overburden dumps located in between the proposed ramps.

In addition, provision has been made for two overburden dumps. A new overburden dump will be developed in the south-east of the project area and the existing overburden dump at the SKS pit will also be used.

Upon steady state mining being achieved, rehabilitation activities can commence safely behind the active dynamic window of operations and the in-pit backfilling of overburden can advance. As the mine pit expand, there will be more opportunity to excavate overburden and apply it directly to re-contoured areas, thus avoiding stockpiling. It has been assumed that overburden stockpiling will be during the initial stages of mining and that direct placement will commence when sufficient placement areas are available (South32, 2017a).

1.7.3 ROM stockpiles and Mixed ROM coal and slurry stockpile areas

An area of the underground No. 2 Seam was historically used for placement of slurry from the processing plant. It is believed to be contained in the southeast portion of the deposit by underground seals and barrier pillars. The expected slurry footprint is indicated in **Figure 1-4**.

Slurry will be mined with the ROM coal and the blended coal and slurry will be transferred to mixed ROM coal and slurry stockpile areas, located to the south of the Vleishaft Dam. The mixed material will be allowed to dewater before it is removed to the existing SKS tip, from where it will be taken to the South Export Processing Plant[3]. Water will be collected and conveyed via a silt trap to the Vleishaft Dam.

ROM coal from the No. 4 and No. 5 seams will be placed on transfer stockpiles. These stockpiles will be located on a partially reclaimed area of the PSS dump footprint. The stockpile positions will be moved as mining progresses but will remain within the footprint of the existing PSS dump or other previously mined out or disturbed areas.

1.7.4 Water consumption requirements

Potable water and wash water for vehicles and workshops will be supplied from the existing water supply at the SKS complex.

Water for dust suppression will be sourced from mine impacted water.

[3] Processing of the slurry at the existing South Plant may require changes to the processing plant. This, however, falls outside of this application process

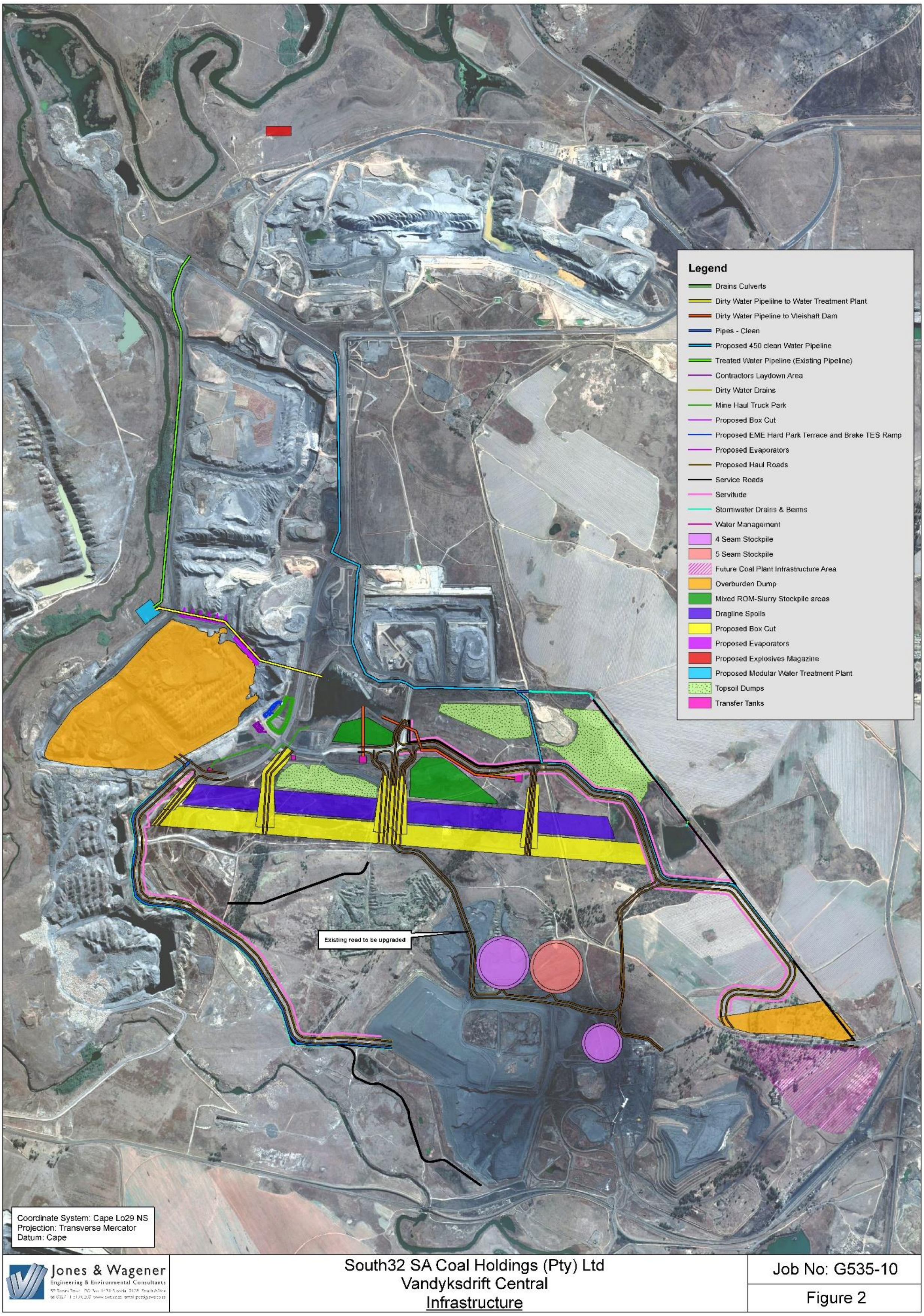

Figure 1-4: Proposed new infrastructure at VDDC

1.7.5 Management of mine impacted water

The proposed mining operations require the management of mine impacted water. Dirty areas that have been identified and included in the water management strategy are:

- Opencast pit;
- Mixed ROM coal and slurry stockpile areas;
- Overburden dumps;
- ROM stockpiles; and
- Hard park area.

Opencast pit

In order to manage the inflow of water into the mining operations, sumps will be constructed in the pit floor where the water will be collected at the bottom of the pit (at lowest points) and pumped out of the pit. These temporary sumps will be situated at the bottom of each access ramp and the piping routed in a berm servitude on the side of the access ramp, up to transfer tanks situated at the top of the ramp. Once the water reaches the transfer tanks, it will join the polluted water management system. Water will be pumped from the pit with self-priming diesel driven pumps mounted on trailers or skids to allow for easy movement (South32, 2017a). Water will be pumped to the Vleishaft Dam and from there, to one of the evaporator sites, or to the proposed modular water treatment plant (WTP) or to Vlaklaagte void,

Mechanical evaporator sites are as follows:

- Three sites will be established as part of the upfront dewatering strategy (refer to section 1.6):
  - 8 evaporators at Vleishaft Dam (2 Mℓ);
  - 20 evaporators at Vlaklaagte void (2 Mℓ); and
  - 12 evaporators (3 Mℓ) at the No. 5 Seam void.
- As part of the VDDC infrastructure development, eight (8) new evaporators (3 Mℓ) will be established at the SKS void.
- As mining progresses at VDDC, the 12 evaporators at No. 5 Seam void will move to the SKS void, bringing the number of evaporators at the SKS void to a total of 20 .

Surplus water which cannot be handled through the evaporation system, will be conveyed to a mobile, modular water treatment plant (WTP) with a maximum treatment capacity of 20 Mℓ/day.

Brine from the WTP will be conveyed to the evaporators on the SKS void.

Effluent from the WTP (i.e. treated mine water) will be conveyed via an existing mine water pipeline to the existing northern clean water canal, from where it will discharge via a wetland area into the Olifants River. Water will be treated to comply with Resource Quality Objectives for the Olifants River catchment as published in GN 466 in April 2016.

Mixed ROM coal and slurry stockpile areas

Mine impacted water from the Mixed ROM coal and slurry stockpile areas will be collected and conveyed to the Vleishaft Dam via silt traps.

Overburden dumps

The overburden dump located at the SKS void will drain to the void and no additional measures are foreseen.

Pollution control measures will be required at the new overburden dump located on the south-eastern boundary to collect dirty runoff and seepage. Mine impacted water will be conveyed via suitable diversion structures to the dirty water management infrastructure and re-used in the existing plant for the reprocessing of material from the PSS and LAC dumps, or pumped into the underground via an existing borehole.

1.7.6 Dust Suppression

Dust on haul roads will be controlled using water bowsers. Bowsers will fill up at filling stations that will be located in close proximity to VDDC pit. The use of chemical dust suppressants will also be considered.

1.7.7 Clean water management

Clean run-off water from the area to the east of the VDDC mining area will be diverted away from the mining areas so that it will not become contaminated by the mining operations.

The existing VDDN clean water diversion canal will be diverted around the proposed new topsoil dumps on the eastern boundary of the mining right area.

High wall drains will be installed to divert clean water away from the mining area where practical. These drains will move as mining progresses.

Two 450 mm diameter clean water diversion pipeline will be installed from the existing clean water diversion dam, to the existing northern canal from where water will be discharged from a proposed WTP via a wetland area into the Olifants River.

1.7.8 Explosives magazine

The existing explosives magazine will be relocated to the north of Pit 4.

1.7.9 New roads

New roads required for the VDDC project include:

- Temporary high wall roads and dragline walkways which will be re-established as mining progresses;
- Earth Moving Equipment (EME) haul roads (40 m width) from the bottom of box cut ramps to the existing haul roads;
- Additional maintenance/service and access roads within the VDDC project area from the existing infrastructure to the box-cut;
- New haul road to the No. 4 seam and No. 5 seam stockpiles.

1.7.10 EME Hard park and Brake Test Ramp

A hard park will be developed between the Vleishaft Dam and the SKS pit. The hard park will include perimeter drains that convey polluted water runoff (primarily polluted with silt) to the SKS void.

A brake test ramp will be provided for EME traffic at the hard park area. The brake test ramp is positioned such that all vehicles will need to traverse the ramp before entering the pit areas. The ramp has been designed to enable the longest expected vehicle entering the mining areas to stop on the inclined sections, with both axles or all wheels. The incline sections are to the steepest recommended grade of these vehicles or to the incline of the ramps to the pits.

In-pit vehicle ramps are of similar construction to the remainder of the haul roads including safety berms.

1.7.11 Access control and security fencing

Access control will be through the existing control measures.

Triple security fencing will be provided at the explosives magazine. Triple fencing includes a triple barrier of 2.4 m high clear mesh, electric and normal security fencing. Electric fencing is connected to the local security system (South32, 2017b).

1.7.12 Other supporting infrastructure

The remainder of the supporting infrastructure is mostly catered for by the existing SKS complex facilities. Existing change houses, stores facilities, office facilities, tracked vehicle workshops, LDV workshops will be used.

No additional fuel or lube storage area, servicing bays or tyre bays are required.

1.7.13 Future coal plant infrastructure area

As indicated earlier, the PSS and LAC dumps are currently reclaimed and processed within the existing VDD processing plant. As mining progresses, this plant will need to be relocated. An area has been allocated for this purpose and is situated to the south of the proposed new overburden dump in the south-eastern corner of the VDDC area.

1.8 Project description: Changes to opencast mining

The VDDC mine lay-out as determined through the pre-feasibility investigation, as well as the mine-lay-out included in the approved 2007 EMPR Amendment is shown on **Figure 1-5.** The area where the existing LAC dump is located, as well as a small area further north-east, were not included in the approved 2007 EMPR Amendment, and therefore requires authorisation for opencast mining.

1.9 Specialist Project Team

The following personnel were involved in the compilation of this report. Refer to **Appendix A** for copies of the curricula vitae (CV's)

Table 1-1: Specialist Team Members.

Name	Organisation	Highest Qualifications	Experience	Role
Konrad Kruger	Jones & Wagener	BSc Honours Geography	14 Years	Specialist
Tolmay Hopkins	Jones & Wagener	MSc (Agric) Microbiology	20 Year	Pr. Sci Nat Reviewer

1.10 Assumptions and Limitations

The following assumptions/limitations were relevant during the assessment:

- The information collected in the previous reports for VDDC are correct and do not require verification. Thus, the information was used as published previously.
- The assessments are based on contours supplied by the mine and supplemented with surveyor general 20m contours. The specialist is not responsible for the accuracy of the surveys supplied.
- No survey verifications were undertaken as part of this assessment.

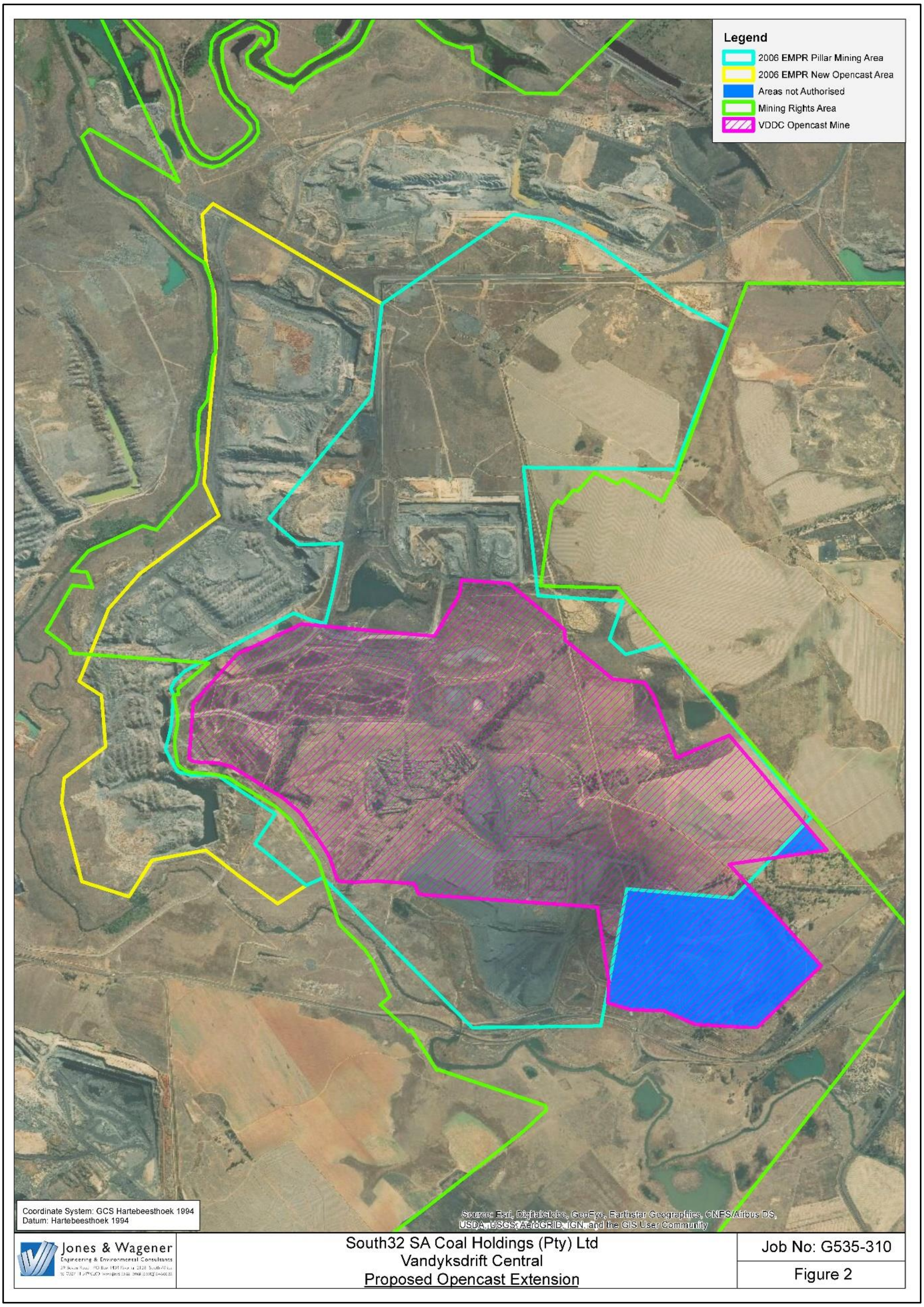

Figure 1-5: VDDC opencast pit compared to mine layout in 2007

2. BASELINE ASSESSMENT

2.1 Approach and Methodology

In order to adequately assess the visual impact, the following methodology was applied:

- All the required data were collected, which included data on topography, existing visual character and quality, plans of the proposed development and other background information;
- Fieldwork (a site visit) was conducted on the 11th July and the 22nd August 2018. The objectives of the fieldwork were to:
  - familiarise the author with the site and its surroundings;
  - to identify key viewpoints/ corridors and visual receptors;
  - groundtruth the sensitivity of the landscape; and
  - determine the distance from which visual impacts are likely to become discernible.
- Landscape characterisation was done by mapping the site location and context and describing the landscape character and sense of place. This considered geological and topographical features, vegetation and land-use.
- Visual sampling was undertaken using photography from a number of viewpoints within approximately 5km of the site. The location of the viewpoints was recorded with a GPS and photographs were taken at a depth of field between 45-55mm. A selection of these are used in the assessment phase of the VIA to illustrate the likely zone of influence and visibility.
- ArcGIS 3D Analyst extension was used to calculate the viewshed making use of a 20m contour interval Digital Elevation Model (DEM) as the input raster.
- The sensitivity of the landscape was analysed, taking the following factors into consideration:
  - Slope and elevation;
  - Proximity of visual receptors (farmsteads and towns);
  - Proximity of major roads and scenic routes;
  - Nature reserves and National Parks; and
  - Other relevant features and buffer guidelines.
- Visual concerns and potential impacts were identified;
- The potential magnitude of visual impacts was evaluated using standard VIA criteria and rating methodologies; and
- Potential visual impacts for each project phase as well as cumulative impacts were assessed using an impact assessment methodology developed by J&W to adhere to the NEMA, Environmental Impact Assessment Regulations, 2014 (as amended). This methodology is explained in detail in Section 3.

2.2 Visual Baseline

2.2.1 Geology, Climate and Topography

The coal reserve falls within the Witbank Coalfield, which consists of sedimentary rocks of the coal-bearing Ecca Group of the Karoo Sequence. Five coal seams are contained in a 70m-average thick succession in the coalfield, consisting primarily of sandstone with subordinate siltstone and mudstone. The succession is the Vryheid Formation of the lower Ecca group and followed the deposition of the Dwyka – the latter is of glacial origin and comprises mainly tillite. Underneath the Dwyka in the area is a volcanic pre-Karoo floor. This basement consists mainly of rhyolitic rocks of the Rooiberg Group, Pretoria.

The partings between the seams are remarkably constant; however, seam splits are fairly common. The basement had a significant influence on the nature, distribution and thickness of the overlying sedimentary rocks, especially the coal seam thickness and coal quality. This is especially true for the lower coal seams (Nos 1 and 2) and less for the higher seams.

The Ogies dyke is situated between 300-1500m north of the proposed mine workings. Literature widely states that the Ogies dyke is about 15m thick and can be followed for about 100 km along strike. It devolitised the coal on either side over a distance of up to 300m, suggesting that it probably acted as a magma conduit for a considerable length of time.

The mean annual precipitation for the area is 711 mm which occurs as showers and thunderstorms and falls mainly from September to April. The area has a temperate climate with warm summers and cold winters with sharp frost. Generally summer temperatures are mild with an average of only 8.2 days annually, on which recorded maxima are above 30°C. Winters are cold with an average 41.4 days recorded below 0°C and 102.2 days recorded below 5°C, annually.

June is the coldest month when the mean monthly minimum has been as low as –5.7°C. An absolute minimum of below -11°C has been recorded. January is the hottest month with temperatures occasionally above 34°C. The diurnal range, particularly in winter, is high with a maximum of 17.3°C in August and a minimum of 12.4°C in February (Douglas EMP Amendment 2006).

The topography associated with the proposed new mining area is gently undulating mine and farmlands at an elevation of between 1520 mamsl and 1590 mamsl (**Figure 2-1**). The Olifants River runs parallel to the western boundary of the proposed mining area, where the topography is frequently steeper due to the presence of sandstone outcrops and depicts scenic cliffs and bends in the river.

Wetlands are associated with open water and stream margins along drainage lines in the study area. Rocky outcrops are often located to one side of the drainage lines and probably developed as streams incised into the landscape.

The drainage pattern is dendritic towards the south and west, with various small tributaries flowing into the Olifants River. The study area falls within the Olifants River Catchment.

This project falls within the larger Wolvekrans Colliery that comprises several different mining areas and mining methods. In areas where bord and pillar mining methods were historically practiced, the topography remains unaffected, apart from the impact of the coal discard and overburden dumps. However, several areas mined underground in the past are impacted on due to pillar collapse. In terms of the study area the topography has been altered by several discard facilities, surface infrastructures and topsoil stockpiles.

2.2.2 Vegetation

The VDDC Project area is situated within the grassland biome. This biome is centrally located in southern Africa, and adjoins all except the desert, fynbos and succulent Karoo biomes (Mucina & Rutherford, 2006). The project area is situated predominantly within one vegetation type; namely the Eastern Highveld Grassland (GM12) vegetation type.

This vegetation type occurs on slightly to moderately undulating planes, including some low hills and pan depressions. The vegetation is a short dense grass land dominated by the usual highveld grass composition (*Aristida, Digitaria, Eragrostis, Themeda, Tristachya* etc.) with small scattered rocky outcrops with, wiry sour grasses and some woody species. Some 44% transformed primarily by cultivation, plantations, mines, urbanisation and by building of dams. No serious alien invasions are reported (Mucina & Rutherford, 2006).

As seen in the photos of **Figure 2-2** below, the grassland found within the study area is very short with intermittent trees close to farmsteads and settlements. In the eastern parts of the site maize is planted and harvested annually, resulting in open fields without cover during the winter months. The vegetation therefore provides little visual cover for structures.

Some visual screening has been planted at the SKS workshops to the north of the mining area, as shown in the photos. The screening is effective for a section of the R544 road, but does not eliminate the visual impact, especially since the proposed new structures will be constructed outside of the area that is screened.

2.2.3 Land Use

The pre-mining land use of the VDDC area was dominated by cultivated fields (38%) and grassland (23%), with some 17% of the area comprising industrial and mining activities. Wetlands comprise some 14% of the land use in the area with some land used for dams, infrastructure and roads.

Most of the infrastructure present in the greater study area stems from mining activities (South32 Wolwekrans, Middelburg, Glencore Impunzi and Anglo Goedehoop). Some other industrial development is concentrated around the towns of eMalahleni and Middelburg. The main road in the area is the N12/N4 Highway, connecting Gauteng with Mpumalanga. In addition, the Duvha and Komati power stations provide further industrial impact. These activities have an industrial visual character and result in a more pronounced impact on the natural character of the landscape. Additionally, prominent Eskom powerlines cross the landscape to and from the two power stations. Refer to **Figure 2-2** for some examples.

2.2.4 Sensitivities

Visually there are no sensitive features or no-go areas on the site itself. In the surrounding area the following are considered to be visually sensitive:

- Topographic Features
  - None
- Surrounding homesteads
  - The area around the site has several settlements overlooking the proposed mining area as well as along the infrastructure routes.
- Towns/urban areas
  - The towns of eMalahleni and Middelburg are located to the north of the project area.

    - The proposed infrastructure should not affect any towns/urban areas.
- Roads
    - The proposed project will be located west of the R544 from eMalahleni.

2.2.5 Viewshed

In order to determine the potential baseline for the proposed new infrastructures, this assessment had to determine the viewshed within the study area.

A viewshed is the geographical area that is visible from a location. It includes all surrounding points that are in line-of-sight with that location and excludes points that are beyond the horizon or obstructed by terrain and other features.

The viewshed from the proposed infrastructures is shown in **Figure 2-3** and extends some 10-12km to the north and south. The elevated views from the Ogies dyke in the north is offset by the flat terrain around the Olifants River floodplain, where the site is located. Views to the east and west are somewhat blocked due to topography, with a few isolated exceptions.

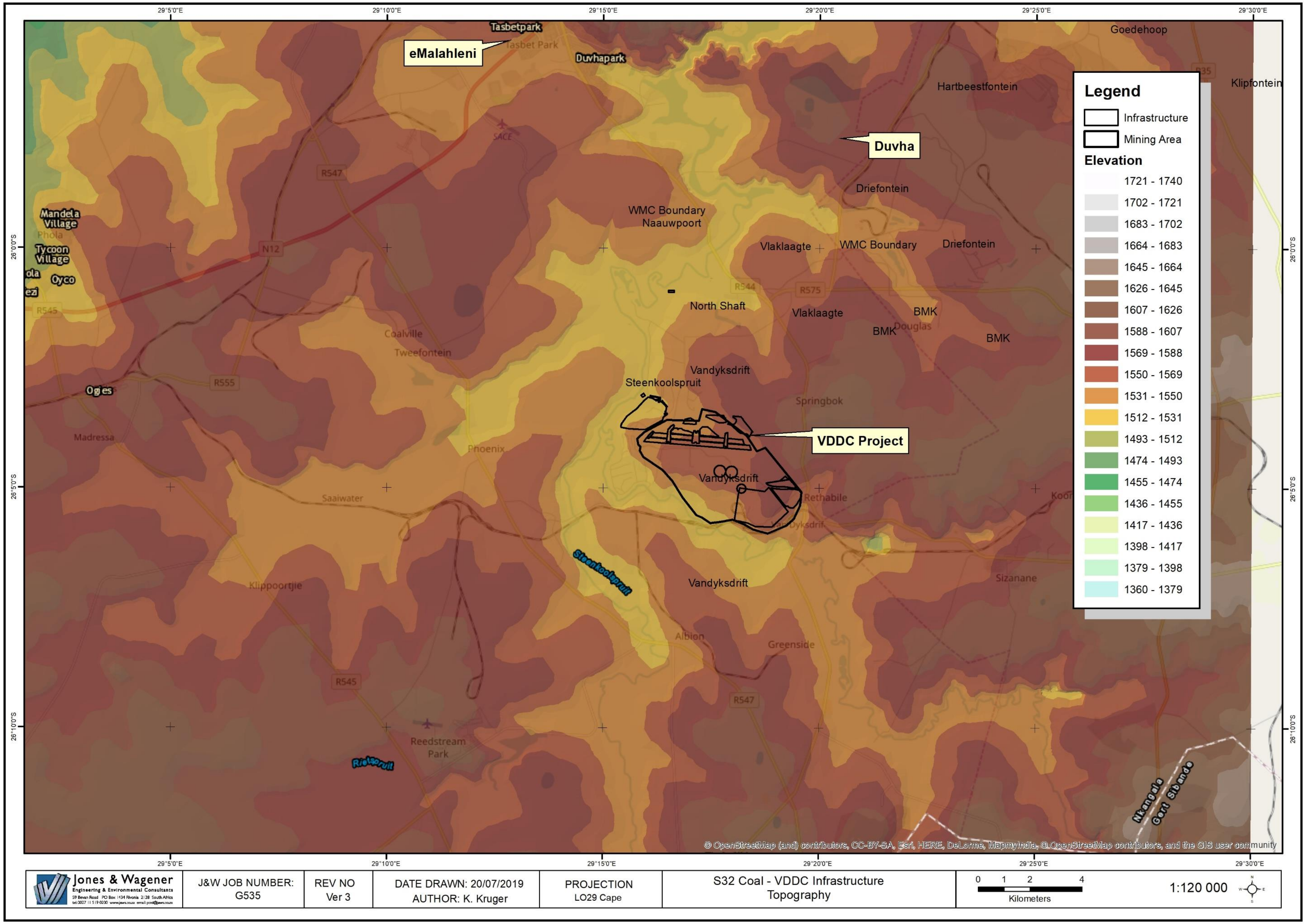

Figure 2-1: **Topography of the VDDC study area**

Panorama of the proposed mining site from the R544 looking southwest. Note the recently harvested cultivated fields in the foreground and the limited vegetation screening. The existing discard dumps can be seen in die background on the left and centre.

Panorama of the SKS workshop area taken from the R544 looking south, showing some visual screening by Blue Gum trees. The new explosives magazine is proposed for the area to the right of picture.

Examples of visual observers on site - vehicles from the R544 dominate

Figure 2-2: Photographs of the visual cover/impact on site

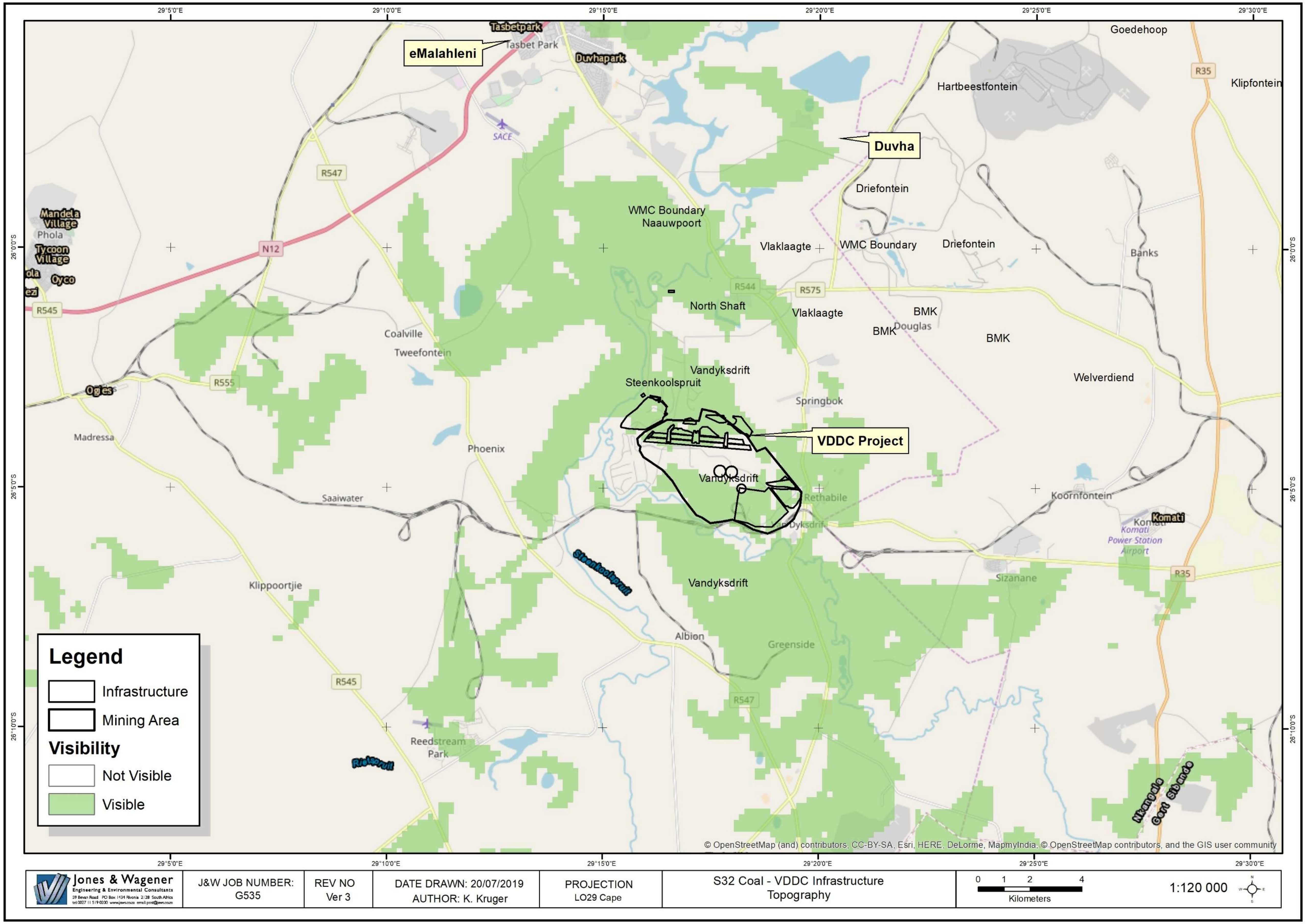

Figure 2-3: **Viewshed of the proposed infrastructure**

3. IMPACT ASSESSMENT METHODOLOGY

In order to ensure uniformity, a standard impact assessment methodology will be utilised so that a wide range of impacts can be compared. The impact assessment methodology makes provision for the assessment of impacts against the following criteria:

- Significance;
- Spatial scale;
- Temporal scale;
- Probability; and
- Degree of certainty.

A combined quantitative and qualitative methodology will be used to describe the impacts for each of the aforementioned assessment criteria. A summary of each of the qualitative descriptors along with the equivalent quantitative rating scale for each of the aforementioned criteria is given in **Table 3-1**.

Table 3-1: Quantitative rating and equivalent descriptors for the impact assessment criteria

RATING	SIGNIFICANCE	EXTENT SCALE	TEMPORAL SCALE
1	VERY LOW	*Isolated corridor / proposed corridor*	Incidental
2	LOW	*Study area*	Short-term
3	MODERATE	*Local*	Medium-term
4	HIGH	*Regional / Provincial*	Long-term
5	VERY HIGH	*Global / National*	Permanent

A more detailed description of each of the assessment criteria is given in the following sections.

3.1 Significance Assessment

Significance rating (importance) of the associated impacts embraces the notion of extent and magnitude but does not always clearly define these since their importance in the rating scale is very relative. For example, the magnitude (i.e. the size) of area affected by atmospheric pollution may be extremely large (1000km^2) but the significance of this effect is dependent on the concentration or level of pollution. If the concentration is great, the significance of the impact would be HIGH or VERY HIGH, but if it is diluted it would be VERY LOW or LOW. Similarly, if 60 ha of a grassland type are destroyed the impact would be VERY HIGH if only 100 ha of that grassland type were known. The impact would be VERY LOW if the grassland type was common. A more detailed description of the impact significance rating scale is given in **Table 3-2** below.

Table 3-2: Description of the significance rating scale

RATING		DESCRIPTION
5	VERY HIGH	Of the highest order possible within the bounds of impacts which could occur. In the case of adverse impacts: there is no possible mitigation and/or remedial activity which could offset the impact. In the case of beneficial impacts, there is no real alternative to achieving this benefit.
4	HIGH	Impact is of substantial order within the bounds of impacts, which could occur. In the case of adverse impacts: mitigation and/or remedial activity is feasible but difficult, expensive, time-consuming or some combination of these. In the case of beneficial impacts, other means of achieving this benefit are feasible but they are more difficult, expensive, time-consuming or some combination of these.
3	MODERATE	Impact is real but not substantial in relation to other impacts, which might take effect within the bounds of those which could occur. In the case of adverse impacts: mitigation and/or remedial activity are both feasible and fairly easily possible. In the case of beneficial impacts: other means of achieving this benefit are about equal in time, cost, effort, etc.
2	LOW	Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts: mitigation and/or remedial activity is either easily achieved or little will be required, or both. In the case of beneficial impacts, alternative means for achieving this benefit are likely to be easier, cheaper, more effective, less time consuming, or some combination of these.
1	VERY LOW	Impact is negligible within the bounds of impacts which could occur. In the case of adverse impacts, almost no mitigation and/or remedial activity is needed, and any minor steps which might be needed are easy, cheap, and simple. In the case of beneficial impacts, alternative means are almost all likely to be better, in one or a number of ways, than this means of achieving the benefit. Three additional categories must also be used where relevant. They are in addition to the category represented on the scale, and if used, will replace the scale.
0	NO IMPACT	There is no impact at all - not even a very low impact on a party or system.

3.2 Spatial Scale

The spatial scale refers to the extent of the impact i.e. will the impact be felt at the local, regional, or global scale. The spatial assessment scale is described in more detail in **Table 3-3**.

Table 3-3: Description of the significance rating scale

RATING		DESCRIPTION
5	Global/National	The maximum extent of any impact.
4	Regional/Provincial	The spatial scale is moderate within the bounds of impacts possible and will be felt at a regional scale (District Municipality to Provincial Level). The impact will affect an area up to 50km from the proposed site / corridor.
3	Local	The impact will affect an area up to 5km from the proposed route corridor / site.
2	Study Area	The impact will affect a route corridor not exceeding the boundary of the corridor / site.
1	Isolated Sites / proposed site	The impact will affect an area no bigger than the corridor / site.

3.3 Duration Scale

In order to accurately describe the impact, it is necessary to understand the duration and persistence of an impact in the environment. The temporal scale is rated according to criteria set out in **Table 3-4**.

Table 3-4: Description of the temporal rating scale

RATING		DESCRIPTION
1	Incidental	The impact will be limited to isolated incidences that are expected to occur very sporadically.
2	Short-term	The environmental impact identified will operate for the duration of the construction phase or a period of less than 5 years, whichever is the greater.
3	Medium term	The environmental impact identified will operate for the duration of life of the project.
4	Long term	The environmental impact identified will operate beyond the life of operation.
5	Permanent	The environmental impact will be permanent.

3.4 Degree of Probability

The probability or likelihood of an impact occurring will be described, as shown in **Table 3-5** below.

Table 3-5: Description of the degree of probability of an impact occurring

RATING	DESCRIPTION
1	Practically impossible
2	Unlikely
3	Could happen
4	Very Likely
5	It's going to happen / has occurred

3.5 Degree of Certainty

As with all studies it is not possible to be 100% certain of all facts, and for this reason a standard "degree of certainty" scale is used as discussed in **Table 3-6**. The level of detail for specialist studies is determined according to the degree of certainty required for decision-making. The impacts are discussed in terms of affected parties or environmental components.

Table 3-6: Description of the degree of certainty rating scale

RATING	DESCRIPTION
Definite	More than 90% sure of a particular fact.
Probable	Between 70 and 90% sure of a particular fact, or of the likelihood of that impact occurring.
Possible	Between 40 and 70% sure of a particular fact, or of the likelihood of an impact occurring.
Unsure	Less than 40% sure of a particular fact or the likelihood of an impact occurring.
Can't know	The consultant believes an assessment is not possible even with additional research.

3.6 Quantitative Description of Impacts

To allow for impacts to be described in a quantitative manner in addition to the qualitative description given above, a rating scale of between 1 and 5 was used for each of the assessment criteria. Thus, the total value of the impact is described as the function of significance, spatial and temporal scale as described below.

$$\textbf{\textit{Impact Risk}} = \frac{\text{SIGNIFICANCE} + \textit{Spatial} + \text{Temporal}}{3} \times \frac{\text{Probability}}{5}$$

An example of how this rating scale is applied is shown in **Table 3-7**.

Table 3-7: Example of Rating Scale

IMPACT	SIGNIFICANCE	SPATIAL SCALE	TEMPORAL SCALE	PROBABILITY	RATING
	LOW	*Local*	Medium Term	*Could Happen*	
Impact to air	**2**	***3***	**3**	**3**	**1.6**

Note: The significance, spatial and temporal scales are added to give a total of 8, that is divided by 3 to give a criteria rating of 2,67. The probability (3) is divided by 5 to give a probability rating of 0,6. The criteria rating of 2,67 is then multiplied by the probability rating (0,6) to give the final rating of 1,6.

The impact risk is classified according to 5 classes as described in **Table 3-8**.

Table 3-8: Impact Risk Classes

RATING	IMPACT CLASS	DESCRIPTION
0.1 – 1.0	1	Very Low
1.1 – 2.0	2	Low
2.1 – 3.0	3	Moderate
3.1 – 4.0	4	High
4.1 – 5.0	5	Very High

4. IMPACT ASSESSMENT

The impact assessment was undertaken for the project components described in Section 1 above. Please note that this assessment only assessed the section of mining not previously assessed in the approved EMPR. The sections below described the various visual impacts per project phase, prior to assessing the impacts. The impact assessment is summarised in **Table 4-1** at the end of this section.

4.1 Baseline

The area of assessment includes the study areas shown in **Figure 1-2** above. The sites fall within the existing Wolvekrans mining area of South32, within the Vandyksdrift section. As this is an active opencast and underground mining area, the visual environment has been widely impacted to the point where the sense of place is no longer associated with farming, but rather dominated by coal mining.

4.2 Additional Impact

4.2.1 Construction Phase

During the construction phase the work carried out will mainly be the construction of the opencast mine supporting infrastructure. This will entail the clearing of areas through excavations as well as the construction of the various stockpiles. The topography and natural drainage lines will be disturbed. The overall impact will be from the visual disturbance by dust, and the vehicle movements. As the stockpiles have not yet reached their full height, the impact is limited to the cleared footprints.

Construction activities will change the land use to mining causing unsuitable conditions for any further commercial farming. Approximately 78 ha out of the 489 ha of footprint to be disturbed by this project is currently natural or farmland. The remaining 411 ha has already been disturbed by either opencast mining, underground mining or associated activities.

The initial impact during the construction phase is rated as probable, LOW, short term impact on the *proposed infrastructure sites*. This impact is going to happen and is rated as a Low impact (1.67).

4.2.2 Operational Phase

During operations the stockpiles will increase in height over time, becoming more and more visible. At the time of writing, the client did not have estimated heights for these stockpiles, so the visual modelling assumed 40m for stockpiles and 10m for workshops, explosive magazines and other structures.

The visual impact was modelled for the static observer scenario (**Figure 4-1** below) and the dynamic observer scenario, driving on the nearby roads (**Figure 4-2**). The model assumed that all structures have reached their final heights and is therefore a representation of the most conservative scenario, that all impacts will be maximised at the same time.

From the static observer model, it can be seen that the visual impact will reach some 8-9km from the structures. The highest visibility will be from the explosive magazine that will be especially visible on the ridge to the north of the site, just south of Duvha power station. Another area of high impact will be to the south-east, near the Vandyksdrift railway loop, where the overburden dump and final reject dump will be very visible. The average impact is low to moderate.

The dynamic impacts from the roads in the area will be intermittent, and as shown in **Figure 4-2**, low in magnitude but can be long in duration. The infrastructure will be visible from the R547, R544, R575, and the R542 roads.

The additional impact during the operational phase is rated as definite, MODERATE, long term impact on the *local area*. This impact is going to happen and is rated as a High impact (3.3).

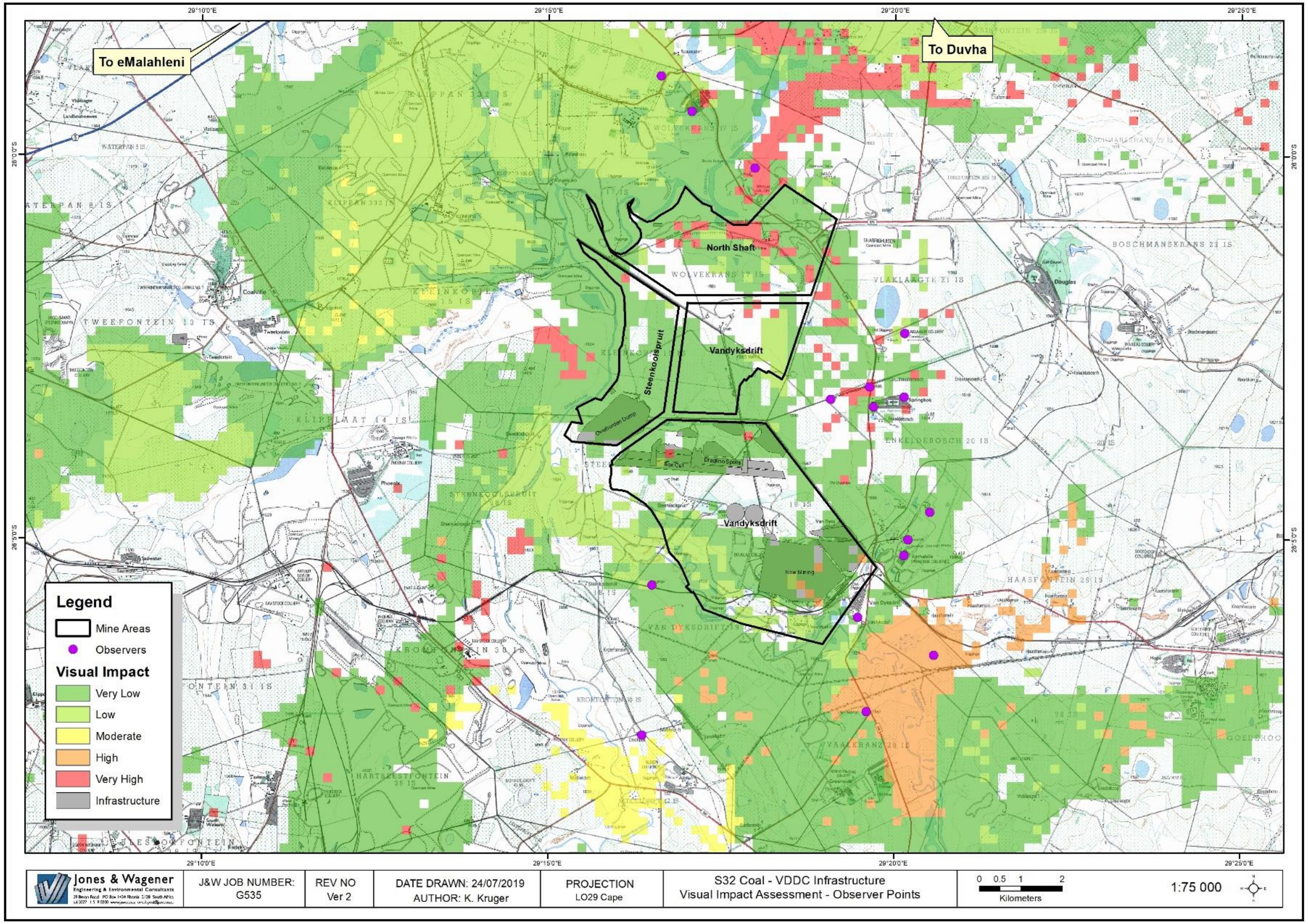

Figure 4-1: Modelled impacts to key observer points

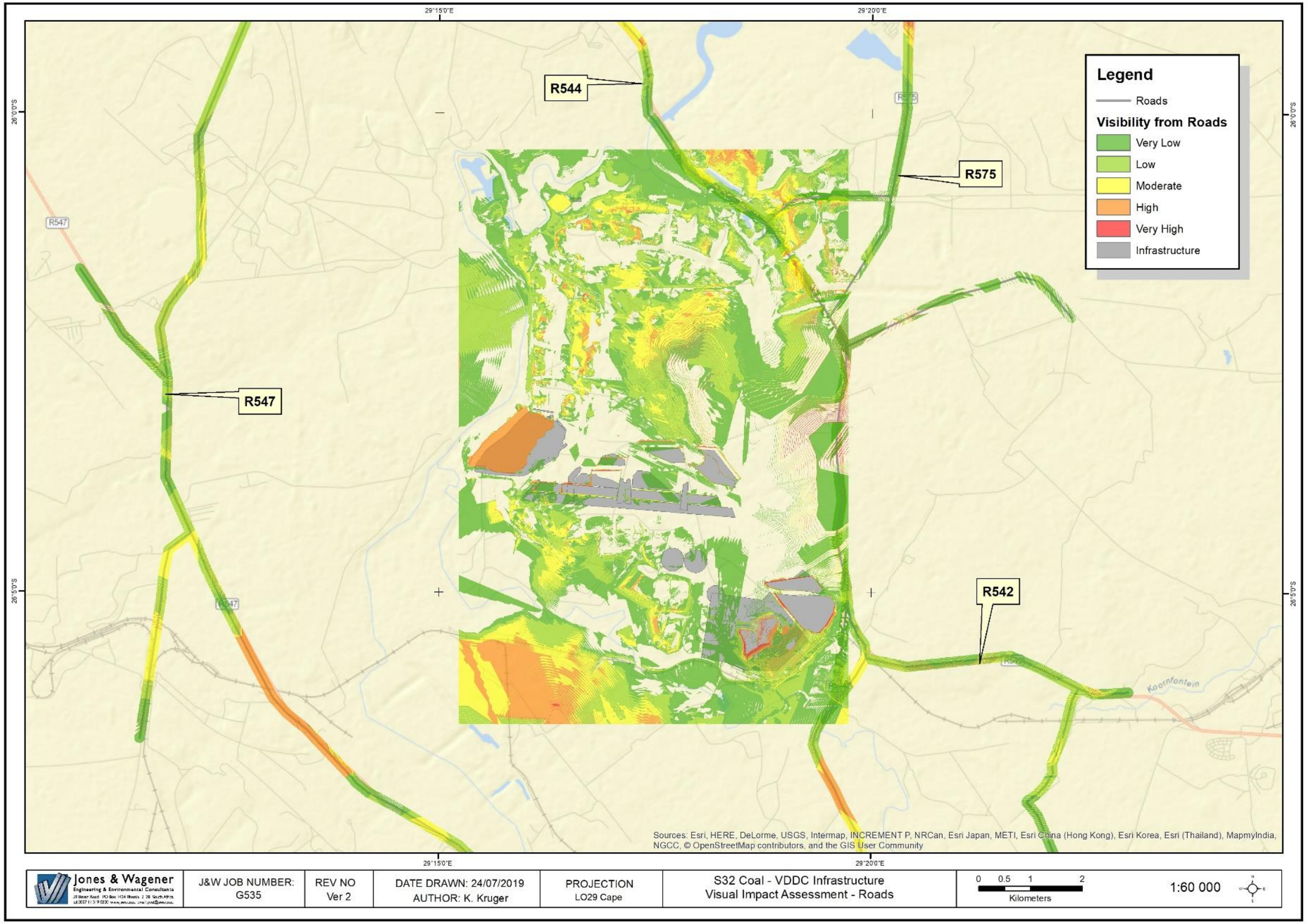

Figure 4-2: Modelled impact to key roads

4.2.3 Rehabilitation and Closure

During the rehabilitation and closure phase, the soil stockpiles will be utilised for rehabilitation of the mining area as well as the overburden stockpiles. Once sloped and vegetated the rehabilitated mine should blend into the surrounding landscape.

