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SAMANCOR

Air Quality Assessment for the Varkensvlei/Nooitgedacht Mining Rights Application

Submitted to:
Heather Booysens
Group Environmental Manager
Samancor

REPORT

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Golder Associates

Executive Summary

Project location

The proposed Varkenvlei/Nooitgedacht mine (NV mine) is located approximately 47km south-west of Thabazimbi, 80km north of Rustenburg and 15 km north-west of the R510 and the town of Northam. The proposed mining area straddles the provincial boarder between the North West and Limpopo provinces.

Project overview

The proposed mining operation will be done by means of a conventional truck and shovel operation with drilling and blasting via a single benching method. The mining bench will be planned at 3 m to 5 m intervals with a catchment berm at 6 m intervals making the effective bench stack height 4 m. The first 18 m bench will be mined or excavated in four 4 m half benches or interim benches (this will depend on the equipment used). There after the second bench of 12 m will be mined or excavated in three 4 m benches. The final bench will be 10 m and will be mined or excavated in three 3 m half benches. This would conclude the final footprint and mineable depth of the opencast mining operation.

During blasting, the pit highwall will be protected against blast induced fracturing by one of two methods:

- The first method is pre-split blast holes closely spaced for the first drill line, close to the final highwall; and
- The second method is the planning of shorter blast holes (and thus shorter drilling benches of 12 m versus 24 m) slightly angled away from the highwall (90° drilling angle). The 10 m blast-hole depth will reduce the explosive gas expansion and ground vibration that influences crack initiation and migration on the final highwall of the pits. The highwall will have a pushback of 6° to 7° or 83° degrees vertical.

All overburden and waste rock will be placed away from chrome sub-outcrop positions, on the highwall side of the maximum highwall position.

There will be no beneficiation plant for this operation and thus the ore processing will consist of crushing and screening provide various saleable products. Waste materials will be deposited on waste rock dumps and later backfilled into the opencast void.

The major items of equipment that will be used in the mobile plant are the following:

- A mobile / moveable crushing unit will crush the oversized ROM ore that exceeds +100 mm after it has passed over the screen;
- Front loaders and dump trucks will be used to transport the ROM ore and products in the following three main areas;
  - ROM ore from opencast to the ROM screening area;
  - Between the different sizing / screening steps; and
  - Final products to the various product stockpiles based on size and quality.
- Front loaders will be used to feed ROM material onto conveyor the screen; and
- Screens will be used to separate the ROM material into different sizes as final product.

Surrounding land uses and sensitive receptors

Land uses in the area include the following:

- Subsistence farming (crop & cattle);

- Mining opertions;
- Residential townships and villages;
- Nature reserves;
- Eco tourism lodges; and
- An extensive network of good quality gravel access roads.

The following are identified as the nearest sensitive receptors (Figure 3):

- The farm located about 4km to the north;
- Kraalhoek village, approximately 4.5km to the west-north-west;
- The Swartklip residential areas located approximately 2.5km to the east-north-east and approximately 3.8km to the east-south-east;
- Mantserre village approximately 2.8 km to the west-south-west;
- Mopyane village approximately 5.7 km to the west-south-west;
- Sesfikele village approximately 9.6 km to the south-east;
- Ga-Ramosidi village approximately 9.7 km to the south-south-east;
- Northam town approximately 14.8 km to the south-south-east; and
- Mojuteng village approximately 14.7 km to the south-south-east.

Meteorological conditions

Samancor does not undertake any meteorological monitoring at the proposed NV Mine site and thus the statistics provided are based on available literature from the region (Pilanesberg and Thabazimbi regions) and MM5 modelled meteorological data.

Based on MM5 Modelled meteorological data, *w*inds at the NV Mine are expected to originate equally from the east-south-east (12.5% of the time) and east (9.5 % of the time). Wind speeds are low to moderate, with a low percentage (19.24%) of calm conditions (<1 m/s). A very slight diurnal variation in wind is observed during the monitoring period. A significant seasonal variation in wind is observed during the monitoring period

In comparing the annual wind roses for the Pilanesberg and the MM5 modelled data wind rose for the NV Mine, it is clear that the outputs are not consistent with each other. Similarly, in when comparing the annual wind roses for the Thabazimbi region and the MM5 modelled data wind rose for the NV Mine, the outputs are found not to be consistent.

This is probably due to the meteorological conditions throughout the District being strongly influenced by the underlying topography in the region (Bojanala Platinum District Municipality AQMP Baseline Assessment, 2010). Due to the uncertainty in this regard, and with the application of the precautionary principal, a low level of confidence is thus instilled in the MM5 modelled data.

Note: In order to obtain a better understanding (an accurate site specific account) of the meteorological conditions on site, Samancor should install and operate a professional meteorological station (required data accuracy of 1-2%) on a continuous basis.

Baseline air quality

Limited air quality monitoring information is available in the both the Waterberg and Bojanala Platinum Districts, which makes it difficult to accurately quantify the current state of the air quality (Gondwana Environmental Solutions, 2009 & 2010). Additionally, Samancor does not undertake any ambient air quality monitoring in the vicinity of the proposed NV mine and the project site is relatively remote and thus very little ambient air quality information is available as most of the monitoring networks are located in the urban areas (i.e. Rustenburg) and/or on the larger mines such as Impala Platinum, Lonmin Platinum and Anglo Platinum (located approximately 60km to 90km's south-south-east of the proposed NV mine) or at the power generation facilities such as the Matimba Power Station (located approximately 150km north-north-east of the proposed NV mine). Data recorded at these stations, although a very long distance from the proposed NV mine may be used to infer a high level regional air overview for the region.

Note: Due to the lack of available baseline ambient air quality information for this region, it is recommended that Samancor deploys an ambient air quality monitoring campaign to determine the background air quality prior to the mines extension. This network should monitor the following pollutants; Dust fallout, PM_{10}, NO_2 and SO_2 and monitor wind speed and direction as a minimum.

Sources

Potential sources of air pollution within the NV Mine area have been identified to include:

- Agricultural activities;
- Current mining activities (platinum, lime and iron);
- Cement production;
- Domestic fuel burning;
- Biomass burning;
- Vehicle emissions (tailpipe and entrained emissions);
- Unpaved roads and exposed areas; and
- The proposed construction activity emissions (I.e. the new NV Mine).

SUMMARY

Based on the qualitative impact assessment and Golders associated professional opinion, without the implementation of particulate mitigation measures during the construction and operational phases of the NV Mine, exceedances of:

- The PM_{10} daily average standard;
- The PM_{10} annual average standard; and
- The draft dust fallout guidelines (both residential and industrial).

Are likely to occur at several of the key sensitive receptors. Without the implementation of suitable mitigation measures the local ambient air quality may be degenerated by the emissions contribution from the NV mine. This degeneration in the local air quality may impact negatively on the key sensitive receptors health and wellbeing.

RECOMMENDATIONS

- Suitable mitigation measures must be implemented to reduce the project's impact to acceptable levels at the sensitive receptors;
- Due to the lack of available baseline ambient air quality information for this region, it is recommended that Samancor deploy an ambient air quality monitoring campaign to determine the site specific background air quality. This network should monitor the following:
  - PM_{10} on a continuous basis;
  - Dust fallout monitoring in alignment with the draft regulations on a continuous basis for the footprint of the mine; and
  - NO_2 and SO_2 via a minimum 3 month monitoring campaign.
- Due to the lack of available site specific meteorological data and the uncertainty around the modelled data, Samancor should install a professional meteorological station (required data accuracy of 1-2%) on site. The station should operate on a continuous basis;
- For all waste rock dump and overburden stockpiles mitigation measures for TSP and PM_{10} generation could include:
  - Progressive rehabilitation and re-vegetation should be implemented;
  - Chemical stabilisation; and
  - Facility design and maintenance to exclude and minimise the development of sharp edges that can lead to excessive particulate dust generation due to air eddy and erosive effects below the sharp edge.
- For paved and unpaved roads mitigation measures for TSP and PM_{10} generation could include:
  - Many dust mitigation measures are available for the minimisation of fugitive dust generation on unpaved roads. These may include:
    - Wet suppression with water;
    - Application of salts - hygroscopic compounds such as calcium chloride, magnesium chloride, hydrated lime, sodium silicates, etc. Salts increase roadway surface moisture by extracting moisture from the atmosphere;
    - Application of surfactants - such as soaps and detergents. Surfactants decrease the surface tension of water, which allows the available moisture to wet more particles per unit volume;
    - Application of soil cements - compounds that are mixed with the native soils to form a new surface. Examples are calcium or ammonium lignin sulphonate, cement, etc.;
    - Application of bitumens - compounds derived from coal or petroleum such as coherex peneprime, asphalt, oils, etc.; and
    - Application of films—polymers that form discrete tissues, layers, or membranes such as latexes, acrylics, vinyls, fabrics, etc. These form coherent surface layers that seal the road surface, thereby reducing the quantity of dust generated.
  - The application of the above measures must be considered carefully as certain measures could possibly lead to surface water contamination and the management thereof must be strictly controlled.

- Furthermore, a detailed cost benefit analysis should be conducted to determine which, is the most cost-effective method with the highest efficiency in dust reduction.

- General transport mitigation measures may include:
  - Reduction in unnecessary traffic volumes;
  - Conversion of the unpaved road surface to a paved surface;
  - Rigorous speed control and the institution of traffic calming measures to reduce vehicle entrainment. A recommended maximum speed of 20 km/h to be set on all unpaved roads and 35 km/h on paved roads;
  - Wet suppression of materials transported by road (i.e. load spraying) or load covering with tarpaulins to reduce fugitive dust generation;
  - Avoidance of dust track-on onto neighbouring paved roads; and
  - All vehicles and other equipment should be maintained and serviced regularly to ensure that tailpipe particulate emissions are kept to a minimum.

- For ore stockpiles, mitigation measures for TSP and PM_{10} generation could include:
  - Haul road dust generation (refer to travelling on unpaved roads section);
  - Drop height reduction during materials handling activities;
  - Wet suppression during materials handling activities;
  - Stockpile height reduction to reduce the stockpiles exposure to wind at elevated heights;
  - Introduction of wind breaks or sheltering; and
  - Wet suppression of materials transported by road (i.e. load spraying) or load covering with tarpaulins to reduce fugitive dust generation.

- For blasting, mitigation measures for TSP and PM_{10} generation could include:
  - Wet suppression is important in controlling dust generated by blasting activities. The area surrounding the blast should be thoroughly wetted down beforehand. This precaution will prevent dust settled out during previous blasts from becoming airborne.
  - The water used for dust suppression during blasting should be as clean as possible, because the evaporation of dirty water can also release dust;
  - The blast charge should be calculated as accurately as possible and kept to the minimum required as the larger the charge, the higher the potential for dust generation; and
  - Consideration of wind speed and direction in the blasting schedule, particularly where communities live nearby and may be affected by blasting emissions.

- For materials handling operations, mitigation measures for TSP and PM_{10} generation could include:
  - Drop height reduction during materials handling activities;
  - Wet suppression during materials handling activities;
  - Load wet suppression of materials transported by road (i.e. load spraying) or load covering with tarpaulins to reduce fugitive dust generation;
  - Removal of fines via pre-washing; and

- Wind speed reduction through sheltering *(where possible)*.

- For drilling activities, mitigation measures for TSP and PM_{10} generation could include:
  - Overburden and waste rock drilling generates most of the respirable dust that affects workers in the mining pit. Both wet and dry methods are available to reduce this drill dust.
  - Typically, wet suppression systems pump water through the drill steel into the bailing air (ILO, 1965). The water droplets in the bailing air trap dust particles as they travel up the annular space of the drilled hole, thus controlling dust as the air bails the cuttings from the drill hole (Page, 1991).
  - Dry collection systems require an enclosure (shroud) around the area where the drill stem enters the ground. This enclosure is typically constructed by hanging a rubber or cloth shroud from the underside of the drill deck. The enclosure is then ducted to a dust collector, the clean side of which has a fan. The fan creates a negative pressure inside the enclosure, capturing dust as it exits the hole during drilling. The dust is removed in the collector, and clean air is exhausted through the fan; and
  - The water used for dust suppression, during drilling should be as clean as possible, because the evaporation of dirty water can also release dust.

- For crushing activities, mitigation measures for TSP and PM_{10} generation could include:
  - Drop height reduction during materials handling activities at the crushers;
  - Wet suppression of materials to be crushed. If the material is dry, a starting point is to add a water quantity equivalent to 1% of the weight of the material being crushed (Quilliam, 1974);
  - Regular cleaning of floor and working surfaces in the vicinity of the crusher/s to reduce fugitive dusts; and
  - Negative pressure should be maintained where possible within the crusher to prevent the escape of fugitive dusts.

LIST OF ABBREVIATIONS AND TERMS

AEL	Atmospheric emission license
APPA	Atmospheric Pollution Prevention Act (Act no. 45 of 1965)
AQIA	Air quality impact assessment
AQMPs	Air quality management plans
ASTMD1739	American Society for Testing and Materials standard method for collection and analysis of windblown dust deposition.
BCR	Bushveld Chrome Resources (Pty) ltd.
BTEX	Benzene, ethylbenzene, toluene & Xylene
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
DEAT	Department of Environmental Affairs and Tourism
DJF	December, January, February
DME	Department of Minerals and Energy
DWEA	Department of Water and Environmental Affairs (New DEAT)
E	East
EIA	Environmental impact assessment
ENE	East-north-east
EMP	Environmental management plan
EMPR's	Environmental management programme reports
ESE	East-south-east
GAA	Golder Associates Africa (Pty) Ltd
JJA	June, July, August
km	Kilometer
km/h	Kilometer per hour
LOM	Life of Mine
MAM	March, April, May
$mg/m^2/day$	Milligrams per meter squared per day
µg	Microgram
$\mu g/m^3$	Micrograms per cubic meter
mg	Milligrams
MPRDA	Minerals Resources Petroleum Development Act (Act no. 28 of 2002)
N	North
NE	North-east
NEMA:AQA	National Environmental Management Act: Air Quality Act (Act no. 39 of 2004)
NNE	North-north-east
NW	North-west
NNW	North-north-west
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NV Mine	Varkenvlei/Nooitgedacht mine
PM_{10}	Particulate matter with an aerodynamic diameter of less than 10 µm

ROM	Run of Mine
SAAQIS	South African Air Quality Information System
SANS	South African National Standards
SANS 1929	South African National Standard 1929
SAWS	South African Weather Service
S	South
SE	South-east
SON	September, October, November
SO2	Sulphur dioxide
SSE	South-south-east
SW	South-west
SSW	South-south-west
t/pd	Tons per day
t/ph	Tons per hour
TSP	Total suspended particulates
US EPA	United States Environmental Protection Agency
W	West
WHO	World health organisation
WNW	West-north-west
WSW	West-south-west

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APPENDICES

1.0 INTRODUCTION

Samancor (Pty) Ltd ('Samancor') approached Golder Associates Africa (Pty) Ltd ('GAA') to undertake a specialist air quality assessment and meteorological overview for the environmental authorisation processes for the proposed Varkenvlei/Nooitgedacht mine near Thabazimbi.

2.0 PROJECT BACKGROUND

The proposed Varkenvlei/Nooitgedacht mine (NV mine) is located approximately 47km south-west of Thabazimbi, 80km north of Rustenburg and 15 km north-west of the R510 and the town of Northam. The proposed mining area straddles the provincial boarder between the North West and Limpopo provinces (Figure 1).

Figure 1: Regional location of the proposed NV Mine (Google Earth, February 2013)

2.1 Summary Description of Proposed Facilities / Activities

2.1.1 Mining

The proposed mining operation will be done by means of a conventional truck and shovel operation with drilling and blasting via a single benching method. The mining bench will be planned at 3 m to 5 m intervals with a catchment berm at 6 m intervals making the effective bench stack height 4 m. The first 18 m bench will be mined or excavated in four 4 m half benches or interim benches (this will depend on the equipment used). There after the second bench of 12 m will be mined or excavated in three 4 m benches. The final bench will be 10 m and will be mined or excavated in three 3 m half benches. This would conclude the final footprint and mineable depth of the opencast mining operation.

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- The first method is pre-split blast holes closely spaced for the first drill line, close to the final highwall; and

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All overburden and waste rock will be placed away from chrome sub-outcrop positions, on the highwall side of the maximum highwall position.

2.1.2 Basic processing plant design

There will be no beneficiation plant for this operation and thus the ore processing will consist of crushing and screening provide various saleable products. Waste materials will be deposited on waste rock dumps and later backfilled into the opencast void. Figure 2 depicts a schematic flow sheet and description of the major items in the proposed plant.

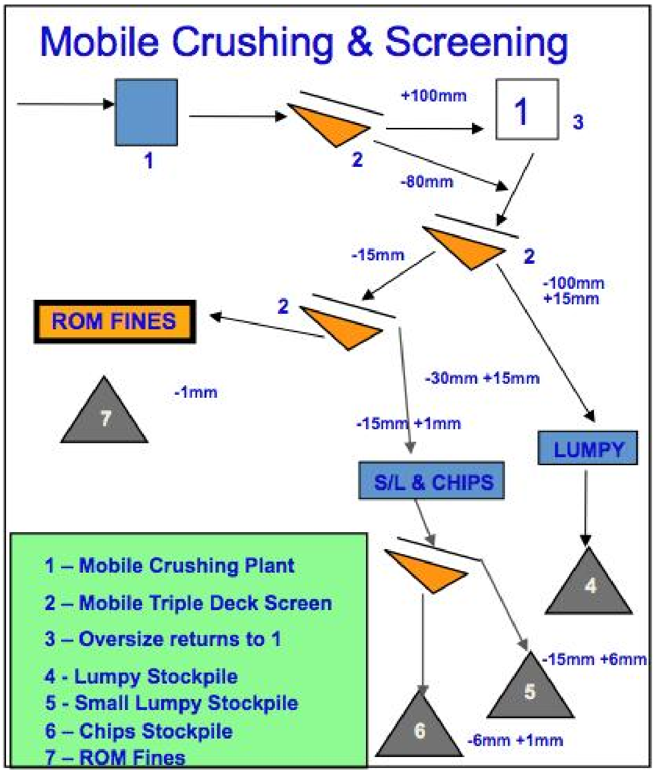

Figure 2: Overview of proposed processing of ore (Samancor, 2013)

The major items of equipment that will be used in the mobile plant are the following:

- A mobile / moveable crushing unit will crush the oversized ROM ore that exceeds +100 mm after it has passed over the screen;
- Front loaders and dump trucks will be used to transport the ROM ore and products in the following three main areas;
  - ROM ore from opencast to the ROM screening area;
  - Between the different sizing / screening steps; and
  - Final products to the various product stockpiles based on size and quality.
- Front loaders will be used to feed ROM material onto conveyor the screen; and

- Screens will be used to separate the ROM material into different sizes as final product.

2.2 Land Use and Sensitive Receptors

Land uses in the area include the following:

- Subsistence farming (crop & cattle);
- Mining opertions;
- Residential townships and villages;
- Nature reserves;
- Eco tourism lodges; and
- An extensive network of good quality gravel access roads.

The following are identified as the nearest sensitive receptors (Figure 3):

- The farm located about 4km to the north;
- Kraalhoek village, approximately 4.5km to the west-north-west;
- The Swartklip residential areas located approximately 2.5km to the east-north-east and approximately 3.8km to the east-south-east;
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- Sesfikele village approximately 9.6 km to the south-east;
- Ga-Ramosidi village approximately 9.7 km to the south-south-east;
- Northam town approximately 14.8 km to the south-south-east; and
- Mojuteng village approximately 14.7 km to the south-south-east.

Figure 3: Identified sensitive receptors surrounding the NV mine (Map Source: Google Earth)

2.3 Topography

The Northam region is generally a mountainous area, particularly towards the north and west of the project area. To the south the area is dominated by the Pilanesberg volcanic crater.

3.0 STUDY APPROACH AND METHODOLOGY

3.1 Background literature review

A background literature review was conducted of various doccuments to gain an overview of the proposed project, and the typical regional climate and expected meteorological conditions. Documentation reviewed included the following:

- Air quality assessment for the Ruighoek Chrome Mine (Report no.: app/07/gaa-02) compiled by Airshed Planning Professionals (Pty) Ltd, April 2007;
- Environmental impact assessment for the proposed Ruighoek open cast chrome mine, North West Province; Environmental Impact Assessment Report and Environmental Management Programme (Report No. 8459/9335/2/E), Golder Associates Africa (Pty) Ltd, 2007
- Environmental Impact assessment for the ammendment of the existing Environmental Management Programme to reflect the new processing plant at Batlhako Mining's Ruighoek Open Cast Chrome mine near Pilanesburg, North West Province, EMP Amendment (Report no.12427-9821-2); August 2010;
- The Bojanala Platinum District Municipality AQMP Baseline Assessment, compiled by Gondwana Environmental Solutions (Pty) Ltd, October 2010.
- Air quality assessment for the Ruighoek Chrome Mine Expansion (Report no: 11615991-11261-3) compiled by Golder Associates Africa (Pty) Ltd, March 2012;

- The Waterberg District Municipality AQMP, compiled by Gondwana Environmental Solutions (Pty) Ltd, June 2009.
- Sishen Iron Ore Thabazimbi Mine review and update of the environmental management programme LP30/5/1/3/2/1(45) and (47)EM, compiled by Shangoni Management Services (Pty) Ltd, 2011;
- Environmental impact assessment for the proposed PPC Dwaalboom secondary materials co-processing programme, compiled by Marsh, March 2010,
- The BCR Nooitgedacht dust fallout report for October 2012, compiled by National Occupational Health & Safety consultants, October 2012;
- The BCR Nooitgedacht dust fallout report for November 2012, compiled by National Occupational Health & Safety consultants, November 2012;
- The BCR Nooitgedacht dust fallout report for December 2012, compiled by National Occupational Health & Safety consultants, December 2012;
- Samancor Chrome Limited Varkenvlei/Nooitgedacht mine Draft Mining Work Programme, February 2013;
- Thabazimbi Municipality Integrated Spatial Development Framework, Final draft for comments, Thabazimbi Municipality and Plan Wize Town and Regional Planners, March 2007.
- SGS, 2011: Monthly dust deposition monitoring progress reports for January 2011 to December 2011; and
- SGS, 2012: Monthly dust deposition monitoring progress reports for January 2012 to June 2012.

3.2 Baseline assessment

Samancor does not undertaken any ambient air quality monitoring on the proposed NV mining site. The assessment of the ambient air quality is thus based on available ambient air quality information identified in the literature review. The meteorological analysis and interpretation will be conducted using MM5 modelled meteorological data.

3.3 Emission estimations – Qualitative assessment

3.3.1 Methodology

In assessing atmospheric impacts from the proposed activities a qualitative emissions inventory was developed based on Golders professional experience with air quality impacts relating to mining operations.

3.3.2 Emissions Inventory

The establishment of an emissions inventory forms the basis for the assessment of the impacts of the proposed project's emissions on the receiving environment. The establishment of an emissions inventory comprises the identification of sources of emission, and the quantification of each source's contribution to ambient air pollution concentrations.

In regards to this specific air quality assessment for the NV mine, only a qualitative emissions inventory was developed.

The main emissions from the proposed mining activities are expected to include pollutants such as PM_{10}, NO_2, SO_2, CO, VOC's and Total Suspended Particulates (TSP). However PM_{10} and TSP are expected to be the most prevalent emissions (key pollutants) from the following sources:

- The removal of overburden by bulldozers, excavators and graders (i.e. scraping equipment);
- Drilling and blasting within the proposed open pit footprint;

- The loading and unloading of overburden and chrome bearing ore (i.e materials handling operations);
- Primary and secondary ore crushing and screening with mechanical crushers and screens;
- Windblown particulate emissions from the overburden stockpiles and waste rock dumps; and
- Vehicles emissions during transporting (trace gas and particulates).

3.4 Impact Assessment

From a technical, conceptual or philosophical perspective the focus of impact assessment ultimately narrows down to a judgment on whether the predicted impacts are significant or not. The concept of significance is at the core of impact identification, prediction, evaluation and decision-making (DEAT, 2002). The determination of significant impacts relates to the degree of change in the environmental resource measured against some standard or threshold. This requires a definition of the magnitude, prevalence, duration, frequency and likelihood of potential change (DEAT, 2002). The following criteria have been proposed by the Department of Environmental Affairs (formerly the Department of Environmental Affairs and Tourism) for the description of the magnitude and significance of impacts (DEAT, 2002).

The *consequence* of impacts can be derived by considering the following criteria:

- Extent or spatial scale of the impact;
- Intensity or severity of the impact;
- Duration of the impact;
- Potential for mitigation;
- Acceptability;
- Degree of certainty/probability;
- Status of the impact; and
- Legal requirements.

Potential impacts were assessed using the calculations and rating system, as provided in Table 1 and Table 2.

Table 1: Impact ranking matrix

Occurrence		Severity	
Probability of occurrence	Duration of occurrence	Magnitude (severity) of impact	Scale / extent of impact

Note: To assess each impact, the following four ranking scales are used

PROBABILITY	DURATION
5 - Definite/don't know	5 - Permanent
4 - Highly probable	4 - Long-term
3 - Medium probability	3 - Medium-term (8-15 years)
2 - Low probability	2 - Short-term (0-7 years) (impact ceases after the operational life of the activity)
1 - Improbable	1 – Immediate
0 - None	
SCALE	**MAGNITUDE**
5 - International	10 - Very high/don't know
4 - National	8 - High
3 - Regional	6 - Moderate
2 - Local	4 - Low
1 - Site only	2 - Minor
0 - None	

The significance of the two aspects, occurrence and severity, is assessed using the following formula:

SP (significance points) = (magnitude + duration + scale) x probability

The maximum value is 100 significance points (SP). The impact significance points are assigned a rating of high, medium or low with respect to their environmental impact as follows (Table 2):

Table 2: Significance ratings

SP >75	Indicates **high** environmental significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 – 75	Indicates **moderate** environmental significance	An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated.
SP <30	Indicates **low** environmental significance	Impacts with little real effect and which should not have an influence on or require modification of the project design.
+	Positive impact	An impact that is likely to result in positive consequences/effects.

4.0 APPLICABLE AIR QUALITY STANDARDS, LEGISLATION, GUIDELINES AND PROJECTS

4.1 National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEMA: AQA)

The NEMA: AQA has shifted the approach of air quality management from source based control to the control of the receiving environment. The Act also devolved the responsibility of air quality management from the national sphere of government to the local municipal sphere of government (district and local municipal authorities). Local municipalities are thus tasked with baseline characterisation, management and operation of ambient monitoring networks, licensing of listed activities, and emissions reduction strategies. The main objectives of the act are to protect the environment by providing reasonable legislative and other measures that (i) prevent air pollution and ecological degradation, (ii) promote conservation and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development alignment with Sections 24a and 24b of the Constitution of the Republic of South Africa.

The NEMA: AQA makes provision for the setting and formulation of national ambient air quality and emission standards. On a provincial and local level, these standards can be set more stringently if the need arises. The control and management of emissions in NEMA: AQA relates to the listing of activities that are sources of emission and the issuing of atmospheric emission licences (AEL's). In terms of Section 21 of the NEMA: AQA, a listed activity is an activity which 'results in atmospheric emissions that are regarded to have a significant detrimental effect on the environment, including human health'. Based on the information supplied to Golder at the time of writing this report, it would appear that none of the activities associated with the proposed mine and associated infrastructure do not trigger any listed activities under Section 21 of NEMA: AQA. It therefore appears that the project will not require the issue of an AEL and need not comply with any specific emission limits listed in NEMA: AQA. The project emissions will however contribute to ambient air quality loads/concentrations and may impact on human health and the broader environment.

4.2 SAAQIS (South African Air Quality Information System)

South African ambient air quality and emissions data have in the past, always been recorded, maintained and managed in a fragmented manner. In order to address this shortfall, the National Department of Water and Environmental Affairs (DWEA) (the old Department of Environmental Affairs and Tourism - DEAT) initiated the South African Air Quality Information System (SAAQIS). The ultimate aims of SAAQIS are to:

- Aid alignment of South African air quality management practices with the requirements of the new National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEMA: AQA);
- Provide a central repository ("one-stop shop") for users to get an overview of what air and atmospheric quality information exists;
- Provide centralised, verified applications for practical implementation of the NEMA: AQA to facilitate compliance with norms and standards by the different stakeholders;
- Foster vertical integration of the three spheres of government - national, provisional and local with regard to air quality information; and
- Provide flexible technological solutions allowing for the utilisation of various current and future air quality management solutions for different stakeholders.

SAAQIS is housed and maintained by the South African Weather Service (SAWS).

4.3 Ambient air quality standards

The South African ambient air quality standards for common pollutants were published in the Government Gazette, No. 32816 on 24 December 2009 (Table 3). These standards prescribe the allowable ambient concentrations of pollutants which are not to be exceeded during a specified time period in a defined area. If the standards are exceeded, the ambient air quality is defined as poor and potential adverse health impacts are likely to occur. If authorised to operate, the NV Mine emissions contributions to the ambient air quality levels must not exceed or cause exceedences of the ambient air quality standards.

Table 3: South African Ambient Air Quality Standards for Criteria Pollutants

Pollutant	Averaging Period	Limit Value ($\mu g/m^3$)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
NO_2 (a)	1 hour	200	106	88	Immediate
	1 year	40	21	0	Immediate
PM_{10} (b)	24 hour	120	-	4	Immediate – 31 December 2014
	24 hour	75	-	4	1 February 2015
	1 year	50	-	0	Immediate – 31 December 2014
	1 year	40	-	0	1 February 2015
O_3 (c)	8 hours (running)	120	61	11	Immediate
Lead (Pb) (d)	1 year	0.5	-	0	Immediate
CO (e)	1 hour	30000	26000	88	Immediate
	8 hour (calculated on 1 hourly averages)	10000	8700	11	Immediate
Benzene (C_6H_6) (f)	1 year	10	3.2	0	Immediate – 31 December 2014
	1 year	5	1.6	0	1 February 2015
SO_2 (g)	10 minute	500	191	526	Immediate
	1 hour	350	134	88	Immediate
	24 hours	125	48	4	Immediate
	1 year	50	19	0	Immediate
$PM_{2.5}$ (h)	24 hours	65	-	0	Immediate – 31 December 2015
	24 hours	40	-	0	1 January 2016 – 31 December 2029
	24 hours	25	-	0	1 January 2030
	1 year	25	-	0	Immediate – 31 December 2015
	1 year	20	-	0	1 January 2016 – 31 December 2029
	1 year	15	-	0	1 January 2030

Notes:

a. *The reference method for the analysis of NO_2 shall be ISO 7996*
b. *The reference method for the determination of the particulate matter fraction of suspended particulate matter shall be EN 12341*
c. *The reference method for the analysis of ozone shall be the UV photometric method as described in ISO 13964*
d. *The reference method for the analysis of lead shall be ISO 9855*
e. *The reference method for analysis of CO shall be ISO 4224*
f. *The reference methods for benzene sampling and analysis shall be either EPA compendium method TO-14 A or method TO-17*
g. *The reference method for the analysis of SO_2 shall be ISO 6767*
h. *The World Health Organization (WHO) sets out an annual and 24-hour average guideline for $PM_{2.5}$ of 25 $\mu g/m^3$.*

4.4 Proposed Draft National Dust Control Regulations

At this current point in time, there are no legislated standards or final regulations in terms of allowable dust fallout rates. Furthermore there is no national standard in terms of the methodology for dust fallout monitoring, nor in terms of the equipment design. The Department of Environmental Affairs and Tourism (DEAT) (now Department of Water and Environmental Affairs) published guideline values for allowable dust fallout which have been accepted by the Department of Minerals and Energy (DME) as the reference fallout rates for dust deposition for the purpose of Environmental Management Programme Reports (EMPR's) (Table 4).

Table 4: DEAT dust fallout guidelines as per SANS 1929.

Classification	Dust fallout averaged over 1 month (30-day average) ($mg/m^2/day$)
Very Heavy	> 1200
Heavy	500 – 1200
Moderate	250 – 500
Slight	< 250

On 7th December 2012 the Department of Water and Environmental Affairs (DWEA), published new proposed Draft National Dust Control Regulations for public comment (Government Gazette no 35931) (replacing those as set in Table 4) . Although these have not been promulgated as yet, due consideration should be given to them in terms of potential future legislative requirements and the impact on the Haakdoorndrift mining operations. In this regard, the draft regulations propose the following:

- Acceptable dust fallout rates as measured (using ASTM D1739:1970 or equivalent) at and beyond the boundary of the premises where dust originates:
  - For residential areas, dust fallout < 600 $mg/m^2/day$ averaged over 30 days. Permitted frequency of exceedances is two per year, not sequential months; and/or
  - For non-residential areas, dust fallout < 1200 $mg/m^2/day$ averaged over 30 days. Permitted frequency of exceedances is two per year, not sequential months.
- Any person who conducts any activity to give rise to dust in quantities and concentrations exceeding these standards must within a year of publication of the regulations submit a monitoring report to the air quality officer. The monitoring report is to include the following information as a minimum:
  - Location of the samples including a coordinate reference on a topographic map and the proximity to residential and non-residential areas;
  - Classification of the sampling site as residential or non-residential;
  - Meteorological data of the sampling area;
  - Other information which might influence the results; and
  - The dust fallout results.
- Any person who has exceeded the standard must within three months of submission of the dust monitoring report develop a dust management plan. The dust management plan is to include the following information as a minimum:
  - Identify all possible sources of dust within the affected areas; and
  - Detail best practice measures to control the dust.

- If the dust fallout monitoring programme indicates towards non-compliance, the air quality officer may require the person to institute permanent online PM_{10} monitoring.

4.5 Air Quality Management Planning Projects

The Waterberg District Municipality is currently associated with relatively good air quality however due to increasing concentrations of industry, mining, power generation and other non-industrial and rapid population growth, the ambient air quality may be at risk of following a trend of degeneration. For this reason, the Minister of Environmental Affairs declared the region a priority area, namely the Waterberg Priority Area (WPA).

The primary motive of the WPA declaration is to protect, achieve and maintain compliance with the national ambient air quality standards across the WPA, using the constitutional principal of progressive realisation of air quality improvements (DEAT, 2007). The WPA Air Quality Management Plan thus allows for the alignment of air quality practices with legal and regulatory requirements to ensure air quality management planning is implemented effectively (DEAT, 2007). Similarly as areas of the NV Mine fall within the Bojanala Platinum District Municipality they will also have align with the air quality practices with legal and regulatory requirements as detailed in the Bojanala Platinum District Municipality Air Quality Management Plan.

As the proposed NV Mine straddles the boundary of both the Bojanala Platinum District Municipality and Waterberg District Municipality, the mine is thus required to operate within the air quality requirements of both the WPA Air Quality Management Plan and the Bojanala Platinum District Municipality Air Quality Management Plan.

4.6 Key Pollutant and Associated Health Effects

4.6.1 Particulates

Particles can be classified by their aerodynamic properties into coarse particles, PM_{10} (particulate matter with an aerodynamic diameter of less than 10 µm) and fine particles, $PM_{2.5}$ (particulate matter with an aerodynamic diameter of less than 2.5 µm) (Harrison and van Grieken, 1998). The fine particles contain the secondarily formed aerosols such as combustion particles, sulphates, nitrates, and recondensed organic and metal vapours. The coarse particles contain earth crust materials and fugitive dusts from roads and industries (Fenger, 2002).

The impact of particles on human health is largely dependent on the particle characteristics, particle size, chemical composition, the duration, frequency and magnitude of the exposure/s. Typically, particulate air pollution is associated with respiratory complaints (WHO, 2000). Particle size is important because it controls where in the respiratory system a given particle deposits. Fine particles are thought to be more damaging to human health than coarse particles as larger particles are less respirable in that they do not penetrate deep into the lungs, compared to smaller particles (Manahan, 1991). Larger particles are deposited into the extra-thoracic part of the respiratory tract, while smaller particles are deposited into the smaller airways leading to the respiratory bronchioles (WHO, 2000).

Acute exposure

Studies have proven that acute exposure to particulate matter at both high and low concentrations is associated with health effects. Various studies undertaken during the 1980s to 1990s have investigated the relationship between daily fluctuations in particulate matter and mortality at low levels of acute exposure. Pope *et al* (1992) studied daily mortality in relation to PM_{10} concentrations in the Utah Valley during 1985 to 1989. A maximum daily average concentration of 365 $\mu g/m^3$ was recorded with effects on mortality observed at concentrations below 100 $\mu g/m^3$. The increase in total daily mortality was 13% per 100 $\mu g/m^3$ increase in the 24 hour average. Schwartz's 1993 studies in Birmingham, recorded daily concentrations of 163 $\mu g/m^3$ and noted that an increase in daily mortality was experienced with increasing PM_{10} concentration levels. Relative risks for chronic lung disease and cardiovascular deaths were higher than deaths from other causes.

Overall, exposure-response can be described as curvilinear, with small absolute changes in exposure at the low end of the curve having similar effects on mortality to large absolute changes at the high end

(WHO, 2000).Morbidity effects associated with acute exposures to particulates include increases in lower respiratory symptoms, medication use and small reductions in lung functioning. Pope and Dockery (1992) studied groups of children in Utah Valley in winter during the period 1990 to 1991. Daily PM_{10} concentrations ranged between 7 to 251 µg/m^3. Peak Expiratory Flow was decreased and respiratory symptoms increased when PM_{10} concentrations increased. Pope and Kanner (1993) utilised lung function data obtained from smokers with mild to moderate chronic obstructive pulmonary disease in Salt Lake City. The estimated effect was a 2% decline in the forced expiratory volume over one second for each 100 µg/m^3 increase in the daily PM_{10} average.

Chronic exposure

Chronic exposure to low concentrations of particulates is associated with mortality and other chronic effects such as increased rates of bronchitis and reduced lung functioning (WHO, 2000). An association between lung function and chronic respiratory disease and airborne particles has been indicated through several studies. Chestnut et al (1991) found that forced vital capacity decreases with increasing annual average particulate levels with an apparent threshold of 60 µg/m^3. Using chronic respiratory disease data, Schwartz (1993) determined that the risk of chronic bronchitis increased with increasing particulate concentrations, with no apparent threshold.

Few studies have been undertaken documenting the morbidity effects of chronic exposure to particulates. Recently, the Harvard Six Cities Study showed increased respiratory illness rates among children exposed to increasing particulate, sulphate and hydrogen ion concentrations. Relative risk estimates suggest an 11% increase in cough and bronchitis rates for each 10 µg/m^3 increase in annual average particulate concentrations.

5.0 BASELINE AIR QUALITY ASSESSMENT

5.1 Regional Climate

The NV Mine is situated in the subtropical high-pressure belt. The mean circulation of the atmosphere over the subcontinent is anticyclonic throughout the year (except for near the surface) (Preston-Whyte and Tyson, 1997). The synoptic patterns affecting the typical weather experienced in the region owe their origins to the subtropical, tropical and temperate features of the general atmospheric circulation over Southern Africa.

The subtropical control is brought via the semi-permanent presence of the South Indian Anticyclone (HP cell), Continental High (HP cell) and the South Atlantic Anticyclone (LP cell) in the high pressure belt located approximately 30°S of the equator (Preston-Whyte and Tyson, 1997). The tropical controls are brought via tropical easterly flows (LP cells) (from the equator to the southern mid-latitudes) and the occurrence of the easterly wave and lows (Preston-Whyte and Tyson, 1997). The temperature control is brought about by perturbations in the westerly wave, leading the development of westerly waves and lows (LP cells) (i.e. cold front from the polar region, moving into the mid-latitudes) (Preston-Whyte and Tyson, 1997).

Seasonal variations in the positioning and intensity of the HP cells determine the extent to which the westerly waves and lows impact the atmosphere over the region. In winter, the high pressure belt intensifies and moves northward while the westerly waves in the form of a succession of cyclones or ridging anticyclones moves eastwards around the South African coast or across the country. The positioning and intensity of these systems are thus able to significantly impact the region. In summer, the anticyclonic HP belt weakens and shifts southwards and the influence of the westerly wave and lows weakens.

Anticyclones (HP cells) are associated with convergence in the upper levels of the troposphere, strong subsidence throughout the troposphere, and divergence in near the surface of the earth. Air parcel subsidence, inversions, fine conditions and little to no rainfall occur as a result of such airflow circulation patterns (i.e. relatively stable atmospheric conditions). These conditions are not favourable for air pollutant dispersion, especially in regards to those emissions emitted close to the ground.

Westerly waves and lows (LP cells) are characterised by surface convergence and upper-level divergence that produce sustained uplift, cloud formation and the potential for precipitation. Cold fronts, which are associated with the westerly waves, occur predominantly during winter. The passage of a cold front is characterised by pronounced variations in wind direction and speed, temperature, humidity, pressure and distinctive cloud bands (i.e. unstable atmospheric conditions). These unstable atmospheric conditions bring about atmospheric turbulence which creates favourable conditions for air pollutant dispersion.

The tropical easterlies and the occurrence of easterly waves and lows affect Southern Africa mainly during the summer months. These systems are largely responsible for the summer rainfall pattern and the north easterly wind component that occurs over the region (Schulze, 1986; Preston-Whyte and Tyson, 1988).

In summary, the convective activity associated with the easterly and westerly waves disturbs and hinders the persistent inversion which sits over Southern Africa. This allows for the upward movement of air pollutants through the atmosphere leading to improved dispersion and dilution of accumulated atmospheric pollution.

5.2 Meteorological Overview

Samancor does not undertake any meteorological monitoring at the proposed NV Mine site and thus the statistics provided below are based on available literature from the region (Pilanesberg and Thabazimbi regions) and MM5 modelled meteorological data.

Notes:

- *Precipitation reduces erosion potential by increasing the moisture content of erodible materials. This represents an effective mechanism for removal of atmospheric pollutants and is therefore considered during air pollution studies.*
- *Ambient air temperature is a key factor affecting both plume buoyancy and the development of mixing and inversion layers. The greater the difference in temperature between the plume and the ambient air, the higher the plume is able to rise.*
- *Wind roses summarize the occurrence of winds at a specified location via representing their strength, direction and frequency. Calm conditions are defined as wind speeds of less than 1 m/s which are represented as a percentage of the total winds in the centre circle. Each directional branch on a wind rose represents wind originating from that specific cardinal direction (16 cardinal directions). Each cardinal branch is divided into segments of different colours which represent different wind speed classes. For Golder developed wind roses, wind speed is represented in classes, 1 to 2 m/s in blue, 2 to 4 m/s in green, 4 to 6 m/s in yellow 6 to 10 m/s in orange and > 10 m/s in red. Each dotted circle represents a percentage frequency of occurrence.*
- *For actual site specific monitoring data a minimum of 80 % data capture is required to achieve minimum data quality assurance for data manipulation and summary (SANAS R07-01).*

5.2.1 Pilanesberg meteorology

The Pilanesberg meteorological station is located at the Pilanesberg airport, approximately 46km south of the NV Mine (25°20' S 27°10' E). A summary of the climatic data for the period 1961 to 1990 is presented in Table 5.

It is assumed that the data recorded at the Pilanesberg airport will be relatively similar to the experienced conditions at the NV mine due to their close proximity to each other however the Pilanesburg mountain crater may induce some degree of influence on the data due to the topography of the area and thus there may be some variances.

5.2.1.1 Precipitation

Based on the observed data (30 year record), the region receives most of its rainfall during the period of December to February. Rainfall of approximately 519mm is experienced annually in the region with the majority of rainfall events being experienced during mid-summer. Rainfall experienced is typically in the form of short, intense thunderstorms.

5.2.1.2 Temperature

Based on the observed data (30 year record) (Table 5), average daily temperatures typically range from 12°C to 28°C (averaged maxima and minima). The region is typically coldest during July when the mercury drops to 2°C on average during the night and hottest during January when the mercury rises to 32°C on average during the midday and early afternoon period.

Table 5: Pilanesberg meteorological station climatic data for 1961-1990
(http://old.weathersa.co.za/Climat/Climstats/PilansbergStats.jsp)

Month	Temperature (° C)				Precipitation		
	Highest Recorded	Average Daily Maximum	Average Daily Minimum	Lowest Recorded	Average Monthly (mm)	Average Number of days with >= 1mm	Highest 24 Hour Rainfall (mm)
January	39	32	19	14	78	10	65
February	39	31	18	10	71	8	51
March	39	30	16	8	58	8	50
April	36	27	12	3	38	6	42
May	31	25	7	-1	6	1	23
June	28	22	3	-5	12	2	23
July	27	22	2	-4	3	1	10
August	32	26	6	-1	5	1	15
September	35	28	11	2	25	4	37
October	37	30	15	6	57	7	44
November	40	31	16	9	61	10	42
December	39	31	18	10	105	12	55
Year	**40**	**28**	**12**	**-5**	**519**	**69**	**65**

5.2.1.3 Wind speed and direction

From wind roses from the Pilanesberg, the dominant wind direction is identified as being from the north (Figure 4).

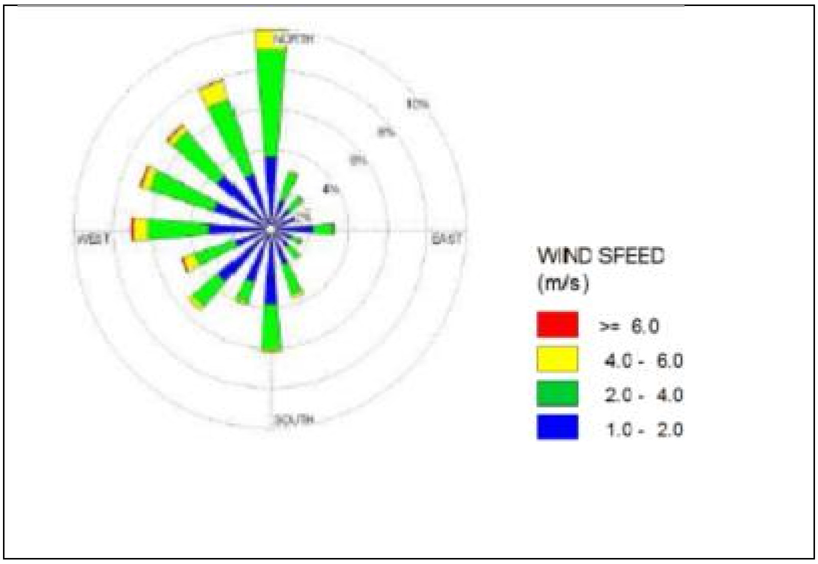


Figure 4: Period surface wind roses for the Pilanesberg for the period 2006 – 2009 (Bojanala Platinum District Municipality AQMP Baseline Assessment, 2010).

5.2.2 Thabazimbi meteorology

Note: The presented meteorological data is specific to the Thabazimbi area surrounding the Thabazimbi mine however the actual monitoring station information and exact location could not be verified as this information was not detailed in the literature source.

It is assumed that the data recorded in the Thabazimbi region will be relatively similar to the experienced conditions at the NV mine due to their close proximity to each and possibly more representative than the Pilanesburg data due to the lack of the influence of the Pilanesberg mountain crater on the metrology. Nevertheless, there may still be some variances.

5.2.2.1 Precipitation

Based on the observed data (75 year record) (Figure 5), the region receives most of its rainfall during the period of October to April (Table 6). Rainfall of approximately 542mm is experienced annually in the region with the majority of rainfall events being experienced during mid-summer. Rainfall experienced is typically in the form of short, intense thunderstorms.

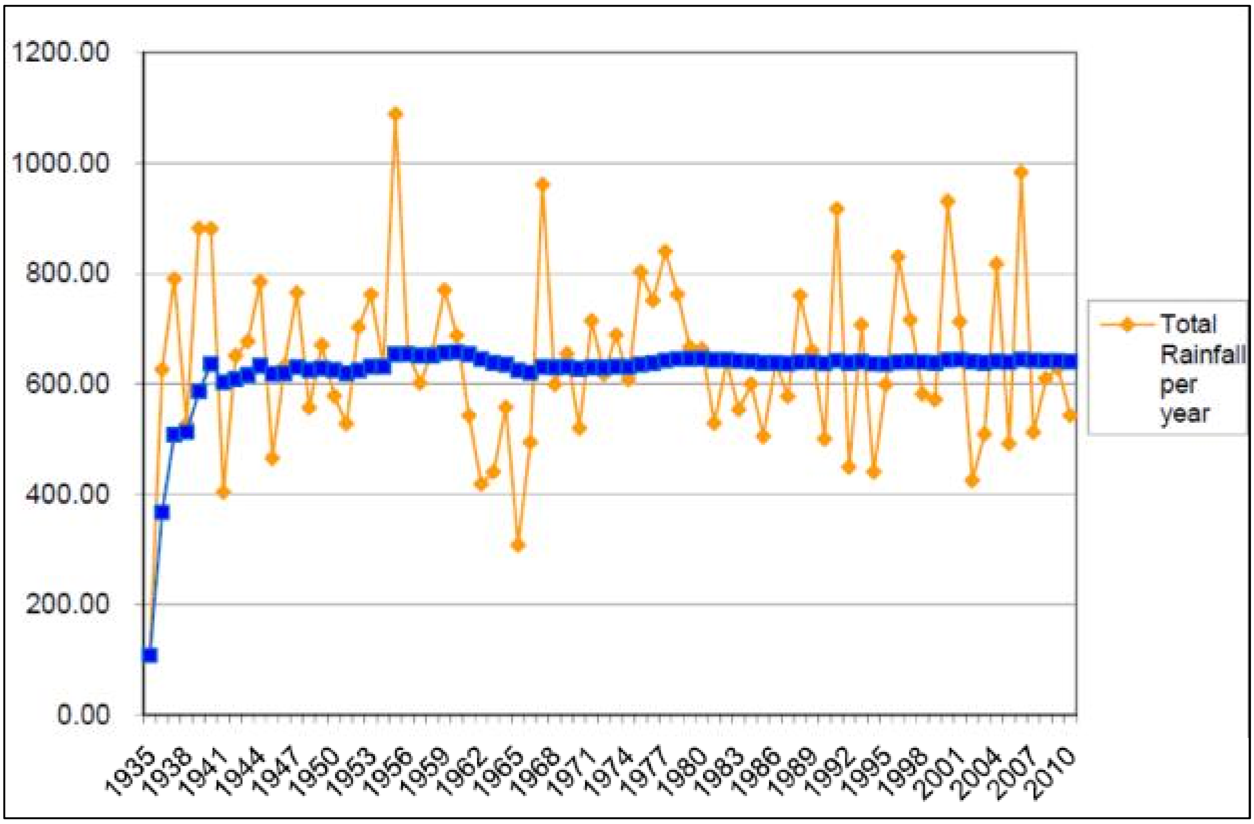


Figure 5: Thabazimbi rainfall graph for 1935 to 2010 (Shangoni Management Services, 2010) (Rainfall in mm).

5.2.2.2 Temperature

Based on the observed data (75 year record) (Table 7), average daily temperatures typically range from 17°C to 30°C (averaged maxima and minima). The region is typically coldest during June and July when the mercury drops to below 0°C during the night and hottest during January when the mercury rises to above 40°C during the midday and early afternoon period.

5.2.2.3 Wind speed and direction

From wind roses from the Thabazimbi Mine for the period 1986 to 1991, the dominant wind direction is identified as being north-east. During winter, wind roses indicate that the dominant wind direction may shift to the south and south-east (Shangoni Management Services, 2010) (Figure 6).

Table 6: Averaged monthly rainfall for 1935 to 2010 (Shangoni Management Services, 2010)

Month	Averaged rainfall (mm)
January	125.32
February	102.64
March	81.88
April	41.03
May	14.41
June	8.12
July	2.60
August	3.75
September	12.32
October	48.15
November	86.15
December	121.72

Table 7: Mean monthly maxima and minima averaged temperatures for 1935 to 2010 (Shangoni Management Services, 2010)

Month	Mean Max temp. (°C)	Mean Min temp. (°C)
January	33.4	20.7
February	32.3	21.1
March	31.9	19.0
April	29.3	16.6
May	27.3	12.8
June	25.1	10.1
July	25.1	11.1
August	27.9	14.4
September	29.8	17.6
October	31.9	19.9
November	32.0	20.4
December	31.6	20.7
Ave.	29.8	17.0

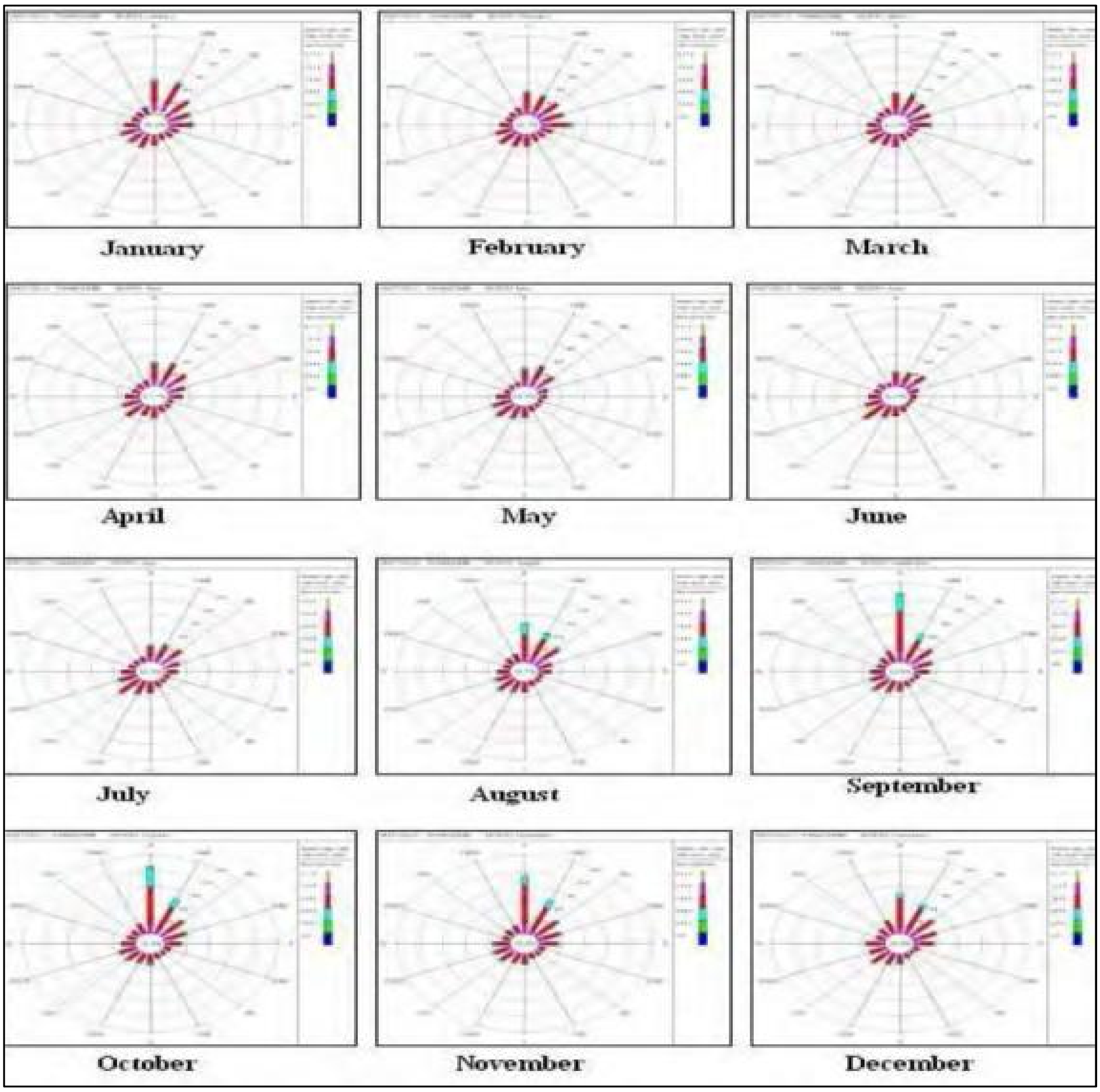


Figure 6: Wind roses from the Thabazimbi Mine for the period 1986 to 1991 (Shangoni Management Services, 2010)

5.2.3 MM5 Modelled Meteorological Data for the NV Mine site

The site specific meteorological overview for the NV Mine was based on the analysis of the MM5 modelled meteorological for 2009-2011. The analysis of the data is assumes and expected to be representative of the actual experienced meteorological conditions on site.

The MM5 data modelling process achieved 100% data recovery thus minimum data quality assurance for data manipulation and summary (SANAS R07-01) is met.

5.2.3.1 Wind rose for the modelled period

Winds at the NV Mine are expected to originate equally from the east-south-east (12.5% of the time) and east (9.5 % of the time) (Figure 7). Wind speeds are low to moderate, with a low percentage (19.24%) of calm conditions (<1 m/s).