The initial impact during the rehabilitation and closure phase is rated as probable, VERY LOW POSITIVE, medium term impact on the *local area*. This impact could happen and is rated as a Very Low positive impact (1.4).

4.3 Cumulative Impact

The visual model shown in the figures above takes the existing visual landscape, adds the contours from the proposed development and models the visual impact of the combined landscape. Therefore, the impact shown in **Figure 4-1** can be regarded as the cumulative impact of the VDDC site.

However, when considering the larger landscape where the mine is located in, then the numerous other mining operations (Kleinkopje, iMpunzi, Steenkoolspruit, North Shaft etc) also have to be considered.

The combined cumulative impact is definitely rated as a VERY HIGH, *local,* long-term impact. This impact will occur and is rated as a High impact (rating 4.0).

4.4 Mitigation Measures

4.4.1 Construction and Operations

- Only clear vegetation when and where necessary;
- Only remove topsoil when and where necessary;
- Topsoil stockpiles should be vegetated where possible;
- Ensure all stockpiles are placed away from surface water and drainage lines as far as practically possible and authorised;
- Monitor and fix any erosion in the landscape or on stockpiles;
- If possible, rehabilitate dumps concurrently;
- Ensure that construction and operations are undertaken in line with the R1147 Annual Rehabilitation Plan and Final Decommissioning and Mine Closure Plan for Wolvekrans.

4.4.2 Rehabilitation and Closure

- Ensure that rehabilitation takes place in line with the R1147 Annual Rehabilitation Plan and Final Decommissioning and Mine Closure Plan for Wolvekrans;
- Ensure that all unnecessary infrastructure/dumps or stockpiles are demolished/removed; and
- Rehabilitate all areas where infrastructure/stockpiles/dumps have been removed.

4.5 Residual Impact

The residual impact assesses the impact considering that the mitigation measures mentioned above have been successfully implemented.

4.5.1 Construction Phase

With the successful implementation of the proposed mitigation measures the residual impact during the construction phase is rated as probable, VERY LOW, short term impact on the *proposed infrastructure sites*. This impact is going to happen and is rated as a Low impact (1.33).

4.5.2 Operational Phase

The residual impact during the operational phase is rated as definite, MODERATE, long term impact on the *local area*. This impact is going to happen and is rated as a High impact (3.3).

4.5.3 Rehabilitation and Closure

The residual impact during the rehabilitation and closure phase is rated as probable, LOW POSITIVE, medium term impact on the *local area*. This impact could happen and is rated as a Low positive impact (1.6).

Table 4-1: Impact Assessment Table:

Activity	Aspect	Impact	Mitigation	Criteria	Rating prior to mitigation (Additional Impact)		Cumulative rating		Rating post mitigation (Residual Impact)	
Construction Phase										
Site/ stockpile preparation and construction	Visual	**NEGATIVE IMPACT:** Dust generated from construction activities as well as views of the activities themselves. Clearing of vegetation and soil.	• Only clear vegetation when and where necessary; • Only remove topsoil when and where necessary; • Topsoil stockpiles should be vegetated where possible; • Ensure all stockpiles are placed away from surface water and drainage lines where possible; • Monitor and fix any erosion in the landscape or on stockpiles; • If possible, rehabilitate dumps concurrently; • Ensure that construction and operations are undertaken in line with the R1147 Annual Rehabilitation Plan and Final Decommissioning and Mine Closure Plan for Wolvekrans.	Significance	2	LOW	5	HIGH	1	LOW
				Spatial	2		3		2	
				Temporal	1		4		1	
				Probability	5		5		5	
Operational Phase										
Operation and increase in height of stockpiles, storing of wastes on site	Visual	**NEGATIVE IMPACT:** Stockpiling will increase in size, increasing in visibility over time. Ongoing vehicle movement and evaporators will also be visible.	• Same as measures for construction	Significance	3	HIGH	5	HIGH	3	HIGH
				Spatial	3		3		3	
				Temporal	4		4		4	
				Probability	5		5		5	
Cloure Phase										
Rehabilitation of VDDC infrastructure project sites.	Visual	**POSITIVE IMPACT** Rehabilitation of infrastructure by replacing stockpiled soils over disturbed areas and returning to a natural mimicking topography that can support an alternative end use	• Ensure that rehabilitation takes place in line with the Land and Rehabilitation Management Plan (Old_Wvk_Prod_Sop_035) for Wolvekrans. • Ensure that all unnecessary infrastructure/dumps or stockpiles are demolished/removed; and • Rehabilitate all areas where infrastructure/stockpiles/dumps have been removed.	Significance	1	LOW POSI-TIVE	5	HIGH	2	LOW POSI-TIVE
				Spatial	1		3		3	
				Temporal	3		4		3	
				Probability	3		5		3	

5. MONITORING REQUIREMENTS

As the bulk of the infrastructure is in the form of stockpiles, the critical parameters to monitor would be dust. That monitoring is specified in the air quality report for the project.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Opinion on Proceeding with Project

The Vandyksdrift Central mining project will utilise available mineral resources. These resources have been undermined previously, and several impacts have already occurred. Furthermore, the mining area is surrounded by other opencast operations, resulting in a landscape dominated by mining and its associated impacts.

The additional impact of the proposed VDDC infrastructure project is mostly located on existing impacted land. However, the areas that are not previously impacted, will be highly impacted by the project.

It is the opinion of this specialist that the development should proceed. Rehabilitation and closure requirements must be enforced with the final end land use as the objective.

6.2 Conditions for approval

It is recommended that the mitigation measures proposed in this report, be seen as the minimum conditions for approval.

7. REFERENCES

- Jaco – K Consulting cc, 2016(a). *VDDC Dewatering Environmental Impact Report.*
- Jaco – K Consulting cc, 2016(b). *Water Use Licence Application for Vandyksdrift Central Dewatering.*
- Pulles, Howard & De Lange, 2006. *Douglas EMP Amendment, New Opencast and Pillar Mining Operations on the farms Kleinkopje 15 IS, Steenkoolspruit 18 IS and Vandyksdrift 19 IS.*
- South32, 2017a. *Van Dyksdrift (VDDC) Project, Pre-Feasibility Mining Report.*
- South32, 2017b. *Van Dyksdrift (VDDC) Project, Pre-Feasibility Report: Infrastructure, Transport and Logistics.*

Konrad Kruger
Specialist

Tolmay Hopkins
Project Manager

for Jones & Wagener

19 July 2019
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APPENDIX A

CURRICULUM VITAE

CURRICULUM VITAE

01 January 2019
kruger_specialistcv_jan2018

KONRAD KRÜGER

Profession	Environmental Scientist
Date of Birth	20 November 1981
Position in firm	Senior Environmental Scientist
Years with the firm	6 years 2 months
Nationality	South African
Education / Qualifications	BSc Honours (Geography) University of Pretoria 2003 (cum laude) BSc Environmental Sciences, University of Pretoria 2002
Languages	Afrikaans, English
Employers	
2005 – 2009	Cymbian Enviro-Social Consulting Services (Randburg) - Environmental Consultant
2009 – 2012	Zitholele Consulting (Pty) Ltd (Midrand) - Environmental Consultant
2012 – Current	Jones & Wagener (Pty) Ltd - Senior Environmental Scientist

About Konrad Krüger

Konrad graduated from the University of Pretoria with a BSc in Environmental Science in 2002 and BSc Honours in Geography in 2003. He has been involved in a variety of environmental projects in the last twelve years and has undertaken a variety of specialist studies, mapping and environmental consulting. The specialist studies included vegetation assessments, soil mapping and agricultural assessments, wetland delineations, visual assessments and terrestrial ecological assessments.

Areas of Expertise

<u>Specialist Assessments:</u>

- Soils and Land Capability / Agricultural Potential;
- Wetland Delineation;
- Flora Assessments;
- Terrestrial Ecological Assessment;

- Visual Impact Assessment; and
- GIS (ArcGIS 10)

Professional Affiliations

- International Association of Impact Assessors (South Africa)
- Land and Rehabilitation Society of South Africa (LARSSA)

Relevant Experience

Wetland Delineation

1. Wetland Assessment for the proposed Era Stene expansion – Delmas, South Africa – Era Stene - 2016
2. Wetland delineation for the proposed Pongola-Candover 132 kV powerline – Pongola, South Africa – Eskom Eastern Regions - 2014
3. Wetland delineation for the proposed Ndumo-Gezisa 132 kV powerline – Pongola, South Africa – Eskom Eastern Regions - 2014
4. Wetland delineation for EnviroServ Holfontein – Holfontein, South Africa – EnviroServ - 2012
5. Wetland delineation for the extension of the Camden Power Station Ash Dump - Ermelo, South Africa - Eskom Generation – 2012
6. Wetland delineation for the proposed Solar Integration Project and the CSP amendment - Upington, South Africa - Eskom Transmission - 2012
7. Dragline Relocation Wetland Assessments and GIS mapping - Kriel, South Africa - Xstrata Coal South Africa – Rietspruit - 2007
8. Conducted the wetland assessment and associated GIS for the integration of the Bravo (Kusile) power station into the Eskom grid. Five EIAs for the proposed construction of overhead power lines and associated infrastructure for the Bravo Integration Project. - Gauteng and Mpumalanga, South Africa - Eskom – Bravo Integration Project – 20009
9. Conducted the wetland assessment and associated GIS for the proposed railway line to the Kusile power station. - Gauteng and Mpumalanga, South Africa - Eskom – Kusile Railway Line - 2010
10. Wetland delineation for the proposed Braamhoekspruit Bridge upgrade WUL. - KwaZulu Natal, South Africa - Eskom – Ingula bridge - 2010
11. Wetland Delineation for the proposed Ingula burial grounds near Van Reenen. - KwaZulu Natal, South Africa - Eskom – Ingula burial ground - 2011
12. Wetland risk assessment for the proposed substation alternatives and connecting power lines. - Gauteng, South Africa - Eskom – Bapsfontein - 2010
13. Wetland risk assessment for the proposed substation and connecting power lines. - Limpopo, South Africa - Eskom – Tabor - 2011
14. Route selection report and associated wetlands assessment for 2 power line route alternatives in Wilgeheuwel. - Gauteng, South Africa - Johannesburg City Power - 2007
15. Wetland delineation for the proposed storm water system upgrade in Soweto - Gauteng, South Africa - Johannesburg Road Agency - 2010
16. Wetland delineation for the proposed Teak Place Estate Development in the Cradle of Humankind. - Cradle of Humankind, South Africa - Teak Place Estate Development – 2007
17. Wetland delineation for the Pala Meetse Eco Estate, Modimolle. - Limpopo Province, South Africa - Pala Meetse Eco Estate - 2008
18. Wetland delineation for the N17 borrow pit application, SANRAL - Mpumalanga, South Africa – SANRAL - 2008

19. Wetland delineation for the proposed development on Farm Nooitgedacht Portions 8 and 32 - Gauteng, South Africa - Viva Construction – Portion 8 and 36 - 2008
20. Wetland assessment for the proposed lodge development in the Vredefort Dome - North West, South Africa - Wesplan Town and Regional Planners - 2006
21. Wetland delineation for the proposed Randfontein Golf Estate. - Gauteng, South Africa - Randfontein Golf Estate – 2008

Soil and Land Capability Assessment

1. Soil, Land Capability and Land Use Assessment for the Vandyksdrift Central extension – South32, Middelburg – 2019
2. Soil, Land Capability and Land Use Assessment for the Chloorkop Landfill Expansion Project – EnviroServ, Johannesburg - 2019
3. Soil, Land Capability and Land Use Assessment for the Syferfontein Alexander Project – Sasol Mining, Secunda – 2018-2019
4. Rehabilitation Assessment for the Schoonoordt Mine – Exxaro Coal, Arnot - 2018
5. Soil, Land Capability and Land Use Quantitative Risk Assessment for the closure of Sasol Sigma – Sasolburg, South Africa – 2017 - 2018
6. Soil, Land Capability and Land Use Quantitative Risk Assessment for the closure of Sasol Twistdraai, Middelbult and Brandspruit Mines – Secunda, South Africa – 2016 and 2019
7. Soil and Land Capability Assessment for the proposed Era Stene expansion – Delmas, South Africa – Era Stene - 2016
8. Long term soil impact monitoring and assessment for the Wolwekrans Evaporator Project – Emalahleni, South Africa – South32 – 2015-16
9. Soil and Land Capability Assessment for the proposed 400kv KIPower powerlines – Delmas, South Africa – KIPower - 2016
10. Soil and Land Capability Assessment for the Boschmanspoort EMPR – Hendrina, South Africa – Xstrata Coal - 2013
11. Soil and Land Capability Assessment for the extension of the Camden Power Station Ash Dump - Ermelo, South Africa - Eskom Generation – 2012
12. Soil and Land Capability Assessment for the proposed Solar Integration Project and the CSP amendment - Upington, South Africa - Eskom Transmission - 2012
13. Dragline Relocation Soil Assessments - Kriel, South Africa - Xstrata Coal South Africa – Rietspruit - 2007
14. Compilation of the Soil Assessments for the EMPR update project - Cullinan, South Africa - De Beers Consolidated Mines – Cullinan - 2005
15. Soil specialist assessments for the proposed Metal Recovery and Slag Processing Plant at Metalloys - Meyerton, South Africa - Samancor Manganese, Metalloys – MRSPP - 2007
16. Soil and Land Capability Assessment for the proposed Sinter Plant at the Mamatwan Mine. - Hotazel, South Africa - Samancor Manganese – Sinter - 2009
17. Conducted the soil and land capability assessment for the integration of the Bravo (Kusile) power station into the Eskom grid. Five EIAs for the proposed construction of overhead power lines and associated infrastructure for the Bravo Integration Project. - Gauteng and Mpumalanga, South Africa - Eskom – Bravo Integration Project – 2009
18. Conducted the soil and land capability assessment for the proposed railway line to the Kusile power station. - Gauteng and Mpumalanga, South Africa - Eskom – Kusile Railway Line - 2010
19. Soil assessment for the proposed Tutuka Power Station general waste disposal site, Standerton. - Mpumalanga, South Africa - Eskom – Tutuka Domestic Waste Site - 2011
20. Soil and Land Capability Assessment for the proposed Ingula burial grounds near Van Reenen. - KwaZulu Natal, South Africa - Eskom – Ingula burial ground - 2011
21. Soil and Land Capability risk assessment for the proposed substation alternatives and connecting power lines. - Gauteng, South Africa - Eskom – Bapsfontein - 2010

22. Soil and Land Capability risk assessment for the proposed substation and connecting power lines. - Limpopo, South Africa - Eskom – Tabor - 2011
23. Route selection report Soil Assessment for 2 power line route alternatives in Wilgeheuwel. - Gauteng, South Africa - Johannesburg City Power - 2007
24. Agricultural feasibility study for the Ramasega development project. - Gauteng, South Africa - Ramasega Agricultural Development Project - 2006
25. Soil and Land Capability Assessment for the proposed Teak Place Estate Development in the Cradle of Humankind. - Cradle of Humankind, South Africa - Teak Place Estate Development – 2007
26. Soil assessment for the Pala Meetse Eco Estate, Modimolle. - Limpopo Province, South Africa - Pala Meetse Eco Estate - 2008
27. Soil and Land Capability assessment for a residential development in Noordheuwel, Krugersdorp. - Gauteng, South Africa - Noordheuwel Ext 17 and 19 - 2008
28. Soil Assessment for Holding 68 and 67 Morningside. - Gauteng, South Africa - Bernard Glazer Trust - 2007
29. Soil mapping for the proposed Harmony Mega Tailings Facility, Welkom. - Free State, South Africa - Harmony Gold – Welkom - 2009
30. Soil assessment for the proposed 3rd bypass line, Richards Bay Coal Terminal. - KwaZulu Natal, South Africa - Transnet, RBCT - 2008
31. Soil assessment for the proposed industrial development of the Farm Nooitgedacht Portion 215. - Gauteng, South Africa - Viva Construction – Portion 215 - 2008
32. Soil assessment for the proposed development of Portions 16, 17 and 18 of the Mostyn Park Smallholdings. - Gauteng, South Africa - Viva Construction – Mostyn Park - 2008
33. Soil assessment for the proposed lodge development in the Vredefort Dome - North West, South Africa - Wesplan Town and Regional Planners - 2006

Terrestrial Ecology Assessment

1. Terrestrial Ecological Assessment for the proposed 400kv KIPower powerlines – Delmas, South Africa – KIPower - 2016
2. Biodiversity Assessment for the extension of the Camden Power Station Ash Dump - Ermelo, South Africa - Eskom Generation – 2012
3. Biodiversity Assessment for the proposed Solar Integration Project and the CSP amendment - Upington, South Africa - Eskom Transmission - 2012
4. Dragline Relocation Vegetation Assessments - Kriel, South Africa - Xstrata Coal South Africa – Rietspruit - 2007
5. Vegetation Assessments for the CDM EMPR update project - Cullinan, South Africa - De Beers Consolidated Mines – Cullinan - 2005
6. Vegetation Assessment for the proposed Metal Recovery and Slag Processing Plant at Metalloys - Meyerton, South Africa - Samancor Manganese, Metalloys – MRSPP - 2007
7. Land use and Fauna and Flora Assessment for the proposed Sinter Plant at the Mamatwan Mine. - Hotazel, South Africa - Samancor Manganese – Sinter - 2009
8. Vegetation Assessment for the proposed day visitor's facility at the Olifants Camp, Kruger National Park - Limpopo & Mpumalanga, South Africa - Kruger National Park – Olifants - 2007
9. Conducted the Ecology assessment and associated GIS) for the integration of the Bravo (Kusile) power station into the Eskom grid. Five EIAs for the proposed construction of overhead power lines and associated infrastructure for the Bravo Integration Project. - Gauteng and Mpumalanga, South Africa - Eskom – Bravo Integration Project – 20009
10. Conducted the Ecology assessment for the proposed railway line to the Kusile power station. - Gauteng and Mpumalanga, South Africa - Eskom – Kusile Railway Line - 2010
11. Terrestrial Ecology Assessment for the proposed Ingula burial grounds near Van Reenen. - KwaZulu Natal, South Africa - Eskom – Ingula burial ground - 2011

12. Biophysical risk assessment (Fauna, Flora) for the proposed substation alternatives and connecting power lines. - Gauteng, South Africa - Eskom – Bapsfontein - 2010
13. Biophysical risk assessment (Fauna, Flora) for the proposed substation and connecting power lines. - Limpopo, South Africa - Eskom – Tabor - 2011
14. Route selection report and associated Fauna and Flora Assessment for 2 power line route alternatives in Wilgeheuwel. - Gauteng, South Africa - Johannesburg City Power - 2007
15. Terrestrial ecology assessment for the proposed storm water system upgrade in Soweto - Gauteng, South Africa - Johannesburg Road Agency - 2010
16. Ecological Assessment for the proposed Teak Place Estate Development in the Cradle of Humankind. - Cradle of Humankind, South Africa - Teak Place Estate Development – 2007
17. Vegetation, Tree Identification and Fauna survey for Holding 68 and 67 Morningside. - Gauteng, South Africa - Bernard Glazer Trust - 2007
18. Vegetation Assessment for the proposed development on Portion 105, 106 and 331 of the Farm Knoppjeslaagte. - Gauteng, South Africa - Vibro Brics - 2008
19. Vegetation assessment for the proposed 3rd bypass line, Richards Bay Coal Terminal. - KwaZulu Natal, South Africa - Transnet, RBCT - 2008
20. Ecological site assessment for the proposed development of Portions 16, 17 and 18 of the Mostyn Park Smallholdings. - Gauteng, South Africa - Viva Construction – Mostyn Park - 2008
21. Vegetation and fauna assessment for the proposed lodge development in the Vredefort Dome - North West, South Africa - Wesplan Town and Regional Planners – 2006

Visual Impact Assessment

1. Visual Assessment for the proposed 400kv KIPower powerlines – Delmas, South Africa – KIPower - 2016
2. Visual Assessment for the proposed Middelburg Colliery extension – Middelburg, South Africa, South32 – 2016
3. Visual Assessment for the proposed Wolwekrans Evaporator Project – Emalahleni, South Africa, South32 - 2015
4. Visual Assessment for the proposed Klipfontein Colliery extension – Middelburg, South Africa, South32 - 2015
5. Visual Assessment for the proposed Pongola-Candover 132 kV powerline – Pongola, South Africa – Eskom Eastern Regions - 2014
6. Visual Assessment for the proposed Ndumo - Gezisa 132 kV powerline – Pongola, South Africa – Eskom Eastern Regions - 2014
7. Visual Assessment for the extension of the Camden Power Station Ash Dump - Ermelo, South Africa - Eskom Generation – 2012
8. Visual Assessment for the proposed day visitor's facility at the Olifants Camp, Kruger National Park - Limpopo & Mpumalanga, South Africa - Kruger National Park – Olifants - 2007
9. Conducted the Visual Specialist Studies for the integration of the Bravo (Kusile) power station into the Eskom grid. Five EIAs for the proposed construction of overhead power lines and associated infrastructure for the Bravo Integration Project. - Gauteng and Mpumalanga, South Africa - Eskom – Bravo Integration Project – 20009
10. Conducted the Visual Specialist Studies for the proposed railway line to the Kusile power station. - Gauteng and Mpumalanga, South Africa - Eskom – Kusile Railway Line - 2010
11. Visual Assessment for the proposed Ingula burial grounds near Van Reenen. - KwaZulu Natal, South Africa - Eskom – Ingula burial ground - 2011
12. Visual Assessment for the proposed substation and connecting power lines - Limpopo, South Africa - Eskom – Tabor - 2011
13. Visual Assessment for the proposed Teak Place Estate Development in the Cradle of Humankind. - Cradle of Humankind, South Africa - Teak Place Estate Development – 2007

Summary of other Training/Courses attended

Centre for Environmental Studies	March 2007	NEMA EIA Regulations and their application
Cameron Cross	May 2008	National Environmental Management Waste Act Seminar
Africa Land-Use Training	April 2010	Tree Identification
Africa Land-Use Training	June 2010	Soil Classification and Mapping

Declaration

I confirm that the above CV is an accurate description of my experience and qualifications.

Signature of Staff Member

2 January 2019

Date

APPENDIX B

DECLARATION OF INDEPENDANCE

I, Konrad Krüger, hereby declare that:

- I act as the independent specialist in this application.
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant.
- I declare that there are no circumstances that may compromise my objectivity in performing such work.
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity.
- I will comply with the Act, Regulations and all other applicable legislation.
- I have not, and will not engage in, conflicting interests in the undertaking of the activity.
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority.
- All the particulars furnished by me in this form are true and correct.
- I realise that a false declaration is an offence in terms of Regulation 48 and is punishable in terms of section 24F of the Act.

Konrad Krüger

A detailed CV of the author is included in **Appendix A**.

8.4 Air quality Assessment

Vandyksdrift Central (VDDC) Infrastructure: Air Quality Impact Assessment

Project done on behalf of **Jones & Wagener**

Project Compiled by:
R Bornman
R von Gruenewaldt
L Burger

Project Manager
L Burger

Report No: 17JAW07AQa | **Date:** December 2018

Address: 480 Smuts Drive, Halfway Gardens | **Postal:** P O Box 5260, Halfway House, 1685
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Report Details

Report No	17JAW07AQa
Status	Draft
Report Title	Vandyksdrift Central (VDDC) Infrastructure: Air Quality Impact Assessment
Date	December 2018
Client	Jones & Wagener
Prepared by	Rochelle Bornman MPhil. GIS and Remote Sensing (Cambridge) Renee von Gruenewaldt, (Pr. Sci. Nat.), MSc (University of Pretoria) Lucian Burger PrEng, PhD, MScEng(chem), BScEng(chem)
Reviewed by	Lucian Burger PrEng, PhD, MScEng(chem), BScEng(chem)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.
Copyright Warning	Unless otherwise noted, the copyright in all text and other matter (including the manner of presentation) is the exclusive property of Airshed Planning Professionals (Pty) Ltd. It is a criminal offence to reproduce and/or use, without written consent, any matter, technical procedure and/or technique contained in this document.

Revision Record

Revision Number	Date	Reason for Revision
Draft	December 2018	Client Review
Revision	September 2019	Client Review

Abbreviations

AEL	Atmospheric Emission License
AIR	Atmospheric Impact Report
Airshed	Airshed Planning Professionals (Pty) Ltd
AMSL	Above Mean Sea Level
AQMP	Air Quality Management Plan
AQSR	Air Quality Sensitive Receptors
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent (the sum of emissions of all GHG gases multiplied by their GWP factors).
DEA	Department of Environmental Affairs (South Africa)
EA	Environmental Authorisation
g	gram
GHG	Greenhouse gases
GLC	Ground Level Concentration
GWP	Global warming potential; the global warming induced by a unit of a specific GHG expressed as the equivalent units of carbon dioxide. Values recommended by the 5th assessment report of the IPCC (IPCC 2013) of 265 for N_2O and 28 for CH_4 are used in this report
HFC	Hydrofluorocarbons
HPA	Highveld Priority Area, declared in terms of s 19 of the National Environmental Management: Air Quality Act (Act No. 39 of 2004)
IFC	International Finance Corporation, of which the World Bank is a division
km	kilometre
kg	kilogram
LM	Local Municipality
MES	Minimum Emission Standards
Mtpa	Million tonne per annum
N_2O	Nitrous oxide
NAAQS	National ambient air quality standards (South Africa)
NAEIS	National Atmospheric Emissions Inventory System
NAERR	National Atmospheric Emission Reporting Regulations
NEMAQA	National Environmental Management Air Quality Act (Act No. 39 of 2004 as amended).
NDCR	National Dust Control Regulations
NGER	National Greenhouse Gas Emission Reporting Regulations
NOAA	National Oceanic and Atmospheric Administration (US)
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides, a mixture of nitrogen oxide and nitrogen dioxide.
$PM_{2.5}$	Particulate matter with and aerodynamic diameter less than 2.5 micron
PM_{10}	Particulate matter with and aerodynamic diameter less than 10 micron

PCD	Pollution control dam
PAHs	polycyclic aromatic hydrocarbons
PFCs	Perfluorocarbons
SAAELIP	South African Atmospheric Emission Licensing and Inventory Portal
SAAQIS	South African Air Quality Information System
SAWS	South African Weather Service
SF_6	Sulfur hexafluoride
SO_2	Sulfur dioxide
South32	South32 SA Coal Holdings (Pty) Ltd
SoW	Scope of Work
ton/tonne	To avoid confusion between Imperial and SI units, tonne has been used for the SI or metric tonne (1000 kg)
TSP	Total suspended particulates
VDDC	Vandyksdrift Central
VOC	Volatile organic compounds

Glossary

Air pollution[(a)]	The presence of substances in the atmosphere, particularly those that do not occur naturally
Dispersion[(a)]	The spreading of atmospheric constituents, such as air pollutants
Dust[(a)]	Solid materials suspended in the atmosphere in the form of small irregular particles, many of which are microscopic in size
Instability[(a)]	A property of the steady state of a system such that certain disturbances or perturbations introduced into the steady state will increase in magnitude, the maximum perturbation amplitude always remaining larger than the initial amplitude
Mechanical mixing[(a)]	Any mixing process that utilizes the kinetic energy of relative fluid motion
Particulate matter (PM)	Total particulate matter, that is solid matter contained in the gas stream in the solid state as well as insoluble and soluble solid matter contained in entrained droplets in the gas stream
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter of less than 2.5 µm
PM_{10}	Particulate Matter with an aerodynamic diameter of less than 10 µm
Stability[(a)]	The characteristic of a system if sufficiently small disturbances have only small effects, either decreasing in amplitude or oscillating periodically; it is asymptotically stable if the effect of small disturbances vanishes for long time periods

Notes:

(a) Definition from American Meteorological Society's glossary of meteorology (AMS, 2014)

Symbols and Units

°C	degrees Celsius
bcm	bank cubic meters
g	gram(s)
ha	hectare
kg	kilograms
km	kilometre
1 kilogram	1 000 grams
km²	square kilometre
m	metre
m/s	metres per second
µg	microgram(s)
µg/m³	micrograms per cubic metre
µm	micro-meter
mg	milligram(s)
mg/m².day	milligrams per square metre per day
m²	square meter
mm	millimetres
$PM_{2.5}$	Inhalable particulate matter
PM_{10}	Thoracic particulate matter
tpa	tonnes per annum
TSP	Total Suspended Particulates
1 ton	1 000 000 grams

Executive Summary

The Vandyksdrift Central (VDDC) area falls within the footprint of historic underground mining operations at the old Douglas Colliery. In 2007, an amendment of the Environmental Management Programme Report (EMPR) for the Douglas Colliery operations was approved, to allow the opencast mining of the remaining No. 5, No. 4, No. 2 and No. 1 seams. The 2007 EMPR Amendment did not include any additional infrastructure in support of the opencast mining operations as it was assumed at that stage that existing infrastructure will be used. The need has since been identified to develop added infrastructure to support the proposed opencast mining. In addition, authorisation for opencast mining is required for an area that was not included in the 2007 approved EMPR amendment.

The proposed opencast mining and infrastructure operations at the VDDC Section of the Wolvekrans Colliery, and changes to opencast mining, has the potential to impact ambient air quality by exposing the public, represented by nearby communities and individual residences, to elevated levels of airborne particulates and the associated potential human health impacts. Criteria pollutants of concern include particulate matter with an aerodynamic diameter of less than 10 µm (PM_{10}) and particulate matter with an aerodynamic diameter of less than 2.5 µm ($PM_{2.5}$).

Emissions due to the construction phase were quantified but not modelled, due to the temporary nature of construction and the lack of a detailed breakdown of construction activities. The assessment of the operational phase considered three scenarios throughout the life of mine, under the assumption of design mitigated emissions. A design mitigated scenario was assumed where emissions as a result of coal haulage, grading, materials handling and drilling are mitigated through water sprays.

The assessment of the change in opencast mining, under the assumption of design mitigated emissions, considered a worst-case scenario of one full year of opencast activities within the extended pit area.

Meteorological data from the Eskom Komati monitoring station over the period January 2013 to December 2015 was used. The co-dominant wind directions, during the period under investigation, were north-north-west, north-east and east-northeast with a frequency of occurrence of approximately 11%.

The total suspended particulates (TSP), PM_{10} and $PM_{2.5}$ emissions during construction were calculated using the US-EPA emission factor for general construction activities as 43.14 tpm, 16.83 tpm and 8.41 tpm respectively. These may be considered conservative estimates, as the quantity of dust emissions is assumed to be proportional to the area of land being worked, in this case 480 hectares in total.

Findings from the dispersion modelling assessment (for opencast mining and infrastructure operations) include:

- Under the assumption of design mitigated emissions, simulated areas of exceedance show non-compliance with the daily PM_{10} National ambient air quality standards (NAAQS) at 6 receptors within 6 km of the mining operations, as well as non-compliance with the annual PM_{10} NAAQS within 5 km of the mining operations (all receptors within compliance with the annual PM_{10} NAAQS).
- For design mitigated emissions, the area of non-compliance with the future daily $PM_{2.5}$ NAAQS extends to within 1 km of the mining operations and within 1 km of off-site roads (all receptors within compliance).
- The areas of exceedance of the NDCR, under the assumption of design mitigation, are limited to the project boundary and within 250 m of off-site roads (all receptors within compliance).

For extended opencast pit operations, the dispersion modelling assessment found the following:

- Under the assumption of design mitigated emissions, the area of non-compliance with the daily and annual PM_{10} NAAQS extends to within 3.2 km and 1.2 km of the mining operations respectively (all receptors within compliance with the annual PM_{10} NAAQS but exceeding the daily PM_{10} NAAQS at one receptor).
- For design mitigated emissions, the area of non-compliance with the future daily and annual $PM_{2.5}$ NAAQS extends to within 1.6 km and 350 m of the mining operations respectively (all receptors within compliance).
- Under the assumption of design mitigation, no exceedance of the NDCR was simulated.

The following mitigation measures are recommended:

- Regular wetting of exposed areas, temporary stockpiles and haul ramps.
- Chemical stabilisation of on- and offsite haul roads.
- Reduce the drop height of the dragline (average drop height of 16.85m was assumed in the calculations).
- Rehabilitation and revegetation of the mined areas as soon as practical, with the option of using watering to suppress dust emissions during dry and windy conditions.

The VDDC Section is located in the Highveld Priority Area – an area of typically poor air quality. As a result of the high background particulate values, the residual impact ratings for opencast mining and infrastructure operations (after mitigation) are HIGH for PM_{10} and MODERATE for $PM_{2.5}$ and dustfall. The residual impact ratings for mitigated infrastructure operations only are estimated to be LOW for all pollutants and compliance time-frames. For the extended opencast pit, the residual impact ratings (after mitigation) are estimated to be MODERATE for PM_{10} and $PM_{2.5}$, and LOW for dustfall.

For compliance with the NDCR, an additional three dust buckets and relocation of two existing dust buckets have been recommended at locations near the downwind boundary of the VDDC Section. It is also recommended that a PM_{10} sampler be placed at any of the recommended dust bucket locations, if security considerations allow for it.

The potential negative risk posed by airborne mine water mist generated by the operation of mechanical evaporators was discussed by referring to a previous study for South32 (Burger and Grobler, 2015). From the previous study, it was found through dispersion modelling that most of the fallout of water droplets and dissolved solids occur in the nearby vicinity of the evaporators, within 50m to 70m of the evaporator. Nearly all of the fallout (99%) occurs within 125m to 150m from the evaporators. Both measurement and model results show that unless removed by rain or other means, monthly deposition of total solids of about 100g/m² (3g/m²-day) is possible at downwind distances of about 300m from the evaporators. These results were used to illustrate the potential fallout on the immediate areas of the proposed locations of the VDDC evaporators, for two optional orientations (north-south and east-west respectively). The final layout provides for an east-west orientation.

A greenhouse gas inventory was compiled for the proposed Project, taking into consideration the Project's diesel fuel and electricity requirements. The total CO_2-e emissions for construction operations is approximately 175 398 tpa of which 39% is due to vehicle exhaust emissions (Scope 1) and 61% is due to electricity consumption (Scope 2). The total CO_2-e emissions for mining and infrastructure operations is approximately 435 438 tpa, of which 168 062 tpa is due to vehicle exhaust emissions (Scope 1). GHGs were declared priority pollutants in March 2014 and pollution prevention plans must be developed if the operation contributes more than 100 000 tons CO_{2eq} emissions. The Project's Scope 1 GHG contribution is above 100 000 tons[1]. Based on this, a Pollution Prevention Plan is required for the proposed VDDC operations, but not for construction.

[1] The Project's Scope 1 GHG emissions were calculated based on annual fuel usage estimates for both mining and infrastructure operations.

The GHG emissions from the project are considered low and not likely to result in a noteworthy contribution to climate change on its own. The project and the community are considered likely to be negatively impacted by climate change, the project less so than the community, firstly due to the short time over which operations are planned to occur, and secondly because the project is likely to have measures in place to cope with the possibility of water shortage (probably the most significant problem faced).

- The following is recommended to reduce the impacts of climate change on the project and the community:
    - Additional support infrastructure can reduce the climate change impact on the staff and project, for example the addition/upgrading of an on-site clinic, ensuring adequate water supply for staff and reducing on-site water usage as much as possible.
- The following is recommended to reduce the GHG emissions from the project:
    - Ensuring the vehicles and equipment is maintained through an effective inspection and maintenance program.
    - Limiting the removal of vegetation and ensuring adequate re-vegetation or addition of vegetation surrounding the project. Vegetation acts as a carbon sink.

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1 INTRODUCTION

South32 SA Coal Holdings (Pty) Ltd (South32) is the holder of an amended mining right for the Wolvekrans Colliery[2]. The mine has an original Environmental Authorisation (EA) dated February 2003 for mainly underground mining operations on the farms Steenkoolspruit 18 IS, Kleinkopje 15 IS and Vandyksdrift 19 IS.

The Vandyksdrift Central (VDDC) area falls within the footprint of historic underground mining operations at the old Douglas Colliery. In 2007, an amendment of the Environmental Management Programme Report (EMPR) for the Douglas Colliery operations was approved, to allow the opencast mining of the remaining No. 5, No. 4, No. 2 and No. 1 seams. The 2007 EMPR Amendment did not include any additional infrastructure in support of the opencast mining operations however, as it was assumed at that stage that existing infrastructure will be used. A pre-feasibility investigation has since been conducted, and the need has been identified to develop additional infrastructure to support the proposed opencast mining. In addition, authorisation for opencast mining is required for an area that was not included in the 2007 approved EMPR amendment.

The development of the additional infrastructure at the VDDC section of the Wolvekrans Colliery, and changes to opencast mining, are hereafter referred to as the Project.

The additional infrastructure includes the following:

- Storm water management structures (drains and berms);
- Water management measures for the management of mine impacted water (modular WTP and evaporators);
- Overburden dumps;
- ROM coal stockpile areas;
- Mixed ROM coal and slurry stockpile areas;
- Topsoil stockpiles following clearance of vegetation;
- Pipelines for the conveyance of water;
- Hard park area and brake test ramp; and
- Haul roads and service roads.

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by Jones & Wagener to undertake a specialist environmental air quality impact study for the project.

1.1 Study Objective

The main objective of the air quality specialist study was to determine the potential for dust impacts on the surrounding environment and human health from the proposed operations, with specific reference to air quality, and to recommend suitable management and mitigation measures.

1.2 Scope of Work

To meet the above objective, the following tasks were included in the Scope of Work (SoW):

1. Baseline air quality study:
    a. Identification of appropriate and relevant statutory air quality criteria/guidelines.

[2] The current Wolvekrans Colliery is the result of mergers and the acquisition of separate collieries, namely Albion, VanDyksdrift, Douglas and Wolvekrans, previously known as the Douglas Colliery.

b. Review available data including any existing meteorological data, air quality monitoring data, previous reports, air quality management plans, and related documents for the study area.
c. It is considered good practice to consider a minimum of three-year's hourly sequential meteorological data in air quality specialist studies. Data is used for describing the local atmospheric dispersion potential as well as in atmospheric dispersion modelling. Should such a data set not be available for the project site, a suitable South African Weather Service (SAWS) data set or simulated meteorological data set (such as MM5 or WRF) will be purchased.
d. A site visit and inspection in order to identify:
    i. Local factors that influence local atmospheric dispersion potential;
    ii. Existing sources of atmospheric emissions;
    iii. Receptors (residential, community, agricultural) that are/may be affected by emissions from the project.
e. A desktop study of local atmospheric dispersion potential.
f. If indicated by the information review, prepare and ambient air quality monitoring plan to address gaps in meteorological and ambient air pollutant concentration/dustfall data.
g. Implementation of ambient air quality monitoring plan. Since the need and extent of monitoring needs are unknown at present, a price list for key air quality monitoring aspects are included separately from the main project cost.
h. A baseline information air quality report.

2. Air quality analysis and impact assessment:
    a. Development of comprehensive atmospheric source and emissions inventory, including:
        i. Source descriptions;
        ii. Source locations;
        iii. Emission rates and the methodology/emission factors used (pollutants to include PM_{10}, $PM_{2.5}$, and TSP as a minimum and if required, NO_2, CO, and SO_2).
    b. Atmospheric dispersion simulations using the United States Environmental Protection Agency's regulatory AERMOD modelling suite.
    c. Human health, nuisance and environmental impact screening.
    d. A qualitative cumulative air quality assessment.
    e. Development of an air quality management, mitigation, and monitoring plan.
    f. A Tier 1 (if required Tier 2) greenhouse gas inventory and qualitative discussion on climate change impacts.
    g. A specialist air quality impact report detailing:
        i. All results and findings of the baseline and impact assessments
        ii. All limitations
        iii. All assumptions

1.3 Description of Project Activities from an Air Quality Perspective

The proposed project is situated within the eMalahleni Local Municipality of the Nkangala District Municipality. It is primarily surrounded by coal-mining operations, agricultural activities, as well as the Duvha, Hendrina, and Komati Eskom Power Stations. Residential areas in the region include Springbok (2.5 km northeast), Komati town (~13 km east), Pullens Hope (~28.5 km east-northeast), Middelburg (~35 km north-northeast), and eMalahleni (~20 km north-northwest). Individual residences (i.e. farm houses) are also in the immediate vicinity of the proposed operations and are considered to be sensitive receptors with respect to air quality.

The mining process will result in atmospheric emissions of particulate matter and therefore the pollutants of concern with potential human health impacts are: PM_{10} (particulate matter with an aerodynamic diameter of less than 10 µm) and $PM_{2.5}$ (particulate matter with an aerodynamic diameter of less than 2.5 µm). Total suspended particulates (TSP) will impact the environment via dustfall.

Air quality impacts will be associated with three distinct phases namely: the construction phase, the operational phase and the closure phase.

Construction phase activities will include bulk earthworks (for the establishment of the boxcut, topsoil stockpiles, overburden stockpiles, mixed ROM and slurry stockpiles, haul routes etc), and temporary facilities. Construction of the infrastructure, including the boxcut, will commence July 2020.

Operational phase: The operational phase is expected to commence 2022. Opencast mining will take place using the conventional truck and shovel mining method, which includes the following:

- Pre-stripping of topsoil using bulldozers;
- Hauling of topsoil and in-pit placement as part of rehabilitation;
- Blasting and excavation of overburden to expose the coal;
- In-pit backfilling of overburden using draglines, whereby the hard material is loaded via the dragline and then side cast into the open pit;
- Blasting and excavation of coal;
- Loading and hauling of coal (or mixed coal and slurry) to haul trucks[3];
- Offloading coal to ROM stockpile or to Mixed ROM coal and slurry stockpile areas; and
- Loading of ROM coal to haul trucks from where it is transported off-site via unpaved access road.

Operational activities due to the infrastructure development only comprise mainly of deposition from the evaporators, materials handling at the newly constructed stockpiles, windblown dust from the stockpiles and vehicle entrained dust from unpaved onsite haul and access roads.

Closure phase: During closure, bulk earthworks and demolishing activities are expected. Very little information regarding the closure phase was available for consideration, from an air quality perspective it is however likely to be similar in character and impact to the construction phase.

The mining schedule and location of air quality sensitive receptors (AQSRs) are shown in Figure 1. The area that was not included in the 2007 approved EMPR amendment and for which authorisation is required is shown in Figure 2. The mining schedule for the extension of the opencast pit beyond the approved boundary is shown in Figure 3.

[3] Where coal mining occurs within the existing slurry footprint, the slurry will be mined with the ROM coal and the blended coal and slurry will be transferred to the processing plant, or stockpiled in new mixed coal and slurry stockpile areas to be developed to the north of the boxcut

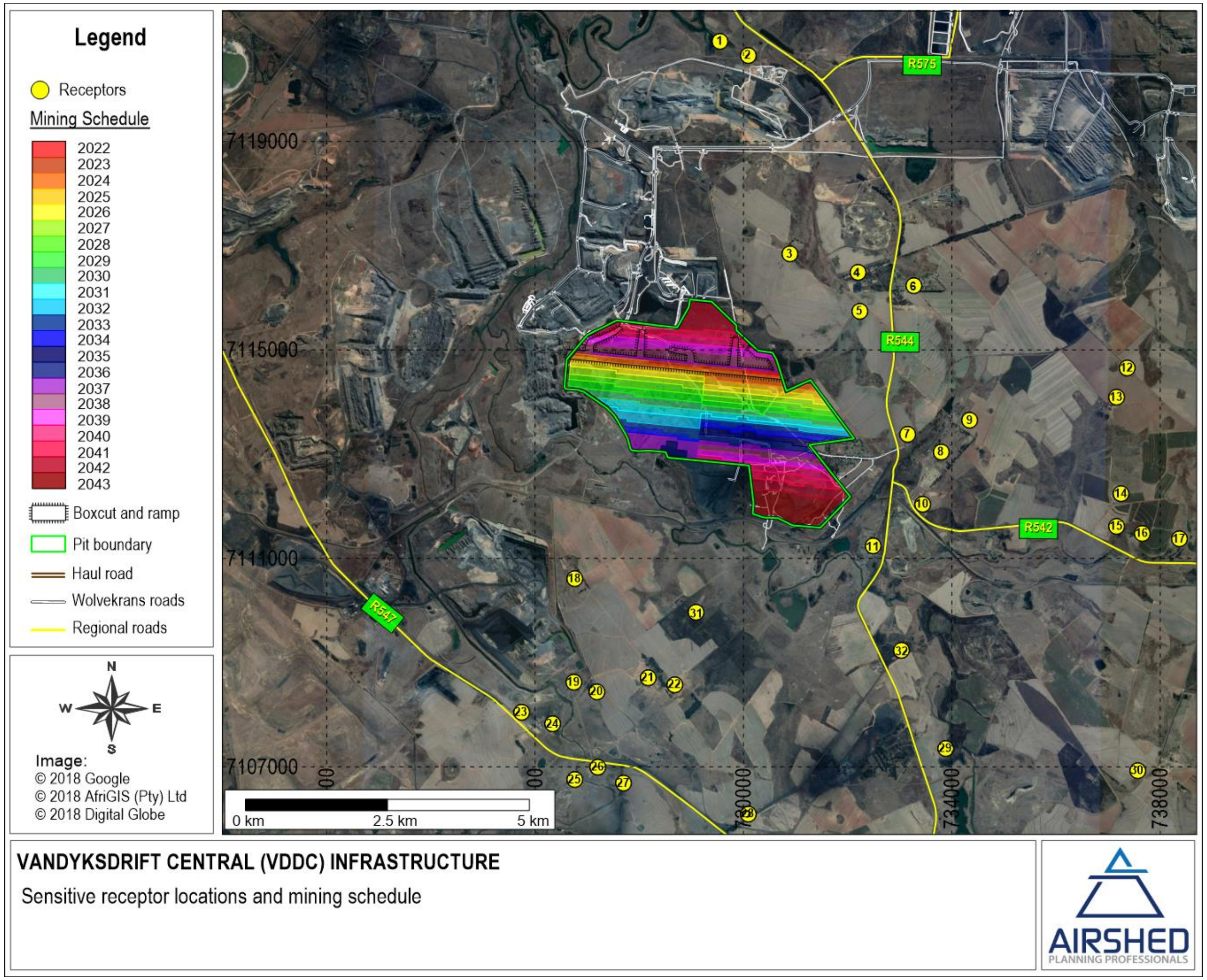

Figure 1: Location map of proposed VDDC Infrastructure Project: Road network, mining schedule and sensitive receptors

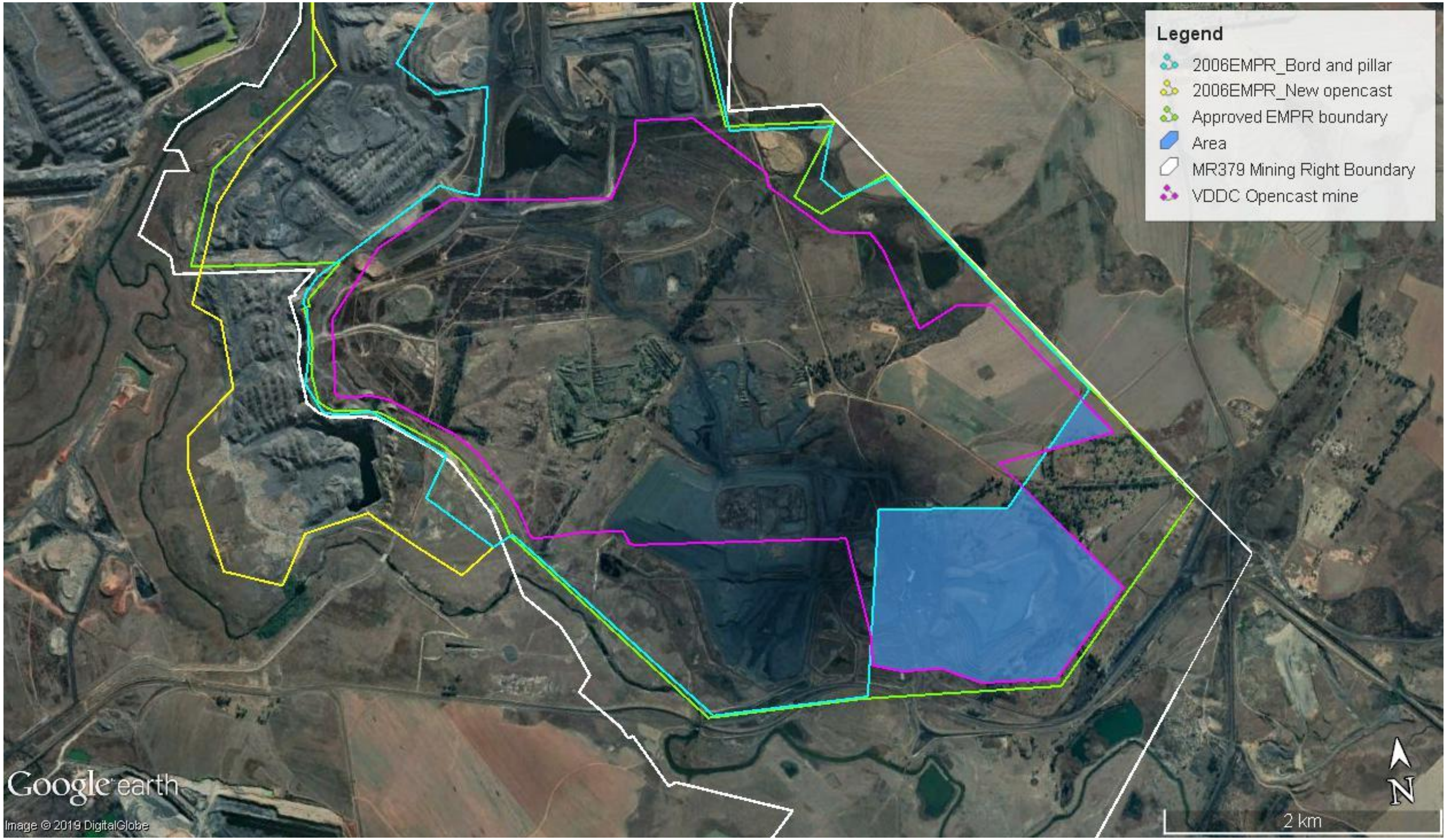

Figure 2: Extension of the opencast pit beyond the approved boundary

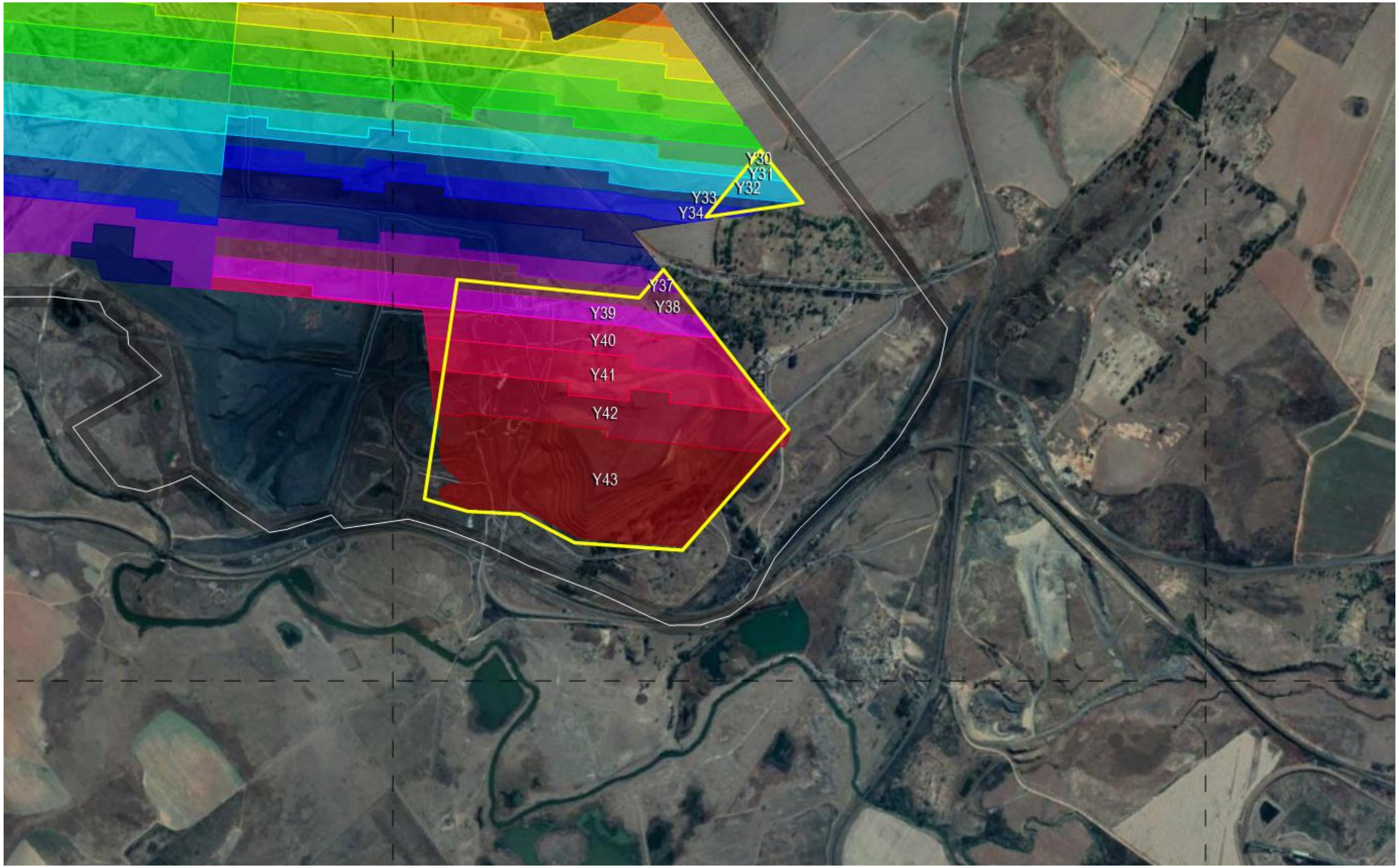

Figure 3: Mining schedule for the extension of the opencast pit beyond the approved boundary

1.4 Approach and Methodology

The approach to, and methodology followed in the completion of tasks that formed part of the SoW are discussed in this section.