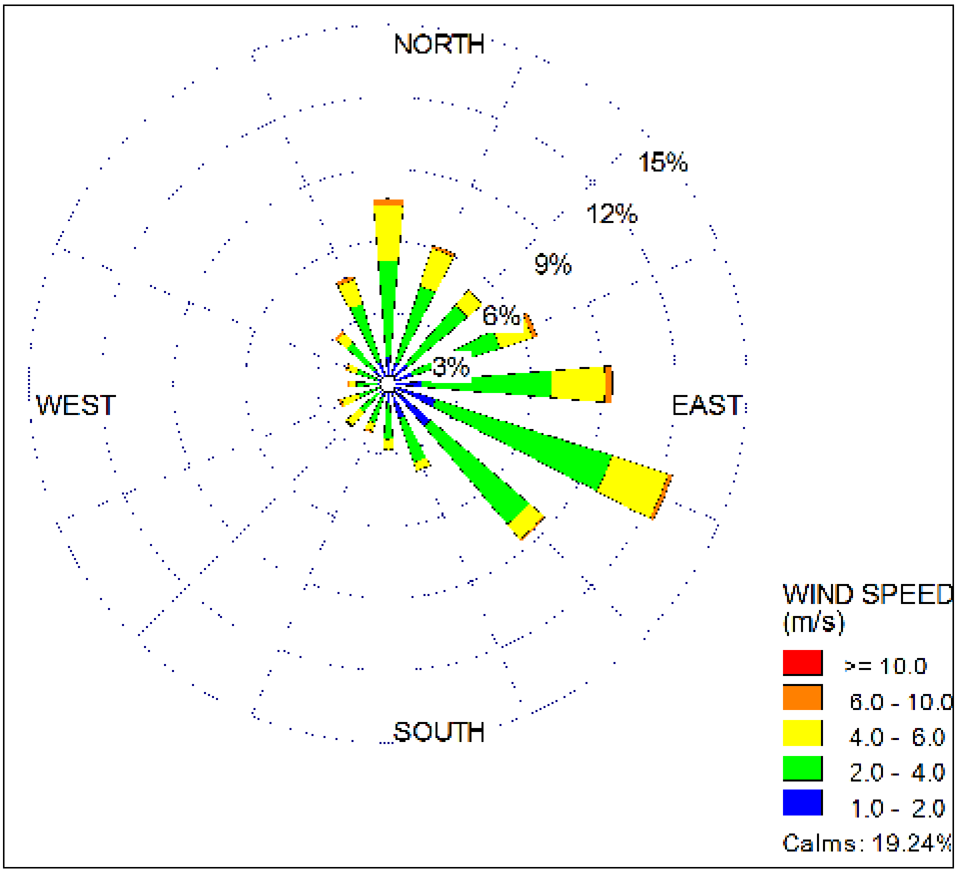
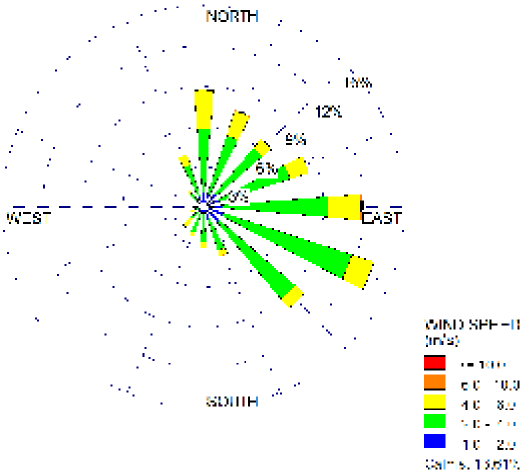


Figure 7: Modelled annual NV Mine wind rose for 2009-2011.

5.2.3.2 Diurnal wind roses

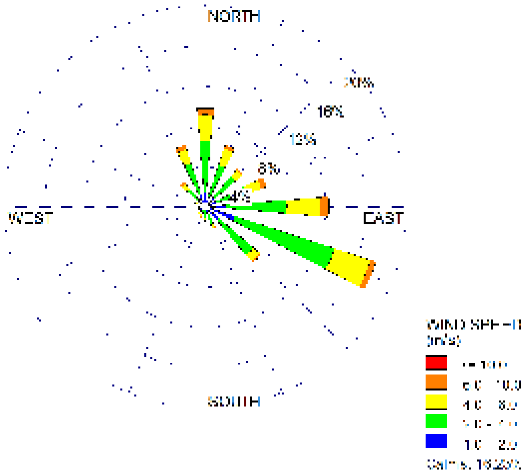
A very slight diurnal variation in wind is observed during the monitoring period (Figure 8).



00:00 to 05:59

ESE 13.5 % of the time

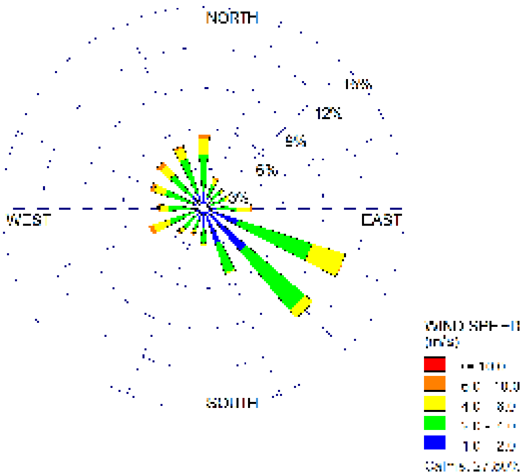
E 12 % of the time



06:00 to 11:59

ESE 18 % of the time

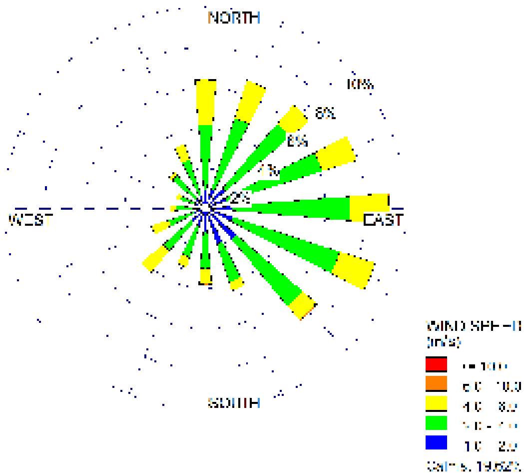
E 12.5 % of the time



12:00 to 17:59

ESE 11.5 % of the time

SE 11 % of the time



18:00 to 23:59

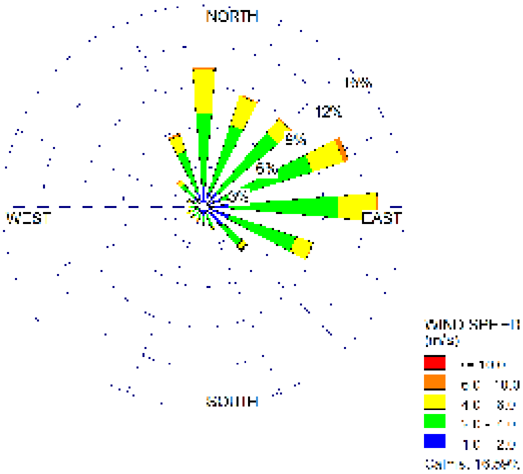
E 9.25 % of the time

ESE 8.75 % of the time

Figure 8: Modelled diurnal wind roses for the NV Mine with predominant wind directions for 2009-2011

5.2.3.3 Seasonal wind roses

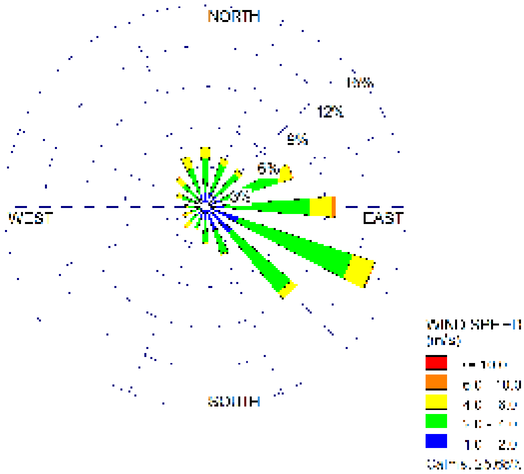
A significant seasonal variation in wind is observed during the monitoring period (Figure 9).



Summer (DJF)

E 13% of the time

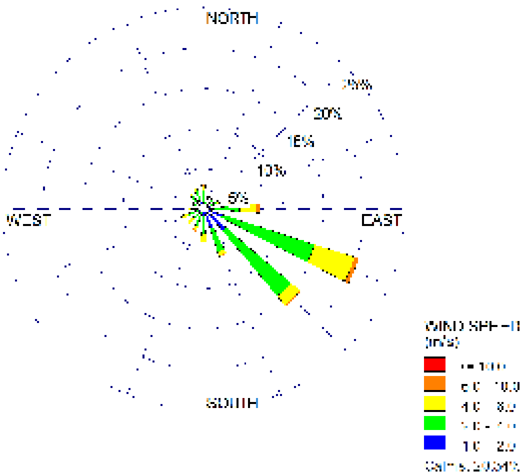
ENE 11.75% of the time



Autumn (MAM)

ENE 13.25 % of the time

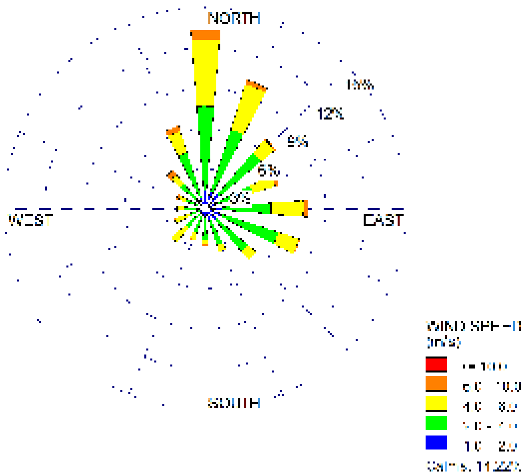
E 9.5% of the time



Winter (JJA)

ESE 20.0 % of the time

EN 16.5% of the time



Spring (SON)

N 13 % of the time

NNE 11% of the time

Figure 9: Modelled seasonal wind roses for the NV Mine with predominant wind directions for 2009-2011

5.2.4 MM5 modelled meteorological data cross-check & confidence

In comparing the annual wind roses for the Pilanesberg (Figure 4) and the MM5 modelled data wind rose for the NV Mine (Figure 7), it is clear that the outputs are not consistent with each other. Similarly, in when comparing the annual wind roses for the Thabazimbi region (Figure 6) and the MM5 modelled data wind rose for the NV Mine (Figure 7), the outputs are found not to be consistent.

This is probably due to the meteorological conditions throughout the District being strongly influenced by the underlying topography in the region (Bojanala Platinum District Municipality AQMP Baseline Assessment, 2010). Due to the uncertainty in this regard, and with the application of the precautionary principal, a low level of confidence is thus instilled in the MM5 modelled data.

In order to obtain a better understanding (an accurate site specific account) of the meteorological conditions on site, Samancor should install and operate a professional meteorological station (required data accuracy of 1-2%) on a continuous basis.

5.3 Boundary Layer Properties and Atmospheric Stability

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere and is directly affected by the earth's surface. The earth's surface affects the boundary layer through the retardation of air flow created by frictional drag, created by the topography, or as result of the heat and moisture exchanges that take place at the surface.

During the day, the atmospheric boundary layer is characterised by thermal heating of the earth's surface, converging heated air parcels and the generation of thermal turbulence, leading to the extension of the mixing layer to the lowest elevated inversion. These conditions are normally associated with elevated wind speeds, hence a greater dilution potential for the atmospheric pollutants.

During the night, radiative flux divergence is dominant due to the loss of heat from the earth's surface. This usually results in the establishment of ground based temperature inversions and the erosion of the mixing layer. As a result, 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 mixed layer ranges in depth from a few metres during night times to the base of the lowest elevated inversion during unstable, daytime conditions. Elevated inversions occur for a variety of reasons, however typically the lowest elevated inversion on the Highveld is located at a mean height above ground of 1550 m during winter months with a 78% frequency of occurrence. During summer, the mean subsidence inversion occurs at about 2 600 m with a 40% frequency. Atmospheric stability is frequently categorised into one of six stability classes. These are briefly described in Table 8.

The atmospheric boundary layer is normally unstable during the day as a result of the turbulence due to the sun's heating effect on the earth's surface. The thickness of this mixing layer depends predominantly on the extent of solar radiation, growing gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. This situation is more pronounced during the winter months due to strong night-time inversions and a slower developing mixing layer. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

Table 8: Atmospheric stability classes

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

Figure 10: Atmospheric stability classes

For elevated releases, the highest ground level concentrations would occur during unstable, daytime conditions. The wind speed resulting in the highest ground level concentration depends on the plume buoyancy. If the plume is considerably buoyant (high exit gas velocity and temperature) together with a low wind, the plume will reach the ground relatively far downwind. With stronger wind speeds, on the other hand, the plume may reach the ground closer, but due to the increased ventilation, it would be more diluted. A wind speed between these extremes would therefore be responsible for the highest ground level concentrations. In contrast, the highest concentrations for ground level, or near-ground level releases would occur during weak wind speeds and stable (night-time) atmospheric conditions.

5.4 Regional ambient air quality overview

Limited air quality monitoring information is available in the both the Waterberg and Bojanala Platinum Districts, which makes it difficult to accurately quantify the current state of the air quality in the District (Gondwana Environmental Solutions, 2009 & 2010). Additionally, Samancor does not undertake any ambient air quality monitoring in the vicinity of the proposed NV mine and the project site is relatively remote and thus very little ambient air quality information is available as most of the monitoring networks are located in the urban areas (i.e. Rustenburg) and/or on the larger mines such as Impala Platinum, Lonmin Platinum and Anglo Platinum (located approximately 60km to 90km's south-south-east of the proposed NV Mine) or at the power generation facilities such as the Matimba Power Station (Figure 11). Data recorded at these stations, although a very long distance from the proposed NV Mine may be used to infer a high level regional air overview for the region.

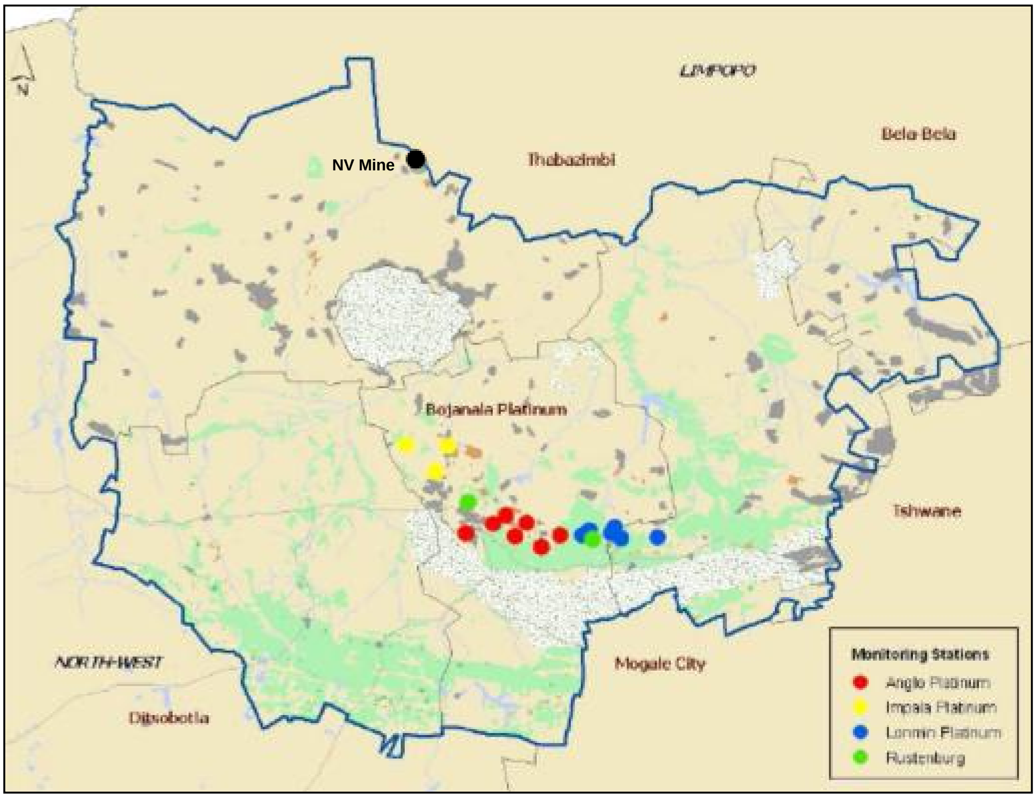


Figure 11: Location of ambient air quality monitoring stations in Bojanala Platinum District Municipality in relation to the NV mine (Bojanala Platinum District Municipality AQMP Baseline Assessment, 2010)

A regional overview of the ambient air quality situation is thus provided using:

- The available ambient air quality monitoring data contained in the Bojanala Platinum District Municipality Air Quality Management Plan Baseline Assessment, compiled by Gondwana Environmental Solutions (Pty) Ltd in 2010;

- The available ambient air quality monitoring data contained in the Waterberg District Municipality AQMP, compiled by Gondwana Environmental Solutions (Pty) Ltd in 2009; and
- Other available literature and data from the region.

5.4.1 Brief regional station siting rationale

The Impala Platinum air quality monitoring network consists of five stations which were commissioned in 2008:

- Services Station: Located close to the smelter;
- Luka Station: Located on the lease area;
- Boshoek Station: Located off the lease area;
- Lebone station: Located at the Lebone Primary School; and
- Shaft 7 Station: Located close to shaft 7.

These stations all measure PM_{10}, SO_2 and suite of meteorological parameters. The station siting rationale is not detailed in the Bojanala Platinum District Municipality Air Quality Management Plan Baseline Assessment however it is assumed that they have been sited to monitor the Impala Platinum operational impacts on site and at sensitive receptors (i.e. Lebone Primary School).

The Lonmin Platinum air quality monitoring network consists of six stations (two decommissioned):

- Base Metal Refinery (BMR): Located at the sewerage package plant adjacent to the BMR plant main access gates;
- K4 Concentrator (decommissioned);
- Karee Mine: Located at the training centre at the Karee mine;
- Wonderkop: Located in the Wonderkop village at a school;
- Western Platinum Limited (WPL) (decommissioned & relocated to Wonderkop); and
- Eastern Platinum Limited (EPL), Located at the EPL offices.

In terms of the current active stations, the BMR station monitors PM_{10}, SO_2 and suite of meteorological parameters. The Wonderkop station monitors PM_{10}, $PM_{2.5}$, SO_2 and suite of meteorological parameters. Karee mine and EPL stations both monitor PM_{10}, $PM_{2.5}$, and suite of meteorological parameters. All of Lonmin's monitoring stations were sited to monitor operational impacts on site, at sensitive receptors (I.e. Wonderkop village).

The Anglo Platinum air quality monitoring network consists of seven stations:

- Bergsig Station: Located at Bergsig High School;
- Waterval Station: Located at Waterval Village;
- Brakspruit Station;
- Klipfontein Station: Located in Klipfontein Village;
- Hexrivier Station: Located on the lease area; and
- Paardekraal Station: Located on the lease area.

These stations all measure PM_{10}, SO_2 and suite of meteorological parameters. The station siting rationale is not detailed in the Bojanala Platinum District Municipality Air Quality Management Plan Baseline Assessment however it is assumed that they have been sited to monitor Anglo Platinum's operational impacts on site and at several sensitive receptors (i.e. Klipfontein village, Bergsig high school etc).

Rustenburg Local Municipality has an air quality monitoring network consists of four stations:

- Boikekong;
- City Centre;
- Marikana; and
- Thlabane.

These stations all measure PM_{10}, SO_2, NO, NO_2, NO_x O_3, CO, BTEX and suite of meteorological parameters. Their siting is based on the monitoring requirements of the Air Quality Act for a Local Municipality to ensure that the ambient air quality is monitored in the residential areas (a representative sample set approach) throughout the municipality. According to the Bojanala Platinum District Municipality Air Quality Management Plan Baseline Assessment, insufficient data recovery was achieved at these stations and thus the minimum data quality assurance for data manipulation and summary (SANAS R07-01) is not met. The analysis and display of this data is thus excluded from this assessment.

5.4.2 Regional ambient SO_2 concentrations

Ambient SO_2 concentrations for the period January 2006 to September 2009 (where available) are presented below bases on the available information from the Bojanala Platinum District Municipality Air Quality Management Plan Baseline Assessment.

5.4.2.1 Anglo Platinum

Daily average SO_2 concentrations at Anglo's monitoring network generally fall below the national SO_2 daily average standard (48 ppb) over the monitoring period and exceedances are experienced infrequently (Figure 12). A distinct seasonal shift is not evident in SO_2 concentrations although elevated concentrations are observable during the winter period at several stations. These elevate levels are expected during this period due to the increase demand for space heating in the residential areas and increased prevalence of biomass burning attributed to wild fires.

Diurnal SO_2 concentrations across Anglo's monitoring network display an industrial signature trend (Figure 13). This signature is indicated by the emissions peaks between (approximately) 07:00 and 13:00 which cannot be attributed to a domestic fuel burning signature which typically displays two peaks (Typically one in the morning 07:00 to 10:00 and in the late afternoon, early evening 18:00 to 22:00. The evening peak is typically of higher amplitude than the morning peak). It is likely that the displayed industrial signature is the result of emissions from tall stacks.

During the evening period, elevated sources emitting above or within the surface inversion are prevented from reaching the ground level, hence the experienced low surface concentrations during these periods. During the day, increased convection erodes the surface inversion and allows for the vertical down mixing of elevated emission plumes. The down mixing gives rise to the elevated ground level concentrations during the mid-morning and early afternoon period (i.e. the observed industrial peak trend).

5.4.2.2 Impala Platinum

Daily average SO_2 concentrations at Impala's monitoring network generally fall below the national SO_2 daily average standard (48 ppb) over the monitoring period and exceedances are experienced relatively infrequently (Figure 14). A distinct seasonal shift is not evident in SO_2 concentrations although elevated concentrations are observable during the winter period at several stations. These elevate levels are expected during this period due to the increase demand for space heating in the residential areas and increased prevalence of biomass burning attributed to wild fires.

Diurnal SO_2 concentrations across Impala's monitoring network appear to display a combined domestic fuel burning and industrial signature trend (Figure 15). The domestic fuel burning trend is indicated by the emissions peaks between (approximately) 05:00 and 10:00 and the peak during 17:00 and 22:00. The Industrial trend is indicated by the amplitude of the morning peak which far exceeds the evening peak which is not the typical norm with a pure domestic fuel burning signature (i.e. It appears that the industrial trend is superimposed during the morning domestic fuel burning peak).

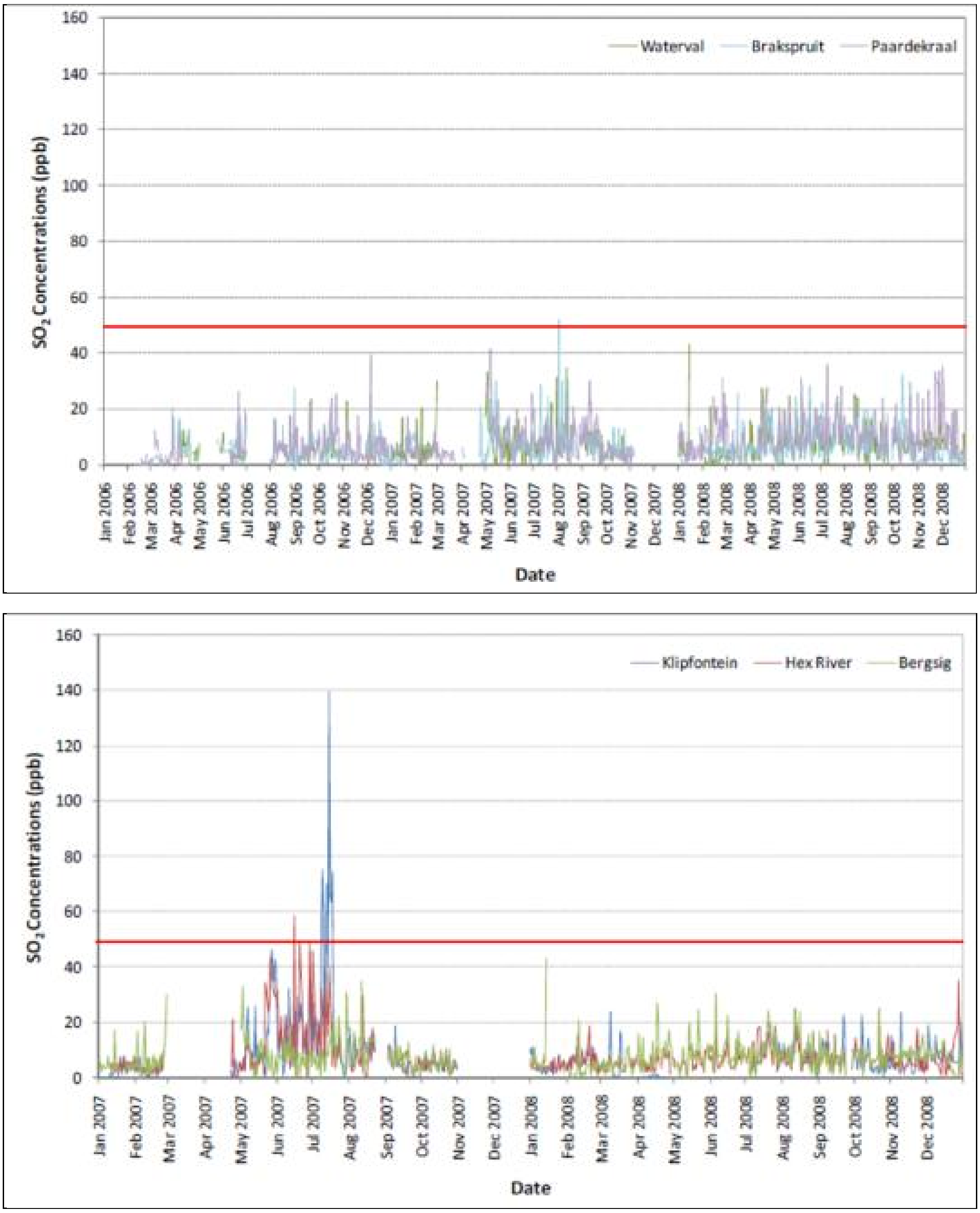


Figure 12: Daily SO2 concentrations (ppb) recorded at the Anglo Platinum Monitoring stations for the period January 2006 – December 2008 (Red line - National daily standard of 48 ppb. (Bojanala Platinum District Municipality AQMP Baseline Assessment, 2010)

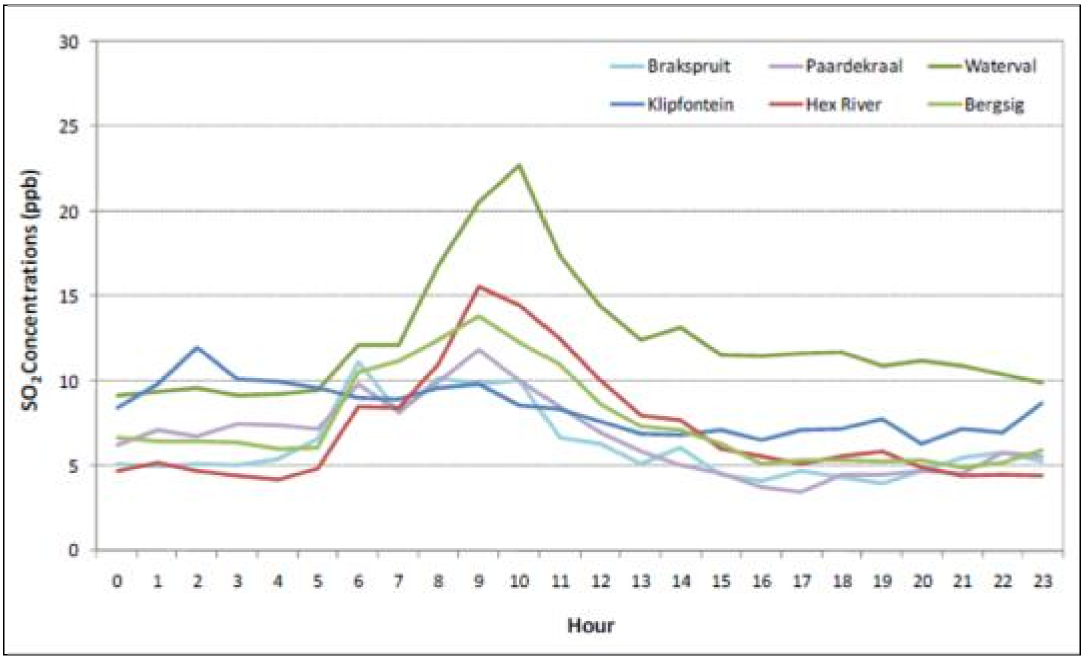


Figure 13: Diurnal SO2 concentrations (ppb) recorded at Anglo Platinum Monitoring stations for the period January 2006 – December 2008 (Bojanala Platinum District Municipality AQMP Baseline Assessment, 2010).

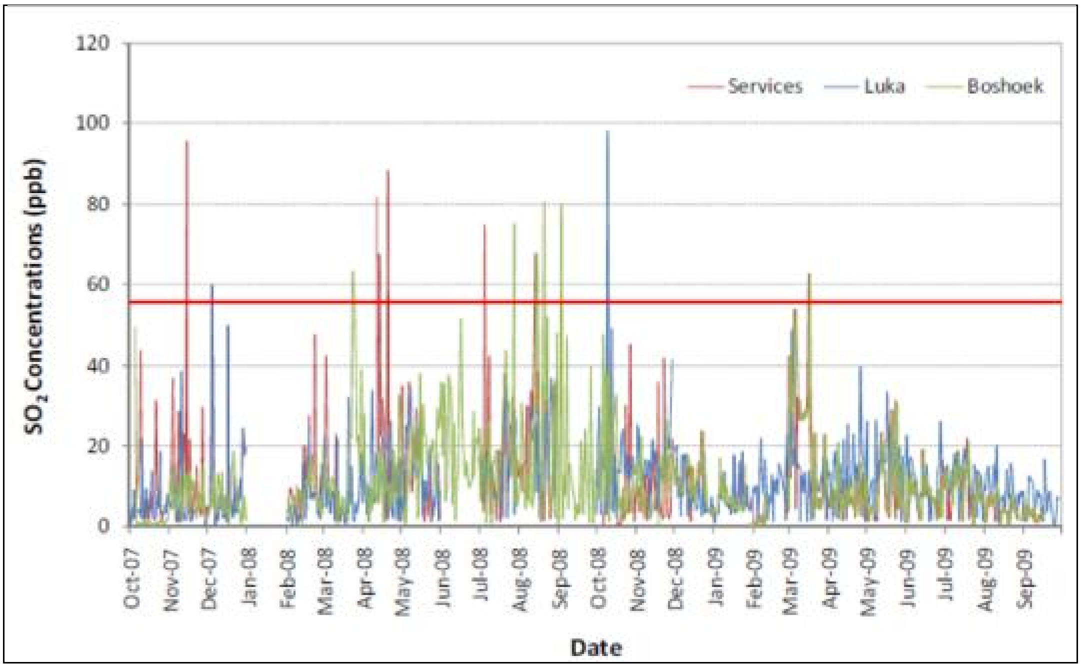


Figure 14: Daily SO2 concentrations (ppb) recorded at Impala Platinum Monitoring stations for the period October 2007 – September 2009 (Red line - National daily standard of 48 ppb (Bojanala Platinum District Municipality AQMP Baseline Assessment, 2010).

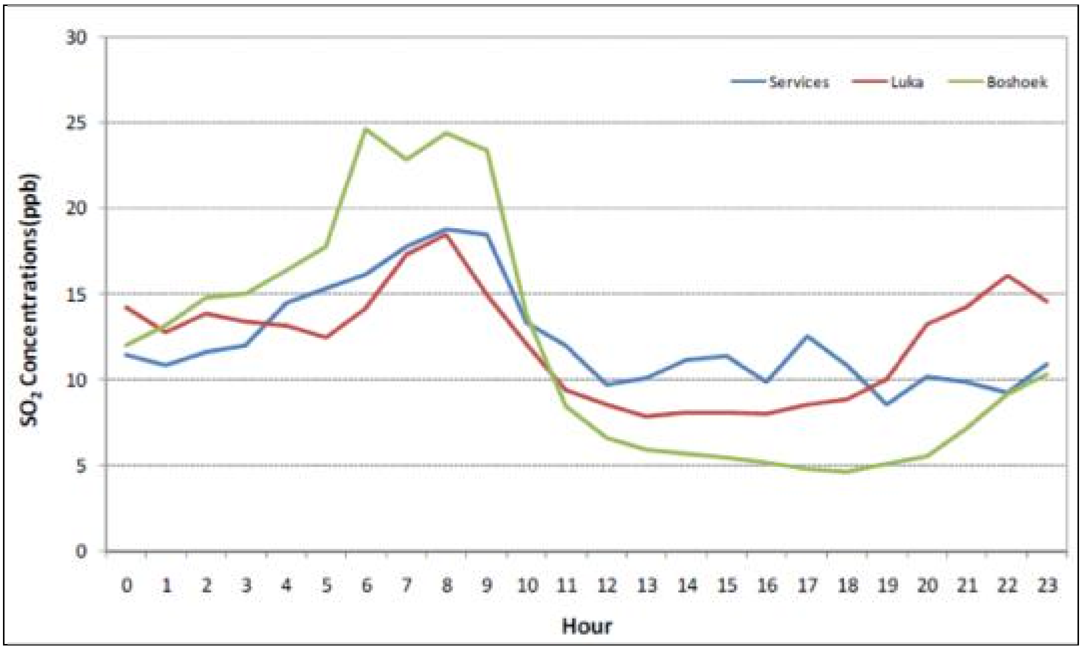


Figure 15: Diurnal SO2 concentrations (ppb) recorded at Impala Platinum Monitoring stations for the period October 2007 – September 2009 (Bojanala Platinum District Municipality AQMP Baseline Assessment, 2010).

5.4.3 Regional ambient PM_{10} concentrations

Ambient PM_{10} concentrations for the period January 2006 to September 2009 (where available) are presented below bases on the available information from the Bojanala Platinum District Municipality Air Quality Management Plan Baseline Assessment.

5.4.3.1 Anglo Platinum

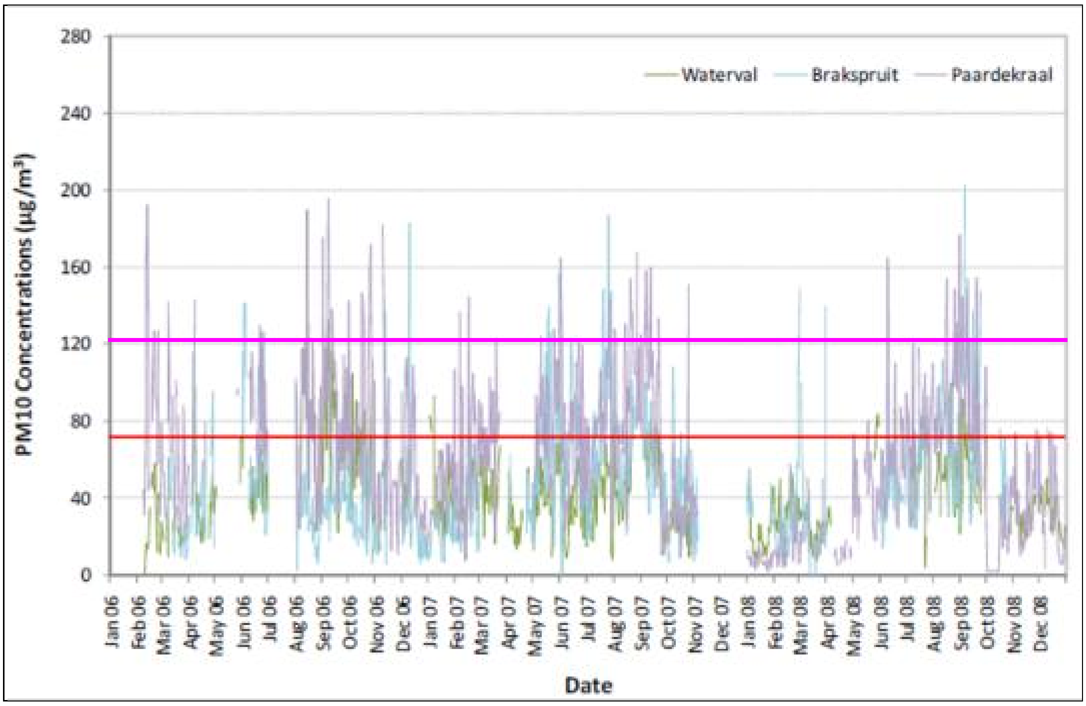
Daily average PM_{10} concentrations at Anglo's monitoring network are elevated and often exceed the current daily average standard (120 µg/m^3) and the 2015 daily average standard (75 µg/m^3) over the monitoring period. Exceedances are experienced relatively frequently at various stations (Figure 16). A relatively distinct seasonal signature is evident in the dataset with elevated concentrations during the autumn and winter months. This is likely linked to the changing meteorological conditions during these months.

Diurnal PM_{10} concentrations across Anglo's monitoring network do not display a common distinctive signature but rather display a trend of relatively stable, except for the Brakspruit and Paardekraal monitoring stations (Figure 17). The Brakspruit monitoring station diurnal trend, appears to display a low level domestic fuel burning signature. The Paardekraal monitoring station diurnal trend appears to be a complex signature, which is the likely result of a combination between fugitive emissions, domestic fuel burning and possible industrial emissions.

5.4.3.2 Impala Platinum

Daily average PM_{10} concentrations at Impala's monitoring network are elevated and exceed the current daily average standard (120 µg/m^3) on several occasions over the monitoring period (Figure 18). If compared to the 2015 daily average standard (75 µg/m^3) numerous exceedances are encountered. A relatively distinct seasonal signature is evident in the dataset with elevated concentrations during the winter and spring months. This is likely linked to the changing meteorological conditions during these months (I.e. dry in winter hence more dust and with increased wind speeds in spring, there will be more dust generation).

Diurnal PM_{10} concentrations at the Services monitoring station appears to display a combined low level domestic fuel burning and industrial signature (Figure 19). The domestic fuel burning signature is indicated by the peaks at approximately 07:00 and 18:00 and the industrial portion of the signature at approximately 13:30. Diurnal PM_{10} concentrations at the Boshoek monitoring station, appears to display a low level industrial signature as the emissions remain relatively constant between 07:00 and 13:00. The Luka station displays a typical domestic fuel burning trend is indicated by the emissions peaks between (approximately) 06:00 and 18:00 and the peak during 17:00 and 22:00.



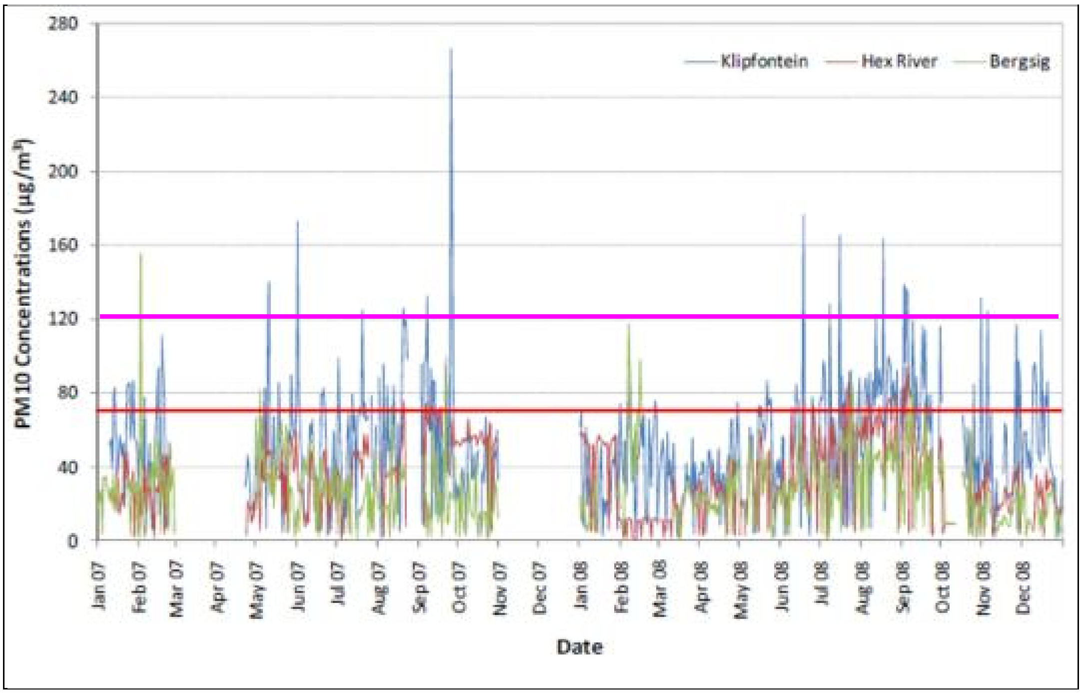


Figure 16: Daily PM10 concentrations recorded at the Anglo Platinum Monitoring stations for the period January 2006 – December 2008 (Red line – 2015 national daily standard of 75 µg/m3, pink line – current national daily standard of 120 µg/m3) (Bojanala Platinum District Municipality AQMP Baseline Assessment, 2010)

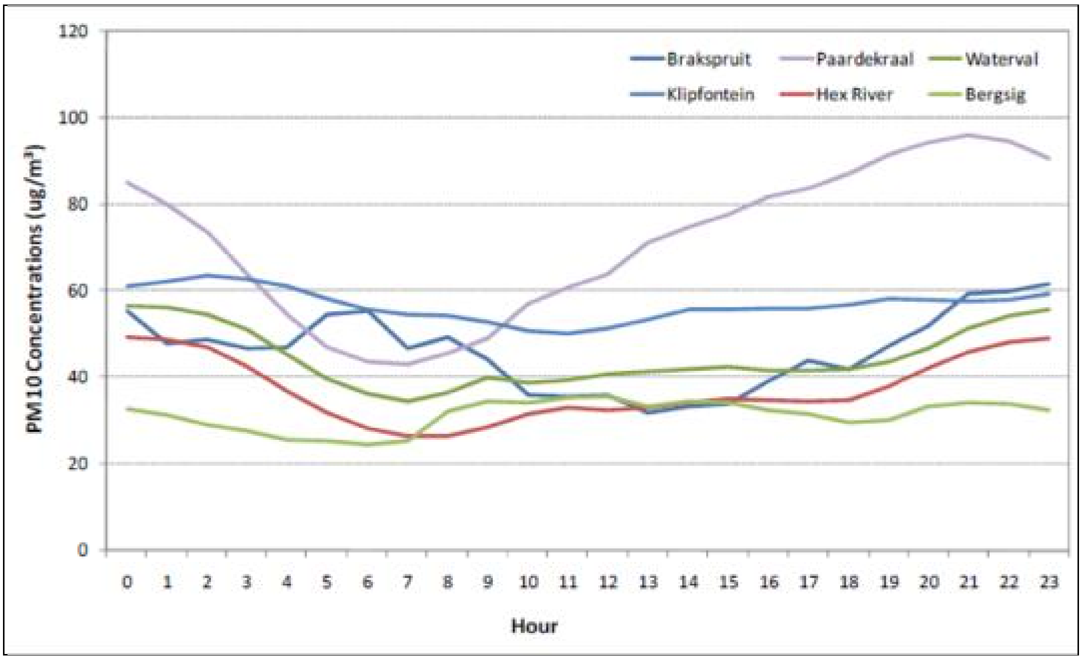


Figure 17: Diurnal PM10 concentrations (µg/m3) recorded at Anglo Platinum Monitoring stations for the period January 2006 – December 2008 (Bojanala Platinum District Municipality AQMP Baseline Assessment, 2010).

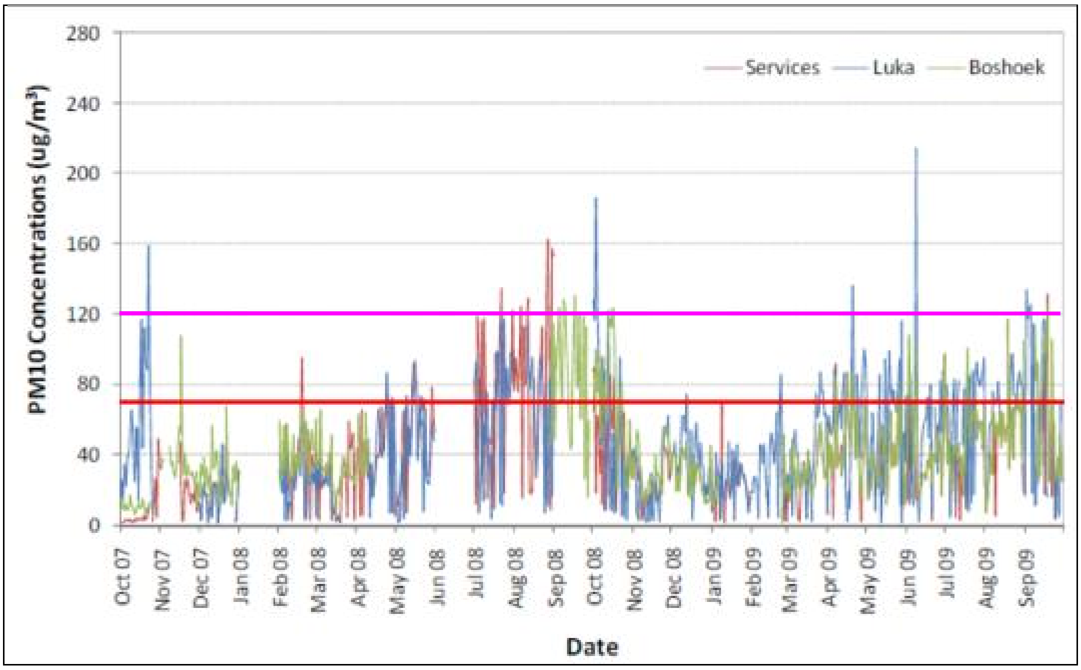


Figure 18: Daily PM10 concentrations (µg/m3) recorded at Impala Platinum Monitoring stations for the period October 2007 – September 2009 (Red line – 2015 national daily standard of 75 µg/m3, pink line – current national daily standard of 120 µg/m3 (Bojanala Platinum District Municipality AQMP Baseline Assessment, 2010).

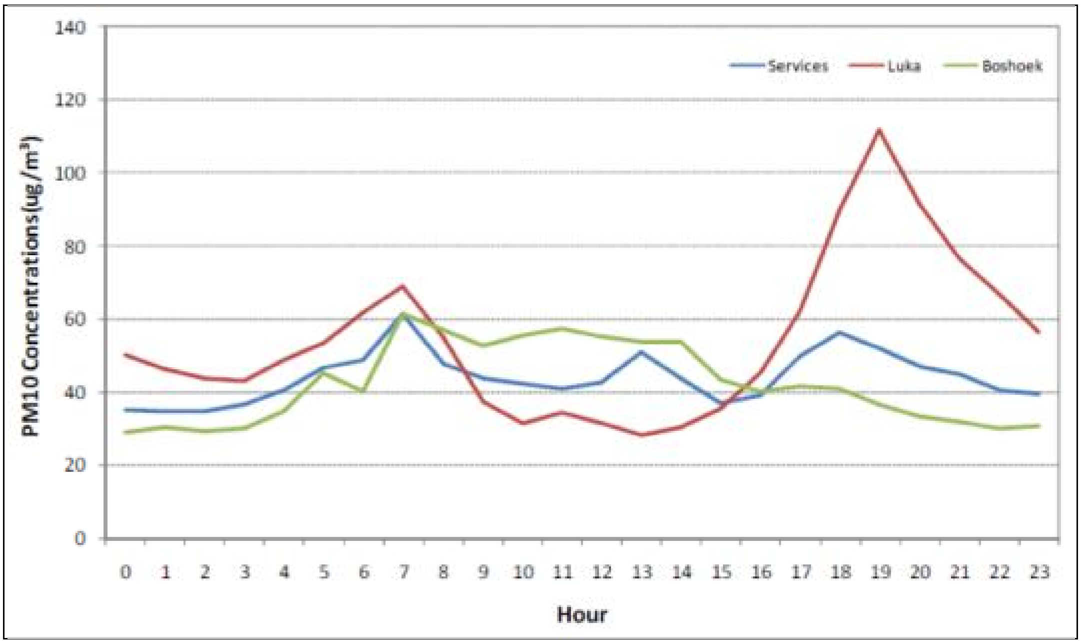


Figure 19: Diurnal PM10 concentrations (µg/m3) recorded at Impala Platinum Monitoring stations for the period October 2007 – September 2009 (Bojanala Platinum District Municipality AQMP Baseline Assessment, 2010).

5.4.4 Regional ambient Dust fallout concentrations

5.4.4.1 Thabazimbi mine

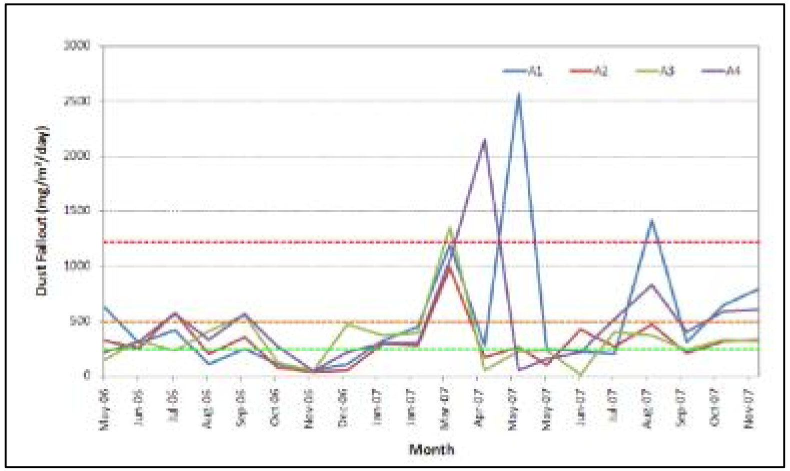
A dust fallout monitoring network was in operation between November 2005 to October 2006 at the Thabazimbi Mine (located approximately 41km's north-east of the proposed Haakdoorndrift mine) but has subsequently been decommissioned (Shangoni Management Services, 2010).
On average, the recorded dust fallout was high (Shangoni Management Services, 2010). The only exceedance of the SANS residential limit was observed at the Thabazimbi Nursery (620 mg/m² /day). (Shangoni Management Services, 2010). No exceedances of the SANS industrial limit were encountered (Shangoni Management Services, 2010).

5.4.4.2 Amandelbult Platinum Mine

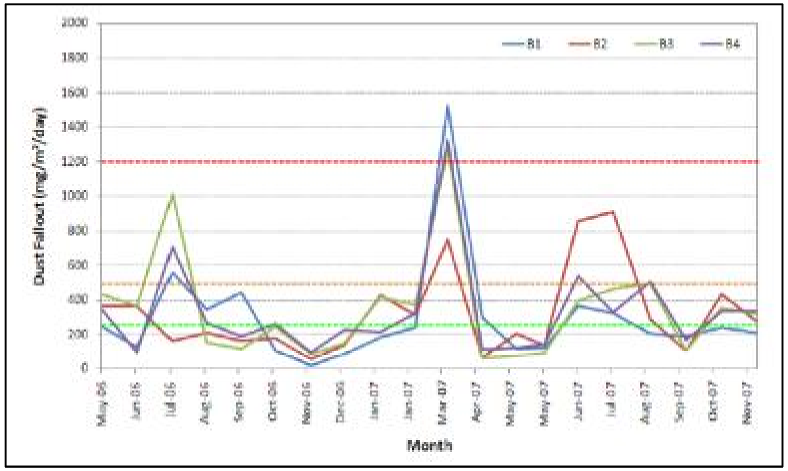
Dust fallout data at Amandelbult Mine (located approximately 25km to the north-east of the proposed NV Mine) was evaluated for the period May 2006 to December 2007. Dust fallout monitoring was undertaken at six locations during this period but has since been discontinued at the mine (Gondwana Environmental Solutions, 2009). The location of the dust fallout buckets was not provided therefore an accurate assessment of dust fallout levels, relative to the dust sources, cannot be undertaken. Dust fallout levels were generally in the moderate to heavy classifications over the monitoring period (Figure 20 and Figure 21). All sites showed a peak in concentrations in March, August and September 2007.The highest concentrations were recorded at sites A and D, with the latter site recording excessive dust fallout levels in 2007.

5.4.4.3 Bushveld Chrome Resource's

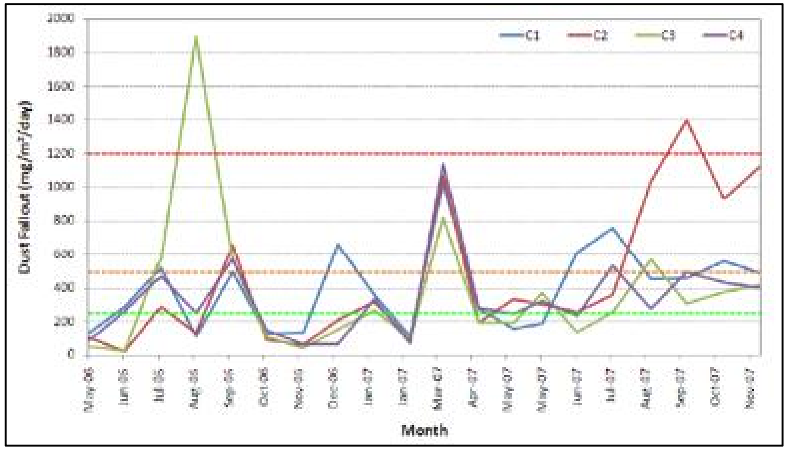
Bushveld Chrome Resources (BCR) undertook dust fallout monitoring from 11 October 2012 to 9 January 2013 approximately 4km east of the proposed NV Mine. Dust fallout monitoring was undertaken at eight locations (Figure 22). Dust fallout levels were all well below the draft residential guideline of 600mg/m^2/day and thus no exceedances of the draft residential standard were encountered (Figure 23).



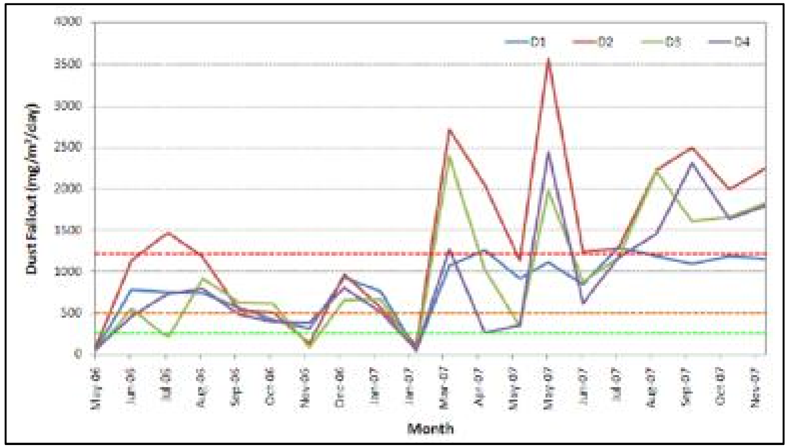
Site A



Site B

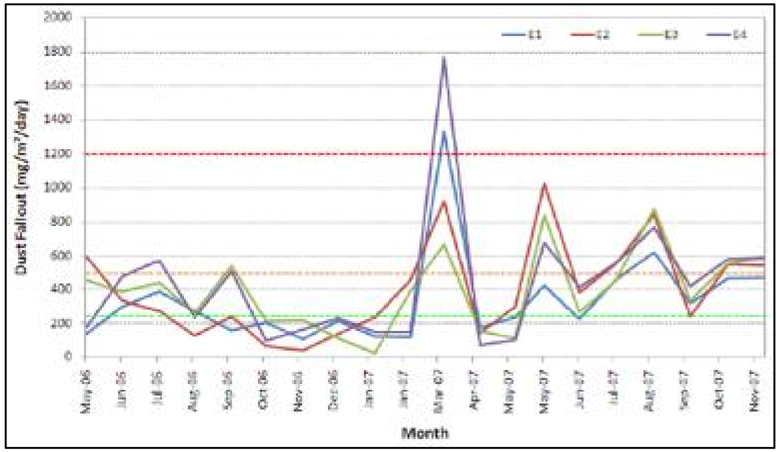


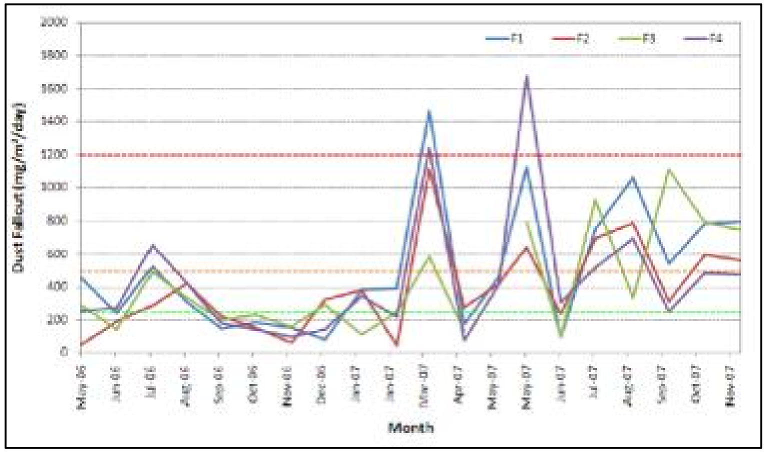
Site C



Site D

Figure 20: Amandelbult Mine dust fallout data for the period May 2006 to December 2007





Site E `

Site F

Figure 21: Amandelbult Mine dust fallout data for the period May 2006 to December 2007

Figure 22: BCR dust fallout monitoring network in relation to the NV Mine.

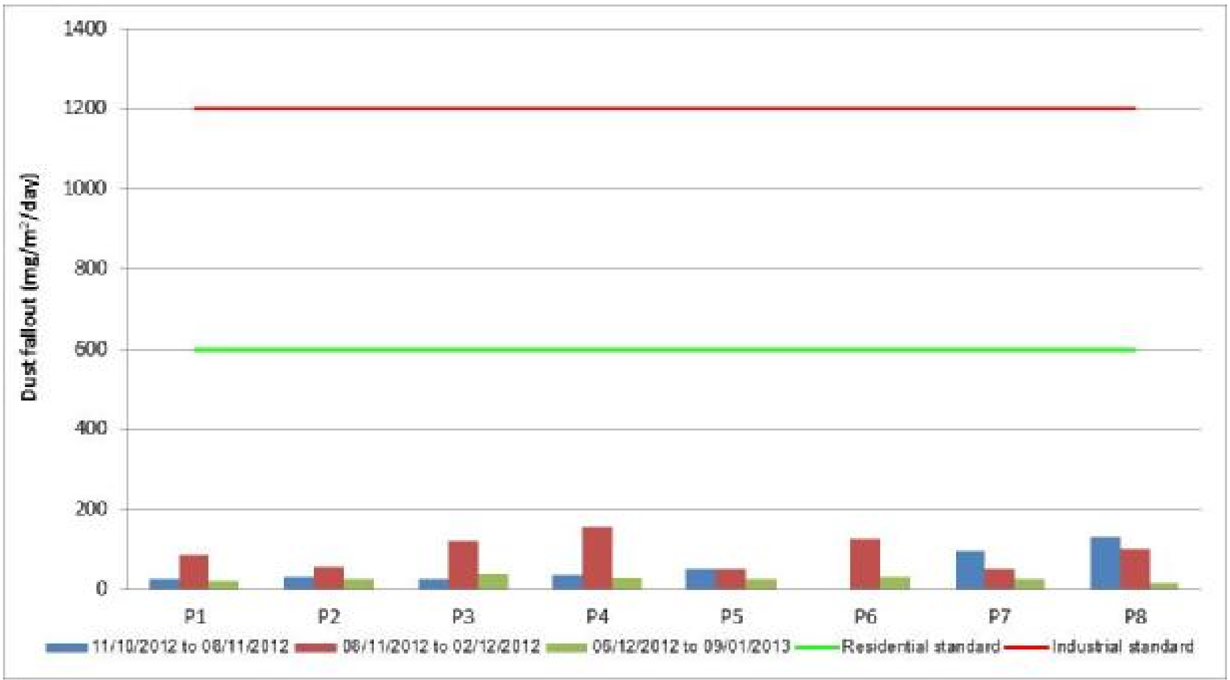


Figure 23: BCR dust fallout data for the period 11/10/2012 to 09/01/2013.

5.4.4.4 Union mine

Union mine undertook dust fallout monitoring from January 2011 to June 2012 approximately 5.5km south-east of the proposed NV mine. Dust fallout monitoring was undertaken at 10 locations (Figure 24 and Figure 25).

The dust fallout levels were typically well below the respective residential and industrial guidelines. The calculated regional average was 183 mg/m^2/day.

Figure 24: Union mine dust fallout monitoring locations (SGS, 2011)

Table 9: Union mine dust fallout data for January 2011 to June 2012

Site	Classification	Dust fallout (mg/m^2/day)																		
		Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Site ave. over monitoring period
MAIN OFFICES	Residential	111	55	44	34	41	56	48	35	112	415	30	273	100	385	402	66	81	35	**129**
ER MANAGER'S HOUSE	Residential	49	75	47	43	88	146	86	47	72	404	393	124	63	459	552	104	115	61	**163**
HOUSE NO1 KANANA VILLAGE	Residential	62	85	63	50	61	69	59	40	288	269	218	411	43	401	783	252	93	102	**186**
SEWAGE PLANT	Industrial	35	13	23	31	12	36	23	16	161	401	253	482	184	322	321	99	49	34	**139**
C HOSTEL	Residential	50	80	56	50	41	120	67	46	139	304	314	387	89	98	215	79	201	46	**132**
MORTIMER SMELTER	Industrial	100	248	266	314	403	152	364	317	461	668	362	806	445	754	664	387	716	319	**430**
NEW OPENCAST	Industrial	10	27	12	18	8	18	19	10	91	255	133	234	34	298	389	78	314	45	**111**
VANSHAFT	Industrial	95	35	60	67	176	214	89	109	363	603	570	ES	75	99	583	201	53	15	**200**
OLD IVAN TAILINGS	Industrial	95	70	11	58	22	35	51	13	262	404	228	542	34	263	301	126	337	43	**161**
MORTIMER TAILINGS DAM	Industrial	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	**ES**
Regional average (mg/m^2/day)																				**183**
Notes:	Exceedances of the guideline highlighted in yellow																			
	ES = Equipment stolen, no sample																			

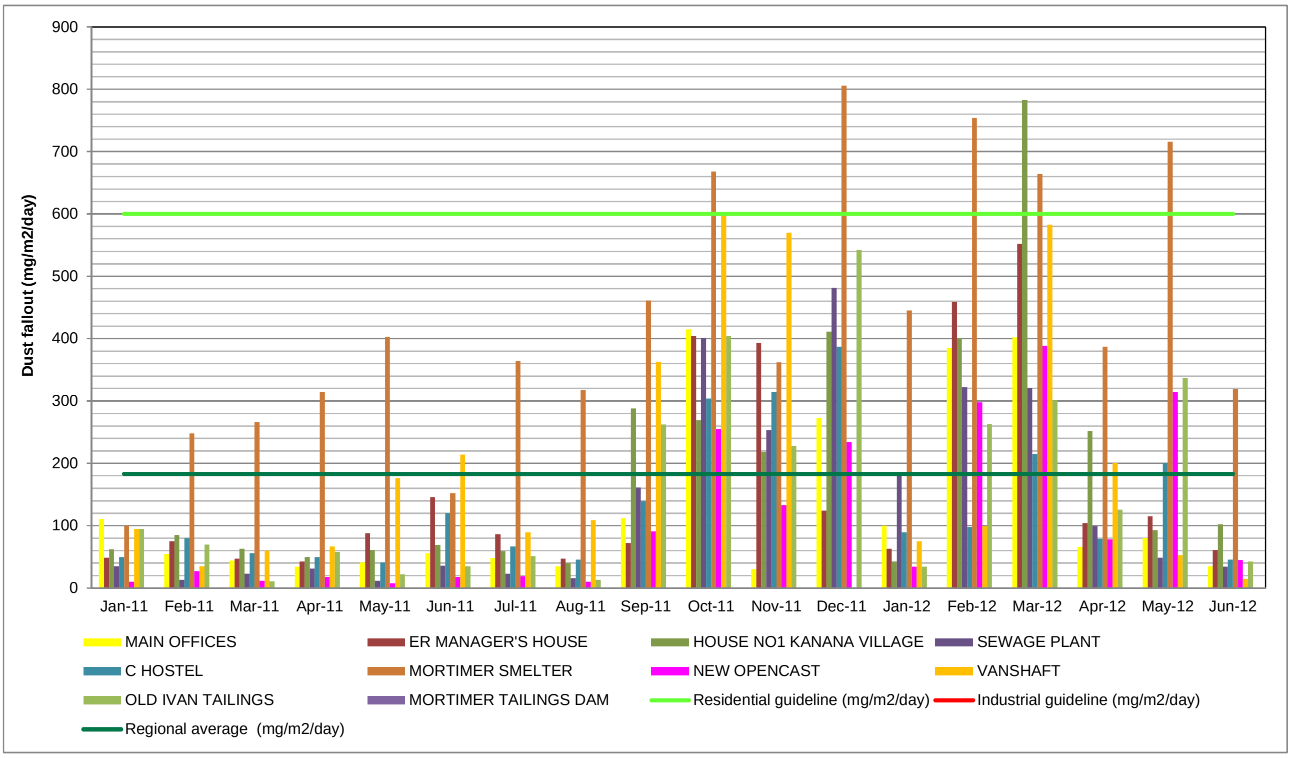


Figure 25: Graphic representation of the union mine dust fallout data for January 2011 to June 2012.

5.4.5 Local sources of emissions

Potential sources of air pollution within the NV Mine area have been identified to include:

- Agricultural activities;
- Current mining activities (platinum, lime and iron);
- Cement production;
- Domestic fuel burning;
- Biomass burning;
- Vehicle emissions (tailpipe and entrained emissions);
- Unpaved roads and exposed areas; and
- The proposed construction activity emissions (I.e. the new NV Mine).

5.4.5.1 Agricultural activities

Biomass burning is an incomplete combustion process that produces PM_{10}, CH_4, CO and NO_2. Emissions from agricultural activities are difficult to control due to the seasonality of emissions and the large surface area producing emissions (USEPA, 1995). Most of the agricultural activities around the mine appear to be of a subsistence farming nature (both crop and livestock) rather than large scale commercial farming. Game farming is also common in the region.

Agricultural emissions are not anticipated to significantly influence the air quality in the area although particulate emissions may increase during the winter period.

5.4.5.2 Mining activities

Dust emissions may be generated by wind erosion from the tailings facilities, waste rock dumps, stock piles, open mining pits, vent shafts, unpaved mine access roads and other exposed areas. Dust emissions occur when the threshold wind speed is exceeded (Cowherd *et al*., 1988). Factors which influence the rate of wind erosion include surface compaction, moisture content, vegetation, shape of storage pile, particle size distribution, wind speed and rain. Dust generated by these sources is termed 'fugitive dust' as it is not emitted to the atmosphere in a confined flow stream (USEPA, 1995). These emissions are often difficult to quantify as they are very diffuse, variable and intermittent (Ministry of the Environment, 2001).

Within the NV Mine project area, there is a relative high density of mining activities. Mines in the area include (Figure 26):

- The Amandabult platinum mine;
- Northam platinum mine;
- The Thabazimbi iron ore mine;
- Union mine;
- Kraalhoek lime mine; and
- Ruighoek chrome mine.

Fugitive dusts generated from these mining operations and associated infrastructure, are anticipated to be one of the dominant emissions in the region. Similarly, fugitive dusts generated by the proposed NV Mine during both the construction and operational phases are anticipated to be the dominant emission. Special attention in regards to mitigation of these emissions will have to be undertaken to prevent the reduction of the ambient air quality.

Figure 26: Local mining sources (red stars) and local industrial sources (orange stars) in relation to the NV mine.

5.4.5.3 Domestic fuel burning

Domestic fuel burning of coal emits a large amount of gaseous and particulate pollutants including sulphur dioxide, heavy metals, total and respirable particulates, inorganic ash, carbon monoxide, polycyclic aromatic hydrocarbons, and benzo(a) pyrene. Pollutants arising due to the combustion of wood include respirable particulates, nitrogen dioxide, carbon monoxide, polycyclic aromatic hydrocarbons, particulate benzo(a) pyrene and formaldehyde. The main pollutants emitted from the combustion of paraffin are nitrogen dioxide, particulates, carbon monoxide and polycyclic aromatic hydrocarbons. Both formal and informal housing (informal being dominant) are noted throughout the region. It is thus highly likely that certain households within the communities are likely to use coal, wood and paraffin for space heating and/or cooking purposes. Emissions from these communities and therefore anticipated to impact the regional, especially during the winter period due to the increased demand for space heating.

5.4.5.4 Biomass burning

Biomass burning may be described as the incomplete combustion process of natural plant matter with carbon monoxide, methane and nitrogen dioxide being emitted during the process. During the combustion process, approximately 40% of the nitrogen in biomass is emitted as nitrogen, 10% remains in the ashes and it is assumed that 20% of the nitrogen is emitted as higher molecular weight nitrogen compounds. In comparison to the nitrogen emissions, only small amount of sulphur dioxide and sulphate aerosols are emitted. With all biomass burning, visible smoke plumes are typically generated. These plumes are created by the aerosol content of the emissions and are often visible for many kilometres from the actual source of origin.

The extent of emissions liberated from biomass burning are controlled by several factors, these include the following:

- The type of biomass material;
- The quantity of material available for combustion;
- The quality of the material available for combustion;
- The fire temperature; and
- Rate of fire progression through the biomass body.

Crop-residue burning and general wild fires represent significant sources of combustion-related emissions associated with agricultural areas. Given that the region has a high concentration of both subsistence and large scale commercial farming (both crop and livestock), it is anticipated that both general wild fires and controlled burning related to the agricultural activities may impact on the ambient air quality in this region. The typical fire season corresponds with the winter period when the quantity and quality of the available combustible material is at its maximum.

5.4.5.5 Vehicle emissions

Air pollution generated from vehicle emissions may be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly to the atmosphere as tail-pile emissions whereas, secondary pollutants are formed in the atmosphere as a result of atmospheric chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. The primary pollutants emitted typically include carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons (including benzene, 1.2-butadiene, aldehydes and polycyclic aromatic hydrocarbons), sulphur dioxide (SO_2), oxides of nitrogen (NO_x) and particulates. Secondary pollutants formed in the atmosphere typically include nitrogen dioxide (NO_2), photochemical oxidants such as ozone, hydrocarbons, sulphur acid, sulphates, nitric acid, sulphates, nitric acid and nitrate aerosols.

The quantity of pollutants emitted by a vehicle depends on specific vehicle related factors such as vehicle weight, speed and age; fuel-related factors such as fuel type (petroleum or diesel), fuel formulation (oxygen, sulphur, benzene and lead replacement agents) and environmental factors such as altitude, humidity and temperature (Samaras and Sorensen, 1999).

Given the low population density living in the region it is anticipated that vehicle exhaust emissions will be relatively limited and its contribution to ambient air pollutant concentrations dispersed and relatively insignificant. In regards to the current mining operations, it is identified as a key source for vehicle emissions due to the high prevalence of heavy vehicles and heavy machinery with combustion engines. Even though the mine is identified as a key source, it is Golder opinion that due to the relative low density of sensitive receptors and the fact that the vehicle emissions will be widely distributed, the impact is likely to be insignificant. Similarly, vehicle emission are anticipated to be encountered during both the construction and operational phases of the open pit mine however they are anticipated to be minimal and should not influence the ambient baseline air quality.

5.4.5.6 Emissions Associated with Construction Sites

Road construction and land clearing are important sources of fugitive dust emissions that may have substantial temporary impact on the local air quality in the vicinity of the activity. Fugitive dust is any solid particulate matter that becomes airborne. The primary chemical constituents of fugitive dust are oxides of silicon, aluminium, iron and other calcium compounds. Daily dust emissions will vary according to the level of activity, the type of operation and the meteorological conditions. Fugitive emissions from road construction have a definable beginning and end and will vary according to the construction phase (USEPA, 1995).

Fugitive emissions are anticipated to be one of the dominant emissions from the NV Mine during both the construction and operational phases. In regards to the construction phase the impacts may be intense however short-lived as construction is envisaged to occur over an approximate two year period.

5.4.5.7 Unpaved Roads and exposed areas

Vehicle entrained dust emissions from paved and unpaved roads represent a potentially significant source of fugitive dust in the region. Identified sources of fugitive road dust emissions include the roads (unpaved & paved roads) from the proposed NV Mine, local farming and access roads and the mine access/haul roads.

Particulate emissions from paved roads occur when loose, spilt material on the road surface becomes suspended as vehicles travel across. At industrial and construction sites the surface loading is continually replenished by spillage of material from unpaved roads and vehicles. Various field studies have shown that even paved roadways can be major sources of atmospheric particulate matter (EPA, 1996). The force of the wheels of vehicles travelling on unpaved roadways the road surface is exposed to strong air currents in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. The quantity of dust emissions from unpaved roads varies linearly with the volume of traffic.

Vehicle entrainments of particulates from unpaved haul roads are anticipated to be one of the dominant emissions during the operational phase of the mine. Special attention in regards to mitigation of these emissions will have to be undertaken to prevent the reduction of the ambient air quality.

5.4.5.8 Cement production

Cement manufacturing is a "high volume process" and correspondingly requires high volumes raw materials, thermal fuels and electrical power. The typical manufacturing process included the following processes:

- Mining and acquisition of the raw materials;
- Raw material milling and fuels preparations;
- Clinker burning;
- Cement grinding; and
- Packaging and distribution.

During the manufacturing process both direct stack emissions and fugitive emissions are released. The key atmospheric pollutants from the processes include trace gas pollutants (CO_2, NO_x, SO_2, Volatile Organic Compounds (VOCs)) and particulates (TSP, PM_{10}, $PM_{2.5}$ and dust fallout).

The Pretoria Portland Cement (PPC) Dwaalboom operation is located approximately 32km west-north-west of the NV mine (Figure 26). The plants fugitive and stack emissions are anticipated to be a significant regional source of the trace gas and particulate pollutants, which may impact on the regional ambient air quality.

5.4.5.9 Summary

Due to the lack of available baseline ambient air quality information for this region, it is recommended that Samancor deploys an ambient air quality monitoring campaign to determine the background air quality prior to the mines extension. This network should monitor the following pollutants; Dust fallout, PM_{10}, NO_2 and SO_2 and monitor wind speed and direction as a minimum.

6.0 AIR QUALITY IMPACT ASSESSMENT

6.1 Assumptions and Limitations

The following assumptions were made:

- The available regional baseline ambient air quality information is site representative of the NV Mine site; and
- MM5 modelled meteorological data is site representative.

The assessment is limited by the following:

- Whilst care has been taken to assess the potential air pollution impact from the proposed NV Mine, changes to the current existing designs after this assessment may result in different conclusions;
- No emissions quantification was undertaken via air dispersion modelling; and
- The lack of site specific meteorological and ambient air quality monitoring data.

6.2 Professional opinion - Construction phase

The fugitive emissions released during the construction of the NV Mine surface infrastructure are anticipated to be associated with land clearing, drilling and blasting, ground excavation and cut and fill operations. The key emissions identified include PM_{10} and total suspended particulates (TSP - as dust fallout). The level of daily emissions will vary according to the intensity of activity, the type of operation and the meteorological conditions. Additionally, these fugitive emissions from the construction activities, will have a definable beginning and end and will vary according to the construction phase (USEPA, 1995). The impact severity may be high however due to the relative short duration (estimated 2 year construction period) and the radius of effect being limited to the immediate vicinity of the activity, the long term impact is anticipated to be negligible.

In Golder’s professional opinion, there are no anticipated air quality impacts for the construction phase which serve as a fatal flaw for the proposed mines expansion. Nevertheless, in order to reduce the nuisance factor of the emissions and aid in ensuring compliance with current legislative requirements, mitigation measures must be implemented. In order to increase the confidence level of this assessment it is recommended that a dispersion model be developed for the facility so that the impacts can be quantified.

6.3 Professional opinion – Operational phase

The fugitive emissions released during the operations phase of the NV Mine surface infrastructure are anticipated to be associated with drilling and blasting, ground excavation, cut and fill operations, ore processing emissions (such as crushing and screening) and ore haulage. The key emissions identified include PM_{10} and total suspended particulates (TSP - as dust fallout).

In Golder’s professional opinion, there are no anticipated air quality impacts for the operations phase which serve as a fatal flaw for the proposed mines expansion. However to reduce the nuisance factor of the emissions and aid in ensuring compliance with current legislative requirements, mitigation measures must be implemented. In order to increase the confidence level of this assessment it is recommended that a dispersion model be developed for the facility so that the impacts can be quantified.

6.4 Impact Analysis Summary

Table 10: Impact analysis summary

Impact	Phase	Impact before mitigation						Impact after mitigation					
		Probability	**Scale**	**Duration**	**Magnitude**	**Total**	**Impact before mitigation**	**Probability**	**Scale**	**Duration**	**Magnitude**	**Total**	**Impact after mitigation**
Degeneration of the ambient air quality due to increased PM_{10} levels from land clearing, drilling and blasting, ground excavation and cut and fill operations	Construction Phase	4	2	1	2	20	Low	2	1	1	2	8	Low
Degeneration of the ambient air quality due to increased TSP levels from land clearing, drilling and blasting, ground excavation and cut and fill operations.	Construction Phase	4	2	1	2	20	Low	2	1	1	2	8	Low
Degeneration of the ambient air quality due to increased TSP levels	Operational phase	4	2	3	4	36	Moderate	4	1	2	2	20	Low
Degeneration of the ambient air quality due to increased PM_{10} levels	Operational phase	4	2	3	4	36	Moderate	4	1	2	2	20	Low

Respective mitigation measure options for the NV Mine are detailed in Section 7 below.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the qualitative impact assessment and Golders associated professional opinion, without the implementation of particulate mitigation measures during the construction and operational phases of the NV Mine, exceedances of:

- The PM_{10} daily average standard;
- The PM_{10} annual average standard; and
- The draft dust fallout guidelines (both residential and industrial).

Are likely to occur at several of the key sensitive receptors. Without the implementation of suitable mitigation measures the local ambient air quality may be degenerated by the emissions contribution from the NV mine. This degeneration in the local air quality may impact negatively on the key sensitive receptors health and wellbeing.

7.1 Recommendations

- Suitable mitigation measures must be implemented to reduce the project's impact to acceptable levels at the sensitive receptors;
- Due to the lack of available baseline ambient air quality information for this region, it is recommended that Samancor deploy an ambient air quality monitoring campaign to determine the site specific background air quality. This network should monitor the following:
  - PM_{10} on a continuous basis;
  - Dust fallout monitoring in alignment with the draft regulations on a continuous basis for the footprint of the mine; and
  - NO_2 and SO_2 via a minimum 3 month monitoring campaign.
- Due to the lack of available site specific meteorological data and the uncertainty around the modelled data, Samancor should install a professional meteorological station (required data accuracy of 1-2%) on site. The station should operate on a continuous basis;
- For all waste rock dump and overburden stockpiles mitigation measures for TSP and PM_{10} generation could include:
  - Progressive rehabilitation and re-vegetation should be implemented;
  - Chemical stabilisation; and
  - Facility design and maintenance to exclude and minimise the development of sharp edges that can lead to excessive particulate dust generation due to air eddy and erosive effects below the sharp edge.
- For the open pit mitigation measures for TSP and PM_{10} generation could include:
  - Haul road dust generation (refer to travelling on unpaved roads section);
  - Blasting (refer to blasting section);
  - Drilling (refer to drilling section);
  - Drop height reduction during materials handling activities;
  - Wet suppression during materials handling activities;

- Load wet suppression spraying to reduce fugitive dust generation during transportation; and
- Pit mining activities should be restricted and minimized on days with excessive wind speed to reduce the generation of dust within the pit.

- For paved and unpaved roads mitigation measures for TSP and PM_{10} generation could include:
  - Many dust mitigation measures are available for the minimisation of fugitive dust generation on unpaved roads. These may include:
    - Wet suppression with water;
    - Application of salts - hygroscopic compounds such as calcium chloride, magnesium chloride, hydrated lime, sodium silicates, etc. Salts increase roadway surface moisture by extracting moisture from the atmosphere;
    - Application of surfactants - such as soaps and detergents. Surfactants decrease the surface tension of water, which allows the available moisture to wet more particles per unit volume;
    - Application of soil cements - compounds that are mixed with the native soils to form a new surface. Examples are calcium or ammonium lignin sulphonate, cement, etc.;
    - Application of bitumens - compounds derived from coal or petroleum such as coherex peneprime, asphalt, oils, etc.; and
    - Application of films—polymers that form discrete tissues, layers, or membranes such as latexes, acrylics, vinyls, fabrics, etc. These form coherent surface layers that seal the road surface, thereby reducing the quantity of dust generated.
  - The application of the above measures must be considered carefully as certain measures could possibly lead to surface water contamination and the management thereof must be strictly controlled.
  - Furthermore, a detailed cost benefit analysis should be conducted to determine which, is the most cost-effective method with the highest efficiency in dust reduction.

- General transport mitigation measures may include:
  - Reduction in unnecessary traffic volumes;
  - Conversion of the unpaved road surface to a paved surface;
  - Rigorous speed control and the institution of traffic calming measures to reduce vehicle entrainment. A recommended maximum speed of 20 km/h to be set on all unpaved roads and 35 km/h on paved roads;
  - Wet suppression of materials transported by road (i.e. load spraying) or load covering with tarpaulins to reduce fugitive dust generation;
  - Avoidance of dust track-on onto neighbouring paved roads; and
  - All vehicles and other equipment should be maintained and serviced regularly to ensure that tailpipe particulate emissions are kept to a minimum.

- For ore stockpiles, mitigation measures for TSP and PM_{10} generation could include:
  - Haul road dust generation (refer to travelling on unpaved roads section);
  - Drop height reduction during materials handling activities;
  - Wet suppression during materials handling activities;

- § Stockpile height reduction to reduce the stockpiles exposure to wind at elevated heights;
- § Introduction of wind breaks or sheltering; and
- § Wet suppression of materials transported by road (i.e. load spraying) or load covering with tarpaulins to reduce fugitive dust generation.

¡ For blasting, mitigation measures for TSP and PM_{10} generation could include:

- § Wet suppression is important in controlling dust generated by blasting activities. The area surrounding the blast should be thoroughly wetted down beforehand. This precaution will prevent dust settled out during previous blasts from becoming airborne.
- § The water used for dust suppression during blasting should be as clean as possible, because the evaporation of dirty water can also release dust;
- § The blast charge should be calculated as accurately as possible and kept to the minimum required as the larger the charge, the higher the potential for dust generation; and
- § Consideration of wind speed and direction in the blasting schedule, particularly where communities live nearby and may be affected by blasting emissions.

¡ For materials handling operations, mitigation measures for TSP and PM_{10} generation could include:

- § Drop height reduction during materials handling activities;
- § Wet suppression during materials handling activities;
- § Load wet suppression of materials transported by road (i.e. load spraying) or load covering with tarpaulins to reduce fugitive dust generation;
- § Removal of fines via pre-washing; and
- § Wind speed reduction through sheltering *(where possible)*.

¡ For drilling activities, mitigation measures for TSP and PM_{10} generation could include:

- § Overburden and waste rock drilling generates most of the respirable dust that affects workers in the mining pit. Both wet and dry methods are available to reduce this drill dust.
- § Typically, wet suppression systems pump water through the drill steel into the bailing air (ILO, 1965). The water droplets in the bailing air trap dust particles as they travel up the annular space of the drilled hole, thus controlling dust as the air bails the cuttings from the drill hole (Page, 1991).
- § Dry collection systems require an enclosure (shroud) around the area where the drill stem enters the ground. This enclosure is typically constructed by hanging a rubber or cloth shroud from the underside of the drill deck. The enclosure is then ducted to a dust collector, the clean side of which has a fan. The fan creates a negative pressure inside the enclosure, capturing dust as it exits the hole during drilling. The dust is removed in the collector, and clean air is exhausted through the fan; and
- § The water used for dust suppression, during drilling should be as clean as possible, because the evaporation of dirty water can also release dust.

¡ For crushing activities, mitigation measures for TSP and PM_{10} generation could include:

- § Drop height reduction during materials handling activities at the crushers;
- § Wet suppression of materials to be crushed. If the material is dry, a starting point is to add a water quantity equivalent to 1% of the weight of the material being crushed (Quilliam, 1974);

- Regular cleaning of floor and working surfaces in the vicinity of the crusher/s to reduce fugitive dusts; and
- Negative pressure should be maintained where possible within the crusher to prevent the escape of fugitive dusts.

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GOLDER ASSOCIATES AFRICA (PTY) LTD.

Adam Bennett	Etienne Roux
Divisional Leader: Atmospheric management Service	Review Manager

AB/ER/ck

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APPENDIX A

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GOLDER ASSOCIATES AFRICA (PTY) LTD

June 2013

SAMANCOR-NOOITGEDACHT & VARKENSVLEI

Groundwater Baseline and Impact Assessment Report for the Mining Rights Application (MRA)

Submitted to:
Heather Booysens
Samancor
Group Environmental Manager

REPORT

Report Number. 13614977-12148-16

Distribution:

1 x Samancor (electronically)
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1 x Project File

Golder Associates

EXECUTIVE SUMMARY

SAMANCOR is required to submit the mining right applications (MRA), EIA Report and EMPR for Nooitgedacht and Varkensvlei near Northam, in the Northwest and Limpopo provinces, South Africa.

The main objectives of this groundwater study are to:

- Characterise the prevailing groundwater situation.
- Define the water bearing strata in the area.
- Determine current groundwater level distribution and flow directions.
- Conduct a gap analyses.
- Conduct a *qualitative* assessment of the impact of the proposed opencast mining on the groundwater system, the water resource and existing groundwater users.

The Bushveld Igneous Complex (BIC) is one of the largest layered mafic intrusions in the world and yields a wide range of mineral commodities including: vanadium, chrome, Platinum Group Elements (PGEs) and titaniferous magnetite. The proposed mining project area is situated in the north-western sector of the BIC and is underlain on surface by the Lower Critical Zone and Upper Critical Zone of the Rustenburg Layered Suite (RLS). The chrome ore to be mined on the proposed mine lease area on the farm Nooitgedacht and Varkensvlei is situated in the Lower Critical Zone and in the transition zone to the Upper Critical Zone of the RLS.

The following two layer aquifer model conceptualises the BIC aquifers:

- A shallow weathered bedrock aquifer system, underlain by a
- deeper fractured bedrock system.

The weathered overburden is considered to have low to moderate transmissivity but high storativity. The underlying solid and unweathered crystalline rocks are generally characterised by very low porosity and high hydraulic conductivity values if fractures are intersected.

A site familiarisation and hydrocensus was conducted on and surrounding the farms Nooitgedacht and Varkensvlei in February 2013. The main findings of the field investigations are:

- The groundwater table varies from approximately 7.54 to 24.3.mbgl
- The groundwater pH ranges from approximately 7.4 to 7.7
- Groundwater is used for domestic, garden watering and golf course irrigation purposes on the two farms in question.

The groundwater impacts of the proposed mining operation seen in isolation are in general considered local and not entirely reversible. Impacts are expected to produce permanent local groundwater recharge and quality changes. A risk does exist that groundwater impacts of the proposed SAMANCOR mining operation are not fully stated, due to the absence of a more substantive baseline groundwater assessment.

It is, therefore recommended to establish a groundwater monitoring system to adequately assess the baseline groundwater conditions. Further management options may need to be recommended once a groundwater monitoring system has been established.

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1.0 INTRODUCTION

SAMANCOR (Pty) Ltd requested Golder Associates Africa (Golder) to provide specialist groundwater input in support of the Mining Rights Applications (MRA) for portions of the farms Varkensvlei/Nooitgedacht to the north of Pilanesberg, straddling the boundary between the Northwest Province (Varkensvlei) and the Limpopo Province (Nooitgedacht). The areas under consideration are shown in Figure 1 &Figure 2 and have been altered by agriculture.

Due to the imminent expiry of prospecting rights for this area, SAMANCOR is required to submit the MRA by 6 May 2013 and final document (EIA Report and EMPR) by mid October 2013.

Although baseline environmental information for the EIA is required, SAMANCOR only has some geological information, so the baseline information primarily relies on literature sources.

This document reports on the baseline groundwater assessment and impact assessment that forms part of the EIA Report and EMPR.

2.0 OBJECTIVES

The main objectives of this groundwater study are to:

- Characterise the prevailing groundwater situation,
- Define the water bearing strata in the area,
- Determine current groundwater level distribution and flow directions,
- Conduct a gap analyses,
- Conduct a *qualitative* assessment of the impact of the proposed opencast mining on the groundwater system, the water resource and existing groundwater users.

3.0 INFORMATION SOURCES

To achieve the objectives specified in Section 2 above, available reports and maps were reviewed to gather groundwater information relevant to the study area. This includes reports compiled by SAMANCOR, Amplats, SRK and other authors (Table 1).

Table 1: List of reports and information reviewed for this baseline report

Title	Type	Date	Author	Information obtained
Dishaba Mine Backfill Project – Draft Scoping report in terms of Reg. 49 (No, R527 of 2004) of the MPRDA and Reg. 28 of Environmental Impact Assessment Regulations, No. R543 of 2010, in terms of the National Environmental Management Act, No. 107 of 1998	Report	August 2012	Anglo American Platinum Ltd (AMPLATS)	Background
Groundwater and Mining in the Bushveld Complex	Scientific Paper	October 2009	TitusRiaan Titus, Kai Witthüser and Bruce Walters	Background
Rustenburg Platinum Mine (RPM) Union: Hydrogeology Report – Phase 1	Consulting Report	August 2011	SRK Consulting	Background
SAMANCOR	Mine Work Programme – Rev 7	2013	SAMANCOR	Geology and location

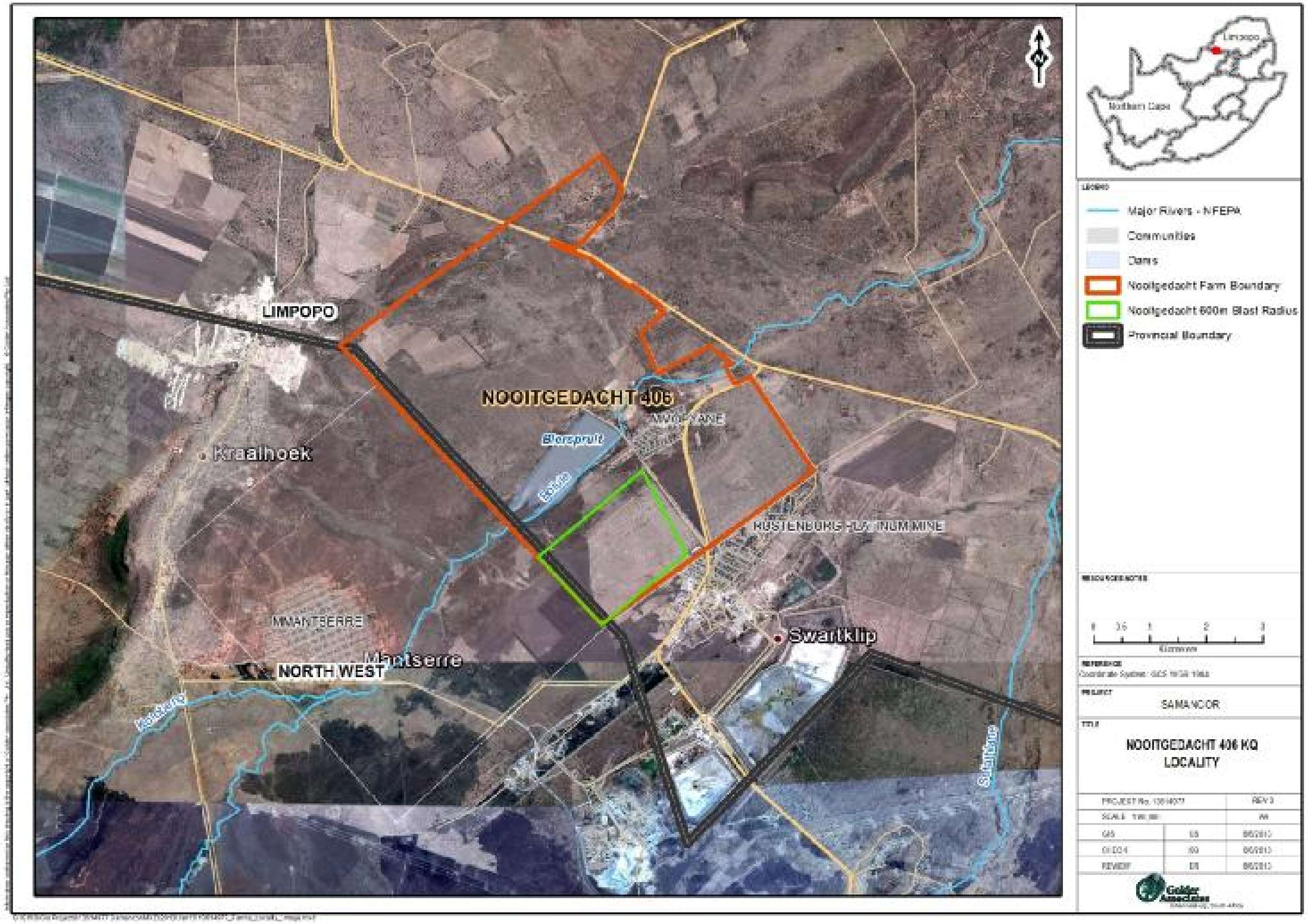

Figure 1: Nooitgedacht locality showing likely project area extent

4.0 PHYSICAL DESCRIPTION OF STUDY AREA BASED ON BACKGROUND INFORMATION

4.1 Location

The mining lease area discussed is located on two adjacent farms, separated by a farm and provincial boundary. The southern portion of the farm Nooitgedacht 406KQ is located in the Limpopo Province under the jurisdiction of the Thabazimbi Local Municipality, The farm Varkensvlei 403KQ, is in the Northwest Province and falls under the jurisdiction of the Moses Kotane Local Municipality. The proposed mine lease area is situated approximately 35-40 km south of Thabazimbi, some 15km west of Northam and about 80km north of Rustenburg. Neighbouring towns include Swartklip, Chromite and various other settlements such as Amandelbult and Rethabile. Refer to Figure 1 and Figure 2 for the general locality of the study site.

4.2 Legal Framework

The South Africa's Constitution guarantees all its citizens the right to an environment that is not harmful to their health and/or wellbeing; and to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation. The Constitutional obligations of the State to protect the environment with respect to new development can only be met through the implementation, enforcement and monitoring of effective legislation.

In order to protect the environment and ensure that the proposed development is undertaken in an environmentally responsible manner, the following pertinent laws apply and guide this groundwater baseline and impact assessment:

- The Mineral and Petroleum Resources Development Act (No. 28 of 2002)
- The National Environmental Management Act (No. 107 of 1998) and the Environmental Impact Assessment Regulations (GNR 543 of 2010)
- The National Water Act (No. 36 of 1998)

4.3 Climate and Rainfall

4.3.1 Temperature

The Thabazimbi/Northam region experiences high temperatures in the summer months and cold to mild temperatures in the winter months. The average monthly minimum and maximum temperatures are depicted in Table 2.

.

4.3.2 Rainfall and Evaporation

The warmer months of November through to March are characterised by high rainfall. Rainfall is generally low between the months of May and September. Long term records indicate that precipitation varies widely and the region is generally characterised by high intensity/short duration thundershowers during the warmer months.

Data for the Mean Annual Precipitation (MAP) and evaporation for the area were provided by the South African Weather Service (SAWS).

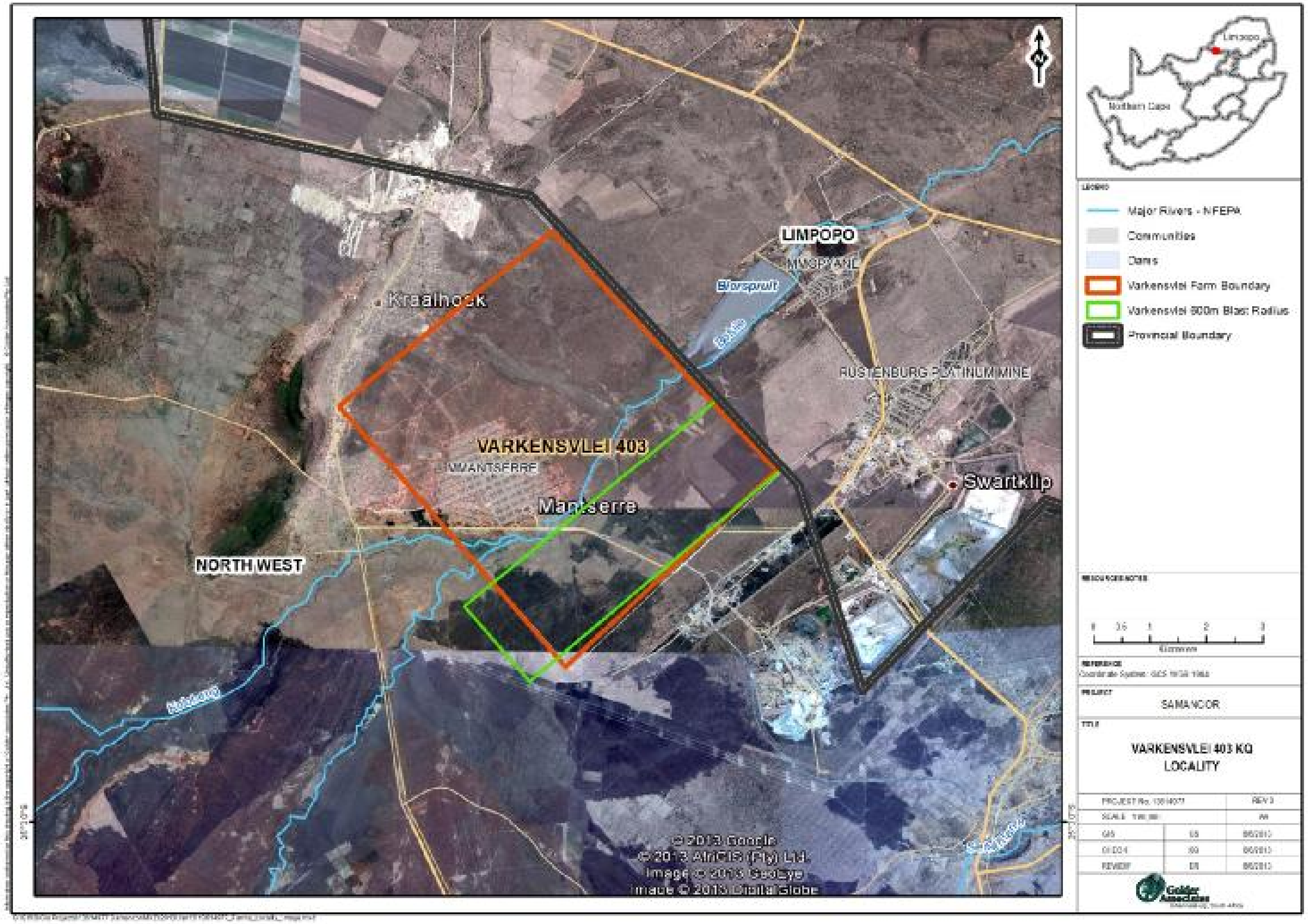

Figure 2: Varkensvlei locality also showing likely project area extent

Table 2: Rainfall, Temperature and Evaporation data (W0587477, Northam and W0587725 Thabazimbi and WR 90) from SAWS.

Month	Avg. Rainfall (mm)	Max. 24 hr. Rainfall Recorded (mm)	Date of max. rainfall record	Mean Daily Temperature (°C)	Average Max. Daily Temperature (°C)	Average Min. Daily Temperature (°C)	S-Pan Evaporation (mm)
Jan	122	90	1995/01/12	25.2	31.8	18.6	199.8
Feb	79.6	99	1978/02/16	24.3	30.7	17.9	162.5
Mar	85.4	130.5	1969/03/11	23.1	30.0	16.2	155.0
Apr	37.8	50	1984/04/02	19.5	27.3	11.6	118.3
May	7.6	32.5	1976/05/04	15.4	25.3	5.5	97.9
Jun	2	16	1995/06/21	12.0	22.1	1.9	82.1
Jul	1.4	9	1970/07/16	12.5	22.5	2.4	90.9
Aug	2.5	10	1977/08/14	15.7	25.4	6.0	124.7
Sep	16.2	41	1997/09/10	20.0	28.4	11.6	165.6
Oct	52.2	57	1973/10/16	22.7	29.8	15.7	200.7
Nov	83.6	104	1994/11/05	23.9	30.6	17.1	198.2
Dec	103.1	163	1995/12/17	24.3	30.5	18.2	204.3
Total (Mean Annual)	593.4			19.9	27.9	11.9	1800.00

4.4 Topography and surface water hydrology

The proposed mine lease area is located in the Crocodile (West) and Marico Water Management Area (WMA 2).

The proposed mine lease is situated in a relatively flat area with no pronounced geomorphological features in the immediate area. The proposed mine lease area straddles two quaternary catchment areas, namely: A24F (Bierspruit) and A24D (Kolobeng). The Bierspruit drains the majority of the proposed mine lease area in a north-easterly direction. The Bierspruit dam, located on the farm Nooitgedacht, immediately north of the proposed mine lease area is reportedly used for recreation but was nearly empty during the late wet season (February 2013)

The Bierspruit, a non-perennial stream characterised by minimal flow between the months of May to October, flows toward the Crocodile River some 40km to the northeast. The Brakspuit, a tributary of the Bierspruit which drains the neighbouring Union mine lease area, to the south-east of the proposed mine lease area, confluences with the Bierspruit approximately 10km downstream (to the north-east).

The DWA and Council for Scientific and Industrial Research (CSIR) consider both the Bierspruit river as a degraded and endangered system. This means the river system has lost a significant amount of its original natural habitat and its functioning is compromised. (AMPLATS 2012)

There are no known significant wetlands in the close proximity of the proposed mine lease area.

4.5 Soils and Vegetation

In the study area a “black turf” cover comprises of a minimum of 1m of the Rustenburg type Arcadia Form. The Arcadia soil form is comprised of a deep Vertic A Horizon with a calcareous B Horizon lens. The soil in the area is classified as sandy, silty clay. Clayey soil is typically characterised by poor drainage and impeded plant growth. The clayey soil is dark in colour and black when moist with a granular surface structure. When dry, hexagonal desiccation cracks at the surface indicate the presence of swelling clays (AMPLATS 2012).

The soil in the area is characteristically high in macro-nutrient elements (P, K, Ca and Mg) which may be associated with moderate to high fertility.

The soil cover grades into residual material extending to 30 metres below ground level (mbgl). Regolith grades rapidly into fresh gabbro and norite of the Bushveld Igneous Complex (BIC) with weathering is limited to fracture surfaces (AMPLATS 2012).

The immediate area on and surrounding the proposed mine lease area is dominated by Turf Thornveld and mixed Bushveld of the Savannah Biome. This is generally characterised by a grassy ground layer and a distinct upper layer of woody plants. The current land use is primarily live stock grazing.

4.6 Regional Geology

The BIC is one of the largest layered mafic intrusions in the world and holds South Africa's Platinum Group Element (PGE) reserves. The BIC yields a wide range of mineral commodities including: vanadium, chrome, PGEs and titaniferous magnetite.

The BIC is extensive in size and is roughly saucer shaped. Norites, pyroxenites, chromitites and gabbros are found at the rim of the saucer (inter-layered in a variety of combinations). The Merensky and UG2 Reefs are two stratiform deposits unique to the BIC that contain economically exploitable quantities of PGMs (Titus et al, 2009).

As depicted in Figure 3, the project area is situated in the north-western sector of the BIC. The Merensky and the UG2 Reefs are the two platinum bearing ore bodies that are currently being exploited by the neighbouring Union Mine to the south-east of the proposed mine lease area; the dip of the ore bodies is toward the south-east (Tutas et al, 2009)

Locally Figure 4 the BIC geological formations dip approximately 20 degrees to the south-east and outcrops strike in a north-easterly direction. Across the site, regional diabase intrusions are believed to strike in a predominantly north-westerly direction with several north-south trending shear and/or fault zones crossing the study area (SRK, 2011).

4.7 Hydrogeology

Crystalline rock, such as the norites and pyroxenites of the Bushveld Complex, comprise of:

- An unweathered and intact rock matrix with negligible matrix porosity and permeability, and
- Planes of discontinuity in the rock matrix, including both faults and joint planes (collectively referred to as fractures).

The infiltration and flow of groundwater in such systems is controlled by the prevailing complex fracture network and can vary in space and time. Such conditions relate to structurally controlled flow systems. However, these fractures are often in-filled by precipitates from late-phase fluids (i.e. vein infill). The hydrogeological characteristics of the crystalline rock stem from, and are related to long-term, tectonically controlled geomorphic processes (Titus et al, 2009).

The following two layer aquifer model conceptualises the BIC aquifers at a regional scale:

- A shallow weathered bedrock aquifer system (i.e. intergranular aquifer) which might be laterally connected to alluvial aquifers associated with river systems.
- Deeper fractured bedrock system.

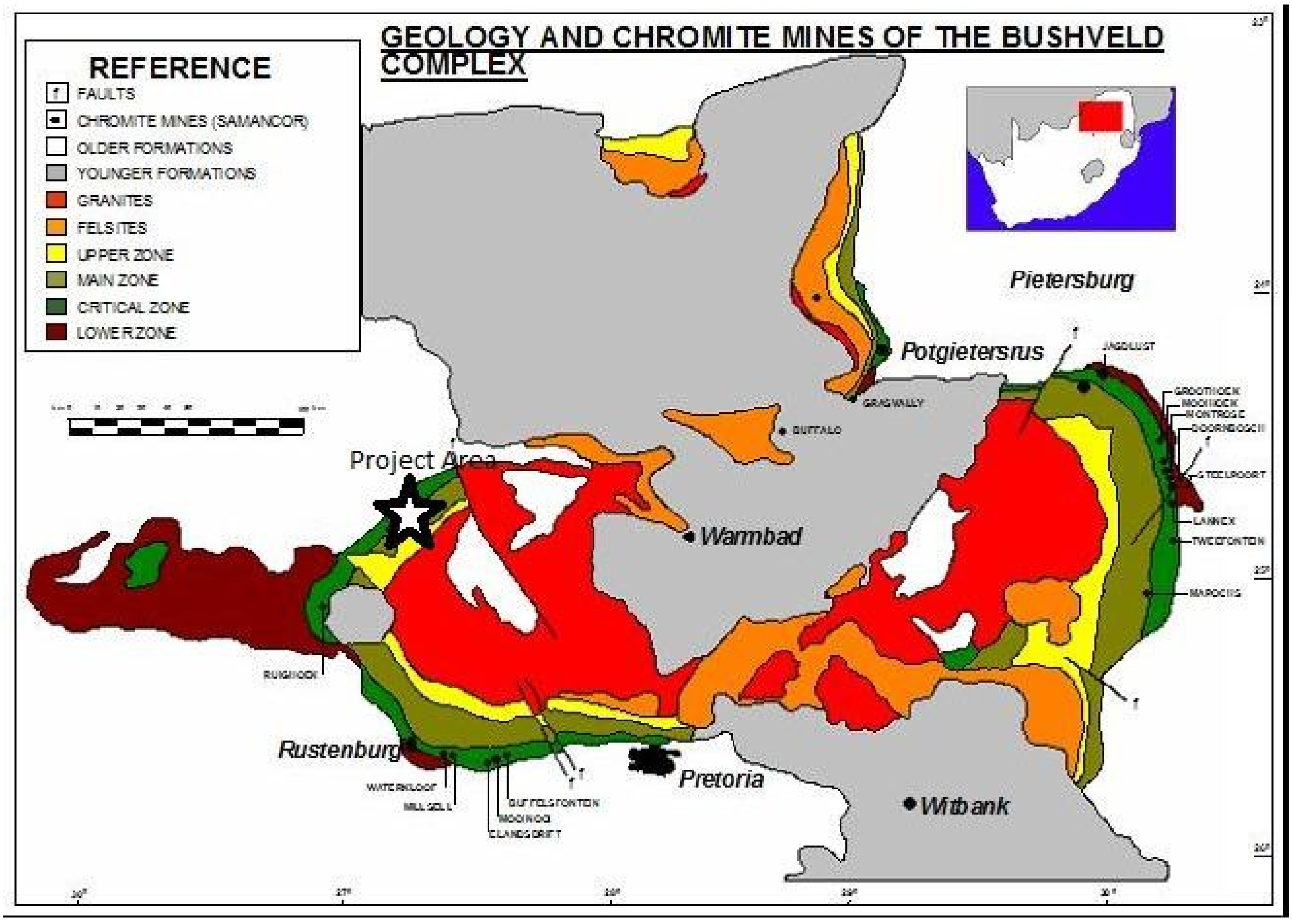

Figure 3: The position of the project area in relation to the BIC centre (taken from SAMANCOR, 2013)

4.7.1 Shallow Weathered Bedrock and Alluvial Aquifers

A shallow unconfined, phreatic aquifer comprising of the saprolite (that has formed as a result of intensive and in-situ weathering processes) to saprock (differentially weathered and fractured upper bedrock underlying the saprolite) zones (Figure 5). The soil and saprolite are collectively termed the regolith (Titus et al, 2009). The saprolite and saprock are generally treated as a single weathered aquifer unit, referred to as the weathered overburden, which varies in thickness from 12 to 50 metres (m). This differentially weathered overburden can be described as highly weathered, yellowish white to yellowish brown sandy, silty soil derived from the in-situ decomposition of the underlying noritic rocks. The degree/intensity of chemical weathering or more specifically the spatial and depth variations thereof, control the geometry of the shallow weathered aquifer profile (Titus et al, 2009).

In the vicinity of river courses, alluvial material overlies or replaces the weathered overburden. The interaction of alluvial aquifers and the river depends, amongst other factors, on the prevailing differences between surface water and groundwater levels (the river might lose or gain water from the aquifer), on the presence (and thickness) or lack of clogging, semi-pervious layers in the streambed resulting in an imperfect hydraulic connection as well as on the aquifer properties (Titus et al, 2009).

The weathered aquifer, in combination with alluvial aquifers (where present), support most irrigation and domestic water-supply demands in the Bushveld Complex, even in areas which are undermined. The latter fact points towards limited hydraulic interaction with the underlying fractured bedrock aquifer (Titus et al, 2009).

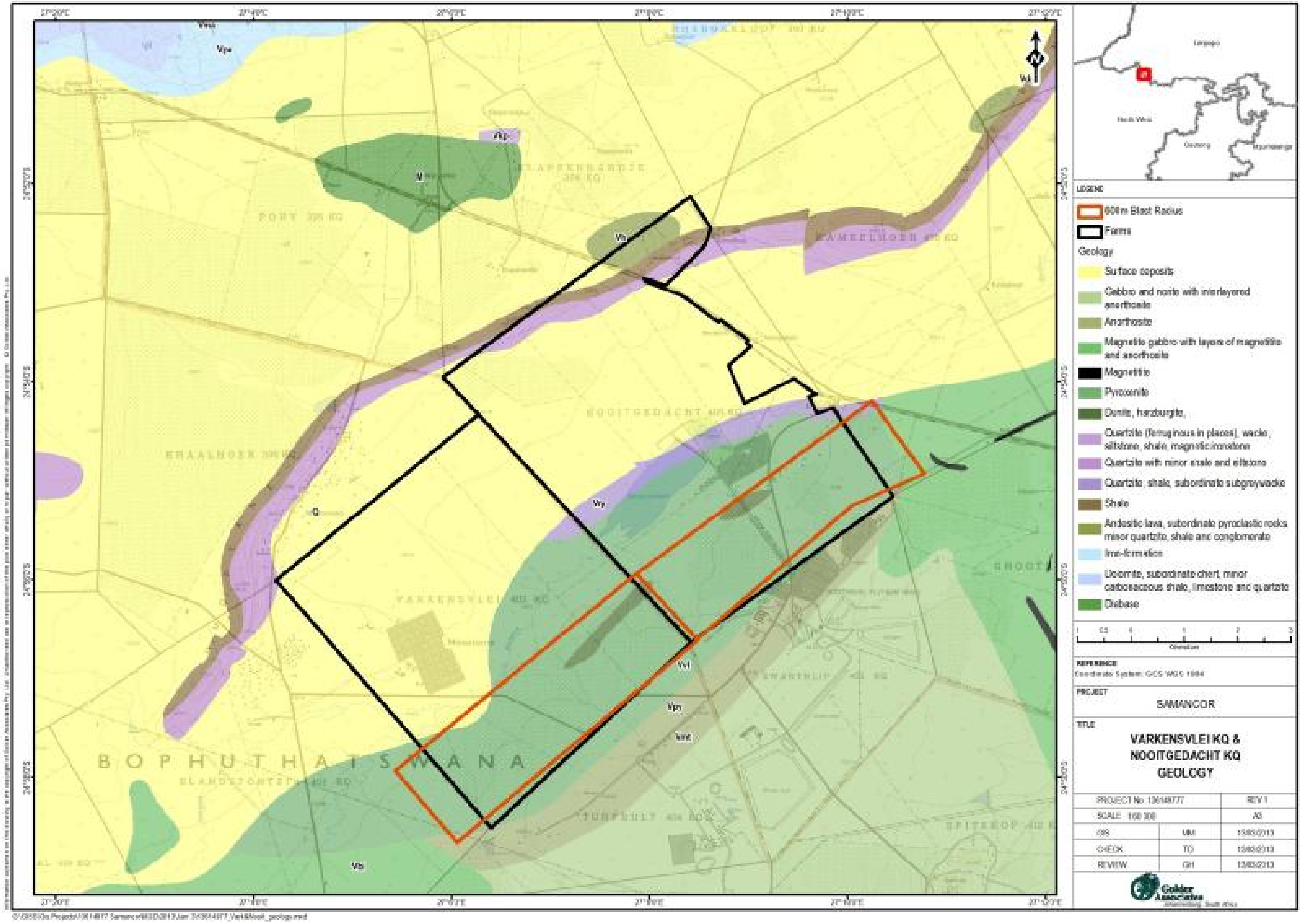

Figure 4: Surface Geology on and surrounding the Nooitgedacht and Varkensvlei proposed project areas

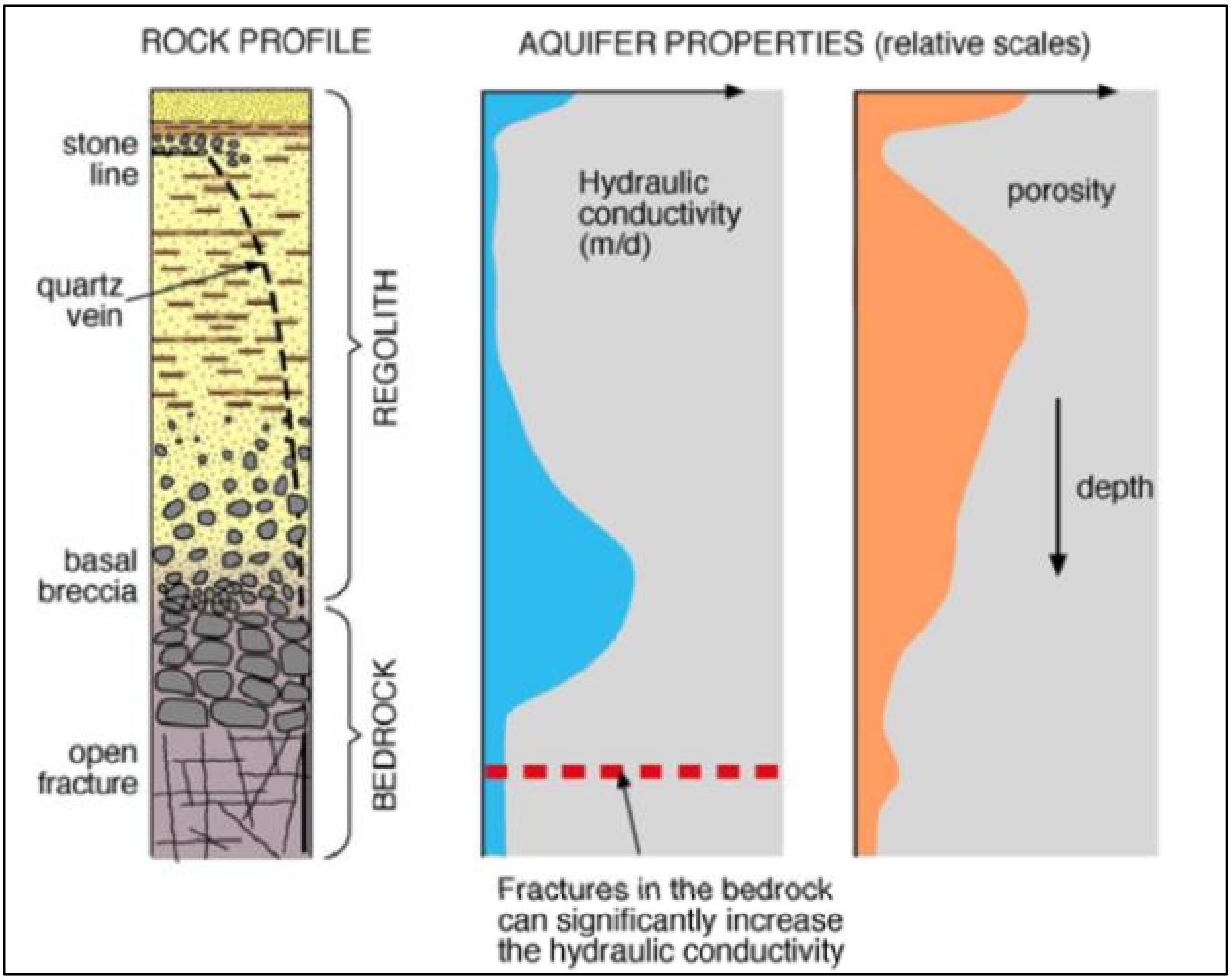

Figure 5: Typical weathered profile for basement rocks from Titus et al, 2009

4.7.2 Deeper Fractured Aquifer

The unweathered and fractured semi-confined bedrock aquifer comprises of fractured norite, anorthosite and pyroxenite underlying the upper weathered aquifer. The intact bedrock matrix has a very low matrix hydraulic conductivity and its effective hydraulic conductivity is determined by fractures and mine voids. Groundwater flows through interconnected fracture systems with the potential of rapid vertical groundwater flow from the weathered overburden (and surface water bodies) to greater depths along interconnected conductive zones (Titus et al, 2009).