1.4.1 Project Information and Activity Review

All project related information referred to in this study was provided by Jones and Wagener. It includes (1) a pre-feasibility study – a mining report, infrastructure, transport and logistics report and addendum to the mining report (dated 1 and 12 December 2017, and 13 February 2018 respectively); and (2) a project description (eighth revision) (dated 25 June 2019). A .kmz file was also provided that indicates the location of existing and proposed infrastructure.

1.4.2 The Identification of Regulatory Air Quality Requirements and Assessment Criteria

In the evaluation regulations pertaining to air quality, reference was made to:

- the National Environmental Management Air Quality Act (Act No. 39 of 2004) (NEMAQA)
    - National Atmospheric Emission Reporting Regulations (Government Gazette 38633);
    - National Ambient Air Quality Standards (NAAQS) for criteria pollutants;
    - National Dust Control Regulations (NDCR); and
    - Regulations Regarding Air Dispersion Modelling.

1.4.3 Study of the Receiving Environment

Physical environmental parameters that influence the dispersion of pollutants in the atmosphere include terrain, land cover and meteorology.

Readily available terrain and land cover data was obtained from the United States Geological Survey (USGS) via the Earth Explorer website (U.S. Department of the Interior, U.S. Geological Survey, 2016). Use was made of Shuttle Radar Topography Mission (SRTM) (90 m, 3 arc-sec) data and Global Land Cover Characterisation (GLCC) data for Africa.

An understanding of the atmospheric dispersion potential of the area is essential to an air quality impact assessment. In the absence of on-site meteorological data (that is required for atmospheric dispersion modelling), use was made of Eskom's measured data for Komati Power Station for a period from 2013 to 2015.

Dustfall sampling data was provided by South32 for the period February 2017 to May 2018 and included monthly dustfall rate measurements for 36 sampling locations. Unfortunately, no ambient air concentration of criteria pollutants was available from South32, but data from Eskom's Komati Power Station for the period 2013 to 2015 was made available to the study.

1.4.4 Site Visit

A site visit was arranged during which the existing sources of air emissions were assessed qualitatively, local factors identified that may influence local atmospheric dispersion potential, as well as identifying receptors (residential, community, agricultural) that are/may be affected by emissions from the Project. The site visit took place on 3 and 4 July 2018.

1.4.5 Determining the Impact of the Project on the Receiving Environment

The establishment of a comprehensive emission inventory formed the basis for the assessment of the air quality impacts of the Project's emissions on the receiving environment. In the quantification of emissions, use was made of design parameters, as well as emission factors and emission equations, which associate the quantity of a pollutant to the activity associated with the release of that pollutant. Pollutants emissions were calculated using emission factors and equations as published by the United States Environmental Protection Agency (US EPA) and Australian Department of Environment and Energy (ADE) National Pollutant Inventory (NPI).

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

1.4.6 Compliance Assessment and Health Risk Screening

Compliance was assessed by comparing simulated ambient criteria pollutant concentrations (PM_{10}, $PM_{2.5}$) and dustfall rates to NAAQS and NDCR respectively.

1.4.7 Recommendation of Air Quality Management Measures

The findings of the above components informed recommendations of air quality management measures, including mitigation and monitoring.

1.5 Assumptions, Exclusions and Limitations

The following important assumptions, exclusions and limitations to the specialist study should be noted:

1. The air quality assessment was based on the site layout, mining schedule, on-site vehicle capacities, annual fuel use and operating hours. Assumptions had to be made on the moisture content of coal, topsoil and overburden materials, drilling and blasting information (e.g. no of drill holes per day, no of blasts per week, blast area for coal and overburden respectively). These assumptions were made based on similar investigations for coal mines in the area.
2. The impact of the operational phase was determined quantitatively through emissions calculation and dispersion simulation. Although the application is limited to infrastructure development, the impact due to the operational phase represents the **cumulative** impact due to mining operations AND infrastructure development.
3. Due to their temporary nature, and because a detailed breakdown of construction activities was not available at the time of the study, the assessment of impacts from the construction and closure phases is mainly of a qualitative nature.
4. Meteorology:
    a. Use was made of data provided by Eskom for Komati Power Station's meteorological station approximately 13 km from the VDDC site. It was assumed that the data is representative of the project area. Alternatively, the South African Weather Services operate a weather station at eMalahleni and since

it is further from the site (27 km), the more appropriate data was considered to be that from Komati Power Station.

   b. The National Code of Practice for Air Dispersion Modelling prescribes the use of a minimum of one year on-site data or at least three years of appropriate off-site data for use in Level 2 assessments. It also states that the meteorological data must be for a period no older than five years to the year of assessment. The data set applied in this study was for the period 2013 to 2015 and complies with the requirements of the code of practice.

5. Emissions:
   a. The impact assessment was limited to airborne particulates (including TSP, PM_{10} and $PM_{2.5}$). These pollutants are either regulated under NAAQS or considered a key pollutant released by this operation.
   b. The quantification of sources of emission was restricted to the proposed Project. Although other existing sources of emission within the area were identified, such sources were not quantified as part of the emissions inventory and simulations. Their impact would be considered by ambient air quality monitoring in the region.
   c. Accurate dust-fall simulations rely on accurate site-specific particle size distributions. Particle size distributions used in calculations were based on analyses of South African collieries. A particle size distribution was selected from these that would result in the highest fallout rates and was assumed to represent the most conservative estimate.
6. Modelling:
   a. The dispersion model cannot compute real-time mining and production processes. Mining areas to be used in dispersion modelling were chosen based on the mining rate, shape and location.
   b. In-pit sources were assumed to be located at a depth of 30 m - after the removal of an initial overburden layer. Surface mining operations will have a larger impact than those at maximum pit depth; however, they are expected to be of shorter duration than those at depths of 30 m or more.
   c. The range of uncertainty of the model predictions could be -50% to 200%. There will always be some error in any geophysical model, but it is desirable to structure the model in such a way to minimise the total error. A model represents the most likely outcome of an ensemble of experimental results. The total uncertainty can be thought of as the sum of three components: the uncertainty due to errors in the model physics; the uncertainty due to data errors; and the uncertainty due to stochastic processes (turbulence) in the atmosphere.
   d. The selection of a modelling domain takes account of the expected impacts and it is possible that the impacts, when modelled, extend beyond the modelling domain. This occurred for the simulated PM_{10} concentrations exceeding the permissible frequency of exceedance in the unmitigated scenario; however, exceedance of the guideline outside of the modelling domain is not expected to cover a substantial area.
7. Greenhouse gas (GHG):
   a. Scope 1 carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions were calculated for the operational phase (using the annual fuel usage for the year 2028, which is the maximum amount of fuel (diesel) used per annum). This includes diesel used for mining and infrastructure operations;
   b. Scope 1 CO_2, CH_4 and N_2O emissions were calculated for the construction phase (using the average annual fuel usage over the construction period 2020 to 2022);
   c. Scope 1 emissions were converted to CO_2 equivalent (CO_2-e) emissions for the operational and construction phases; and
   d. Modelling was not included in the scope of work.

2 Regulatory Requirements and Impact Assessment Criteria

Prior to assessing the impact of proposed activities on human health and the environment, reference needs to be made to the environmental regulations governing the impact of such operations i.e. air emission standards, ambient air quality standards and dust control regulations:

- Air emission standards are generally provided for point sources and specify the amount of the pollutant acceptable in an emission stream and are often based on proven efficiencies of air pollution control equipment. The Department of Environmental Affairs (DEA) published a list of activities (MES – see 2.1 below), identifying those activities that are regulated by the DEA and which require the application for an Atmospheric Emission License (AEL).
- Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air pollution concentration standards included in the NAAQS indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. These air quality standards are normally given for specific averaging or exposure periods.
- Dust controls are regulated under the NDCR and provide dustfall rate standards for residential and non-residential areas.

This section summarises legislation for criteria pollutants and dustfall, as well as screening criteria for animals and vegetation. Regulations regarding the HPA air quality management, dispersion modelling and emissions reporting are also provided.

2.1 Listed Activities and Minimum National Emission Standards (MES)

The Minister, in terms of *Section 21* of the NEMAQA, published a list of activities which result in atmospheric emissions and which are believed to have significant detrimental effects on the environment, human health and social welfare. All scheduled processes as previously stipulated under Air Pollution Prevention Act 45 of 1965 (APPA) were included as listed activities with additional activities being added to the list. The MES were first published on 31 March 2010 (Government Gazette No. 33064) with a revision of the schedule on the 22 November 2013 (Government Gazette No. 37054).

Based on the information provided for the Project, none of the proposed activities trigger any of the listed activities in the MES.

2.2 Atmospheric Emissions Reporting Regulations (NAERR)

The NAERR (Government Notice R283 in Government Gazette 38633) came into effect on 2 April 2015 with the purpose to regulate the reporting of air emission data in an internet-based system (NAEIS). The NAEIS is a component of the SAAQIS and its objective is to provide all stakeholders with relevant, up to date and accurate information on South Africa's air emissions profile for informed decision making. Emission sources and data providers are classified according to groups. The Project would be classified under either Group A ("Listed activity published in terms of section 21(1) of the Act") or Group C ("Mines"). Emission reports from both groups must be made in the format required for NAEIS.

As per the regulations, South32 and/or their data provider should be registered on the NAEIS system as they are currently operating. Data providers must inform the relevant authority of changes if there are any:

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

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

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

2.3 National Ambient Air Quality Standards (NAAQS)

The initial NAAQS were published for comment in the Government Gazette on 9 June 2007. The revised NAAQS were subsequently published for comment in the Government Gazette on the 13th of March 2009. The final NAAQS was published in the Government Gazette on the 24th of December 2009 (Government Gazette 32816) and additional standards for particulate matter less than 2.5 µm in aerodynamic diameter ($PM_{2.5}$) was published on the 29th June 2012. The standards were developed for those pollutants that are most commonly found in the atmosphere, that have proven detrimental health effects when inhaled and are regulated by ambient air quality criteria. These generally include CO, NO_2, SO_2, benzene, lead (Pb), PM_{10}, $PM_{2.5}$, and ground level ozone (O_3), as listed in Table 1.

2.4 National Dust Control Regulations (NDCR)

The NDCR were published on 1 November 2013, with the purpose to prescribe general measures for the control of dust in all areas including residential and non-residential areas. The standard for acceptable dustfall rates is set out in Table 2 for residential and non-residential areas. According to these regulations, the dustfall rates at the boundary or beyond the boundary of the premises where it originates cannot exceed 600 mg/m²/day in residential and light commercial areas; or 1 200 mg/m²/day in areas other than residential and light commercial areas.

Table 1: National Ambient Air Quality Standards

Pollutant	Averaging Period	Concentration (µg/m³)	Permitted Frequency of Exceedance	Compliance Date
Sulphur Dioxide (SO_2)	10 minutes	500	526	Immediate
	1 hour	350	88	Immediate
	24 hour	125	4	Immediate
	1 year	50	0	Immediate
Benzene	1 year	5	0	1 January 2015
Carbon Monoxide (CO)	1 hour	30000	88	Immediate
	8 hour[(a)]	10000	11	Immediate
Lead (Pb)	1 year	0.5	0	Immediate

Pollutant	Averaging Period	Concentration (µg/m³)	Permitted Frequency of Exceedance	Compliance Date
Nitrogen Dioxide (NO_2)	1 hour	200	88	Immediate
	1 year	40	0	Immediate
Ozone (O_3)	8 hour(b)	120	11	Immediate
$PM_{2.5}$	24 hour	40	4	1 January 2016 till 31 December 2029
	24 hour	25	4	1 January 2030
	1 year	20	0	1 January 2016 till 31 December 2029
	1 year	15	0	1 January 2030
PM_{10}	24 hour	75	4	1 January 2015
	1 year	40	0	1 January 2015

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

Table 2: Acceptable dust fall rates

Restriction Area	Dust-fall rate (D) (mg/m²/day, 30-day average)	Permitted frequency of exceeding dust fall rate
Residential	D < 600	Two within a year, not sequential months.
Non-residential	600 < D < 1 200	Two within a year, not sequential months

Note: The method to be used for measuring dustfall rate and the guideline for locating sampling points shall be ASTM D1739: 1970, or equivalent method approved by any internationally recognized body

In addition to the dust fall limits, the NDCR prescribe monitoring procedures and reporting requirements. This will be based on the measuring reference method ASTM 01739:1970 (or an equivalent method approved by any internationally recognised body) averaged over 30 days.

2.5 Atmospheric Dispersion Modelling Regulations

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to determine compliance with the relevant ambient air quality standards. Dispersion modelling provides a versatile means of assessing various emission options for the management of emissions from existing or proposed installations. The *Regulations Regarding Air Dispersion Modelling* (Gazette No. 37804, 11 July 2014) recommend a suite of dispersion models to be applied for regulatory practices as well as guidance on modelling input requirements, protocols and procedures to be followed. These Regulations are applicable –

- in the development of an air quality management plan, as contemplated in *Chapter 3* of the NEMAQA;
- in the development of a *Priority Area Air Quality Management Plan*, as contemplated in *Section 19* of the NEMAQA;

- in the development of an *Atmospheric Impact Report* (AIR), as contemplated in *Section 30* of the NEMAQA; and,
- in the development of a specialist air quality impact assessment study, as contemplated in *Chapter 5* of the NEMAQA.

Three *Levels of Assessment* are defined in the Regulations. The three levels are:

- Level 1: where worst-case air quality impacts are assessed using simpler screening models;
- Level 2: for assessment of air quality impacts as part of license application or amendment processes, where impacts are the greatest within a few kilometres downwind (less than 50km);
- Level 3: require more sophisticated dispersion models (and corresponding input data, resources and model operator expertise) in situation:
    - where a detailed understanding of air quality impacts, in time and space, is required;
    - where it is important to account for causality effects, calms, non-linear plume trajectories, spatial variations in turbulent mixing, multiple source types & chemical transformations;
    - when conducting permitting and/or environmental assessment process for large industrial developments that have considerable social, economic and environmental consequences;
    - when evaluating air quality management approaches involving multi-source, multi-sector contributions from permitted and non-permitted sources in an air-shed; or,
    - when assessing contaminants resulting from non-linear processes (e.g. deposition, ground-level O_3, particulate formation, visibility).

Dispersion modelling provides a versatile means of assessing various emission options for the management of emissions from existing or proposed installations. Chapter 3 of the Regulation prescribe the source data input to be used in the model. Dispersion models are particularly useful under circumstances where the maximum ambient concentration approaches the ambient air quality limit value and provide a means for establishing the preferred combination of mitigation measures that may be required.

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

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

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

Chapter 5 provides general guidance on geophysical data, model domain and coordinates system requirements, whereas Chapter 6 elaborates more on these parameters as well as the inclusion of background air pollutant concentration data. Chapter 6 also provides guidance on the treatment of NO_2 formation from NOx emissions, chemical transformation of SO_2 into sulfates and deposition processes.

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

The first step in the dispersion modelling exercise requires a clear objective of the modelling exercise and thereby gives clear direction to the choice of the dispersion model most suited for the purpose. Accordingly, *Level 2* was deemed the most appropriate due to the relatively uncomplicated nature of the study area as well as the anticipated impacts to be confined within 50 km of the Project location.

2.6 Air Quality Management Plans (AQMP) – the Highveld Priority Area (HPA)

The *Highveld Airshed Priority Area* (HPA) was declared the second national air quality priority area (after the Vaal Triangle Airshed Priority Area) by the Minister of Environmental Affairs at the end of 2007 (HPA 2011). This required that an Air Quality Management Plan for the area be developed. The plan includes the establishment of emissions reduction strategies and intervention programmes based on the findings of a baseline characterisation of the area. The implication of this is that all contributing sources in the area will be assessed to determine the emission reduction targets to be achieved over the following few years. Most of the HPA experiences relatively good air quality, but there are nine extensive areas where ambient air quality standards for SO_2, NO_2, PM_{10} and O_3 are exceeded. These "hot spots" are illustrated in Figure 4 by the number of modelled exceedances of the 24-hour PM_{10} limit.

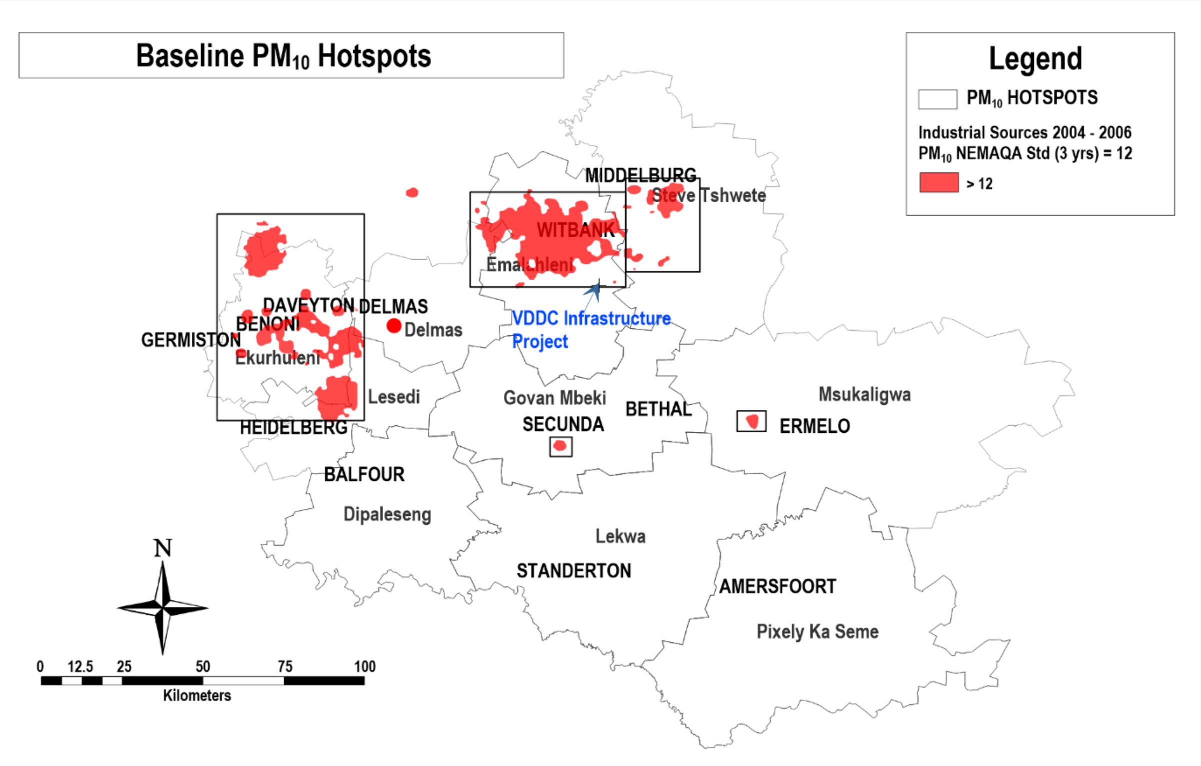

Figure 4: Modelled frequency of exceedance of the 24-hour ambient PM10 standard in the HPA, indicating the modelled air quality Hot Spot areas

The air quality hot spots result from a combination of emissions from the different industrial sectors and residential fuel burning, with motor vehicle emissions, mining and cross-boundary transport of pollutants into the HPA adding to the base loading.

The DEA published the AQMP for the Highveld Priority Area on the 2nd of March 2012 (Government Gazette No. 35072). Included in this management plan are seven goals, each of which has a further list of objectives that must be met. The seven goals for the Highveld Priority area are as follows:

- **Goal 1:** By 2015, organisational capacity in government is optimised to efficiently and effectively maintain, monitor and enforce compliance with ambient air quality standards.
- **Goal 2:** By 2020, industrial emissions are equitably reduced to achieve compliance with ambient air quality standards and dust fall-out limit values.
- **Goal 3:** By 2020, air quality in all low-income settlements is in full compliance with ambient air quality standards.
- **Goal 4:** By 2020, all vehicles comply with the requirements of the National Vehicle Emission Strategy.
- **Goal 5:** By 2020, a measurable increase in awareness and knowledge of air quality exists.
- **Goal 6:** By 2020, biomass burning and agricultural emissions will be 30% less than current.
- **Goal 7:** By 2020, emissions from waste management are 40% less than current.

The proposed Project falls within the HPA. Therefore, the particulate emissions from the facility are likely to contribute to the air quality of the HPA. The proposed project is located in the vicinity of the eMalahleni Hot Spot (HPA 2011) and the ambient air quality, with particular reference to particulates, is outlined below.

The poor ambient air quality in the eMalahleni Hot Spot is a result of emissions from power generation, metallurgical manufacturing processes, opencast coal mining and residential fuel burning; where industrial processes dominate the source contribution (HPA 2011). Dispersion modelling simulated exceedances of the daily PM_{10} limit for more than 12 days across the eMalahleni Hot Spot (HPA 2011). Monitored daily PM_{10} (Figure 5) concentrations at the eMalahleni (Witbank) monitoring station operated by the DEA show regular exceedances of the daily NAAQS limit, between 2012 and 2015. Daily $PM_{2.5}$ concentrations recorded at the monitoring station also showed exceedances of the relevant NAAQS in 2012, 2013 and 2015 (Figure 6). No exceedances were recorded in 2014, but the largest number of exceedances (in the 4-year period was recorded in 2015.

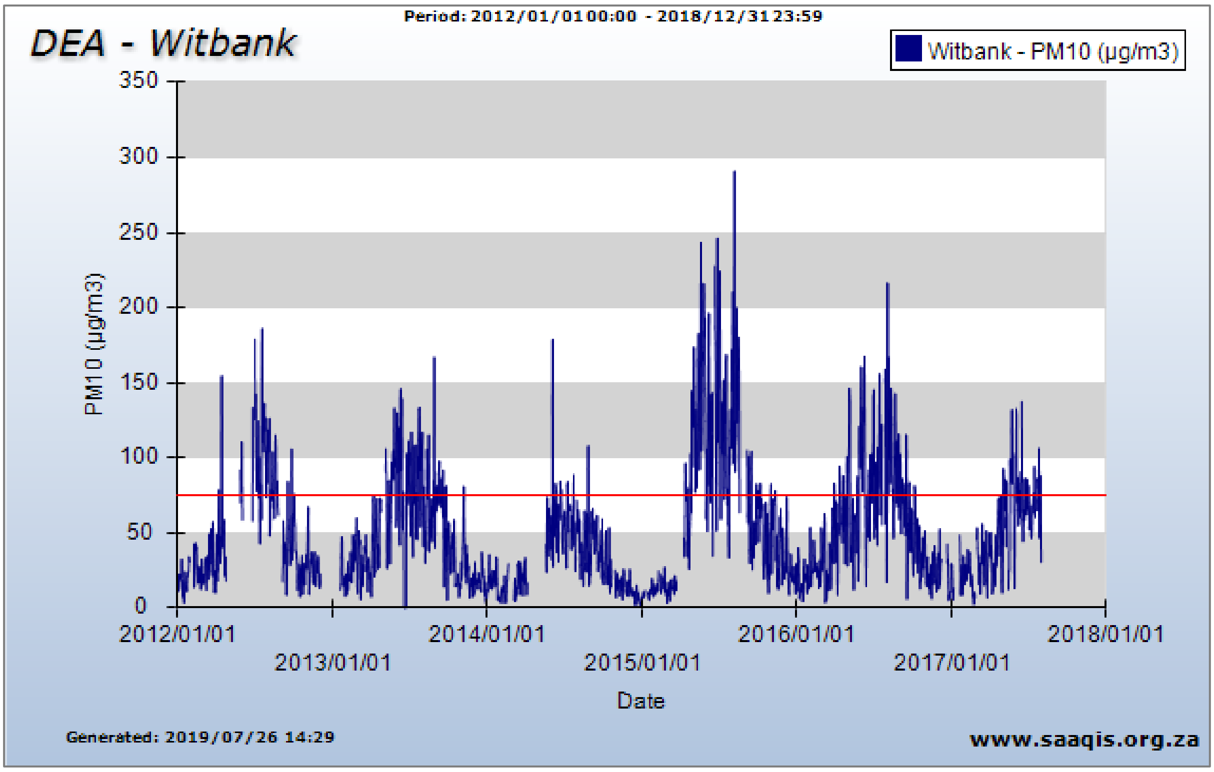

Figure 5: Daily PM_{10} concentrations monitored at the eMalahleni station between 2012 and 2018 (from www.saaqis.org.za). The horizontal red line indicates the daily limit concentration (75 µg/m^3)

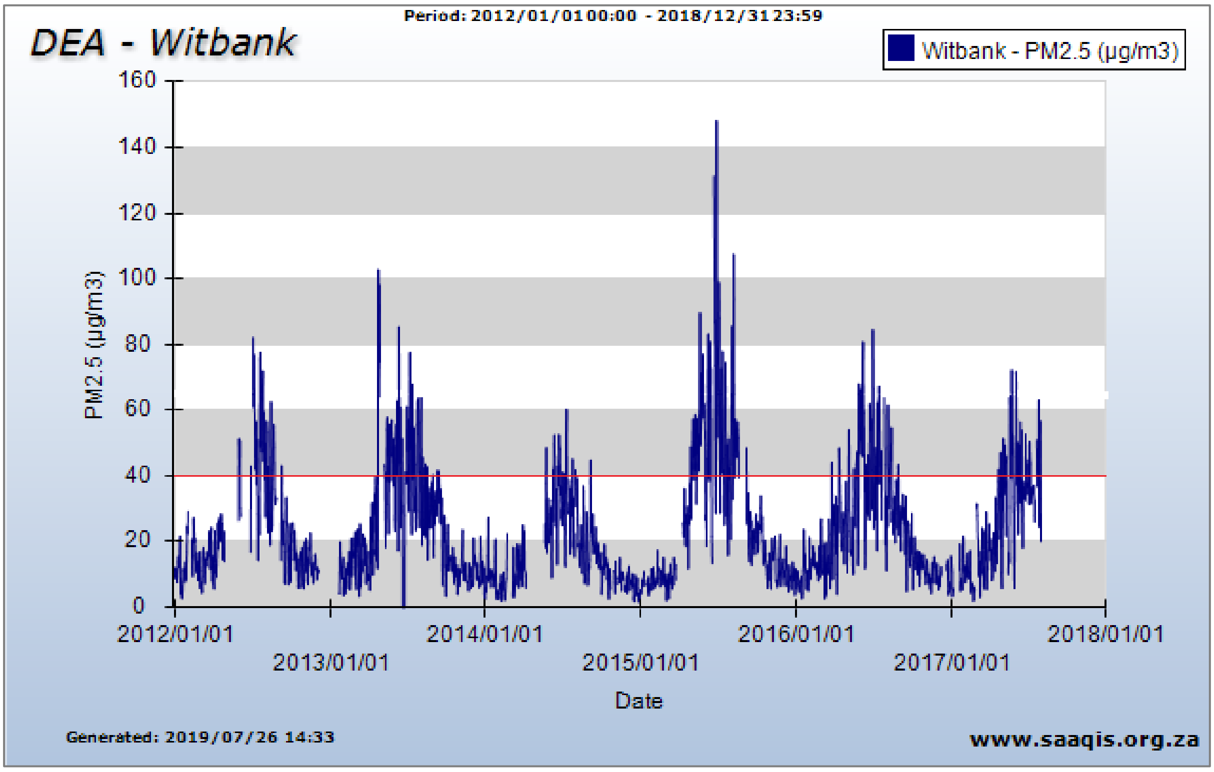

Figure 6: Daily $PM_{2.5}$ concentrations monitored at the eMalahleni station between 2012 and 2018 (from www.saaqis.org.za). The horizontal red line indicates the daily limit concentration (40 µg.m^{-3})

2.7 South African Climate Change Literature and Legislation

2.7.1 National Climate Change Response Policy 2011

South Africa ratified the United Nations Framework Convention on Climate Change (UNFCCC)[4] in August 1997 and acceded to the Kyoto protocol in 2002, with effect from 2005. However, since South Africa is a non-annex I country[5] it implies no binding commitment to cap or reduce GHG emissions.

The National Climate Change Response White Paper stated that in responding to climate change, South Africa has two objectives: to manage the inevitable climate change impacts and to contribute to the global effort in stabilising GHG emissions at a level that avoids dangerous anthropogenic interference with the climate system. The White Paper proposes mitigation actions, especially a departure from coal-intensive electricity generation, be implemented in the short- and medium-term to match the GHG trajectory range. Peak GHG emissions are expected between 2020 and 2025 before a decade long plateau period and subsequent reductions in GHG emissions.

The White Paper also highlighted the co-benefit of reducing GHG emissions by improving air quality and reducing respiratory diseases by reducing ambient particulate matter, ozone and SO_2 concentrations to levels in compliance with NAAQS by 2020. In order to achieve these objectives, the DEA has appointed a service provider to establish a national GHG emissions inventory, which will report through SAAQIS.

2.7.2 Intended Nationally Determined Contribution

The South African Intended Nationally Determined Contribution (INDC) submission was completed in 2015. This was undertaken to comply with decision 1/CP.19 and 1/CP.20 of the Conference of the Parties to the UNFCCC. This document describes South Africa's INDC on adaptation, mitigation and finance and investment necessities to undertake the resolutions.

As part of the adaptation portion the following goals have been assembled:

1. Goal 1: Development and implementation a National Adaption Plan. The implementation of this will also result in the implementation of the National Climate Change Response Plan (NCCRP) as per the 2011 policy.
2. Goal 2: In the development of national, sub-national and sector strategy framework, climate concerns must be taken into consideration.
3. Goal 3: An official institutional function for climate change response planning and implementation needs to be assembled.
4. Goal 4: The creation of an early warning, vulnerability and adaptation monitoring system
5. Goal 5: Develop policy regarding vulnerability assessment and adaptation needs.
6. Goal 6: Disclosure of undertakings and costs with regards to past adaptation strategies.

As part of the mitigation portion the following have been or can be implemented:

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[4] The UNFCCC is an international environmental treaty adopted on 9 May 1992 and entered into force on 21 March 1994, after a sufficient number of countries had ratified it. The framework sets non-binding limits on greenhouse gas emissions for individual countries and contains no enforcement mechanisms. Instead, the framework outlines how specific international treaties (called "protocols" or "Agreements") may be negotiated to specify further action towards the objective of the UNFCCC.

[5] Annex I and Annex B Countries/Parties are the signatory nations to the Kyoto Protocol that are subject to caps on their emissions of GHGs and committed to reduction targets–countries with developed economies. As a developing country (non-annex I country), South Africa is mandated to provide the prescribed data in the emission inventory and submit periodic national communications to the UNFCCC secretariat, although there are several other contributions that can be made which are essentially of a voluntary nature. Climate change response measures must be consistent with the national development needs and government priorities.

- The approval of 79 (5 243 MW) renewable energy Independent Power Producer (IPP) projects as part of a Renewable Energy Independent Power Producer Procurement Programme (REI4P). An additional 6 300 MW is being deliberated.
- A "Green Fund" has been created to back green economy initiatives. This fund will be increased in the future to sustain and improve successful initiatives.
- It is intended that by 2050 electricity will be decarbonised.
- Carbon Capture and Sequestration (or Carbon Capture and Storage) (CCS) which is discussed in more detail in the mitigation section.
- To support the use of electric and hybrid electric vehicles.
- Reduction of emissions can be achieved through the use of energy efficient lighting; variable speed drives and efficient motors; energy efficient appliances; solar water heaters; electric and hybrid electric vehicles; solar PV; wind power; CCS; and advanced bio-energy.

2.7.3 Greenhouse Gas as a Priority Pollutant

Greenhouse gases – CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 – have been declared priority pollutants under Section 29(1) of the Air Quality Act (Government Gazette 37421 of 14 March 2014). The declaration provides a list of sources and activities including (i) fuel combustion (both stationary and mobile), (ii) fugitive emission from fuels, (iii) industrial processes and other product use, (iv) agriculture; forestry and other land use and (v) waste management. GHGs in excess of 0.1 Megatons or more, measured as CO_2-e, is required to submit a pollution prevention plan to the Minister for approval.

2.7.4 Greenhouse Gas Inventories

2.7.4.1 *National Greenhouse Gas Emissions Inventory*

South Africa is perceived as a global climate change contributor and is undertaking steps to mitigate and adapt to the changing climate. DEA is categorised as the lead climate change institution and is required to coordinate and manage climate related information such as development of mitigation, monitoring, adaption and evaluation strategies (DEA, 2014a). This includes the establishment and updating of the National GHG Inventory. The National Greenhouse Gas Improvement Programme (GHGIP) has been initiated; it includes sector specific targets to improve methodology and emission factors used for the different sectors and improving the availability of data.

The 2000 to 2010 National GHG Inventory was prepared using the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines (IPCC, 2006). According to the National GHG Inventory (DEA, 2014a) the 2010 total GHG emissions were estimated at approximately 544.314 million metric tonnes CO_2-e (excluding Forestry and Other Land Use (FOLU)). This was a 21.1% increase from the 2000 total GHG emissions (excluding FOLU). FOLU is estimated to be a net carbon sink which reduces the 2010 GHG emissions to 518.239 million metric tonnes CO_2-e. The assessment (excluding FOLU) showed the main sectors contributing to GHG emissions in 2010 to be the energy industries (solid fuels); road transport; manufacturing industry and construction (solid fuels); and energy industries (liquid fuels). In 2010 the energy industry contributed 78.7% to the total GHG emissions (excluding FOLU), this increased by 3.6% from 2000.

The DEA is working together with local sectors to develop country specific emissions factors in certain areas; however, in the interim the IPCC default emission figures may be used to populate the SAAQIS GHG emission factor database. These country specific emission factors will replace some of the default IPCC emission factors.

2.7.4.2 *Greenhouse Gas Emission Inventory for the Sector*

The VDDC operations would most likely fall under the category of "industry" for the global GHG inventory and "manufacturing industries and construction" for the national GHG inventory. According to the "mitigation of climate change" document as part of the IPCC fifth Assessment Report (AR5) (IPCC, 2014) the 2010 global GHG emissions were 49 (±4.5) Gt CO_2-e, 21% (10 Gt CO_2-e) of which is as a result of industry. This category contributes approximately 41.117 million metric tonnes CO_2-e (excluding FOLU). 4.6% (1.891 million metric tonnes CO_2-e) of this emission is as a result of liquid fuel use.

2.7.5 Greenhouse Gas Reporting

Regulations pertaining to GHG reporting using the NAEIS was published on 3 April 2017 (Government Gazette 40762, Notice 275 of 2017). The South African mandatory reporting guidelines focus on the reporting of Scope 1 emissions only. The NAEIS web-based monitoring and reporting system will also be used to collect GHG information in a standard format for comparison and analyses. The system forms part of the National Atmospheric Emission Inventory component of the South African Atmospheric Emission Licensing and Inventory Portal (SAAELIP) and SAAQIS.

2.7.5.1 *Greenhouse Gas Reporting Requirements*

Based on the new GHG reporting regulations (Department Environmental Affairs, 2017a), VDDC is required to:

1. Register all facilities where activities exceed the thresholds (for coal mining there is no threshold, so therefore the data provider has to report activity data and greenhouse gas emissions irrespective of the size of greenhouse gas emissions and the scale of the operation of the activity) listed in Annexure 1 by providing the relevant information as listed in Annexure 2 to these Regulations, within 30 days after the commencement of these Regulations or within 30 days after commencing such an activity after the commencement of these Regulations.
2. Ensure that the registration details are complete and are an accurate reflection of the IPCC emission sources at each facility.
3. The registration contemplated in sub-regulation (1) must be done as follows:
    i. on the NAEIS;
    ii. in cases where the NAEIS is unable to meet the registration requirements, the registration must be done by submitting the information specified in Annexure 2 in an electronic format to the competent authority.

The reporting requirements are:

1. Submit the greenhouse gas emissions and activity data as set out in the Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry (Department Environmental Affairs, 2017c) for each of the relevant greenhouse gases and IPCC emission sources specified in Annexure 1 to these Regulations for all of its facilities and in accordance with the data and format requirements specified in Annexure 3 to these Regulations for the preceding calendar year, to the competent authority by 31 March of each year.
2. Where the 31 March falls on a Saturday, Sunday or public holiday, the submission deadline is the next working day.
3. The reporting contemplated in sub-regulations (1) and (2) must be done as follows:
    i. on the NAEIS;
    ii. in cases where the NAEIS is unable to meet the reporting requirements, the reporting must be done by submitting the information specified in Annexure 3 in an electronic format to the competent authority.

The technical guidelines (Department Environmental Affairs, 2017c) referenced by the National Greenhouse Gas Emission Reporting Regulations (NGER) will be used for quantifying GHG inventories. Coal mining (code 1B1a as specified in Annexure

1) needs to report applying a tier[6] 2 or tier 3 methodology after 5 years from the date of promulgation of the regulations. Tier 1 can be used in the first 5 years.

The anticipated carbon tax will be calculated based on the CO_2eq emissions[7].

2.7.6 Carbon Tax Legislation

The Carbon Tax Act 15 of 2019 was signed by President Cyril Ramaphosa on 22 May 2019, commencement date 1 June 2019 (Gazette No. 42483). The Act provides for the imposition of a tax on the carbon dioxide (CO_2) equivalent of greenhouse gas emissions, and to provide for matters connected therewith.

[6] "Tier" means a method used for determining greenhouse gas emissions as defined by the "IPCC Guidelines for National Greenhouse Gas Inventories (2006)" and include–

i. Tier 1 method: A method using readily available statistical data on the intensity of processes (activity data) and IPCC emission factors (specified in the Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry or available in 2006 IPCC);
ii. Tier 2 method: similar to Tier 1 but uses country-specific emission factors;
iii. Tier 3 method: Tier 3 is any methodology more detailed than Tier 2 and might include amongst others, process models and direct measurements as specified in the 2006 IPCC guidelines.

[7] It should be noted that Wolvekrans Colliery is an existing colliery with reporting requirements are already in place, which should therefore be expanded to include the VDDC project.

3 Description of the Receiving/Baseline Environment

3.1 Air Quality Sensitive Receptors

The NAAQS (Section 2.1.1) are based on human exposure to specific criteria pollutants and as such, possible sensitive receptors were identified where the public is likely to be unwittingly exposed. NAAQS are enforceable outside the mine boundary and therefore a number of sensitive receptors have been identified (Figure 1). These sensitive receptors are small residential communities, individual residences and farmsteads in the vicinity of the proposed project. The simulated ground-level concentrations of PM_{10} and $PM_{2.5}$ are compared against relevant NAAQS (Section 1.1) and dustfall rates compared with the NDCR acceptable dustfall rates, at these receptors (Section 4.3).

3.2 Topography

The topography of the study area is simple and relatively flat or gently undulating. As shown in Figure 7, the elevation varies between 1490 m above mean sea level (AMSL) to a maximum of 1650 m AMSL (SRTM1 from the United States Geological Survey at https://earthexplorer.usgs.gov). The land cover is predominantly grassland and irrigated agricultural lands.

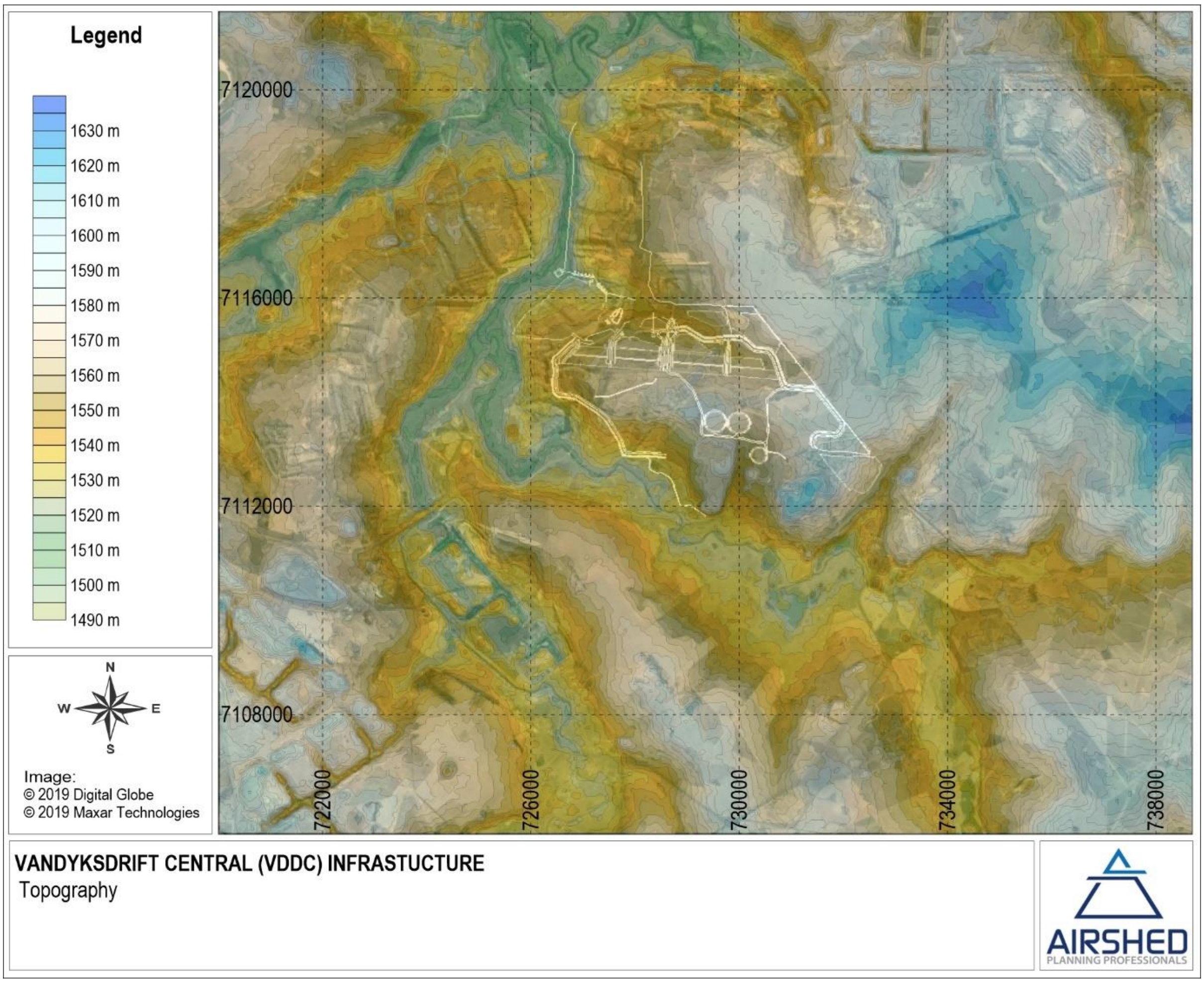


Figure 7: Topography for the study area

3.3 Atmospheric Dispersion Potential

The meteorological characteristics of a site govern the dispersion, transformation and eventual removal of pollutants from the atmosphere (Pasquill & Smith; 1983; Godish, 1990). The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. Dispersion comprises vertical and horizontal components of motion. The vertical component is defined by the stability of the atmosphere and the depth of the surface mixing layer. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness (due to buildings, topography, vegetation cover, etc.). The wind direction and the variability in wind direction, determine the general path pollutants will follow, and the extent of cross-wind spreading (Shaw & Munn, 1971; Pasquill & Smith, 1983; Oke, 1990).

Pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field. Spatial variations and diurnal and seasonal changes in the wind field and stability regime are functions of atmospheric processes operating at various temporal and spatial scales (Goldreich & Tyson, 1988). Atmospheric processes at macro- and meso-scales must be accounted for to accurately parameterise the atmospheric dispersion potential of a particular area. A qualitative description of the synoptic climatology of the study region is provided based on a review of the pertinent literature. The analysis of meteorological data observed for the proposed site will provide the basis for the parameterisation of the meso-scale ventilation potential of the site.