The structural features are extremely variable in nature with regard to frequency, spatial extent, aperture or interconnectedness within the relatively impervious crystalline rock mass. The latter factors account for the observed variable chemical and isotopic signatures obtained for mine fissure inflows in the Bushveld Complex.

4.7.3 Hydraulic Characteristics

4.7.3.1 Shallow Weathered Bedrock and Alluvial Aquifers

The weathered overburden is considered to have low to moderate transmissivity but high storativity (Titus et al, 2009). Such composite or ‘near surface’ aquifers are described as approximately uniform, characterised regionally by a mean transmissivity rather than the sporadic fault or fault zones although these are more permeable and extend to great depths.

Numerous pumping tests (Titus et al, 2009) have yielded reasonable and comparable transmissivities (T) of 3 to 8 metres per day per metre (m^2/day) for the weathered bedrock aquifer in the BIC. However, the determined storativities can vary by several orders of magnitude due to semi-confined conditions in areas overlain by confining layers (e.g. black turf) or semi to unconfined conditions in localities where they have been tested are absent. Typical storativity (S) values range from E-04 to E-03 (no units) (Titus et al, 2009).

Selected boreholes have shown considerably higher transmissivity (T) values of up to 50 m^2/day and the ability to sustain higher pumping rates. For long-term groundwater abstractions around 2 L/s are proposed for these boreholes, while the recommended abstraction rates for most boreholes are approximately 0.5 to 1L/s. Constructed artificial recharge systems, employing mined-out areas, could potentially support boreholes with even higher yields.

Higher transmissivities (T) of up to 500 m^2/day and storativities in the range of 0.15 have been determined for highly transmissive aquifer zones (comprising the shallow weathered and deeper fractured aquifer) within the BIC (Titus, et al, 2009)

The Frank fault, which may be described as a highly transmissive zone occurs some 17km to the west of the proposed mine lease areas and constitutes a major aquifer in the area, with boreholes yielding 10 L/s and more It is, however, not considered that there is a connection between the proposed mine lease areas and this highly transmissive aquifer zone (Titus et al, 2009,)..

4.7.3.2 Deeper Fractured Bedrock Aquifers

The underlying solid and unweathered crystalline BIC rocks are generally characterised by very low porosity and high hydraulic conductivity values if fractures are intersected. Water is generally stored and transmitted in fractures and fissures within a relatively impermeable matrix. Fractured crystalline rocks are characterised, by extreme heterogeneity in their hydraulic properties and the hydraulic conductivity can vary, within the same rock mass, by orders of magnitude and over short distances. This structurally controlled heterogeneity and the typical scarcity of sufficient deep boreholes renders regional estimates of aquifer properties difficult. However, regional hydraulic conductivity (K)values in the range of E-03 to E-01 metre per day (m/day), with higher conductivities assigned to fault zones, have yielded satisfactory calibrations of regional numerical models. (Titus et al, 2009)

4.7.4 Recharge

Regionally recharge to the groundwater regime in the BIC is estimated to be approximately 3% of the MAP. (Amplats,2012).

4.7.5 Regional Groundwater Chemistry

Based on the prevailing aquifer types three dominant water facies are typically encountered in the Bushveld Complex:

- A Magnesium- Calcium – Hydroxide (Mg-Ca-HCO_3) water type for the shallow weathered aquifer which changes towards a very similar Mg-Ca-HCO_3-chloride (Cl) water facies in the alluvial aquifers along major river systems (e.g. Crocodile River). Impacts of irrigation return flows (i.e. elevated Cl concentrations) are therefore difficult to assess based on the major ion chemistry and the use of isotopes is recommended (Titus et al, 2009).

- Water in the deeper fractured bedrock aquifer, as encountered in deeper mine fissure inflows, shows a typical, highly evolved Sodium- Chloride (Na-Cl) water facies (Titus et al, 2009).

Visualisation of the relative mineralisation in percentage milliequivalents per litre (%-meq/L) in a Piper diagram allows a graphical grouping of groundwater samples (Figure 6).

The recently recharged and shallow groundwater is typically dominated by the Mg-Ca-HCO_3 attributed to silicate weathering processes associated with the Bushveld Complex.

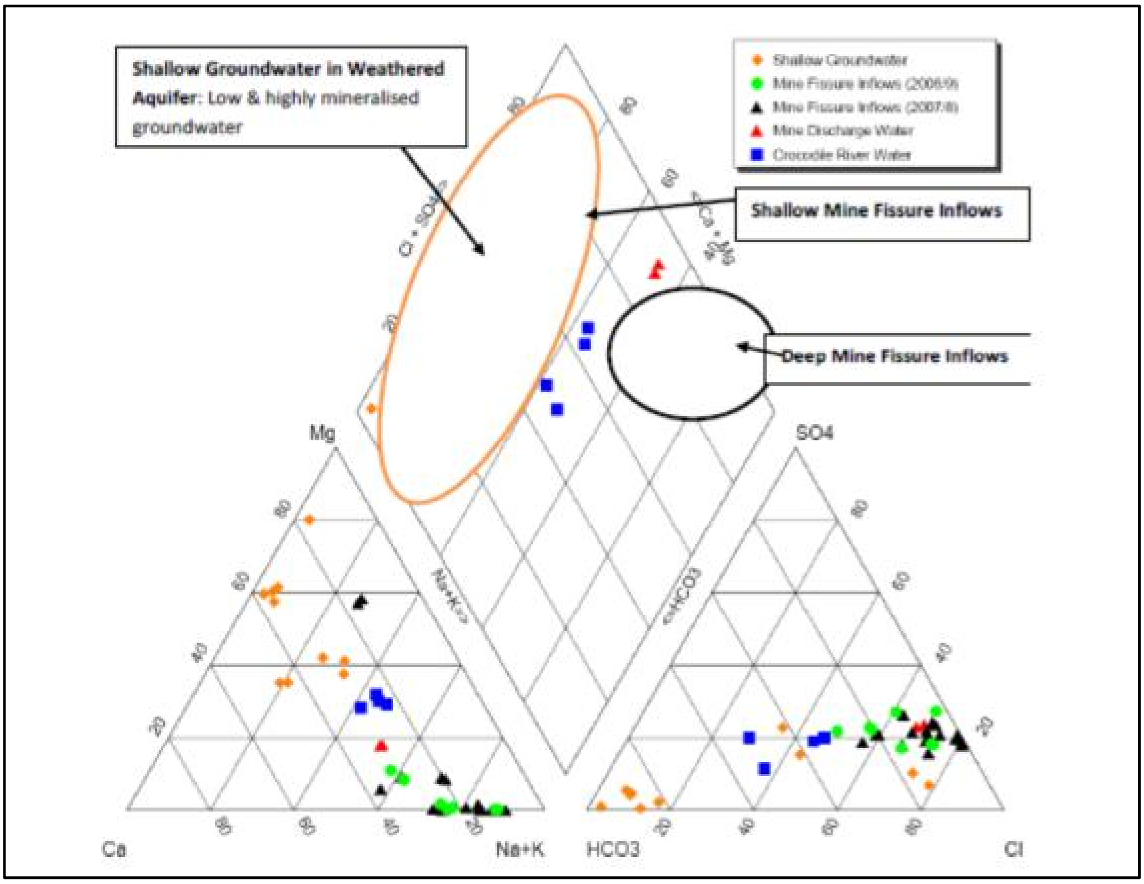

Figure 6: Piper Diagram depicting shallow groundwater as well as deep mine fissure water composition in terms of major ions in solution, taken from Titus et al, 2009

Deep mine fissure inflows are typically classified as Na-Ca-Cl or Ca-Na-Cl water facies. The total dissolved solids (TDS) concentrations for the mine inflows present a range of values from 350 milligrams per litre (mg/L) to more than 1000 mg/L. The TDS concentrations increase with increasing residence times in the subsurface, i.e. time to equilibrate with the aquifer material. The final mineralisation is then determined by the solubility of dissolved minerals / salts (Titus, Witthüser and Walters).

The following observations are based on the major ion ratios (Figure 6), (Titus et al, 2009):

- Deeper mine fissure inflows are chemically and isotopically different to shallow groundwater, including shallow mine inflows, associated with the weathered Bushveld Complex aquifer and groundwater associated with the alluvial aquifer systems.
- Deep mine fissure inflows are fairly uniform in chemical character (i.e. with a dominant Na-Cl water type) compared to the variable chemical character of the shallow groundwater samples and the Crocodile River water.
- The stable isotope ratios and tritium concentrations point to an indirect link between irrigation return flows from alluvial aquifer systems and a considerable number of deep mine fissure inflows.
- Overall groundwater quality within the Crocodile River drainage direction appears to be unaffected by the current platinum mining activities;
- Elevated nitrate concentrations are more often than not associated with the usage of nitrate based explosives, and are therefore expected to originate from shaft areas.

4.8 Local Hydrogeology

In early 2011 SRK undertook a hydrocensus for the neighbouring Amplats UNION mine. This included sampling of selected boreholes within the UNION mine lease area immediately to the south-east of and surrounding SAMANCOR's proposed mine lease areas on Nooitgedacht and Varkensvlei. A map illustrating the position of the boreholes investigated by SRK is shown in Figure 7.

According to SRK (2011) groundwater levels in the vicinity of the proposed mine lease area vary from approximately 2.4 metres below ground level (mbgl) (near the Fraser Alexander return water dam on the UNION Mine property) to 23.6 mbgl (near Bierspruit village) with an average depth of approximately 18mgbl. Higher groundwater levels are observed in the vicinity of surface mine waste infrastructure on the adjacent UNION mine property to the south-east of the proposed mine lease area. SRK concluded that groundwater levels in the region broadly follow the topography, with the exception of where the water levels are affected by anthropogenic (mining or other) activities.

Figure 8, taken from SRK (2011), shows groundwater contours and flow directions, highlighting higher groundwater elevations in the vicinities of surface mine waste infrastructure and lowered groundwater elevations near shafts, corresponding to anthropogenic recharge and dewatering respectively.

The proposed SAMANCOR mine lease areas on the farms Nooitgedacht and Varkensvlei are situated within the two quaternary catchments A24D, and A24F, (FIGURE XX). It is therefore expected and confirmed by the groundwater elevations shown on Figure 8 that groundwater flows away from the southern boundaries towards the north and north-east.

Based on SRK's 2011 survey the groundwater quality in the region of the proposed mine lease area is generally marginal (Class 2) in terms of one or more constituents, but varies from ideal (Class 0) to poor (Class 3) when compared to the DWAF Domestic Water Quality Guidelines (1998). SRK indicates that the groundwater quality to the north and north-east of the Union Mine may potentially be impacted by mining activities and that groundwater underlying the UNion Mine has been contaminated as a result of mining activities.

The hydrochemical character of groundwater sampled at the Union Mine is different to that of groundwater sampled in private off-site boreholes as those off-site have a Mg-Ca-$(HCO_3)_2$ character while those on the mine property tend towards a Mg-Cl or Mg-SO_4 character (Figure 9).

5.0 HYDROCENSUS

As part of the current SAMANCOR EIA a hydrocensus was conducted on and surrounding the farms Nooitgedacht and Varkensvlei in late February 2013.

5.1 Methodology

The methodology followed for this hydrocensus was firstly to search the National Groundwater Database (NGDB) for records of existing boreholes registered with, or drilled by the DWA. A familiarisation visit and client representative meeting in Northam was held on 20 February 2013. This was followed by a hydrocensus on the farms Nooitgedacht, Varkensvlei and surrounding farms to visually search and gain access to boreholes in order to:

- Determine ownership of boreholes
- Measure water level (static or dynamic) where possible
- Measure and record basic borehole information such as borehole co-ordinates, borehole depth, borehole diameter, casing height, operational status, usage and equipment.
- Collect a groundwater sample.

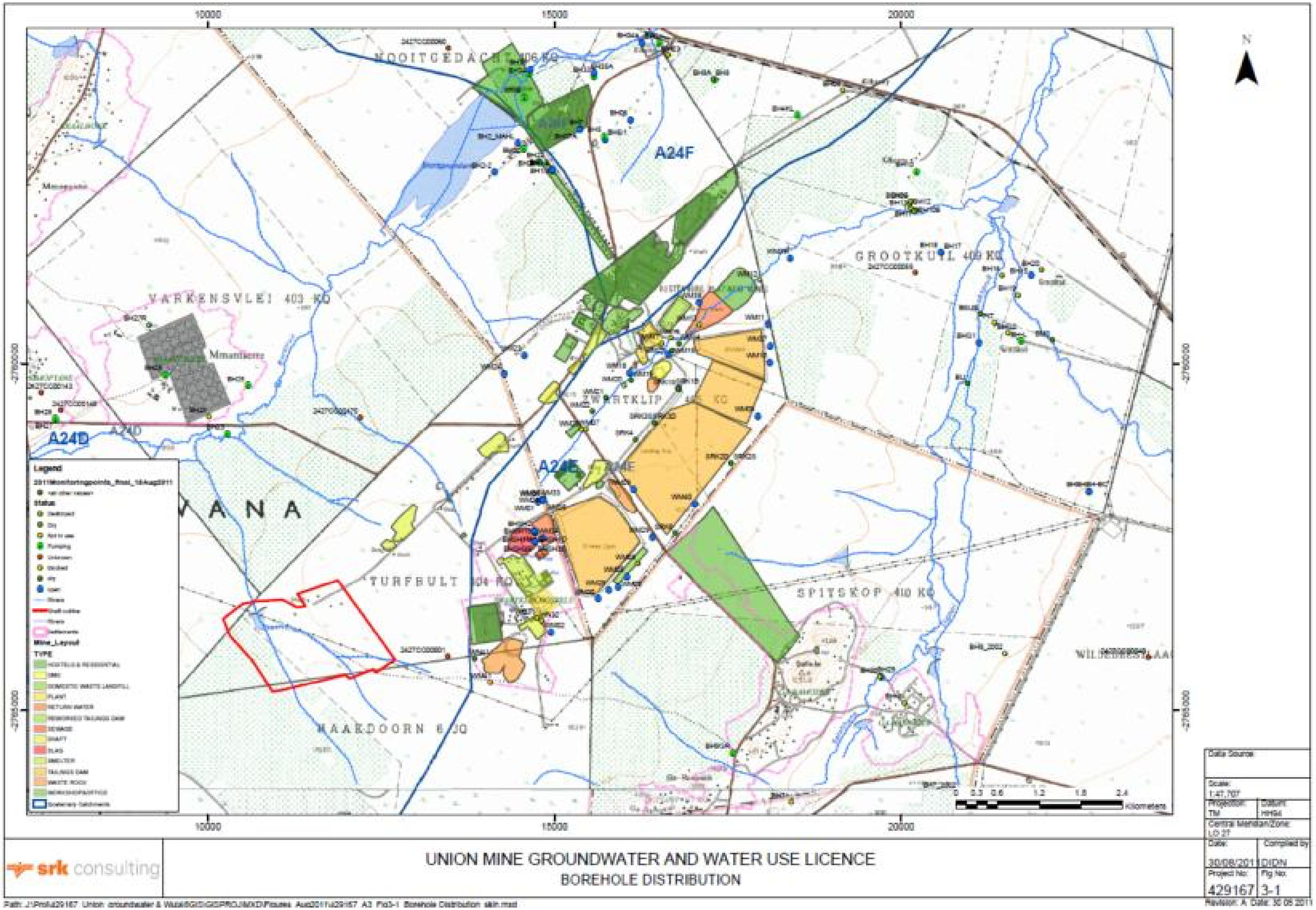

Figure 7: Hydrocensus boreholes taken from SRK,2011

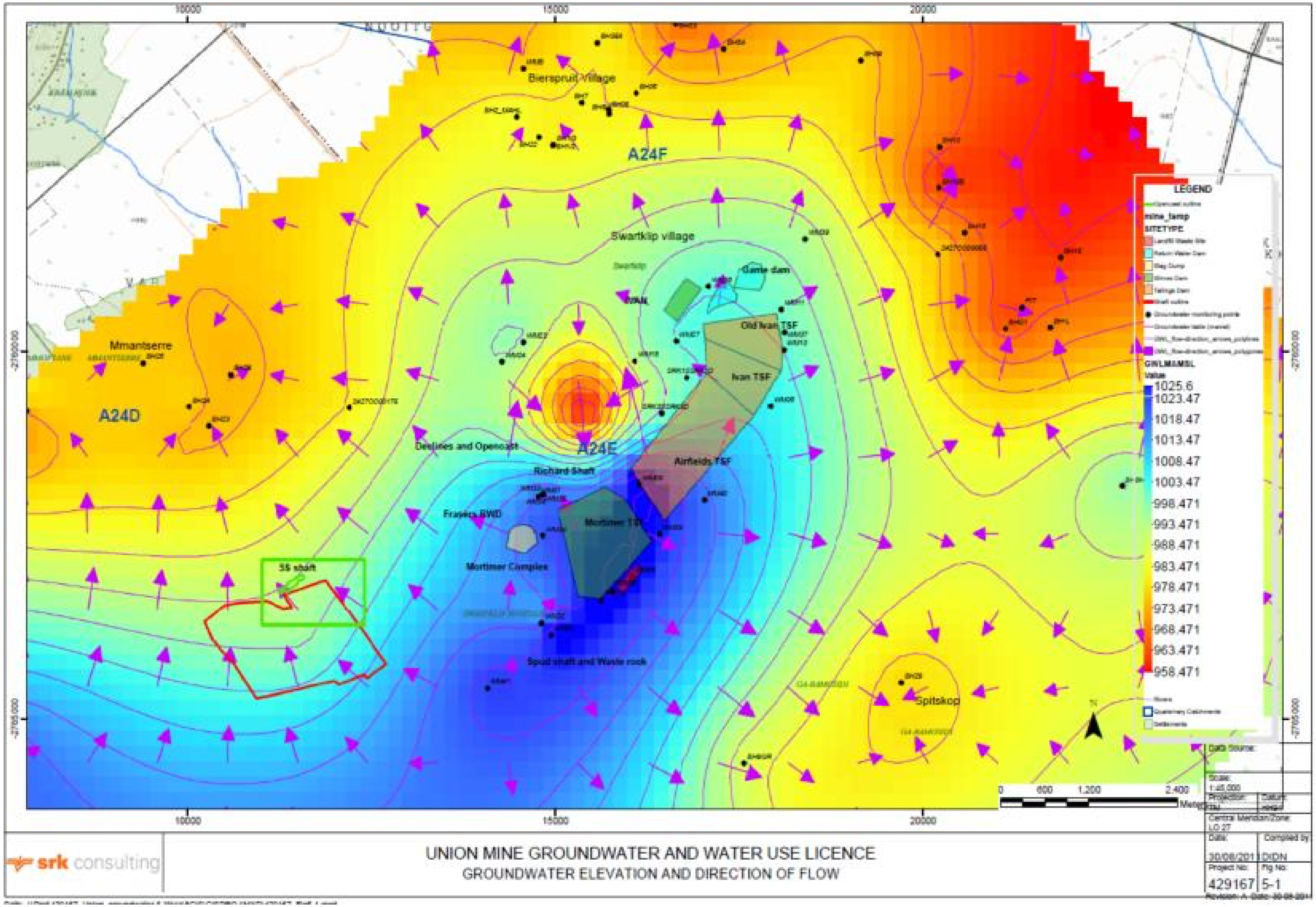

Figure 8: Groundwater Elevation and Flow Direction around Union Mines taken from SRK (2011)

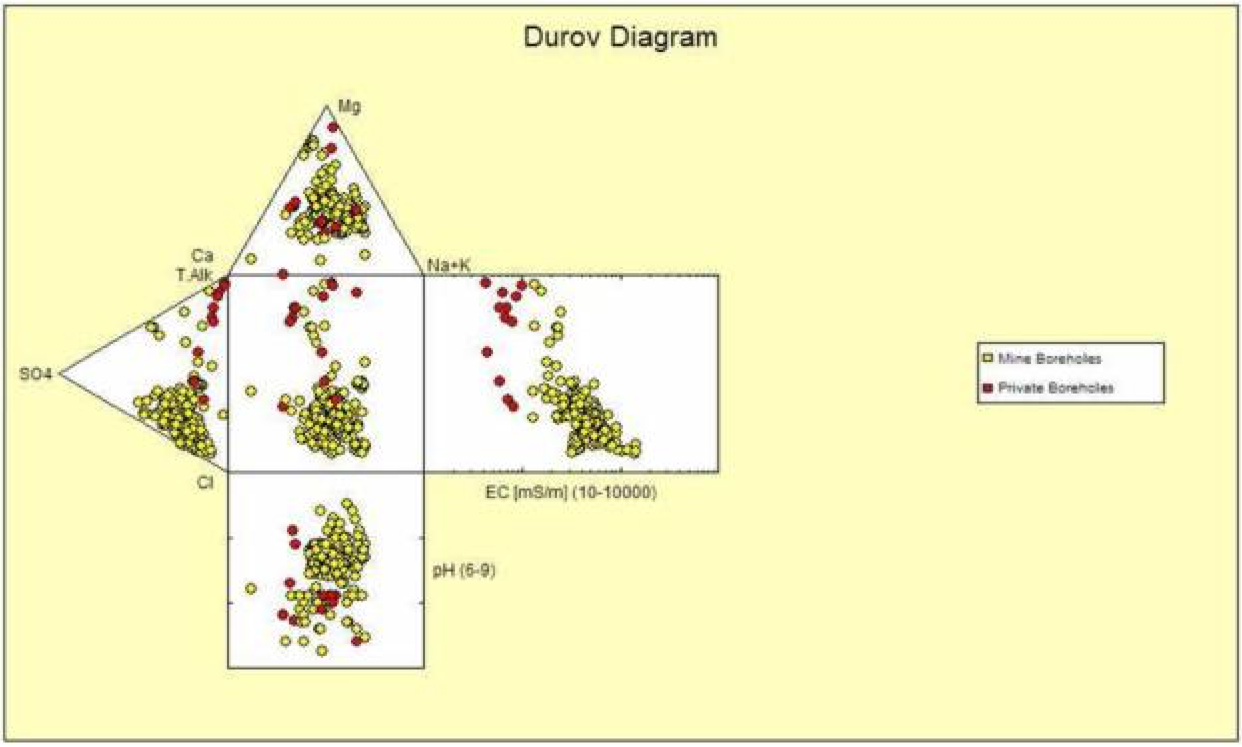

Figure 9: Groundwater quality variation at the Union Mine boreholes compared to off-site private boreholes (Taken from SRK, 2011)

5.2 Results

The results of the hydrocensus undertaken in 2013 are shown in Table 3. A total of eight (8) borehole sites were found. Access allowing the dipping of water levels was obtained at all these eight (8) sites. Groundwater samples were, however, only obtainable from four (4) of these boreholes.

5.2.1 General Description of the Area Investigated

The proposed mine lease area on the south-western portion of the farm Nooitgedacht and the southern portion of the farm Varkensvlei appears to have been used for limited cattle grazing in the past.. The area is flat and no groundwater is currently being extracted from any boreholes on the lease area itself (Figure 10 and Figure 11). The Bierspruit dam is located to the north of the proposed mine lease area on the farm Nooitgedacht. This dam is currently empty in the rainy season (February 2013), reportedly due to low rainfall.

Several boreholes used primarily for garden/golf course irrigation and domestic purposes have been located in communities surrounding the proposed mine lease areas. Access to monitoring boreholes on Amplats Union mine property to the south-east was not possible during the hydrocensus and several other boreholes indicated on Figure 7 could not be found.

5.2.2 Water Levels

Groundwater levels measured in the currently accessible boreholes on or surrounding SAMANCOR's proposed mine lease areas on the farms Nooitgedacht and Varkensvlei are shown in Figure 12. Groundwater levels range from approximately 7.5mbgl near the Bierspruit dam on the farm Nooitgedacht to 24.25 mbgl at Mmantserre on the farm Varkensvlei. The average water table is approximately 17 mbgl, which is slightly less than the average water table depth calculated by SRK in 2011. Due to the variability of the water tables in close proximity to one another, it is also uncertain whether the water levels measured in all the boreholes are static water levels (SWL). The range of water levels measured does, however, roughly coincide with ranges stated by SRK in 2011.

Table 3: Hydrocensus Information

Borehole No/Name	Coordinates (WGS84)		Measured water level (mbcl)	Collar Height (m)	SWL (mbgl)	Owner	Farm	Use	Field Measurements			Sampled	Pumping Equipment installed
	Latitude	Longitude							pH	EC mS/m	TDS (mg/L)		
BH3	24.95187	27.08701	23.57	0.2	23.37	Funeral home	Mmantserre	Domestic	7.45	142	630	Yes	Submersible
BH4	24.95136	27.08967	24.76	0.5	24.26		Mmantserre	Domestic	7.54	159	720	Yes	Submersible
BH5	24.90687	27.16882	12.84	0	12.84	Gerhard Young	Kameelhoek	Domestic	7.73	132	570	Yes	Submersible
BH6	24.90704	27.17156	18.19	0.1	18.09	Gerhard Young	Kameelhoek	Domestic	7.36	293	1320	Yes	Submersible
BH7	24.919058	27.146294	23.89	0.4	23.49		Bierspruit dam	Domestic				No	Submersible
BH8	24.90755	27.14484	7.68	0.2	7.48		Bierspruit dam					No	none
BH9	24.92033	27.13992	9.56	0.3	9.26	Mine	Bierspruit dam					No	none
BH10	24.95451	27.10183	17.2	0.3	16.9		Mantserre	Domestic				No	Submersible

Figure 10: Photograph illustrating general of view across proposed mine lease area.

Figure 11: View from Union mine property towards northeast across the proposed new mine lease area.

5.2.3 Water Quality

The four groundwater samples collected from boreholes during the current hydrocensus indicate that the groundwater on the farms Nooitgedacht and Varkensvlei range in the concentrations of total dissolved solids from approximately 600 to 1300 mg/L (Figure 13). Due to the distance from the mining activity on Union Mine and the surface water quaternary catchment divides it is not expected that the quality of the groundwater on the proposed mining lease has been affected by the mining related activity on the Amplats mine lease area. The pH of the groundwater samples taken appears to be slightly above neutral and ranges from approximately 7.4.to 7.7. The groundwater samples were submitted for analysis of major dissolved cations and anions as well as most common metals.

The four samples were submitted to the SANAS accredited UIS Analytical Services in Centurion.

The results of the groundwater sample analyses were used to develop a qualitative and quantitative understanding of the groundwater quality of the framework in the boreholes found during the hydrocensus.

5.2.3.1 General Chemistry

Based on the water quality analyses presented in Table 4 groundwater quality from the hydrocensus boreholes generally complies with the SANS 241 (Class I) Drinking Water guidelines. The magnesium (Mg) concentrations of all the groundwater samples exceed the limit for the SANS 241 (Class I) drinking water guidelines. This is typical of the geology in the area. BH6 (300mS/m) has electrical conductivity (EC) values that exceed the limit according to the SANS 241 (Class I) drinking water guidelines, however, it meets Class 2 criteria, which is allowable but for a limited duration of time. The Total Dissolved Solids (TDS) values in for BH6 (1980 mg/L) meets Class 2 criteria. BH6 has an elevated Cl concentration (636 mg/l) which exceeds Class 2 criteria. BH 4 (19.8 mg/L) has elevated nitrate (NO_3) concentrations that exceed the Class limit but meets Class 2.

5.2.3.2 Macro Chemistry

The macro chemistry of the groundwater samples is illustrated by means of graphical representations known as a Piper diagram (Figure 14) and an Expanded Durov Diagram (Figure 15).

Table 4: Groundwater Analytical Results

Site ID	pH	pH Temp. [Deg C]	Total Cond [mS/m]	TDS [mg/L]	TDS by Sum [mg/L]	P Alk. [mg/L CaCO3]	M Alk. [mg/L CaCO3]	Ca [mg/L]	Fe [mg/L]	Mg [mg/L]	Mn [mg/L]	Na [mg/L]
SANS 241 Drinking Water Guidelines (Class 1 and Class 2) 2005												
Class 1 mg/L	**5-9.5**		**<170**	**<1000**				**<150**	**<0.2**	**<70**	**<0.1**	**<200**
Class 2 mg/L	**4 - 10**		**170 - 370**	**1000 - 2400**				**150 - 250**	**0.2-2**	**70 - 100**	**0.1 - 1**	**200 - 400**
UIS Analytical Results, 2013												
BH3	7.99	22	129	888	794	<0.6	673	37.2	<0.05	135	<0.05	59
BH4	8	22	152	860	969	<0.6	652	54.2	<0.05	157	<0.05	75
BH5	8.07	21.8	105	692	675	<0.6	585	4.85	<0.05	158	<0.05	33.2
BH6	7.86	21.6	300	1980	1840	<0.6	474	38.8	<0.05	320	<0.05	174

Site ID	Si [mg/L]	F [mg/L]	Cl [mg/L]	NO2 [mg/L]	NO3 [mg/L]	NO3 as N [mg/L]	PO4 [mg/L]	SO4 [mg/L]	Sum of Cat [me/L]	Sum of Ani [me/L]	Ion Balanc [%]	Cr6+ [ppm]	TotCr as Cr [mg/L]
SANS 241 Drinking Water Guidelines (Class 1 and Class 2) 2005													
Class 1 mg/L		**<1.0**	**<200**			**< 10**		**<400**				**<0.05**	**<0.1**
Class 2 mg/L		**1.0 – 1.5**	**200 - 600**			**10 - 20**		**400 - 600**					**0.1 – 0.5**
UIS Analytical Results, 2013													
BH3	22.8	0.658	68.8	<0.2	12.2	2.76	<0.8	54.6	15.5	16.2	-1.96	<0.05	<0.05
BH4	24.5	0.643	116	<0.2	87.5	19.8	<0.8	63	18.9	18.7	0.63	<0.05	<0.05
BH5	38.1	<0.1	34.1	<0.2	38.3	8.66	<0.8	17	14.7	14.4	1	<0.05	<0.05
BH6	34.2	<0.1	636	<0.2	2.74	0.62	<0.8	347	35.8	35.6	0.41	<0.05	<0.05

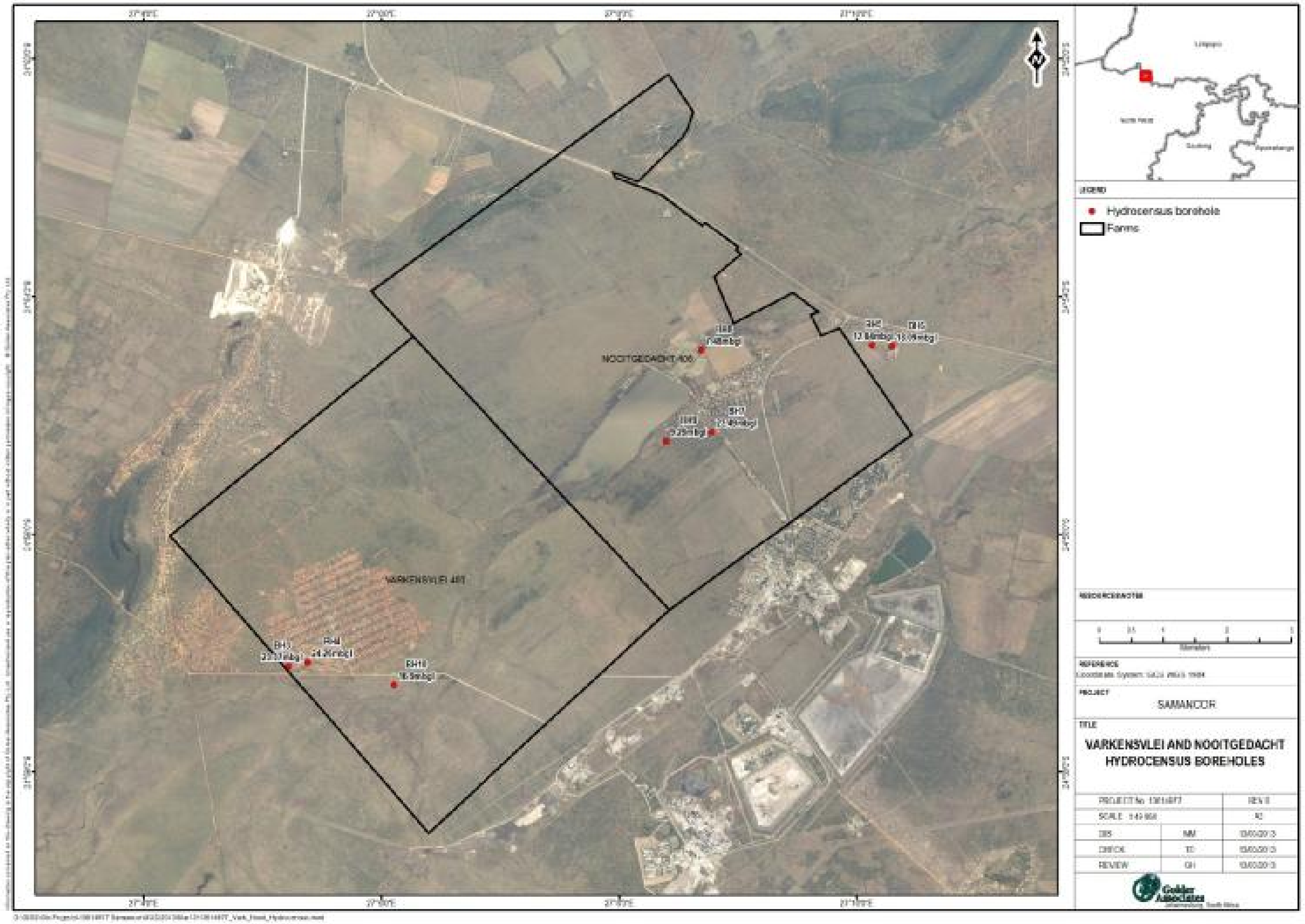

Figure 12: Figure illustrating position and measured ground water levels in boreholes located during the hydrocensus (February 2013)

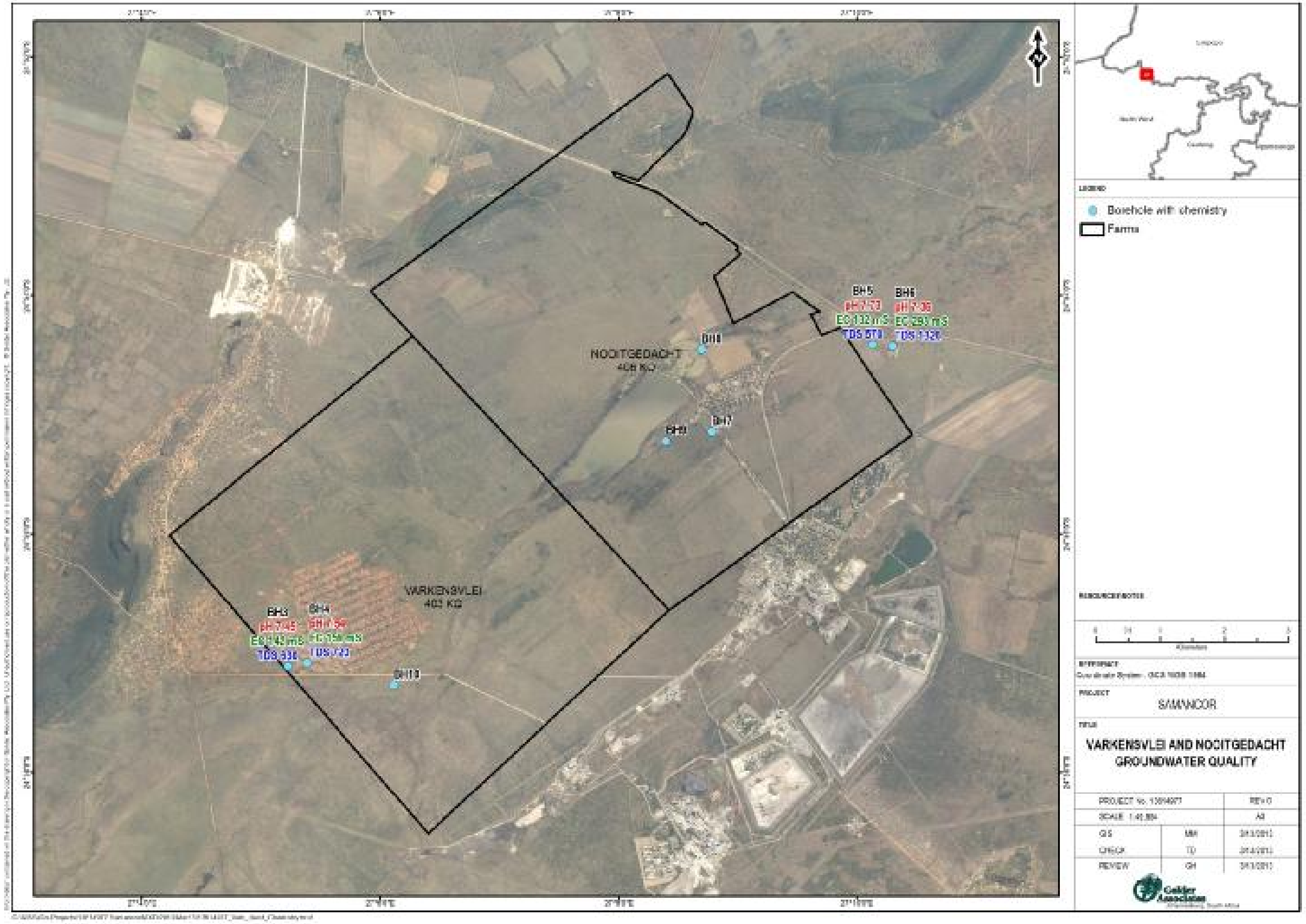

Figure 13: Figure illustrating groundwater field parameters measured in boreholes during hydrocensus (Feb 2013))

The groundwater samples from all the boreholes are dominated by Mg on the ternary cation plot while the samples from boreholes BH3, BH4 and BH5 are dominated by carbonate (HCO_3) on the ternary anion plot. When projected on the diamond shaped plot the samples from boreholes BH3, BH4 and BH5 exhibit an Mg-Ca-HCO_3 signature, which is interpreted as relatively recently recharged groundwater. The groundwater sample obtained from borehole BH6, however, has a high chloride concentration and exhibits a Ca-Mg-Cl signature. The high Cl (636 mg/L) suggests possible anthropogenic chloride enrichment, typically associated with contamination from domestic waste and/or contaminated mine drainage.

On the expanded Durov Diagram (Figure 2) groundwater samples from boreholes BH3, BH4 and BH5 plot in the HCO_3 and Mg ranges of the triangles respectively. This is characteristic of natural groundwater. The composition of the sample obtained from borehole BH6 is seldom found in natural groundwater, however, since it lies in the Cl and Mg ranges on the triangles. The elevated Cl concentration is more typical of leachate from domestic waste and/or dewatering of deep mines.

5.2.3.3 Metals

Although a full metal scan was not undertaken, analyses for iron (Fe), manganese (Mn) and chrome (Cr), both for total Cr and importantly for the proposed development of a chrome mine, hexavalent chrome (Cr^{6+}), were done.

The Cr and Cr^{6+} concentrations of all the groundwater samples collected on the study site meet Class 1 of the SANS 241 drinking water guidelines criteria, which is less than 0.1 mg/L for the Cr and 0.05 mg/L for Cr^{6+}. Cr^{6+} is below 0.05 mg/L for both chrome and hexavalent chrome in all the samples analysed. The iron (Fe) and manganese (Mn) concentrations in the groundwater samples all meet Class 1 SANS 241 drinking water guidelines criteria with respect to the metals analysed.

6.0 PROPOSED MINING PROJECT DESCRIPTION

SAMANCOR Chrome holds prospecting rights on the farms Varkensvlei 403 KQ (portions 1, 2 and Remainder) and Nooitgedacht 406 KQ (portions 2, 6, 7, and 10), and has applied for a mining right. The following information has been extracted from SAMANCOR's Mining Works Proposal Revision 7.

The LG6 forms the principal seam of economic interest based on its high chrome content and thickness, the LG6 consists of 4.8 million tons in-situ to a mineable depth of 50m below surface, with an average thickness of 1.08m and a chrome grade of 45.52% Cr_2O_3. Sufficient chrome ore reserves have been proven on the farms Varkensvlei 403 KQ (portions 1, 2 and Remainder) and Nooitgedacht 406 KQ (portions 2, 6, 7, and 10), to support opencast mining of the LG6 and LG6A (approximately 12m above the LG6) chromitite seams to a depth of 50 metres over an area of about 1273 hectares

Both chromitite seams occur over a strike length of nearly 6.9km across both farms with an average dip of 25^0, reaching a depth of 300 metres (Figure 16). With an average thickness of about 1 metre, there is a potential for underground mining of the LG6 seam. The LG6A is only about 0.3 metres thick, too thin for economically viable underground mining.

Figure 17 shows an existing opencast operation on a chromitite seam at the adjacent Bushveld Chrome Resources (BCR) (McQuade, 2013) in the same area. The proposed SAMANCOR Chrome opencast operation will be similar.

The initial engineering work and construction of the surface infrastructure for the site would take about 2 to 3 months. Based on an average production rate of 45 000 tons of run of mine (RoM) ore per month, the life of mine for the opencast will be approximately 8 years. During this time SAMANCOR Chrome will undertake a detailed assessment of the viability of underground mining, which could increase the life of mine (LoM) to about 30 years

Mining operations will be done by means of drilling and blasting using the single benching method as defined in the blast design.

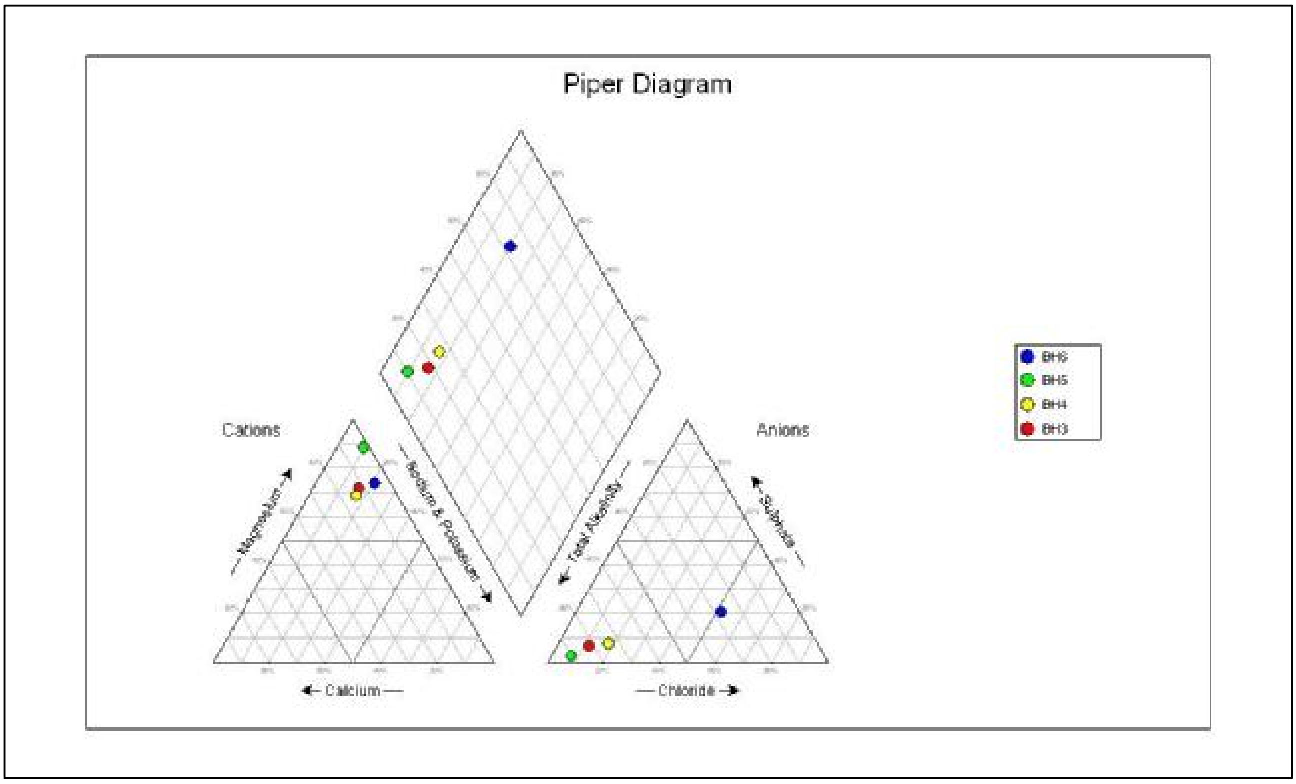

Figure 14: Piper Diagram- Hydrocensus boreholes

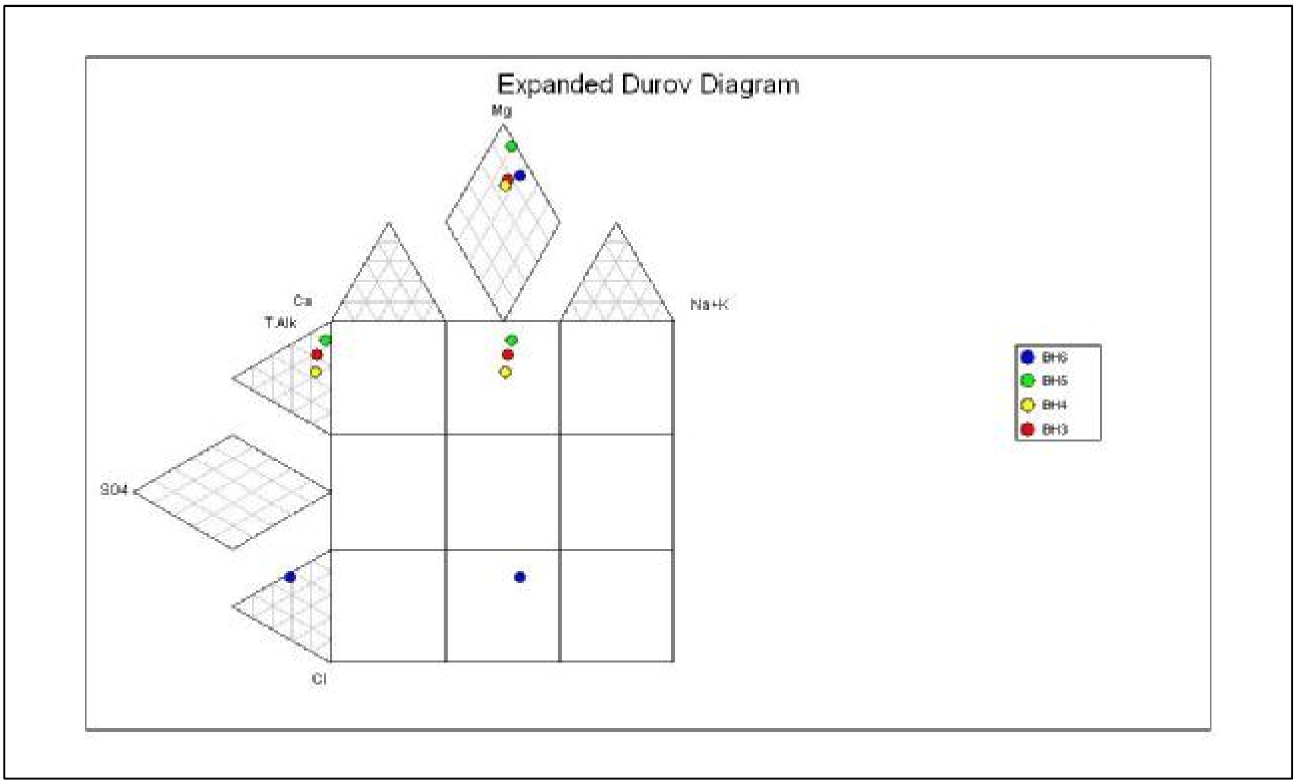

Figure 15: Expanded Durov Diagram- Hydrocensus boreholes

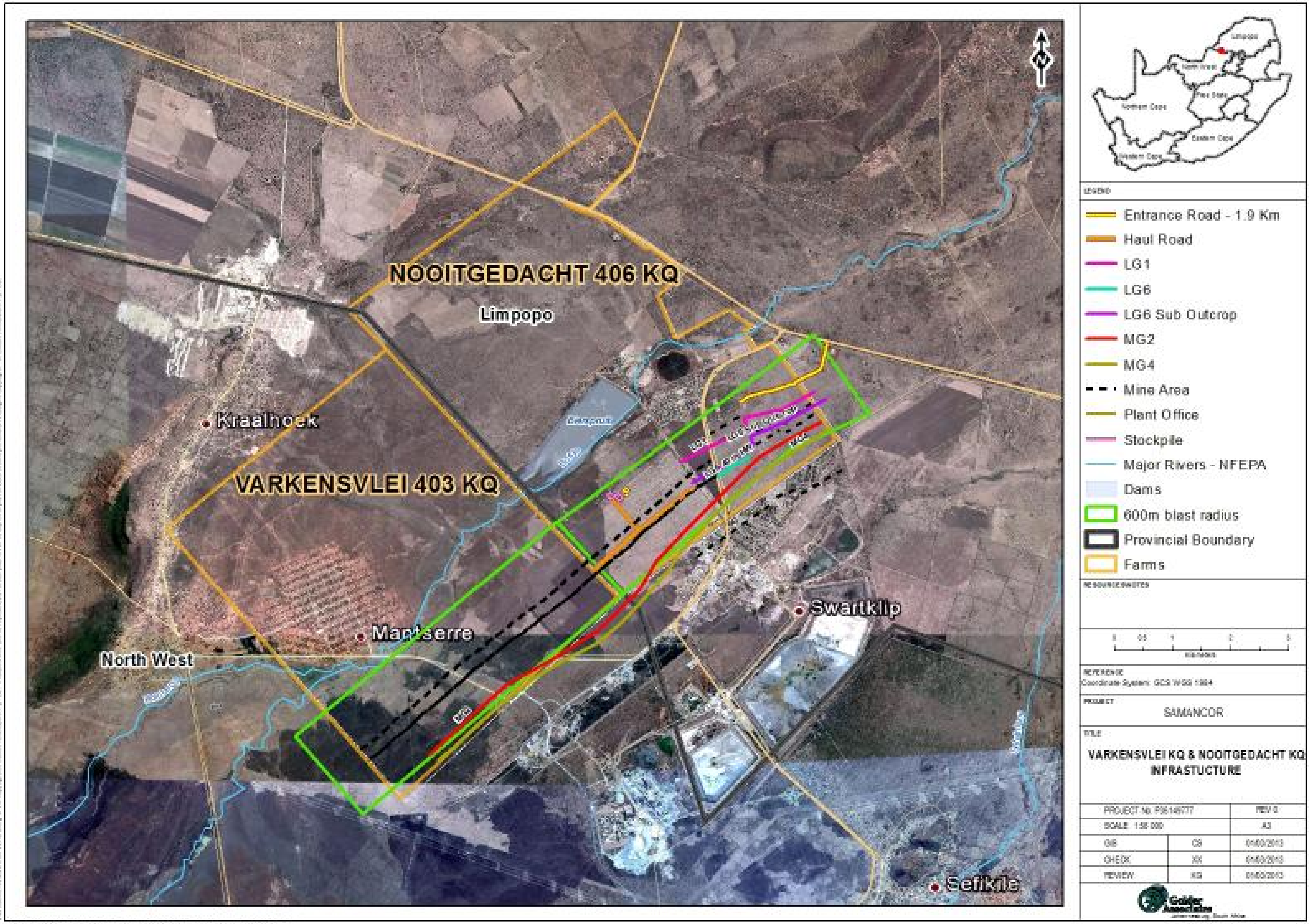

Figure 16: Infrastructure and suboutcrop positions of chromitite seams on Varkensvlei and Nooitgedacht

Figure 17: Opencast layout of the LG6 and LG6A chromitie seams at BCR mine

The blast design will involve the blasting of three benches. Typically, the first bench will be drilled to a depth of 18m and blasted. Once this bench has been mined to the 18m depth after several cuts, the second bench will be drilled and blasted to a further depth of 12m, and this bench will be mined out after several cuts to the final bench. The final bench will be drilled and blasted to a depth of 10m, which will be the final depth of the opencast pit. This bench will be mined out, after which the opencast will be rehabilitated

Topsoil and overburden removal and mining of the chrome ore will be done by means of the truck and shovel method. Topsoil and overburden will be stockpiled separately.

The rollover mining method will be practised, whereby the topsoil and overburden from the first cut of the opencast mine are stockpiled at the position of the last cut. As the opencast mine progresses, the overburden and topsoil from each successive cut is backfilled into the void from the previous cut, the surface will then be shaped to be free draining. The topsoil will be analysed and treated appropriately and the surface re-vegetated. At the end of the life of the opencast mine the final void will be backfilled with the overburden from the final cut of the last remaining pit.

The chrome ore will be trucked to a mobile crushing and screening plant for processing. Other surface infrastructure will include power supply, a workshop, a parkhome for office space and a security kiosk.

Ore recovery from the opencast mining operation is expected to be between 85% and 95% with minimal dilution. Dry crushing and screening will be done, with dust control. There will be no gravity or spiral separation, i.e. the process will not produce any tailings. This method has been tested and proven successful in a similar type of opencast design at BCR Mine adjacent to the study area.

7.0 GAP ANALYIS

The preceding discussions of the regional baseline hydrogeological conditions are based primarily on regional background literature and sparse local information obtained during the site familiarisation visit and hydrocensus. Together with the information provided by the client with respect to the proposed project activities this only allows a broad, conservative and qualitative assessment of the potential groundwater impacts. The limited available information only allows a low level of confidence in the actual baseline and qualitative groundwater impact assessment.

More specifically information that is lacking and that would be necessary to more accurately predict groundwater impact includes:

- Local hydrogeological data obtained from drilling.
- Local hydrogeological parameters obtained from aquifer testing.
- Local hydrochemical data obtained from sampling and analyses of groundwater.
- Predictive modelling data of groundwater levels and quality resulting from pit dewatering.

8.0 IMPACT ASSESSMENT

8.1 Assessment Methodology

The significance of the impacts identified during the impact assessment phase will be determined using the approach outlined below.

Table 5 provides the methodology for defining magnitude, geographic extent and duration. Table 6 provides the methodology for combining magnitude, geographic extent and duration to determine environmental significance. The Local Study Area (LSA) will encompass the full site boundary area, as shown in Figure 1 and Figure 2

8.2 Project Phases

For the purposes of this impact assessment, the SAMANCOR Mining Project is being phased as follows:

- Construction Phase;
- Operational Phase; and
- Decommissioning and Closure Phase

8.2.1 Construction Phase Impact Assessment

From a hydrogeological perspective, Table 7 summarises the potential impacts that are related to the construction phase of the SAMANCOR Mining Project.

Hazardous waste materials will be generated during the construction phase ranging from used solvents, used oil and grease, etc. The magnitude of the impact of the generation of hazardous waste is moderate. The potential impact will be short term and localised. The overall environmental significance is therefore considered low.

Construction employees will not be based on site during construction and therefore the likely generation of sanitary waste is considered a low magnitude impact. Management of this type of waste can be easily achieved. After the implementation of mitigation measures, such as permanent and adequate sanitary facilities the magnitude of the impact will further be reduced. The impact will be for a short term, localised and the overall environmental significance is considered negligible.

Potential contaminant materials will be stored and handled on site. The risk of a spill has to be considered as a potential impact. The magnitude of the impact is high. The probability of a spill is considered high before mitigation such as designated storage and handling procedure are in place. The overall environmental significance is considered moderate.

Table 5: Method for defining magnitude, geographic extent and duration

Resource	Direction[(a)]	Magnitude[(b)]	Geographic Extent[(c)]	Duration[(d)]	Reversibility[(e)]	Frequency[(f)]
Hydrogeology	**positive**, **negative** or **neutral**	**negligible**: no change from the current conditions **low**: near (i.e., slightly above) current conditions **moderate**: above current conditions **high**: substantially above current conditions	**local**: effect restricted to the LSA **regional**: effect extends beyond the LSA into the RSA **beyond regional**: effect extends beyond the RSA	**short-term**: construction **medium-term**: operations **long-term**: >operations	**reversible** or **irreversible**	**low**: occurs once **medium**: occurs intermittently **high**: occurs continuously
Water Quality	**positive**, **negative** or **neutral**	**negligible**: releases do not cause guidelines or existing backgrounds to be exceeded **low**: releases contribute slightly to existing background being exceeded **moderate**: releases cause the guidelines to be exceeded (where guidelines were not previously exceeded) **high**: releases cause the guidelines to be exceeded substantially	**local**: effect restricted to the LSA **regional**: effect extends beyond the LSA into the RSA **beyond regional**: effect extends beyond the RSA	**short-term**: construction **medium-term**: operations **long-term**: >operations	**reversible** or **irreversible**	**low**: occurs once **medium**: occurs intermittently **high**: occurs continuously

Table 6: Screening system for environmental consequence

Magnitude	Geographic Extent	Duration	Environmental Consequence
negligible	all	all	negligible
low	local	short-term	negligible
low	local	medium-term	low
low	local	long-term	low
low	regional	short-term	low
low	regional	medium-term	moderate
low	regional	long-term	moderate
low	beyond regional	short-term	low
low	beyond regional	medium-term	moderate
low	beyond regional	long-term	moderate
moderate	local	short-term	low
moderate	local	medium-term	low
moderate	local	long-term	moderate
moderate	regional	short-term	moderate
moderate	regional	medium-term	moderate
moderate	regional	long-term	high
moderate	beyond regional	short-term	moderate
moderate	beyond regional	medium-term	high
moderate	beyond regional	long-term	high
high	local	short-term	moderate
high	local	medium-term	high
high	local	long-term	high
high	regional	short-term	moderate
high	regional	medium-term	high
high	regional	long-term	high
high	beyond regional	short-term	high
high	beyond regional	medium-term	high
high	beyond regional	long-term	high

Table 7: Groundwater Impact assessment for the construction phase of the SAMANCOR mine pit

Impacts		Occurrence			Severity				Environmental Consequence
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	
Construction Phase	*Waste generated during maintenance/refuelling of equipment or machinery, i.e. oily rags, used oil filters, and used oil as well as spilled cleanup materials from oil and fuel spills.*	Negative	Definite	Short-term	Moderate	Local	Irreversible	High	Low
	Generation of sanitary wastewater discharges	Negative	Definite	Short-term	Low	Local	Irreversible	High	Negligible
	Accidental spill of materials stored on site, fuel, oil products	Negative	Medium Probability	Short-term	High	Local	Irreversible	Low	Moderate
	Water Use for Construction	Negative	Definite	Short-term	Low	Local	Reversible	High	Negligible

Water will be required for construction purposes as well as for domestic use by construction workers. The magnitude of the impact on the water resource is, however, considered low, since the groundwater resource at this stage will still be relatively unaffected by the mining activities. The overall environmental significance is considered negligible.

8.2.2 Operational Phase Impact Assessment

Table 8 summarises the potential impacts that are related to the operational phase of the proposed SAMANCOR Mining Project

The requirement to store and transport potential contaminants is unavoidable for the entire operational life of the proposed development. Regarding the storage of hydrocarbon products such as diesel this is regulated by various legislative acts and the design of the proposed mine will ensure that all requirements are observed and applied. Similarly the transport of hazardous products is strictly regulated and the applicable regulations will apply. Over the operational period of the development the probability of such an accident occurring is considered medium risk to the groundwater regime because of the implementation of precautionary measures and best practice guidelines during operation. The magnitude of the impact is however high and the duration is over the entire operational period, although localised. The environmental significance is considered high.

The design and application of drainage management ensures that contamination of groundwater, surface water and other receptors is avoided. The drainage management system requires permanent maintenance in order to ensure it has the capacity to handle the required volumes. A potential impact is associated with the failure of the drainage system to function to its capacity. The magnitude of the impact would be high and it can affect receptors at regional level. The environmental significance is considered high.

Poor waste management could impact on groundwater systems. Expected waste steams include maintenance chemicals, production chemicals, and various domestic waste streams. An unknown number of employees will be working on site and therefore the likely generation of sanitary waste is considered an impact. The magnitude of the impact is rated as low. Management of these waste streams of waste can be easily achieved. The impact will be for a medium- term and localised. The environmental significance is considered is low.

Domestic quality water will be required to for domestic use by workers. . The magnitude of the impact on the water resource is considered low, since adequate water volumes may be generated by dewatering of the mine pit. The environmental significance is considered negligible.

The initial development of the mine pit will not have significant impacts on the regional groundwater resources, but with time as the mine grows in size and the dewatering volumes increase the impacts will establish themselves on the region. Backfilling of the mine pit is intended. However, the backfilled material is disturbed and original hydrogeological conditions are unlikely to be re-established. It is therefore anticipated that dewatering of a section of the backfilled material close to the advancing open pit will continue to be required to maintain dry conditions in the open pit section.

At this stage the extent of dewatering requirements is not known. Dewatering will result in an area of groundwater level impact the extent of which is not known but is not expected to be spatially extensive. This is mainly due to the relatively low hydraulic conductivity of the strata. Dewatering may, however, impact on the local groundwater users in villages and farms surrounding the site where several boreholes provide the main source of fresh water for domestic purposes. The impact will be medium-term and localised. The environmental significance is considered high

The cumulative impact of dewatering the proposed SAMANCOR pit, together with the potential dewatering of the neighbouring open pit (BCR) and the underground Angloplats Union mine, will cause a greater impact on groundwater levels than any impact predicted only for the SAMANCOR Mining Project. The cumulative impact of mine pit dewatering will be medium-term and regional. The environmental significance is considered high.

Table 8: Groundwater Impact Assessment for the operational phase of the proposed SAMANCOR Mine Pit

Impacts		Occurrence			Severity				Environmental Consequence
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	
Operation of Acid Plant	*Accidental spillage of potential contaminants*	Negative	Medium Probability	Medium-term	High	Local	Irreversible	Moderate	Low
	Inadequate stormwater drainage and management	Negative	Definite	Medium-term	High	Regional	Reversible	High	Low
	Poor waste management	Negative	Definite	Medium-term	Low	Regional	Reversible	High	Low
	Water Use	Negative	Definite	Medium-term	Negligible	Local	Reversible	High	Negligible
	Dewatering of the mine pit/ Cumulative Impact	Negative	Definite	Medium-term	High	Regional	Reversible	High	High
	Blasting activities	Negative	Definite	Long-term	Low	Local	Reversible	High	Low

Blasting activities associated with the extraction of chromitite from the mine could affect the groundwater quality. Depending on the blasting method used and the type of explosives, the water quality of the underlying aquifers may be impacted increased in nitrate concentrations and changes in hydraulic properties. However, this impact can be minimised by proper management and best practice operations of blasting activities. The magnitude of the impact is considered low and localised but could be long-term. The environmental significance is considered low.

8.2.3 Decommissioning and Closure Phase Impact Assessment

From a hydrogeological perspective, Table 9 summarises the potential impacts that are related to the decommissioning and closure of the proposed SAMANCOR Mining Project.

Rehabilitation of the mine pit area is very important to mitigate lasting impacts on the groundwater systems. Impacts that will result from rehabilitation of the mine pit include interference with natural groundwater flow and recharge of the groundwater system. The decommissioning needs to be implemented following a controlled plan, which will entail simultaneous mining and backfilling with overburden, covering with top soil and planting of vegetation over the decommissioned area to mitigate potential erosion of the rehabilitated pit areas. Local groundwater recharge will increase as the permanent feature of the rehabilitated mine pit may form a depressed landscape. The backfilling of the pit will result in higher hydraulic conductivity to a depth of 50m over the entire rehabilitated mine pit footprint. Groundwater will therefore also be more sensitive to pollution from surface. This risk can, however, be minimised through positive land and water management initiatives during decommissioning phase of the project. The impact will be long-term and localised. The environmental significance is considered moderate.

Once the open pit exploitation of chromitite on the site is completed, decommissioning and removal of all infrastructure will be required. Activities that could lead to groundwater impacts include chemical spills from decommissioned storage facilities of chemicals used/stored on site; these have a high probability of occurrence unless mitigation measures are included in the decommissioning plan for the plant. The magnitude of such events is low, and is of a localised scale and short-term. The environmental significance is considered negligible.

Temporary storage of structures, equipment, contaminated soil and other waste may be required depending on the decommissioning plan. Due to the likely low number of potential contaminants handled within a relatively short period of time the environmental significance of temporary storage during decommissioning is rated as low. The impact will be limited to the mine offices and separation plant site only and will be for a short-term period. The environmental significance is considered negligible.

9.0 CONCLUSIONS

The proposed mine lease areas on the farms Nooitgedacht and Varkenslvlei, are located on uninhabited land with a very flat topography, underlain by BIC rocks. The geology and geomorphological process have given give rise to two aquifer zones.

- An upper shallow weathered saprolite and saprock aquifer and,
- a much deeper fractured rock aquifer.

Locally the shallow aquifer zone supports mainly domestic abstraction and some golf course watering at Bierspruit village. The effect of mining on the groundwater resource has been established on the Union Mine operational areas. Significant groundwater related information for the proposed mine lease application area was, however, not available from the nearby local neighbouring mining operations.

On the proposed mine lease area, the groundwater appears to be largely unaffected by mining operations from the neighbouring mine lease area. Due to the lack of groundwater infrastructure, however, the baseline groundwater conditions are not well assessed.

The main conclusions drawn are:

- The groundwater table ranges from approximately 7.5 4 to 24.3.mbgl
- The groundwater pH ranges from approximately 7.4 to 7.7

Table 9: Groundwater Impact Assessment for decommissioning and closure of the proposed SAMANCOR mine pit

Impacts		Occurrence			Severity				Environmental Consequence
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	
Decommissioning and Closure of Acid Plant	*Rehabilitation of the mine pit*	Negative	Definite	Long-term	Moderate	Local	Irreversible	High	Moderate
	Chemical Spills as a result of decommissioning storage infrastructure	Negative	High	Short-term	Low	Local	Reversible	High	Negligible
	Temporary storage of various dismantled structures, equipment, contaminated soil and other waste	Negative	High	Short-term	Low	Local	Reversible	High	Negligible

- Groundwater is used for domestic, garden watering and golf course irrigation purposes on the two farms in question.

The groundwater impacts of the proposed mining operation seen in isolation are in general considered local and not reversible. They will produce permanent local increased groundwater recharge impacts; however, when the potential cumulative groundwater impacts arising from the nearby existing and proposed operations are considered, a significant impact on the local and regional groundwater system is anticipated. A risk also exists that a disproportionate amount of impact may be attributed to the proposed SAMANCOR operation in the absence of a more quantitative groundwater impact assessment that is able to separate the proportional contribution of each of the existing and proposed mining operations in the area.

10.0 RECOMMENDATIONS

Due to the lack of groundwater monitoring infrastructure in the area, it is proposed that a groundwater monitoring system and monitoring programme is established prior to the commencement of mining operations on the proposed mine lease areas on Nooitgedacht and Varkensvlei.

The proposed work programme involves the establishment of a groundwater monitoring system and the undertaking of a quantitative impact assessment report based on the quantified baseline groundwater conditions. The programme will broadly entail the following activities.

- A geophysical investigation to establish drilling targets.
- A drilling and test pumping programme.
- A regular groundwater sampling and monitoring programme.
- A quantitative impact assessment based on data gathered from the field investigations and taking into consideration the existing impacts from adjoining mining operations and/or any other groundwater impacting activities in the area.

The groundwater monitoring system will allow a better understanding of the baseline groundwater conditions. A groundwater monitoring programme will ensure that the groundwater impact of the mining activities can be measured, understood and managed, during all phases if the proposed Mining Project.

11.0 REFERENCES

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GOLDER ASSOCIATES AFRICA (PTY) LTD.

Thomas Demmer
Senior Hydrogeologist

Graham Hubert
Principal

TD/GVDL/sk

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February 2013

SAMANCOR CHROME

Ecological Baseline Assessment for Mining Right Applications on Varkensvlei /Nootgedacht and Haakdoorndrift

Submitted to:
Samancor Chrome

REPORT

Report Number. 13614977-11940-11

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Golder Associates

Executive Summary

Samancor Chrome (Pty) Ltd appointed Golder Associates Africa (Pty) Ltd (GAA) to undertake a terrestrial ecology assessment of the proposed sites earmarked for development near Thabazimbi and Northam located approximately120 and 60 kilometres north-east of Rustenburg, South Africa, respectively.

This report presents the results of the February 2013 field survey.

The sites for development are located on the farms Varkenvlei and Nooitgedacht near Northam and the farm Haakdoringdrift, near Thabazimbi. The areas are currently owned by Samancor and will be developed as underground mines. The purpose of this study is to fulfil the requirements for the mining rights application as required by the National Environmental Management Act, 1998 (NEMA).

The two mining rights areas are located in the Limpopo Province, however half of the Nooitgedacht/Varkenvlei site is located within the North West Province. The surrounding landscape matrix consists of various land uses including livestock production, communal land and other mining operations.

The current study aims to determine the presence/absence of flora and fauna within the study area with special reference to Red Data species and provincially or nationally protected species, which may be seen as red flags for the proposed development. The terms of reference for the terrestrial ecology specialist study, for the purpose of this report, are thus:

To conduct a flora and fauna survey of the site;

To identify the potential for threatened species (Red Data fauna and flora species) to occupy the study site;

To conduct a habitat suitability assessment for fauna species, particularly Red Data species; and

To provide an indication of the ecological function of the study site and identify specific areas of sensitivity or conservation importance.

The scope of work compromises the following tasks:

Conduct an initial literature review of vegetation likely to occur in the study area; and

Develop a species list of Red Data and protected plants.

Conduct a detailed field survey of the study area (using standard scientific methodology) to:

- Identify general vegetation communities in the study area;
- Identify dominant plant species;
- Record Red Data and protected species;
- Identify invader or exotic species;
- Identify sensitive landscapes and habitats including wetland and riparian habitats as these are often intricately linked to the surrounding terrestrial habitats; and
- Identify possible impacts of the proposed development during the operation of the mine.

The tasks for the fauna component comprised the following:

Conduct initial literature review of fauna species likely to occur in the study area;

Develop a species list of Red Data and protected.

Conduct a field survey (using standard scientific methodology), in order to:

- Identify terrestrial fauna occurring within the study area;
- Record Red Data and protected fauna species;
- Identify any exotic species; and
- Identify possible impacts of the proposed development on fauna populations.

The report is based on the following assumptions:

- The accuracy of GPS points taken in the field is within 15m;
- Delineations and related spatial data generated by GAA can be supplied in GIS (shapefile) format only and will be for use in conceptual planning purposes only and not detailed design;
- The assessment of the impact of past activities on the ecosystems will be based on professional judgement;
- Due to time constraints the study was conducting over a very short time period;
- Historical data relating to terrestrial ecosystems provided to GAA by the client is assumed to be correct;
- Data and information obtained through official documents or websites, peer reviewed scientific articles and previous ecological studies are assumed to be correct;
- No review or correction of any data obtained by any means, other than the study itself, will be undertaken by GAA;
- It is noted that unusual environmental conditions (such as unusual high or low rainfall) may cause unusual states of biodiversity during the period of study, which may not normally exist, but none such conditions occurred during the site visit; and
- It is noted that the site survey was conducted during the dry season, over a single sampling bout and will not account for seasonal variation or long term temporal changes in biodiversity.

During the flora assessment it was determined that the herbaceous layer is dominated by pioneer grass species and exotic herbaceous species. A total of 56 plant species were recorded during the floristic survey of the study areas.

The entirety of the two study sites can be described as degraded/recuperating vegetation. Floral diversity in this community is low with a total of 56 plant species recorded during the survey. Woody species are the lowest contributors of this diversity with 10 species, followed by grasses (25 species) and herbs/forbs (11 species).

This vegetation community is dominated by pioneer graminoid species such as Aristida spp, Eragrostis spp, Sporobolis spp and Digitaria spp. No Red Data plant species were recorded in this vegetation community, and due to the transformed nature it is highly unlikely that any Red Data or protected species will occur in this vegetation community.

Thirteen species of Red Data plant occur in the region. According to reviewed literature, three of these species potentially occur in the study area, while five species of protected tree may occur in the study area, however, no Red Data or protected species were recorded during the site survey.

Very low mammal species diversity was recorded on site with a total of only 5 mammal species recorded during the survey. The degraded nature of the study areas may be the most likely cause of the low mammal species diversity as well as the fact that it is unlikely that any Red Data or protected mammal species occur on site.

None of the 23 bird species recorded during the 2013 survey are listed as Red Data or Protected species, and six Red Data and protected species listed, only one is possibly occurring on the sites. A large number of reptiles were recorded on sight, but these all belonged to only five species. The increased activity of these animals may be due to the very hot weather persistent during the study.

Twenty eight amphibian species could potentially occur in the study area, although none were recorded during the surveys due to the lack of open water in the study areas. A total of 21 arthropoda taxa were recorded during the 2013 site survey. All recorded species are common to savanna areas and have widespread distributions. Four species of Red Data and Protected arthropods may occur within the study area, however, the probability of occurrence of these species is low.

In general, based on the species diversity and the lack of redundancy in species occurring in the study areas the ecological integrity of the study areas were determined to be moderate to low. Furthermore, due to lack of protected or Red Data species occurring in the study areas the conservation importance of the study areas is also determined to be low.

It is suggested that further studies be conducted in order to determine the presence or absence of the Giant Bullfrog (*Pyxicephalus adspersus*), African Rock python (*Python sebae natalensis*), Yellow-throated Sandgrouse (*Pterocles gutturalis*) and other Red Data species, which have even a low probability of occurrence, before any development is commenced.

It is likely that, if a good exotic species control program is implemented, the development in the area could have a positive effect on undisturbed vegetation in the area.

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1.0 INTRODUCTION

Samancor Chrome (Pty) Ltd appointed Golder Associates Africa (Pty) Ltd (GAA) to undertake a terrestrial ecology assessment of the proposed sites earmarked for development near Thabazimbi and Northam located approximately120 and 60 kilometres north-east of Rustenburg, South Africa, respectively.

This report presents the results of the February 2013 field survey.

2.0 PROJECT DESCRIPTION

2.1 Background and location

The sites for development are located on the farms Varkenvlei and Nooitgedacht near Northam and the farm Haakdoringdrift, near Thabazimbi. The areas are currently owned by Samancor and will be developed as opencast mines. The purpose of this study is to fulfil the requirements for the mining right application as required by the Mineral and Petroleum Resources Development Act, 2002 (MPRDA).

The two mining right areas are located in the Limpopo Province, but a portion of the Nooitgedacht/Varkenvlei site is located within the North West Province. The surrounding landscape matrix consists of various land uses including livestock production, communal land and other mining operations. The location of the study area is shown in Figure 1.

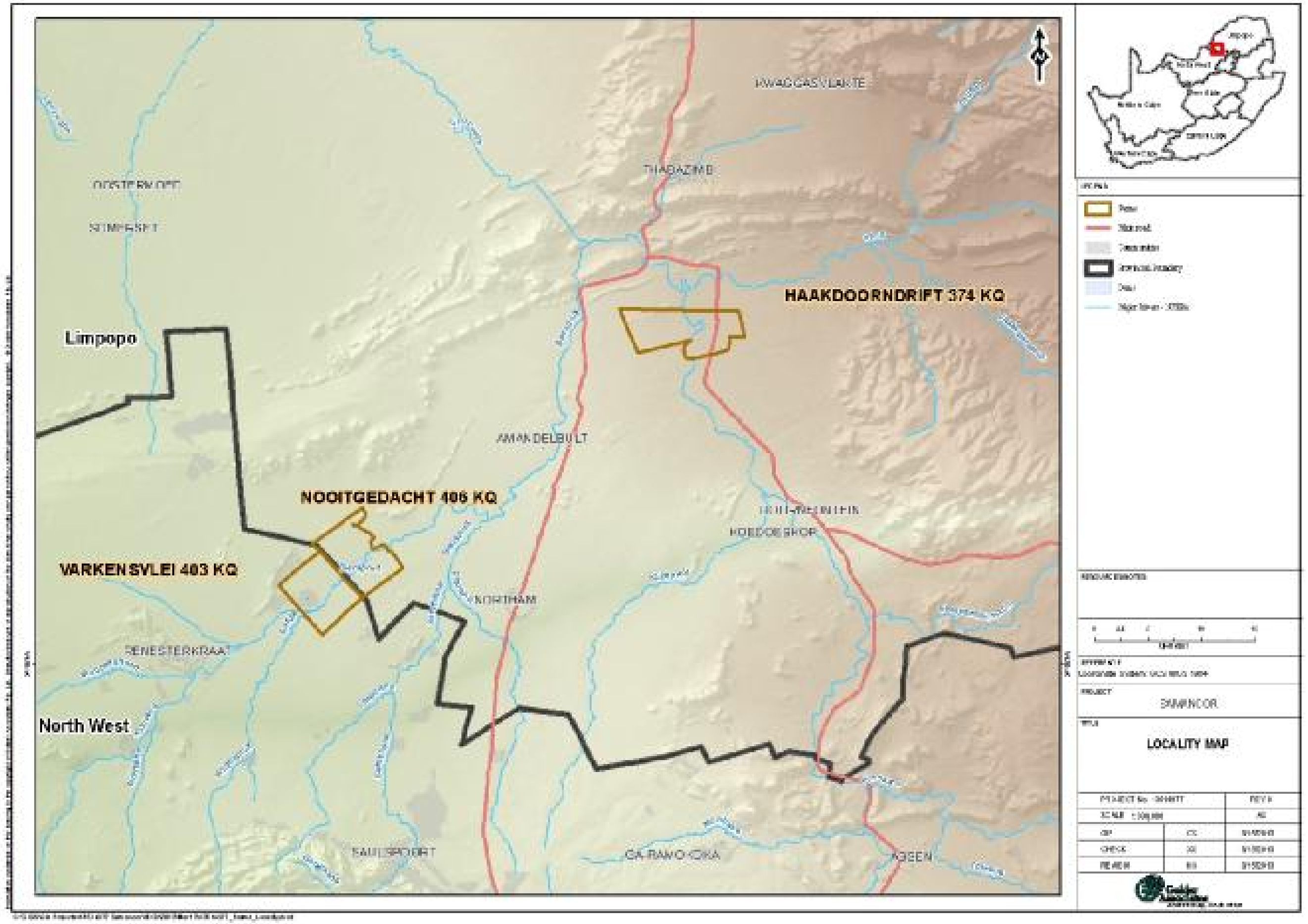

Figure 1: Regional location of study area

3.0 TERMS OF REFERENCE

The current study aims to determine the presence/absence of flora and fauna within the study area with special reference to Red Data species and provincially or nationally protected species, which may be seen as red flags for the proposed development. The terms of reference for the terrestrial ecology specialist study, for the purpose of this report, are thus:

- To conduct a flora and fauna survey of the site;
- To identify the potential for threatened species (Red Data fauna and flora species) to occupy the study site;
- To conduct a habitat suitability assessment for fauna species, particularly Red Data species; and
- To provide an indication of the ecological function of the study site and identify specific areas of sensitivity or conservation importance.

4.0 SCOPE OF WORK

4.1 Flora component

The scope of work compromised the following tasks:

- Conduct an initial literature review of vegetation likely to occur in the study area;
- Develop a potential species list of Red Data and protected plants according to the relevant literature for the (IUCN, 2012) and South Africa (NEMBA, 2007);
- Conduct a detailed field survey of the study area (using standard scientific methodology) to:
  - Identify general vegetation communities in the study area;
  - Identify dominant plant species;
  - Record Red Data and protected species;
  - Identify invader or exotic species;
  - Identify sensitive landscapes and habitats including wetland and riparian habitats as these are often intricately linked to the surrounding terrestrial habitats; and
  - Identify possible impacts of the proposed development during the operation of the mine.

4.2 Fauna component

The tasks for the fauna component comprised the following:

- Conduct initial literature review of fauna species likely to occur in the study area;
- Develop a list of potential Red Data species and protected animals according to the (IUCN, 2012) and South African protected and Red Data species lists (NEMBA, 2007);
- Conduct a field survey (using standard scientific methodology), in order to:
  - Identify terrestrial fauna occurring within the study area;
  - Record Red Data and protected fauna species;
  - Identify any exotic species; and
  - Identify possible impacts of the proposed development on fauna populations.

4.3 Assumptions and Limitations

The report is based on the following assumptions:

- The accuracy of GPS points taken in the field is within 15m;
- Delineations and related spatial data generated by GAA can be supplied in GIS (shapefile) format only and will be for use in conceptual planning purposes only and not detailed design;
- The assessment of the impact of past activities on the ecosystems will be based on professional judgement;
- Due to time constraints the study was conducting over a very short time period;
- Historical data relating to terrestrial ecosystems provided to GAA by the client is assumed to be correct;
- Data and information obtained through official documents or websites, peer reviewed scientific articles and previous ecological studies are assumed to be correct;
- No review or correction of any data obtained by any means, other than the study itself, will be undertaken by GAA;
- It is noted that unusual environmental conditions (such as unusual high or low rainfall) may cause unusual states of biodiversity during the period of study, which may not normally exist, but none such conditions occurred during the site visit; and
- It is noted that the site survey was conducted over a single sampling bout and will not account for seasonal variation or long term temporal changes in biodiversity.

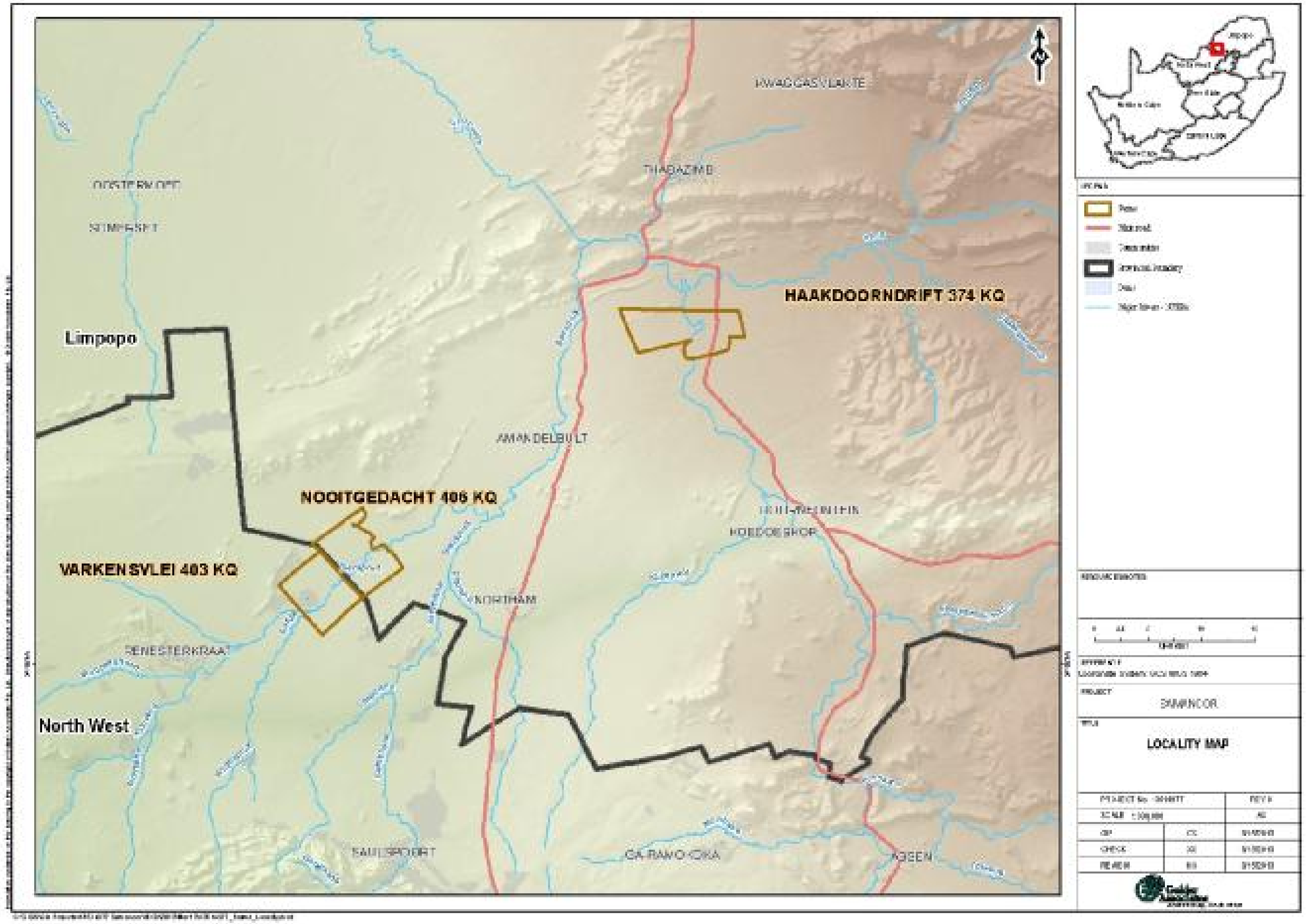

Figure 1: Regional location of study area

5.0 METHODOLOGY

The methodology used for this ecological assessment can be subdivided into three components, namely a desktop literature review component, a field survey data collection component, and a data assessment and reporting component. The methodologies associated with each are detailed in Sections 5.1 to 5.3.

5.1 Literature review

Although both study areas fall mainly within the Limpopo Province, the Limpopo Province does not have an equivalent ecological database to that of the North West Province. Be that as it may, both study areas are found within Mucina & Rutherfords (2006) Dwaalboom Thornveld vegetation type, which is well represented in the North West Province. As such, ecological information contained in the NW Biodiversity Inventory and Database (2003) relating to this vegetation type was consulted *apropos* ecological information.

5.1.1 Vegetation

Flora species lists for the relevant grid squares (2427CB and 2427CC) were obtained from the PRECIS (National Herbarium Pretoria Computer Information System) database (SIBIS:SABIF, 2009, internet) and the Plants of South Africa database (Plants of Southern Africa, 2009, internet). Information relating to specific species of concern for the grid square was obtained from NW Biodiversity Inventory and Database (2003). Other literature sources including (Low & Rebelo, 1996) and (Mucina & Rutherford, 2006) were also consulted.

5.1.2 Mammals

A list of expected mammal species was compiled by consultation of a number of literature sources including Skinner & Smithers (1990) and field guides such as Stuart & Stuart (2007). In addition, information relating to species of concern and general field observations for the area was obtained from NW Biodiversity Inventory and Database (2003).

5.1.3 Avifauna (Birds)

A list of expected bird species was compiled by consultation of a number of literature sources relevant to the study area, including the SANBI's SIBIS database (SIBIS: SABIF, 2009, internet), Harrison *et al.* (1997 a and b), and field guides such as Sinclair et al. (2002). Information relating to species of concern for the grid square was also obtained from the ornithologist based at the North West Department of Economic Development, Environment, Conservation and Tourism.

5.1.4 Herpetofauna (Reptiles and Amphibians)

Expected reptile and amphibian species lists were compiled by consultation of field guides. Branch (1994) was used for reptiles, while Carruthers (2001) and Du Preez & Carruthers (2009) were used for amphibian species.

5.1.5 Arthropoda

A list of expected arthropod species list was compiled based on the field guides Picker *et al* (2004) and Migdoll (1994).

5.1.6 Red Data and protected flora and fauna

In order to assess the Red Data status of species in the study area, the following sources were consulted:

- National Environmental Management: Biodiversity Act (No. 10 of 2004) – Lists of critically endangered, endangered, vulnerable and protected species (NEMBA, 2007);
- National Forests Act (No. 84 of 1998) – List of Protected Tree Species;
- Rare, endangered and endemic flora of the Bojanala Platinum District, North West Province (Hahn, 2011);
- North West Biodiversity Inventory and Database (2003);

- Limpopo Environmental Management Act (No. 7 of 2003);
- International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (2011); and
- International Union for the Conservation of Nature (IUCN) Red List Categories and Criteria (2008).

5.2 Field methodology

5.2.1 Vegetation sampling

Satellite imagery of the area was consulted as a first approximation of the vegetation communities within the study area. Plant communities were roughly delineated based on satellite imagery and previous studies were consulted in order to determine the general vegetation characteristics. In order to study the vegetation in greater detail, relevés were selected according to the vegetation characteristics identified. A total of 15 sites were selected at which to conduct vegetation surveys. Relevé data was collected in the field by means of point transects (for species occurring in the herbaceous layer) and belt transects (for tree and shrub species).

Species that were not identified in the field were sampled or photographed for identification at a later stage by consulting additional literature sources. Identification of plant species was undertaken using Van Wyk & Van Wyk (1997), Pooley (1998) and Van Oudtshoorn (1999) were applicable.

Vegetation data was collected during the field survey that was conducted for five days from the 28 February and 2 March 2013.

5.2.2 Fauna surveys

Fauna surveys were conducted at 12 sites. These sites were selected to encompass all of the possible habitats found on site as well as concentrate on sites which will either be directly affected by the mining or be likely to host increased diversity or protected and Red Data species. Field work was conducted for five days from the 28 February and 2 March 2013.

5.2.2.1 Mammals

Small mammals were trapped by means of seven Sherman traps placed in a single grid at each of the fauna survey sites. The data collected during Sherman trapping was augmented by visual observations, surveys of tracks and signs, as well as anecdotal evidence provided by residents and land users. Stuart & Stuart (2007) was used to identify mammals captured in the study area.

The mammal sensitivity assessment was based on the suitability of available habitat for species of particular conservation concern such as Red Data and protected species. The sensitivity of the mapped habitats was then assessed in terms of how the potential impacts of mining would alter the state of the habitat and therefore the continued presence of the particular species.

5.2.2.2 Avifauna (Birds)

Bird surveys were conducted by means of point counts of 15 min each (Bibby, et al., 1993) at each of the fauna survey sites.

During the survey, bird species were identified, and where necessary, identifications were verified using Sinclair *et al*. (2002). Particular attention was paid to suitable roosting, foraging and nesting habitats for Red Data species.

5.2.2.3 Herpetofauna (Reptiles and Amphibians)

Active searching was conducted at each of the fauna survey sites. Active searching was conducted on foot and included searching all suitable habitats (rocks, logs, artificial cover, leaf litter, artificial litter, bark, pools and streams etc), and scanning basking sites and places where specimens were likely to be found. Branch (1994) was used to identify observed reptile species, while Du Preez & Carruthers (2009) was used to identify amphibians found in the study area.

5.2.2.4 *Arthropoda*

Active searching was conducted at each of the fauna survey sites. Active searching was conducted on foot and included searching in suitable habitats (rocks, logs, artificial cover, leaf litter, bark, leaf axils, etc), and scanning sites where specimens were likely to be found. In addition, the presence of burrows, mounds and nests were also noted. Picker *et al* (2002) were used to identify species.

5.3 Assessment methodology

5.3.1 Floristic sensitivity analysis

Floristic sensitivity analysis was determined by subjectively assessing the ecological integrity and conservation importance of the vegetation, as defined in Table 1.

Table 1: Rating of ecological function and conservation importance

	Ecological integrity	**Conservation importance**
High	Sensitive ecosystems with either low inherent resistance or resilience towards disturbance factors or highly dynamic systems considered to be stable and important for the maintenance of ecosystems integrity (e.g. pristine grasslands, pristine wetlands and pristine ridges).	Ecosystems with high species richness and usually provide suitable habitat for a number of threatened species. Usually termed 'no-go' areas and unsuitable for development, and should be protected.
Medium	Relatively important ecosystems at gradients of intermediate disturbances. An area may be considered of medium ecological function if it is directly adjacent to sensitive/pristine ecosystem.	Ecosystems with intermediate levels of species diversity without any threatened species. Low-density development may be allowed, provided the current species diversity is conserved.
Low	Degraded and highly disturbed systems with little or no ecological function.	Areas with little or no conservation potential and usually species poor (most species are usually exotic).

5.3.2 Red Data assessment

Based on the potential Red Data species lists compiled during the literature review and on the findings of the field survey, the probability of occurrence of Red Data species in the study area were assessed for each species. The following parameters were used in the assessment:

- Habitat requirements (HR): Most Red Data species have very specific habitat requirements and the presence of these habitat characteristics in the study area was evaluated;
- Habitat status (HS): The status or ecological condition of available habitat in the area was assessed. Often a high level of habitat degradation prevalent in a specific habitat will negate the potential presence of Red Data species (this is especially evident in wetland habitats); and
- Habitat linkage (HL): Movement between areas for breeding and feeding forms an essential part of the existence of many species. Connectivity of the study area to surrounding habitat and the adequacy of these linkages are evaluated for the ecological functioning of Red Data species within the study area.

Probability of occurrence is presented in four categories, namely:

- Low;
- Medium;
- High; and
- Recorded.

6.0 BIOPHYSICAL ENVIRONMENT

6.1 Location

The study sites both fall within Mucina & Rutherford's (2006) Dwaalboom thornveld (SVcb1) vegetation type of the savanna biome.

The Haakdoringdrift site is located in the Crocodile River basin. The site is a largely flat area covering approximately 470 ha, varying in altitude between 934 m and 958 m.

Half of the Varkenvlei/Nooitgedacht site is situated in the North West Province and half in the Limpopo Province. The Bofule River intersects the northern portion of the North West Province section. The Varkenvlei/Nooitgedacht site is also a largely flat area of approximately 163 ha, varying in altitude between 997 m and 1023 m.

6.2 Vegetation and Associated Factors

6.2.1 Savanna Biome

The Savanna Biome is the largest biome in South Africa, extending throughout the east and north-eastern areas of the country (Manning, 2009). Savannas are characterised by a dominant grass layers, over-topped by a discontinuous, but distinct woody plant layer. At a structural level African savannas can be broadly categorised as either fine-leaved (microphyllous) savannas or broad-leaved savannas. Fine-leaved savannas typically occur on nutrient rich soils and are dominated by microphyllous woody plants of the *Mimosaceae* family (Common genera include *Acacia* and *Albizia*) and a generally dense herbaceous layer (Scholes & Walker, 1993). These savannas van support a high herbivore biomass of both grazers and browsers. Conversely, broad-leaved savannas occur on nutrient poor soils, are characterised by woody plants from the *Combretaceae* family (Common genera include *Combretum* and *Terminalia*) and typically support a low herbivore biomass (Scholes & Walker, 1993). Along with fire and a distinct seasonal climate, browsing and grazing by large herbivores are the dominant determinants of the composition, structure and functioning of savanna ecosystems (Scholes & Walker, 1993).

6.2.1.1 Dwaalboom Thornveld

Dwaalboom Thornveld is restricted in distribution in the Limpopo and North West Provinces within flats north of the Dwarsberge and associated ridges mainly west of the Crocodile River in the Dwaalboom area but including a patch around Sentrum. South of the ridges it extends eastwards from the Nietverdiend area, north of the Pilanesberg to the Northam area at an altitude range of between 900 and 1,200m AMSL. This vegetation type is dominated by elements of Low & Rebelo's (1996) Mixed Bushveld and Acocks (1953) Sourish Mixed Bushveld (Mucina & Rutherford, 2006). The following notes summarise the characteristics of this vegetation type.

Vegetation and Landscape features

Its main vegetation and landscape features include plains with a layer of scattered, low to medium high, deciduous microphyllous trees and shrubs with a few broad-leaved tree species. There is almost a continuous herbaceous layer dominated by grass species. *Acacia tortilis* and *Acacia nilotica* dominate on the medium clays (at least 21% clay in the upper soil horizon but high in the lower horizons). On particularly heavy clays (>55% clay in all horizons) most other woody plants are excluded and the diminutive *Acacia tenuispina* dominates at a height of less than 1 m above ground. On the sandy clay loam soils (with not more than 35% clay in the upper horizon but high in the lower horizons) *Acacia erubescens* is the most prominent tree. The alternation of these substrate types creates a mosaic of patches typically 1 – 5 km across, for example in the unit west of Thabazimbi (Mucina & Rutherford, 2006).

Geology and Soils

The sediments of the Pretoria Group that underlie this vegetation type, particularly the Silverton and Rayton Formations, are mostly shale, while carbonates, volcanic rocks, breccias and diamicites are also present. Bronzite, harzburgite, gabbro and norite of the Rustenburg Layered Suite (Bushveld Igneous Complex) are also frequently found underlying areas of Dwaalboom Thornveld (Mucina & Rutherford, 2006).

Soils are mostly deep, red and yellow apedal, which drain freely and have a high base status. Both vertic and melanic clays also occur in certain areas (Mucina & Rutherford, 2006).

Climate

As with all vegetation types in the Savanna Biome, areas of Dwaalboom Thornveld experience summer rainfall with dry, very cold winters. Frost occurs frequently in winter with temperatures as low as -4 ^{o}C recorded. Summer temperatures peak at 36 ^{o}C. Mean annual precipitation for this vegetation type ranges from 550 - 600 mm (Mucina & Rutherford, 2006).

Important Plant Taxa

Based on Mucina & Rutherford's (2006) vegetation classification, important plant taxa are those species that have a high abundance, a frequent occurrence (not being particularly abundant) or are prominent in the landscape within a particular vegetation type. They note the following species are important taxa in the Dwaalboom Thornveld vegetation type:

Trees: *Acacia erioloba, Acacia erubescens, Acacia nilotica, Acacia tortilis subsp heteracantha, Acacia fleckii, Acacia burkei, Rhus lancea* (Mucina & Rutherford, 2006).

Shrubs: *Diospyros lycioides subsp. lycioides, Grewia flava, Mystroxylon aethiopicum, subsp. burkenum, Agathisanthemum bojeri* (Mucina & Rutherford, 2006).

Graminoids: *Aristida bipartite, Bothriochloa insculpta, Digitaria eriantha subsp eriantha, Ischaemum afrum, Panicum maximum and Cymbopogon pospischilii* (Mucina & Rutherford, 2006).

Herbs: *Blepharis integrifolia, Chaemecrista absus, Cleome Maculata, Dicoma anomala, Kyphocarpa angustifolia, Limeum viscosum, Lophiocarpus tenuissimus* (Mucina & Rutherford, 2006).

Endemic Taxon: The low shrub *Rhus maricoana* is endemic to this region (Mucina & Rutherford, 2006).

Conservation

According to Mucina & Rutherford (2006) Dwaalboom Thornveld is classified as Least Threatened. Although the target for conservation is 19%, only 6% of this vegetation type is currently under statutory conservation in reserves such as the Madikwe Game Reserve. Cultivation and to a lesser extent urbanisation have resulted in the transformation of approximately 14% of Dwaalboom Thornveld and exotic invasive plants are present. Incidences of erosion are low to very low (Mucina & Rutherford, 2006).

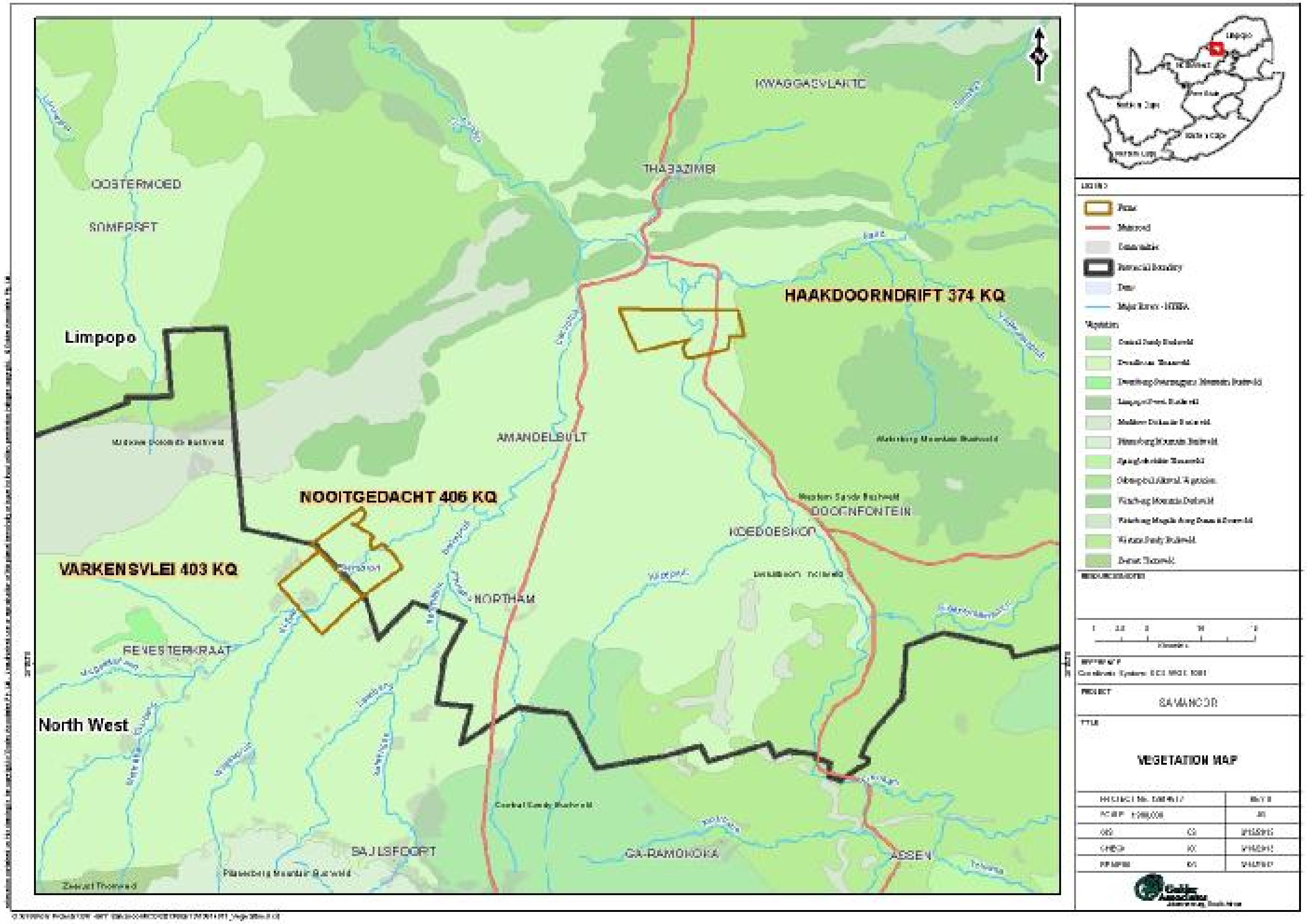

Figure 2: Vegetation types of the study area and surrounding regions according to Mucina & Rutherford (2006)

7.0 FLORAL ASSESSMENT

The flora assessment was conducted between the 28 February and 2 March 2013.

7.1 General Site Characteristics

7.1.1 Haakdoringdrift Study Area

The entire extent of the Haakdoringdrift study area has been previously placed under agriculture and judging by the age of the trees in the area, it is deduced that agriculture ceased in the area approximately 20 to 25 years ago (*Figure **3***). Previous and current mining activities have heavily impacted upon the western part of the site and the vegetation in this area is considered completely transformed. The area previously under cultivation is also considered transformed vegetation as it is very different to the natural local vegetation, which can be observed in the private nature reserve to the north of the site. Although the site is seen to be recuperating from a structural point of view the area is considered much degraded from a species composition point of view. The herbaceous layer is dominated by pioneer grass species and exotic herbaceous species. The shrub stratum is also completely absent from the area and the area has a vegetation structure more similar to that of Kalahari Thornveld of the drier far northern areas of the North West Province. Field observations indicate that fire is not actively or frequently used as a veldt management tool.

Figure 3: The Haakdoringdrift study area photographed from east to west.

7.1.2 Varkenvlei/Nooitgedacht Study Area

As with the Haakdoringdrift site, the entire extent of the Varkenvlei/Nooitgedacht site has been previously placed under agriculture and judging by the age of the trees in the area, it is deduced that agriculture ceased in the area approximately 20 to 35 years ago. Previous and current mining activities have slightly impacted upon the south eastern part of the site although this impact is mainly due to edge effects, rather than physical transformation of the site. Edge effect refers to changes in microclimate near the edge (boundary) of habitat patches that not only reduce the effective size of viable, interior habitat, but may also create parameter conditions that are more conducive to predators, parasites and exotic species invasion. The area previously under cultivation is considered transformed vegetation as it is very different to the natural local vegetation. Although the site is seen to be recuperating from a structural point of view the area is considered much degraded from a species composition point of view. The herbaceous layer is dominated by pioneer grass species and exotic herbaceous species. Parts of the study area are also severely encroached by *Acacia mellifera* and the area is also utilised for the collection of traditional food plants and medicinal plants. Field observations indicate that fire has been unsuccessfully utilised to try and control bush encroachment by *Acacia mellifera*.

Figure 4: Photograph of the Varkensvlei/Nooitgedacht study area from south to north (Note the encroachment by Acacia mellifera in the foreground)

7.2 Vegetation Communities

A total of 56 plant species were recorded during the floristic survey of the study areas (Table 2). This is markedly lower than the 116 plant species presented in the PRECIS dataset by SANBI for the relevant quarter degree squares and can be attributed to the degraded nature of the study areas. Furthermore many of the species recorded (12) are exotic species and are not included in the PRECIS database.

Based primarily on physiognomy, moisture regime, rockiness, slope, species composition and soil properties, only one vegetation community was identified, namely the Degraded/ Secondary vegetation community.

In addition, areas of complete or severe transformation and disturbance occur throughout the study area. These include *inter alia*, villages, haul roads, spoil heaps, old pit areas and un-rehabilitated areas. These areas were noted but not surveyed intensively.

7.2.1 Transformed/ Secondary vegetation community

The entirety of the two study sites can be described as degraded/ recuperating vegetation. Floral diversity in this community is low with a total of 56 plant species recorded during the survey. Woody species are the lowest contributors of this diversity with 10 species, followed by grasses (25 species) and herbs/forbs (11 species) (Table 2).

This vegetation community is dominated by pioneer graminoid species such as *Aristida* spp, *Eragrostis* spp, *Sporobolus* spp and *Digitaria* spp . Woody species have begun to recolonise the area and the woody layer is dominated by species such as *Acacia erubescens, A. karroo* and *A. mellifera*. To a far lesser extent species such *Grewia subspathulata, Acacia gerrardii and Ozoroa paniculosa* are also found in this vegetation community. In areas where rehabilitation of the grassy layer was more successful graminoid species are dominant. Areas where bush encroachment control has not been as successful, woody species such as *Acacia mellifera* have encroached on the area, thereby further preventing the colonisation of the area by graminoid species and ultimately leading to low diversity and abundance of graminoid species, such as *Schmidtia pappophoroides, Aristida canescens* and *Aristida adscensionis*.

No Red Data plant species were recorded in this vegetation community, and due to the transformed nature it is highly unlikely that any Red Data or protected species will occur in this vegetation community.

Areas of this vegetation community in which open cast mining activities occur will not be significantly impacted upon.

Table 2: Plant species recorded at the Varkenvlei/Nooitgedacht and Haakdoringdrift study areas

FAMILY	Exotic	Species	Life cycle	Growth Form
POACEAE	*	*Cymbopogon pospischilii*	Perennial	Graminoid
POACEAE		*Eragrostis curvula*	Perennial	Graminoid
MALVACEAE	*	*Malvastrum coromandelianum*	Biennial	Dwarf shrub
MOLLUGINACEAE	*	*Mollugo nudicaulis*	Annual	Herb
LAMIACEAE	*	*Salvia reflexa Hornem.*	Annual	Herb
SOLANACEAE		*Solanum elaeagnifolium*		
FABACEAE		*Acacia caffra*	Perennial	Shrub, tree
FABACEAE		*Acacia erubescens*	Perennial	Shrub, tree
FABACEAE		*Acacia galpinii*	Perennial	Tree
FABACEAE		*Acacia gerrardii*	Perennial	Shrub, tree
FABACEAE		*Acacia mellifera*	Perennial	Shrub, tree
BUDDLEJACEAE		*Buddleja salviifolia*	Perennial	Shrub, tree
BURSERACEAE		*Commiphora mollis*	Perennial	Tree
ANACARDIACEAE		*Ozoroa paniculosa*	Perennial	Shrub, tree
ANACARDIACEAE		*Searsia tenuinervis*	Perennial	Shrub, tree
ASPARAGACEAE		*Asparagus cooperi*	Perennial	Dwarf shrub, shrub
CONVOLVULACEAE		*Ipomoea magnusiana*	Perennial	Herb
CONVOLVULACEAE		*Merremia palmata*	Perennial	Herb

FAMILY	Exotic	Species	Life cycle	Growth Form
CUCURBITACEAE		*Cucumis hirsutus*	Perennial	Herb, succulent
EUPHORBIACEAE		*Jatropha zeyheri*	Perennial	Dwarf shrub, herb, succulent
EUPHORBIACEAE		*Euphorbia schinzii*	Perennial	Dwarf shrub, shrub, succulent
EUPHORBIACEAE		*Jatropha schlechteri*	Perennial	Dwarf shrub, herb, succulent
MALVACEAE		*Grewia subspathulata*	Perennial	Shrub
POACEAE		*Aristida adscensionis*	Annual	Graminoid
POACEAE		*Aristida congesta*	Perennial (occ. annual)	Graminoid
POACEAE		*Aristida stipitata*	Perennial	Graminoid
POACEAE		*Brachiaria deflexa*	Annual	Graminoid
POACEAE		*Brachiaria nigropedata*	Perennial	Graminoid
POACEAE		*Dactyloctenium aegyptium*	Annual	Graminoid
POACEAE		*Digitaria eriantha*	Perennial	Graminoid
POACEAE		*Diheteropogon amplectens*	Perennial	Graminoid
POACEAE		*Elionurus muticus*	Perennial	Graminoid
POACEAE		*Enneapogon cenchroides*	Annual (occ. perennial)	Graminoid
POACEAE		*Eragrostis barbinodis*	Perennial	Graminoid
POACEAE		*Eragrostis curvula*	Perennial	Graminoid
POACEAE		*Eragrostis gummiflua*	Perennial	Graminoid
POACEAE		*Heteropogon contortus*	Perennial	Graminoid
POACEAE		*Hyperthelia dissoluta*	Perennial	Graminoid
POACEAE		*Loudetia flavida*	Perennial	Graminoid
POACEAE		*Perotis patens*	Annual (occ. perennial)	Graminoid
POACEAE		*Pogonarthria squarrosa*	Perennial (occ. annual)	Graminoid
POACEAE		*Schizachyrium sanguineum*	Perennial	Graminoid
POACEAE		*Schmidtia pappophoroides*	Perennial	Graminoid
POACEAE		*Setaria verticillata*	Annual	Graminoid
POACEAE		*Sporobolus fimbriatus*	Perennial	Graminoid
POACEAE		*Stipagrostis uniplumis*	Perennial (occ. annual)	Graminoid
POACEAE		*Tricholaena monachne*	Perennial (occ. annual)	Graminoid
AMARANTHACACEAE	*	*Achyranthes aspera*	Annual	Herb
PAPAVERACEAEA	*	*Argemone mexicana*	Annual	Herb
SOLANACEAE	*	*Datura ferox*	Annual	Herb
SOLANACEAE	*	*Datura stramonium*	Annual	Herb

FAMILY	Exotic	Species	Life cycle	Growth Form
ASTERACEAE	*	*Xanthium spinosum*	Annual	Herb
ONAGRACEAEA	*	*Oenothera* sp	Annual	Herb
CONVOLVULACEAE	*	*Cuscata campestris*	Annual	Herb
AGAVACEAE	*	*Agave americana*	Perrenial	Succulent
CACTACEAE		*Opuntia ficus-indica*	Perrenial	Succulent

7.3 Red Data Floral Assessment

Based on Hahn's (2011) study, 13 species of Red Data plant occur within the Bojanala Platinum District of the North West Province these species can be extrapolated to the study area due to the same vegetation type occurring in the study area. According to reviewed literature, three of these species potentially occur in the study area, while five species of protected tree may occur in the study area (SANBI, 2004; NEMBA, 2007) **Table 3**.

No Red Data or protected species were recorded during the field survey.

Table 3: Potential Red Data and protected plant species that may occur in study area

Species	South African Red Data List (2009)	IUCN Red Data List (2011)	Protected Tree Species (National Forest Act No. 84 of 1998)	NEMBA ToPS List (2007)
Ledeboria atrobrunnea	Vulnerable	-	-	-
Delosperma macellum	Endangered	Critically endangered	-	-
Erythrophysa transvaalensis	-	Least Concern	Protected	-
Sclerocarya birrea subsp. *caffra*	-	-	Protected	-
Boscia albitrunca	-	-	Protected	-
Combretum imberbe	-	-	Protected	-
Acacia erioloba	-	-	Protected	-
Pittosporum viridiflorum	-	-	Protected	-

8.0 FAUNA ASSESSMENT

The fauna assessment was conducted between the 28 February and 2 March 2013.

8.1 Recorded fauna species

8.1.1 Mammals

A total of 5 mammal species were recorded during the survey, four of which were recorded at both study areas (**Table 4**). Based on species distribution maps documented in Stuart & Stuart (1997), and considering the existing land uses in the general region, 83 species of mammal could potentially occur in the study area which has a mammal diversity ranking of medium-high (NW Biodiversity Inventory and Database 2003). The low mammal species diversity recorded during the survey can be attributed to direct and indirect disturbances resulting from anthropogenic activities, as well as historic land uses such as agriculture and hunting. In addition, the poaching of small mammals by local communities in the study area and on adjacent land may further reduce the diversity of mammals.

Table 4: Mammal species recorded during the 2013 survey

Scientific Name	Common Name	NEM:BA Threatened and Protected Species List (2007)	IUCN Red List of Threatened Species (2012.2)	Study area recorded
Lemniscomys rosalia	Striped Mouse	-	Least concern	Haakdorindrift Varkenvlei/ Nooitgedacht
Mastomys coucha	Multimammate Mouse	-	Least concern	Haakdorindrift Varkenvlei/ Nooitgedacht
Saccostomus campestris	Pouched Mouse	-	Least concern	Haakdorindrift Varkenvlei/ Nooitgedacht
Lepus saxatili	Scrub Hare	-	Not listed	Haakdorindrift Varkenvlei/Nooitgedacht
Hystrix africaeaustralis	Porcupine	-	Least concern	Haakdorindrift

Red Data and Protected mammal species

Species recorded during the survey are common, with generally widespread distributions, and have accordingly been categorised as Least Concern on the IUCN Red Data List (2012).