The analysis of at least one year of hourly average meteorological data for the study is required to facilitate a reasonable understanding of the ventilation potential of the site. The most important meteorological parameters to be considered are: wind speed, wind direction, ambient temperature, atmospheric stability and mixing depth. Atmospheric stability and mixing depths are not routinely recorded and frequently need to be calculated from diagnostic approaches and prognostic equations, using as a basis routinely measured data, e.g. temperature, predicted solar radiation and wind speed.

Meteorological data for the current assessment was made available by Eskom from the Komati ambient air quality monitoring station. Eskom provided data for the period 1 January 2013 to 31 December 2015 – a period of three years, a period in compliance with the Regulations Regarding Air Dispersion Modelling (Government Gazette No. 37804, vol. 589; 11 July 2014). The following sections summarise the meteorological conditions at the site over this period.

3.3.1 Surface Wind Field

The co-dominant wind directions (Figure 8), during the period under investigation, north-north-west, north-east and east-northeast with a frequency of occurrence of approximately 11%. North-north-easterly winds are the next dominant with a frequency of 9%. Winds from the southern and south-western sectors occur relatively infrequently (<4% of the total period). Calm conditions (wind speeds <1 m/s) occur 13.5% of the time.

A frequent north-westerly flow dominates day-time conditions with >12% frequency of occurrence. At night, an increase in north-easterly flow is observed (~17% frequency).

During summer months, winds from the east become slightly more frequent (Figure 9). There is an increase in the frequency of calm periods (i.e. wind speeds <1 m/s) during the autumn (18.4%) and winter months (21.0%). The predominant wind direction in winter is from the north-east, increasing in dominance in spring-time (~13%). During spring-time, winds are more likely to exceed 5.0 m/s, with calm conditions only 6.1% of the time.

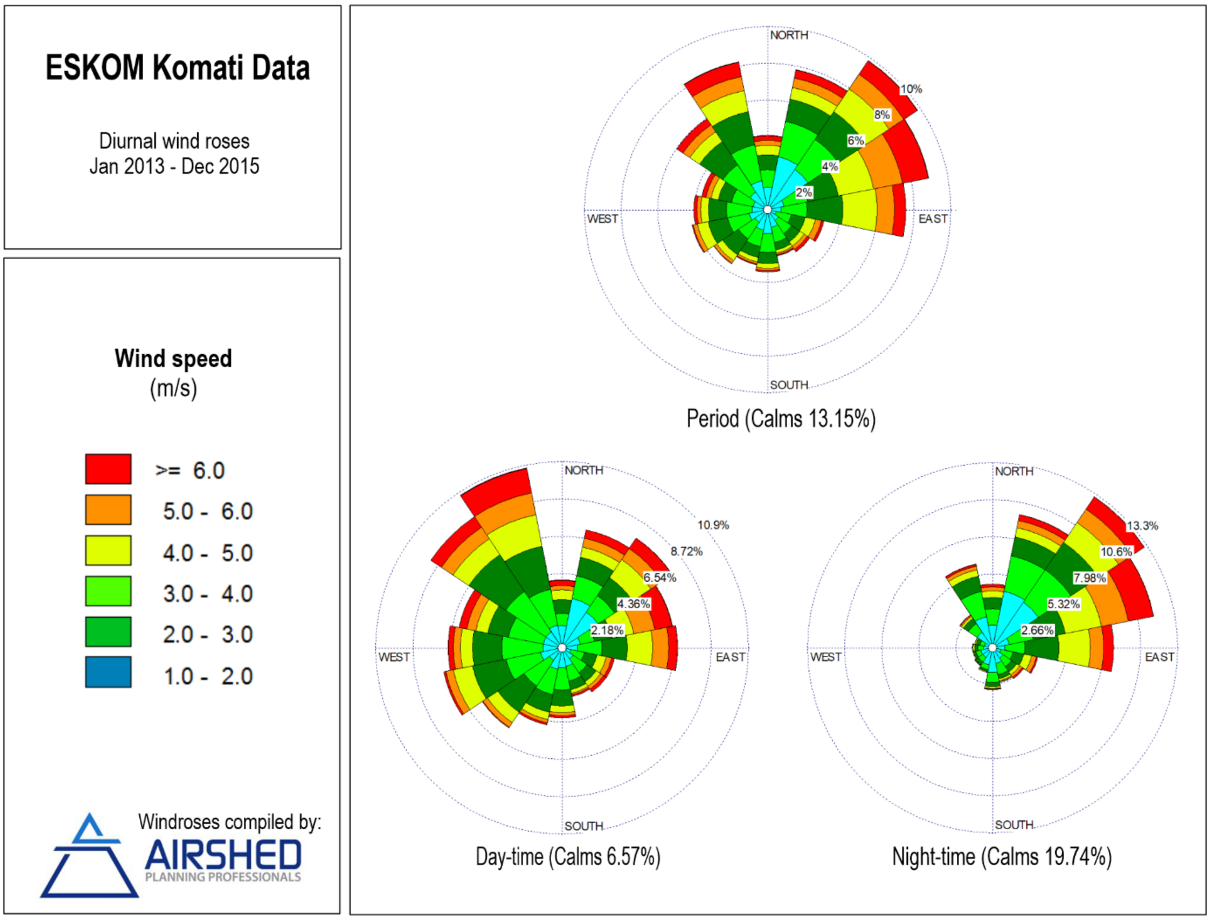


Figure 8: Period, day-time and night-time wind roses for Eskom Komati monitoring station (January 2013 – December 2015)

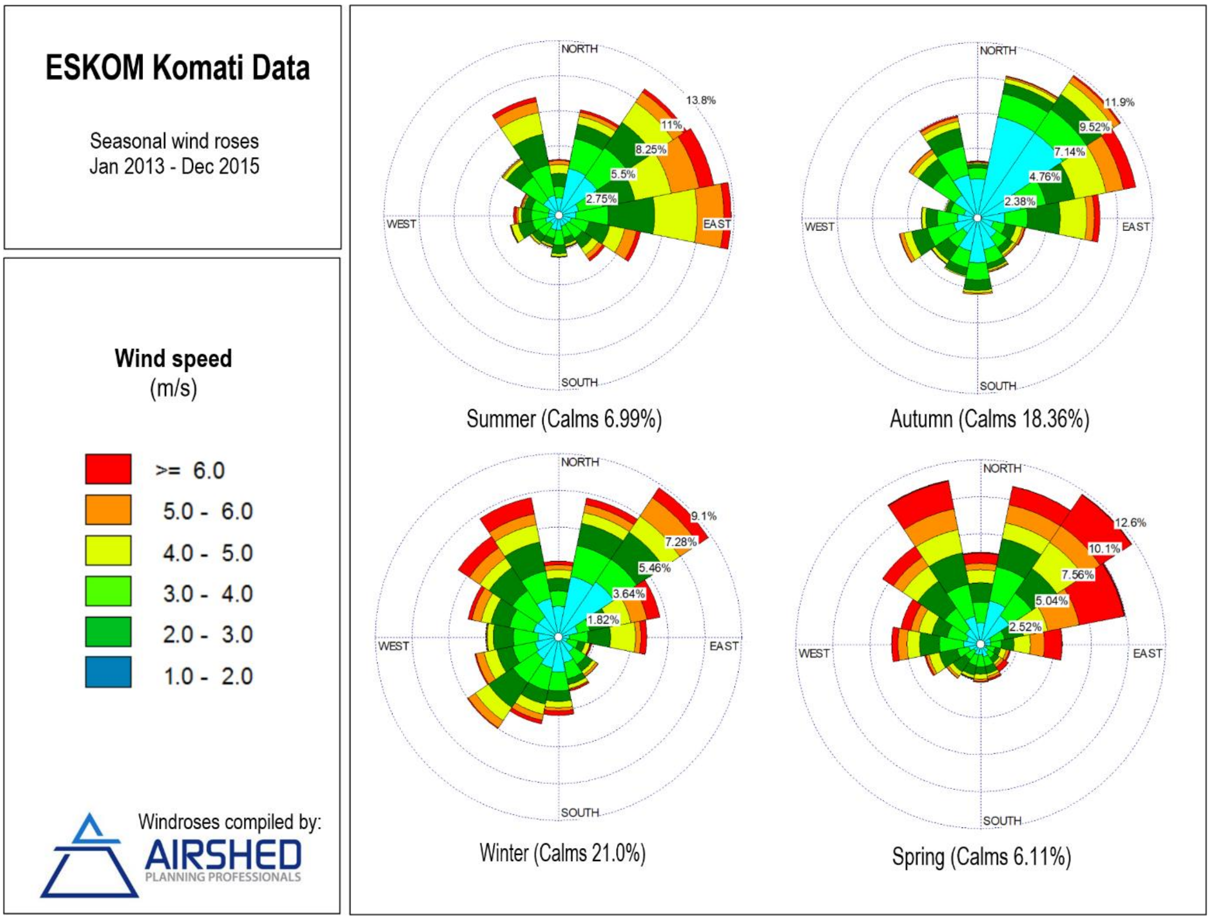


Figure 9: Seasonal wind roses for the Eskom Komati monitoring station (January 2013 – December 2015)

3.3.2 Surface Temperature

Air temperature provides an indication of the extent of insolation, and therefore of the rate of development and dissipation of the mixing layer. A temperature profile average of temperatures in each hour of every month is presented in Figure 10. Average daily maximum, minimum and mean temperatures for the site are given as 19.0°C, 13.2°C and 16.1°C, respectively, based on the measured data at Eskom's Komati ambient air quality monitoring station for the period 2013 - 2015. Daily maximum temperatures range from 33.9°C in February to 23.9°C in July, with daily minima ranging from 10.0°C in January to -4.3°C in July.

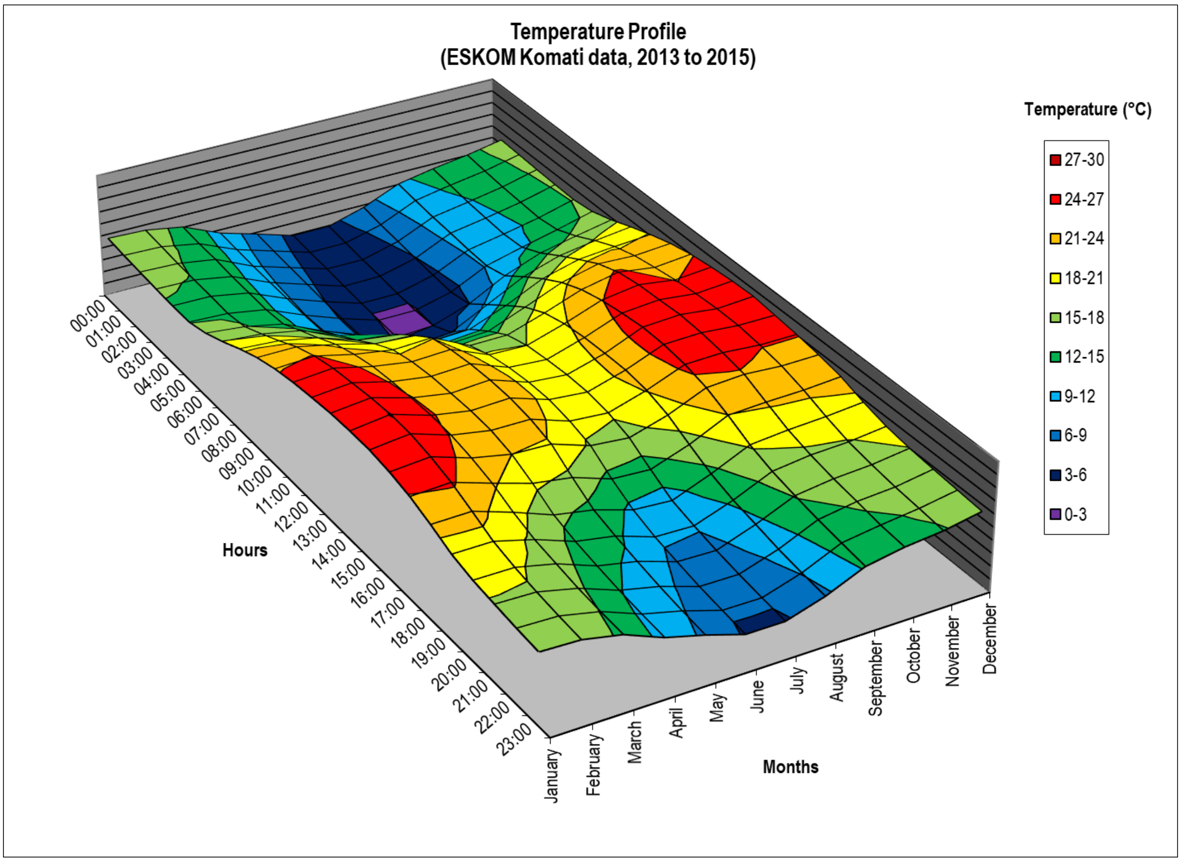


Figure 10: Diurnal monthly average temperature profile (data for Komati station, 2013 to 2015)

3.3.3 Precipitation

Rainfall represents an effective removal mechanism of atmospheric pollutants and is therefore frequently considered during air pollution studies. Precipitation data were not available for the proposed site; however, long-term precipitation records for Middleburg and Bethal are presented below in the absence of these records. Long-term total annual rainfall figures for various stations within the eMalahleni region is in the range of 730 mm to 750 mm (Table 3). Rain falls mainly in summer from October to April, with the peak for the region being in January.

Table 3: Long-term mean monthly rainfall figures (mm) for various stations within the eMalahleni region.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Middelburg (1904 – 1950)	132	103	88	42	19	7	9	8	22	63	124	118	735
Bethal (1904 – 1984)	134	94	78	46	19	7	8	10	25	78	128	120	747

3.3.4 Atmospheric Stability

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. This layer is directly affected by the earth's surface, either through the retardation of flow due to the frictional drag of the earth's surface, or as result of the heat and moisture exchanges that take place at the surface. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated inversion. Radiative flux divergence during the night usually results in the establishment of ground-based inversions and the erosion of the mixing layer. Night times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds, hence less dilution potential.

The most widely used atmospheric dispersion models have generally been based on the assumption that air pollutants behave according to a Gaussian probability distribution. Furthermore, these dispersion models have relied on the atmosphere being classified into one of six stability classes suggested by Pasquill (1961), and later modified by Gifford (1962)., into seven classes. These stability classes are described as follows:

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

The largest difference between the different atmospheric stability classes can be observed in the vertical plume behaviour, as shown in Figure 11. The difference is closely related to the vertical temperature gradient (i.e. lapse rate), as shown in the figures. During unstable condition, the air temperature decreases with height (i.e. negative lapse rate), whereas during stable conditions, the lapse rate is positive. When the lapse rate is near the dry adiabatic lapse rate of 0.98°C drop in temperature for every 100 m vertical rise, the atmosphere is considered to be neutral.

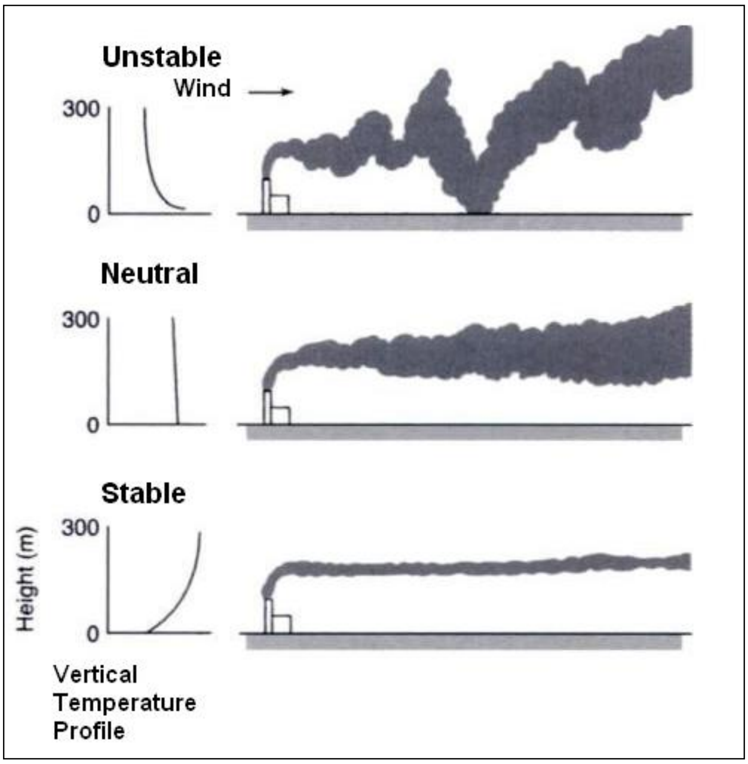


Figure 11: Effect of atmospheric turbulence on plume behaviour (after Oke, 1987)

The new generation air dispersion models differ from the models traditionally used in a number of aspects, the most important of which are the description of atmospheric stability as a continuum rather than discrete classes. The atmospheric boundary layer properties are therefore described by two parameters; the boundary layer depth and the Obukhov length, rather than in terms of the single parameter Pasquill Class. The Obukhov length (L_o) provides a measure of the importance of buoyancy generated by the heating of the ground and mechanical mixing generated by the frictional effect of the earth's surface. Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC 2004). The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface. Night-times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds and lower dilution potential.

Diurnal variation in atmospheric stability, as calculated from the Eskom Komati weather station for the period 2013 to 2015 and described by the inverse Obukhov length and the boundary layer depth, is provided in Figure 12. Negative Obukhov lengths indicate unstable conditions, whereas positive values indicate stable conditions.

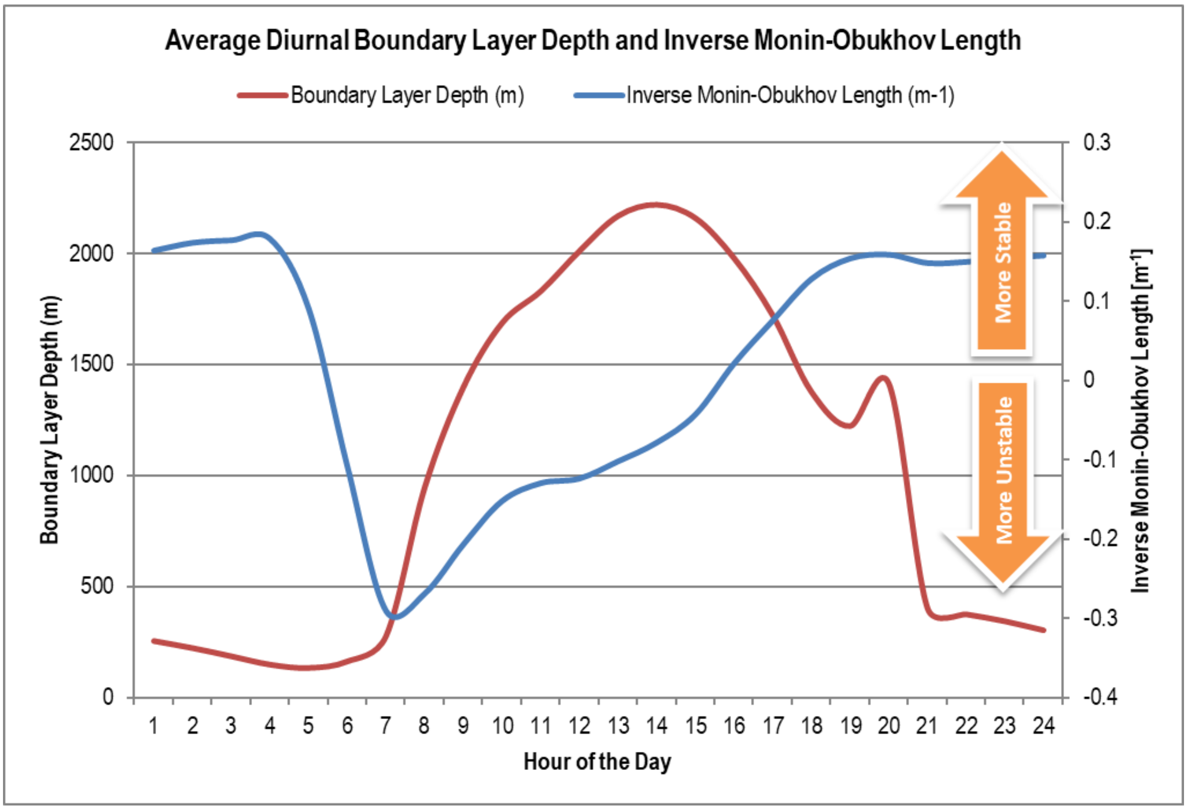


Figure 12: Diurnal atmospheric stability (AERMET processed measured data, 2013 to 2015)

As is illustrated in the figure, the calculated average inverse Obukhov length for the period from around 15h00 to 04h00 is about 0.14 m^{-1}, indicating stable atmospheric conditions (inversion conditions) and would result in the highest concentrations for ground level, or near-ground level releases from non-wind dependent sources. Unstable conditions are strongest around 07:00, with the average inverse Obukhov length remaining below -0.20 m^{-1} from 06h00 to 08h00. This period often represents looping conditions for elevated releases.

3.4 Sources of Air Pollution in the Region

Power generation, mining activities, farming and residential land-uses occur in the vicinity of the proposed Project. These land-uses contribute to baseline pollutant concentrations. Long-range transport of particulates, emitted from remote tall stacks and from large-scale biomass burning in countries to the north of South Africa, has been found to contribute to background fine particulate concentrations within the South African boundary. The main sources of air pollution are described in Table 4.

Table 4: Sources of air pollution near the Project area

Source of air pollution	Description	Pollutants released
Power generation	Operational power stations that are in proximity of the Project include Duvha (approximately 15 km north-northeast), Komati (approximately 15 km east-southeast) and Kendal (approximately 34 km west).	The main emissions from such electricity generation operations are carbon dioxide (CO_2), SO_2, NOx and ash (PM). Fly-ash particles emitted comprise various trace elements such as arsenic, chromium, cadmium, lead, manganese, nickel, vanadium and zinc. Small quantities of volatile organic compounds are also released from such operations.
Primary and secondary metallurgical operations	–Primary metallurgical production takes place in the eMalahleni and Steve Tshwete Local Municipalities (LM). Although relatively far removed from the Project study area, it is possible that these sources contribute cumulatively to the degradation of the air quality. –Non-ferroalloy industries are located in the eMalahleni LM, Steve Tshwete LM and Ekurhuleni MM.	–Emissions from the primary metallurgical sector include particulate matter (PM_{10}, $PM_{2.5}$ and dustfall) as well as SO_2 and NO_2. The particulate matter includes metals associated with smelting operations. –Emissions from the non-ferroalloy industries are released from relatively low stacks. This results in relatively limited dispersion and a localised effect in the ambient environment (HPA 2011).
Mining operations	Fugitive emissions from opencast mining operations (and to a lesser extent underground mining) in the study area are the main contributing sources of air pollution. These emissions mainly originate from land clearing operations (i.e. scraping, dozing and excavating), materials handling operations (i.e. draglines, tipping, off-loading and loading, conveyor transfer points), vehicle entrainment from haul roads, wind erosion from open areas, drilling and blasting.	These activities mainly result in particulates and dust emissions, with varying amounts of oxides of nitrogen (NO_x), CO, SO_2, and CO_2. The latter air pollutants originate from combustion sources, including on- and off-road vehicle engines, generators, as well as spontaneous combustion of discard coal dumps and potentially previously mined board-and-pillar mining operations that are exposed to air. Volatile organic compounds (VOCs), including benzene, may be released during spontaneous combustion. Methane emissions are also associated with coal mining and contribute to the greenhouse gas inventory.
Domestic fuel combustion	Domestic households are known to have the potential to be one the most significant sources that contribute to poor air quality within residential areas. Individual households are low volume emitters, but their cumulative impact is significant. It is likely that households within	Pollutants arising from the combustion of wood include respirable particulates, CO and SO_2 with trace amounts of polycyclic aromatic hydrocarbons (PAHs), in particular benzo(a)pyrene and formaldehyde. Coal is relatively inexpensive in the Mpumalanga region and is easily

Source of air pollution	Description	Pollutants released
	the local communities or settlements utilize coal, paraffin and/or wood for cooking and/or space heating (mainly during winter) purposes.	accessible due to the proximity of the region to coal mines and the well-developed coal merchant industry. Coal burning emits a large amount of gaseous and particulate pollutants including SO_2, heavy metals, PM including heavy metals and inorganic ash, CO, PAHs (recognized carcinogens), NO_2 and various toxins. The main pollutants emitted from the combustion of paraffin are NO_2, particulates, CO and PAHs.
Vehicle tailpipe emissions	Gaseous air emissions resulting from motor vehicles can be grouped into primary and secondary pollutants. While primary pollutants are emitted directly into the atmosphere, secondary pollutants are formed in the atmosphere as a result of chemical reactions. Both small and heavy private and industrial vehicles travelling along the R542 and R544 roads as well as unpaved public and private roads, are notable sources of vehicle tailpipe emissions.	Significant primary pollutants emitted by internal combustion engines include CO_2, CO, carbon (C), SO_2, NOx (mainly NO), particulates and Pb. Secondary pollutants include NO_2, photochemical oxidants such as ozone, sulfur acid, sulfates, nitric acid, and nitrate aerosols (particulate matter).
Biomass burning	Biomass burning includes the burning of evergreen and deciduous forests, woodlands, grasslands, and agricultural lands. Within the project vicinity, crop-residue burning and wild fires (locally known as veld fires) may represent significant sources of combustion-related emissions. The frequency of wildfires in the Highveld grasslands is generally annually, with the most significant period from August to October.	Air emissions due to wood residue combustion include the gaseous products of oxides of nitrogen (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), and greenhouse gases (GHG) such as CO_2, methane (CH_4), and nitrous oxide (N_2O).
Other fugitive dust sources	Other sources of suspended dust include public paved and unpaved roads; agricultural tilling operations; and wind erosion of sparsely vegetated surfaces.	Particulates and dust emissions, with varying amounts of oxides of nitrogen (NO_x), CO, SO_2, and CO_2 due to combustion sources.

3.5 Monitored Ambient Concentrations and Dustfall Levels

3.5.1 Ambient Monitoring

Although not necessarily a direct reflection of the conditions that may exist in the Project study area, the PM_{10} and $PM_{2.5}$ concentrations observed at the nearest particulate monitoring station have been included as a typical reference of the air quality in the Highveld region. The graphs in this section summarise the observed concentrations of particulates at the nearest Eskom monitoring site for Komati. Daily PM_{10} and $PM_{2.5}$ concentrations monitored at the Komati station between 2014 and 2017 (Figure 13 and Figure 14) show regular exceedances of the NAAQS daily limit (4 daily exceedances of 75 µg/m³ and 40 µg/m³ respectively). The figures show elevated concentrations during autumn and winter months due to the larger contribution from domestic fuel burning, dust from uncovered soil and the lack of the settling influence of rainfall.

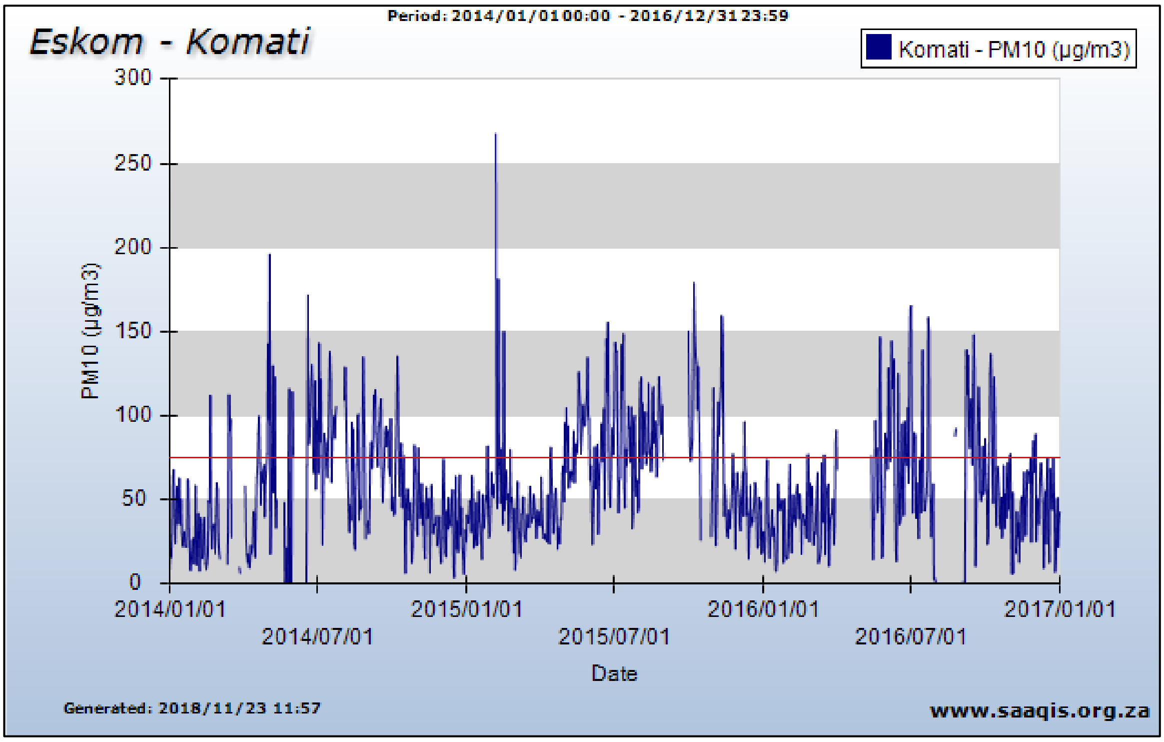


Figure 13: Daily PM_{10} concentrations monitored at the Komati station between 2014 and 2016 (from www.saaqis.org.za). The horizontal red line indicates the daily limit concentration applicable during the period (75 µg.m^{-3}).

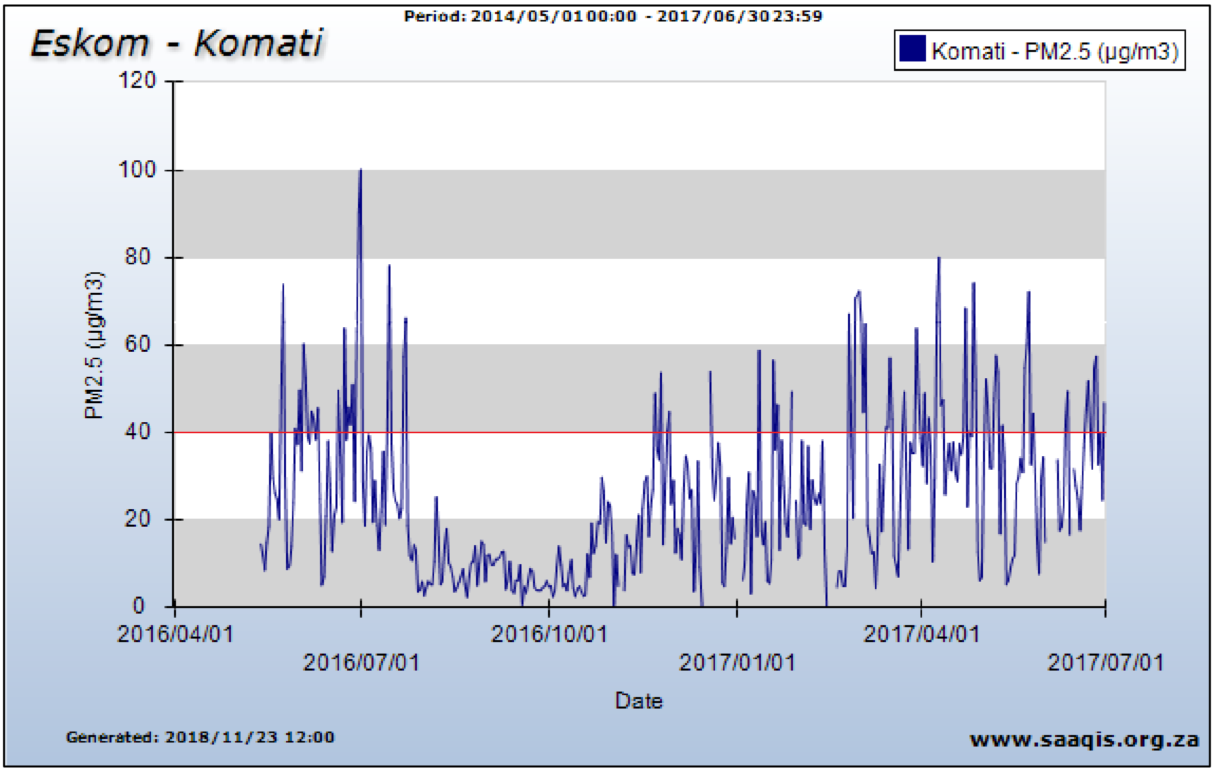


Figure 14: Daily $PM_{2.5}$ concentrations monitored at the Komati station between 2016 and 2017 (from www.saaqis.org.za). The horizontal red line indicates the daily limit concentration applicable during the period (40 µg.m^{-3}).

An analysis of the observed PM_{10} concentrations at Komati was completed, in which the concentration values were categorised into wind speed and direction bins for different concentrations, and visualised in the form of pollution roses and polar plots, respectively. Pollution roses identify the direction of contributing sources by specifying which direction is associated with higher or lower concentrations. Percentile roses are most useful for showing the distribution of concentrations by wind direction and often can reveal different sources e.g. those that only affect high percentile concentrations such as a chimney stack. The diurnal percentile roses for Komati station are shown in Figure 15. The daytime percentile rose shows that PM_{10} concentrations of less than or equal to 100 µg/m³ occur 50 to 75% of the time during the day. The shape of the 90-95th percentile rose indicates a local source distribution (0-270°) whereas the night-time percentile rose shows a more even distribution (0-360°) (indicative of very local sources, such as roads).

In addition the observed PM_{10} concentrations at Komati were visualised in the form of polar plots, where the centre of the polar plot refers to the location of the monitoring station. These polar plots (Carslaw and Ropkins, 2012; Carslaw, 2013) provide an indication of the directional contribution as well as the dependence of concentrations on wind speed. Whereas the directional display is fairly obvious, i.e. when higher concentrations are shown to occur in a certain sector, it is understood that most of the high concentrations occur when winds blow from that sector (i.e. east or south). When the high concentration pattern is more symmetrical around the centre of the plot, it is an indication that the contributions are near-equally distributed. Particulate concentrations recorded at the Komati station show high concentrations from the north-west and north-east, at high wind speeds (above 4 m/s), and a local source at low wind speeds (Figure 15). Sources in the south-westerly sector contribute the lowest concentrations, especially at higher wind speeds

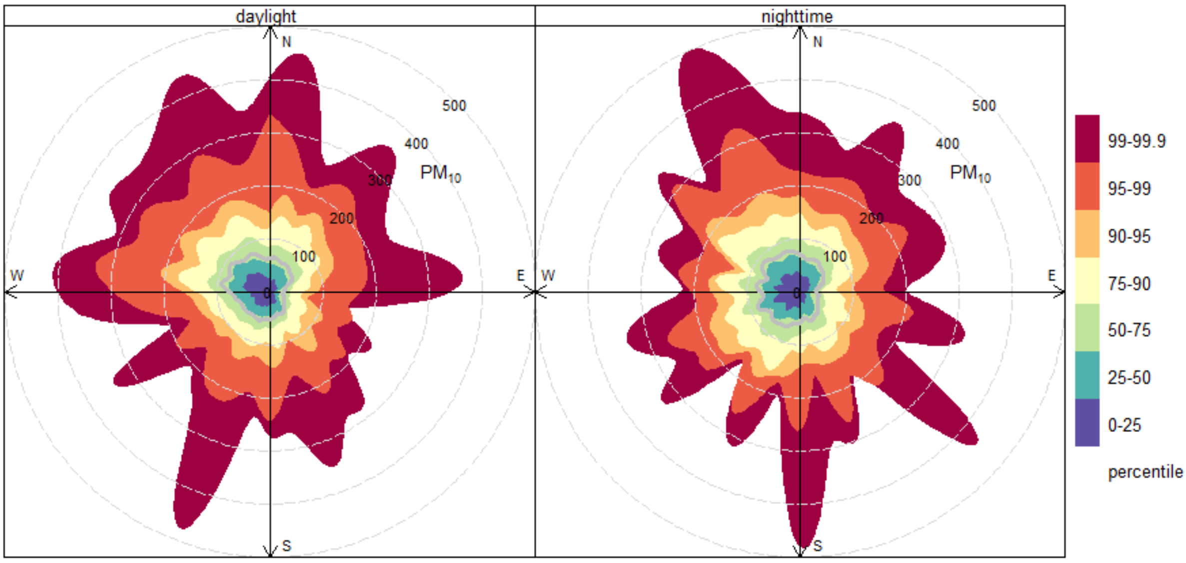


Figure 15: Diurnal PM_{10} percentile roses monitored at the Komati station between 2013 and 2015

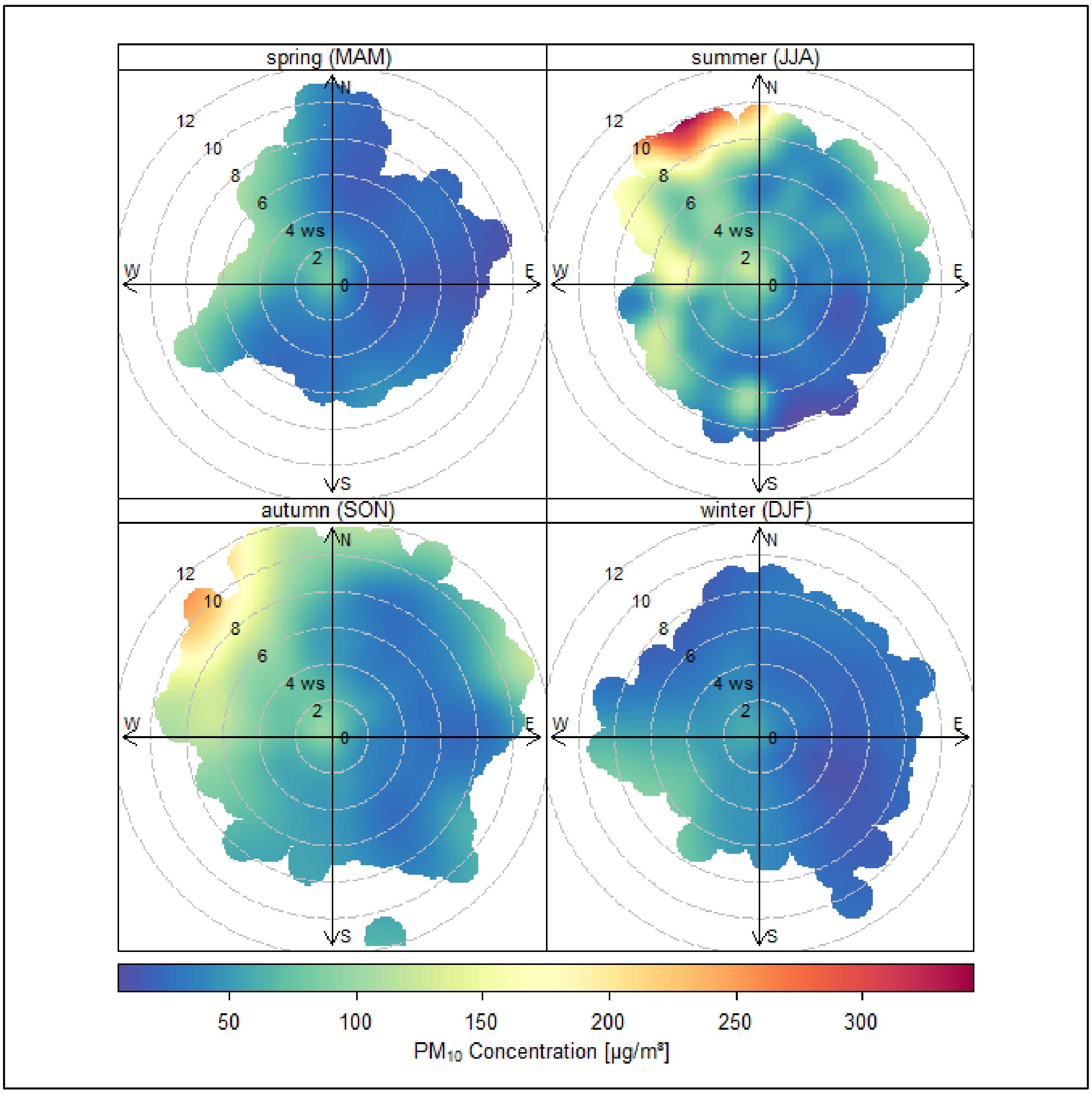


Figure 16: Seasonal PM_{10} polar plots monitored at the Komati station between 2013 and 2015

3.5.2 Nuisance dustfall in the vicinity of the Project area

South32 manage a network of 36 dustfall monitoring units (buckets) in the greater vicinity of the Project operations. The 8 closest to the Project were selected to establish the nuisance dust levels in the study area (Figure 17). These included 6 single buckets and 2 locations with directional buckets as listed in Table 5.

Table 5: Dustfall sampling locations

Sample Location	Bucket Type	Distance from Project Centre [km]
Vandyksdrift Plant	Single Bucket	1.8
Vandyksdrift Village		2.4
BCP10		2.7
SKS Prefab Offices		2.9
DGS Next to Anglo (single bucket)		4.4
Pit Haul Road		6.2
DGS21	Directional Buckets	4.3
DGS Next to Anglo		4.4

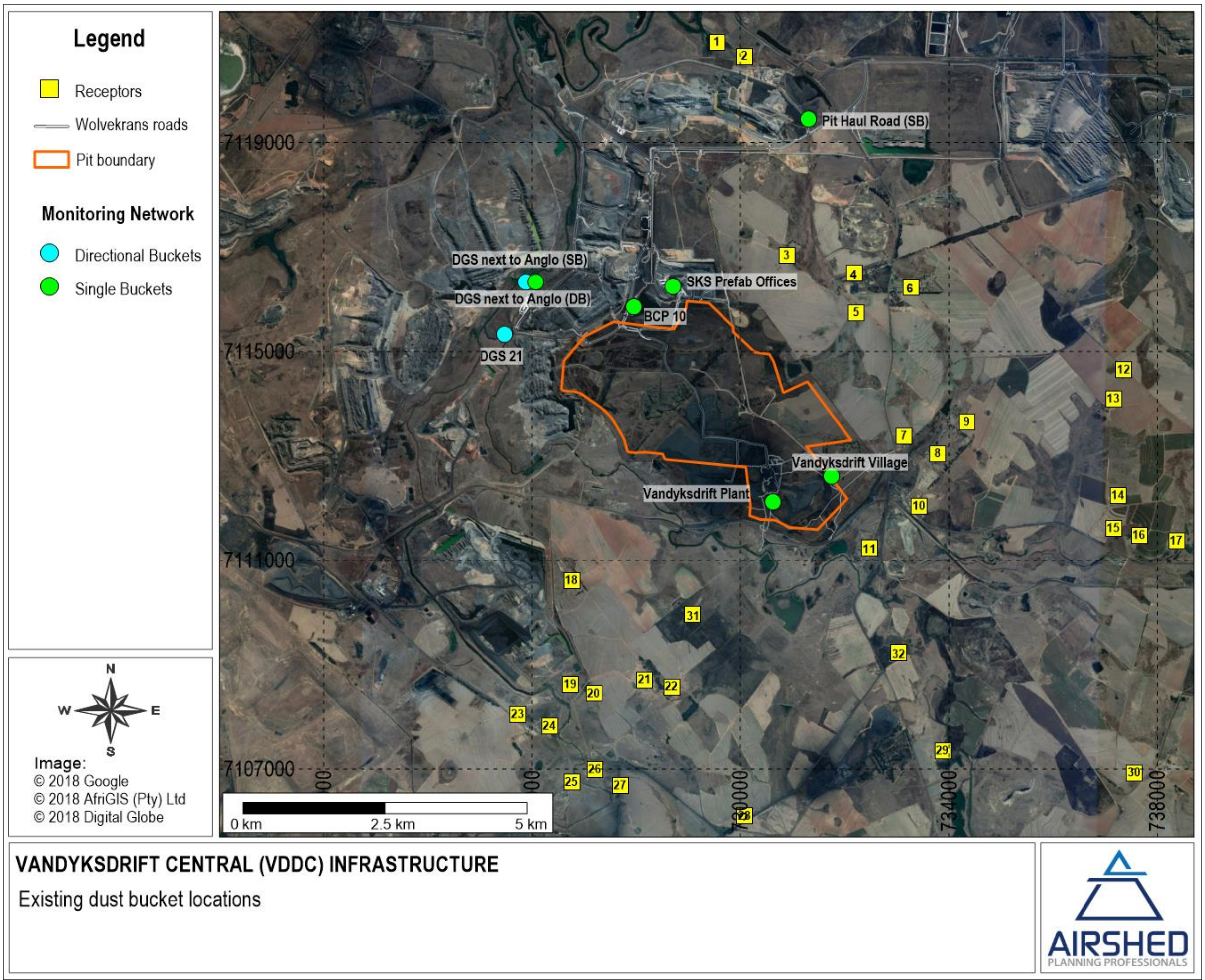
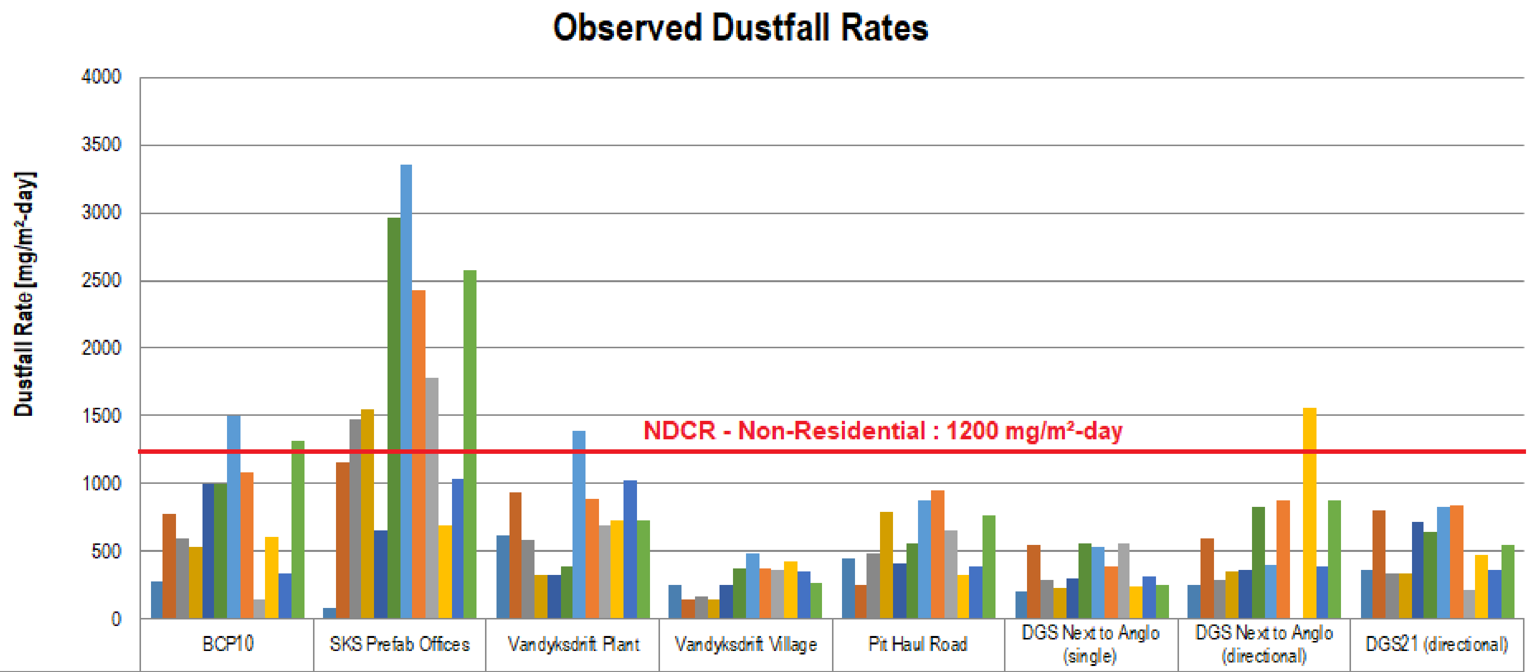


Figure 17: South32 dustfall monitoring network in the near vicinity of the Project

From Figure 18 the sampler located at the SKS Prefab Offices recorded the highest dustfall rate with an average of 1 644 mg/m²-day and exceeding the NDCR limit value on 7 months of the year. The samplers located at BCP10 and Vandyksdrift Plant each exceeded the limit for one month. Their annual averages were 762 mg/m²-day and 721 mg/m²-day, respectively. The lowest dustfall rates were recorded at Vandyksdrift Village (300 mg/m²-day), followed by DHS next to Anglo (368 mg/m²-day) and Pit Haul Road (577 mg/m²-day). Whilst not quite correct to compare with the NDCR, the directional dust buckets located at DGS21 had an average of the maximum bucket dustfall rate of 540 mg/m²-day.



	BCP10	SKS Prefab Offices	Vandyksdrift Plant	Vandyksdrift Village	Pit Haul Road	DGS Next to Anglo (single)	DGS Next to Anglo (directional)	DGS21 (directional)
Feb-Mar 2017	278	88	623	260	450	208	256	367
Mar-Apr 2017	776	1153	941	143	253	551	591	799
Apr-May 2017	591	1471	579	165	491	289	286	336
May-Jun 2017	529	1548	332	145	792	232	356	344
Jun-Jul 2017	994	654	332	255	414	304	365	721
July-Aug 2017	995	2962	386	371	554	553	829	644
Aug-Sep 2017	1495	3354	1395	480	881	531	396	828
Sep-Oct 2017	1082	2425	884	382	948	383	875	839
Dec 2017-Jan 2018	143	1782	699	368	660	558		221
Jan-Feb 2018	603	687	735	423	330	243	1560	476
Feb-Mar 2018	345	1034	1022	349	387	313	385	360
Mar-May 2018	1315	2568	728	266	762	257	873	550

Figure 18: Dustfall rates for February 2017 to May 2018 at 8 locations at and near the Project

4 Impact of Proposed Project on the Receiving Environment

4.1 Atmospheric Emissions

The main pollutant of concern associated with the proposed operations is particulate matter. Particulates are divided into different particle size categories with Total Suspended Particulates (TSP) associated with nuisance impacts (dustfall) and the finer fractions of PM_{10} and $PM_{2.5}$ linked with potential health impacts. PM_{10} is primarily associated with mechanically generated dust whereas $PM_{2.5}$ is associated with combustion sources. Gaseous pollutants (such as SO_2, NO_X, CO, etc.) derive from vehicle exhausts and other combustions sources. These are, however, insignificant in relation to the particulate emissions and will not be considered in detail in this assessment.

4.1.1 Construction Phase

Unmitigated construction activities provide the potential for impacts on local communities. On-site dustfall may also represent a nuisance to employees. The temporary nature of the construction activities, and the likelihood that these activities will be localised and for small areas at a time, will reduce the potential for significant off-site impacts. The Australian Environmental Protection Agency recommends a management zone of 300 m from the nearest sensitive receptor when materials handling activities occur (AEPA, 2007).

A list of all the potential dust generation activities expected during the construction phase is provided in Table 6. Each of the operations in Table 6 has their own duration and potential for dust generation. It is therefore often necessary to estimate area wide construction emissions, without regard to the actual plans of any individual construction process. Emissions were calculated for general infrastructure construction activities, which was assumed to include clearing of groundcover, levelling of areas, construction of on-site roads, and general infrastructure edifices, wind erosion from open areas, vehicle entrained dust and materials handling.

Table 6: Typical sources of fugitive particulate emission associated with construction

Impact	Source	Activity
Gases	Vehicle tailpipe	Transport and general construction activities
TSP, PM_{10} and $PM_{2.5}$	Open cast mining area	Clearing of groundcover
		Levelling of area
		Infrastructure edifice (on site roads, storage areas, offices, workshops)
		Wind erosion from open areas
		Materials handling
	Transport infrastructure	Clearing of vegetation and topsoil
		Levelling of proposed transportation route areas

4.1.1.1 *General Construction Activities*

The US-EPA documents emissions factors which aim to provide a general rule-of-thumb as to the magnitude of emissions which may be anticipated from construction operations. The quantity of dust emissions is assumed to be proportional to the area of land being worked and the level of construction activity. The approximate emission factors for general construction activity operations are given as:

E = 2.69 Mg/hectare/month of activity (269 g/m²/month)

The PM_{10} fraction is given as ~39% of the US-EPA total suspended particulate factor, and the $PM_{2.5}$ fraction was assumed to be half that of PM_{10}. These emission factors are most applicable to construction operations with (i) medium activity levels, (ii) moderate silt contents, and (iii) semiarid climates. The emission factor for TSP considers 42 hours of work per week of construction activity. Test data were not sufficient to derive the specific dependence of dust emissions on correction parameters. Because the above emission factor is referenced to TSP, use of this factor to estimate particulate matter (PM) no greater than 10 µm in aerodynamic diameter (PM_{10}) emissions will result in conservatively high estimates. Also, because derivation of the factor assumes that construction activity occurs 30 days per month, the above estimate is somewhat conservatively high for TSP as well.

The proposed new infrastructure at VDDC is shown in Figure 19. The project literature indicated a construction period of 30 months. The total area that needs to be cleared for infrastructure at the Project site was approximated from Google Earth and spatial .kmz files as 480 ha. A breakdown of the areas and associated emissions is shown in Table 7. An estimate of the significance ratings for the construction phase before and after mitigation is given in Table 8. The significance rating methodology is given in Appendix B.

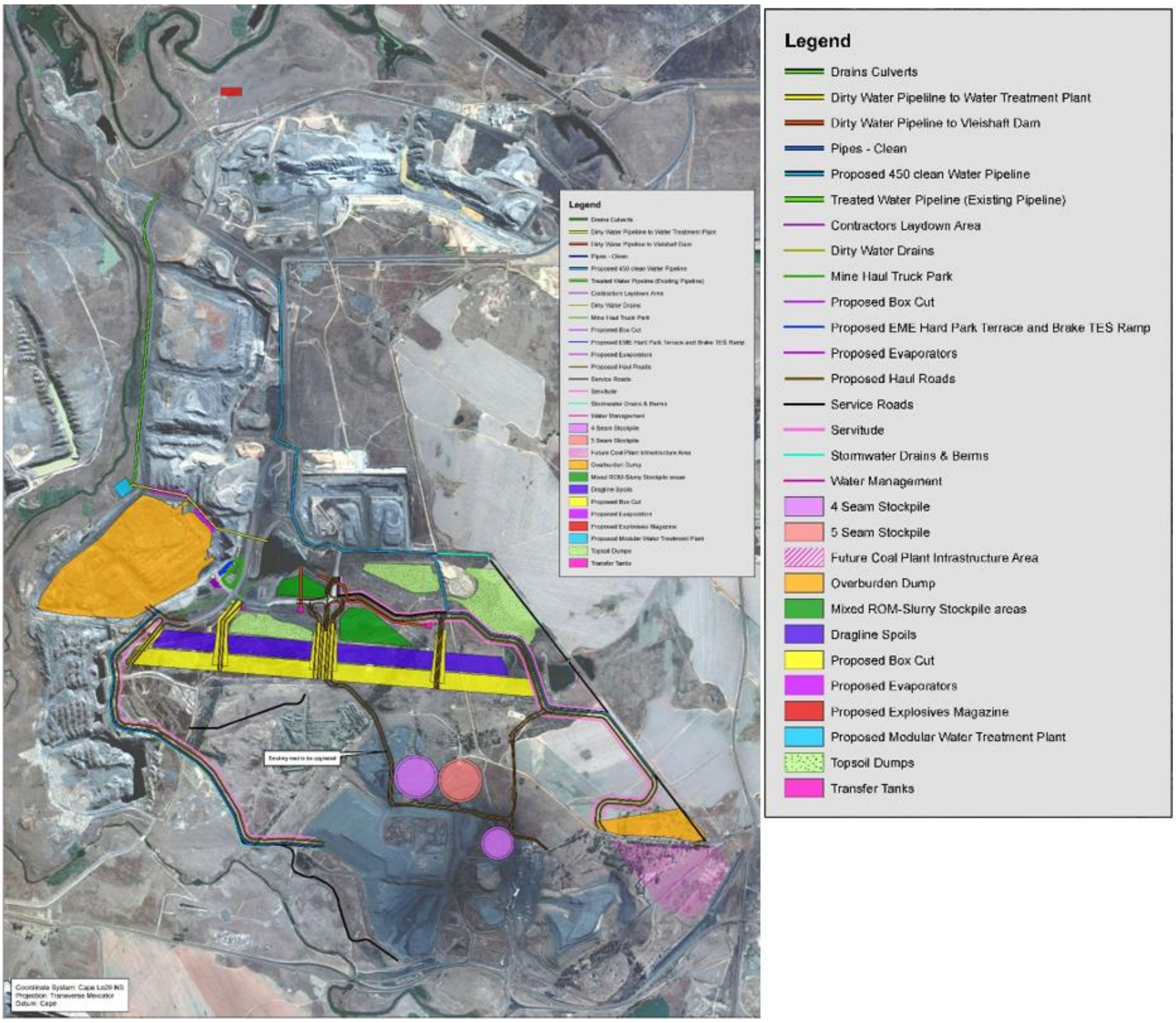


Figure 19: Proposed new infrastructure at VDDC

Table 7: Estimated particulate emissions associated with general construction activities (in tonnes per month) for the construction phase of the VDDC project

Type of Infrastructure	Area (ha)	Emissions (tonnes per 30-month period)		
		$PM_{2.5}$	PM_{10}	TSP
Hard park + mine haul truck park	4.43	2.32	4.65	11.92
Proposed explosives magazine	4.39	2.30	4.61	11.81
Proposed modular water treatment plant	3.44	1.80	3.61	9.25
Transfer tanks	0.99	0.52	1.04	2.66
New evaporators	1.72	0.90	1.80	4.63
Proposed haul roads and service roads	83.61	43.86	87.71	224.91
Proposed boxcut	93.88	49.24	98.49	252.54
Dragline spoil stockpiles	54.22	28.44	56.88	145.85
Mixed ROM coal and slurry stockpiles	25.86	13.56	27.13	69.56
4 Seam + 5 Seam stockpiles	70.84	37.16	74.32	190.56
Topsoil dumps	61.23	32.12	64.24	164.71
Overburden dump	22.48	11.79	23.58	60.47
Future coal plant infrastructure area[8]	54.07	28.36	56.72	145.45
TOTAL (tonnes per 30-month period)		**252**	**505**	**1294**
TOTAL (tonnes per month)		**8.41**	**16.83**	**43.14**

[8] Although the future coal plant is indicated on the layout, there is no detail on what this will entail.

Table 8: Impact rating matrix for the construction phase of the proposed mining and infrastructure project

Scenario	Impact description	Significance	Spatial Scale	Duration Scale	Probability	Certainty	Rating
Unmitigated [b]	Estimated non-compliance with annual PM_{10} standards	2	2	2	3	3	1.2
	Estimated impact area of non-compliance with daily PM_{10} standards	2	3	2	3	3	1.4
	Estimated non-compliance with annual $PM_{2.5}$ standards	1	2	2	3	3	1
	Estimated impact area where dustfall rates exceed 600 $mg/m^2/day$	1	1	2	3	3	0.8
Mitigated [c]	Simulated non-compliance with annual PM_{10} standards	2	2	2	3	3	1.2
	Estimated impact area of non-compliance with daily PM_{10} standards	2	2	2	3	3	1.2
	Estimated non-compliance with annual $PM_{2.5}$ standards	1	1	2	3	3	0.8
	Estimated impact area where dustfall rates exceed 600 $mg/m^2/day$	1	1	2	3	3	0.8
Residual [d]	Non-compliance with daily PM_{10} standards	3	3	2	3	3	1.6
	Non-compliance with annual $PM_{2.5}$ standards	2	3	2	3	3	1.4
	Dustfall rates exceed 600 $mg/m^2/day$	1	2	2	3	3	1

[a] Existing air quality

[b] Impact of the proposed mining and infrastructure construction phase with unmitigated emissions; excluding existing air quality

[c] Impact of the proposed mining and infrastructure construction phase with mitigated emissions; excluding existing air quality

[d] Impact of the proposed mining and infrastructure construction phase with mitigated emissions; including existing air quality

4.1.2 Operational Phase

To determine the significance of air pollution impacts from the proposed Project, three scenarios were assessed:

- **Year 2027 operations (Scenario 1)** – representative of opencast mining activities at VDDC (total opencast area) for the year 2027, with an estimated throughput of 6 784 612 tonnes of ore and 31 887 676 BCM (bank cubic metre) of overburden; total ore includes 2 507 551 tonnes Seam 4 ROM, 77 276 tonnes Seam 5 ROM, and 4 705 519 tonnes (mixed ROM and slurry);
- **Year 2034 operations (Scenario 2)** – representative of opencast mining activities at VDDC (total opencast area) in the year 2034 with an estimated throughput of 8 434 064 tonnes of ore and 34 748 344 BCM of overburden; total ore includes 3 117 178 tonnes Seam 4 ROM, 96 063 tonnes Seam 5 ROM, and 5 827 863 tonnes (mixed ROM and slurry), and
- **Year 2041 operations (Scenario 3)** – representative of opencast mining activities at VDDC (total opencast area) in the year 2041 with an estimated throughput of 8 180 757 tonnes of ore and 31 168 684 BCM of overburden; total ore includes 3 023 558 tonnes Seam 4 ROM, 93 178 tonnes Seam 5 ROM, and 5 560 182 tonnes (mixed ROM and slurry).

Tonnages of overburden were calculated by using the following bulking factors (obtained from a conceptual design for a closure plan of Wolvekrans North Section GD and GP Pits). The document is in the public domain and is available online at: http://www.jaws.co.za/uploads/PPDocs/E812_Wolvekrans%20%20DEIR/11_1_ConceptRehabGDGP.pdf.

Table 9: Bulking factors for various material layers (Marshall, 2016)

Material Layer	Bulking Factor
Topsoil	1
Softs	1.2
Overburden	1.2
4 & 2 Burden	1.2
2 Parting	1.2

By applying the bulking factors to the detailed breakdown of topsoil, hard overburden (dragline), and soft overburden (truck and shovel) in BCM as provided by the client, it was possible to calculate the annual mining rate (coal and waste material, in tons per annum) as 45 100 329 tpa, 44 068 655 tpa and 42 739 234 tpa for the years 2027, 2034 and 2041 respectively. These mining areas represent opencast mining impacts throughout the mine's lifetime, and were chosen based on similar mining rates, location (evenly distributed across the mine) and to represent the shape of the mine (see Figure 1 for locations of opencast mining areas for Years 2027, 2034 and 2041).

The emission equations used to quantify emissions from the proposed activities are shown in Table 10. The estimated emissions for the three scenarios are provided in Table 11, Table 12 and Table 13 (for opencast operations), and in Table 14, Table 15 and Table 16 (for all mining and infrastructure activities) respectively.

Table 10: Emission equations used to quantify fugitive dust emissions from the proposed Project

Activity	Emission Equation	Source	Information assumed/provided
Materials handling	$E = 0.0016 \frac{(U/_{2.2})^{1.3}}{(M/_{2})^{1.4}}$ Where, E = Emission factor (kg dust / t transferred) U = Mean wind speed (m/s) M = Material moisture content (%) The $PM_{2.5}$, PM_{10} and TSP fraction of the emission factor is 5.3%, 35% and 74% respectively. An average wind speed of 2.73 m/s was used based on data for Komati for the period 2013 – 2015.	US-EPA AP42 Section 13.2.4	The moisture content of materials are as follows: *Overburden*: 7.9% (US EPA default mean moisture content, Table 11.9-3) *ROM coal*: 2.5% (Assumed – low moisture ore) *Slurry:* 25% (Assumed) *Topsoil*: 3.4% (US EPA default mean moisture content, Table 11.9-3) Hours of operation were given as 24 hrs per day, 7 days per week
Vehicle entrainment on unpaved surfaces	$E = k \left(\frac{s}{12}\right)^{a} \left(\frac{W}{3}\right)^{b} \cdot 281.9$ Where, E = particulate emission factor in grams per vehicle km travelled (g/VKT) k = basic emission factor for particle size range and units of interest s = road surface silt content (%) W = average weight (tonnes) of the vehicles travelling the road = 178 t (coal), 212 t (overburden) and 54 t (topsoil). The particle size multiplier (k) is given as 0.15 for $PM_{2.5}$ and 1.5 for PM_{10}, and as 4.9 for TSP The empirical constant (a) is given as 0.9 for $PM_{2.5}$ and PM_{10}, and 4.9 for TSP The empirical constant (b) is given as 0.45 for $PM_{2.5}$, PM_{10} and TSP	US-EPA AP42 Section 13.2.2	In the absence of site-specific silt data, use was made of US EPA default mean silt content of 8.4%. Operational transport activities onsite include in-pit haul roads, hauling of ROM coal to the ROM stockpile or Mixed ROM coal and slurry stockpile areas, and the transport of coal offsite. Hours of operation were given as 24 hrs per day, 7 days per week The capacity of the haul trucks to be used was given as 119 t. (coal haulers), 181 t (waste haulers) and 38 t (topsoil haulers). The layout of the roads was provided. The width of the roads was given as 40 m.
Drilling	$E_{TSP} = 0.59\, kg/hole\ drilled$ $E_{PM_{10}} = 0.31\, kg/hole\ drilled$ $E_{PM_{2.5}} = 0.31\, kg/hole\ drilled$	NPI Section: Mining	Number of drill holes per day was assumed as 80 (for waste rock and for ore). Drilling areas of 2000 m² and 5000 m² were assumed for ore and waste respectively. Hours of operation were given as 24 hours per day, 7 days a week.

Activity	Emission Equation	Source	Information assumed/provided
Blasting	$$E = 0.00022 \cdot (A)^{1.5}$$ Where, E = Emission factor (kg dust / t transferred) A = Blast area (m²) The $PM_{2.5}$, PM_{10} and TSP fraction of the emission factor is 5.3%, 35% and 74% respectively.	NPI Section: Mining	The blast area was assumed as 2000 m² (for ore) and 5000 m² (for waste) respectively. The number of blasts for waste rock and ore was assumed as 3 blasts per week for ore, and 4 blasts for overburden, on alternate days.
Bulldozing	$$E = k \cdot (s)^{a}/(M)^{b}$$ Where, E = Emission factor (kg dust / hr / vehicle) s = Material silt content (%) M = Material moisture content (%)	NPI Section: Mining	The particle size multiplier (k) is given as 2.6 for TSP, and 0.34 for PM_{10} The empirical constant (a) is given as 1.2 for TSP, and 1.5 for PM_{10} The empirical constant (b) is given as 1.3 for TSP, and 1.4 for PM_{10} Fraction of $PM_{2.5}$ assumed to be 10% of PM_{10}
Draglines on overburden	$$EF = k \times \left(\frac{d^{1.1}}{M^{0.3}}\right)$$ Where, E = Emission factor (kg / bcm) d = drop height (m) M = Material moisture content (%) The particle size multiplier (k) is given as 0.0022 for PM_{10}, and as 0.0046 for TSP. Fraction of $PM_{2.5}$ assumed to be 15% of PM_{10}.	NPI Section: Mining	The activity rate was given as 2285 m³/hr. The moisture content was assumed as 7.9%. An average drop height of 16.85m was assumed. The calculated emission rate was assumed to apply over a 12-hour period per day.
Grading	$$E_{TSP} = 0.0034(S)^{2.5}\ kg/VKT$$ $$E_{PM15} = 0.0056(S)^{2.0}\ kg/VKT$$ Where, E = Emission factor (kg dust / t transferred) S = Mean vehicle speed (km/h) Fraction of PM_{10} given as 60% of PM_{15} Fraction of $PM_{2.5}$ given as 3.1% of TSP	US-EPA AP42 Section 11.9.1	The speed of the grader was assumed to be 11.4 km/hr. The grader blade width was assumed to be 4.0 m and the grader blade depth was assumed to be 0.4 m. Hours of operation were assumed as 24 hrs per day, 7 days per week.
Wind Erosion	$$E(i) = G(i)10^{(0.134(\%clay)-6)}$$ For	Marticorena & Bergametti, 1995	Wind erosion was modelled for the ROM, overburden, topsoil and discard stockpiles.

Activity	Emission Equation	Source	Information assumed/provided
	$$G(i) = 0.261\left[\frac{P_a}{g}\right]u^{*3}(1+R)(1-R^2)$$ And $$R = \frac{u_*{}^t}{u^*}$$ where, $E_{(i)}$ = emission rate (g/m²/s) for particle size class i P_a = air density (g/cm³) G = gravitational acceleration (cm/s³) $u_*{}^t$ = threshold friction velocity (m/s) for particle size i u^* = friction velocity (m/s)		The particle size distribution for the various materials was obtained from similar processes (see Table 17). The moisture contents of ROM ore, overburden and topsoil were assumed as 0.1%, 0.1% (hard overburden), 1% (soft overburden), and 0.1% respectively. The particle densities of ROM ore, soft overburden, hard overburden and topsoil were assumed as 1.6 t/m³, 2.2 t/m³, 3.8 t/m³ and 1.8 t/m³. Layout of ROM, overburden and topsoil stockpiles was provided. Hourly emission rate file was calculated and simulated.

Table 11: Calculated emission rates due to the full extent of opencast operations at VDDC (in g/s) – YEAR 2027

Activity	SC1a – Unmitigated			SC1b – Design Mitigated		
	$PM_{2.5}$ (g/s)	PM_{10} (g/s)	TSP (g/s)	$PM_{2.5}$ (g/s)	PM_{10} (g/s)	TSP (g/s)
OPENCAST AREA – YEAR 2027 (EXTRACTION OF ORE AND WASTE)						
Materials handling	0.062	0.407	0.861	0.031	0.204	0.430
Inpit road	1.156	11.562	40.562	0.289	2.891	10.141
Drilling	0.574	0.574	1.093	0.172	0.172	0.328
Dozing (inpit cleaning)	0.157	0.376	1.498	0.157	0.376	1.498
Dragline (average height = 16.85m)	0.419	2.71	17.55	0.419	2.71	17.55
Total (g/s)	**2.29**	**15.44**	**60.81**	**0.99**	**6.17**	**29.20**
Total (tpa) (including pit retention factor)	**69**	**463**	**959**	**30**	**185**	**460**
OPENCAST AREA – YEAR 2026 (ROLLOVER)						
Materials handling	0.001	0.005	0.010	0.000	0.002	0.005
Inpit road	0.040	0.402	1.411	0.010	0.101	0.353
Dozing (levelling of backfilled topsoil)	0.052	0.125	0.499	0.052	0.125	0.499

Activity	SC1a – Unmitigated			SC1b – Design Mitigated		
	$PM_{2.5}$ (g/s)	PM_{10} (g/s)	TSP (g/s)	$PM_{2.5}$ (g/s)	PM_{10} (g/s)	TSP (g/s)
Dozing (levelling of backfilled overburden)	0.105	0.251	0.999	0.105	0.251	0.999
Grading	0.009	0.081	0.275	0.004	0.040	0.138
Total (g/s)	**0.13**	**0.68**	**2.45**	**0.09**	**0.33**	**1.24**
Total (tpa) (including pit retention factor)	**4**	**20**	**39**	**3**	**10**	**20**

Table 12: Calculated emission rates due to the full extent of opencast operations at VDDC (in g/s) – YEAR 2034

Activity	SC2a – Unmitigated			SC2b – Design Mitigated		
	$PM_{2.5}$ (g/s)	PM_{10} (g/s)	TSP (g/s)	$PM_{2.5}$ (g/s)	PM_{10} (g/s)	TSP (g/s)
OPENCAST AREA – YEAR 2034 (EXTRACTION OF ORE AND WASTE)						
Materials handling	0.064	0.420	0.889	0.032	0.210	0.444
Inpit road	1.006	10.057	35.282	0.251	2.514	8.821
Drilling	0.574	0.574	1.093	0.172	0.172	0.328
Dozing (inpit cleaning)	0.157	0.376	1.498	0.157	0.376	1.498
Dragline (average height = 16.85m)	0.419	2.71	17.55	0.419	2.71	17.55
Total (g/s)	**2.14**	**13.95**	**55.56**	**0.95**	**5.80**	**27.89**
Total (tpa) (including pit retention factor)	**64**	**418**	**876**	**29**	**174**	**440**
OPENCAST AREA – YEAR 2033 (ROLLOVER)						
Materials handling	0.001	0.005	0.010	0.000	0.002	0.005
Inpit road	0.037	0.370	1.298	0.009	0.093	0.325
Dozing (levelling of backfilled topsoil)	0.052	0.125	0.499	0.052	0.125	0.499
Dozing (levelling of backfilled overburden)	0.105	0.251	0.999	0.105	0.251	0.999
Grading	0.008	0.072	0.246	0.004	0.036	0.123
Total (g/s)	**0.12**	**0.63**	**2.30**	**0.09**	**0.32**	**1.20**
Total (tpa) (including pit retention factor)	**4**	**19**	**36**	**3**	**10**	**19**

Table 13: Calculated emission rates due to the full extent of opencast operations at VDDC (in g/s) – YEAR 2041

Activity	SC3a – Unmitigated			SC3b – Design Mitigated		
	$PM_{2.5}$ (g/s)	PM_{10} (g/s)	TSP (g/s)	$PM_{2.5}$ (g/s)	PM_{10} (g/s)	TSP (g/s)
OPENCAST AREA – YEAR 2041 (EXTRACTION OF ORE AND WASTE)						
Materials handling	0.061	0.400	0.846	0.030	0.200	0.423
Inpit road	0.799	7.993	28.042	0.200	1.998	7.010
Drilling	0.574	0.574	1.093	0.172	0.172	0.328
Dozing (inpit cleaning)	0.157	0.376	1.498	0.157	0.376	1.498
Dragline (average height = 16.85m)	0.419	2.71	17.55	0.419	2.71	17.55
Total (g/s)	**1.93**	**11.87**	**48.28**	**0.90**	**5.27**	**26.06**
Total (tpa) (including pit retention factor)	**58**	**356**	**761**	**27**	**158**	**411**
OPENCAST AREA – YEAR 2040 (ROLLOVER)						
Materials handling	0.000	0.001	0.002	0.000	0.001	0.001
Inpit road	0.007	0.071	0.249	0.002	0.018	0.062
Dozing (levelling of backfilled topsoil)	0.052	0.125	0.499	0.052	0.125	0.499
Dozing (levelling of backfilled overburden)	0.105	0.251	0.999	0.105	0.251	0.999
Grading	0.009	0.086	0.294	0.005	0.043	0.147
Total (g/s)	**0.10**	**0.35**	**1.29**	**0.09**	**0.25**	**0.96**
Total (tpa) (including pit retention factor)	**3**	**10**	**20**	**3**	**7**	**15**

Table 14: Calculated emission rates due to routine operations at VDDC mining and infrastructure operations (in tpa) – YEAR 2027

Activity	SC1a – Unmitigated			SC1b – Design Mitigated		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Pre-stripping (bulldozer)	0.14	0.33	1.31	0.14	0.33	1.31
Opencast (including drilling, in-pit cleaning through dozing, draglines)	68.60	462.68	958.93	29.66	184.75	460.39

Activity	SC1a – Unmitigated			SC1b – Design Mitigated		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Rollover (including levelling of overburden and topsoil, grading)	3.84	20.25	38.56	2.80	9.93	19.63
Blasting	0.49	10.01	19.25	0.49	10.01	19.25
Materials handling	3.69	24.37	51.53	1.85	12.19	25.77
Vehicle entrainment on unpaved roads (on-site)	84.60	845.97	2967.84	21.15	211.49	741.96
Vehicle entrainment on unpaved roads (off-site)	5.19	51.90	182.07	1.30	12.97	45.52
Wind erosion	31.22	79.31	271.90	31.22	79.31	271.90
Total	**198**	**1 495**	**4 491**	**89**	**521**	**1 586**

Table 15: Calculated emission rates due to routine operations at VDDC mining and infrastructure operations (in tpa) – YEAR 2034

Activity	SC2a – Unmitigated			SC2b – Design Mitigated		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Pre-stripping (bulldozer)	0.14	0.33	1.31	0.14	0.33	1.31
Opencast (including drilling, in-pit cleaning through dozing, draglines)	64.15	417.98	876.11	28.56	173.67	439.80
Rollover (including levelling of overburden and topsoil, grading)	3.71	19.02	36.31	2.55	7.48	15.13
Blasting	0.49	10.01	19.25	0.49	10.01	19.25
Materials handling	4.19	27.66	58.48	2.09	13.83	29.24
Vehicle entrainment on unpaved roads (on-site)	119.26	1192.57	4183.79	31.96	319.60	1121.23
Vehicle entrainment on unpaved roads (off-site)	5.43	54.33	190.60	1.61	16.09	56.45
Wind erosion	41.06	101.12	335.42	41.06	101.12	335.42
Total	**248**	**1 919**	**6 038**	**108**	**642**	**2 018**

Table 16: Calculated emission rates due to routine operations at VDDC mining and infrastructure operations (in tpa) – YEAR 2041

Activity	SC3a – Unmitigated			SC3b – Design Mitigated		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Pre-stripping (bulldozer)	0.14	0.33	1.31	0.14	0.33	1.31
Opencast (including drilling, in-pit cleaning through dozing, draglines)	57.87	355.54	761.27	26.97	157.91	410.92
Rollover (including levelling of overburden and topsoil, grading)	2.85	10.38	20.42	2.55	7.48	15.13
Blasting	0.49	10.01	19.25	0.49	10.01	19.25
Materials handling	4.03	26.65	56.34	2.02	13.32	28.17
Vehicle entrainment on unpaved roads (on-site)	132.12	1321.21	4635.09	33.03	330.30	1158.77
Vehicle entrainment on unpaved roads (off-site)	6.18	61.77	216.70	1.54	15.44	54.17
Wind erosion	32.40	82.46	283.75	32.40	82.46	283.75
Total	**236**	**1 868**	**5 994**	**99**	**617**	**1 971**

Table 17: Particle size distribution of ROM, overburden and topsoil material (given as a fraction) (from similar processes)

ROM/ Overburden		Topsoil	
Size µm	Mass Fraction	Size µm	Mass Fraction
2000	0.158	2000	0.056
1000	0.211	1000	0.067
425	0.447	425	0.389
75	0.079	75	0.189
40	0.026	40	0.033
30	0.053	30	0.067
10	0.026	10	0.067
4	0	4	0.044
2	0	2	0.089

The estimated control factors for the various mining operations are given in Table 18 below[9].

Table 18: Estimated control factors for various mining operations (NPi, 2012)

Operation/Activity	Control method and emission reduction
Bulldozing	No control
Blasting	No control
Draglines	No control
Windblown dust from stockpiles	No control
Drilling	70% CE for water sprays
Unpaved haul roads	75% CE for water sprays
Materials handling (loading and unloading)	50% CE for water sprays
Grading	50% CE for water sprays

Note: CE is Control Efficiency

4.1.2.1 *Source emission ranking*

The source groups described in the above sections have been ranked based on the calculated annual emissions (Table 19). In all cases materials handling is the lowest ranked source, followed by blasting and pre-stripping. Blasting emissions are one of the lowest ranked sources, due to the non-continuous nature of the emissions. Opencast mining activities is the highest ranked source for both unmitigated and design mitigated $PM_{2.5}$ emissions, whereas unpaved haul roads (on-site) is the highest ranked source for unmitigated PM_{10} and TSP emissions. With design mitigation applied, the highest ranked source for PM_{10} and TSP is opencast activities. Opencast mining is the highest ranked source due to bulldozing and dragline activities, which make up about 85%, 75% and 83% of design mitigated $PM_{2.5}$, PM_{10} and TSP emissions respectively.

[9] Design mitigated activities include: 75% CE on unpaved haul roads; 50% CE on materials handling; 50% CE on grading activities; and 70% CE on drilling operations.

Table 19: Source group rankings for all scenarios (based on tonne per annum emissions)

Source group	Scenario 1 (2027)						Scenario 2 (2034)						Scenario 3 (2041)					
	Unmitigated Emissions			Mitigated Emissions			Unmitigated Emissions			Mitigated Emissions			Unmitigated Emissions			Mitigated Emissions		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Pre-stripping	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Opencast	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	3	2	2
Rollover	5	6	6	4	7	6	6	6	6	4	7	7	6	6	6	4	7	7
Blasting	7	7	7	7	6	7	7	7	7	7	6	6	7	7	7	7	6	6
Materials handling	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Unpaved haul roads (on-site)	1	1	1	3	1	1	1	1	1	2	1	1	1	1	1	1	1	1
Unpaved haul roads (off-site)	4	4	4	6	4	4	4	4	4	6	4	4	4	4	4	6	4	4
Wind erosion	3	3	3	1	3	3	3	3	3	1	3	3	3	3	3	2	3	3

4.1.3 Closure Phase

It is assumed that all the operations will have ceased by the closure phase of the project. Aspects and activities associated with the closure phase of the proposed operations are listed in Table 20. Simulations of the closure phase were not included in the current study due to its temporary impacting nature. The significance ratings, before and after mitigation, are likely to be similar to those listed for the construction phase (Table 8).

Table 20: Activities and aspects identified for the closure phase

Impact	Source	Activity
Generation of TSP, PM_{10}, and $PM_{2.5}$	Opencast area	Backfilling of final void
	Infrastructure edifice	Removal of any infrastructure (e.g. buildings) at the proposed project site
	Unpaved roads	Vehicle entrainment on unpaved road surfaces
Gas emissions	Vehicles	Tailpipe emissions from vehicles utilised during the closure phase.

4.1.4 Atmospheric Emissions due to Changes in Opencast Mining

In order to calculate emissions due to opencast mining of the extended pit area (opencast areas not previously authorised) (shown in Figure 2) it was necessary to determine the area of each mining strip that falls within the extended pit footprint (see mining schedule corresponding to extended pit area in Figure 3). The area (in m^2) was expressed as a fraction of the total area of the mining strip for a specific year, and multiplied with the number of days in a year (viz. 365) to estimate the number of days of operation for that portion of mining strip (see Table 21). The annual material throughputs for each mining strip (expressed in tonnes per day) were then multiplied with the estimated number of days of operation to determine the tonnes of materials mined per portion.

The calculated emission rates for unmitigated and mitigated operations during the period 2030-2037 are shown in Table 22 and Table 23 respectively, whereas the calculated emission rates for unmitigated and mitigated operations during the period 2038-2043 are shown in Table 24 and Table 25 respectively[10].

Table 21: Estimated material throughputs (in tonnes) for extended opencast pit as per mining schedule

Year	Area (m^2)	Fraction of total area	Estimated number of days of operation	ROM+Slurry (tonnes)	Dragline (tonnes)	Truck & Shovel (tonnes)	Topsoil (tonnes)
2030	6 627	0.012	5	93 942	179 091	362 409	7 276
2031	9 425	0.018	7	181 469	374 157	510 252	8 622
2032	31 157	0.059	22	622 814	1 225 144	1 716 813	41 072
2033	15 957	0.040	15	415 780	816 661	580 110	21 772
2034	7 218	0.020	8	180 378	410 099	292 733	8 110
2037	8 511	0.013	5	104 809	257 463	184 274	6 160
2038	62 441	0.066	24	485 127	1 331 140	937 466	27 041
2039	124 218	0.148	54	1 108 043	3 051 542	2 165 417	84 759
2040	222 227	0.335	123	3 047 088	6 689 066	4 960 432	146 800
2041	249 013	0.430	157	3 727 162	8 422 569	6 246 705	175 290
2042	337 131	0.461	168	2 623 535	7 410 060	6 359 901	155 376
2043	682 706	1.000	365	5 713 338	3 091 975	13 893 192	348 805

[10] To determine the significance of air pollution impacts from the changes in opencast mining, Year 2043 operations (i.e. a full year of operations with highest material throughputs) were assessed using dispersion modelling (Scenario 4).

Table 22: Calculated emission rates due to unmitigated routine operations at extended opencast pit (in tpa) – YEARS 2030 – 2037

	2030			2031			2032			2033			2034			2037		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Pre-stripping	0.00	0.00	0.02	0.00	0.01	0.03	0.01	0.02	0.08	0.01	0.01	0.05	0.00	0.01	0.03	0.00	0.00	0.02
Opencast	1.09	9.36	22.89	1.98	13.91	33.51	6.47	46.23	109.90	3.71	24.62	62.29	1.88	12.17	31.47	1.17	7.52	19.52
Rollover	0.07	0.38	1.29	0.09	0.51	0.90	0.33	2.04	3.59	0.21	1.21	2.12	0.10	0.52	0.92	0.06	0.35	0.63
Blasting	0.01	0.14	0.26	0.01	0.19	0.37	0.03	0.60	1.16	0.02	0.41	0.79	0.01	0.22	0.42	0.01	0.14	0.26
Unpaved haul road	0.13	1.28	4.49	0.25	2.47	8.68	0.85	8.49	29.79	0.57	5.67	19.89	0.25	2.46	8.63	0.14	1.43	5.01
TOTAL	**1**	**11**	**29**	**2**	**17**	**43**	**8**	**57**	**145**	**5**	**32**	**85**	**2**	**15**	**41**	**1**	**9**	**25**

Table 23: Calculated emission rates due to mitigated routine operations at extended opencast pit (in tpa) – YEARS 2030 – 2037

	2030			2031			2032			2033			2034			2037		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Pre-stripping	0.00	0.00	0.02	0.00	0.01	0.03	0.01	0.02	0.08	0.01	0.01	0.05	0.00	0.01	0.03	0.00	0.00	0.02
Opencast	0.66	5.06	15.02	1.31	7.30	21.41	4.18	23.59	68.47	2.67	14.32	43.48	1.40	7.39	22.74	0.87	4.59	14.17
Rollover	0.04	0.18	0.33	0.06	0.25	0.45	0.21	0.90	1.62	0.14	0.57	1.02	0.07	0.27	0.49	0.04	0.17	0.32
Blasting	0.01	0.14	0.26	0.01	0.19	0.37	0.03	0.60	1.16	0.02	0.41	0.79	0.01	0.22	0.42	0.01	0.14	0.26
Unpaved haul road	0.03	0.32	1.12	0.06	0.62	2.17	0.21	2.12	7.45	0.14	1.42	4.97	0.06	0.61	2.16	0.04	0.36	1.25
TOTAL	**1**	**6**	**17**	**1**	**8**	**24**	**5**	**27**	**79**	**3**	**17**	**50**	**2**	8	**26**	**1**	**5**	**16**

Table 24: Calculated emission rates due to unmitigated routine operations at extended opencast pit (in tpa) – YEARS 2038 – 2043

	2038			2039			2040			2041			2042			2043		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Pre-stripping	0.01	0.02	0.09	0.02	0.05	0.19	0.05	0.11	0.44	0.06	0.14	0.56	0.06	0.15	0.60	0.14	0.33	1.31
Opencast	5.62	36.32	94.12	12.81	83.30	214.66	29.96	197.30	502.54	37.84	247.88	634.29	37.72	238.29	630.05	82.08	519.10	1371
Rollover	0.29	1.62	2.88	0.73	4.32	7.72	1.58	8.82	15.50	1.97	10.84	19.06	1.90	9.95	17.90	4.17	21.94	39.49
Blasting	0.04	0.66	1.27	0.09	1.48	2.86	0.20	3.38	6.50	0.25	4.32	8.30	0.27	4.62	8.88	0.58	10.04	19.30
Unpaved haul road	0.66	6.61	23.20	1.51	15.11	53.00	4.15	41.54	145.75	5.08	50.82	178.28	3.58	35.77	125.49	7.79	77.90	273.3
TOTAL	**7**	**45**	**122**	**15**	**104**	**278**	**36**	**251**	**671**	**45**	**314**	**840**	**44**	**289**	**783**	**95**	**629**	**1 705**

Table 25: Calculated emission rates due to mitigated routine operations at extended opencast pit (in tpa) – YEARS 2038 – 2043

	2038			2039			2040			2041			2042			2043		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Pre-stripping	0.01	0.02	0.09	0.02	0.05	0.19	0.05	0.11	0.44	0.06	0.14	0.56	0.06	0.15	0.60	0.14	0.33	1.31
Opencast	4.18	22.10	68.13	9.45	50.14	154.03	21.74	116.22	354.40	27.65	147.31	450.52	28.83	150.52	469.50	62.68	327.38	1021
Rollover	0.21	0.80	1.47	0.48	1.98	3.63	1.08	4.33	7.83	1.37	5.40	9.79	1.38	5.18	9.65	3.02	11.34	21.12
Blasting	0.04	0.66	1.27	0.09	1.48	2.86	0.20	3.38	6.50	0.25	4.32	8.30	0.27	4.62	8.88	0.58	10.04	19.30
Unpaved haul road	0.17	1.65	5.80	0.38	3.78	13.25	1.04	10.39	36.44	1.27	12.70	44.57	0.89	8.94	31.37	1.95	19.47	68.32
TOTAL	**5**	**25**	**77**	**10**	**57**	**174**	**24**	**134**	**406**	**31**	**170**	**514**	**31**	**169**	**520**	**68**	**369**	**1 131**

4.2 Screening of Simulated Human Health Impacts

4.2.1 *Design Mitigated Emission Scenario - Impact on PM_{10} and $PM_{2.5}$*

The dispersion modelling included the assessment of impacts as a result of emissions from a scenario where particulate emissions will be controlled. Mitigation activities will apply to unpaved roads, materials handling, grading and drilling through the use of water sprays. The control efficiencies for watering were assumed to be 75% for unpaved roads, 50% for materials handling and grading, and 70% for drilling (NPi, 2012).

4.2.1.1 *Operational Phase*

PM_{10} emissions from the unpaved on-site haul roads were the largest source for both unmitigated and mitigated Scenario 1, 2 and 3 activities (Table 19). Simulated areas of exceedance show non-compliance with the daily PM_{10} NAAQS within 6 km of the mining operations, as well as non-compliance with the annual PM_{10} NAAQS within 5 km of the mining operations (Figure 20)[11]. Simulated PM_{10} concentrations were in non-compliance with the daily NAAQS (i.e. more than 4 days exceeding the daily limit concentration of 75 µg/m^3) at 2 of the 32 receptors for Year 2027, 6 of 32 receptors for Year 2034 and 7 of 32 receptors for Year 2041 (Table 26). Simulated annual average PM_{10} concentrations were within the NAAQS at all receptors and for all scenarios[12].

Simulated $PM_{2.5}$ concentrations under design mitigation complied with the current daily NAAQS applicable 1 January 2016 to 31 December 2029 (i.e. fewer than 4 days exceeding the daily limit concentration of 40 µg/m^3) (Figure 22), as well as the future daily NAAQS applicable from 1 January 2030 (Figure 23). Simulated annual average concentrations were below the NAAQS at all receptors and for all scenarios (Figure 22 and Figure 23).

4.2.1.2 *Extended Opencast Pit*

PM_{10} emissions from the opencast pit was the largest source for both unmitigated and design mitigated activities for Scenario 4 (i.e. Year 43 operations) (Table 24 and Table 25). Simulated areas of exceedance show non-compliance with the daily PM_{10} NAAQS within 3.2 km of the mining operations, as well as non-compliance with the annual PM_{10} NAAQS within 1.2 km of the mining operations (Figure 21). Simulated PM_{10} concentrations were in non-compliance with the daily NAAQS (i.e. fewer than 4 days exceeding the daily limit concentration of 75 µg/m^3) at 1 of the 32 receptors (Table 27). Simulated annual average PM_{10} concentrations were within the NAAQS at all receptors.

For simulated $PM_{2.5}$ concentrations under design mitigation the area of non-compliance with the future daily NAAQS extends to within 1.6 km of the mining operations. Simulated $PM_{2.5}$ concentrations complied with the current daily NAAQS as well as

[11] Note on isopleth contours, where standards are exceeded:
The areas of exceedance are not only limited to concentration (i.e. 40 or 75 µg/m^3) but are linked to a timeframe and the average expected concentration over that period.

For example, in terms of the NAAQS, the allowable PM_{10} concentrations are:

- 75 µg/m^3 per day (24hr) – you are allowed 4 daily exceedances of this per year
- 40 µg/m^3 per annum – no exceedance allowed.

The isopleths therefore indicate the areas where:

- The daily average concentrations exceed the allowable concentration (75 µg/m^3) more than 4 times per year
- The annual average concentrations exceed the allowable concentration (40 µg/m^3).

[12] Why the footprint area of daily exceedances is larger than the area of annual exceedances:
The annual average, i.e. the average of all simulated PM_{10} concentrations over one year, is intuitively lower than the highest daily averages (simulated under poor air dispersal conditions). For example, there may be 5 days per year when the PM_{10} concentrations simulated for areas relatively close to emission sources, such as opencast mining areas, exceed 75 µg/m³. But the annual average for that same area may be lower than 40 µg/m³.

the future daily NAAQS at all receptors (Figure 24 and Figure 25). Simulated annual average $PM_{2.5}$ concentrations were in non-compliance for a distance up to 350 m from the mining boundary but were below the NAAQS at all receptors.