Other species not observed during the field survey, but which show a regional distribution that includes the study area according to Stuart & Stuart (1997) are listed in **Table 5**.

Table 5: List of threatened or protected mammal species that may occur in the study area

Scientific Name	Common Name	NEM:BA Threatened and Protected Species List (2007)	IUCN Red Data List (2012a)	Probability of occurrence
Neamblysomus julianae	Juliana's Golden Mole	Vulnerable	Vulnerable	Low
Amblysomus septentionalis	Highveld Golden Mole	-	Near Threatened	Low
Eidolon helvum	Straw-coloured Fruit-bat	-	Near Threatened	Low
Parahyaena brunnea	Brown Hyaena	Protected	Near Threatened	Low
Mellivora capensis	Honey Badger	Protected	Near Threatened	Moderate

8.1.2 Avifauna

The NW Biodiversity Inventory and Database (2003) categorises the region in which the study area is located as having low-medium bird diversity. Data presented on SANBI's SIBIS database (SIBIS:SABIF, 2009, internet) indicates that a total of 140 bird species have been recorded in the relevant quarter degree grid square. This is substantially more than the 23 bird species recorded during the field survey. This low diversity can be attributed to:

- The lack of vegetation structural diversity on the study areas;
- Mining activities, most notably blasting would disturb many bird species in the immediate area, and
- Egg collecting by adjacent land users and bird hunting may reduce the abundance and diversity of resident bird species.

The bird species listed in **Table 6** were recorded at both study areas during the 2013 field survey.

Table 6: Bird species recorded during the 2013 survey

Scientific Name	Common Name
Mirafra sabota	Sabota Lark
Bostrychia hagedash	Hadeda Ibis
Vanellus coronatus	Crowned Lapwing
Vanellus armatus	Blacksmith Lapwing
Streptopelia senegalensis	Laughing Dove
Streptopelia capicola	Ring-necked Dove
Corthaixoides concolor	Grey Go-away-bird
Urocolinus indicus	Redfaced Mousebird
Coracias caudata	Lilacbreasted Roller
Upupa africana	African Hoopoe
Corvus albus	Pied Crow
Pyconotus nigricans	Black-fronted Bulbul
Pyconotus barbatus	Common Bulbul
Cossypha humeralis	Whitethroated Robin-Chat
Zosterops pallidus	Cape White-eye
Tchagra senegala	Blackcrowned Tchagra
Nectarinia mariquensis	Marico Sunbird
Passer domesticus	House Sparrow
Ploceus velatus	Southern Masked Weaver
Pytilia melba	Melba Finch
Estrilda erythronotos	Blackcheeked Waxbill
Uraeginthus angolensis	Blue Waxbill
Bubuculus ibis	Cattle Egret

Red Data and Protected avifauna

No bird species recorded during the 2013 survey are listed as Red Data or Protected species. Six listed bird species are included on SANBI's SIBIS database for the relevant quarter degree grid squares (**Table 7**). It is considered to be unlikely that any of these species with the exception of the Yellow throated Sandgrouse (*Pterocles gutturalis*), could actively nest in the study area. The Yellow throated Sandgrouse favours short, open grassland with clay like soils, similar to that occurring in the study area.

Table 7: Red Data avifauna species recorded in 2427CB & 2427CC quarter degree grid square

Scientific Name	Common name	IUCN Red Data List (2012)	NEM:BA Threatened and Protected Species List (2007)	Probability of occurrence
Buphagus erythrorhynchus	Red billed Oxpecker	Near threatened	-	Low
Gyps africanus	African White-backed Vulture	Vulnerable	Endangered	Low
Gyps coprotheres	Cape Griffon Vulture	Vulnerable	Endangered	Low
Polemaetus bellicosus	Martial Eagle	Vulnerable	Vulnerable	Low
Pterocles gutturalis	Yellow throated Sandgrouse	Near threatened	-	Probable
Torgos tracheliotus	Lappet-faced Vulture	Vulnerable	Endangered	Low

8.1.3 Herpetofauna

According to the NW Biodiversity Inventory and Database (2003) the Dwaalboom thornveld vegetation type in which the study area is located has a reptile and amphibian biodiversity ranking of medium. Only five species, namely the Spotted Bush Snake (*Philothamnus semivariegatus*), Puff Adder (Bitis arietans), Mozambique Spitting cobra (*Naja mossambica*) and the Variable Skink (*Mabuya varia*) were recorded during the 2013 field survey. All these species have wide distributions and are common. What was noticeable during the surveys was the large number of reptiles recorded (22 in total). This may be attributed to the very hot weather persisting during the time of the survey. No amphibians were recorded during the field survey. This was attributed to the absence of open water at either of the study areas.

Red Data and Protected Herpetofauna

A total of 65 species could potentially occur in the study area. Of these, only the African Rock Python (*Python sebae natalensis*) is categorised as a Protected species, according to the NEM:BA TOPS List (2007). The African Rock Python favours open savannas and rocky areas (Branch, 1994), Open savanna occurs in both the study area, but the area is severely impacted thus the probability of this species being present on site is considered moderate.

Of amphibians potentially occurring in the study area only the Giant Bullfrog (*Pyxicephalus adspersus*) is listed as Near Threatened by the IUCN (2012) and categorised as Protected on the NEM:BA TOPS List (2007). This species breeds in the shallows of temporary rain filled depressions in grasslands and dry savanna, and spends much of the year buried (Carruthers, 2001). Although no evidence of the presence of Giant Bullfrogs was observed during the field survey, there is potential for this species to occur in the dry riverbed areas of the Varkenvlei/Nooitgedacht study area. These areas are characterised by poorly drained soils which allow for the formation of temporary pools during the wet season. The probability of this species is, however, rated as low – moderate due to the disturbed nature of this area.

8.1.5 Arthropoda

A total of 21 arthropoda taxa were recorded during the 2013 field survey. All recorded species are common to savanna areas and have widespread distributions. These species are generally subtropical and reflect the southern extension of the Afrotropical range (Picker et al 2004).

Table 8: Arthropoda species recorded during the 2013 survey

Order	Family	Species Name
Lepidoptera	Nymphalidae	*Vanessa cardui*
		Acraea eponina eponina
		Junonia hierta
	Pieridae	*Mylothris rueppellii*
Coleoptera	Coccinellidae	*Henosepilachna bifasciata*
Thysanura	Lepismatidae	
Odonata	Protoneuridae	
	Libellulidae	
Blattodea	Blattidae	*Periplaneta americana*
Isoptera	Hodotermitidae	*Hodotermes mossambicus*
Orthoptera	Gryllidae	
	Acrididae	
Phasmatodea	Bacillidae	
Diptera	Muscidae	*Musca domestica*
Hymenoptera	Vespidae	*Belonogaster dubia*
	Apidae	*Apis mellifera*
	Anthophoridae	*Amegilla caelestina*
	Formicidae	*Pachycondyla tarsata*
		Dorylus helvolus

Red Data and Protected Arthropoda

Four species of Red Data and Protected arthropods may occur within the study area (**Table 9**). Both species of flat rock scorpions from the genus *Hadogenes* occur in rocky habitats, which were not found in either of the study areas. The probability of these species occurring in either of the study areas is therefore considered to be low.

As the name suggests the Marsh Slyph (*Metisella meninx*) is a wetland specialist favouring marshy grassland (Henning & Roos, 2001). The probability of this species occurring in the study areas is considered low. *Spialia paula* is a savanna species, occurring on the slopes of hills (Henning & Henning, 1989). According to the NW Biodiversity Inventory and Database (2003) this species has been found in Lekubu Mixed Thornveld habitat type, which does not occur in close proximity to either of the study areas. The probability of this species occurring on either of the study areas is considered low.

Table 9: List of Red Data and protected Arthropods that may occur in study area

Scientific Name	Common name	NEM:BA Threatened and Protected Species List (2007)	Probability of occurrence
Hadogenes gracilis	Rock Scorpion	Protected	Low
Hadogenes troglodytes	Rock Scorpion	Protected	Low

Scientific Name	Common name	NEM:BA Threatened and Protected Species List (2007)	Probability of occurrence
Metisella meninx	Marsh Sylph	Vulnerable	Low
Spialia paula	Mite Sandman	Vulnerable	Low

9.0 ECOLOGICAL INTEGRITY

The precautionary principle was applied throughout the determination of the ecological function of the study areas; therefore if ecological function was found to be borderline between two categories, the site was classified in the higher category.

Haakdoorindrift

Portions of the Haakdoringdrift study area are currently under agriculture and completely transformed, while large areas comprising natural vegetation communities have been previously transformed and are now in the early stages of succession, and in places are encroached with exotic plant species. In addition, other anthropogenic activities including agriculture and livestock grazing have also disturbed large tracts of the surrounding area, impacting on the Haakdoringdrift study area by means of edge effects. Edge effect refers to changes in microclimate near the edge (boundary) of habitat patches that not only reduce the effective size of viable, interior habitat, but may also create parameter conditions that are more conducive to predators, parasites and exotic species invasion.

Based on these factors, recorded species diversity and the lack of redundancy in species present the ecological integrity of the Haakdoringdrift study area was determined to be moderate to low.

Varkenvlei/Nooitgedacht

The Varkenvlei/Nooitgedacht study area has similarly been impact by historic agricultural activities and residential developments. Moreover, previous and current mining activities have slightly impacted upon the south-eastern part of the study area although this impact is mainly due to edge effects, rather than physical transformation of the site. Like the Haakdoringdrift study area, the vegetation at this study area has been previously transformed and is therefore now in the early stages of succession with a number of exotic plant species present, and is accordingly regarded as secondary vegetation.

Considering these factors and the recorded species diversity, the ecological integrity of the Varkenvlei/Nooitgedacht study area is also regarded as being moderate to low.

9.1 Conservation Importance

The precautionary principle was applied throughout the determination of the conservation importance of the various vegetation communities. In instances where conservation importance was found to be borderline between two categories, the community was classified in the higher category.

Due to their disturbed nature and the lack of presence or, for that matter, the lack of the likelihood of presence of protected or Red Data species at the Haakdoringdrift study area and the Varkenvlei / Nooitgedacht study area, the conservation importance of both sites is considered low.

10.0 DISCUSSIONS & CONCLUSIONS

As a result of previous and current disturbances both the Haakdoringdrift study area and the Varkenvlei/Nooitgedacht study area can be described as degraded/secondary vegetation.

The floral diversity is low with a total of 56 plant species across the two study areas being recorded during the survey. Woody species are the lowest contributors of this diversity with 10 species, followed by grasses (25 species) and herbs/forbs (11 species). The herbaceous layer is dominated by pioneer grass species, such as *Aristida* spp, *Eragrostis* spp, *Sporobolus* spp and *Digitaria* spp. Pioneer species are hardened annual plants that grow in very unfavourable conditions, such as those in disturbed areas. According to reviewed literature, 13 species of Red Data plant occur in the region, of which three species potentially occur in the two study areas. An additional five species of protected tree may also be present. This notwithstanding, no Red Data plant species were recorded in the degraded/secondary vegetation community at either study area. Due to the transformed nature of both sites, it is also highly unlikely that any Red Data or protected species will occur.

Very low mammal species diversity was recorded during the 2013 field survey, with four species being recorded at the Varkenvlei/Nooitgedacht study area and five at Haakdoringdrift study area. The degraded nature of both study areas may be the most likely cause of the low mammal species diversity. This fact also renders it unlikely that any Red Data or protected mammal species do actually occur on site.

None of the 23 bird species recorded during the 2013 survey are listed as Red Data or protected species. Of the six Red Data and protected species that potentially may occur in the area, only the Yellow throated Sandgrouse is considered to be likely to be present. This species favours short, open grassland with clay like soils, similar to that occurring in both study areas.

Reptile abundance was high, but species diversity was low with only five species recorded (3 species at Haakdoringdrift and 4 at Varkenvlei/Nooitgedacht). The increased activity of these animals may be due to the very hot weather persistent during the survey.

Twenty eight amphibian species could potentially occur in the study area, although none were recorded during the surveys due to the lack of open water at both study areas. A total of 21 arthropoda taxa were recorded during the 2013 site survey across both study areas. All recorded species are common to savanna areas and have widespread distributions. Four species of Red Data and Protected arthropods may occur within the study area, however, the probability of occurrence of these species is considered to be low.

Based on the species diversity and the lack of redundancy in species at both study areas, the ecological integrity of both was determined to be moderate to low. Although a number of protected or Red Data species, such as the Yellow-throated sandgrouse (*Pterocles gutturalis*), may potentially occur in the study areas, none were recorded during the survey, and coupled with the disturbed nature of both sites, the conservation importance of the study areas is also determined to be low.

11.0 RECOMMENDATIONS

It is suggested that further studies be conducted in order to confirm the presence or absence of the Giant Bullfrog (*Pyxicephalus adspersus*), African Rock python (*Python sebae natalensis*), Yellow-throated Sandgrouse (*Pterocles gutturalis*) and other Red Data species, which have even a low probability of occurrence, before any development is commenced.

It is likely that, if a good exotic species control program is implemented, the development in the area could have a positive effect on undisturbed vegetation in the area.

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GOLDER ASSOCIATES AFRICA (PTY) LTD.

Adrian Hudson
Senior Ecologist

Peter Kimberg
Divisional Leader Ecology

AH/PK/ah

Reg. No. 2002/007104/07

Directors: SAP Brown, L Greyling, RGM Heath, FR Sutherland

APPENDIX A

Vegetation potentially occurring in the study areas according to PRECIS data

Family	Naturalised	Species	Threat status	Lifecycle	Growth forms
ACANTHACEAE		Barleria bremekampii Oberm.	LC	Perennial	Dwarf shrub, shrub
ACANTHACEAE		Barleria crossandriformis C.B.Clarke	LC	Perennial	Herb, shrub
ACANTHACEAE		Crabbea hirsuta Harv.	LC	Perennial	Herb
ACANTHACEAE		Crossandra zuluensis W.T.Vos & T.J.Edwards	LC	Perennial	Herb
ACANTHACEAE		Dicliptera minor C.B.Clarke subsp. minor	LC	Annual	Herb
AMARYLLIDACEAE		Crinum crassicaule Baker	LC	Perennial	Geophyte
AMARYLLIDACEAE		Nerine laticoma (Ker Gawl.) T.Durand & Schinz	LC	Perennial	Geophyte
ANACARDIACEAE		Ozoroa paniculosa (Sond.) R.& A.Fern. var. paniculosa	LC	Perennial	Shrub, tree
ANACARDIACEAE		Searsia tenuinervis (Engl.) Moffett	LC	Perennial	Shrub, tree
ANACARDIACEAE		Searsia dentata (Thunb.) F.A.Barkley	LC	Perennial	Shrub, tree
ANACARDIACEAE		Searsia magalismontana (Sond.) Moffett subsp. magalismontana	LC	Perennial	Dwarf shrub
APOCYNACEAE		Diplorhynchus condylocarpon (Müll.Arg.) Pichon	LC	Perennial	Shrub, tree
ASPARAGACEAE		Asparagus cooperi Baker	LC	Perennial	Dwarf shrub, shrub
ASTERACEAE		Tarchonanthus trilobus DC. var. galpinii (Hutch. & E.Phillips) Paiva	LC	Perennial	Shrub, tree
ASTERACEAE		Aspilia mossambicensis (Oliv.) Wild	LC	Perennial	Herb
BRYACEAE		Brachymenium acuminatum Harv.		Perennial	Bryophyte
BUDDLEJACEAE		Buddleja salviifolia (L.) Lam.	LC	Perennial	Shrub, tree
BURSERACEAE		Commiphora mollis (Oliv.) Engl.	LC	Perennial	Tree
CAPPARACEAE		Maerua angolensis DC. subsp. angolensis	LC	Perennial	Shrub, tree
COMBRETACEAE		Terminalia sericea Burch. ex DC.	LC	Perennial	Tree
CONVOLVULACEAE		Evolvulus alsinoides (L.) L.	LC	Annual (occ. perennial)	Herb
CONVOLVULACEAE		Ipomoea magnusiana Schinz	LC	Perennial	Herb
CONVOLVULACEAE		Merremia palmata Hallier f.	LC	Perennial	Herb
CUCURBITACEAE		Cucumis hirsutus Sond.	LC	Perennial	Herb, succulent
CYPERACEAE		Bulbostylis burchellii (Ficalho & Hiern) C.B.Clarke	LC	Perennial	Cyperoid, herb, mesophyte
CYPERACEAE		Cyperus austro-africanus C.Archer & Goetgh.	LC	Perennial	Cyperoid, herb, mesophyte
CYPERACEAE		Cyperus decurvatus (C.B.Clarke) C.Archer & Goetgh.	LC	Perennial	Cyperoid, herb, mesophyte
CYPERACEAE		Cyperus digitatus Roxb. subsp. auricomus (Sieber ex Spreng.) Kük.	LC	Perennial	Cyperoid, helophyte, herb
CYPERACEAE		Cyperus margaritaceus Vahl var. margaritaceus	LC	Perennial	Cyperoid, herb, mesophyte
CYPERACEAE		Cyperus sexangularis Nees	LC	Perennial	Cyperoid, emergent hydrophyte, helophyte, herb
DITRICHACEAE		Ceratodon purpureus (Hedw.) Brid. subsp. stenocarpus (Bruch & Schimp. ex Müll.Hal.) Dixon		Perennial	Bryophyte

Family	Naturalised	Species	Threat status	Lifecycle	Growth forms
EUPHORBIACEAE		Croton megalobotrys Müll.Arg.	LC	Perennial	Tree
EUPHORBIACEAE		Jatropha zeyheri Sond.	LC	Perennial	Dwarf shrub, herb, succulent
EUPHORBIACEAE		Euphorbia schinzii Pax	LC	Perennial	Dwarf shrub, shrub, succulent
EUPHORBIACEAE		Jatropha schlechteri Pax subsp. setifera (Hutch.) Radcl.-Sm.	LC	Perennial	Dwarf shrub, herb, succulent
FABACEAE		Acacia caffra (Thunb.) Willd.	LC	Perennial	Shrub, tree
FABACEAE		Acacia erubescens Welw. ex Oliv.	LC	Perennial	Shrub, tree
FABACEAE		Acacia galpinii Burtt Davy	LC	Perennial	Tree
FABACEAE		Acacia gerrardii Benth. subsp. gerrardii var. gerrardii	LC	Perennial	Shrub, tree
FABACEAE		Acacia karroo Hayne	LC	Perennial	Shrub, tree
FABACEAE		Calpurnia aurea (Aiton) Benth. subsp. aurea	LC	Perennial	Shrub, tree
FABACEAE		Indigofera circinnata Benth. ex Harv.	LC	Perennial	Dwarf shrub, herb
FABACEAE		Pterocarpus rotundifolius (Sond.) Druce subsp. rotundifolius	LC	Perennial	Shrub, tree
FABACEAE		Rhynchosia densiflora (Roth) DC. subsp. chrysadenia (Taub.) Verdc.	LC	Perennial	Climber, herb
FABACEAE		Rhynchosia monophylla Schltr.	LC	Perennial	Herb
FABACEAE		Tephrosia purpurea (L.) Pers. subsp. leptostachya (DC.) Brummitt var. leptostachya	LC	Annual (occ. perennial)	Herb
FABACEAE		Rhynchosia holosericea Schinz	LC	Perennial	Climber, herb
LAMIACEAE		Clerodendrum ternatum Schinz	LC	Perennial	Dwarf shrub
LAMIACEAE	*	Salvia reflexa Hornem.	Not Evaluated	Annual	Herb
LAMIACEAE		Tetradenia brevispicata (N.E.Br.) Codd	LC	Perennial	Shrub, succulent, tree
LAMIACEAE		Vitex pooara Corbishley	LC	Perennial	Tree
MALVACEAE		Abutilon angulatum (Guill. & Perr.) Mast. var. angulatum	LC	Perennial	Shrub
MALVACEAE		Grewia subspathulata N.E.Br.	LC	Perennial	Shrub
MALVACEAE		Hibiscus sidiformis Baill.	LC	Annual	Herb
MALVACEAE	*	Malvastrum coromandelianum (L.) Garcke	Not Evaluated	Biennial	Dwarf shrub
MOLLUGINACEAE	*	Mollugo nudicaulis Lam.		Annual	Herb
MORACEAE		Ficus salicifolia Vahl	LC	Perennial	Tree
ORCHIDACEAE		Habenaria filicornis Lindl.	LC	Perennial	Geophyte, herb
OXALIDACEAE		Oxalis smithiana Eckl. & Zeyh.	LC	Perennial	Geophyte
POACEAE		Anthephora pubescens Nees	LC	Perennial	Graminoid
POACEAE		Aristida adscensionis L.	LC	Annual	Graminoid
POACEAE		Aristida congesta Roem. & Schult. subsp. barbicollis (Trin. & Rupr.) De Winter	LC	Perennial (occ. annual)	Graminoid
POACEAE		Aristida scabrivalvis Hack. subsp. scabrivalvis	LC	Annual	Graminoid
POACEAE		Aristida stipitata Hack. subsp. graciliflora (Pilg.) Melderis	LC	Perennial	Graminoid

Family	Naturalised	Species	Threat status	Lifecycle	Growth forms
POACEAE		Brachiaria brizantha (A.Rich.) Stapf	LC	Perennial	Graminoid
POACEAE		Brachiaria deflexa (Schumach.) C.E.Hubb. ex Robyns	LC	Annual	Graminoid
POACEAE		Brachiaria nigropedata (Ficalho & Hiern) Stapf	LC	Perennial	Graminoid
POACEAE		Chloris virgata Sw.	LC	Annual (occ. perennial)	Graminoid
POACEAE	*	Cymbopogon pospischilii (K.Schum.) C.E.Hubb.	Not Evaluated	Perennial	Graminoid
POACEAE		Dactyloctenium aegyptium (L.) Willd.	LC	Annual	Graminoid
POACEAE		Dichanthium annulatum (Forssk.) Stapf var. papillosum (A.Rich.) de Wet & Harlan	LC	Perennial	Graminoid
POACEAE		Digitaria eriantha Steud.	LC	Perennial	Graminoid
POACEAE		Diheteropogon amplectens (Nees) Clayton var. amplectens	LC	Perennial	Graminoid
POACEAE		Elionurus muticus (Spreng.) Kunth	LC	Perennial	Graminoid
POACEAE		Enneapogon cenchroides (Licht. ex Roem. & Schult.) C.E.Hubb.	LC	Annual (occ. perennial)	Graminoid
POACEAE		Eragrostis barbinodis Hack.	LC	Perennial	Graminoid
POACEAE		Eragrostis curvula (Schrad.) Nees	LC	Perennial	Graminoid
POACEAE		Eragrostis gummiflua Nees	LC	Perennial	Graminoid
POACEAE		Eragrostis nindensis Ficalho & Hiern	LC	Perennial	Graminoid
POACEAE		Eragrostis rigidior Pilg.	LC	Perennial	Graminoid
POACEAE		Eragrostis superba Peyr.	LC	Perennial	Graminoid
POACEAE		Eragrostis trichophora Coss. & Durieu	LC	Perennial	Graminoid
POACEAE		Eustachys paspaloides (Vahl) Lanza & Mattei	LC	Perennial	Graminoid
POACEAE		Heteropogon contortus (L.) Roem. & Schult.	LC	Perennial	Graminoid
POACEAE		Hyperthelia dissoluta (Nees ex Steud.) Clayton	LC	Perennial	Graminoid
POACEAE		Loudetia flavida (Stapf) C.E.Hubb.	LC	Perennial	Graminoid
POACEAE		Panicum coloratum L. var. coloratum	LC	Perennial	Graminoid
POACEAE		Perotis patens Gand.	LC	Annual (occ. perennial)	Graminoid
POACEAE		Pogonarthria squarrosa (Roem. & Schult.) Pilg.	LC	Perennial (occ. annual)	Graminoid
POACEAE		Schizachyrium jeffreysii (Hack.) Stapf	LC	Perennial	Graminoid
POACEAE		Schizachyrium sanguineum (Retz.) Alston	LC	Perennial	Graminoid
POACEAE		Schmidtia pappophoroides Steud.	LC	Perennial	Graminoid
POACEAE		Setaria verticillata (L.) P.Beauv.	LC	Annual	Graminoid
POACEAE		Sporobolus fimbriatus (Trin.) Nees	LC	Perennial	Graminoid
POACEAE		Sporobolus ioclados (Trin.) Nees	LC	Perennial	Graminoid
POACEAE		Sporobolus nitens Stent	LC	Perennial	Graminoid
POACEAE		Stipagrostis uniplumis (Licht.) De Winter var. uniplumis	LC	Perennial (occ. annual)	Graminoid
POACEAE		Tricholaena monachne (Trin.) Stapf & C.E.Hubb.	LC	Perennial (occ. annual)	Graminoid

Family	Naturalised	Species	Threat status	Lifecycle	Growth forms
POACEAE		Trichoneura grandiglumis (Nees) Ekman	LC	Perennial	Graminoid
POACEAE		Urochloa mosambicensis (Hack.) Dandy	LC	Perennial	Graminoid
POACEAE		Ischaemum fasciculatum Brongn.	LC	Perennial	Graminoid
POLYGALACEAE		Polygala albida Schinz subsp. albida	LC	Annual	Herb
POLYPODIACEAE		Lepisorus excavatus (Bory ex Willd.) Ching	LC	Perennial	Epiphyte, herb, lithophyte
POLYTRICHACEAE		Pogonatum capense (Hampe) A.Jaeger		Perennial	Bryophyte
POLYTRICHACEAE		Polytrichum commune Hedw.		Perennial	Bryophyte
POTTIACEAE		Trichostomum brachydontium Bruch		Perennial	Bryophyte
RICCIACEAE		Riccia atropurpurea Sim		Perennial	Bryophyte
SAPINDACEAE		Erythrophysa transvaalensis I.Verd.	LC	Perennial	Shrub, tree
SCROPHULARIACEAE		Freylinia tropica S.Moore	Rare	Perennial	Shrub
SCROPHULARIACEAE		Jamesbrittenia bergae P.Lemmer	VU	Perennial	Dwarf shrub
SCROPHULARIACEAE		Teedia lucida (Sol.) Rudolphi	LC	Perennial (occ. annual)	Dwarf shrub, herb, shrub
SCROPHULARIACEAE		Aptosimum lineare Marloth & Engl. var. lineare	LC	Perennial	Dwarf shrub
SELAGINELLACEAE		Selaginella dregei (C.Presl) Hieron.	LC	Perennial	Geophyte, herb, lithophyte
SPHAGNACEAE		Sphagnum capense Hornsch.		Perennial	Bryophyte, hydrophyte
SPHAGNACEAE		Sphagnum violascens Müll.Hal.		Perennial	Bryophyte, hydrophyte
VERBENACEAE		Lantana rugosa Thunb.	LC	Perennial	Shrub

APPENDIX B

Mammal species possibly occurring in the study area

Scientific Name	Common name
Neamblysomus julianae	Juliana's Golden Mole
Amblysomus septentrionalis	Highveld Golden Mole
Elephantulus brachyrhynchus	Short-snouted Sengi
Elephantulus myurus	Eastern Rock Sengi
Atelerix frontalis	Southern African Hedgehog
Mysorex varius	Forest Shrew
Crocidura mariquensis	Swamp Musk Shrew
Crocidura fuscomurina	Tiny Musk Shrew
Crocidura cyanea	Reddish-grey Musk Shrew
Crocidura silacea	Lesser Grey Musk Shrew
Crocidura hirta	Lesser Red Musk Shrew
Eidolon helvum	Straw-coloured Fruit-bat
Hipposideros caffer	Sundevall's Leaf-nosed Bat
Cloeotis percivali	Short-eared Trident Bat
Nycteris thebiaca	Egyptian Slit-faced Bat
Rhinolophus clivosus	Geoffrey's Horseshoe Bat
Rhinolophus darlingi	Darling's Horseshoe Bat
Rhinolophus blasii	Peak-saddle Horseshoe Bat
Rhinolophus simulator	Bushveld Horseshoe Bat
Miniopterus schriebersii	Schrieber's Long-fingered Bat
Myotis welwitschii	Welwitch's Hairy Bat
Myotis tricolor	Temminck's Hairy Bat
Neoromicia capensis	Cape Serotine Bat
Pipistrellus hesperidus	African Pipistrelle
Scotophilus dinganii	Yellow House Bat
Tadarida aegyptiaca	Egyptian Free-tailed Bat
Papio cynocephalus ursinus	Savanna Baboon
Cercopithecus pygerythrus	Vervet Monkey
Galago moholi	Southern Lesser Galago
Manis temminckii	Ground Pangolin
Lepus saxatillis	Scrub Hare
Pronolagus randensis	Jameson's Red Rock Rabbit
Paraxerus cepapi	Tree Squirrel
Cryptomys hottentotus	Common (African) Mole-rat
Hystrix africaeaustralis	Cape Porcupine
Thryonomys swinderianus	Greater Cane-rat
Saccostomus campestris	Pouched Mouse
Steatomys pratensis	Fat Mouse
Dendromus melanotis	Grey Climbing Mouse
Desmodillus auricularis	Cape Short-tailed Gerbil
Tatera leucogaster	Bushveld Gerbil
Tatera brantsii	Highveld Gerbil
Acomys spinosissimus	Spiny Mouse
Michaelamys namaquensis	Namaqua Rock Mouse
Aethomys chrysophilus	Red Veld Rat
Rhabdomys pumilio	Four-striped Grass Mouse
Lemniscomys rosalia	Single-striped Grass Mouse
Mus minutoides	Pygmy Mouse
*Mus musculus**	House Mouse

Scientific Name	Common name
Thallomys paedulcus	Acacia Rat
Mastomys coucha	Southern Multimammate Mouse
*Rattus rattus**	House Rat
Otomys angoniensis	Angoni Vlei Rat
Otomys irroratus	Vlei Rat
Vulpes chama	Cape Fox
Otocyon megalotis	Bat-eared Fox
Canis mesomelas	Black-backed Jackal
Aonyx capensis	Cape Clawless Otter
Mellivora capensis	Honey Badger (Ratel)
Poecilogale albinucha	African Striped Weasel
Ictonyx striatus	Striped Polecat
Mungos mungo	Banded Mongoose
Gallerella sanguinea	Slender Mongoose
Attilax paludinosus	Water (Marsh) Mongoose
Helogale parvula	Dwarf Mongoose
Ichneumia albicauda	White-tailed Mongoose
Cynictis penicillata	Yellow Mongoose
Genetta genetta	Small-spotted Genet
Genetta tigrina	South African Large-spotted Genet
Civettictis civetta	African Civet
Parahyaena brunnea	Brown Hyaena
Proteles cristatus	Aardwolf
Felis silvestris lybica	African Wild Cat
Leptailurus serval	Serval
Caracal caracal	Caracal
Procavia capensis	Rock Dassie (Hyrax)
Phacochoerus africanus	Common Warthog
Potamochoerus larvatus	Bushpig
Redunca fulvorufula	Mountain Reedbuck
Redunca arundinum	Common (Southern) Reedbuck
Pelea capreolus	Grey Rhebok
Oreotragus oreotragus	Klipspringer
Raphicerus campestris	Steenbok
Sylvicapra grimmia	Common Duiker

APPENDIX C

Avifauna species possibly occurring in the study areas

Scientific Name
Amadina erythrocephala
Amadina fasciata
Anthoscopus minutus
Anthus cinnamomeus
Anthus lineiventris
Anthus vaalensis
Apalis thoracica
Apus affinis
Apus caffer
Apus horus
Aquila verreauxii
Batis molitor
Bradornis mariquensis
Bradornis mariquensis
Bubalornis niger
Bubulcus ibis
Buphagus erythrorhynchus
Bradornis mariquensis
Buteo vulpinus
Calendulauda sabota
Camaroptera brevicaudata
Cercomela familiaris
Calendulauda sabota
Camaroptera brevicaudata
Cercomela familiaris
Cercotrichas leucophrys
Cercotrichas paena
Chalcomitra amethystina
Chrysococcyx caprius
Cinnyris mariquensis
Cinnyris talatala
Circaetus cinereus
Circaetus pectoralis
Cisticola chiniana
Cisticola fulvicapilla
Columba guinea
Coracias caudatus
Corvus albus
Corvus capensis
Corythaixoides concolor
Cossypha humeralis
Creatophora cinerea

Scientific Name
Crithagra mozambicus
Dendroperdix sephaena
Dendropicos fuscescens
Dendropicos namaquus
Dicrurus adsimilis
Dryoscopus cubla
Elanus caeruleus
Elanus caeruleus
Emberiza flaviventris
Emberiza tahapisi
Eremomela icteropygialis
Eremomela usticollis
Eremopterix leucotis
Estrilda erythronotos
Euplectes albonotatus
Falco rupicoloides
Glaucidium perlatum
Granatina granatina
Gyps africanus
Gyps coprotheres
Halcyon albiventris
Halcyon chelicuti
Halcyon leucocephala
Hirundo abyssinica
Hirundo semirufa
Hirundo semirufa
Indicator indicator
Lagonosticta rhodopareia
Lagonosticta senegala
Lamprotornis nitens
Lamprotornis nitens
Laniarius atrococcineus
Lanius collaris
Lybius torquatus
Melierax canorus
Melierax gabar
Merops apiaster
Merops pusillus
Monticola brevipes
Motacilla capensis
Nilaus afer
Numida meleagris

Scientific Name
Oena capensis
Parisoma subcaeruleum
Parisoma subcaeruleum
Parus cinerascens
Parus niger
Passer diffusus
Passer domesticus
Passer melanurus
Passer motitensis
Petronia superciliaris
Plocepasser mahali
Ploceus velatus
Polemaetus bellicosus
Prinia flavicans
Prinia subflava
Psophocichla litsipsirupa
Pternistis natalensis
Pternistis swainsonii
Pterocles gutturalis
Pycnonotus tricolor
Pytilia melba
Quelea quelea
Rhinopomastus cyanomelas
Saxicola torquatus
Scopus umbretta
Sigelus silens
Sporopipes squamifrons
Sporopipes squamifrons
Streptopelia capicola
Streptopelia semitorquata
Streptopelia senegalensis
Sylvietta rufescens
Tchagra australis
Tchagra senegalus
Telophorus sulfureopectus
Thamnolaea cinnamomeiventris
Tockus erythrorhynchus
Tockus leucomelas
Tockus nasutus
Torgos tracheliotus
Trachyphonus vaillantii
Tricholaema leucomelas

Scientific Name
Turdoides bicolor
Turdoides jardineii
Turdus libonyanus
Turnix sylvaticus
Tyto alba
Uraeginthus angolensis
Uraeginthus angolensis
Urocolius indicus
Vanellus armatus
Vanellus coronatus
Vidua macroura
Vidua paradisaea
Vidua regia

APPENDIX D

Herpetofauna possibly occurring in the study area

Scientific Name	Common name
Reptiles	
Homopholis wahlbergi	Velvety Gecko
Hemidactylus mabouia	Tropical Gecko
Lygodactylus c. capensis	Common Dwarf Gecko
Pachydactylus affinis	Transvaal Thicktoed Gecko
Pachydactylus capensis	-Cape Thicktoed Gecko
Pachydactylus turneri	Turners Thicktoed Gecko
Acanthocercus atricollis	Tree Agama
Agama aculeata distanti	Spiny Agama
Agama atra atra	Southern Rock Agama
Chamaeleo d. dilepis	Flap-necked Chameleon
Mabuya varia varia	-Variegated Skink
Mabuya striata punctatissimus	Stripped Skink
Mabuya capensis	Three-lined Skink
Lygosoma s. sundevallii	Sundeval's Skink
Panaspis wahlbergii	Snake-eyed Skink
Acontias percevalli occidentalis	Percival's Legless Skink
Nucras holobi	Holob's Sand Lizard
Nucras intertexta	Spotted Sand Lizard
Ichnotropis squamulosa	Rough-scaled Lizard
Ichnotropis capensis	Cape Rough-scaled Sand Lizard
Cordylus tropidosternum jonesii	Jones' Girdled Lizard
Cordylus vittifer	Transvaal Girdled Lizard
Gerrhosaurus flavigularis	Yellow-throated Plated Lizard
Varanus albigularis albigularis	Rock / Tree Leguaan
Varanus niloticus	Water Leguaan
Monopeltis infuscata	Cape Worm-lizard
Typhlops bibronii	Bibron's Blind Snake
Rhinotyphlops lalandei	Lalande's Blind Snake
Leptotyphlops s. scutifrons	Peters' Thread Snake
Leptotyphlops distanti	Distant's Tread Snake
Python sebae natalensis	African Python
Lycodonomorphus rufulus	Brown Water Snake
Lamprophis fuliginosus	Brown House Snake
Lycophidion c. capense	Cape Wolf Snake
Mehelya c. capensis	Cape File Snake
Mehelya nyassae	Black File Snake
Philothamnus semivariegatus	Spotted Bush Snake
Philothamnus hoplogaster	Green Water Snake
Philothamnus natalensis occidentalis	Natal Green Snake
Prosymna bivittata	Twinstriped Shovel-snout
Prosymna s. sundevallii	Lined Shovel-snout

Scientific Name	Common name
Pseudaspis cana	Mole Snake
Dasypeltis scabra	Common Egg-eater
Telescopus s. semiannulatus	Eastern Tiger Snake
Crotaphopeltis hotamboeia	Herald Snake
Dispholidus t. typus	Tree Snake
Thelotornis c. capensis	Vine Snake
Psammophylax tritaeniatus	Striped Skaapsteker
Psammophis s. subtaeniatus	Yellow-bellied Sand Snake
Psammophis b. brevirostris	Short-snouted Sand Snake
Psammophis leightoni trinasalis	Fork-marked Sand Snake
Psammophis angolensis	Pygmy Sand Snake
Aparallactus capensis	Black-headed Centipede-eater
Atractaspis bibronii	Side-stabbing Snake
Aspidelaps s. scutatus	Shield-nose snake
Elapsoidea boulengeri	Half-banded Garter Snake
Naja a. annulifera	Snouted Cobra
Naja mossambica	Mozambique Spitting Cobra
Dendroaspis polylepis	Black Mamba
Causus rhombeatus	Rhombic Night Adder
Bitis a. arietans	Puff-adder
Geochelone pardalis babcocki	Leopard tortoise
Kinixys lobatsiana	Lobatse Hinged-back Tortoise
Pelomedusa subrufa	MarshTerrapin
Pelusios sinuatus	Serrated Terrapin
Amphibians	
Xenopus laevis laevis	Common Platanna
Bufo gutturalis	Common Toad
Bufo garmani	Olive Toad
Schismaderma carens	Red Toad
Bufo fenoulheti	Northern Pygmy Toad
Breviceps adspersus adspersus	Bushveld Rainfrog
Phrynomantis bifasciatus	Red-banded rubber Frog
Pyxicephalus adspersus	Bullfrog
Pyxicephalus edulis	African Bullfrog
Tomopterna cryptotis	Tremelo Sand Frog
Tomopterna natalensis	Natal Sand Frog
Afrana angolensis	Common Rana
Ptychadena anchietae	Plain Grass Frog
Ptychadena mossambica	Broad-banded Grass Frog
Phrynobatrachus natalensis	Snoring Puddle Frog
Cacosternum boettgeri	Common Caco
Chiromantis xerampelina	Foam Nest Frog

Scientific Name	Common name
Kassina senegalensis	Bubbling Kassina
Strongylopus fasciatus fasciatus	Striped Rana
Tomopterna krugerensis	Knocking Sand Frog
Afrana fuscigula	Cape river frog
Bufo vertebralis	Southern Pygmy toad
Hemisus marmoratus	Mottled Shovel-nosed Frog
Bufo rangeri	Raucous toad
Bufo maculatus	flat-backed toad
Bufo poweri	Western Olive Toad

APPENDIX E

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ENVIRONMENTAL IMPACT ASSESSMENT FOR THE EIA AND EMP AT THE PROPOSED VARKENSVLEI/NOOITGEDACHT OPEN CAST MINE ON FARMS VARKENSVLEI 403KQ AND NOOITGEDACHT 406KQ, NORTHAM, LIMPOPO PROVINCE.

Environmental Impact Report
Noise Impact Assessment

Barend van der Merwe
PO Box 1219
Allensnek, 1737
Tel no. 011 782 7193

DECLARATION OF INDEPENDENCE

I, **Barend J B van der Merwe** as duly authorised representative of **dBAcoustics**, hereby confirm my independence and declare that I have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which **Golder Associates Africa (Pty) Ltd** was appointed as environmental assessment practitioner in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), other than fair remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act) for the **compilation of an EIA and EMP for the Varkensvlei Open cast mine – Noise Impact Assessment**. I further declare that I am confident in the results of the studies undertaken and conclusions drawn as a result of it. I have disclosed, to the environmental assessment practitioner, in writing, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act. I have further provided the environmental assessment practitioner with written access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not. I am fully aware of and meet the responsibilities in terms of NEMA, the Environmental Impact Assessment Regulations, 2010 and any other specific and relevant legislation (national and provincial), policies, guidelines and best practice.

Signature: ____________________

Full Name: Barend Jacobus Barnardt van der Merwe

Date: 10 June 2013
Title / Position: Environmental noise specialist
Qualification(s): BSc Honours in Geography
Experience (years/ months): 12 years
Registration(s): SAAI and SAIOH

EXECUTIVE SUMMARY

Introduction

The purpose of the noise and vibration study was to determine the prevailing ambient levels along the boundary of the mine and in the vicinity of the abutting noise sensitive areas. The evaluation and assessment of the different areas will assist management to identify possible noise and ground vibration impacts during the construction and operational phases of the project which may have an impact on the abutting noise sensitive areas. These noise sensitive areas Kraalhoek, Bierspruit Village and Mantserre are north of the proposed opencast pit whereas Swartklip and Sefikele are south of the proposed opencast pit. There are furthermore mine accommodation to the south of the proposed open cast pit area. There are existing mining activities (underground mining, conveyors, haul roads, crushers, mine ventilation shafts, open cast mining and blasting activities) to the south of the proposed open cast mine study area. There is a feeder road from the north-east to the south-west which is used by normal vehicles and mine related vehicles to access Mantserre. The people living in the immediate vicinity of the existing mine activities are already exposed to higher prevailing ambient noise levels because of some mining activity noise such as ventilation shaft noise, blasting, and other mining activity noises.

The prevailing ambient noise levels along the proposed opencast mine boundary will vary because of the existing mine activities, roads and the ventilation shafts. The levels of noise emissions and noise sources are a function of:

- The distance the receptors are from the existing mine activities, roads, and blasting;
- The operation hours of the existing mining activities;
- The intervening topography and structures that may shield the noise from the receiver;
- Meteorological conditions such as wind speed, temperature and the season.

The topography is slightly undulated areas with scattered trees, grass, feeder roads and existing residential areas, business complex and mine buildings and medium ground conditions. There are existing mines throughout the entire study area, with feeder roads, railway lines, mines and ventilation shafts. This is a typical mining area with residential properties in the vicinity of existing linear and/or point noise sources.

Traffic noise, wind noise, domestic type noise and mine activity noises such as fans, ventilation shafts, crushers, and blowers are the main contributors to the prevailing ambient noise level of the different areas. The prevailing noise level is proportional to the distance from the main noise sources and the prevailing ambient noise level is higher in the vicinity of the existing feeder roads and/or mine activities.

The proposed open cast is situated in an area where there are already an underground mine and open cast mine with the subsequent increased noise levels because of traffic and mine activities. The sensitivity analysis of the region is illustrated in the following Table.

Sensitivity Analysis

	Description
Low Sensitivity	Residential properties in the vicinity of roads.
Medium Sensitivity	Isolated residential areas where there are intermittent type noises such as passing traffic and distant mine activity noise.
High Sensitivity	Noise sensitive areas within a radius of 600m from the proposed open cast mine activities.

The impact approach will be to determine what the impact of the opencast mine and additional traffic may have on the abutting noise sensitive areas.

The following methodology was followed:

- Identify all the noise sensitive areas within the vicinity of the study area and identify such by means of their spatial position on Google Imagery;
- Determine the prevailing ambient noise level at each of the measuring points by means of the recommended noise measuring procedure in SANS 10103 of 2008;
- Calculate or determine the acceptable rating level for each measuring point;
- Calculate, determine and/or research the projected noise level of each noise source that is part of the construction and/or operational phase of the project;
- Calculate the noise impact at each of the noise sensitive areas; and
- Assess the proposed project in terms of the SANS 10103 of 2008, SANS 10328 of 2008, Noise Control Regulations, Environmental Health and Safety Guidelines for Mining by the World Bank.

Results

Two aspects are important when considering potential noise impacts of a project and it is:

- The increase in the noise level because of the construction (temporary increase) and operational phases (more permanent of nature), and;
- The overall noise level produced by the proposed mine activities.

The average ambient noise level along the northern boundaries of the noise sensitive areas (MP 12, 13 and 14) is 38.9dBA during daytime and 43.3dBA during night time and 40.2dBA during daytime and 48.4dBA during night time along the southern boundary (MP8, 9, 10, 15 and 16) of the proposed open cast pit and the noise sensitive area.

Conclusion

The distant existing mine activities, traffic and ventilation shaft noise was slightly audible in the vicinity of the noise sensitive areas at times when there was a slight wind blowing towards the residential areas and during winter periods when there are inversion conditions in the atmosphere.

The construction activities during the construction phase of the project will increase the prevailing noise level at the immediate vicinity of the site on a temporary basis and the following noise levels at different distances from the site is envisaged for the construction phase.

The residential areas in the vicinity of the proposed open cast mine are exposed to existing blasting which is taking place to the south, mining activities, traffic and industrial type noises because of the existing mining which is taking place within boundaries of the mine.

The distances between the proposed open cast mine and the noise sensitive areas play an important role in the propagation of the mine activity noises. The calculated noise level during a blast at NSA A will be 68.7dB, NSA B will be 68.6dB, NSA C will be 52.6dB, NSA D will be 68.6dB and at NSA E the noise level will be 52.2dB. This will be a once of noise increase which will be a finite type noise increase. The average ambient noise level along the northern boundaries of the noise sensitive areas next to the proposed opencast pit is 38.9dBA during daytime and 43.3dBA during night time and 40.2dBA during daytime and 48.4dBA during night time along the southern boundary of the proposed open cast pit and the noise sensitive area. The night time ambient noise levels are higher because there are insect activities which increase the noise levels accordingly.

A noise monitoring program must be in place where noise surveys can be carried out on a six monthly basis at the measuring points identified in the recent noise survey in order to determine if there is an increase in the prevailing noise levels of the study areas. The ground vibration and air-over pressure noise levels at a distance of 700m from the blast must be recorded during each blast and these records must be kept in a safe place for easy access.

The noise intrusion can however be controlled by means of approved acoustic screening measures, state of the art equipment, proper noise management principles and compliance to the Local Noise Control Regulations, and the International Finance Corporation's Environmental Health and Safety Guidelines.

Barend van der Merwe
Environmental Acoustic Specialist

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE EIA AND EMP AT THE PROPOSED VARKENSVLEI OPEN CAST MINE, NORTHAM, LIMPOPO PROVINCE.

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ABBREVIATIONS

dBA – A-weighted sound pressure level;

dB – Decibel;

IFC – International Finance Corporation;

m – Meters;

m/s – meters per second;

N, E, S, W – North, East, West, South

L_{Basic} – Basic noise level in dBA;

NSA – Noise sensitive areas;

MP – Measuring points;

PPV – Peak particle velocity;

SANS – South African National Standards;

Glossary of Acoustic Terminology

Ambient noise level	The totally encompassing sound in a given time usually being composed of sound from many sources near and far.
Amplitude	Is the objective measurement of the degree of change (positive or negative) in atmospheric pressure (the compression and rarefaction of air molecules) caused by sound-waves. The unit of measurement is the Newton per square meter (N/m^2).
A – Weighting	An electronic filter that simulates the human hearing characteristic which is less sensitive to sounds at low frequencies than at high frequencies.
Blasting	The use of Ammonium Nitrate Fuel Oil (ANFO) and gel cartridges or pumpable slurry to fragment the rock and ore body.
Damping	The process by which a fluid (such as air), material or structure absorbs sound by dissipating the impinging or transmitted sound energy. Also known as absorption.
Decibel (dB)	A descriptor that is used to indicate the level determined as 10 times the logarithmic ratio of two quantities with the same units.
dBA	A descriptor that is used to indicate that 10 times the logarithmic ratio of two quantities with the same units have been A-weighted.
Environmental zone	The physical component such as ground, rock and sand, which transmits vibration from the source to the person.
Equivalent noise level	A single value noise level that has the same energy content as a time varying noise level measured over a given period of time. It is therefore a time averaged noise level.
Frequency	The characteristic of a time varying signal that describes the number of cycles per second, expressed in Hertz, Hz.

Ground vibration	Ground vibration is caused by the release of energy from an activity such as compaction, drilling, traffic or blasting.
Integrated noise level	A time and energy averaged measure of a noise signal varying as a function of time.
Level	The property of any parameter that expresses its magnitude as 10 times the logarithm of the ratio of the value of parameter to a reference value with the same units. For a noise level the reference value is 20µPa for sound pressure and 1pW for sound power.
Noise	Sound is pressure fluctuations in the air, or other supporting medium, that can be detected by the ear or by a microphone. Noise is sound which is loud or perceived to be unpleasant in a given situation and thus causes disturbance. Any unwanted sound.
Noise emission	The noise energy that is transmitted from a point, line or surface source into the environment.
Over-air pressure	Overpressure (or blast overpressure) is the pressure caused by a shock wave over and above normal atmospheric pressure. The shock wave is caused by explosive detonations.

1 DETAILS OF SPECIALIST AND EXPERTISE

I, Barend JB van der Merwe of 43th Street, Linden Johannesburg am an environmental noise and ground vibration specialist for the last 12 years. I have been instrumental in the pre-feasibility studies of proposed projects which may have an impact on the environment and noise sensitive areas. I am also involved with the noise and ground vibration impact assessments and the environmental management plans compilation of large projects such as wind farms, mining, roads, trains (primarily the Gautrain) and various point noise sources. As a post-graduate student in Environmental Management at the University of Johannesburg, I am currently researching the impact of noise and ground vibration on a village close to a new underground mine. I have played a major role in the identification, evaluation and control of physical factors such as noise and ground vibration in the following projects – wind farms, various platinum and coal mines and the quarterly noise evaluation of the Gautrain, the rehabilitation of the N11 near Mokopane, construction of the P166 near Mbombela, design of the Musina by-pass, noise mitigatory measures at the N17 road near Trichardt, establishment of the weigh bridge along the N3 near Pietermaritzburg, George Western by-pass. The following large environmental companies are amongst my clients : Gibb, Royal Haskoning DHV, Coffey Environmental, Golder Associates Africa(Pty)Ltd, GCS Environmental(Pty)Ltd, Knight Piesold Environmental(Pty)Ltd and SRK Engineering(Pty)Ltd.

Qualifications

1. BSc Honours in Geography and Environmental Management – University of Johannesburg;
2. National Higher Diploma in Environmental Health - Witwatersrand Technikon;
3. National Diploma in Public Health - Cape Town Technikon;
4. National Certificate in Noise Pollution - Technikon SA;
5. National Certificate in Air Pollution - Technikon SA;
6. National Certificate in Water Pollution - Technikon SA;
7. Management Development Diploma - Damelin Management School; and
8. Advanced Business Management Diploma - Rand Afrikaans University.

Experience

- Member South African Acoustics Institute.
- Noise Control Officer I.t.o. Noise Control Regulations.
- Member of the South African Institute of Occupational Health
- Moderator Wits Technikon – Environmental Pollution III.
- Various road projects for SANRAL.
- Compilation of the Integrated Pollution strategy for Ekurhuleni Town Council.
- Represent clients at Town Planning Tribunals.
- Represent clients at Housing Board tribunals.
- Determine residual noise levels in certain areas as required by clients.
- Noise attenuation at places of entertainment.

- Design and implementation of sound attenuators.
- Noise projections and contouring.
- Advisory capacity regarding noise related cases to local authorities: - Sandton, Roodepoort, Randburg, Krugersdorp, Alberton, Centurion, Vereeniging. Due to my previous experience in Local Government I provide a service to these Local government departments on the implementation of the Noise Control Regulations and SANS 10103 of 2008 – The measurement and rating of environmental noise with respect to land use, health annoyance and to speech communication.
- Identification, Evaluation and Control of noise sources in industry.

The following are noise impact assessments of existing alleged noise related problems where I was involved with during the identification, evaluation and mitigation phases:

- EIA and scoping phases of new wind farms at Caledon;
- Installation of new power generation plants at Sandton City, Eastgate shopping centre and smaller locations;
- Fence line monitoring of the power generation at Kelvin Power Plant, Kempton Park;
- Noise impact assessment of blasting at pylons in Centurion for Gautrain Project;
- Noise problem at Protea Hotel – Zambia;
- Fence line noise and vibration monitoring for new mine in Rustenburg – Project period - two years;
- Fence line noise monitoring – Engen Refinery, Durban;
- Sasol engine testing laboratory in Cape Town;
- Sasol coal train in Secunda;
- Export of maize at East London harbour;
- Top Gear event at the Dome, Randburg;
- Various environmental noise evaluation at places of entertainment, churches and industries;
- Mitigation recommendations for Checkers at their refrigeration and mechanical ventilation plants; and
- Involved in some of the outdoor soccer fan parks during the soccer world cup.

2 INTRODUCTION

2.1 Background

The purpose of the noise and vibration study was to determine the prevailing ambient levels along the boundary of the mine and in the vicinity of the abutting noise sensitive areas. The evaluation and assessment of the different areas will assist management to identify possible noise and ground vibration impacts during the construction and operational phases of the project which may have an impact on the abutting noise sensitive areas. These noise sensitive areas Kraalhoek, Bierspruit Village and Mantserre are north of the proposed opencast pit whereas Swartklip and Sefikele are south of the proposed opencast pit. There are furthermore mine housing to the south of the proposed open cast pit area. There are existing mining activities (underground mining, conveyors, haul roads, crushers, mine ventilation shafts, open cast mining and blasting activities) to the south of the proposed open cast mine study area. There is a feeder road from the north-east to the south-west which is used by normal vehicles and mine related vehicles to access Mantserre. The people living in the immediate vicinity of the existing mine activities are already exposed to higher prevailing ambient noise levels because of some mining activity noise such as ventilation shaft noise, blasting, and other mining activity noises.

The other aspects such as mine construction vehicle noise, blasting, mine vehicle noise and plant activities are all variables that may change on a daily basis, which may have an influence on the prevailing noise levels and how the resultant noise is perceived by the residents within the mine boundaries and in the vicinity of the mine. The location of the study area is illustrated in Figure 1.

Figure 1: Proposed open cast mine

The proposed open cast mine (green area) and the mine activities in relation to the ore-body are illustrated in Figure 2.

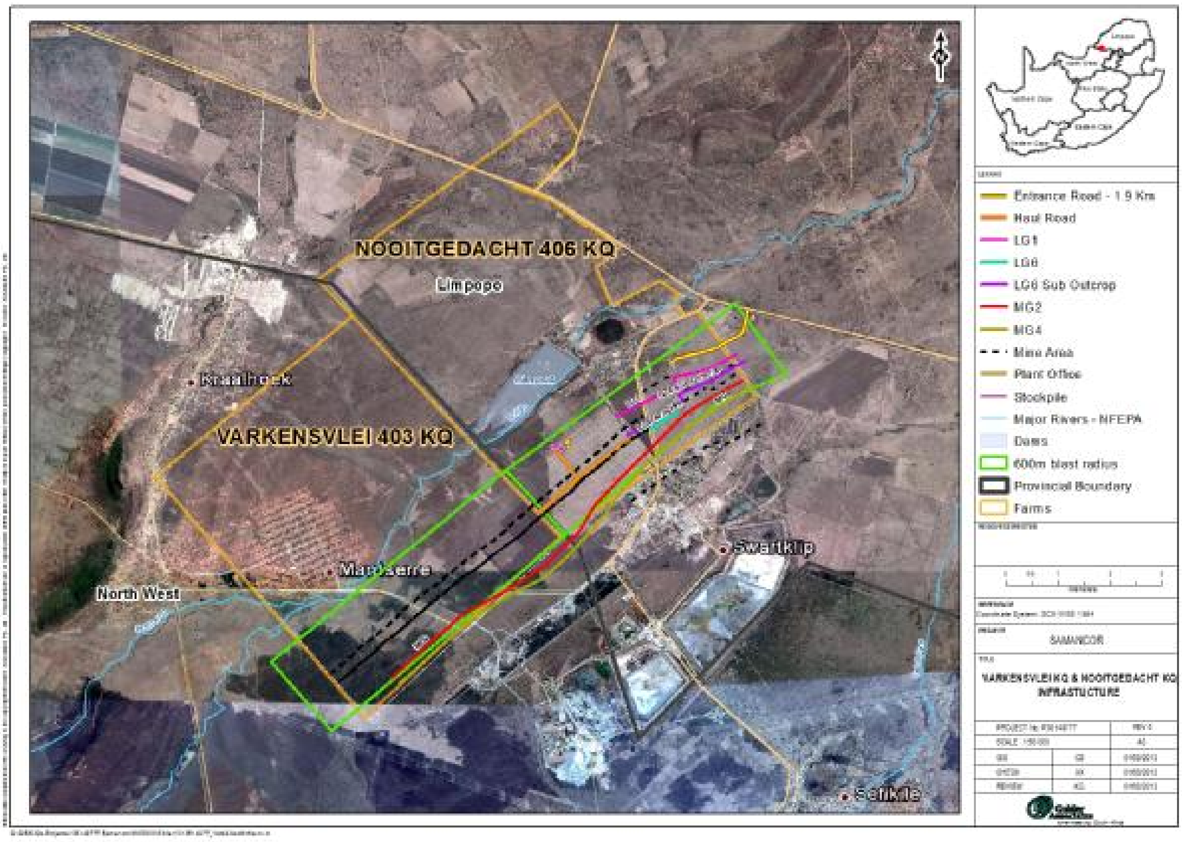


Figure 2: Varkensvlei/Nooitgedacht mine infra-structure

The prevailing ambient noise levels along the proposed opencast mine boundary will vary because of the existing mine activities, roads and the ventilation shafts. The levels of noise emissions and noise sources are a function of:

- The distance the receptors are from the existing mine activities, roads, and blasting;
- The operation hours of the existing mining activities;
- The intervening topography and structures that may shield the noise from the receiver;
- Meteorological conditions such as wind speed, temperature and the season.