Table 26: Simulated PM_{10} NAAQS compliance at sensitive receptors due to the operational phase, for the design mitigated scenario, where bold text indicates non-compliance

Receptor	Design mitigated scenario					
	Scenario 1 (2027)		Scenario 2 (2034)		Scenario 3 (2041)	
	Daily PM_{10} frequency of exceedance	Annual average PM_{10}	Daily PM_{10} frequency of exceedance	Annual average PM_{10}	Daily PM_{10} frequency of exceedance	Annual average PM_{10}
SR1	**14**	14.8	**20**	18.7	**22**	18.7
SR2	**14**	18.4	**29**	23.0	**29**	23.0
SR3	<4	22.1	**22**	28.8	**23**	28.8
SR4	<4	13.3	**5**	17.2	**5**	17.3
SR5	<4	12.7	**6**	16.6	**7**	16.7
SR6	<4	8.2	<4	10.8	<4	11.0
SR7	<4	7.1	**7**	10.3	<4	10.8
SR8	<4	5.8	<4	8.2	<4	8.5
SR9	<4	5.1	<4	7.2	<4	7.2
SR10	<4	5.9	<4	8.3	<4	8.9
SR11	<4	8.4	<4	12.4	**6**	13.6
SR12	<4	2.4	<4	3.2	<4	3.1
SR13	<4	2.4	<4	3.4	<4	3.4
SR14	<4	2.2	<4	3.1	<4	3.0
SR15	<4	2.2	<4	3.0	<4	3.1
SR16	<4	2.0	<4	2.7	<4	2.8
SR17	<4	1.8	<4	2.4	<4	2.4
SR18	<4	19.4	**41**	28.7	**9**	22.8
SR19	<4	11.4	<4	17.2	<4	15.0
SR20	<4	10.1	<4	16.0	<4	14.3
SR21	<4	7.7	<4	11.6	<4	11.5
SR22	<4	6.6	<4	9.6	<4	10.3
SR23	<4	10.9	<4	15.3	<4	13.6
SR24	<4	9.9	<4	14.4	<4	13.0
SR25	<4	7.4	<4	11.2	<4	10.5
SR26	<4	6.9	<4	10.8	<4	10.1
SR27	<4	5.1	<4	7.9	<4	7.6
SR28	<4	3.3	<4	4.6	<4	4.8
SR29	<4	4.1	<4	5.8	<4	5.9

SR30	<4	2.0	<4	2.7	<4	2.7
SR31	<4	10.9	<4	16.8	<4	18.0
SR32	<4	5.8	<4	8.3	<4	8.9

Table 27: Simulated PM_{10} NAAQS compliance at sensitive receptors due to the extended opencast pit, for the design mitigated scenario, where bold text indicates non-compliance

Receptor	Design mitigated scenario	
	Scenario 4 (2043)	
	Daily PM_{10} frequency of exceedance	Annual average PM_{10}
SR1	<4	0.8
SR2	<4	0.9
SR3	<4	2.3
SR4	<4	2.3
SR5	<4	2.9
SR6	<4	2.0
SR7	<4	3.8
SR8	<4	3.2
SR9	<4	2.1
SR10	<4	4.0
SR11	<4	7.8
SR12	<4	0.8
SR13	<4	0.9
SR14	<4	1.0
SR15	<4	0.8
SR16	<4	0.7
SR17	<4	0.6
SR18	<4	3.4
SR19	<4	4.8
SR20	<4	6.4
SR21	<4	10.0
SR22	<4	11.0
SR23	<4	3.2
SR24	<4	4.5
SR25	<4	5.0
SR26	<4	5.6
SR27	<4	5.4
SR28	<4	2.8

SR29	<4	2.6
SR30	<4	0.8
SR31	**24**	19.8
SR32	<4	4.8

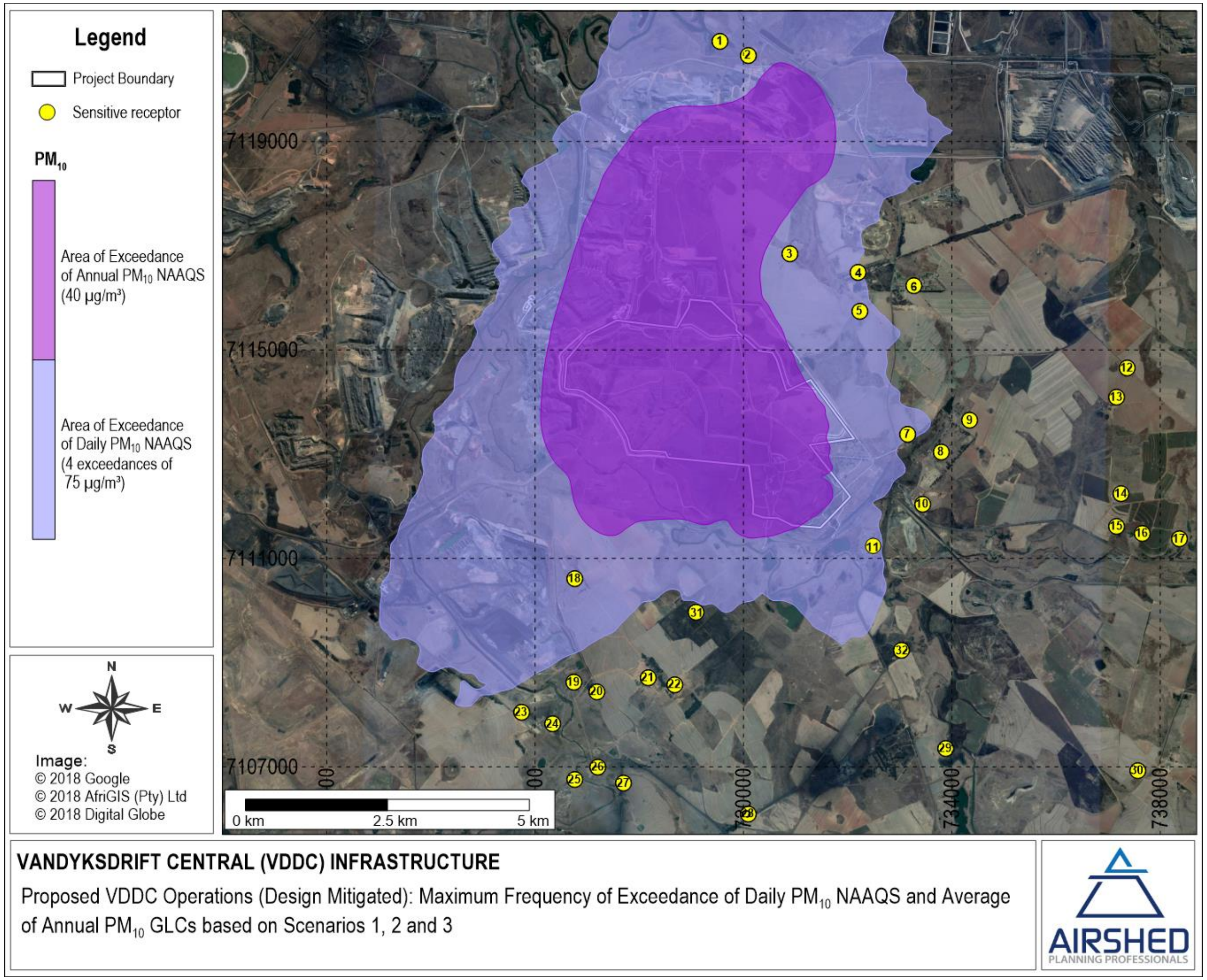


Figure 20: Simulated PM_{10} impacts as a result of the <u>mining + infrastructure operations</u> at the VDDC Project – design mitigated scenario, indicating areas of non-compliance with the daily and annual NAAQS

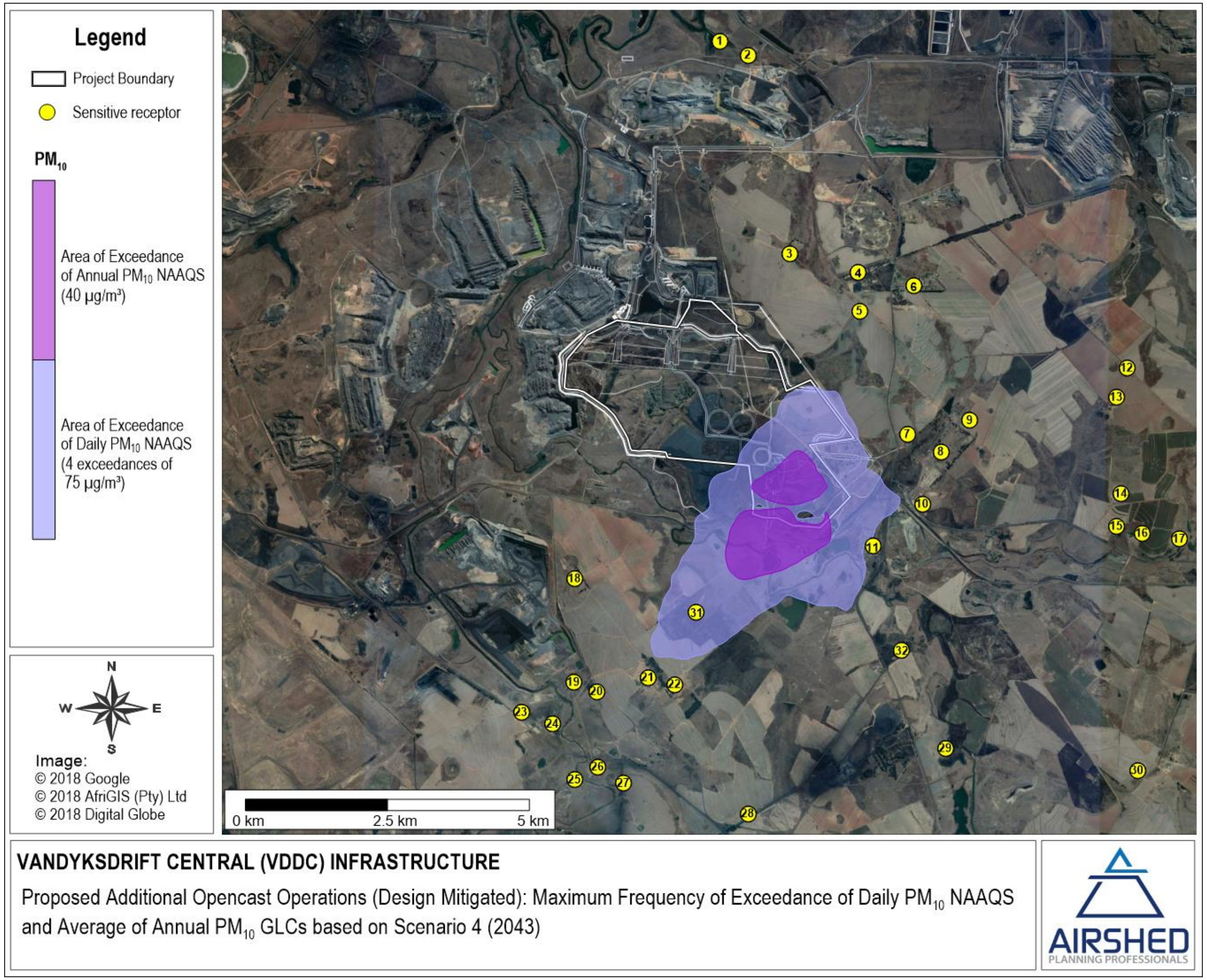


Figure 21: Simulated PM_{10} impacts as a result of the extended opencast pit at the VDDC Project – design mitigated scenario, indicating areas of non-compliance with the daily and annual NAAQS

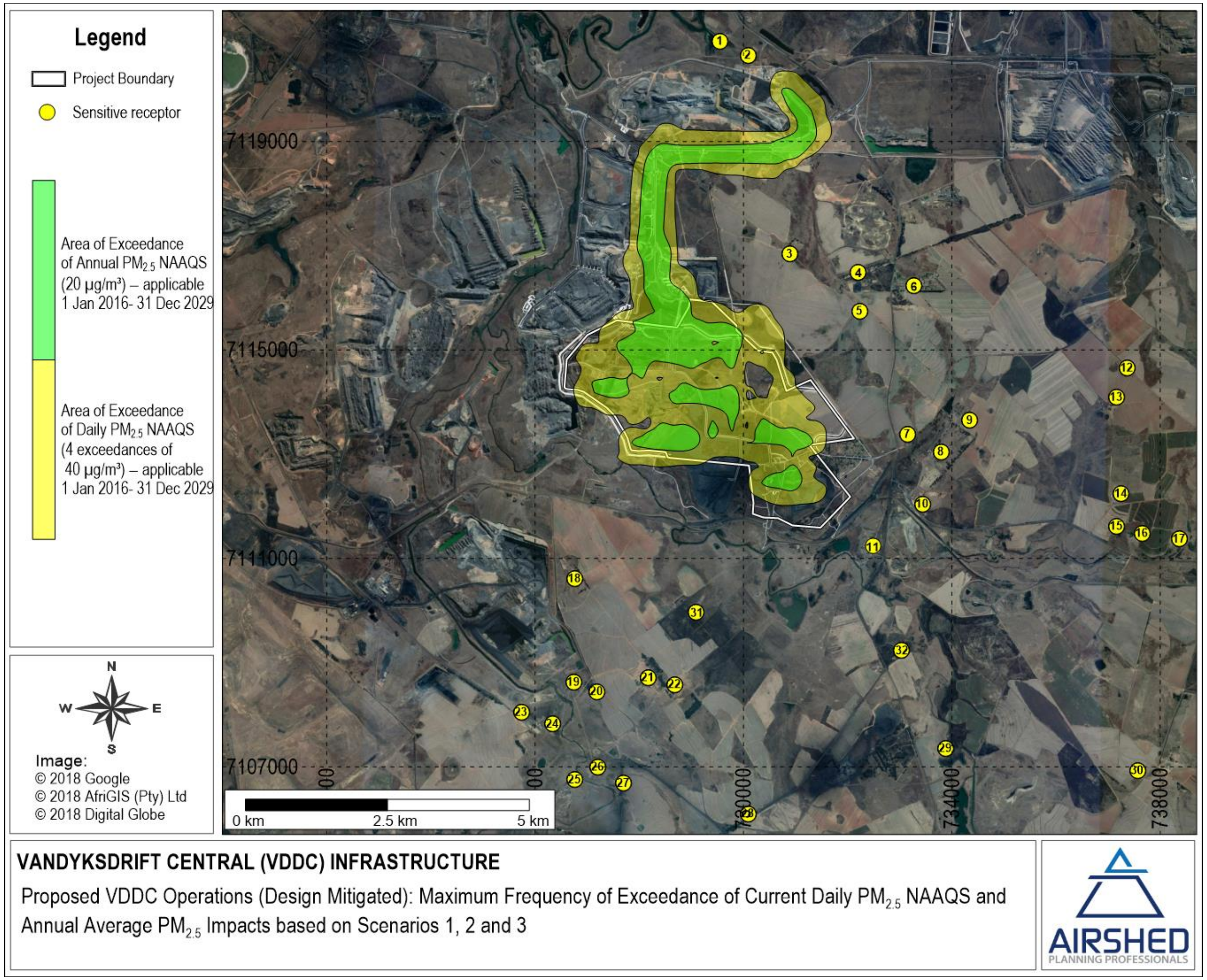


Figure 22: Simulated $PM_{2.5}$ impacts as a result of the mining + infrastructure operations at the VDDC Project – design mitigated scenario, indicating areas of non-compliance with the daily and annual NAAQS (applicable between 1 January 2016 and 31 December 2029)

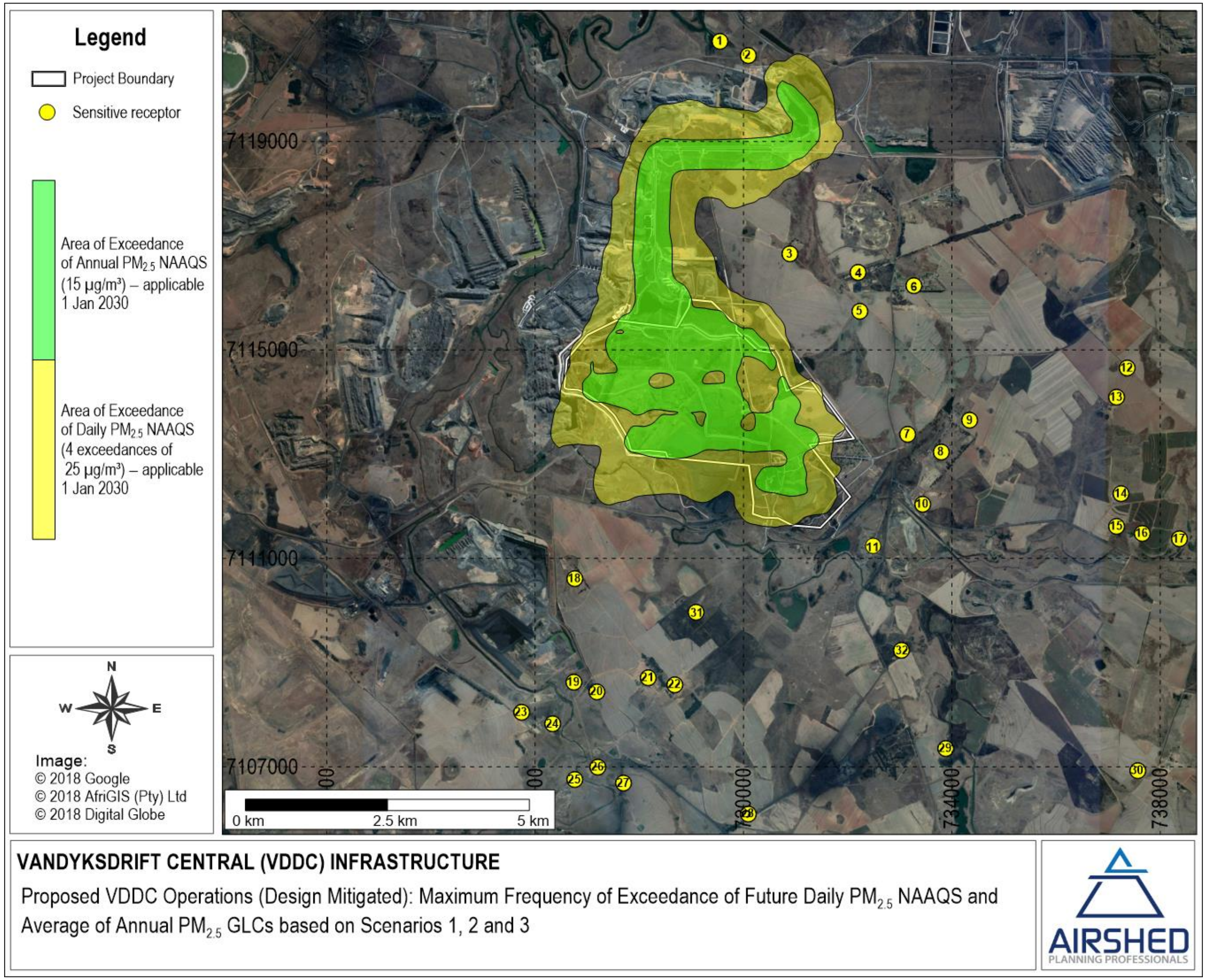


Figure 23: Simulated $PM_{2.5}$ impacts as a result of the mining + infrastructure operations at the VDDC Project – design mitigated scenario, indicating areas of non-compliance with the daily and annual NAAQS (applicable from 1 January 2030)

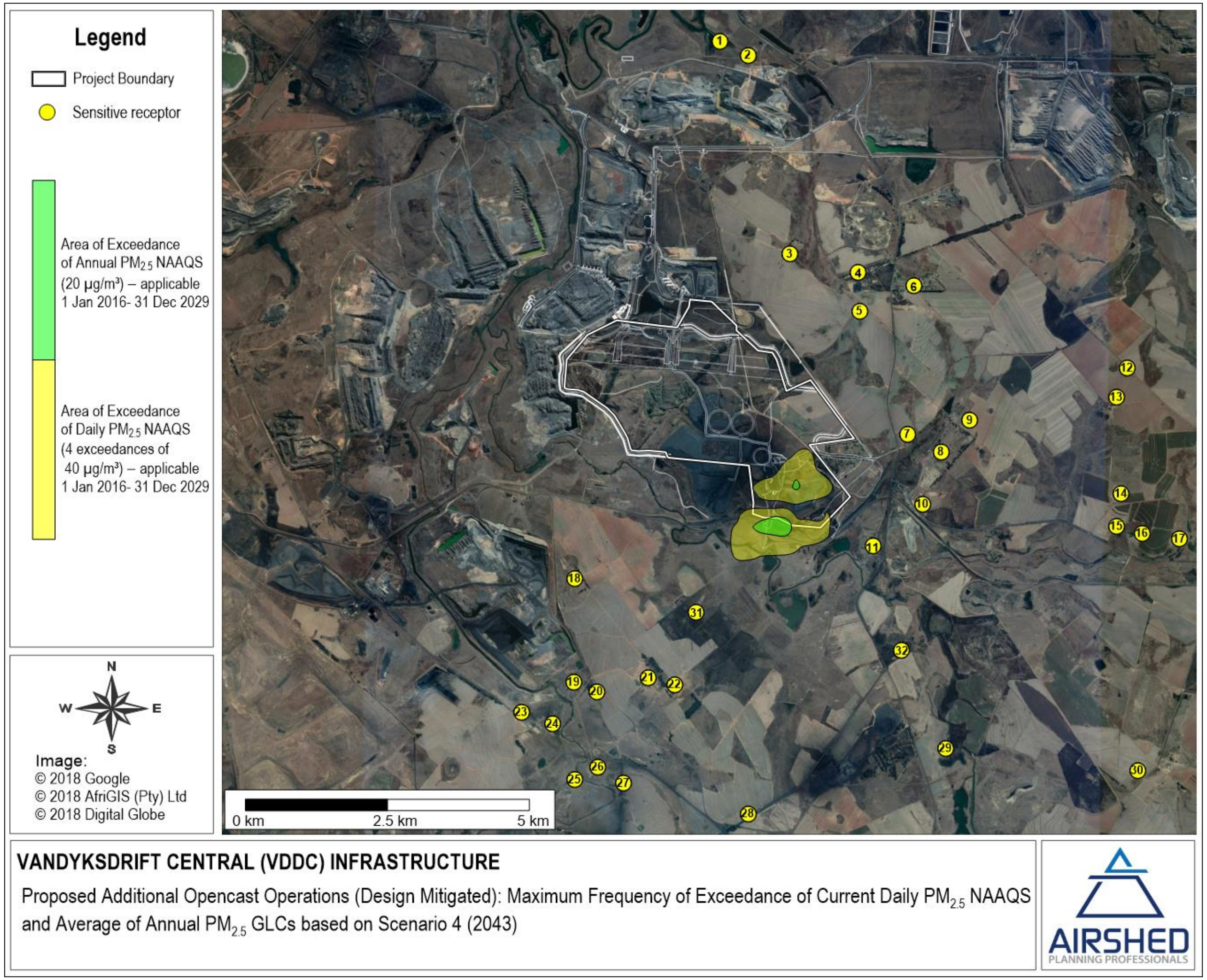


Figure 24: Simulated $PM_{2.5}$ impacts as a result of the extended opencast pit at the VDDC Project – design mitigated scenario, indicating areas of non-compliance with the daily and annual NAAQS (applicable between 1 January 2016 and 31 December 2029)

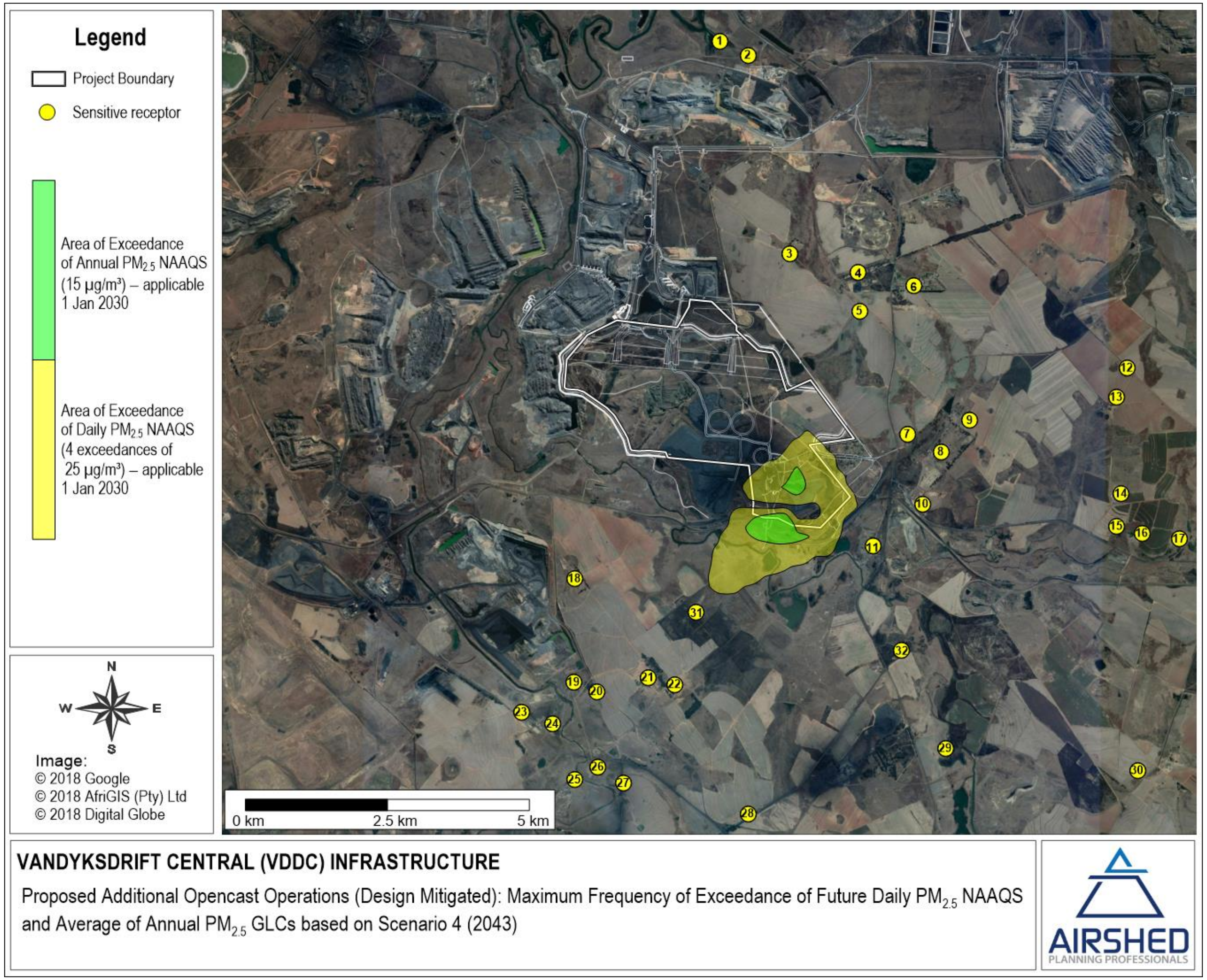


Figure 25: Simulated $PM_{2.5}$ impacts as a result of the extended opencast pit at the VDDC Project – design mitigated scenario, indicating areas of non-compliance with the daily and annual NAAQS (applicable from 1 January 2030)

4.3 Analysis of Emissions' Impact on the Environment (Dustfall)

4.3.1 Design Mitigated Scenario - Simulated Dustfall Rate

4.3.1.1 *Operational Phase*

Isopleth plots showing the areas of exceedance of the residential limit due to design mitigated dustfall rates are shown in Figure 26. The areas of exceedance are limited to the project boundary and within 250 m of off-site roads. The simulated maximum daily dustfall rates due to Scenarios 1, 2 and 3 are well within the NDCR for residential areas at all AQSRs (Table 28).

Table 28: Simulated daily dustfall rates due to the operational phase, at receptors located close the proposed boundary of the proposed project

Receptor [a]	Design mitigated scenario (mg/m^2.day)		
	Scenario 1 (2027)	Scenario 2 (2034)	Scenario 3 (2041)
SR1	9.1	11.4	10.8
SR2	15.3	19.5	17.6
SR3	18.2	22.2	22.1
SR4	11.4	14.0	13.6
SR5	12.0	14.5	14.2
SR6	7.9	9.6	9.3
SR7	9.5	14.7	10.3
SR8	7.4	11.2	7.9
SR9	7.2	9.1	6.8
SR10	11.2	13.5	11.2
SR11	9.3	12.0	18.1
SR12	3.6	4.4	4.0
SR13	3.7	4.8	4.1
SR14	2.6	3.7	3.1
SR15	2.5	3.1	2.9
SR16	2.3	2.8	2.6
SR17	2.0	2.4	2.3
SR18	16.5	19.8	12.3
SR19	7.4	9.5	8.8
SR20	7.3	9.9	8.2
SR21	9.2	10.5	7.6
SR22	10.0	11.3	7.6
SR23	6.3	7.8	6.8
SR24	6.1	7.6	6.5
SR25	4.9	6.3	5.3
SR26	5.4	6.9	5.9

Receptor [a]	Design mitigated scenario (mg/m^2.day)		
	Scenario 1 (2027)	Scenario 2 (2034)	Scenario 3 (2041)
SR27	5.5	6.5	5.2
SR28	2.5	3.1	4.9
SR29	3.6	4.4	4.6
SR30	1.7	2.1	1.9
SR31	16.6	19.4	15.6
SR32	5.3	6.6	7.7

4.3.1.2 *Extended Opencast Pit*

Dustfall rates for design mitigated activities were not plotted as no exceedances of the NDCR for residential areas were simulated. The simulated maximum daily dustfall rates due to Scenario 4 (2043) are well within the NDCR for residential areas at all AQSRs (Table 29).

Table 29: Simulated daily dustfall rates due to the extended opencast pit, at receptors located close the proposed boundary of the proposed project

Receptor [a]	Design mitigated scenario (mg/m^2.day)
	Scenario 4 (2043)
SR1	0.2
SR2	0.3
SR3	0.9
SR4	1.1
SR5	1.5
SR6	0.9
SR7	3.8
SR8	3.4
SR9	2.1
SR10	9.1
SR11	15.1
SR12	0.8
SR13	0.9
SR14	1.7
SR15	1.7
SR16	1.6
SR17	1.4
SR18	5.6
SR19	2.9
SR20	3.4
SR21	4.6

Receptor [a]	Design mitigated scenario (mg/m^2.day)
	Scenario 4 (2043)
SR22	5.8
SR23	1.8
SR24	2.3
SR25	1.9
SR26	2.4
SR27	2.7
SR28	1.7
SR29	1.8
SR30	1.0
SR31	11.0
SR32	3.7

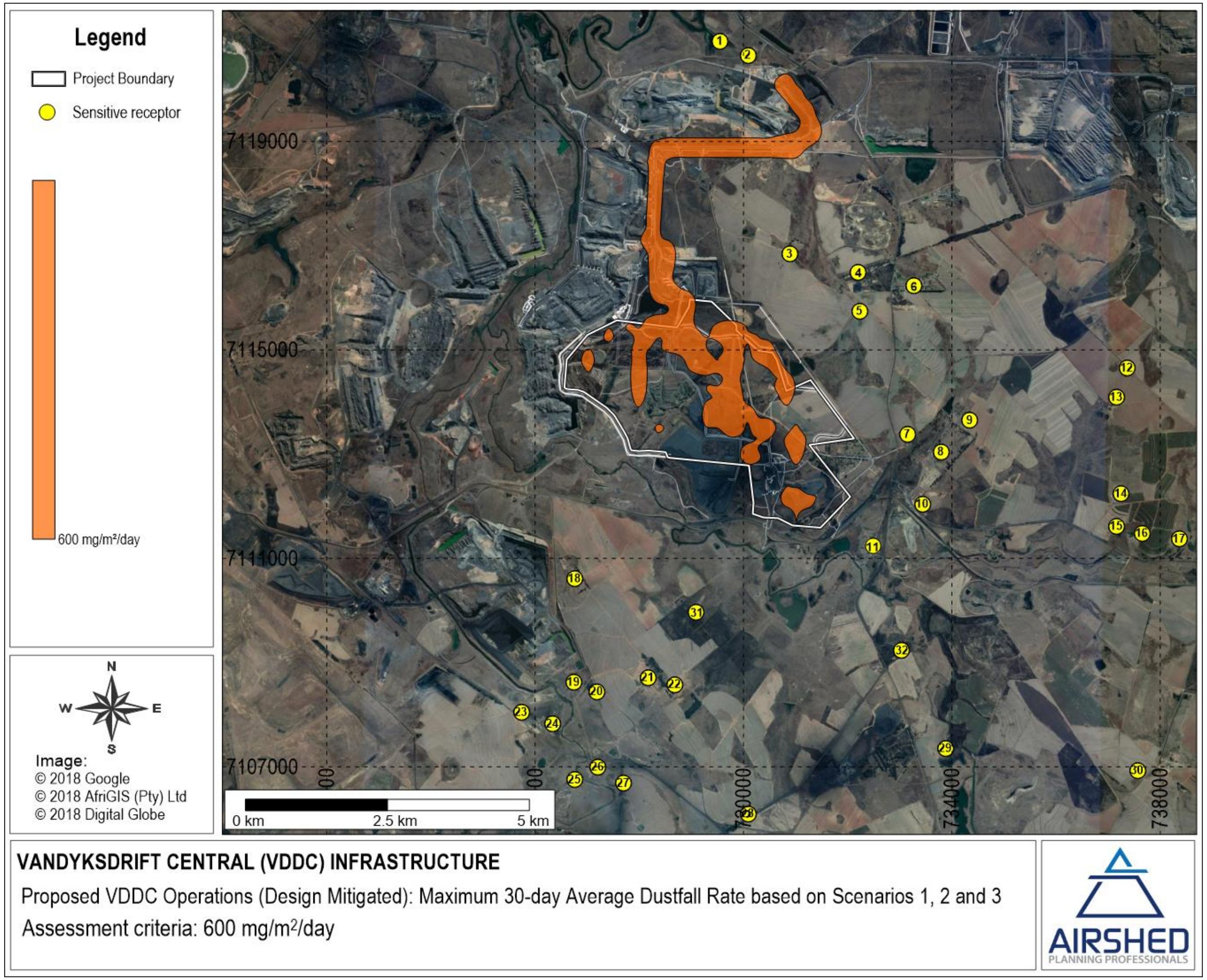


Figure 26: Simulated dustfall rates as a result of the mining + infrastructure operations at the VDDC Project – design mitigated scenario

4.4 Ranking of Sources

The ranking of sources serves to confirm the current understanding of the significance of specific sources, and to evaluate the emission reduction potentials required for each. Source ranking can be established on:

- Emissions ranking[13]; based on the comprehensive emissions inventory established for the operations (Section 4.1); and
- Impacts ranking; based on the simulated pollutant ground level concentrations (GLCs).

The emissions for the three scenarios are very similar (Section 4.1.2 and Table 18). The source rankings presented here are based on emissions and impacts for Scenario 2 (2034), since it has the largest ROM tonnage of the three scenarios. The main source of emissions for design mitigated $PM_{2.5}$ is wind erosion (38%) followed by onsite unpaved roads (29%). The main sources of emissions for design mitigated PM_{10} and TSP are onsite unpaved roads (51% and 56% respectively) followed by in-pit operations (27% and 23% respectively).

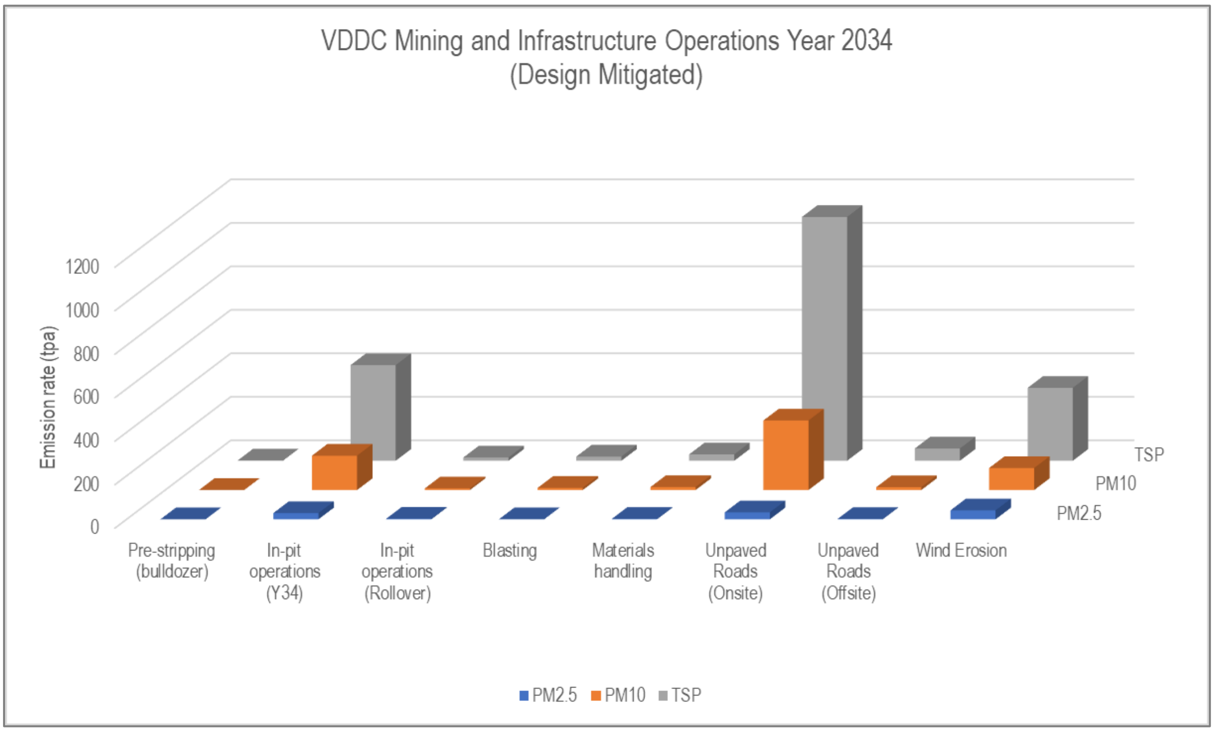


Figure 27: Source rankings for $PM_{2.5}$, PM_{10} and TSP emissions due to design mitigated mining and infrastructure operations for Scenario 2 (2034)

Ranking of sources based on simulated impacts at the 5 receptors closest to the mine, viz. SR3 and SR5 (to the northeast), SR7 (to the east), SR11 (to the southeast) and SR18 (to the south) (see Figure 1), are as follows:

- **$PM_{2.5}$**: From Figure 28 the main source of cumulative $PM_{2.5}$ impacts due to mining and infrastructure operations is unpaved offsite roads (at SR3), unpaved on-site roads (at SR5) and opencast activities (at SR7, SR11 and SR18). Incremental VDDC infrastructure operations comprise mainly of materials handling at stockpiles, windblown dust from stockpiles and unpaved on-site roads. The combined contribution from VDDC infrastructure operations to total $PM_{2.5}$ impacts at the nearest receptors range between 27% and 35%.

[13] Source rankings are provided for the VDDC mining and infrastructure project only (Scenarios 1 to 3). The extended opencast pit scenario (Scenario 4) focused mainly on opencast operations, and thus no further analysis is warranted.

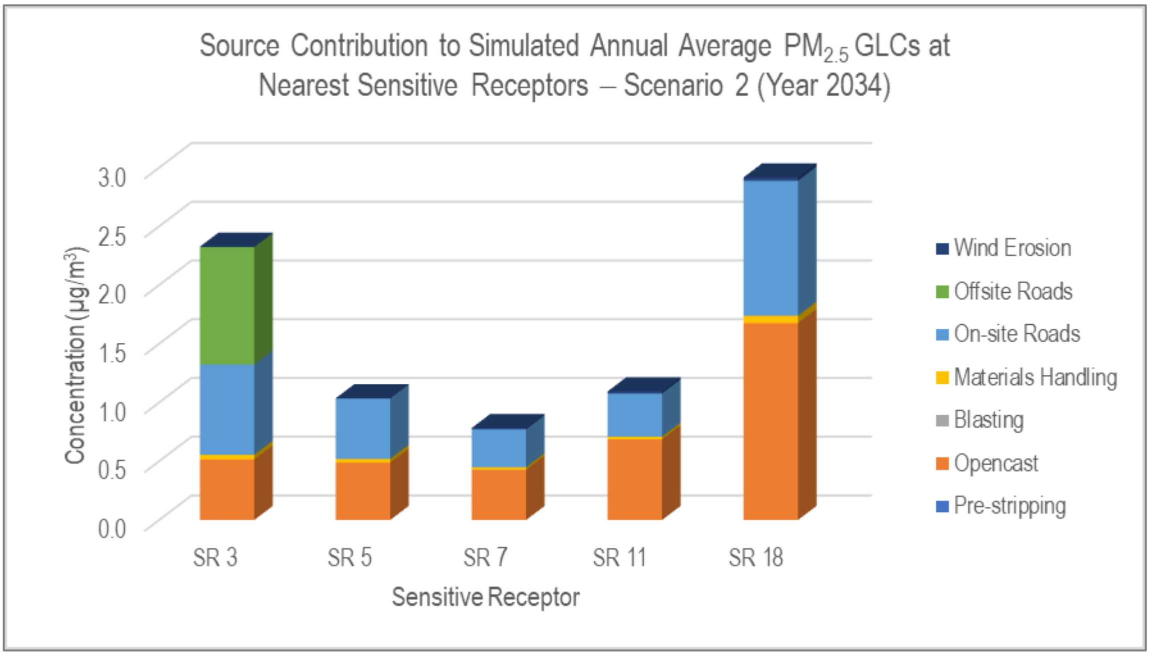


Figure 28: Source group contribution to annual average $PM_{2.5}$ ground level concentrations (in µg/m³) due to design mitigated mining and infrastructure operations for Scenario 2 (2034)

- **PM_{10}**: Similar to $PM_{2.5}$, the main source of cumulative PM_{10} impacts due to mining and infrastructure operations is unpaved offsite roads (at SR3), unpaved on-site roads (at SR5) and opencast activities (at SR7, SR11 and SR18) (Figure 29). The combined contribution from VDDC infrastructure operations to total PM_{10} impacts at the nearest receptors range between 29% and 43%.

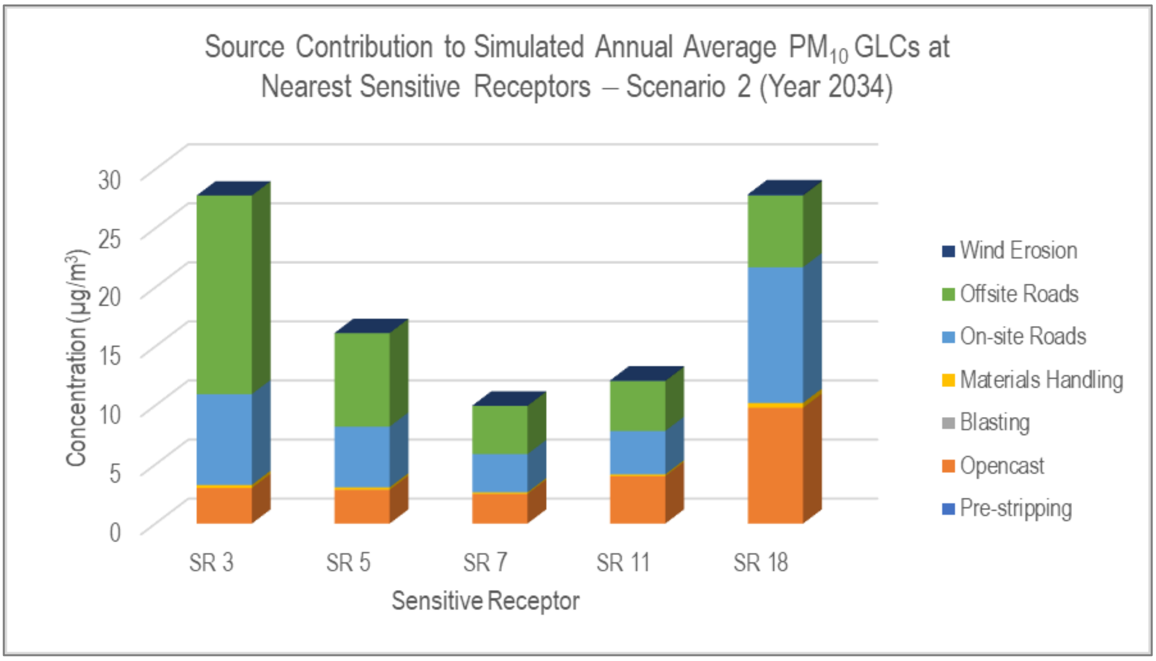


Figure 29: Source group contribution to annual average PM_{10} ground level concentrations (in µg/m³) due to design mitigated mining and infrastructure operations for Scenario 2 (2034)

- **Dustfall rates**: From Figure 30 the main source of cumulative dustfall rates due to mining and infrastructure operations is unpaved off-site roads (at SR3), unpaved on-site roads (at SR5), opencast activities (at SR7), and wind erosion at SR11 and SR18. The combined contribution from VDDC infrastructure operations to total simulated dustfall rates at the nearest receptors range between 33% and 71%.

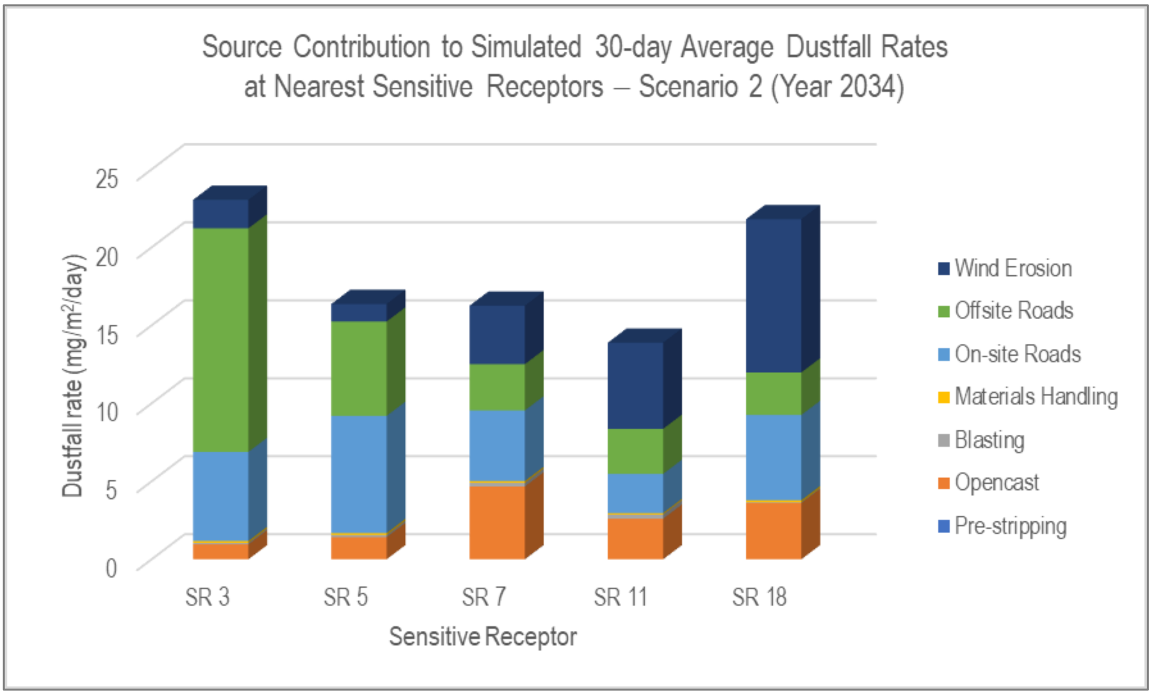


Figure 30: Source group contribution to monthly average dustfall rates (in mg/m²/day) due to design mitigated mining and infrastructure operations for Scenario 2 (2034)

4.5 Impact Significance Rating

The environmental impact significance rating that follows applies to the operational phase of the proposed project. The operational phase is considered to be the phase with the largest impact on ambient air quality. Although the impacts for Scenario 2 (year 2034) have a larger extent and higher production rate, the impact significance rating is likely to be similar for all three scenarios assessed. The Construction and Rehabilitation (Closure) phases are not likely to impact the ambient air quality more than the existing (status quo) status. All impacts are based on the dispersion modelling results where the certainty of impacts is considered "**very likely**". The impact significance rating for the operational scenario is presented in Table 30 (for opencast mining and infrastructure operations) and Table 31 (for extended pit operations).

4.5.1 Existing Status

The existing sources of particulate emissions in the vicinity include: agricultural activities; coal mining; and, power stations and the associated ash disposal facilities (Section 3.5). The site is located within the Highveld Priority Area near the eMalahleni Hot Spot – an area of already poor air quality. The available data show that between 2012 and 2016 the daily PM_{10} concentrations are likely to be in non-compliance with the daily NAAQS (i.e. more than 4 days per year where the concentration exceeds the 75 µg/m³ limit concentration). The existing air quality is of MODERATE significance at a *regional* scale. The impacts of the existing air quality <u>*have occurred*</u> over the <u>long-term</u>, resulting in a **HIGH** impact risk.

4.5.2 Operational Impact

Given the large impacts simulated for design mitigated operations, the incremental impacts as a result of unmitigated mining and infrastructure activities only will likely elevate ambient PM_{10} concentrations, exceeding the annual NAAQS, outside of the mining rights boundary, where communities outside of 5 km will be affected. The scale of impact of the operational VDDC Section on ambient $PM_{2.5}$ concentrations is likely to be lesser than PM_{10} concentrations. The impacts of the proposed project (mining and infrastructure), when unmitigated, are *very-likely* to result in impacts of MODERATE significance at the *regional* scale over the *medium-term*, resulting in **MODERATE** impact risk. The impacts of the proposed project (extended pit operations), when unmitigated, *could* result in impacts of MODERATE significance at the *regional* scale in the *short-term*, resulting in **MODERATE** impact risk.

4.5.3 Mitigation Measures

Effective mitigation of particulate emissions will include:

- Regular wetting of exposed areas and haul ramps;
- Water sprays and/or chemical stabilisation of on- and offsite haul roads;
- Water sprays on drilling operations;
- Enclosure or covering of haul trucks;
- Reduce the drop height of the dragline; and
- Rehabilitation and revegetation of the mined areas as soon as practical, with the option of using watering to suppress dust emissions during dry and windy conditions.

Dust control measures that may be implemented during construction activities are shown in Table 32.

4.5.4 Residual Impact

With the application of effective mitigation measures, the residual impact due to the proposed mining and infrastructure activities is *very likely* to result in impacts of HIGH significance at a *local* scale over the *medium-term*, resulting in **HIGH** impact risk. The impact rating reduces (Table 30) between the Existing Air Quality and the Residual Impact on air quality. This is due to a reduced Probability rating for the Residual Impact based on dispersion model uncertainties (Section 1.5). Under the assumption of design mitigated activities the residual impact due to the extended pit activities is *likely (i.e. could happen)* to result in impacts of HIGH significance at a *local* scale over the *short-term*, resulting in **MODERATE** impact risk.

The contribution of the VDDC infrastructure project to cumulative $PM_{2.5}$ and PM_{10} ground level concentrations and dustfall rates is analysed in Section 4.3. From the above discussion and Section 4.3 it may be inferred that the residual impact due to the proposed infrastructure activities only is *likely* to result in impacts of LOW significance at a *local* scale over the *medium-term*, resulting in **LOW** impact risk

Table 30: Impact rating matrix for the operational phase of mining for the proposed mining and infrastructure project

Scenario	Impact description	Significance	Spatial Scale	Duration Scale	Probability	Certainty	Rating
Existing [a]	Non-compliance with daily PM_{10} standards	3	4	4	5	4	3.7
	Non-compliance with annual $PM_{2.5}$ standards	3	4	4	5	4	3.7
	Dustfall rates exceed 600 $mg/m^2/day$	2	2	4	5	4	2.7
Unmitigated [b]	Estimated non-compliance with annual PM_{10} standards	3	3	3	4	3	2.4
	Estimated impact area of non-compliance with daily PM_{10} standards	3	4	3	4	3	2.7
	Estimated non-compliance with annual $PM_{2.5}$ standards	2	2	3	4	3	1.9
	Estimated impact area where simulated dustfall rates exceed 600 $mg/m^2/day$	2	1	3	4	3	1.6
Mitigated [c]	Simulated non-compliance with annual PM_{10} standards	3	3	3	4	3	2.4
	Impact area where non-compliance with daily PM_{10} standards was simulated	3	3	3	4	3	2.4
	Simulated non-compliance with annual $PM_{2.5}$ standards	1	2	3	4	3	1.6
	Impact area where simulated dustfall rates exceed 600 $mg/m^2/day$	1	1	3	4	3	1.3
Residual [d]	Non-compliance with daily PM_{10} standards	4	4	4	4	4	3.2
	Non-compliance with annual $PM_{2.5}$ standards	3	4	4	4	4	2.9
	Dustfall rates exceed 600 $mg/m^2/day$	2	2	4	4	4	2.1

[a] Existing air quality
[b] Impact of the proposed mining and infrastructure project with unmitigated emissions; excluding existing air quality
[c] Impact of the proposed mining and infrastructure project with mitigated emissions; excluding existing air quality
[d] Impact of the proposed mining and infrastructure project with mitigated emissions; including existing air quality

Table 31: Impact rating matrix for the operational phase of mining for the extended opencast pit

Scenario	Impact description	Significance	Spatial Scale	Duration Scale	Probability	Certainty	Rating
Existing [a]	Non-compliance with daily PM_{10} standards	3	4	4	5	4	3.7
	Non-compliance with annual $PM_{2.5}$ standards	3	4	4	5	4	3.7
	Dustfall rates exceed 600 mg/m²/day	2	2	4	5	4	2.7
Unmitigated [b]	Estimated non-compliance with annual PM_{10} standards	3	3	2	4	3	2.1
	Estimated impact area of non-compliance with daily PM_{10} standards	3	4	2	4	3	2.4
	Estimated non-compliance with annual $PM_{2.5}$ standards	3	3	2	4	3	2.1
	Estimated impact area where simulated dustfall rates exceed 600 mg/m²/day	2	1	2	4	3	1.3
Mitigated [c]	Simulated non-compliance with annual PM_{10} standards	3	3	2	3	3	1.6
	Impact area where non-compliance with daily PM_{10} standards was simulated	3	3	2	3	3	1.6
	Simulated non-compliance with annual $PM_{2.5}$ standards	3	3	2	3	3	1.6
	Impact area where simulated dustfall rates exceed 600 mg/m²/day	1	1	2	3	3	0.8
Residual [d]	Non-compliance with daily PM_{10} standards	4	3	2	4	3	2.4
	Non-compliance with annual $PM_{2.5}$ standards	3	3	2	4	4	2.1
	Dustfall rates exceed 600 mg/m²/day	2	2	2	4	4	1.6

[a] Existing air quality
[b] Impact of the extended opencast pit with unmitigated emissions; excluding existing air quality
[c] Impact of the extended opencast pit with mitigated emissions; excluding existing air quality
[d] Impact of the extended opencast pit with mitigated emissions; including existing air quality

5 Recommended Air Quality Management Measures

5.1 Air Quality Management Objectives

The objective of air quality management will be to minimise particulate emissions from the proposed project operations to maintain or improve the ambient air quality and reduce nuisance impacts of dustfall.

5.2 Source Specific Recommended Management and Mitigation Measures

The following sections describe the mitigation and management measures appropriate to each stage of the proposed project development. These are described as distinct phases here, but in practice are likely to occur concurrently.

5.2.1 Construction Phase

The construction of the proposed project will be a mostly sporadic process, including vegetation and topsoil clearing for infrastructure development. The complexity of estimating dust emissions during this phase is a result of the types of activities, the varying duration and extent of each activity. The impact of the construction phase on air quality is expected to be limited to on-site impacts.

The implementation of effective controls during the construction phase would, in addition to reducing the scale of impact, serve to set the precedent for mitigation during the operational phase. Dust control measures which may be implemented during the construction phase are outlined in Table 32. Control techniques for fugitive dust sources generally involve watering, chemical stabilization, and the reduction of surface wind speed though the use of windbreaks and source enclosures.

Table 32: Dust control measures that may be implemented during construction activities

Construction Activity	Recommended Control Measure(s)
Debris handling	Wet suppression (continuous as required)
Truck transport and road dust entrainment	Wet suppression (continuous as required) or chemical stabilization of unpaved roads Haul trucks to be restricted to specified haul roads using the most direct route Reduction of unnecessary traffic Strict on-site speed control (according to mine driving rules)
Materials storage, handling and transfer operations	Wet suppression where feasible
Earthmoving operations	Wet suppression (continuous as required) where feasible
Open areas (wind-blown emissions)	Reduction of extent of open areas in order to minimise the time between clearing and infrastructure construction; and/or use wind breaks and water suppression to reduce emissions from open areas Stabilisation (chemical, rock cladding or vegetative) of disturbed soil Re-vegetation of cleared areas as soon as practically feasible

5.2.2 Operational Phase

The dispersion model simulations show that design mitigation of dust emissions through wet suppression on unpaved haul roads, materials handling, grading and drilling did not bring PM_{10} concentrations in compliance with NAAQS, but minimised areas of non-compliance with future $PM_{2.5}$ NAAQS and NDCR in the case of $PM_{2.5}$ and dustfall. To minimise the impact of unpaved haul roads, operational mitigation should include as far as possible chemical stabilisation of onsite haul roads.

The impact due to dragline operation is likely to be high during dropping activities. To minimise the impact of the dragline, operational mitigation should include reducing the drop height from the dragline as far as possible (informed by safety requirements for specific dragline bucket size dimensions).

The potential impacts due to evaporators are discussed in Section 6.

5.2.3 Rehabilitation Phase

Rehabilitation is likely to occur concurrently as the active mining area progresses. The impacts of this phase are likely to be similar to those of the construction phase and therefore similar mitigation measures are recommended. This will include dust suppression by watering and covering with top-soil and replanting of grass seeds.

5.3 Performance Indicators

5.3.1 Source Monitoring

Visual inspection of dust plumes from the proposed project, especially the dragline and during coal haulage, will be an important indicator ineffective mitigation measures. Response to minimise particulate emissions during these periods should be as rapid as possible. To avoid these conditions the following activities are recommended.

- Monitoring local weather forecasts for windy and/or dry conditions – for example during late winter, spring, and early summer. Contingency systems should be in place to respond with additional dust suppression during these periods.
- During dry and windy conditions, reduce the drop height of the dragline, as well as the drop height from loaders into haul trucks.
- Regular checks of the dust suppression equipment, for example the bowser trucks on ramps, road surface on the haul road where chemical suppressants are used.
- Regular visual inspection of rehabilitated / revegetated areas for complete vegetation cover.

5.3.2 Ambient Air Quality Monitoring

In order to ensure that mitigation is effective, it is recommended that the current dustfall monitoring network is expanded in the vicinity of the proposed project site. Three additional dust buckets, and relocation of single dust buckets at Vandyksdrift Plant and Vandyksdrift Village are recommended (Figure 31). Final locations of the expanded dust monitoring network will be subject to security considerations. It is also recommended that a PM_{10} sampler be placed at any of the recommended dust bucket locations, if security considerations allow for it.

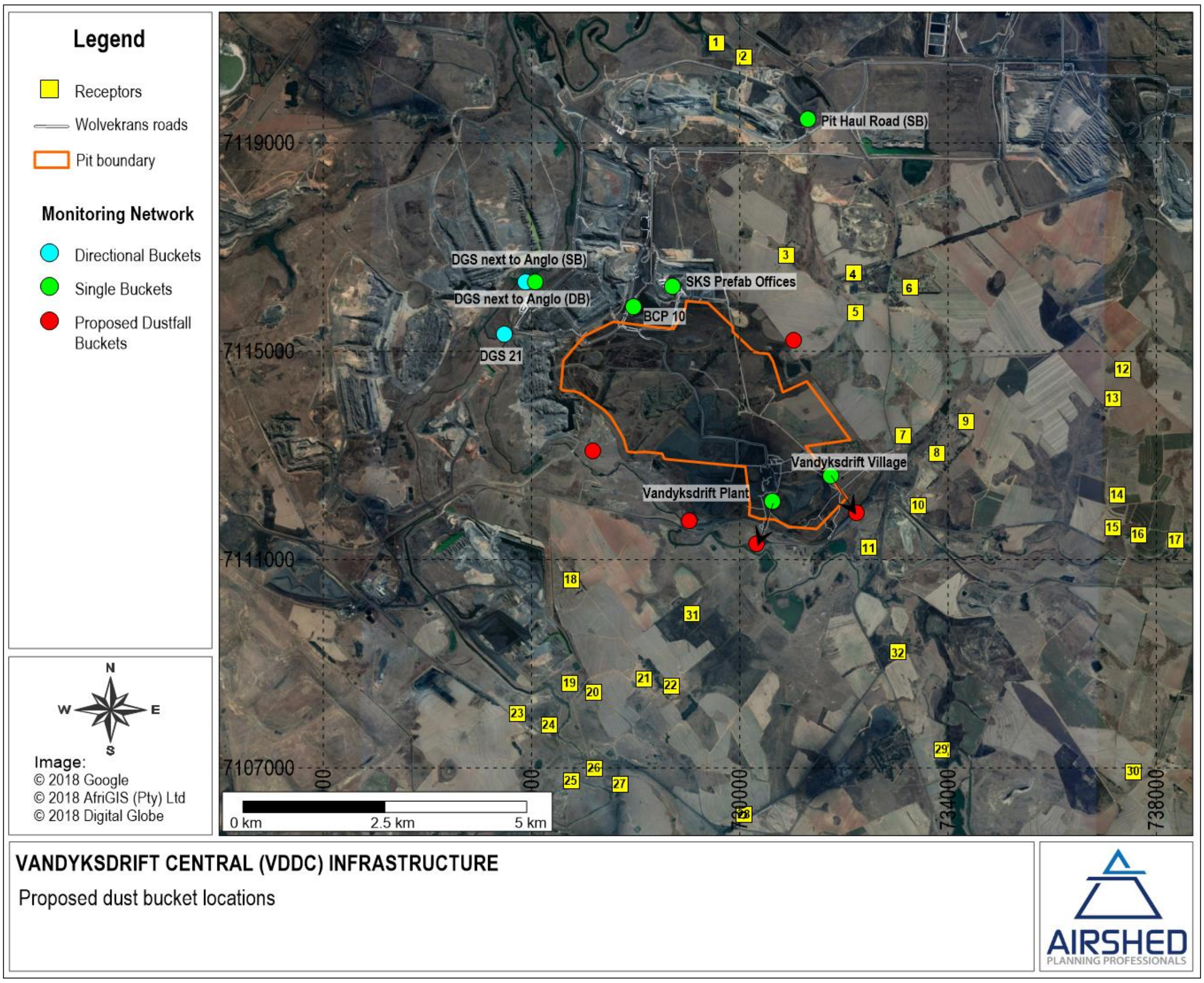


Figure 31: Proposed dust bucket locations

5.4 Record-Keeping, Environmental Reporting and Community Liaison

5.4.1 Periodic Inspections and Audits

The NDCR requires that monitoring reports be submitted to the local air quality officer where exceedances of the dustfall standards occur.

5.4.2 Liaison Strategy for Communication with I&APs

Stakeholder forums provide possibly the most effective mechanisms for information dissemination and consultation. Management plans should stipulate specific intervals at which forums will be held and provide information on how people will be notified of such meetings. Given the close proximity of the study site to the nearby receptors (SR3, SR5, SR7, SR11 and SR18), it is recommended that stakeholder engagements be held. A complaints register must be kept at all times.

6 Salt Deposition of Mechanical Evaporators

Once water has come into contact with the coal mine operations, the potential exists for this water to become contaminated with the various inorganic salts (mainly sulfates) found in the mined material. From a regulatory perspective, this water is considered dirty and may not be freely discharged into the environment. Whilst water treatment options are available to reduce the contamination in the water, it is more common for mine operators to store the potentially contaminated water in ponds from where the water is allowed to evaporate. Evaporating ponds require low operating costs and maintenance; however, the discharge of water into these ponds is limited by the capacity of the pond and the water evaporation rate. Mechanically-enhanced evaporation may be used to complement the storage and evaporation of water from these ponds.

South32 plans to install three sets of evaporators as part of the upfront dewatering of the No. 2 seam at VDDC, namely:

- 20 evaporators at Vlaklaagte (Pit 4) (2 Mℓ),
- 8 evaporators at Vleishaft Dam (2 Mℓ), and
- 12 evaporators at the No. 5 Seam void (3 Mℓ).

The Project proposes that an additional 8 evaporators will be located at the SKS void once mining of the VDDC opencast pit commences (3 Mℓ), and as mining progresses at VDDC the 12 evaporators at No. 5 Seam void will move to the SKS void, bringing the total number of evaporators at the SKS void to a total of 20 (3 Mℓ).

The location for the evaporators at the SKS void has been finalised, as close to the overburden dump to be located on the SKS pit, close to the water treatment plant. South32 currently uses Minetek water cannons at Vandyksdrift Pit 4, and it is understood that similar mechanical evaporators would be utilised in the proposed Project. Each cannon ejects the affected water into the air through number of nozzles (typically 72) at a relatively high (typically 7 bar or higher) pressure. Each water evaporator is equipped with an air blower that carries the water droplets formed by the nozzles at an initial angle of approximately 45° at a velocity of approximately 46 m/s.

Airshed assisted South32 on a previous project to identify the hazards and assess the potential negative risk posed by the airborne mine water mist generated by the operation of these mechanical evaporators (Burger and Grobler 2015). The hazards identified include the potential build-up of salts contained in the mine water on nearby topsoil, vegetation and water bodies, as well as infrastructure. The overall project objective was to develop a mathematical model that would enable the quantification of the potential negative risk posed by the airborne mine water mist generated by the operation of the water cannons. The model simulates the behaviour of the water droplet jet stream, the dispersion of the water droplets as it mixes with air, the evaporation of water droplets and the deposition of the salt contained in the droplets. The model clearly indicated that most of the fallout of water droplets and dissolved solids occur in the nearby vicinity of the evaporators, within 50m to 70m of the evaporator. Nearly all of the fallout (99%) occurs within 125m to 150m from the evaporators. Although low deposition rates were predicted beyond these distances, the accumulation of the salts over time was shown to become non-trivial. Both measurement and model results show that unless removed by rain or other means, monthly deposition of total solids of about 100g/m² (3g/m²-day) is possible at downwind distances of about 300m from the evaporators. These calculations assumed an average of 5% total dissolved solids in the contaminated water.

The results of the previous study were used to illustrate of the potential fallout on the immediate areas of the proposed locations, as shown in Figure 32.

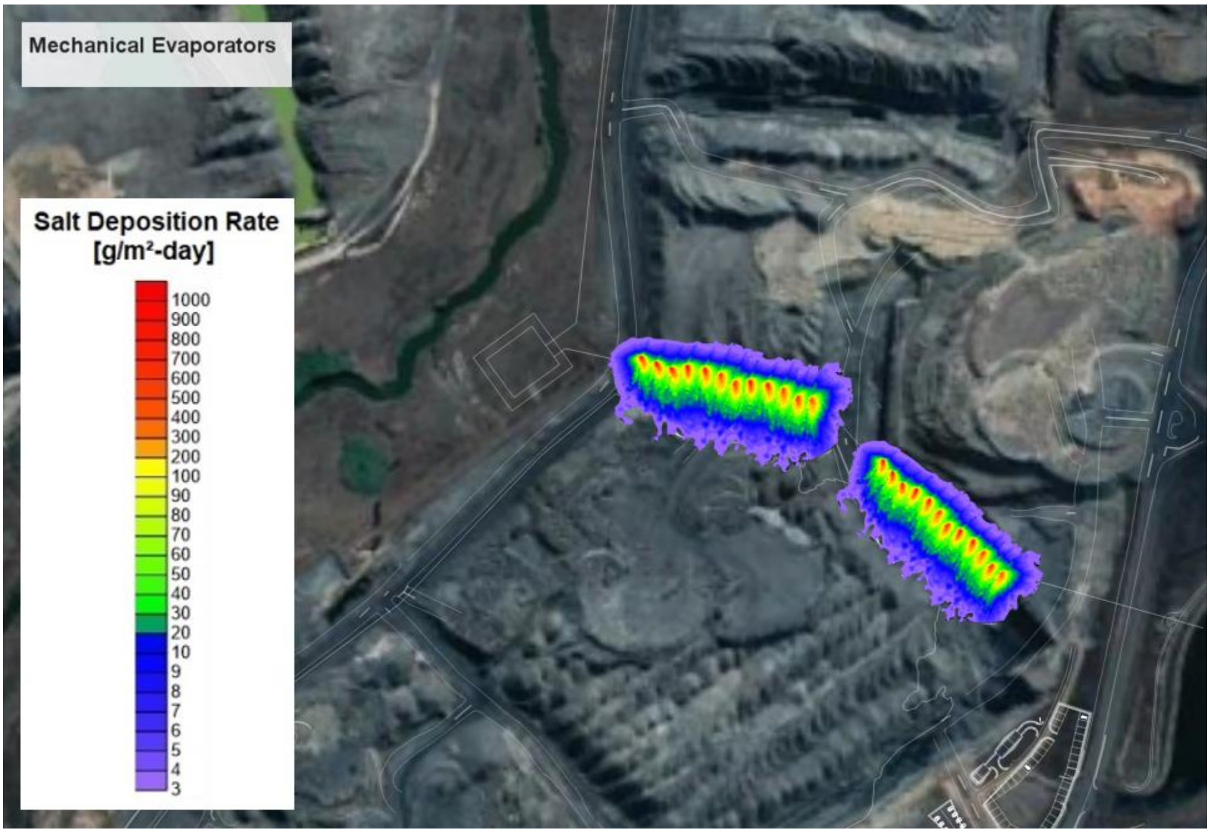


Figure 32: Potential fallout from the mechanical evaporator

7 GREENHOUSE GAS EMISSION STATEMENT

7.1 Introduction

7.1.1 The greenhouse effect

Greenhouse gases are “those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth’s surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth’s atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine and bromine containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (IPCC, 2007). Human activities since the beginning of the Industrial Revolution (taken as the year 1750) have produced a 40% increase in the atmospheric concentration of carbon dioxide, from 280 ppm in 1750 to 406 ppm in early 2017. This increase has occurred despite the uptake of a large portion of the emissions by various natural "sinks" involved in the carbon cycle. Anthropogenic carbon dioxide (CO_2) emissions (i.e., emissions produced by human activities) come from combustion of fossil fuels, principally coal, oil, and natural gas, along with deforestation, soil erosion and animal agriculture (IPCC, 2007).

7.2 The Project’s Operational Phase Carbon Footprint

7.2.1 GHG Emissions Estimation

7.2.1.1 *Scope 1 Emissions*

The Intergovernmental Panel on Climate Change (IPCC) provides default emission factors for diesoline in kg CO_2/unit energy content, while the density and calorific values are available from a number of standard engineering databases. Using the values in Table 33, the CO_2 emission factor can be calculated per litre of fuel used, which allows calculation of the total emissions directly from fuel records. The average amount of diesel used during the construction period is 25 239 198 litres (for the period 2020 to 2022). The maximum amount of fuel (diesel) used per annum is 62 222 264 litres (for the year 2028). The fuel usage per annum was obtained from the Pre-feasibility Mining Report, dated 30 November 2017. The methane (CH_4) and nitrous oxide (N_2O) emission factors are given in Table 34.

Table 33: Calculation of liquid fuel-related CO_2 emission factors (for vehicles)

Type of fuel	CO_2 emission factor kg/TJ	Density kg/m^3	Calorific value kJ/kg	Emission factor kg CO_2/litre fuel
Diesoline	74100	840	43 400	2.701

Table 34: Vehicles - liquid fuel-related methane and nitrous oxide emission factors (EPA, 2018)

Type of fuel	Density kg/m^3	Emission factor g CH_4/gallon	Emission factor g N_2O/gallon
Diesoline	840	0.57	0.26

7.2.1.2 *Scope 2 Emissions*

These emissions are related to purchased energy, heat or steam, and can be calculated from the average South African emission factor published annually by Eskom in its annual report (more recently its integrated sustainability report). The numbers for the four-year period 2007-2011 are given in Table 35. This allows the scope 2 emissions to be calculated directly from electricity consumption from the Eskom or local authority account. The current electricity usage, which may be assumed for the construction period, is 8 724 MWh (assuming 8760 hours of operation). The estimated project's electricity usage per month during the operational phase is 21 754 MWh (assuming 8760 hours of operation) (electricity usage provided by the client).

Table 35: Eskom electricity emission factors

Year	Emission Factor kg CO_2/kWh	Source
2007/2008	1.00	Eskom 2009 Annual Report
2008/2009	1.03	Eskom 2009 Annual Report
2009/2010	1.03	Eskom 2010 Integrated Report
2010/2011	0.99	Eskom 2011 Integrated Report

7.2.1.3 *Summary*

A summary of the greenhouse gas emissions is provided in Table 36 (for the construction period) and Table 37 (for operational year 2028). For CH_4 and N_2O, the CO_2 equivalents were used, given as 25 times for CH_4 and 298 times for N_2O (http://www.climatechangeconnection.org/emissions/CO2_equivalents.htm).

Table 36: Summary of estimated greenhouse gas emissions for the construction period

Source group	CO_2	CH_4 as CO_2-e	N_2O as CO_2-e	Total CO_2-e
	t/a	t/a	t/a	t/a
Vehicle exhaust (scope 1)	68 171	95	517	**68 784**
Electricity (scope 2)	105 991	212	411	**106 614**
Total	**174 162**	**307**	**929**	**175 398**

Table 37: Summary of estimated greenhouse gas emissions for the proposed mining operations (cumulative scenario)

Source group	CO_2	CH_4 as CO_2-e	N_2O as CO_2-e	Total CO_2-e
	t/a	t/a	t/a	t/a
Vehicle exhaust (scope 1)	168 062	235	1 275	**169 572**
Electricity (scope 2)	264 311	529	1 026	**265 866**
Total	**432 373**	**764**	**2 301**	**435 438**

The total CO_2 (equivalent) emissions of approximately 175 398 tpa (Table 36) for the construction period and 435 438 tpa (Table 37) for the operational year 2028, should be seen in the perspective of the annual South African emission rate of GHG, which is approximately 544.31 million metric tonnes CO_2-e.

The calculated CO_2-e emissions due to the construction period and future VDDC operations (entire opencast area) respectively contribute 0.03% and 0.08% to the total of South Africa's GHG emissions, and 0.17% and 0.41% respectively to the total "manufacturing industry and construction" sector. As indicated in Section 2.7.3, GHGs were declared priority pollutants in March 2014 and pollution prevention plans must be developed if the operation contributes more than 100 000 tons CO_{2eq} emissions. The scope 1 GHG contribution of the future operational period is above 100 000 tons (Table 37). Based on this, a Pollution Prevention Plan is required for the future VDDC mining operations, but not for the construction period.

7.2.2 The Project's GHG Impact

7.2.2.1 Magnitude

The GHG emissions due to the project's construction period as well as the mining operations are low and will not likely result in a noteworthy contribution to climate change on its own.

7.2.2.2 Impact on the sector

The GHG emissions from construction and mining operations form 0.17% and 0.41% respectively of the "manufacturing industry and construction" sector's total annual CO_2-e emissions and will therefore not make a significant contribution towards the sector's GHG impact.

7.2.2.3 Impact on the National Inventory

The GHG emissions from construction and mining operations respectively form 0.03% and 0.08% of the national inventory's total annual CO_2-e emissions, which is very low.

7.2.2.4 Alignment with national policy

As from the next NAEIS reporting period, after construction has commenced, VDDC will have to start reporting on Scope 1 GHG emissions.

7.3 Potential Effect of Climate Change on the Project

The most significant of the discussed climate change impacts on the project would be as a result of:

- Temperature increase[14],
- Possible reduction in rainfall[15].

With the increase in temperature there is the likelihood of an increase in discomfort and possibility of heat related illness (such as heat exhaustion, heat cramps, and heat stroke). Both of these have the potential to negatively affect staff performance and productivity. There is also the increased risk of overheating of equipment/machinery with effects on production, and a possible increase in demand for energy to satisfy an increased cooling need (in buildings). The potential exists for higher evaporation

[14] Under a no intervention scenario, temperatures are projected to rise over the Project region, by 2.5°C to 3°C over the South African interior in the near-future and even higher in the far-future.

[15] The region is projected to become systematically drier, with considerably more dry years than wet years. The drastically higher temperatures may have a negative impact on water availability from local dams due to enhanced evaporation.

rates and thus the need for increased watering of the roads. Higher temperatures also increase the risk of veld fires and spontaneous combustion of coal stockpiles.

A decrease in rainfall may result in severe water shortages, which may interrupt mining activities and increase working costs, thereby potentially making the project unprofitable. Lower rainfall will also have a negative impact on food security, possibly resulting in food shortages which may negatively affect staff performance.

7.4 Potential Effect of Climate Change on the Community

Of the discussed climate change impacts, significant effect on the surrounding communities will be as a cumulative result of land uses contributing to GHG emissions and not the VDDC project only. As stated in Section 7.2.2.1 the project's contribution to climate change is not noteworthy.

7.5 Adaptation and Management Measures

Climate change management includes both mitigation and adaptation. The main aim of mitigation is to stabilise or reduce GHG concentrations as a result of anthropogenic activities. This is achievable by lessening sources (emissions) and/or enhancing sinks through human intervention.

7.5.1 Project adaptation and mitigation measures

7.5.1.1 *General*

Additional support infrastructure can reduce the climate change impact on the staff and project, for example ensuring adequate water supply for staff and reducing on-site water usage as much as possible.

7.5.1.1.1 Scope 1 (technology/sector-specific)

One way to keep GHG emissions to a minimum would be to ensure there is minimal fuel use, this can be achieved by ensuring the vehicles and equipment is maintained through an effective inspection and maintenance program. A measure of reducing the project's impact is to limit the removal of vegetation and to ensure that as much as possible revegetation occurs, e.g. that concurrent rehabilitation is implemented, and possibly even the addition of vegetation surrounding the project area.

7.6 Conclusions and recommendations

- Calculation of the Scope 1 GHG emissions from the proposed operations is at this stage an uncomplicated procedure involving the use of liquid fuel consumption figures from estimated amounts based on fleet and power supply requirements; and multiplying by simple emission factors as given in tables above. The total CO_2-e emissions for VDDC mining operations is not likely to be more than 435 438 tpa, and for the construction period not more than 175 398 tpa. The calculated CO_2-e emissions from the proposed mining operations contribute less than 0.08% to the total of the national inventory's GHG emissions (excluding land-use change and forestry) and 0.41% to the national inventory's "manufacturing industry and construction" sector GHG emissions. For the construction period, the calculated CO_2-e emissions contribute less than 0.03% to the total of the national inventory's GHG emissions (excluding land-use change and forestry) and 0.17% to the national inventory's "manufacturing industry and construction" sector GHG emissions.

- GHGs were declared priority pollutants in March 2014 and pollution prevention plans must be developed if the operation contributes more than 100 000 tons CO_{2eq} emissions. The scope 1 GHG contribution due to the proposed mining operations is above 100 000 tons. Based on this, a Pollution Prevention Plan is required for the proposed VDDC operations, but not for the construction period.
- The GHG emissions from the proposed construction and operational phases are not likely to result in a noteworthy contribution to climate change on its own.
- The project and the community are likely to be negatively impacted by climate change, the project less than the community due to the short time operations are planned to occur for.
- The following is recommended to reduce the impacts of climate change on the project and the community:
  - Additional support infrastructure can reduce the climate change impact on the staff and project, for example the upgrading of an on-site clinic.
- The following is recommended to reduce the GHG emissions from the project:
  - Ensuring the vehicles and equipment is maintained through an effective inspection and maintenance program.
  - Limiting the removal or vegetation and ensuring adequate re-vegetation or addition of vegetation surrounding the project. Vegetation acts as a carbon sink.

8 CONCLUSIONS

The VDDC area falls within the footprint of historic underground mining operations at the old Douglas Colliery. In 2007, an amendment of the Environmental Management Programme Report (EMPR) for the Douglas Colliery operations was approved, to allow the opencast mining of the remaining No. 5, No. 4, No. 2 and No. 1 seams. The 2007 EMPR Amendment did not include any additional infrastructure in support of the opencast mining operations as it was assumed at that stage that existing infrastructure will be used. The need has since been identified to develop added infrastructure to support the proposed opencast mining. In addition, authorisation for opencast mining is required for an area that was not included in the 2007 approved EMPR amendment.

The proposed opencast mining and infrastructure operations at the VDDC Section of the Wolvekrans Colliery, and changes to opencast mining, have the potential to impact ambient air quality by exposing the public (represented by nearby communities and individual residences) to elevated levels of airborne particulates and the associated potential human health impacts. Criteria pollutants of concern include particulate matter with an aerodynamic diameter of less than 10 µm (PM_{10}) and particulate matter with an aerodynamic diameter of less than 2.5 µm ($PM_{2.5}$).

Emissions due to the construction phase were quantified but not modelled, due to the temporary nature of construction and the lack of a detailed breakdown of construction activities. The assessment of the operational phase considered three scenarios throughout the life of mine, under the assumption of design mitigated emissions. A design mitigated scenario was assumed where emissions as a result of coal haulage, grading, materials handling and drilling are mitigated through water sprays.

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The assessment of the change in opencast mining, under the assumption of design mitigated emissions, considered a worst-case scenario of one full year of opencast activities within the extended pit area.

Meteorological data from the Eskom Komati monitoring station over the period January 2013 to December 2015 was used. The co-dominant wind directions, during the period under investigation, were north-north-west, north-east and east-northeast with a frequency of occurrence of approximately 11%.

The TSP, PM_{10} and $PM_{2.5}$ emissions during construction were calculated using the US-EPA emission factor for general construction activities as 43.14 tpm, 16.83 tpm and 8.41 tpm respectively. These may be considered conservative estimates, as the quantity of dust emissions is assumed to be proportional to the area of land being worked, in this case 480 hectares in total.

Findings from the dispersion modelling assessment (for opencast mining and infrastructure operations) include:

- Under the assumption of design mitigated emissions, simulated areas of exceedance show non-compliance with the daily PM_{10} National ambient air quality standards (NAAQS) at 6 receptors within 6 km of the mining operations, as well as non-compliance with the annual PM_{10} NAAQS within 5 km of the mining operations (all receptors within compliance with the annual PM_{10} NAAQS).
- For design mitigated emissions, the area of non-compliance with the future daily $PM_{2.5}$ NAAQS extends to within 1 km of the mining operations and within 1 km of off-site roads (all receptors within compliance).
- The areas of exceedance of the NDCR, under the assumption of design mitigation, are limited to the project boundary and within 250 m of off-site roads (all receptors within compliance).

For extended opencast pit operations, the dispersion modelling assessment found the following:

- Under the assumption of design mitigated emissions, the area of non-compliance with the daily and annual PM_{10} NAAQS extends to within 3.2 km and 1.2 km of the mining operations respectively (all receptors in compliance with the annual PM_{10} NAAQS but exceeding the daily PM_{10} NAAQS at one receptor).
- For design mitigated emissions, the area of non-compliance with the future daily and annual $PM_{2.5}$ NAAQS extends to within 1.6 km and 350 m of the mining operations respectively (all receptors within compliance).
- Under the assumption of design mitigation, no exceedance of the NDCR was simulated.

The following mitigation measures are recommended:

- Regular wetting of exposed areas, temporary stockpiles and haul ramps;
- Chemical stabilisation of on- and offsite haul roads;
- Reduce the drop height of the dragline (average drop height of 16.85m was assumed in the calculations);
- Rehabilitation and revegetation of the mined areas as soon as practical, with the option of using watering to suppress dust emissions during dry and windy conditions.

The VDDC Section is located in the Highveld Priority Area – an area of typically poor air quality. As a result of the high background particulate values, the residual impact ratings for opencast mining and infrastructure operations (after mitigation) are HIGH for PM_{10} and MODERATE for $PM_{2.5}$ and dustfall. The residual impact ratings for mitigated infrastructure operations only are estimated to be LOW for all pollutants and compliance time-frames. For the extended opencast pit, the residual impact ratings (after mitigation) are estimated to be MODERATE for PM_{10} and $PM_{2.5}$, and LOW for dustfall.

For compliance with the NDCR, an additional three dust buckets and relocation of two existing dust buckets have been recommended at locations near the downwind boundary of the VDDC Section. It is also recommended that a PM_{10} sampler be placed at any of the recommended dust bucket locations, if security considerations allow for it.

The potential negative risk posed by airborne mine water mist generated by the operation of mechanical evaporators was discussed by referring to a previous study for South32 (Burger and Grobler 2015). From the previous study, it was found through dispersion modelling that most of the fallout of water droplets and dissolved solids occur in the nearby vicinity of the evaporators, within 50m to 70m of the evaporator. Nearly all of the fallout (99%) occurs within 125m to 150m from the evaporators. Both measurement and model results show that unless removed by rain or other means, monthly deposition of total solids of about 100g/m² (3g/m²-day) is possible at downwind distances of about 300m from the evaporators. These results were used to illustrate the potential fallout on the immediate areas of the proposed location of the VDDC evaporators, for two optional orientations (north-south and east-west respectively). The **second option (east-west orientation)** is recommended since it will have less impact on the nearby haul road to the east of the void.

A greenhouse gas inventory was compiled for the proposed Project, taking into consideration the Project's diesel fuel and electricity requirements. The total CO_2-e emissions for construction operations is approximately 175 398 tpa of which 39% is due to vehicle exhaust emissions (Scope 1) and 61% is due to electricity consumption (Scope 2). The total CO_2-e emissions for mining and infrastructure operations is approximately 435 438 tpa, of which 168 062 tpa is due to vehicle exhaust emissions (Scope 1). GHGs were declared priority pollutants in March 2014 and pollution prevention plans must be developed if the operation contributes more than 100 000 tons CO_{2eq} emissions. The Project's Scope 1 GHG contribution is above 100 000 tons[16]. Based on this, a Pollution Prevention Plan is required for the proposed VDDC operations, but not for construction.

[16] The Project's Scope 1 GHG emissions were calculated based on annual fuel usage estimates for both mining and infrastructure operations.

The GHG emissions from the project are considered low and not likely to result in a noteworthy contribution to climate change on its own. The project and the community are considered likely to be negatively impacted by climate change, the project less so than the community, firstly due to the short time over which operations are planned to occur, and secondly because the project is likely to have measures in place to cope with the possibility of water shortage (probably the most significant problem faced).

- The following is recommended to reduce the impacts of climate change on the project and the community:
    - Additional support infrastructure can reduce the climate change impact on the staff and project, for example ensuring adequate water supply for staff and reducing on-site water usage as much as possible.
- The following is recommended to reduce the GHG emissions from the project:
    - Ensuring the vehicles and equipment is maintained through an effective inspection and maintenance program.
    - Limiting the removal or vegetation and ensuring adequate re-vegetation or addition of vegetation surrounding the project. Vegetation acts as a carbon sink.

9 REFERENCES

Department of Environmental Affairs (2013). Gazette No: 37054 ed. 22 November 2013 s.l.:s.n.

Department of Environmental Affairs (2014). Gazette No. 10229 ed. s.l.:s.n.

AEPA, 2007. *Guidelines for Separation Distances.* s.l.:Australian Environmental Protection Agengy.

CSIR, 2016. *Council for Scientific and Industrial Research Report 20170331-CSIR-EC-ESPO-REP-DOE-1.1A Rev 1.1,* Pretoria: Council for Scientific and Industrial Research.

DEA, 2014a. *GHG Inventory for South Africa 2000 -2010,* s.l.: Department of Environmental Affairs.

Department of Environmental Affairs, 2013. s.l.:Government Gazette no 37054.

Department of National Treasury, 2013. *Carbon Tax Policy Paper,* s.l.: s.n.

DOE, 2011. *Integrated Resource Plan for Electricity 2010-2030 Revision 2.* [Online] Available at: http://www.energy.gov.za/IRP/irp%20files/IRP2010_2030_Final_Report_20110325.pdf

Godish, R., 1990. *Air Quality.* Michigan: Lewis Publishers.

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

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

HPA, 2011. *Highveld Priority Area Air Quality Management Plan.,* Pretoria: Department of Environmental Affairs, Chief Directorate: Air Quality Management.

IFC, 2012. *Performance Standard 3 Resource Efficiency and Pollution Prevention.* [Online] Available at: https://www.ifc.org/wps/wcm/connect/25356f8049a78eeeb804faa8c6a8312a/PS3_English_2012.pdf?MOD=AJPERE

IPCC, 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories.* [Online] Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/

IPCC, 2007. *Intergovernmental Panel on Climate Change 4th Assessment Report.* [Online] Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_appendix.pdf

IPCC, 2013. *Intergovernmental Panel on Climate Change 5th Assessment Report.* [Online] Available at: https://www.ipcc.ch/report/ar5/

IPCC, 2014. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the IPCC,* United States of America: Cambridge University Press.

IPCC, 2014. *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the IPCC,* Cambridge, United Kingdom and New York, USA: Cambridge University Press.

Minister of Finance, 2017. *Draft Carbon Tax Bill.* s.l.:s.n.

NOAA, 2017. *Earth System Research Laboratory Global Monitoring Division.* [Online] Available at: https://www.esrl.noaa.gov/gmd/ccgg/trends/global.html

NPI, 2012. *Emission Estimation Technique Manual for Mining. Version 3.1.* s.l.:Australian Government Department of Sustainability, Environment, Water, Population and Communities.

Oke, T. T., 1990. *Boundary Layer Climates.* London and New York: Routledge.

Pasquill, F., 1974. *Atmospheric Diffusion.* 2nd ed. New York, NY: John Wiley and Sons.

Pasquill, F. & Smith, F. B., 1983. *Atmospheric Diffusion: Study of the Dispersion of Windborne Material from Industrial and Other Sources.* Chichester: Ellis Horwood Ltd.

Shaw, R. W. & Munn, R. E., 1971. Air Pollution Meteorology. In: *Introduction to the Scientific Study of Air Pollution.* Dordrecht-Holland: Reidel Publishing Company, pp. 53-96.

U.S. Department of the Interior, U.S. Geological Survey, 2016. *Digital Elevation: SRTM 1 Arc-Second Global.* [Online] Available at: http://earthexplorer.usgs.gov

UNFCCC, 2017. *United Nations Framework Convention on Climate Change e-Handbook.* [Online] Available at: http://bigpicture.unfccc.int/

US EPA, 1995. *AP 42, 5th Edition, Volume 1, Chapter 13: Miscellaneous, 13.2.3 Heavy Construction Operations,* s.l.: s.n.

US-EPA, 1995. *Compmilation of Air Pollution Emission Factors (AP-42) 6th edition, Volume I, as containted in the AirChIEF (Air Cleaning House for Inventories and Emission Factors) CD-ROM (compact disk read only).* Research Triangle Park, North Carolina: US Environmental Proctection Agency.

US-EPA, 1995. *User's guide for the Industrial Source Comples (ISC) Dispersion Model. Volume I: Description of Model Algorithms,* Research Triangle Park, North Carolina: US-Environmental Protection Agency.

US-EPA, 1996. *Compilation of Air Pollution Emission Factors (AP-42),* Research Triangle Park, NC: US Environmental Protection Agency.

10 APPENDIX A – SPECIALIST CURRICULUM VITAE

CURRICULUM VITAE

Name	Rochelle Bornman
Date of Birth	24 August 1974
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Air Quality Specialist
Profession	Scientist
Years with Firm	10

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Member of National Association for Clean Air (NACA)

EXPERIENCE

- Emissions inventory compilation
- Meteorological, topographical and land use data processing and preparation
- Dispersion modelling experienced in SCREEN, AERMOD, ADMS, CALINE and CALPUFF dispersion models.
- Impact and compliance assessment
- Air quality and dust management plan preparation
- Atmospheric emission license application
- Industry sectors in which experience have been gained with specific reference to air quality include:
    - Opencast and underground mining of: copper, platinum, gold, iron, and coal.
    - Production of: copper, platinum, gold, base metals, iron, steel, and tyre pyrolysis.
    - Biomass to Energy production
    - Fire behaviour modelling

SOFTWARE PROFICIENCY

- Atmospheric Dispersion Models: AERMOD, ISC, CALPUFF, ADMS (United Kingdom), TANKS
- Other: Golden Software Surfer, Lakes Environmental WRPlot, MS Word, MS Excel, MS PowerPoint, ArcMap, ArcView

EDUCATION

- B. Land Surveying: 1997, *University of Pretoria*
- MPhil: (Geographical Information Systems and Remote Sensing) 1998, *University of Cambridge*

COURSES COMPLETED AND CONFERENCES ATTENDED

- NACA Conference 2010, 2011
- Laboratory Systems Course (ISO 17025: 2017) March 2018

COURSES PRESENTED

- Geodesy and Land Surveying at the University of Pretoria (1999)

COUNTRIES OF WORK EXPERIENCE

- South Africa, Namibia, Mozambique, Saudi Arabia, Mali

LANGUAGES

Language	Proficiency
English	Full professional proficiency
Afrikaans	Full professional proficiency

REFERENCES

Name	Position	Contact Number
Dr. Gerrit Kornelius	Associate of Airshed Planning Professionals	+27 (82) 925 9569 gerrit@airshed.co.za
Dr Lucian Burger	Director at Airshed Planning Professionals	+27 (82) 491 0385 lucian@airshed.co.za
Dr. Hanlie Liebenberg Enslin	Managing Director at Airshed Planning Professionals	+27 (83) 416 1955 hanlie@airshed.co.za

CERTIFICATION

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

11 APPENDIX B: IMPACT ASSESSMENT SIGNIFICANCE RATING METHODOLOGY

In order to ensure uniformity, a standard impact assessment methodology will be utilised so that a wide range of impacts can be compared. The impact assessment methodology makes provision for the assessment of impacts against the following criteria:

- Significance;
- Spatial scale;
- Temporal scale;
- Probability; and
- Degree of certainty.

A combined quantitative and qualitative methodology will be used to describe the impacts for each of the aforementioned assessment criteria. A summary of each of the qualitative descriptors along with the equivalent quantitative rating scale for each of the aforementioned criteria is given in Table 38.

Table 38: Quantitative rating and equivalent descriptors for the impact assessment criteria

RATING	SIGNIFICANCE	EXTENT SCALE	TEMPORAL SCALE
1	VERY LOW	Isolated corridor / proposed corridor	Incidental
2	LOW	Study area	Short-term
3	MODERATE	Local	Medium-term
4	HIGH	Regional / Provincial	Long-term
5	VERY HIGH	Global / National	Permanent

A more detailed description of each of the assessment criteria is given in the following sections.

Significance Assessment

Significance rating (importance) of the associated impacts embraces the notion of extent and magnitude but does not always clearly define these since their importance in the rating scale is very relative. For example, the magnitude (i.e. the size) of the area affected by atmospheric pollution may be extremely large (1 000 km^2) but the significance of this effect is dependent on the concentration or level of pollution. If the concentration is great, the significance of the impact would be HIGH or VERY HIGH, but if it is diluted it would be VERY LOW or LOW. Similarly, if 60 ha of a grassland type are destroyed the impact would be VERY HIGH if only 100 ha of that grassland type were known. The impact would be VERY LOW if the grassland type was common. A more detailed description of the impact significance rating scale is given in Table 39 below.

Table 39: Description of the significance rating scale

RATING		DESCRIPTION
5	VERY HIGH	Of the highest order possible within the bounds of impacts which could occur. In the case of adverse impacts: there is no possible mitigation and/or remedial activity which could offset the impact. In the case of beneficial impacts, there is no real alternative to achieving this benefit.
4	HIGH	Impact is of substantial order within the bounds of impacts, which could occur. In the case of adverse impacts: mitigation and/or remedial activity is feasible but difficult, expensive, time-consuming or some

RATING		DESCRIPTION
		combination of these. In the case of beneficial impacts, other means of achieving this benefit are feasible but they are more difficult, expensive, time-consuming or some combination of these.
3	MODERATE	Impact is real but not substantial in relation to other impacts, which might take effect within the bounds of those which could occur. In the case of adverse impacts: mitigation and/or remedial activity are both feasible and fairly easily possible. In the case of beneficial impacts: other means of achieving this benefit are about equal in time, cost, effort, etc.
2	LOW	Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts: mitigation and/or remedial activity is either easily achieved or little will be required, or both. In the case of beneficial impacts, alternative means for achieving this benefit are likely to be easier, cheaper, more effective, less time consuming, or some combination of these.
1	VERY LOW	Impact is negligible within the bounds of impacts which could occur. In the case of adverse impacts, almost no mitigation and/or remedial activity is needed, and any minor steps which might be needed are easy, cheap, and simple. In the case of beneficial impacts, alternative means are almost all likely to be better, in one or a number of ways, than this means of achieving the benefit. Three additional categories must also be used where relevant. They are in addition to the category represented on the scale, and if used, will replace the scale.
0	NO IMPACT	There is no impact at all - not even a very low impact on a party or system.

Spatial Scale

The spatial scale refers to the extent of the impact i.e. will the impact be felt at the local, regional, or global scale. The spatial assessment scale is described in more detail in Table 40.

Table 40: Description of the spatial scale

RATING		DESCRIPTION
5	Global/National	The maximum extent of any impact.
4	Regional/Provincial	The spatial scale is moderate within the bounds of impacts possible and will be felt at a regional scale (District Municipality to Provincial Level). The impact will affect an area up to 50km from the proposed site / corridor.
3	Local	The impact will affect an area up to 5km from the proposed route corridor / site.
2	Study Area	The impact will affect a route corridor not exceeding the boundary of the corridor / site.
1	Isolated Sites / proposed site	The impact will affect an area no bigger than the corridor / site.

Temporal Scale

In order to accurately describe the impact, it is necessary to understand the duration and persistence of an impact in the environment. The temporal scale is rated according to criteria set out in Table 41.

Table 41: Description of the temporal rating scale

RATING		DESCRIPTION
1	Incidental	The impact will be limited to isolated incidences that are expected to occur very sporadically.
2	Short-term	The environmental impact identified will operate for the duration of the construction phase or a period of less than 5 years, whichever is the greater.
3	Medium term	The environmental impact identified will operate for the duration of life of the project.
4	Long term	The environmental impact identified will operate beyond the life of operation.

RATING		DESCRIPTION
5	Permanent	The environmental impact will be permanent.

Degree of Probability

The probability or likelihood of an impact occurring will be described, as shown in Table 42 below.

Table 42: Description of the degree of probability of an impact occurring

RATING	DESCRIPTION
1	Practically impossible
2	Unlikely
3	Could happen
4	Very Likely
5	It's going to happen / has occurred

Degree of Certainty

As with all studies it is not possible to be 100% certain of all facts, and for this reason a standard "degree of certainty" scale is used as discussed in Table 43. The level of detail for specialist studies is determined according to the degree of certainty required for decision-making. The impacts are discussed in terms of affected parties or environmental components.

Table 43: Description of the degree of certainty rating scale

RATING	DESCRIPTION
Definite	More than 90% sure of a particular fact.
Probable	Between 70 and 90% sure of a particular fact, or of the likelihood of that impact occurring.
Possible	Between 40 and 70% sure of a particular fact, or of the likelihood of an impact occurring.
Unsure	Less than 40% sure of a particular fact or the likelihood of an impact occurring.
Can't know	The consultant believes an assessment is not possible even with additional research.

Quantitative Description of Impacts

To allow for impacts to be described in a quantitative manner in addition to the qualitative description given above, a rating scale of between 1 and 5 was used for each of the assessment criteria. Thus, the total value of the impact is described as the function of significance, spatial and temporal scale as described below.

Impact Risk = (SIGNIFICANCE **+** *Spatial* **+** Temporal) / 3 X Probability / 5

The significance, spatial and temporal scales are added and divided by 3 to give a criteria rating. The probability is divided by 5 to give a probability rating. The criteria rating is then multiplied by the probability rating to give the final rating. The impact risk is then classified according to 5 classes as described in Table 44.

Table 44: Impact Risk Classes

RATING	IMPACT CLASS	DESCRIPTION
0.1 – 1.0	1	Very Low
1.1 – 2.0	2	Low
2.1 – 3.0	3	Moderate
3.1 – 4.0	4	High
4.1 – 5.0	5	Very High

12 APPENDIX C: EFFECTS OF CLIMATE CHANGE ON THE REGION

12.1 Climate Change Reference Atlas

In 2017 the SAWS published an updated Climate Change Reference Atlas (CCRA) based on Global Climate Change Models (GCMs) projections. It must be noted that as with all atmospheric models there is the possibility of inaccuracies in the results as a result of the model's physics and accuracy of input data; for this reason, an ensemble of models' projections is used to determine the potential change in near-surface temperatures and rainfall depicted in the CCRA. The projections are for two 30-year periods described as the near future (2036 to 2065) and the far future (2066 to 2095). Projected changes are defined relative to a historical 30-year period (1976 to 2005). The Rossby Centre regional model (RCA4) was used in the predictions for the CCRA which included the input of nine GCMs results. The RCA4 model was used to improve the spatial resolution to 0.44° x 0.44°- the finest resolution GCMs in the ensemble were run at resolutions of 1.4° x 1.4° and 1.8° x 1.2°.

Two trajectories are included based on the four Representative Concentration Pathways (RCPs) discussed in the IPCC's fifth assessment report (AR5) (IPCC, 2013). RCPs are defined by their influence on atmospheric radiative forcing in the year 2100. RCP4.5 represents an addition to the radiation budget of 4.5 W/m^2 as a result of an increase in GHGs. The two RCPs selected were RCP4.5 representing the medium-to-low pathway and RCP8.5 representing the high pathway. RCP4.5 is based on a CO_2 concentration of 560 ppm and RCP8.5 on 950 ppm by 2100. RCP4.5 is based on if current interventions to reduce GHG emissions are sustained (after 2100 the concentration is expected to stabilise or even decrease). RCP8.5 is based on if no interventions to reduce GHG emissions are implemented (after 2100 the concentration is expected to continue to increase).

12.1.1 RCP4.5 trajectory

Based on the median and the region in which the VDDC Project and AQSRs discussed are situated, the annual average near surface temperatures (2 m above ground) are expected to increase by between 1°C and 2.5°C for the near future and between 2.5°C and 3°C for the far future. The seasonal average temperatures are expected to increase for all seasons. The total annual rainfall is expected to decrease by between 0 mm and 10 mm for the near future and between 0 mm and 10 mm for the far future. For the near future the total seasonal rainfall is expected to increase in summer, remain the same or slightly increase for autumn. Winter total rainfall is expected to decrease and spring to stay the same or decrease slightly for near future. The total seasonal rainfall is expected to remain the same or slightly decrease for summer, winter and spring for the far future. Autumn total rainfall is expected to increase for the far future.