The prevailing ambient noise levels within the study area is created by the existing mining operations, traffic along the internal roads, traffic along the feeder road situated along the north-eastern boundary, ventilation shafts, conveyors, plant activities, domestic type noise and insects. Insect noise such as crickets increases the prevailing ambient noise level during the summer period.

2.1.1 Environmental noise

Sound is a wave motion, which occurs when a sound source sets the nearest particles of air in motion. The movement gradually spreads to air particles further away from the source. Sound propagates in air with a speed of approximately 340 m/s.

The sound pressure level in free field conditions is inversely proportional to the square of the distance from the sound source – Inverse Square Law. Expressed logarithmically as decibels, this means the sound level decrease 6 dB with the doubling of distance. This applies to a point source only. If the sound is uniform and linear then the decrease is only 3 dB per doubling of distance.

The decibel scale is logarithmic therefore decibel levels cannot be added together in the normal arithmetic way, for example, two sound sources of 50 dB each do not produce 100 dB but 53 dB, nor does 50 dB and 30 dB equal 80 dB, but remains 50 dB.

Air absorption is important over large distances at high frequencies and it depends on the humidity but is typically about 40 dB/km @ 4000 Hz. Traffic noise frequencies are mainly mid/low and will be unaffected below 200m.

When measuring the intensity of a sound, an instrument, which duplicates the ear variable sensitivity to sound of different frequency, is usually used. This is achieved by building a filter into the instrument with a similar frequency response to that of the ear. This is called an A-weighting filter because it conforms to the internationally standardized A-weighting curves. Measurements of sound level made with this filter are called A-weighted sound level measurements, and the unit is dB.

Sound propagation is affected by wind gradient rather than the wind itself. The profile of the ground causes such a gradient. The sound may be propagated during upwind conditions upwards to create a sound shadow. A downwind refracts the sound towards the ground producing a slight increase in sound level over calm isothermal conditions.

The velocity of sound is inversely proportional to the temperature therefore a temperature gradient produces a velocity gradient and a refraction of the sound. Temperature decreases with height and the sound is refracted upwards.

For a source and receiver close to the ground quite large attenuation can be obtained at certain frequencies over absorbing surfaces, noticeably grassland. This attenuation is caused by a change in phase when the reflected wave strikes the absorbing ground and the destructive interference of that wave with the direct wave. The reduction in sound tends to be concentrated between 250 Hz and 600 Hz.

Noise screening can be effective when there is a barrier between the receiver and the source i.e. walls, earth mounds, cuttings and buildings. The performance of barriers is frequency dependent. To avoid sound transmission through a barrier the superficial mass should be greater than 10 Kg/m^2.

There is a complex relation between subjective loudness and the sound pressure level and again between annoyance due to noise and the sound pressure level. In general the ear is less sensitive at low frequencies and the ear will only detect a difference in the sound pressure level when the ambient noise level is exceeded by 3-5 dBA.

There are certain effects produced by sound which, if it is not controlled by approved acoustic mitigatory measures, seem to be construed as undesirable by most people and they are:

- Long exposure to high levels of sound, which may damage the hearing or create a temporary threshold shift – in industry or at areas where music is played louder than 95 dBA. This will seldom happen in far-field conditions;
- Interference with speech where important information by the receiver cannot be analyzed due to loud noises;
- Excessive loudness;
- Annoyance.

A number of factors, for example clarity of speech, age of listener and the presence of noise induced threshold displacement, will influence the comprehensibility of speech communication.

The effect of noise (with the exception of long duration, high level noise) on humans is limited to disturbance and/or annoyance and the accompanying emotional reaction. This reaction is very difficult to predict and is influenced by the emotional state of the complainant, his attitude towards the noisemaker, the time of day or night and the day of the week.

Types of noise exposure:

- Continuous exposure to noise – The level is constant and does not vary with time such as traffic on freeway and 24-hour mining activities;
- Intermittent exposure to noise – The noise level is not constant and occurs at times such as reverse signals and sirens;
- Exposure to impact noise – A sharp burst of sound at intermittent intervals such as explosions and low frequency sound.

Depending upon the intensity of the sound, the length of time of exposure and how often over time the ear is exposed to it, noise affects humans differently. People are besieged by noise, not only in the city streets but also in the busy workplaces and household noises.

Table 1: Recommended sound pressure levels for certain areas.

Descriptor	Limit	Situation or effect
LAeq, 24	70 dBA	Negligible risk of hearing impairment
LAeq, 8	75 dBA	Negligible
LAeq	30 dBA	Excellent speech intelligibility
LAeq	55 dBA	Fairly good speech intelligibility
LAeq	30 dBA	No sleep disturbance in a bedroom
LAmax	45 dBA	No sleep disturbance – peak inside bedroom

LAeq	55 dBA	Residential areas, outdoors, daytime
LAeq	45 dBA	Residential areas, outdoors, night time

This time-varying characteristics of environmental noise are described using statistical noise descriptors:

Leq: The Leq is the constant sound level that would contain the same acoustic energy as the varying sound level, during the same period of time.

L_{Max}: The instantaneous maximum noise level for a specified period of time.

L_{Min}: The instantaneous minimum noise level for a specified period of time.

The following relationships occur for increases in A-weighted noise levels:

- The trained healthy human ear is able to discern changes in sound levels of 1 dBA under controlled conditions in an acoustic laboratory;
- It is widely accepted that the average healthy ear can barely perceive noise level changes of 3 dBA;
- A change in sound level of 5 dBA is a readily perceptible increase in noise level;
- A 10-dBA change in the sound level is perceived as twice as loud as the original source.

The World Bank in the Environmental Health and Safety Regulations has laid down the following noise level guidelines:

- Residential area – 55 dBA for the daytime and 45 dBA for the nighttimes period;
- Industrial area – 70 dBA for the day- and night time periods.

The difference between the actual noise and the ambient noise level and the time of the day and the duration of the activity, will determine how people will respond to sound and what the noise impact will be. In order to evaluate such, there must be uniform guidelines to evaluate each scenario. The SANS 10103 of 2008 has laid down sound pressure levels for specific districts and has provided the following continuous noise levels per district as illustrated in Table 2.

Table 2: Recommended noise levels for different districts.

1	2	3	4	5	6	7
	Equivalent continuous rating level $L_{Req.T}$ for ambient noise - dBA					
	Outdoors			**Indoors, with open windows**		
Type of district	***Day-night*** L_{Rdn} [2)]	**Daytime** L_{Rd} [1)]	**Night-time** L_{Rn} [1)]	***Day-night*** L_{Rdn} [2)]	**Daytime** L_{Rn} [1)]	**Night-time** L_{Rn} [1)]
a) Rural districts	45	45	35	35	35	25
b) Suburban districts with little road traffic	50	50	40	40	40	30
c) Urban districts	55	55	45	45	45	35
d) Urban districts with some workshops, with business premises and with main roads	60	60	50	50	50	40
e) Central business district	65	65	55	55	55	45
f) Industrial districts	70	70	60	60	60	50

The reference time intervals can be specified to cover typical human activities and variations in the operation of noise sources and are for daytime between 6h00 to 22h00 and for night time between 22h00 and 6h00.

The response to noise can be classified as follows:

- An increase of 1dBA to 3dBA above ambient noise level will cause no response from the affected community. For a person with normal hearing an increase of 0dBA to 3 dBA will not be noticeable
- An increase between 1dBA – 10dBA will elicit little to sporadic response. When the difference is more than 5 dBA above the ambient noise level a person with normal hearing will start to hear the difference.
- An increase between 5dBA and 15 dBA will elicit medium response from the affected community.
- An increase between 10dBA and 20 dBA will elicit strong community reaction.

Because there is no clear-cut transition from one community response to another as well as several variables, categories of responses can overlap. This should be taken into consideration during the evaluation of a potential noise problem.

There is therefore a mixture of activities and higher noise levels as per the above recommended continuous rating levels within i.e. residential, industrial and feeder roads in close proximity of each other.

The ambient noise level will therefore differ throughout the study area, depending on the region and the measuring position in relation to areas with existing mining activities.

People exposed to an increase in the prevailing ambient noise level will react differently to the noise levels and the response is given in Table 3.

Table 3: Estimated community/group response when the ambient noise level is exceeded

1	2	3
Excess)$L_{Req,T}$[1)]	**Estimated community/group response**	
dB	**Category**	**Description**
0	None	No observed reaction
0-10	Little	Sporadic complaints
5-15	Medium	Widespread complaints
10-20	Strong	Threats of community/group action
>15	Very strong	Vigorous community/group action

1) Calculate)$L_{Req,T}$ from the appropriate of the following:

a))$L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS $L_{Req,T}$ of the residual noise (determined in the absence of the specific noise under investigation).

b))$L_{Req,T}$ = $L_{req,T}$ of ambient noise under investigation MINUS the maximum rating level for the ambient noise given in table 1.

c))$L_{Req,T}$ = $L_{Req,T}$ of ambient noise under investigation MINUS the typical rating level for the applicable district as determined from table 2.

The difference between the actual noise and the ambient noise level will determine how people will respond to sound.

The human perception of sound may be influenced by the acoustical characteristics of the noise (whether it has audible tones or other characteristics that may annoy the receptor) and how much louder the propagated sound is above the prevailing ambient noise level. The perception of the noise is furthermore influenced by the attitude towards the noise source. One person may find the singing of birds in the morning delightful whereas another person may find the sound aggravating. If a person has a negative attitude towards a noise source is much more likely to view the new noise itself negatively however low it is (Rogers and Manwell, 2002).

2.1.2 Ground vibrations

There are two aspects which must be considered during a blast and it is the over-air pressure which is the change in the air-pressure (shock wave) and ground vibration which is a direct result of the fragmentation of the ore body which need to be dislodged.

Vibration can be defined as regularly repeated movement of a physical object about a fixed point. The parameter normally used to assess the ground vibration is the peak particle velocity (PPV) expressed in millimetres per second (mm/s).

Environmental ground vibrations can come from various sources, both human-made (compaction, drilling and blasting) and natural (earth tremors and earth quakes). In most settings, particularly in urban and semi-urban settings, human activities comprise the most important sources. Han and body vibration can be experienced in the workplace when working with machinery. In the environmental context ground vibration is caused by the release of energy from an activity such as compaction, drilling, traffic or blasting. Ground type vibration will be concentrated on where there is a risk of cosmetic or structural damage to buildings in the vicinity of the blasting and mining operations (Guild *et al* 2001).

The movement in the ground caused by compaction, vehicular movement, blasting and stock piling can be described in three ways namely displacement, velocity and acceleration. Velocity is responsible for the most damage to structures and the velocity measurement can be converted to obtain displacement or acceleration. The velocity of ground vibration is usually measured in millimetres per second. (Goodquarry,2004).
Every person is exposed to whole body vibration on a daily basis in cars, busses and also whilst walking (Kubo et al, 2001). Whole body-vibration in excessive amounts may cause discomfort, fatigue and physical pains (Lui et al, 1995).

The aim is therefore to minimize or reduce the amount of vibration from products and vehicles (Kubo et al, 2001). The reduction of vibration in the environment caused by a point source such as compaction or blasting is however more complex and will require that a lot of variables will have to be considered to determine the impact and degree of damage to structures. The real cause of complaints by people exposed to blasting activities is how much the house and ground is shaking during each blast (Singh & Roy, 2010).

The environmental zone is the physical component such as ground, rock, sand, which transmits vibration from the source to the person. The environmental zone can play an important role to reduce the vibration amplitude to prevent damage to structures and medical conditions in a person (Kim & Lee, 2000). It is however difficult to estimate the percentage of reduction as the ground conditions are not always known or the same. In order to determine damage it is necessary to take into account the characteristics of the vibration source, the site characteristics (ground conditions), propagation of body and surface waves in the ground and the response of structures to vibrations (Massarsch, 1993).

The attenuation of vibration with distance from the source is based on the geometric damping and material damping. Geometric damping depends on the type and the location of the vibration source whereas material damping relates to the properties of the ground in the environmental zone and the vibration amplitude (Woods, 1985).
Vibration loses energy during propagation in the ground due to various physical characteristics of the ground such as clay conditions, fractures and loses ground. The amplitude of the vibration decreases with increasing the distance from the source by means of geometric radiation (vibration energy is reduced due to the friction and

cohesion between soil particles) and material dampening (soil type and the frequency of the vibration (Kim & Lee, 2000).

In Table 4 is an illustration of the typical vibration levels that are generated by normal day-to-day human activities which were measured adjacent to the source of the activity.

Table 4: Vibration levels for different human activities (Source: Consultnet.ie)

Household activity	**Vibration level (mm/s peak particle velocity)**
Jumping	≤ 250
Heel drop	≤ 150
Nail hammering	≤ 100
Walking	≤ 40
Shutting door	≤ 30
Sliding door	≤ 10

Typical levels measured during construction activities are illustrated in Table 5. These are the measured ground vibration at different distances from construction activities whereas the above vibration levels were measured next to within a meter from the activity.

Table 5: Ground vibration during construction activities (Source: Consultnet.ie)

Construction Activity	**Typical Ground Vibration Level – mm/s**
Vibratory roller	Up to 1.5mms @ 25m
Hydraulic rock breakers	4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m
Compactor	20mm/s @ 5m, <0.3mm/s @30m
Pile driving	1-3mm/s @ 50m depending on soil conditions and piling technique
Bulldozer	1-2mm/s @ 5m, 0.1 @ 50m
Truck traffic (smooth surface) Truck traffic (rough surface)	<0.2mm/s @ 20m <2mm/s @ 20m

Air over pressure (Air blast)

An explosion during a blast is an imperfect use of energy, and the energy is transmitted through the earth in the form of pulsating waves or vibrations. A part of the energy is also dissipated in the air, which produces over air-pressure noise. The sound pressure level is measured in dB. There is currently no blasting taking place therefore the people in the vicinity of the study area has never experienced this condition.

People respond differently to ground vibration levels and these levels in mm/s will elicit some response by people when exposed to these levels. The response levels vary from barely perceptible to unpleasant and intolerable. These vibration levels and the response from people are illustrated in Table 6. The brake-up of rock during blasting and close to the blasting activity takes place between 25mm/s to 50.0mm/s.

The slamming of a door will result in vibration level of 17mm/s whereas a footfall will record 0.5mm/s. Structural damage may occur at 25mm/s at properly constructed buildings and for clay huts and historical buildings damage may occur at 10mm/s (Goodquarry, 2004).

Table 6: Vibration levels and subsequent response

Response	Ground Vibration Range (mm/s)
Barely to distinctly perceptible	0.05- 2.54
Distinctly perceptible to strongly perceptible	2.54 – 12.7
Strongly perceptible to mildly unpleasant	12.7 – 25.0
Mildly unpleasant to distinctly unpleasant	25.0 – 50.0
Distinctly unpleasant to intolerable	50.0 – 200.0

* U.S Department of the Interior, Bureau of Reclamation – State Water Resources Control Board – Noise

The effects of these ground vibration sources vary immensely. The variation is caused not only by intensity or number of sources only. The soil condition and the soil geology play a critical role in the long-distance propagation of ground vibrations. Site vibration tests must be carried out before construction and during the construction and operational phases of the project to determine how the ground vibration levels are propagated during a blast or compaction. It often happens that the ground vibration will disappear when the topsoil is removed and replaced with more stable soil. *(Vibro-Acoustic Consultants, 2007).*

2.2 Legislative and Policy Context

<u>International Guidelines</u>

- Environmental, Health and Safety (EHS) Guidelines, World Health Organisation (WHO, 2002).

<u>National legislation</u>

- National Environmental Management Act. 2006 Act 62 of 2008 (RSA, 2008).

<u>Provincial legislation</u>

- Noise Regulations (1998).

<u>National Standards</u>

- SANS 10357 of 2004 – The calculation of sound propagation by the concave method (SANS, 2004);
- SANS 10210 of 2004 – Calculating and predicting road traffic noise (SANS, 2004);
- SANS 10328 of 2008 – Methods for environmental noise impact assessments (SANS, 2008); and

- SANS 10103 of 2008 – The measurement and rating of environmental noise with respect to annoyance and to speech communication (SANS, 2008).

A noise disturbance is classified in terms of the Noise Control Regulations as a noise that cause the ambient noise level to rise above the designated zone level by more than 7.0dBA, or if no zone level has been designated, the typical rating levels for ambient noise in districts, indicated in table 2 of SANS 10103.

Ground vibration levels

USBM R1 8507 the United States Bureau of Mines vibration standards.

2.2.1 Legislative requirements

Constitution of South the Republic of South Africa (RSA, 1996)[i]

Article 24: Everyone has the right -
(a) to an environment that is not harmful to their health and well-being; and
(b) to have the environment protected for the present and future generations through reasonable legislative and other measures that-
(i) prevent pollution and ecological degradation;
(ii) promote conservation; and
(iii) secure ecological sustainable development and use of natural resources, while promoting justifiable economic and social development.

2.3 Scope and limitations

There is no noise data for each of the areas and the recommended noise levels according to Table 2 of SANS 10103 of 2008 and the results from the noise survey of the study area will have to be used to determine the noise impact the proposed mine activities may have on the abutting noise sensitive areas.

Limitations:

There are no noise and/or ground vibration data available on the prevailing ambient levels of the study area and the formal residential areas.

2.4 Methodology

2.4.1 Instrumentation

The noise survey was conducted in terms of the provisions of SANS 10103 of 2008 - The measurement and rating of environmental noise with respect to annoyance and to speech communication and the Noise Control Regulations.

The instruments that was used in the noise survey:

Instrument 1

- Larsen Davis Integrated Sound Level meter Type 1 – Serial no. S/N 0001072;
- Larsen Davis Pre-amplifier – Serial no. PRM831 0206;
- Larsen Davis ½" free field microphone – Serial no. 377 B02 SN 102184; and
- Larsen Davis Calibrator 200 – Serial no.9855.

Instrument 2

- Tri-axle Instantel Minimate Plus ground vibration meter.

2.4.2 Measuring points

The measuring points within the study area are illustrated in Figure 3. These measuring points (MPs) were selected to be at or in the vicinity of the abutting NSAs.

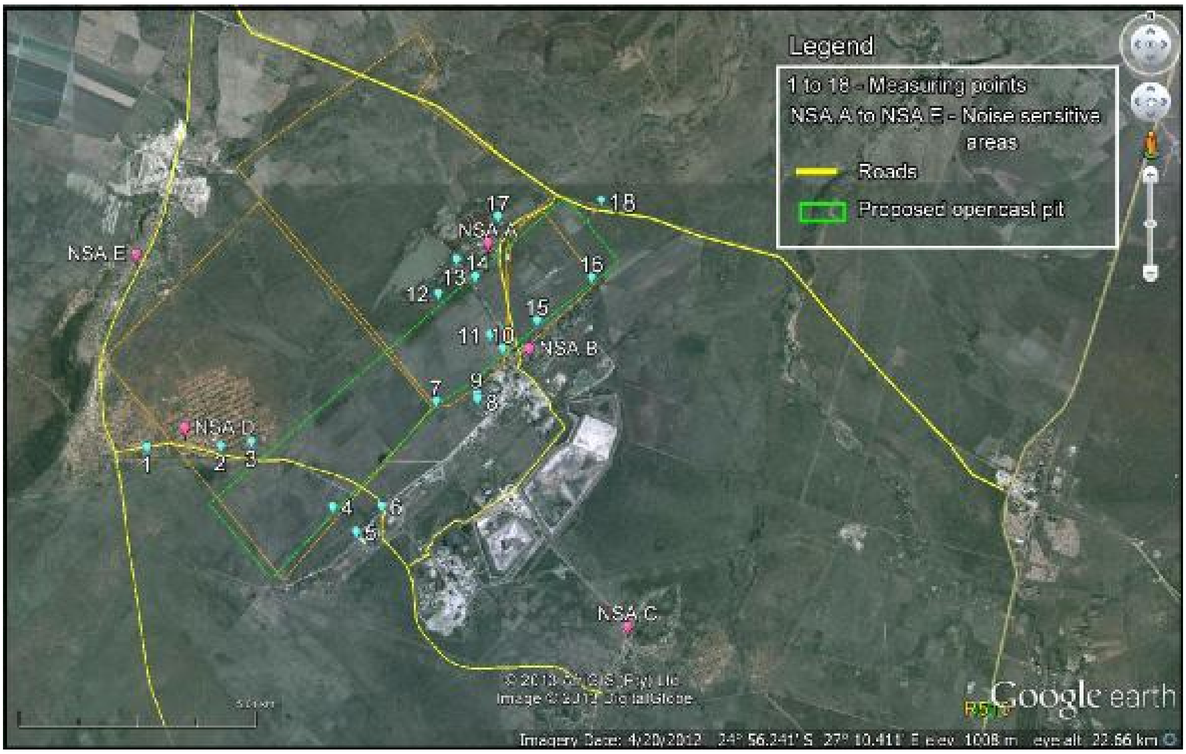


Figure 3: Measuring points in and around the study area.

The geographic information of the measuring points in terms of the spatial position and characteristics is illustrated in Table 7. There are busy feeder roads, existing mining operations, and existing ventilation shafts in the vicinity of the study area.

Table 7: Measuring points and co-ordinates

Position	X WGSDD	Y WGSDD	Remarks
1	24^0 57,099 S	027^0 06,093 E	Western noise sensitive area of Mantserre village. Distant existing mine activities noise
2	24^0 57,148 S	027^0 05,708 E	Mantserre village. Distant mine activity noise and traffic noise.
3	24^0 57,162 S	027^0 06,783 E	Mantserre village. Distant mine activity noise and traffic noise.
4	24^0 57,846 S	027^0 07,123 E	South-eastern boundary of the proposed open cast mine. Distant mine activities noise.
5	24^0 58,127 S	027^0 07,415 E	South-eastern boundary of the proposed open cast mine. Distant mine activities noise.
6	24^0 57,837 S	027^0 07,737 E	Along the existing feeder road between Mantserre Village and the mine. Silo, reverse signal and mine activity noise.
7	24^0 56,637 S	027^0 08,423 E	Southern boundary of the proposed opencast mine. Distant mine noise.
8	24^0 56,612 S	027^0 08,942 E	Within the residential area east of the proposed opencast mine. Domestic and distant mine activity noise.
9	24^0 56,550 S	027^0 08,934 E	Within the residential area east of the proposed opencast mine. Domestic and distant mine activity noise.
10	24^0 56,037 S	027^0 09,257 E	At the school which is situated in the residential area east of the proposed opencast mine. Domestic type noise such as people and traffic.
11	24^0 57,884 S	027^0 09,098 E	Open area within the proposed opencast mine. Distant traffic, insects and birds.
12	24^0 55,413 S	027^0 08,451 E	Within the residential area west of the proposed opencast mine. Domestic and traffic noise.
13	24^0 55,215 S	027^0 08,913 E	Within the residential area west of the proposed opencast mine. Domestic and traffic noise.
14	24^0 55,021 S	027^0 08,678 E	At the entrance to the Rock Cottage B&B at the residential area north of the proposed opencast mine. Domestic and traffic noise.
15	24^0 55,722 S	027^0 09,689 E	Within the residential area north of the proposed opencast mine. Domestic and traffic noise.
16	24^0 57,162 S	027^0 06,783 E	Within the residential area south of the proposed opencast mine. Domestic and traffic noise.
17	24^0 57,162 S	027^0 06,783 E	Within the residential area south of the proposed opencast mine. Domestic and traffic noise.
18	24^0 57,162 S	027^0 06,783 E	Along the main feeder road north of the proposed opencast mine. Traffic noise.

2.4.3 Site Characteristics

The topography is slightly undulated areas with scattered trees, grass, feeder roads and existing residential areas, business complex and mine buildings and medium ground conditions. There are existing mines throughout the entire study area, with feeder roads, railway lines, mines and ventilation shafts. This is a typical mining area with residential properties in the vicinity of existing linear and/or point noise sources.

2.4.4 Current noise sources

Traffic noise, wind noise, domestic type noise and mine activity noises such as fans, ventilation shafts, crushers, and blowers are the main contributors to the prevailing ambient noise level of the different areas. The prevailing noise level is proportional to the distance from the main noise sources and the prevailing ambient noise level is higher in the vicinity of the existing feeder roads and/or mine activities.

2.5 Assessment Methodology

The impact approach will be to determine what the impact of the proposed open cast pit and the mine activities may have on the abutting noise sensitive areas. The following methodology was followed:

- Identify all the noise sensitive areas within the vicinity of the study area and identify such by means of their spatial position on Google Imagery;
- Determine the prevailing ambient noise level at each of the measuring points by means of the recommended noise measuring procedure in SANS 10103 of 2008;
- Calculate or determine the acceptable rating level for each measuring point;
- Calculate, determine and/or research the projected noise level of each noise source that is part of the construction and/or operational phase of the project;
- Calculate the noise impact at each of the noise sensitive areas; and
- Assess the proposed project in terms of the SANS 10103 of 2008, SANS 10328 of 2008, Noise Control Regulations, Environmental Health and Safety Guidelines for Mining by the World Bank.

The control of noise in the Limpopo Province is regulated by the Noise Control Regulations, Gazette Number (R 154 GG 13717 of 10 January 1992), which was promulgated under the Environment Conservation Act, 1989. Act No 73 of 1989.

Section 4 of the above Noise Regulations say that "No person shall make , produce or cause a disturbing noise, allow it to be made, produced or caused by any person, animal, device or apparatus or any combination thereof." A disturbing noise means a noise level that exceeds the prevailing ambient noise level measured continuously at the same measuring point by 7.0dBA or more.

In order to determine the level of intrusion it will be required to determine the prevailing ambient noise levels at each measuring point and to calculate the increase in the noise level during the operational phase of the project. The following formula (SANS 10328 of 2008) is used to determine the difference between the future expected rating level (calculated noise levels) and the typical rating level (prevailing ambient noise level):

$$N_i = L_{\text{Req.T (expected)}} - L_{\text{Req. T (typical)}}$$

Where

N_i is the noise impact, in decibels;
$L_{\text{Req.T (expected)}}$ is the calculated equivalent continuous A-weighted sound pressure level, in decibels;
$L_{\text{Req. T(typical)}}$ is the prevailing ambient equivalent continuous A-weighted sound pressure level, in decibels.

The alleged noise impact on the environment and the residents living in the vicinity of the proposed open cast mine will be investigated.

2.5.1 Study area sensitivity analysis

The proposed open cast is situated in an area where there are already an underground mine and open cast mine with the subsequent increased noise levels because of traffic and mine activities. The sensitivity analysis of the region is illustrated in Table 8.

Table 8: Sensitivity Analysis

	Description
Low Sensitivity	Residential properties in the vicinity of roads.
Medium Sensitivity	Isolated residential areas where there are intermittent type noises such as passing traffic and distant mine activity noise.
High Sensitivity	Noise sensitive areas within a radius of 600m from the proposed open cast mine activities.

3 DESCRIPTION OF AFFECTED ENVIRONMENT

The noise sensitive areas A to E will be the affected or receiving environment throughout the study area and the NSAs are illustrated in Figure 4. The NSAs are already exposed to other mine activity noises and traffic because of the existing mine operations and roads which runs through or in the vicinity of the study area. NSA A, B and D is north and south of the proposed opencast mine whereas NSA E and C is some distance from the proposed opencast mine.

Figure 4: Location of the noise sensitive areas

The distances between NSAs A, B and D and the 600m safe distance boundary (green line) of the open cast mine are given in Table 9. The existing noise sources such as traffic creates an finite to continuous noise and the mine and the ventilation shaft a continuous point source during the day and night time periods. This will increase the prevailing ambient noise levels in the vicinity of these linear and/or point noise sources on a permanent or temporary basis.

Table 9: Distance between proposed opencast mine boundaries and the noise sensitive areas

Noise sensitive area	Distance between the noise sensitive area and the opencast 600m mine boundary
A	50 to 340m
B	60 to 80m
C	3 740m
D	340 to 580m
E	3 850m

The noise levels at the different NSAs to which the residents will be exposed to during the operational phase of the project is illustrated in Table 10. The calculations are based on the following noise levels:

- Haul route – 80.0dBA;
- Pit noise levels – 100.0dBA;
- Blast – 140dB

The calculations to determine the noise level at the noise sensitive areas are based on the following equation:

L_R = SPL – 20log(R) – α_a
Where:
L_R = Sound pressure level at a distance from the source;
SPL = Sound pressure level at the source;
R = Distance from the source;
α_a = Sound reduction due ground conditions and trees and distance from the source and an average value of 5.0dB is used according to BS5228:Part1(1997).

Table 10: Mine activity noise levels during the operational phase of the project

	Calculated noise level at the different noise sensitive areas - dBA		
Noise sensitive area	**During a blast of 130dB at 600m + distance from the NSA.**	**Haul road in the middle of the opencast activities at 300m from the green boundary – 80.0dBA**	**Middle of the opencast pit with activities such as drilling and hauling at 600m + distance from the NSA at a cumulative noise level of 100.0dBA**
A	68.7dB	18.7dBA	38.7dBA
B	68.6dB	18.6dBA	38.6dBA
C	52.6dB	20.3dBA	22.0dBA
D	68.6dB	18.6dBA	38.6dBA
E	52.2dB	22.5dBA	22.3dBA

3.1 Prevailing noise regime

3.1.1 Results

The noise survey was done at the different measuring points during the day and night time with a north-westerly wind blowing during the daytime between 1.6m/s to 2.7m/s and during the night time with a north-easterly wind between 1.0m/s to 1.7m/s. The wind speed at each measuring point will however be indicated with the prevailing ambient noise levels in Table 9.

Table 9: Noise levels and wind speed for the day and night time periods.

Measuring point	Daytime				Night time			
	Leq-dBA	Predominant noise source	Wind speed – m/s	Wind	Leq-dBA	Predominant noise source	Wind speed – m/s	Wind
1	**42.2**	Insects, birds and distant traffic	1.8	S/W	**46.6**	Insects, distant mine and odd vehicle	0.2	S/W
2	**44.9**	Traffic, birds and domestic	1.5	S/W	**47.6**	Distant vent shaft noise, mine activities and insects	0.2	S/W
3	**44.1**	Traffic, birds and domestic	2.7	S/W	**48.4**	Distant vent shaft noise, mine activities and insects	0.4	S/W
4	**35.5**	Insects, distant traffic and exploration	1.9	S/W	**50.6**	Insects and Silo noise	0.4	S/W
5	**39.4**	Distant mine activities	1.9	S/W	**50.3**	Mine activity noise, reverse signal, insects and silo noise	0.2	S/W
6	**61.5**	Silo noise, traffic and mine noise	1.9	S/W	**52.3**	Ventilation shaft noise	0.2	S/W
7	**43.2**	Distant mine	0.6	S/W	**48.4**	Distant mine and insects	0.2	S/W
8	**38.7**	Domestic	0.4	S/W	**48.6**	Distant mine and insects	0.2	S/W
9	**38.1**	Domestic	0.6	S/W	**48.6**	Distant mine and insects	0.2	S/W
10	**41.9**	Domestic and insects	2.0	S/W	**53.5**	Distant mine and insects	0.2	S/W
11	**44.5**	Traffic	0.7	S/W	**47.1**	Traffic, insects and birds	0.2	S/W
12	**37.3**	Birds and insects	0.9	S/W	**60.6**	Distant mine and insects	0.2	S/W
13	**37.4**	Distant traffic and birds	0.5	S/W	**45.2**	Insects	0.2	S/W
14	**42.1**	Insects, birds, train hooting	1.5	S/W	**41.4**	Distant mine and insects	0.2	S/W
15	**40.5**	Domestic and traffic noise	0.6	S/W	**51.3**	Traffic and insects	0.2	S/W
16	**41.7**	Mine activities and traffic	0.5	S/W	**48.1**	Distant mine noise	0.2	S/W
17	**43.4**	Traffic and noise from security gate	0.7	S/W	**41.3**	Traffic and insect noise	0.2	S/W
18	**62.7**	Traffic	1.7	S/W	**53.5**	Traffic	0.2	S/W

The prevailing ground vibration levels at all the measuring points are well below 0.050mm/s which at this stage are insignificant because there was no blasting taking place in the vicinity of the study area.

3.2 Discussion

3.2.1 Prevailing noise levels within the study area

The existing mine activities and traffic noise in the vicinity of the NSAs contribute to the higher ambient noise levels within these areas. The distant mine and ventilation shaft noise was audible along the southern boundaries of the proposed opencast pit area. The prevailing ambient noise levels at the measuring points differ because of the size of the study area and the location of the measuring points to existing mine activities, roads, domestic areas. The prevailing ambient noise levels within the noise sensitive areas are during daytime between 37.4dBA to 44.9dBA with an arithmetic mean average of 41.4dBA. The prevailing ambient noise levels within the noise sensitive areas are during night time between 41.4dBA to 48.4dBA with an arithmetic mean average of 45.9dBA. The prevailing ambient noise level along the main feeder road to the north of the proposed development is 62.7dBA during daytime and 53.5dBA during night time.

3.3 Noise survey results

Two aspects are important when considering potential noise impacts of a project and it is:

- The increase in the noise level because of the construction (temporary increase) and operational phases (more permanent of nature), and;
- The overall noise level produced by the proposed mine activities.

The average ambient noise level along the northern boundaries of the noise sensitive areas (MP 12, 13 and 14) is 38.9dBA during daytime and 43.3dBA during night time and 40.2dBA during daytime and 48.4dBA during night time along the southern boundary (MP8, 9, 10, 15 and 16) of the proposed open cast pit and the noise sensitive area.

The distant existing mine activities, traffic and ventilation shaft noise was slightly audible in the vicinity of the noise sensitive areas at times when there was a slight wind blowing towards the residential areas and during winter periods when there are inversion conditions in the atmosphere.

The construction activities during the construction phase of the project will increase the prevailing noise level at the immediate vicinity of the site on a temporary basis and the following noise levels at different distances from the site is envisaged for the construction phase. These noise levels are illustrated in Table 12. Engineering control measures and topography can have an influence on how the noise level is perceived by the receptor some distance away from the activities.

Table 12: Sound pressure levels of construction machinery

Equipment	Line-of-Sight Estimated Noise Level Attenuation - dBA						
	5m	30m	60m	120m	240m	480m	960m
Dump truck	91	61.3	55.2	49.1	43.1	34.9	26.6
Backhoe	85	55.3	49.3	43.3	37.3	29.1	20.8
Drilling Equipment	100	70.3	64.3	58.3	52.3	44.1	35.9
Flatbed truck	85	55.3	49.3	43.3	37.3	29.1	20.8
Pickup truck	70	40.3	34.3	27.3	21.3	15.3	9.3
Tractor trailer	85	55.3	49.3	43.3	37.3	29.1	20.8
Crane	85	55.3	49.3	43.3	37.3	29.1	20.8
Pumps	70	40.3	34.3	27.3	21.3	15.3	9.3
Welding Machine	72	42.3	36.3	29.3	23.3	18.3	12.3
Generator	90	61.3	55.2	49.1	43.1	34.9	26.6
Compressor	85	55.3	49.3	43.3	37.3	29.1	20.8
Pile driver	100	70.3	64.3	58.3	52.3	44.1	35.9
Jackhammer	90	61.3	55.2	49.1	43.1	34.9	26.6
Rock drills	100	70.3	64.3	58.3	52.3	44.1	35.9
Pneumatic tools	85	55.3	49.3	43.3	37.3	29.1	20.8
Excavator	90	61.3	55.2	49.1	43.1	34.9	26.6
Grader 140H	91.0	61.3	55.2	49.1	43.1	34.9	26.6
TLB	92.0	61.3	55.2	49.1	43.1	34.9	26.6

The highest noise level at 960m from the NSA during the construction phase will be 35.9dBA during the time drilling equipment will be used and the cumulative noise level when four of the machinery will operate at one time will be 37.5dBA. The noise increase during the construction phase will be on a temporary basis for short spells.

SANS 10210 of 2004, the national standard for the calculating and predicting of road traffic noise was used to calculate the noise level to be generated by the trucks and other vehicles. The calculation will be based on 4 trucks and 4 motor-vehicles per hour.

Basic Model:
$L_{Basic} = 38.3 + 10 \text{ Log } (Q_r)$ dBA,
Where L_{Basic} = basic noise level in dBA and Q_r is the mean traffic flow per hour.
Primary corrections to the basic model:
Corrections for speed of traffic and percentage of heavy vehicles, $L_{P,v}$;
Correction for gradient, L_{gr};
Correction for road surface texture, L_{t};
Correction for ground conditions and distance of the receiver, $L_{d,hr}$;
$L_{Aeq}(1h) = L_{Basic} + L_{P,v} + L_{gr} + L_{t} + L_{d,hr}$

The noise level which these additional vehicles will create on the existing roads is 52.3dBA.

Blasting will be done in the pits by using an emulsion in both the development and production operations to uplift the overburden soil and ore body. Experience has shown that there are two sound pressure levels that should be adhered to such as 120dB and 140dB at the blasting area during a blast and it depends on the amount of rock to be dislodged. The calculations and subsequent impact was based on these sound pressure levels. A typical impact of a blast at 900m from the blast is illustrated in Figure 5 and the impact above the prevailing ambient noise level is for a period of 3-seconds only.

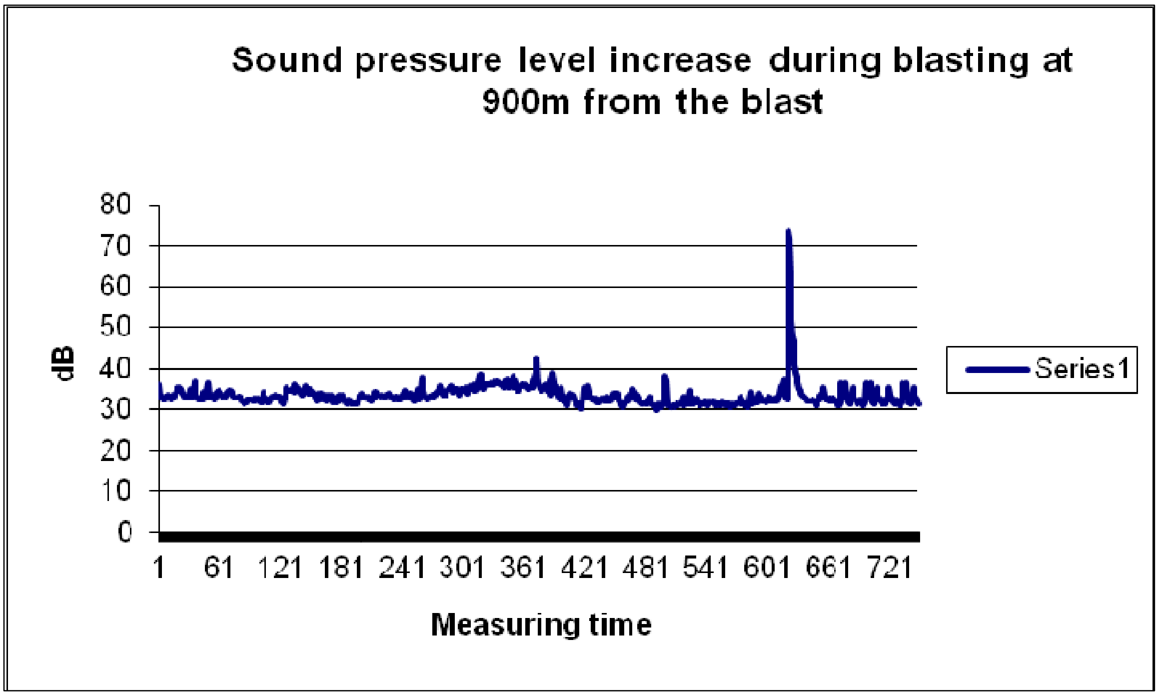
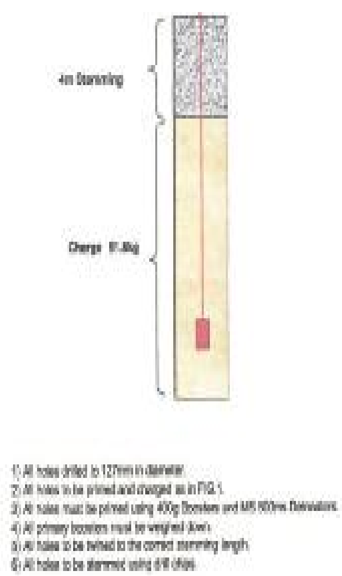


Figure 5: Increase in the ambient noise level during a blast

A water resistant emulsion will be used and the emulsion is a water resistant explosive material containing substantial amounts of oxidizers, often ammonium nitrate, dissolved in water and forming droplets, surrounded by fuel oil. The droplets of the oxidizer solution are surrounded by a thin layer of oil and are stabilized by emulsifiers. The blast design is illustrated in Table 13.

Table 13: Pre-blast design parameters

Average geometry values		Charging Instructions
Total holes	155	
Hole diameter (mm)	127mm	
Hole depth (m)	3m - 10m	
Sub-drill depth (m)	0	
Burden and spacing (m)	3m x 3m	
Stemming length (m)	4m	
Average charge mass values		
Charge mass/hole (kg)	91.2kg	
Charge/meter of hole (kg)	15.2kg/m	
Average energy measures		
Powder factor (kg/m^3)	0.75 – 0.8	
Energy factor (Rel.energy/m^3)	0.65	
Scaled Burden (m/(kg/m)$^{0.5}$)	0.66	
Quantities		
Bench cubic meter (m^3)	18 135m^3	
Total charged mass	7 068kg	

3.4 Noise contours

The noise contours for the pit operations are illustrated in Figure 6. These are the noise levels when the pit operations are in progress only. The mine machinery noise will be slightly audible to audible at times at the abutting noise sensitive areas.

Figure 6: Noise contours for the open cast pit activities

The noise contours for a blast is illustrated in Figure 7 western side, Figure 8 middle and Figure 9 eastern side. Blasting will take place once a week and the contours illustrated the noise level during the blast which last for three seconds at a time.

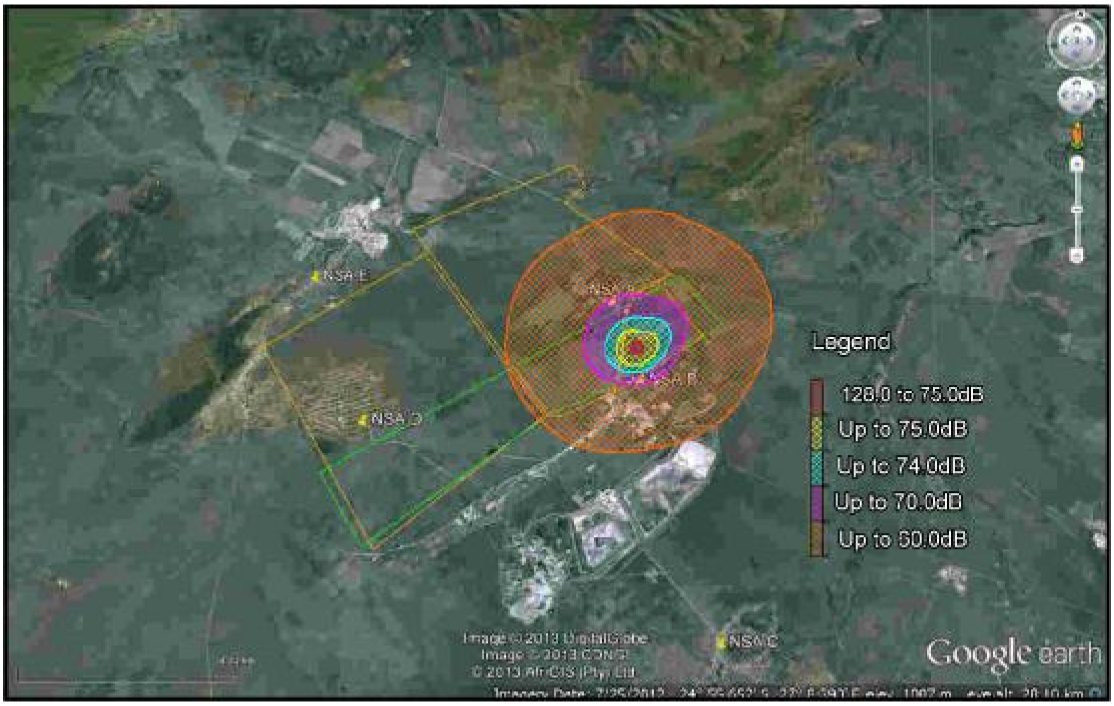


Figure 7: Contours during a blast at opencast pit to the eastern side

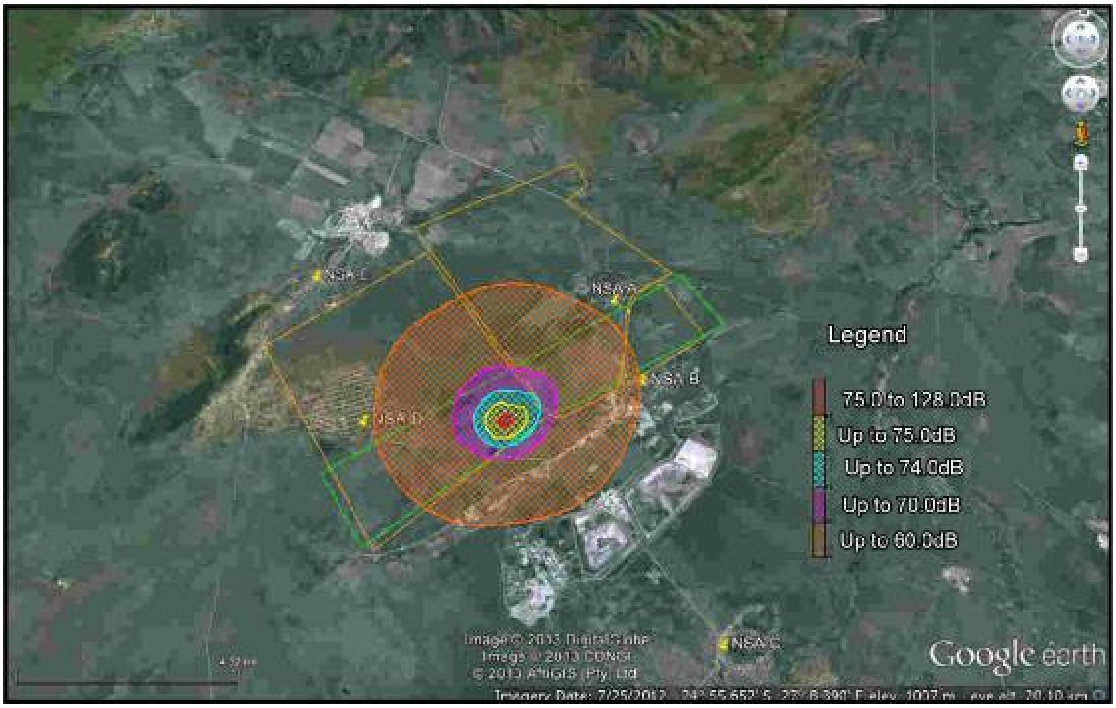


Figure 8: Contours during a blast at opencast pit in the middle

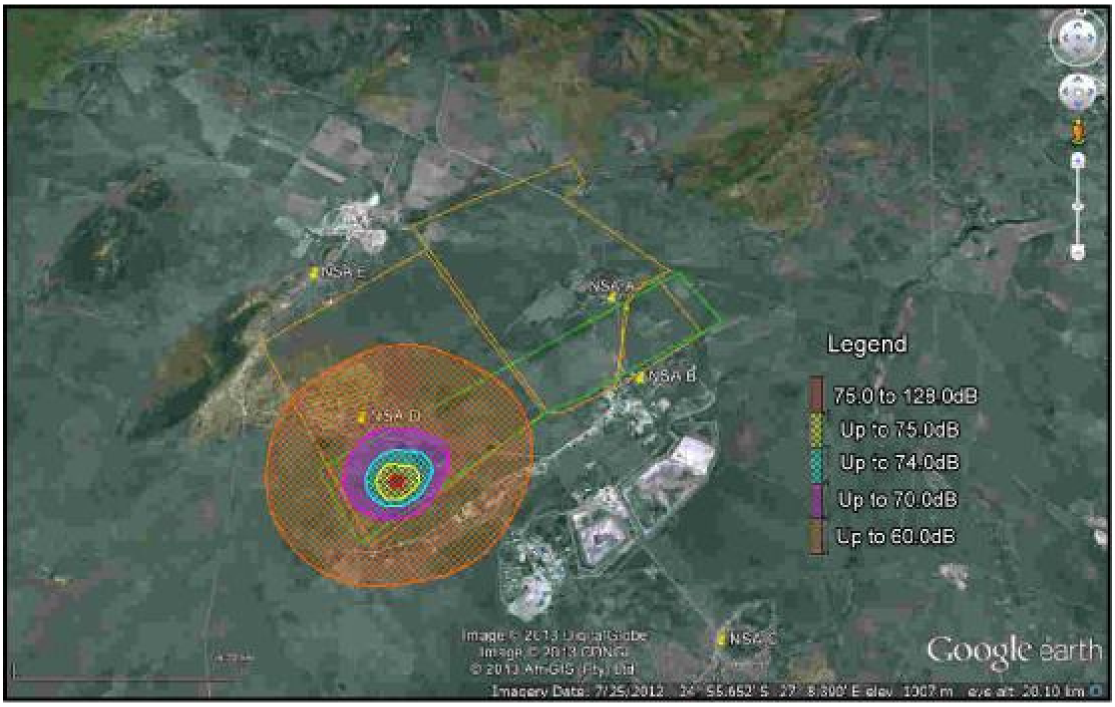


Figure 9: Contours during a blast at opencast pit to the western side

4. IMPACTS IDENTIFICATION AND ASSESSMENT

4.1 Introduction

The impact on the environment and the NSAs will be different, where the construction phase will be more of a temporary nature and the operational phase will be more of a permanent nature or for the duration of the life of mine. During both of these periods engineering mitigatory measures will be essential to minimise the noise intrusion of an activity with industrial noise levels within a mine and agricultural type environment with lower prevailing ambient noise levels. There will be different noise sources during the different activities and it will now be discussed.

4.2 Preparation of the open cast pit and the construction of the mine infra-structure

The machinery that will be used during the preparation of the open cast pit and the construction of the mine infra-structure will be excavators, dozers, graders, earth-moving equipment, cranes, drilling rigs, dump trucks, generators and TLB's, which will be for a limited period only depending on the size of the specific project.

The following activities will generate noise during the construction phase of the additional mine infra-structure:

- Removal and transportation of top soil from the site;
- Earthmoving equipment at the foot print area;
- Hauling of material to and from the specific area;
- Assembling of mine related equipment and/or structures;
- Emergency generators.

The following activities will generate noise on a permanent or temporary basis during the operational phase of the mine:

- Open pit mining;
- Stockpile management;
- Road maintenance;
- Blast hole drilling in ore and overburden;
- Blasting;
- Removal of ore from pit and hauling thereof;
- Loading and off-loading waste;
- Loading and off-loading of ore;
- Processing plant such as crushing of ore, grinding and classification, flotation, concentration and filtration;
- Haulage of final product from the site to end-user.

The following activities will generate noise on a permanent or temporary basis during the rehabilitation phase of the mine:

- Rehabilitation of open pit and disturbed areas;
- Demolition of plant and infra-structure;
- Emergency generators.

The impact rating during the construction phase of a project is given in Table 14.

Table 14: Impact rating during the construction phase

Aspect	Impact (Consequence + Likelihood) *	Significance Rating	Mitigation	Impact after mitigation measures	Significance rating after mitigatory measures	EMP
Removal and transportation of topsoil from the site	36	Low	Machinery with low noise levels to be used.	24	Very Low	Baseline noise monitoring
Earthmoving machinery at the foot print area	36	Low	Machinery with low noise levels to be used.	24	Very Low	Baseline noise monitoring
Hauling of building material to and from the specific area	36	Low	Vehicles with low noise levels to be used.	24	Very Low	Baseline noise monitoring
Assembling of mine related equipment and/or structures	36	Low	Machinery with low noise levels to be used. Construction activities to take place during daytime period only.	24	Very Low	Baseline noise monitoring
Emergency generators	36	Low	Generators must be placed in such a manner that it is away from noise sensitive areas	24	Very Low	Baseline noise monitoring

*Impact assessment methodology attached as Appendix C

The impact rating during the operational phase of a project is given in Table 15.

Table 15: Impact rating during the operational phase

Aspect	Impact (Consequence + Likelihood) *	Significance Rating	Mitigation	Impact after mitigation measures	Significance rating after mitigatory measures	EMP
Open pit mining	88	Medium to High	Noise mitigatory measures to be made use of at all point sources which radiate noise in excess of 85.0dBA and the point sources where practicable possible to be encapsulated with acoustic screening measures. Engineering control mitigatory measures Earthberm of 8m to be	63	Low to medium	Baseline noise monitoring on a six monthly basis

			constructed on both sides of the open cast pit opposite the noise sensitive areas			
Stockpile management	88	Medium to High	Vehicles to comply with the standards as provided in the IFC's Environmental Health & Safety Regulations.	63	Low to Medium	Baseline noise monitoring on a six monthly basis
Road maintenance	63	Low to medium	Vehicles to comply with the standards as provided in the IFC's Environmental Health & Safety Regulations.	48	Low	Baseline noise monitoring on a six monthly basis
Blast hole drilling in ore and overburden	88	Medium to High	Vehicles and machinery to comply with the standards as provided in the IFC's Environmental Health & Safety Regulations.	63	Low to Medium	Baseline noise monitoring on a six monthly basis
Blasting	96	Medium to High	Proper blast design to take place prior to blasting; Blasting not to take place during overcast conditions and when the wind is blowing higher than 5m/s; The blast design chart to be complied with at all times.		Low to Medium	Over-air pressure and ground vibration monitoring to take place during each blast at 700m from the blasting area
Removal of ore from pit and hauling thereof	63	Low to medium	Earthmoving and hauling vehicles with low noise levels to be used.	48	Low	Baseline noise monitoring on a six monthly basis
Loading and off-loading waste	63	Low to medium	Vehicles to comply with the standards as provided in the IFC's Environmental Health & Safety Regulations.	48	Low	Baseline noise monitoring on a six monthly basis
Processing plant such as crushing of ore, grinding and classification, flotation, concentration and filtration	63	Low to medium	Noise mitigatory measures to be made use of at all point sources which radiate noise in excess of 85.0dBA and the point sources where practicable possible to be encapsulated with acoustic screening measures. Engineering control mitigatory measures	48	Low	Baseline noise monitoring on a six monthly basis
Haulage of final product from the site to end-user	63	Low to medium	Vehicles to comply with the standards as provided in the IFC's Environmental Health & Safety Regulations.	48	Low	Baseline noise monitoring on a six monthly

						basis
Emergency generators	30	Low	Generators must be placed in such a manner that it is away from noise sensitive areas	24	Very Low	Baseline noise monitoring

*Impact assessment methodology attached as Appendix C

The impact assessment during the rehabilitation phase of a project is illustrated in Table 16.

Table 16: Impact rating during the rehabilitation phase

Aspect	Impact (Consequence + Likelihood) *	Significance Rating	Mitigation	Impact after mitigation measures	Significance rating after mitigatory measures	EMP
Preparation and the covering of tailing storage facility dams, and any other areas with vegetation	63	Low Medium	Vehicles to comply with the standards as provided in the IFC's Environmental Health & Safety Regulations.	48	Low	Noise monitoring program to be in place to monitor the noise levels.
Removal of structures	63	Low Medium	Vehicles to comply with the standards as provided in the IFC's Environmental Health & Safety Regulations.	48	Low	Baseline noise monitoring
Emergency generators	30	Low	Generators must be placed in such a manner that it is away from noise sensitive areas	24	Very Low	Baseline noise monitoring

*Impact assessment methodology attached as Appendix C

5. Recommendations

The following three primary variables should be considered when designing acoustic screening measures for the control of sound and/or noise:

- The source – Reduction of noise at the source;
- The transmission path – Reduction of noise between the source and the receiver;
- The receiver – Reduction of the noise at the receiver.

The last option is not applicable as it is easier to control the noise levels at the source.

5.1 Acoustic screening recommendations

The acoustic screening measures are summarized and given in Table 17. These are based on the best practicable methods, acoustic screening techniques and the IFC's Health and Safety Regulations.

Table 17: Recommended acoustic screening measures

Additional mine infra-structure	
Activity	Recommendations
Construction phase	1. Machinery with low noise levels to be used which is in accordance with the IFC's Health and Safety Regulations; 2. Building activities to take place during daytime only; 3. Safe blasting methods to be used under controlled conditions; 4. Vehicles with low noise levels to be used; 5. Emergency generators to be placed in such a manner that it is away from residential areas.
Operational phase	1. Noise mitigatory measures to be made use of at all point sources which radiate noise in excess of 85.0dBA; 2. Earthberm of 8m to be constructed on the boundaries of the open cast pit opposite the noise sensitive areas. 2. Machinery and vehicles which comply with the recommendations of the IFC to be used at all times; 4. Maintenance programs to be initiated which can prevent noise from being propagated from the mine; 5. All point sources to be acoustically screened off and a maintenance program to be in place to identify areas where there are noise break outs; 6. All machinery, vehicles and equipment to comply with the standards as provided in the IFCs environmental health and safety regulations; 7. Maintenance program in place to keep all internal roads, gravel roads in a good and smooth condition; 8. Blasting to be done in terms of the safe blasting principles and blasting chart according to the IFC requirements; 9. Earthberm to be erected opposite open cast pits in the vicinity of residential areas; 10. Emergency generators to be placed in such a manner that it is away from residential areas.
Rehabilitation phase	1. Vehicles, equipment and machinery to comply with the standards as provided in the IFCs environmental health & safety regulations; 2. Emergency generators to be placed in such a manner that it is away from residential areas.