12.1.2 RCP8.5 trajectory

Based on the median, the region in which the VDDC Project and AQSRs discussed are situated, the annual average near surface temperatures (2 m above ground) are expected to increase by between 2.5°C and 3°C for the near future and between 4.5°C and 5°C for the far future. The seasonal average temperatures are expected to increase for all seasons. The total annual rainfall is expected to decrease by between 0 mm and 10 mm for the near future and far future. For the near future the total seasonal rainfall is expected to increase for summer and remain the same or slightly increase for autumn and spring. Winter total rainfall is expected to decrease for the near future. The total seasonal rainfall is expected to decrease for autumn and winter for the far future. Spring and summer total rainfall is expected to increase for the far future.

8.5 Paleontological Impact Assessment

Palaeontological Impact Assessment for the proposed infrastructure development and opencast mining at Vandyksdrift Central (VDDC) Section of South32's Wolvekrans Colliery.
Mpumalanga Province

Desktop Study

For

Jones and Wagener Engineering and Environmental Consultants

05 July 2019

Prof Marion Bamford
Palaeobotanist
P Bag 652, WITS 2050
Johannesburg, South Africa
Marion.bamford@wits.ac.za

Expertise of Specialist

The Palaeontologist Consultant is Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, ASSAf
Experience: 30 years research; 22 years PIA studies

Refer to Appendix D for a detailed Curriculum vitae.

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by Jones and Wagener Engineering and Environmental Consultants, Johannesburg, South Africa. The views expressed in this report are entirely those of the author and no other interest was displayed during the decision making process for the Project.

Specialist: Prof Marion Bamford

Signature: 

Executive Summary

South32 SA Coal Holdings (Pty) Ltd (South32), is the holder of an amended mining right for coal for Wolvekrans and Ifalethu Collieries, south of Middelburg in the Witbank coalfield, Mpumalanga. As part of the request approved, to allow the opencast mining of the remaining No. 5, No. 4, No. 2 and No. 1 seams, some additional infrastructure is required. The Vandyksdrift Central (VDDC) area falls within the footprint of historic underground mining operations at the old Douglas Colliery.

The whole mining property falls in palaeontologically sensitive sediments (shales, mudstones and coal) of the early Permian Vryheid Formation in the Witbank coalfield. Coal seams are between 15-110m below the land surface that is covered by soils. It is very unlikely that any fossils would be impacted upon by the excavations for the proposed infrastructure because the fossils would occur in the shales associated with the coal seams and, furthermore, the fossils are rare and sporadic.

The potential impact of the proposed opencast mining not previously authorised on paleontological resources have been assessed. The Impact Risk Class is 3 as the Rating is 2.1 and falls in the range 2.1 – 3.0, so the impact is rated as moderate. This is attributed to the depth of excavation associated with the opencast mining.

It is, therefore, recommended that a Fossil Chance Find Protocol be included in the EMPr. Any further palaeontological assessment is only required once mining activities have commenced and if the responsible person finds fossils.

Table of Contents

1. Background

South32 SA Coal Holdings (Pty) Ltd (South32), is the holder of an amended mining right for coal, granted by the Minister of Mineral Resources, in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002) (MPRDA) and notarially executed on the 21st of May 2015 under DMR reference MP30/5/1/2/2/379MR, in respect of its Wolvekrans – Ifalethu Colliery. This mining right comprises of the following areas:

- Ifalethu Colliery (previously referred to as Wolvekrans North Section, and prior that as the Middleberg Colliery) consisting of the Hartbeestfontein, Bankfontein (mining now ceased), Goedehoop, Klipfontein sections and the North Processing Plant; and
- Wolvekrans Colliery (previously referred to as the Wolvekrans South Section) consisting of the Wolvekrans, Vlaklaagte (mining ceased), Driefontein, Boschmanskrans, Vandyksdrift, Albion and Steenkoolspruit sections, as well as the South Processing Plants (Eskom and Export). Some of these areas were previously known as Douglas Colliery.

The Vandyksdrift Central (VDDC) area falls within the footprint of historic underground mining operations at the old Douglas Colliery. In 2007, an amendment of the Environmental Management Programme Report (EMPR) for the Douglas Colliery operations was approved, to allow pillar mining (opencast) of the area previously mined by underground bord and pillar mining. Authorisation of the VDDC mining project included the following:

- Opencast operation on the farm Kleinkopje 15 IS;
- Opencast operation on the farm Steenkoolspruit 18 IS;
- Pillar extraction operation on the farm Vandyksdrift 19 IS;
- Reclamation of existing slurry ponds; and
- Rewashing of existing discard dumps (PHD, 2006).

The water uses associated with the opencast mining have been authorised in terms of Water Use Licence (WUL) number 24084535 dated 10 October 2008, issued to Douglas Colliery Services Limited.

The No. 2 seam workings are flooded with water and must be dewatered to enable the open pit development to proceed. A dewatering strategy has therefore been developed and an application for Environmental Authorisation (EA) of the dewatering activities was submitted to the Department of Mineral Resources (DMR) (Jaco-K Consulting, 2016(a)); a decision in this regard is pending. The water use activities associated with this upfront dewatering strategy have been authorised by WUL number 06/B11F/GCIJ/7943 dated 19 July 2018.

The 2007 approved EMPR Amendment included limited additional infrastructure in support of the opencast mining operations, as it was assumed at that stage that existing infrastructure will be used. In addition, the applications for authorisation of the activities associated with the dewatering strategy, were limited to the infrastructure to facilitate dewatering (i.e. dewatering boreholes, pumps, pipelines, storage tanks, mechanical evaporators, roads and power lines).

A pre-feasibility investigation has since been conducted, and the need to develop additional infrastructure to support the proposed opencast mining was identified. The additional infrastructure includes the following:

- Storm water management structures (drains and berms);
- Water management measures for the management of mine impacted water;
- Overburden dumps;
- ROM coal stockpile areas;
- Mixed ROM coal and slurry stockpile areas;
- Topsoil stockpiles following clearance of vegetation;
- Pipelines for the conveyance of water;
- Hard park area and brake test ramp; and
- Haul roads and service roads.

The proposed VDDC opencast pit boundary as determined through the pre-feasibility investigation also differs from the mining area approved in the 2007 EMPR amendment. An area of approximately 196 hectares in the latest mine lay-out was not included in the previous mine lay-out and is therefore not approved to be opencast mined.

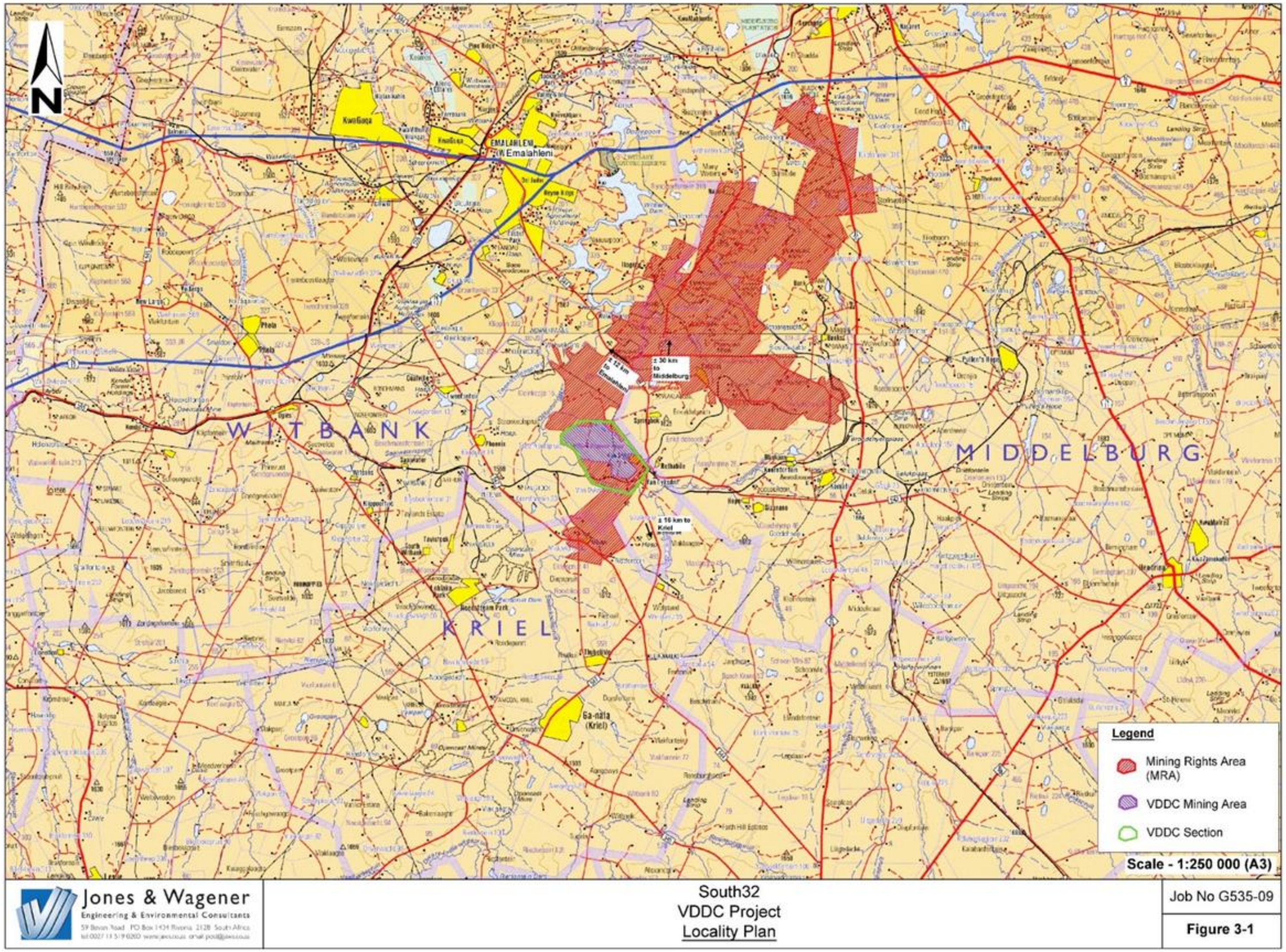

Figure 1: **General plan of the Wolvekrans Colliery with VDDC (Vandyksdrift Central) shown in purple. Map supplied by Jones and Wagener.**

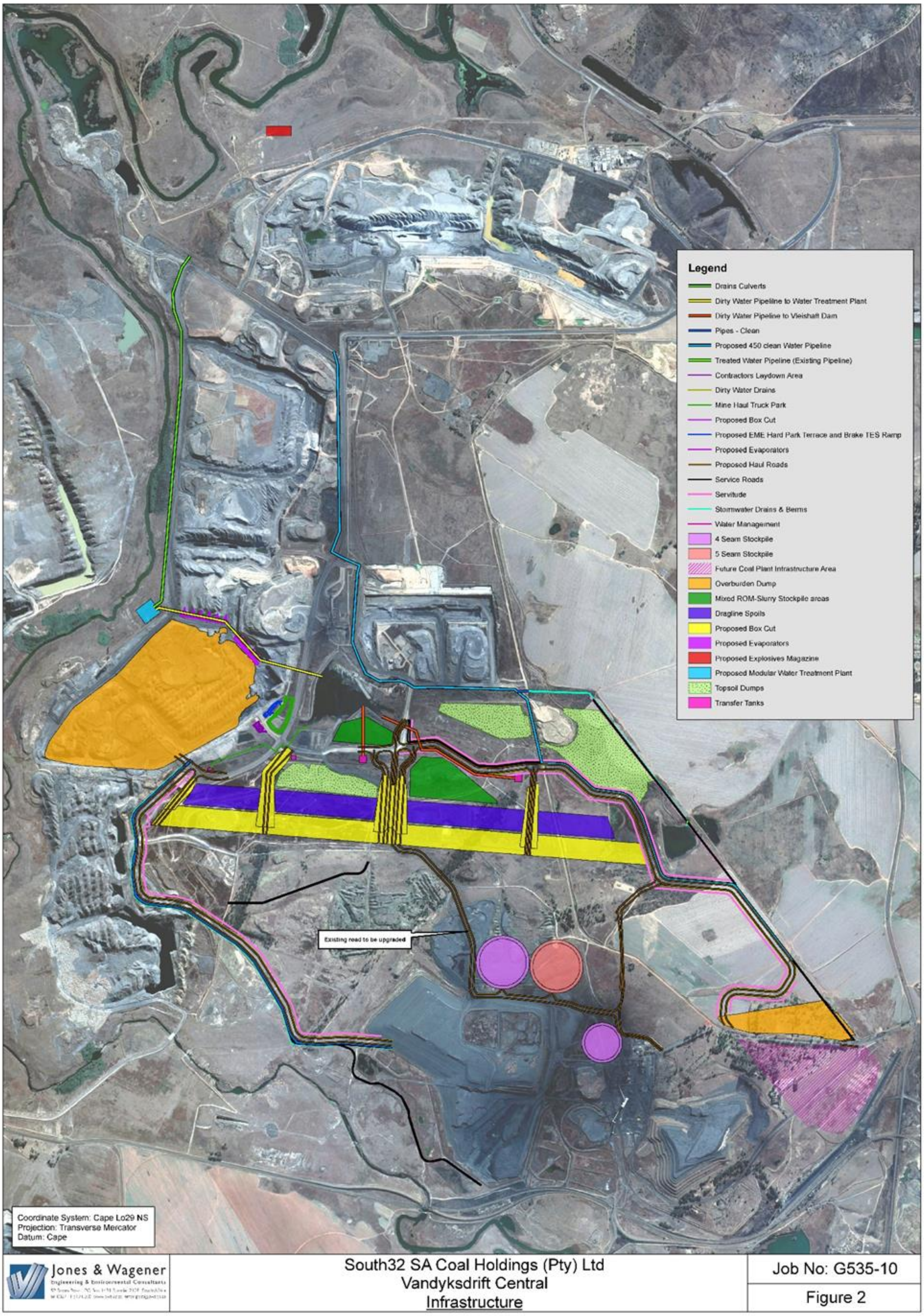

Figure 2: **Detailed map of the VDDC development.**

This report is the palaeontological impact assessment (PIA) for the project.

Table 1: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (2017)

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	**Relevant section in report**
ai	Details of the specialist who prepared the report	Appendix B
aii	The expertise of that person to compile a specialist report including a curriculum vitae	Appendix B
b	A declaration that the person is independent in a form as may be specified by the competent authority	Page i
c	An indication of the scope of, and the purpose for which, the report was prepared	Section 1
ci	An indication of the quality and age of the base data used for the specialist report: SAHRIS palaeosensitivity map accessed – date of this report	Yes
cii	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5
d	The date and season of the site investigation and the relevance of the season to the outcome of the assessment	N/A
e	A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 2
f	The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 4
g	An identification of any areas to be avoided, including buffers	N/A
h	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	N/A
i	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 5
j	A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 4
k	Any mitigation measures for inclusion in the EMPr	Appendix A
l	Any conditions for inclusion in the environmental authorisation	N/A
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Appendix A
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	N/A
nii	If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	N/A
o	A description of any consultation process that was undertaken during the course of carrying out the study	N/A

p	A summary and copies if any comments that were received during any consultation process	N/A
q	Any other information requested by the competent authority.	N/A

2. Methods and Terms of Reference

The Terms of Reference (ToR) for this study were to undertake a PIA and provide feasible management measures to comply with the requirements of South African Heritage Resources Agency (SAHRA).

The methods employed to address the ToR included:

1. Consultation of geological maps, literature, palaeontological databases, published and unpublished records to determine the likelihood of fossils occurring in the affected areas. Sources included records housed at the Evolutionary Studies Institute at the University of the Witwatersrand and SAHRA databases;

3. Geology and Palaeontology

i. Project location and geological context

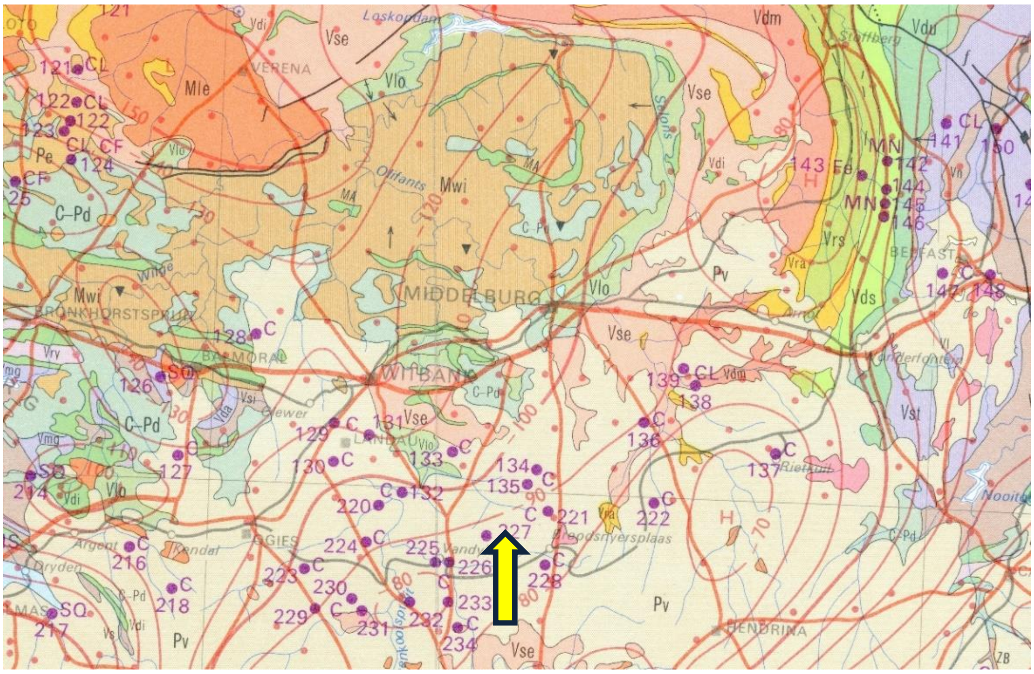

Figure 3: **Geological map of the area around Vandyksdrift, Mpumalanga Province, where the proposed mining project is located. The proposed site is indicated by the yellow arrow. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 1 000 000 map 1984.**

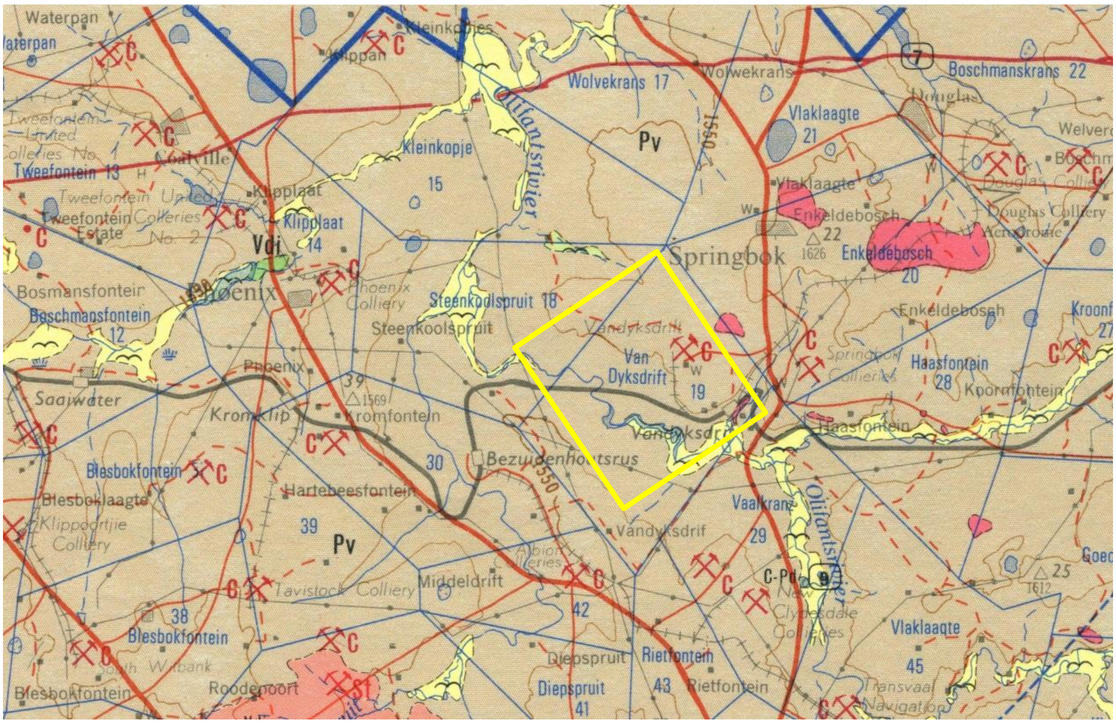

Figure 4: **Detailed geological map of the Vandyksdrift farm (within the yellow outline) and adjacent farms. Geological Survey 1:250 000 map 2628 East Rand 1996.**

Table 2: **Explanation of symbols for the geological map and approximate ages (Barker *et al*., 2006; Cawthorne et al., 2006; Cornell *et al*., 2006; Johnson *et al*., 2006;). SG = Supergroup; Fm = Formation; Ma = Million years.**

Symbol	Group/Formation	Lithology	Approximate Age
Pv	Vryheid Fm, Ecca Group, Karoo SG	Sandstone, shale, coal	Lower Permian, Middle Ecca
C-Pd	Dwyka Group	Tillite, sandstone, mudstone, shale	Upper Carboniferous, Early Permian 295-290 Ma
Mwi	Wilge River Fm, Waterberg Group	Red-bed sandstones, conglomerates	Ca 1700 Ma
Mle	Lebowa Granite Suite, Bushveld Complex	Granite	Ca 2050 Ma
Vlo	Loskop Fm, top of Transvaal Sequence	Shale, sandstone, conglomerate, volcanic rocks	Ca 2000 – 1700 Ma
Vse	Selons River Fm, Rooiberg Group, Bushveld Magmatic Province	Red porphyritic rhyolite	Ca 2061 - 2052 Ma

The VDDC project is in the southern part of the Witbank Coalfield where there are typically all five coal seams and sometimes several layers of No 4 seam (Snyman, 1998). They are overlain by soils for 5-10m from the land surface and then sandstones, shales and siltstones.

In this coalfield the various coal seams occur anywhere between 15m below surface down to 110m. Between the coal seams are bands of sandstones, shales and siltstones.

The older rocks distal from the collieries do not contain fossils and will not be considered further. Most are igneous in origin.

ii. Palaeontological context

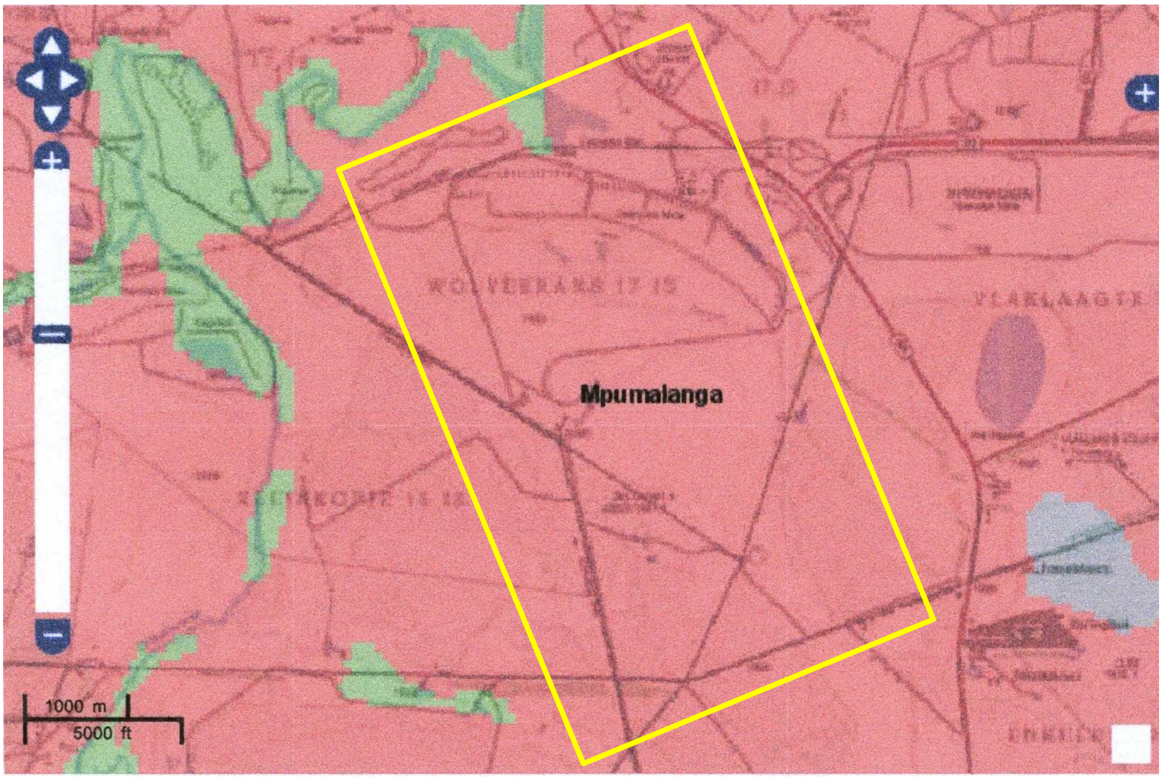

Figure 4: SAHRIS palaeosensitivity map of the region around Vandyksdrift Central of the Wolvekrans Colliery, Mpumalanga. The site in the red area. Colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

The project is located in a well established coal mining area with economically productive coal seams. While coal *per se* does not preserve any recognisable fossil plant material because it has been altered and compressed by high temperatures and pressures, impressions of the coal flora can be found in the shales and mudstones between the coal lenses. Typical coal flora plants are the seed fern *Glossopteris*, various lycopods, sphenophytes and ferns, with rare early gymnosperms.

The sediments in this area are the middle Ecca Group Vryheid Formation sandstones, shales and coals. Based on the palynological record the Vryheid Formation is 269-265 million years old and equivalent to the Wordian stage of the Guadalupian Epoch (Barbolini *et al*., 2016). The macroplant flora does not assist with age constraints but the Vryheid Formation taxa are listed in Appendix A. Vertebrates are seldom found to occur with fossil plants as the preservation conditions are different and vertebrate fossils are extremely rare at this time.

4. Impact assessment

The criteria and rating scales for the impact assessment are given in **Table 4-1 to Table 4-5**.

Table 4-1: Quantitative rating and equivalent descriptors for the impact assessment criteria

RATING	SIGNIFICANCE	EXTENT SCALE	TEMPORAL SCALE	PROBABILITY
1	VERY LOW	Isolated corridor / proposed corridor	Incidental	Practically impossible
2	LOW	Study area	Short-term	Unlikely
3	MODERATE	Local	Medium-term	Could happen
4	HIGH	Regional / Provincial	Long-term	Very Likely
5	VERY HIGH	Global / National	Permanent	It's going to happen / has occurred

Table 4-2: Description of the significance rating scale

RATING		DESCRIPTION
5	VERY HIGH	Of the highest order possible within the bounds of impacts which could occur. In the case of adverse impacts: there is no possible mitigation and/or remedial activity that could offset the impact. In the case of beneficial impacts, there is no real alternative to achieving this benefit.
4	HIGH	Impact is of substantial order within the bounds of impacts, which could occur. In the case of adverse impacts: mitigation and/or remedial activity is feasible but difficult, expensive, time-consuming or some combination of these. In the case of beneficial impacts, other means of achieving this benefit are feasible but they are more difficult, expensive, time-consuming or some combination of these.
3	MODERATE	Impact is real but not substantial in relation to other impacts, which might take effect within the bounds of those that could occur. In the case of adverse impacts: mitigation and/or remedial activity are both feasible and fairly easily possible. In the case of beneficial impacts: other means of achieving this benefit are about equal in time, cost, effort, etc.

2	LOW	Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts: mitigation and/or remedial activity is either easily achieved or little will be required, or both. In the case of beneficial impacts, alternative means for achieving this benefit are likely to be easier, cheaper, more effective, less time consuming, or some combination of these.
1	VERY LOW	Impact is negligible within the bounds of impacts that could occur. In the case of adverse impacts, almost no mitigation and/or remedial activity is needed, and any minor steps which might be needed are easy, cheap, and simple. In the case of beneficial impacts, alternative means are almost all likely to be better, in one or a number of ways, than this means of achieving the benefit. Three additional categories must also be used where relevant. They are in addition to the category represented on the scale, and if used, will replace the scale.
0	NO IMPACT	There is no impact at all - not even a very low impact on a party or system.

Table 4-3: Description of the spatial scale

RATING		DESCRIPTION
5	Global/National	The maximum extent of any impact.
4	Regional/Provincial	The spatial scale is moderate within the bounds of impacts possible and will be felt at a regional scale (District Municipality to Provincial Level). The impact will affect an area up to 50km from the proposed site / corridor.
3	Local	The impact will affect an area up to 5km from the proposed route corridor / site.
2	Study Area	The impact will affect a route corridor not exceeding the boundary of the corridor / site.
1	Isolated Sites / proposed site	The impact will affect an area no bigger than the corridor / site.

Table 4-4: Description of the temporal rating scale

RATING		DESCRIPTION
1	Incidental	The impact will be limited to isolated incidences that are expected to occur very sporadically.
2	Short-term	The environmental impact identified will operate for the duration of the construction phase or a period of less than 5 years, whichever is the greater.
3	Medium term	The environmental impact identified will operate for the duration of life of the project.
4	Long term	The environmental impact identified will operate beyond the life of operation.
5	Permanent	The environmental impact will be permanent.

Table 4-5: Description of the degree of probability of an impact occurring

RATING	DESCRIPTION
1	Practically impossible
2	Unlikely
3	Could happen
4	Very Likely
5	It's going to happen / has occurred

Table 4-5: Impact Risk Classes

RATING	IMPACT CLASS	DESCRIPTION
0.1 – 1.0	1	Very Low
1.1 – 2.0	2	Low
2.1 – 3.0	3	Moderate
3.1 – 4.0	4	High
4.1 – 5.0	5	Very High

Based on the nature of the infrastructure development, the surface soils will be excavated to a depth of several metres for the construction of the storm water management structures, Mixed ROM coal and slurry management area; topsoil stockpile following clearance of vegetation; pipelines for the conveyance of water; and new haul roads. Since there is no chance of finding fossils in the top soils and down to about 15m or more, there would be no impact on the fossil heritage. Taking account of the defined criteria, the potential impact to fossil heritage resources associated with the infrastructure development is very low.

Opencast mining in the area not approved previously will result in the excavation of the shales and mudstones between the coal lenses where paleontological finding could be made.
The results are summarised below for the palaeontology impact of the opencast mining:

- Significance = 2 (Impact is of a low order and therefore likely to have little real effect)
- Spatial scale = 1 (Isolated Sites / proposed site. The impact will affect an area no bigger than the corridor / site)
- Temporal scale = 5 (Permanent. The environmental impact will be permanent)
- Probability = 4 (Very Likely)

Degree of certainty = high.

When the results are inserted into the following formula to obtain the Impact Risk rating = 2.133 (moderate; see table 4-6)

Impact Risk = (SIGNIFICANCE **+** *Spatial* **+** Temporal) X Probability

3 5

(2 + 1 + 5)/3 X 4/5 = 2.1333333

A Chance Find Protocol should be added to the EMPr given that there are fossiliferous sediments below ground and associated with the coal seams.

5. Assumptions and uncertainties

Based on the geology of the area and the palaeontological record as we know it, it can be assumed that the formation and layout of the shales, mudrocks and coal seams could contain impressions of leaves of the Glossopteris flora in the associated shales BUT these would not be preserved in the surface soils or coarse sandstones. Vertebrate fossils are extremely rare at this time and seldom occur with fossil plants. Although no fossils have been recorded from this region, there is a small chance that they could, so a Chance Find Protocol should be included (see appendix A and photographs of fossil plants).

6. Recommendation

Since the whole area of this project is palaeontologically sensitive, a monitoring programme and Chance Find Protocol should be included in the EMPr that should come into effect once mining for the project commence. It is not known at what depth fossils could occur. Topsoils do not preserve fossils so there is no point in carrying out a site visit before excavations begin as any potential fossils would not be visible. If recognisable fossils are found by the responsible person monitoring the excavated sediments, then a palaeontologist should be called to assess them. As far as the palaeontology is concerned the proposed development can go ahead. Any further palaeontological assessment would only be required after mining has commenced and if fossils are found by the geologist or environmental personnel.

7. References

Aitken, G. 1994. Permian palynomorphs from the Number 5 Seam, Ecca Group, Witbank Highveld Coalfields, South Africa. Palaeontologia africana 31: 97-109.

Anderson, J.M., Anderson, H.M., 1985. Palaeoflora of Southern Africa: Prodromus of South African megafloras, Devonian to Lower Cretaceous. A.A. Balkema, Rotterdam. 423 pp.

Barbolini, N., Bamford, M.K., Rubidge, B., 2016 Radiometric dating demonstrates that Permian spore-pollen zones of Australia and South Africa are diachronous. Gondwana Research 37, 241-251.

Johnson, M.R., van Vuuren, C.J., Visser, J.N.J., Cole, D.I., Wickens, H.deV., Christie, A.D.M., Roberts, D.L., Brandl, G., 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R., Anhaeusser, C.R. and Thomas, R.J., (Eds). The Geology of South Africa. Geological Society of South Africa, Johannesburg / Council for Geoscience, Pretoria. Pp 461 – 499.

Plumstead, E.P., 1969. Three thousand million years of plant life in Africa. Geological Society of southern Africa, Annexure to Volume LXXII. 72pp + 25 plates.

Rubidge BS (ed). 1995. Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Stratigraphy Biostratigraphic Series 1. Council for Geoscience, South Africa.

Snyman, C.P., 1998. Coal. In: Wilson, M.G.C., and Anhaeusser, C.P., (Eds) The Mineral Resources of South Africa: Handbook, Council for Geosciences 16, 136-205.

Appendix A – Chance Find Protocol and examples of fossil plants from the Vryheid Formation

Monitoring programme is outlined below.

Monitoring Programme for Palaeontology – to commence once the mining activities have begun.

1. The following procedure is required when deep excavations commence. The surface activities most likely would not impact on the fossil heritage as the coal and any associated fossil plants are below ground.
2. When mining operations commence the shales and mudstones (of no economic value) that will be cut through in order to reach the coal seam must be given a cursory inspection by the mine geologist or designated person before being added to the waste rock dump used by the mine. Any fossiliferous material should be put aside in a suitably protected place. This way the mining activities will not be interrupted.
3. Photographs of similar fossil plants must be provided to the mine to assist in recognizing the fossil plants in the shales and mudstones (for example see Figure 1 and 2). This information will be built into the mine's training and awareness plan and procedures.
4. On a regular basis, to be determined by the mine management, the responsible person should examine a representative sample of non-coal material and look for fossil plants and take digital photographs of them to send to a qualified palaeontologist/ palaeobotanist sub-contracted for this project to get an opinion on their scientific value.
5. Fossil plants that are considered to be of good quality or scientific interest by the palaeobotanist must be removed, catalogued and housed in a suitable institution where they can be made available for further study. Before the fossils are removed from the mine property a SAHRA permit must be obtained. A report must be submitted to SAHRA as required by the relevant permits.
6. If any open pit inspection is deemed necessary then the normal safety procedures that the mine management endorses, must be followed by the palaeontologist and associated mine employees.
7. If no good fossil material is recovered then no site visits will be required by the palaeontologist.

Table 1: List of Vryheid Formation flora and fauna (Aitken, 1994; Anderson & Anderson, 1985; Barbolini et al., 2016; Plumstead, 1969; Rubidge et al., 1995).

Flora - macroplants	Flora – microfossils	Fauna
Azaniodendron fertile, *Cyclodendron leslii,* *Sphenophyllum hammanskraalensis,* *Annularia sp.,* *Raniganjia sp.,* *Asterotheca spp.,* *Liknopetalon enigmata*, *Glossopteris* > 20 species, *Hirsutum 4 spp.,* *Scutum 4 spp.,* *Ottokaria 3 spp.,* *Estcourtia sp.,* *Arberia 4 spp.,* *Lidgetonia sp.,* *Noeggerathiopsis sp.* *Podocarpidites sp*	*Protohaploxypinus microcarpus* *Praecolpatities sinuous* *Microbaculispora trisina* *Striatopodocarpites cancellatus* *Striatopodocarpites fusus* *Pseudoreticulatispora pseudoreticulata* *Pseudoreticulatispora confluens* Taeniate bisaccate pollen	*Mesosaurus* in the lowest part

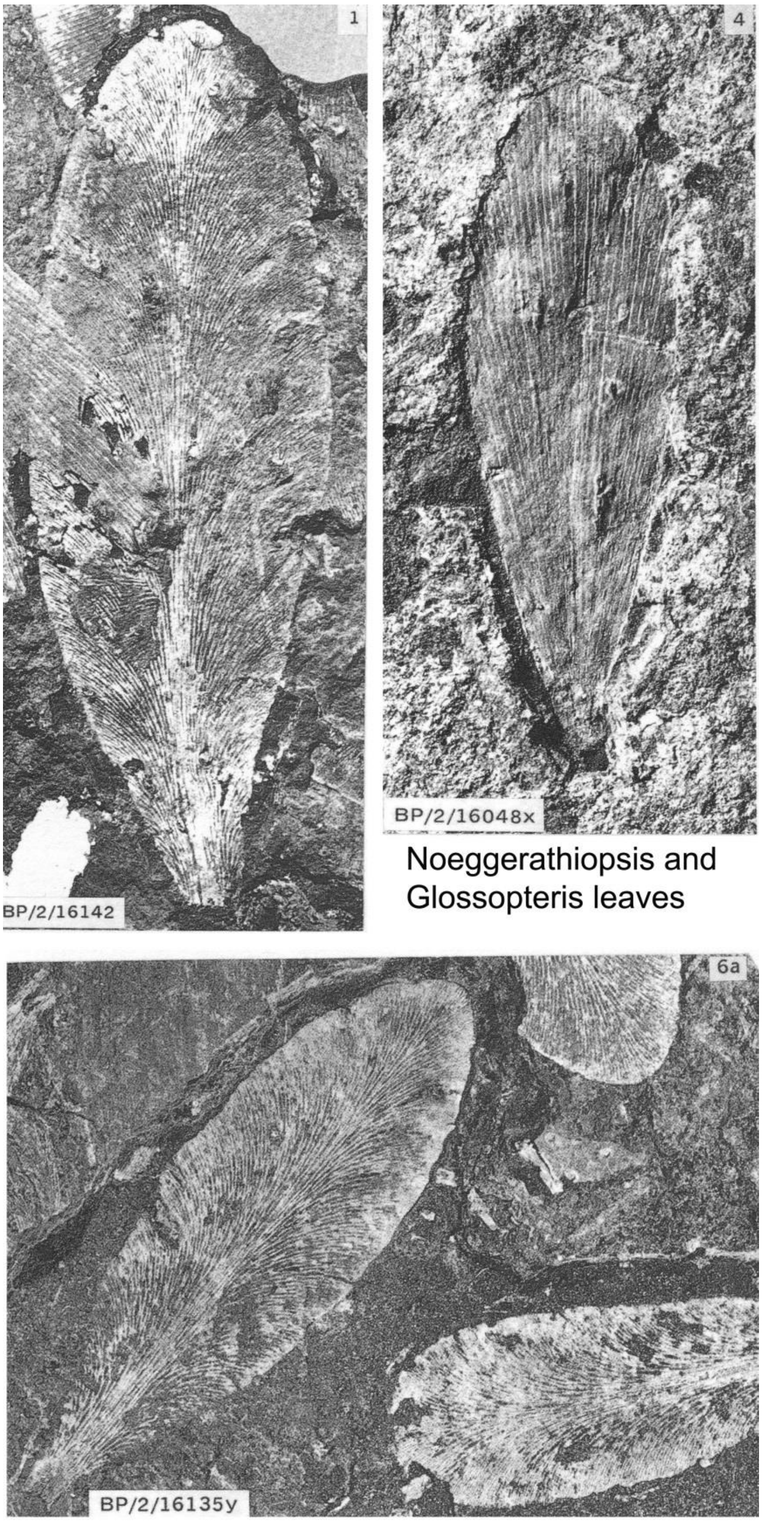

Figure 1: **examples of fossils from the Vryheid Formation, *Glossopteris* sp. and *Noeggerathiopsis* sp.**

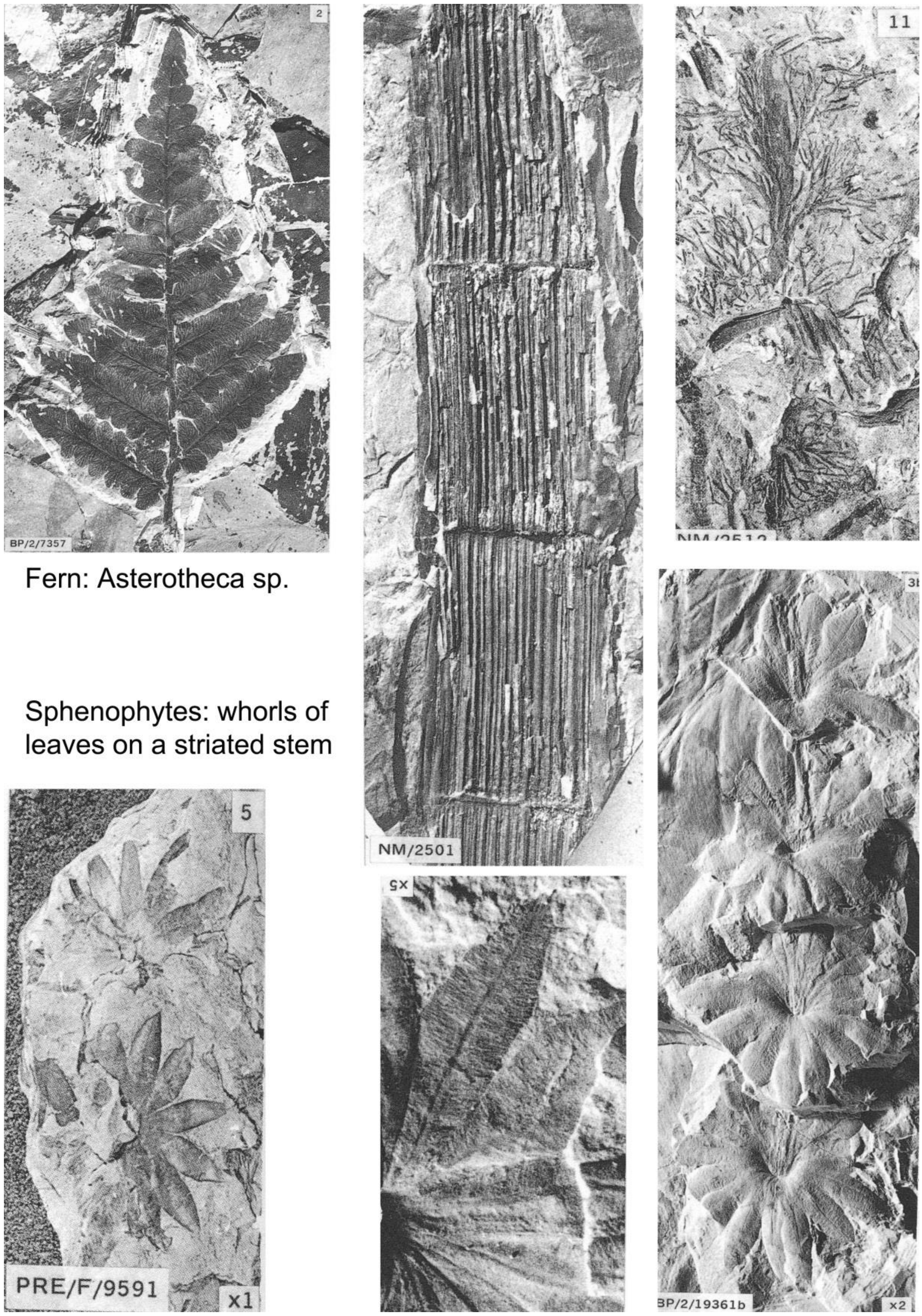

Figure 2: Examples of ferns and sphenophytes (horsetails) from the Vryheid Formation.

Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD
June 2019

i) Personal details

Surname	:	**Bamford**
First names	:	**Marion Kathleen**
Present employment	:	Professor; Director of the Evolutionary Studies Institute. Member Management Committee of the NRF/DST Centre of Excellence Palaeosciences, University of the Witwatersrand, Johannesburg, South Africa-
Telephone	:	+27 11 717 6690
Fax	:	+27 11 717 6694
Cell	:	082 555 6937
E-mail	:	marion.bamford@wits.ac.za ; marionbamford12@gmail.com

ii) Academic qualifications

Tertiary Education: All at the University of the Witwatersrand:
1980-1982: BSc, majors in Botany and Microbiology. Graduated April 1983.
1983: BSc Honours, Botany and Palaeobotany. Graduated April 1984.
1984-1986: MSc in Palaeobotany. Graduated with Distinction, November 1986.
1986-1989: PhD in Palaeobotany. Graduated in June 1990.

iii) Professional qualifications

Wood Anatomy Training (overseas as nothing was available in South Africa):
1994 - Service d'Anatomie des Bois, Musée Royal de l'Afrique Centrale, Tervuren, Belgium, by Roger Dechamps
1997 - Université Pierre et Marie Curie, Paris, France, by Dr Jean-Claude Koeniguer
1997 - Université Claude Bernard, Lyon, France by Prof Georges Barale, Dr Jean-Pierre Gros, and Dr Marc Philippe

iv) Membership of professional bodies/associations

Palaeontological Society of Southern Africa
Royal Society of Southern Africa - Fellow: 2006 onwards
Academy of Sciences of South Africa - Member: Oct 2014 onwards
International Association of Wood Anatomists - First enrolled: January 1991
International Organization of Palaeobotany – 1993+

Botanical Society of South Africa
South African Committee on Stratigraphy – Biostratigraphy - 1997 - 2016
SASQUA (South African Society for Quaternary Research) – 1997+
PAGES - 2008 –onwards: South African representative
ROCEEH / WAVE – 2008+
INQUA – PALCOMM – 2011+onwards

vii) Supervision of Higher Degrees

All at Wits University

Degree	Graduated/completed	Current
Honours	5	2
Masters	8	1
PhD	10	2
Postdoctoral fellows	9	3

viii) Undergraduate teaching
Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 25 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 2-8 students per year.

ix) Editing and reviewing
Editor: Palaeontologia africana: 2003 to 2013; 2014 – current Assistant editor
Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology: 2010 – current
Cretaceous Research: 2014 - current

Review of manuscripts for ISI-listed journals: 25 local and international journals

x) Palaeontological Impact Assessments

Selected – list not complete:

- Thukela Biosphere Conservancy 1996; 2002 for DWAF
- Vioolsdrift 2007 for Xibula Exploration
- Rietfontein 2009 for Zitholele Consulting
- Bloeddrift-Baken 2010 for TransHex
- New Kleinfontein Gold Mine 2012 for Prime Resources (Pty) Ltd.
- Thabazimbi Iron Cave 2012 for Professional Grave Solutions (Pty) Ltd
- Delmas 2013 for Jones and Wagener
- Klipfontein 2013 for Jones and Wagener
- Platinum mine 2013 for Lonmin
- Syferfontein 2014 for Digby Wells

- Canyon Springs 2014 for Prime Resources
- Kimberley Eskom 2014 for Landscape Dynamics
- Yzermyne 2014 for Digby Wells
- Matimba 2015 for Royal HaskoningDV
- Commissiekraal 2015 for SLR
- Harmony PV 2015 for Savannah Environmental
- Glencore-Tweefontein 2015 for Digby Wells
- Umkomazi 2015 for JLB Consulting
- Ixia coal 2016 for Digby Wells
- Lambda Eskom for Digby Wells
- Alexander Scoping for SLR
- Perseus-Kronos-Aries Eskom 2016 for NGT
- Mala Mala 2017 for Henwood
- Modimolle 2017 for Green Vision
- Klipoortjie and Finaalspan 2017 for Delta BEC
- Isondlo and Kwasobabili 2018 for GCS
- Kanakies Gypsum 2018 for Cabanga
- Nababeep Copper mine 2018
- Glencore-Mbali pipeline 2018 for Digby Wells
- Remhoogte PR 2019 for A&HAS
- Bospoort Agriculture 2019 for Kudzala
- Overlooked Quarry 2019 for Cabanga
- Richards Bay Powerline 2019 for NGT
- Eilandia dam 2019 for ACO

xi) Research Output

Publications by M K Bamford up to June 2019 peer-reviewed journals or scholarly books: over 135 articles published; 5 submitted/in press; 8 book chapters.
Scopus h-index = 26; Google scholar h-index = 30;
Conferences: numerous presentations at local and international conferences.

xii) NRF Rating

NRF Rating: B-2 (2016-2020)
NRF Rating: B-3 (2010-2015)
NRF Rating: B-3 (2005-2009)
NRF Rating: C-2 (1999-2004)