The following are the Environmental, Health and Safety Guidelines of the IFC of the World Bank, which should be taken into consideration during the construction, operational and rehabilitation phases of the project:

- Selecting equipment with lower sound power levels;
- Installing silencers for fans;
- Installing suitable mufflers on engine exhausts and compressor components;
- Installing acoustic enclosures for equipment causing radiating noise;
- Installing vibration isolation for mechanical equipment;
- Re-locate noise sources to areas which are less noise sensitive, to take advantage of distance and natural shielding;
- Taking advantage during the design stage of natural topography as a noise buffer;
- Develop a mechanism to record and respond to complaints.

<u>Blasting</u>

Blasts must be designed so that ground vibration levels not exceeding 12.5mm/s at houses and the air over pressure level of 140dB and 120dB in the vicinity of schools and/or churches are adhered to. In order to comply with the above, the following measures should be implemented:

- A scheme of vibration and air over pressure monitoring to be implemented;
- A scheme by which air over pressure is controlled;
- Days and times of blasting operations to be established;

- Ensure that the correct design relationship exists between burden, spacing and hole diameter;

- Ensure the maximum amount of water resistant emulsion on any one day delay interval, the maximum instantaneous charge, is optimized by considering:

- Reduce the number of holes per detonator delay interval;

- Reduce the instantaneous charge by in-hole delay techniques;

- Reduce the bench height or hole depth;

- Reduce the borehole diameter.

- Always attempt to minimize the resulting environmental effects of blasting operations and to recognize the fact that the perception of blasting events occurs at levels of vibration well below those necessary for the possible onset of the structural damage, but nevertheless at levels that can concern occupants abutting the mining area;
- Be aware that relatively small changes in blast design can produce noticeable differences in environmental emissions. It is very often in response to changes in these emissions rather than their absolute value that complaints are made.

Scheme of vibration monitoring must include the following:
- The location and number of monitoring points;

- The type of equipment to be used and the parameters to be measured;

- The frequency of monitoring;

- The method by which such data are made available to management;

- The method by which such data are used in order to ensure that the site vibration limit is not exceeded and to mitigate any environmental effects of blasting.

The design of the blast must be in line with the blast design chart as illustrated in Figure 9.

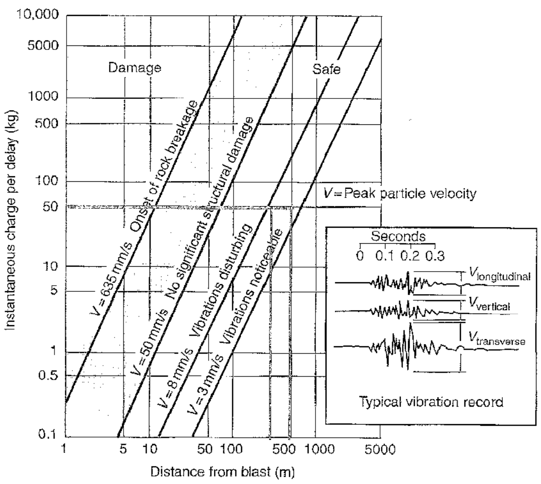


Figure 9: Blast design chart (Wyllie and Mah, 2006)

6. Conclusion

The residential areas in the vicinity of the proposed open cast mine are exposed to existing blasting which is taking place to the south, mining activities, traffic and industrial type noises because of the existing mining which is taking place within boundaries of the mine.

The distances between the proposed open cast mine and the noise sensitive areas play an important role in the propagation of the mine activity noises. The calculated noise level during a blast at NSA A will be 68.7dB, NSA B will be 68.6dB, NSA C will be 52.6dB, NSA D will be 68.6dB and at NSA E the noise level will be 52.2dB. This will be a once of noise increase which will be a finite type noise increase. The average ambient noise level along the northern boundaries of the noise sensitive areas next to the proposed opencast pit is 38.9dBA during daytime and 43.3dBA during night time and 40.2dBA during daytime and 48.4dBA during night time along the southern boundary of the proposed open cast pit and the noise sensitive area. The night time ambient noise levels are higher because there are insect activities which increase the noise levels accordingly.

A noise monitoring program must be in place where noise surveys can be carried out on a six monthly basis at the measuring points identified in the recent noise survey in order to determine if there is an increase in the prevailing noise levels of the study areas. The ground vibration and air-over pressure noise levels at a distance of 700m from the blast must be recorded during each blast and these records must be kept in a safe place for easy access.

The noise intrusion can however be controlled by means of approved acoustic screening measures, state of the art equipment, proper noise management principles and compliance to the Local Noise Control Regulations, and the International Finance Corporation's Environmental Health and Safety Guidelines.

Barend van der Merwe
Environmental Acoustic Consultant

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Appendix A

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Calibration Laboratory
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M AND N ACOUSTIC SERVICES (Pty) Ltd
Co. Reg. No. [illegible]
VAT NO: 4300255876
P.O. Box 61713, Pierre van Ryneveld, 0045
Shop 13, Ryneveld Corner Shopping Centre,
cnr Fouche & Van Ryneveld Sts, Pierre van Ryneveld, 0045
Tel: 012 689 2007/8 • Fax: 086 211 4690
E-mail: calservice@mweb.co.za

CERTIFICATE OF CALIBRATION

CERTIFICATE NUMBER	2013-0741
ORGANISATION	dB ACOUSTICS
ORGANISATION ADDRESS	P.O. BOX 1219, ALLENSNEK, 1737
CALIBRATION OF	INTEGRATING SOUND LEVEL METER, ½" MICROPHONE and built-in ⅓-OCTAVE/OCTAVE FILTER
CALIBRATED BY	M. NAUDÉ
MANUFACTURERS	LARSON.DAVIS and PCB
MODEL NUMBERS	831 and 277B02
SERIAL NUMBERS	0001072 and 02184
DATE OF CALIBRATION	25 APRIL 2013
RECOMMENDED DUE DATE	APRIL 2014
PAGE NUMBER	PAGE 1 OF 4

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26 April 2013
DATE OF ISSUE

Director: Marianka Naudé

Appendix B – Risk assessment matrix

SEVERITY OF IMPACT	RATING
Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful	5
SPATIAL SCOPE OF IMPACT	**RATING**
Activity specific	1
Mine specific (within the mine boundary)	2
Local area (within 5 km of the Activity boundary)	3
Regional	4
National	5
DURATION OF IMPACT	**RATING**
One day to one month	1
One month to one year	2
One year to ten years	3
Life of operation	4
Post closure / permanent	5

SIGNIFICANCE

FREQUENCY OF ACTIVITY / DURATION OF	RATING
Annually or less / low	1
6 monthly / temporary	2
Monthly / infrequent	3
Weekly / life of operation / regularly / likely	4
Daily / permanent / high	5
FREQUENCY OF IMPACT	**RATING**
Almost never / almost impossible	1
Very seldom / highly unlikely	2
Infrequent / unlikely / seldom	3
Often / regularly / likely / possible	4
Daily / highly likely / definitely	5

LIKELIHOOD

Color Code	Significance Rating	Value	Negative Impact Management Recommendation	Positive Impact Management Recommendation
	Very high	126-150	Improve current management	Maintain current management
	High	101-125	Improve current management	Maintain current management
	Medium-high	76-100	Improve current management	Maintain current management
	Low-medium	51-75	Maintain current management	Improve current management
	Low	26-50	Maintain current management	Improve current management
	Very low	1-25	Maintain current management	Improve current management

	CONSEQUENCE (Severity + Spatial Scope + Duration)														
LIKELIHOOD (Frequency of activity + Frequency of impact)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

Appendix C

Construction Phase

Impact: ***Removal and hauling of topsoil from the site***		
Severity: 2	Spatial scope: 2	Duration: 2
Consequence rating: 6		
Frequency of activity: 4	Frequency of impact: 2	
Likelihood rating: 6		
Risk rating: Low		
Suggested management: Machinery with low noise levels to be used		
Risk rating following mitigation: Very Low		

Impact: ***Earthmoving activities at the foot print of the mine infra-structure***		
Severity: 2	Spatial scope: 2	Duration: 2
Consequence rating: 6		
Frequency of activity: 4	Frequency of impact: 2	
Likelihood rating: 6		
Risk rating: Low		
Suggested management: Machinery with low noise levels to be used		
Risk rating following mitigation: Very Low		

Impact: ***Hauling of building material to and from the specific area***		
Severity: 2	Spatial scope: 2	Duration: 2
Consequence rating: 6		
Frequency of activity: 4	Frequency of impact: 2	
Likelihood rating: 6		
Risk rating: Low		
Suggested management: Machinery with low noise levels to be used		
Risk rating following mitigation: Very Low		

Impact: ***Assembling of mine related equipment and/or structures***		
Severity: 2	Spatial scope: 2	Duration: 2
Consequence rating: 6		
Frequency of activity: 4	Frequency of impact: 2	
Likelihood rating: 6		
Risk rating: Low		
Suggested management: Machinery with low noise levels to be used		
Risk rating following mitigation: Very Low		

Impact: ***Diesel emergency generators***		
Severity: 2	Spatial scope: 2	Duration: 2
Consequence rating: 6		
Frequency of activity: 4	Frequency of impact: 2	
Likelihood rating: 6		
Risk rating: Low		

Suggested management: Machinery with low noise levels to be used
Risk rating following mitigation: Very Low

Operational Phase

Impact: ***Open pit mining***		
Severity: 3	Spatial scope: 3	Duration: 5
Consequence rating: 11		
Frequency of activity: 5	Frequency of impact:3	
Likelihood rating: 8		
Risk rating: Medium - High		
Suggested management: Noise mitigatory measures to be made use of at all point sources which radiate noise in excess of 85.0dBA; Machinery and vehicles which comply with the recommendations of the IFC to be used at all times; Maintenance programs to be initiated which can prevent noise from being propagated from the mine.		
Risk rating following mitigation: Low to medium		

Impact: ***Stockpile management***		
Severity: 3	Spatial scope: 3	Duration: 5
Consequence rating: 11		
Frequency of activity: 5	Frequency of impact:3	
Likelihood rating: 8		
Risk rating: Medium - High		
Suggested management: Noise mitigatory measures to be made use of at all point sources which radiate noise in excess of 85.0dBA; Machinery and vehicles which comply with the recommendations of the IFC to be used at all times; Maintenance programs to be initiated which can prevent noise from being propagated from the mine.		
Risk rating following mitigation: Low		

Impact: ***Road maintenance***		
Severity: 3	Spatial scope: 2	Duration: 4
Consequence rating: 9		
Frequency of activity: 4	Frequency of impact:3	
Likelihood rating: 7		
Risk rating: Low-Medium		
Suggested management: Noise mitigatory measures to be made use of at all point sources which radiate noise in excess of 85.0dBA; Machinery and vehicles which comply with the recommendations of the IFC to be used at all times; Maintenance programs to be initiated which can prevent noise from being propagated from the mine.		
Risk rating following mitigation: Low		

Impact: ***Blast hole drilling in ore and overburden***		
Severity: 3	Spatial scope: 3	Duration: 5
Consequence rating: 11		
Frequency of activity: 5	Frequency of impact:3	
Likelihood rating: 8		
Risk rating: Medium - High		

Suggested management: Noise mitigatory measures to be made use of at all point sources which radiate noise in excess of 85.0dBA; Machinery and vehicles which comply with the recommendations of the IFC to be used at all times; Maintenance programs to be initiated which can prevent noise from being propagated from the mine.
Risk rating following mitigation: Low

Impact: ***Blasting***			
Severity: 4	Spatial scope: 3		Duration: 5
Consequence rating: 12			
Frequency of activity: 4		Frequency of impact:4	
Likelihood rating: 8			
Risk rating: High - Medium			
Suggested management: Noise mitigatory measures to be made use of at all point sources which radiate noise in excess of 85.0dBA; Machinery and vehicles which comply with the recommendations of the IFC to be used at all times; Maintenance programs to be initiated which can prevent noise from being propagated from the mine.			
Risk rating following mitigation: Low to Medium			

Impact: ***Removal of ore from pit and hauling thereof to plant***			
Severity: 3	Spatial scope: 2		Duration: 4
Consequence rating: 9			
Frequency of activity: 4		Frequency of impact:3	
Likelihood rating: 7			
Risk rating: Low-Medium			
Suggested management: Noise mitigatory measures to be made use of at all point sources which radiate noise in excess of 85.0dBA; Machinery and vehicles which comply with the recommendations of the IFC to be used at all times; Maintenance programs to be initiated which can prevent noise from being propagated from the mine.			
Risk rating following mitigation: Low			

Impact: ***Loading, hauling and off-loading of waste***			
Severity: 3	Spatial scope: 2		Duration: 4
Consequence rating: 9			
Frequency of activity: 4		Frequency of impact:3	
Likelihood rating: 7			
Risk rating: Low-Medium			
Suggested management: Noise mitigatory measures to be made use of at all point sources which radiate noise in excess of 85.0dBA; Machinery and vehicles which comply with the recommendations of the IFC to be used at all times; Maintenance programs to be initiated which can prevent noise from being propagated from the mine.			
Risk rating following mitigation: Low			

Impact: ***Processing plant, such as crushing of ore, grinding and classification, flotation, concentration and filtration***			
Severity: 3	Spatial scope: 2		Duration: 4
Consequence rating: 9			
Frequency of activity: 4		Frequency of impact:3	
Likelihood rating: 7			
Risk rating: Low-Medium			

Suggested management: Noise mitigatory measures to be made use of at all point sources which radiate noise in excess of 85.0dBA; Machinery and vehicles which comply with the recommendations of the IFC to be used at all times; Maintenance programs to be initiated which can prevent noise from being propagated from the mine.
Risk rating following mitigation: Low

Impact: ***Hauling of final product from the site to the end-user***		
Severity: 3	Spatial scope: 2	Duration: 4
Consequence rating: 9		
Frequency of activity: 4	Frequency of impact:3	
Likelihood rating: 7		
Risk rating: Low-Medium		
Suggested management: Noise mitigatory measures to be made use of at all point sources which radiate noise in excess of 85.0dBA; Machinery and vehicles which comply with the recommendations of the IFC to be used at all times; Maintenance programs to be initiated which can prevent noise from being propagated from the mine.		
Risk rating following mitigation: Low		

Impact: ***Diesel emergency generators***		
Severity: 2	Spatial scope: 1	Duration: 2
Consequence rating: 5		
Frequency of activity: 5	Frequency of impact: 1	
Likelihood rating: 6		
Risk rating: Low		
Suggested management: Machinery with low noise levels to be used		
Risk rating following mitigation: Very Low		

Rehabilitation phase

Impact: ***Preparation and the covering of tailing storage facility, dams and any other areas with vegetation***		
Severity: 3	Spatial scope: 2	Duration: 4
Consequence rating: 9		
Frequency of activity: 4	Frequency of impact:3	
Likelihood rating: 7		
Risk rating: Low-Medium		
Suggested management: Noise mitigatory measures to be made use of at all point sources which radiate noise in excess of 85.0dBA; Machinery and vehicles which comply with the recommendations of the IFC to be used at all times; Maintenance programs to be initiated which can prevent noise from being propagated from the mine.		
Risk rating following mitigation: Low		

Impact: ***Removal of structures***		
Severity: 3	Spatial scope: 2	Duration: 4
Consequence rating: 9		
Frequency of activity: 4	Frequency of impact:3	
Likelihood rating: 7		
Risk rating: Low-Medium		

Suggested management: Noise mitigatory measures to be made use of at all point sources which radiate noise in excess of 85.0dBA; Machinery and vehicles which comply with the recommendations of the IFC to be used at all times; Maintenance programs to be initiated which can prevent noise from being propagated from the mine.
Risk rating following mitigation: Low

Impact: ***Diesel emergency generators***		
Severity: 2	Spatial scope: 1	Duration: 2
Consequence rating: 5		
Frequency of activity: 5	Frequency of impact: 1	
Likelihood rating: 6		
Risk rating: Low		
Suggested management: Machinery with low noise levels to be used		
Risk rating following mitigation: Very Low		

Impact: ***Preparation of the foot print, digging of trenches, earthworks and drilling of the pilot hole***		
Severity: 2	Spatial scope: 2	Duration: 4
Consequence rating: 8		
Frequency of activity: 4	Frequency of impact: 2	
Likelihood rating: 6		
Risk rating: Low		
Suggested management: Machinery with low noise levels to be used		
Risk rating following mitigation: Very Low		

Impact: ***Raise bore drilling***		
Severity: 3	Spatial scope: 2	Duration: 4
Consequence rating: 9		
Frequency of activity: 4	Frequency of impact:3	
Likelihood rating: 7		
Risk rating: Low-Medium		
Suggested management: Machinery with low noise levels to be used		
Risk rating following mitigation: Low		

Impact: ***Construction of the ventilation shaft***		
Severity: 3	Spatial scope: 2	Duration: 4
Consequence rating: 9		
Frequency of activity: 4	Frequency of impact:3	
Likelihood rating: 7		
Risk rating: Low-Medium		
Suggested management: Machinery with low noise levels to be used		
Risk rating following mitigation: Low		

Impact: ***Diesel emergency generators***		
Severity: 2	Spatial scope: 1	Duration: 2
Consequence rating: 5		
Frequency of activity: 5	Frequency of impact: 1	
Likelihood rating: 6		
Risk rating: Low		
Suggested management: Machinery with low noise levels to be used		
Risk rating following mitigation: Very Low		

Operational phase

Impact: ***Up cast ventilation shaft***		
Severity: 4	Spatial scope: 2	Duration: 4
Consequence rating: 10		
Frequency of activity: 5	Frequency of impact: 4	
Likelihood rating: 9		
Risk rating: Medium High		

Suggested management: Outlet of the up cast shaft to face away from any residential areas The distance between the shaft and the residential areas to be in excess of 500m Acoustic screening measures to be in place between the shaft and the residential areas and as close as possible to the shaft
Risk rating following mitigation: Medium

Impact: ***Up cast emergency ventilation shaft***		
Severity: 4	Spatial scope: 2	Duration: 4
Consequence rating: 10		
Frequency of activity: 5	Frequency of impact: 4	
Likelihood rating: 9		
Risk rating: Medium High		
Suggested management: Outlet of the up cast shaft to face away from any residential areas The distance between the shaft and the residential areas to be in excess of 500m Acoustic screening measures to be in place between the shaft and the residential areas and as close as possible to the shaft		
Risk rating following mitigation: Medium		

Impact: ***Down cast ventilation shaft***		
Severity: 2	Spatial scope: 1	Duration: 4
Consequence rating: 7		
Frequency of activity: 4	Frequency of impact: 2	
Likelihood rating: 6		
Risk rating: Low		
Suggested management: Outlet of the up cast shaft to face away from any residential areas The distance between the shaft and the residential areas to be in excess of 200m		
Risk rating following mitigation: Very Low		

Rehabilitation phase

Impact: **Preparation and the covering of redundant ventilation shaft**		
Severity: 2	Spatial scope: 1	Duration: 4
Consequence rating: 7		
Frequency of activity: 4	Frequency of impact: 2	
Likelihood rating: 6		
Risk rating: Low		
Suggested management: Vehicles and machinery used during the rehabilitation period to comply with the standards as provided in the IFC's Environmental Health & Safety Regulations.		
Risk rating following mitigation: Very Low		

Impact: ***Diesel emergency generators***		
Severity: 2	Spatial scope: 1	Duration: 2
Consequence rating: 5		
Frequency of activity: 5	Frequency of impact: 1	
Likelihood rating: 6		
Risk rating: Low		
Suggested management: Machinery with low noise levels to be used		
Risk rating following mitigation: Very Low		

Impact: ***Preparation of the foot print, digging of trenches, earthworks and drilling of the pilot hole***		
Severity: 2	Spatial scope: 2	Duration: 4
Consequence rating: 8		
Frequency of activity: 4	Frequency of impact: 2	
Likelihood rating: 6		
Risk rating: Low		
Suggested management: Machinery with low noise levels to be used		
Risk rating following mitigation: Very Low		

Impact: ***Construction of the concentrator plant***		
Severity: 3	Spatial scope: 2	Duration: 4
Consequence rating: 9		
Frequency of activity: 4	Frequency of impact:3	
Likelihood rating: 7		
Risk rating: Low-Medium		
Suggested management: Machinery with low noise levels to be used		
Risk rating following mitigation: Low		

Impact: ***Diesel emergency generators***		
Severity: 2	Spatial scope: 1	Duration: 2
Consequence rating: 5		
Frequency of activity: 5	Frequency of impact: 1	
Likelihood rating: 6		
Risk rating: Low		
Suggested management: Machinery with low noise levels to be used		
Risk rating following mitigation: Very Low		

Operational phase

Impact: ***New Concentrator plant***		
Severity: 3	Spatial scope: 3	Duration: 4
Consequence rating: 10		
Frequency of activity: 4	Frequency of impact: 4	
Likelihood rating: 8		
Risk rating: Medium High		
Suggested management: All noise generating sources to be acoustically screened off. Maintenance program to be in place and all noise sources to be identified.		
Risk rating following mitigation: Medium		

Impact: ***Upgrade of the existing concentrator plant***		
Severity: 5	Spatial scope: 3	Duration: 4
Consequence rating: 11		
Frequency of activity: 5	Frequency of impact: 5	
Likelihood rating: 10		

Risk rating: High
Suggested management: Transportation and hauling and/or conveyor to be acoustically screened off
Risk rating following mitigation: Medium High

<u>Rehabilitation phase</u>

Impact: **Removal and dismantling of concentrator plant**			
Severity: 2	Spatial scope: 1		Duration: 4
Consequence rating: 7			
Frequency of activity: 4		Frequency of impact: 2	
Likelihood rating: 6			
Risk rating: Low			
Suggested management: Vehicles and machinery used during the rehabilitation period to comply with the standards as provided in the IFC's Environmental Health & Safety Regulations.			
Risk rating following mitigation: Very Low			

Impact: ***Diesel emergency generators***			
Severity: 2	Spatial scope: 1		Duration: 2
Consequence rating: 5			
Frequency of activity: 5		Frequency of impact: 1	
Likelihood rating: 6			
Risk rating: Low			
Suggested management: Machinery with low noise levels to be used			
Risk rating following mitigation: Very Low			

REPORT

June 2013

SAMANCOR CHROME MINE

Surface Water Baseline and Impact Assessment Report for Varkensvlei and Nooitgedacht Chrome Mine

Submitted to:
Heather Booysens
Samancor Chrome

Report Number. 13614977-11938-9

Distribution:

1 x Copy to client
1 x unbound copy to project file
1 x Copy to library

Golder Associates

Executive Summary

Samancor Chrome (Pty) Ltd requested Golder Associates Africa (Golder) to provide specialist surface water input in support of the Mining Rights Applications (MRA) for portions of the farms Varkensvlei/Nooitgedacht to the north of Pilanesberg, straddling the boundary between the Northwest Province (Varkensvlei) and the Limpopo Province (Nooitgedacht). Due to the imminent expiry of prospecting rights for this area, Samancor is required to submit the MRA by 6 May 2013 and final document (EIA Report and EMPR) by mid October 2013.

This document reports on the baseline groundwater assessment and impact assessment that forms part of the EIA Report and EMPR.

The surface water baseline report and impact assessment forms part of the EIA Report and the EMPR. This report highlights the surface water baselines conditions for the Varkensvlei and Nooitgedacht farms.

Objectives

The surface water baseline study objectives were the following:

- To characterise the climate and rainfall data to produce statistics such as monthly rainfall averages, number of rain days per month, distribution of annual rainfall averages and the 24 hour storm depths for various recurrence intervals and monthly potential evaporation;
- To compile a map showing the catchment areas, mining infrastructure and the major surface water drainage lines;
- To collect the available flow and water quality records from the Department of Water Affairs (DWA) will be and analyse it to characterise the flow regimes and water quality in the local streams;
- The 50 year and 100 year floodlines will be determined for the major streams that could be impacted by the proposed mining;
- A baseline flow measuring programme will be set up for the main drainages that could be impacted on by the proposed mining. Based on the gaps identified during the data overview assessment and the mine layout, the locations of water quality and quantity monitoring sites will be selected and a monitoring programme will be undertaken as follows:
  - The Cross-sections of monitoring will be surveyed and flow and quality will be measured;
  - The sites will be visited twice (February and May) to collect water samples and measure discharge as well as in-situ water quality; and
  - Water users will be identified and recorded.
- A high level stormwater management plan will be set up and applied to the layout to ensure that the clean and dirty water collection systems and pollution control dams meet the requirements of Regulation 704 of the NWA;
- A high level conceptual annual water balance will be developed for the proposed mining area. The water balance model will be used for the WUL applications; and
- The impacts of the proposed mining operations on the local surface water resources will be assessed and appropriate mitigation measures will be recommended for inclusion in the EMP.

Methodolgy

The following steps were undertaken to describe the surface water baseline conditions:

- The study area and catchment was described;
- The selection of rainfall stations for analyses was based on the length of the data record, the distance from the site;
- The following datasets were analysed and described:
  - Rainfall
  - Evaporation
  - Flow data
  - Water quality
- A high level water balance and stormwater management plan for the infrastructure was developed based on the available information and the size of the pollution control dam (PCD) is estimated.

Summary of Baseline conditions

The available climate and rainfall data was analysed to describe the baseline conditions on the site. The 24 hour rainfall depths for different recurrence intervals were generated for use in infrastructure design. A daily rainfall and average monthly evaporation records were produced for use in the feasibility studies. The Northam (POL) weather station was used as the data for this study which is located 15.9 km east of this study.

A monitoring programme has been set up to collect flow and water quality data on the project area. Although the area is very dry water quality samples were taken from the Bierspruit Dam.

The water quality and flow data collected by DWA was sourced and assessed. The water quality results from the monitoring programme are presented in the report. The results show that the water has undesirable standards of TSS to sustain aquatic ecosystems although there is evidence of wildlife. The fluoride levels in the dam are very high and approach the limits from livestock and irrigation which is unacceptable for domestic consumption. Aluminium content in the dam is high for aquatic ecosystems and can be high for domestic use. Phosphorus is high for domestic consumption. The COD in the dam is unacceptable and indicates large amounts of waste in the dam.

The 50 year and 100 year flood peaks and floodlines have been determined for the rivers crossing the Varkensvlei and Nooitgedacht farms. The analysis shows that the open pit is located within the floodlines of four of the tributaries.

A high level conceptual water balance was done based of the infrastructure information available. The size of the PCD was estimated according to rough values by the specialists.

A conceptual stormwater management plan was made based on the above information of the water balance.

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APPENDICES

1.0 INTRODUCTION

Samancor Chrome (Pty) Ltd requested Golder Associates Africa (Golder) to provide specialist surface water input in support of the Mining Rights Applications (MRA) for portions of the farms Varkensvlei/Nooitgedacht to the north of Pilanesberg, straddling the boundary between the Northwest Province (Varkensvlei) and the Limpopo Province (Nooitgedacht). Due to the imminent expiry of prospecting rights for this area, Samancor is required to submit the MRA by 6 May 2013 and final document (EIA Report and EMPR) by mid October 2013.

This document reports on the baseline surface water assessment and impact assessment that forms part of the EIA Report and EMPR.

The surface water baseline report and impact assessment forms part of the EIA Report and the EMPR. This report highlights the surface water baselines conditions for the Varkensvlei and Nooitgedacht farms.

2.0 OBJECTIVES

The surface water baseline study objectives were the following:

- To compile a map showing the catchment areas, mining infrastructure and the major surface water drainage lines;
- Collect and analyse the rainfall data for use in surface water modelling. This includes statistics such as monthly averages, number of rain days per month, distribution of annual averages and the 24 hour storm depths for various recurrence intervals;
- Local climatic data will be collected and reviewed to produce monthly potential evaporation statistics;
- The available flow records from the Department of Water Affairs (DWA) (Department of Water Affairs, 2008) will be collected and analysed to characterise the flow regimes in the local streams;
- Available water quality data will be assessed (Department of Water Affairs, 2011) and compared with the local Resource Water Quality Objectives (RWQO’s);
- The 50 year and 100 year floodlines will be determined for the major streams that could be impacted by the proposed mining;
- A baseline flow measuring programme will be set up for the main drainages that could be impacted on by the proposed mining. Based on the gaps identified during the data overview assessment and the mine layout, the locations of water quality and quantity monitoring sites will be selected and a monitoring programme will be undertaken as follows:
  - The Cross-sections of monitoring will be surveyed and flow and quality will be measured;
  - The sites will be visited twice (February and May) to collect water samples and measure discharge as well as in-situ water quality; and
  - Water users will be identified and recorded.
- A high level stormwater management plan will be set up and applied to the layout to ensure that the clean and dirty water collection systems and pollution control dams meet the requirements of Regulation 704 of the NWA;
- A high level conceptual annual water balance will be developed for the proposed mining area. The water balance model will be used for the WUL applications; and
- The impacts of the proposed mining operations on the local surface water resources will be assessed and appropriate mitigation measures will be recommended for inclusion in the EMP.

3.0 METHODOLOGY

The following steps were undertaken to describe the surface water baseline conditions:

- The study area and catchment was described;
- The selection of rainfall stations for analyses was based on the length of the data record, the distance from the site;
- The following datasets were analysed and described:
  - Rainfall
  - Evaporation
  - Flow data
  - Water quality
- A high level water balance and stormwater management plan for the infrastructure was developed based on the available information and the size of the pollution control dam (PCD) is estimated.

4.0 SURFACE WATER BASELINE CONDITIONS

4.1 Catchment Description

Regionally the area is located in the Crocodile (West) and Marico Water Management Area (shown in Figure 2). Locally the area falls over quaternary catchments A24D, A24E and A24F (Figure 1). The study area includes the Varkensvlei farm next to the Nooitgedacht farm draining into the Bierspruit River (Figure 1).

4.2 Rainfall data

Rainfall data was extracted using the Daily Rainfall Extraction Utility (Kunz, 2004) and was found for 6 rainfall stations in the area around the Samancor sites. The rainfall stations are presented in Table 1. The locations of the rainfall stations appear in Figure 3.

Table 1: Available rainfall data around the Varkensvlei and Nooitgedacht farms

Station	Name	Element	Length of record	Years of data	Distance from site (km)	Altitude (masl)	MAP (mm)
A2E012	Nooitgedacht @ Bierspruitdam	Rainfall, Evaporation	January 1970 to September 1986	15	3.01		
A2E021	Zwartklip @ Rustenburg Platinum Mine	Rainfall, Evaporation	November 1970 to September 1986	9	5.19		
0587139_W	Middelkop	Rainfall	April 1924 to May 1972	48	11.55	1150	607
0587475_W	Jersey Farm	Rainfall	July 1927 to March 1953	25	15.77	982	533
0587477_W	Northam (POL)	Rainfall	November 1968 to August 2000	31	15.90	1007	642.73
0587499_W	Thabazimbi Amandelbult	Rainfall	September 1989 to July 2000	10	21.51	961	530.53

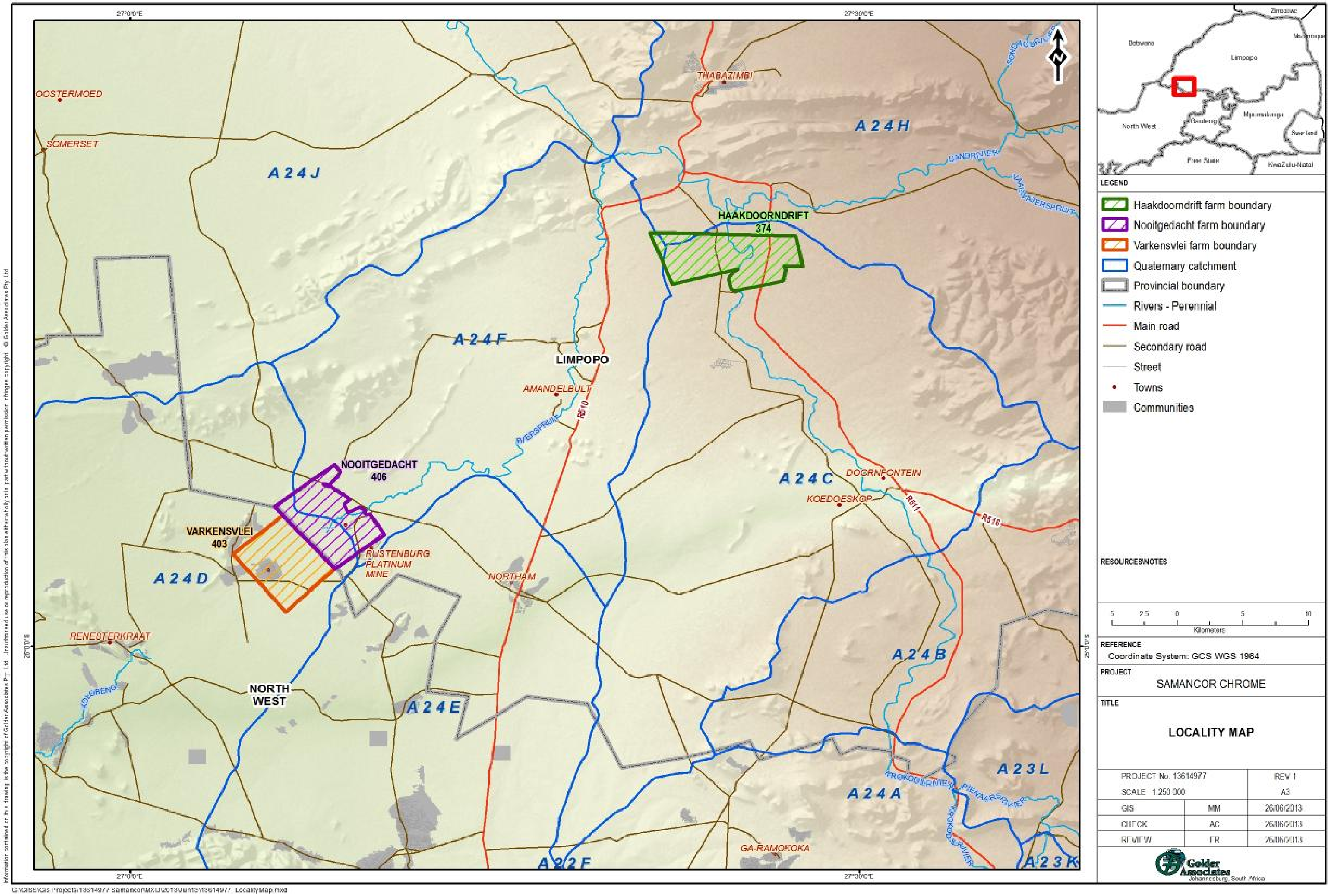


Figure 1: Location and quaternary catchments for the Samancor Chrome sites

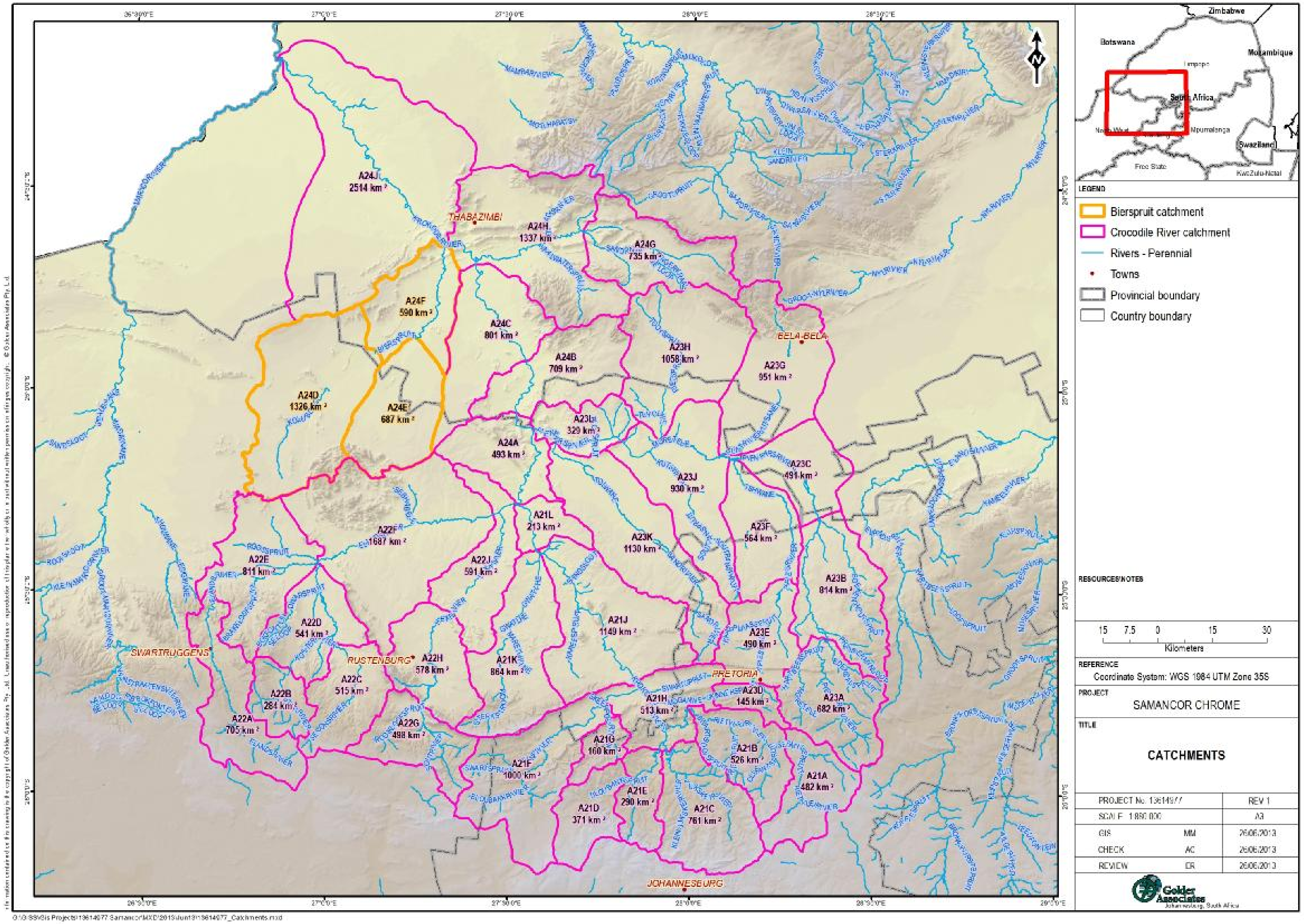


Figure 2: Catchments of the Crocodile and Bierspruit Rivers

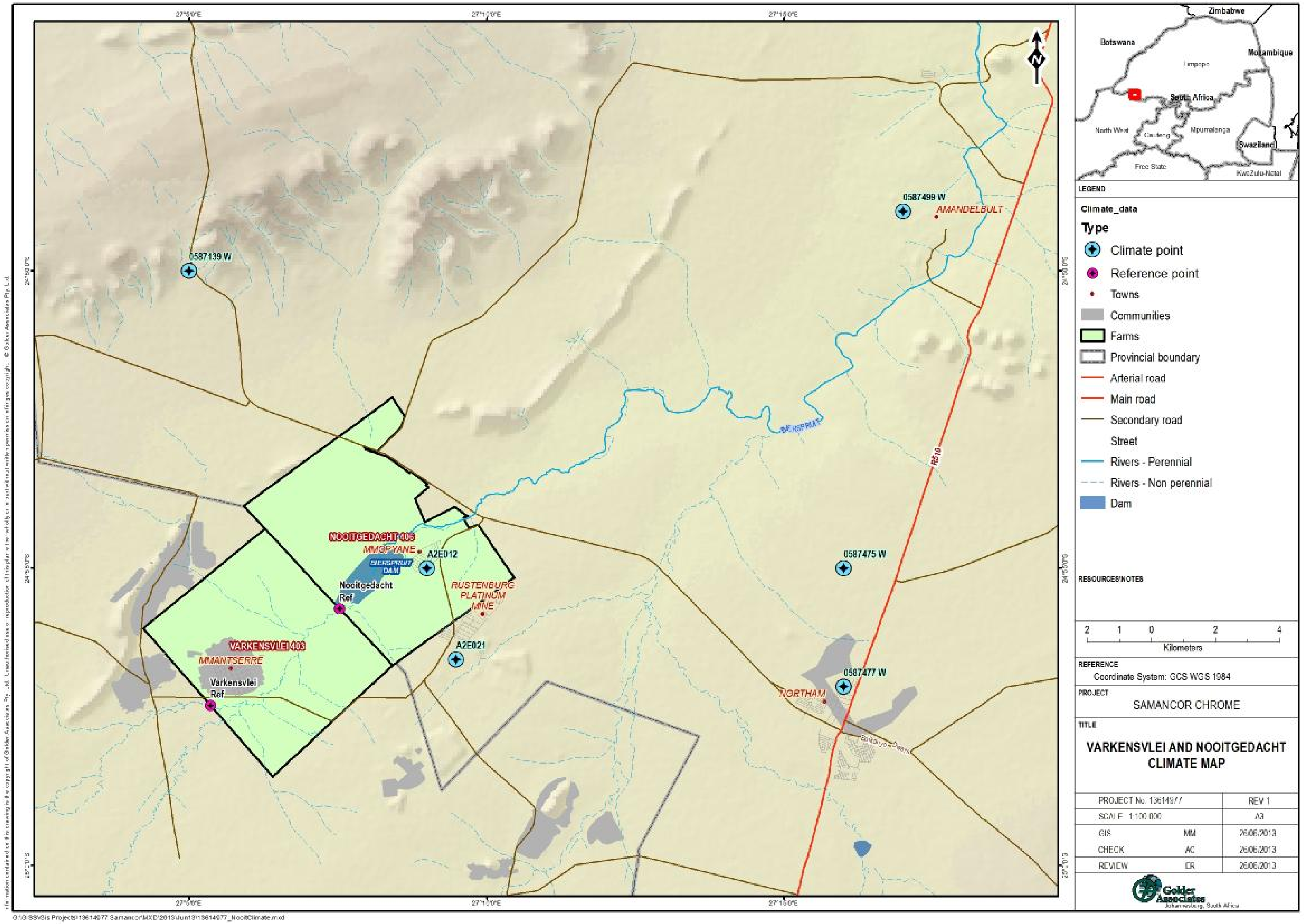


Figure 3: Locations of rainfall stations for the Varkensvlei and Nooitgedacht farms

Based on the integrity of the data and previous studies done in the area (SRK Consulting (Pty) Ltd, 2011) the station that was used for the Nooitgedacht and Varkensvlei farms was 0487477 W Northam (POL). A summary of the hydrological data for this station is described in Table 2.

Table 2: Summary of rainfall station data used for Varkensvlei and Nooitgedacht site

Location	**Water Management Area**	**Crocodile (West) and Marico**
	Study area	**Varkensvlei Nooitgedacht**
	Quaternary Catchments	**A24D, A24F**
Rainfall	Rainfall gauge	0587477_W Northam (POL)
	Data period	1903 – 2000
	Mean Annual Precipitation (MAP)	642.73 mm
	Wet Season Rainfall (October - March) *	569.97 mm
	Wet Season Rainfall % of MAP	88.7 %
	Dry Season Rainfall (April - September) *	72.70 mm
	Dry Season Rainfall % of MAP	11.3 %
Evaporation	Mean Annual Evaporation (MAE)	1800 mm
	Evaporation Zone (WR90 study) ≠	2B

Note: **The sum of the average monthly rainfall does not necessarily correspond to the MAP*
≠ Midgley et al, 1994

The area is situated on the Escarpment where most of the rainfall falls in the summer months. Table 2 shows that the average rainfall is between 570 mm/annum and 643 mm/annum. More than 89 % of the precipitation occurs between October and March. The cumulative rainfall for the Northam (POL) station is shown in Figure 4.

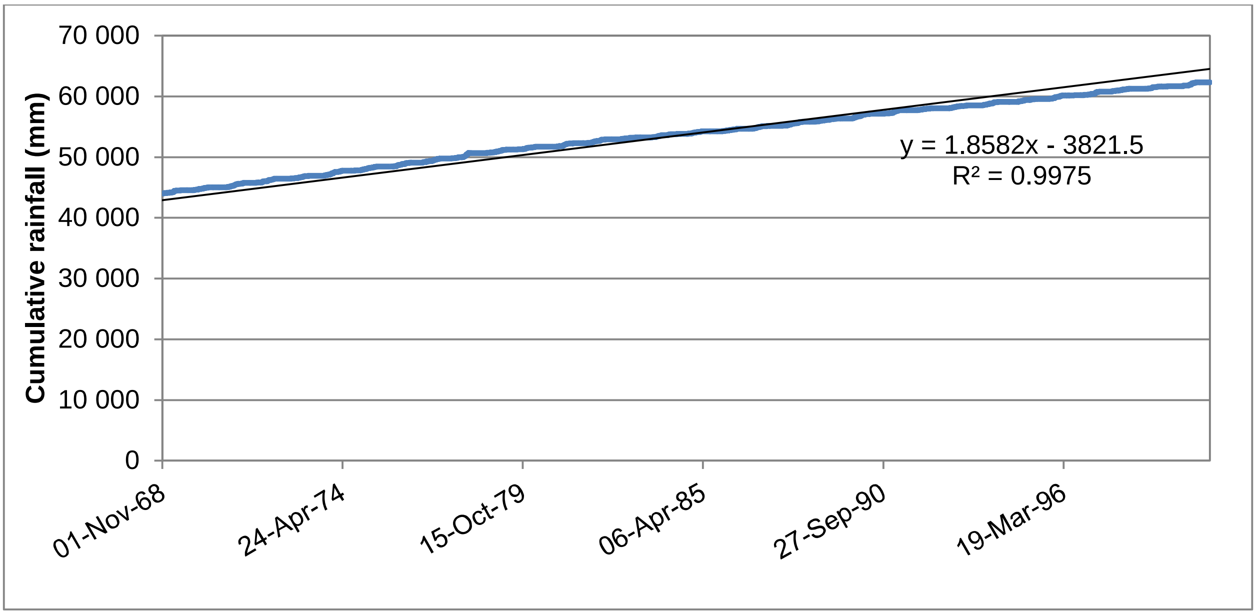


Figure 4: Cumulative rainfall for station 0587477_W Northam (POL)

The virtually linearity of the line in Figure 4 shows the data is reliable and can be used for this area. The monthly rainfall distribution is shown in Figure 5.

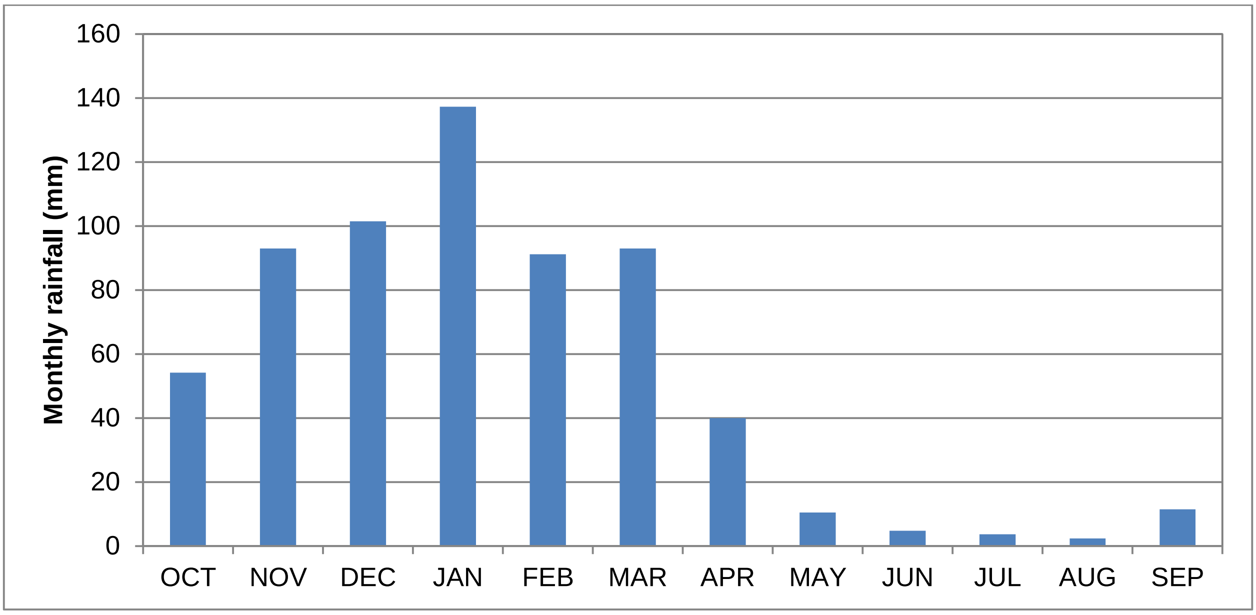


Figure 5: Monthly rainfall distribution for 0587477_W Northam (POL)

As can be seen in Figure 5 the rain mainly falls between November and March. The annual rainfall distribution over the record available is shown in Figure 6.

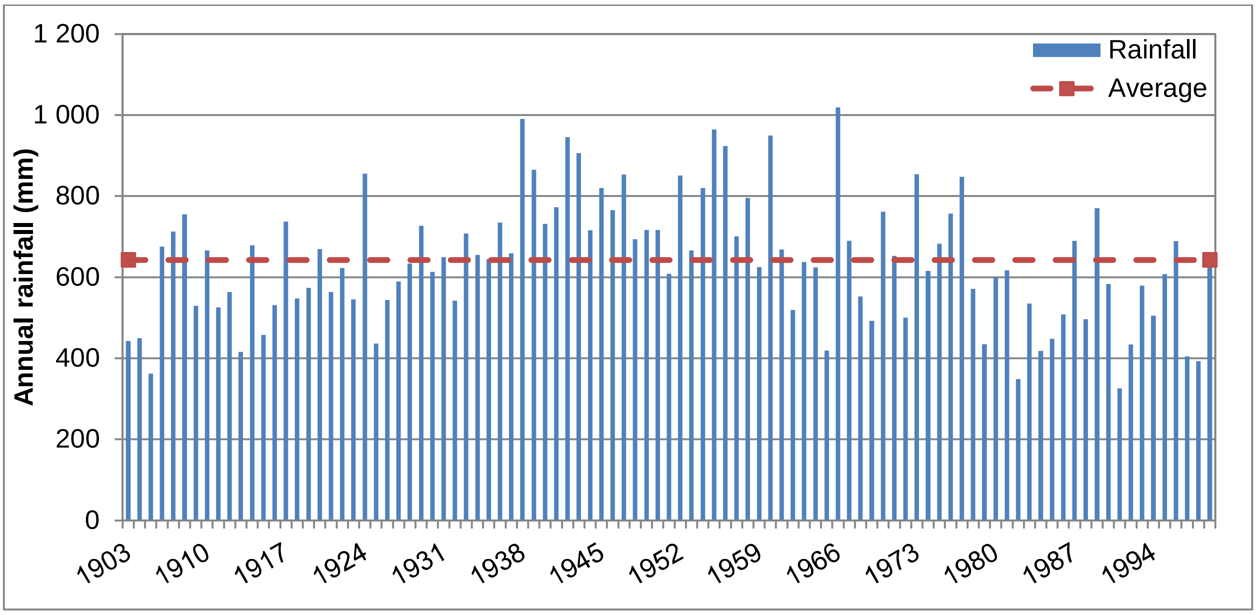


Figure 6: Annual rainfall for station 0587477_W Northam (POL)

The mean annual rainfall for Northam is 643 mm. The lowest rainfall year was 1991 with 326 mm and the highest rainfall year was 1966 with 1019 mm.

The 5, 50 and 95 percentile of the annual rainfall totals for the rainfall station is presented in Table 3.

Table 3: 5, 50 and 95 percentile of the annual rainfall totals

Station number	Station name	5%	50%	95%
0587477_W	Northam (POL)	413.72	644.90	928.12

Table 3 shows for Northam (POL) there was:

- Less than 414 mm/annum rainfall for 5 % of the time;
- Less than 645 mm/annum rainfall for 50 % of the time; and
- Less than 928 mm rainfall for 95 % of the time.

At the Northam (POL) station 47 events measured more than 50 mm/day and rainfall events with more than 100 mm/day was recorded 4 times for during the data period. These events are summarised in Table 4.

Table 4: Rainfall events with more than 100 mm/day

Date	0587477_W Northam (POL)
25/03/1968	109.3
11/03/1969	130.5
05/11/1994	104
17/12/1995	163

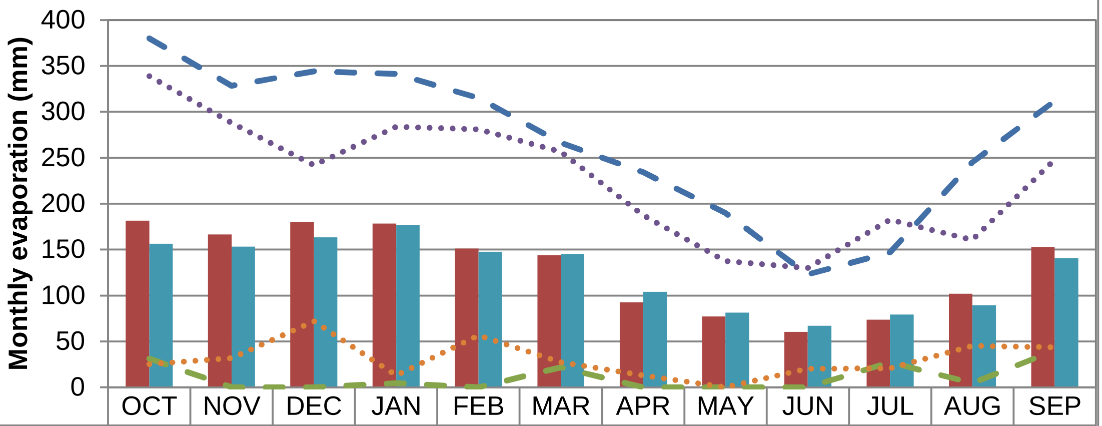
The 24-hour rainfall depths for the 1 in 2, 1 in 5, 1 in 10, 1 in 20, 1 in 50, 1 in 100 and 1 in 200 recurrence intervals at the station were calculated from the data available. In order to determine the likely magnitude of storm events, a statistical approach, using the Reg Flood program, (Alexander, et al., 2003) was applied, to the available recorded daily rainfall depths. The maximum 24 hour rainfall depth for each year was analysed. This method statistically analyses the maximum daily rainfall depths for each year to determine the different recurrence interval daily rainfall depths. The best fit is the Log Pearson distribution which resulted in the 24 h storm rainfall depths summarised in Table 5. The data used and the Log Pearson curve appear in APPENDIX B.

Table 5: 24 hour storm rainfall depths for Northam (POL)

Recurrence Interval (years)	1 in 2	1 in 10	1 in 20	1 in 50	1 in 100	1 in 200
Rainfall depth (mm)	31	79	104	142	175	213

4.3 Evaporation data

Monthly evaporation data was available for the DWA station A2E012 Nooigedacht @ Bierspruit Dam. There are two sets of evaporation data that were measured at this station. From December 1960 A-Pan Evaporation was measured then in September 1968 a Symons Pan (S-Pan) was also placed at the site and began measuring evaporation data. The station was closed in November 1970 thus the S-Pan data is limited but can be used for comparison against the A-Pan data. The mean annual evaporation from this station for the period December 1960 to October 1970 was 2337 mm for A-Pan and 1790 for S-Pan. Monthly mean, minimum and maximum evaporation is shown in Figure 7 where the first set of mean evaporation data and the dashed minimum and maximum data show the A-Pan evaporation that has now been converted into S-Pan and then factored for use in open water evaporation. The second set of data in Figure 7 of mean evaporation and the dotted lines for minimum and maximum evaporation show the S-pan data which has now been factored for use in open water evaporation. For comparison, Table 6 shows the A-Pan and S-pan data from station A2E012 that has been converted for use in open water evaporation as well as the WR90 data for S-pan evaporation converted for use in open water evaporation.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Mean Evap	182	167	180	178	151	144	92	77	61	74	102	153
Mean Evap	156	153	163	176	148	145	104	81	67	79	89	141
Max Evap	380	328	344	341	315	266	234	190	123	147	245	312
Min Evap	31.0	0.0	0.0	4.7	0.0	21.7	0.0	0.0	0.0	27.2	4.5	40.3
Max Evap	339	288	242	284	281	256	187	138	130	183	161	248
Min Evap	25.1	32.0	72.0	13.0	56.7	27.3	13.2	0.0	20.4	20.6	45.2	43.7

Figure 7: Monthly mean, minimum, maximum open water evaporation for station A2E012 Nooitgedacht @ Bierspruitdam

Figure 7 shows that the most evaporation happens in the summer months from August to March.

Table 6: Monthly open water evaporation from A2E012 and WR90

Month	A2E012 Original A - pan	A2E012 Original S - pan	WR90 (S-pan)
Oct	181.70	156.39	182.08
Nov	166.61	153.14	182.01
Dec	179.97	163.26	189.92
Jan	178.22	176.48	187.97
Feb	151.26	147.66	160.20
Mar	143.74	145.33	152.75
Apr	92.40	104.15	116.56
May	77.32	81.48	95.41
Jun	60.60	67.15	78.14
Jul	73.81	79.47	84.50
Aug	101.87	89.34	113.16
Sep	152.82	140.81	150.23
Total	**1560**	**1505**	**1693**

5.0 BASELINE FLOW AND WATER QUALITY

5.1 Flow monitoring

During a site visit conducted by three Golder Employees, Amanda Cassa, Eugeshin Naidoo and Xanthe Roux in February 2013 it was observed that the rivers running through the Varkensvlei and Nooitgedacht farms are completely dry except for one or two spots of ponding therefore no flow data was recorded. The site was revisited at the end of May 2013 to which the same was observed.

On researching the DWA website it was found that there used to be a pipeline pumping out of the Bierspruit Dam. This pipeline pumped water fairly constantly from January 1961 to August 1973. Figure 8 shows the daily flow being pumped over that period and Figure 9 shows the average monthly box plots for the pipeline.

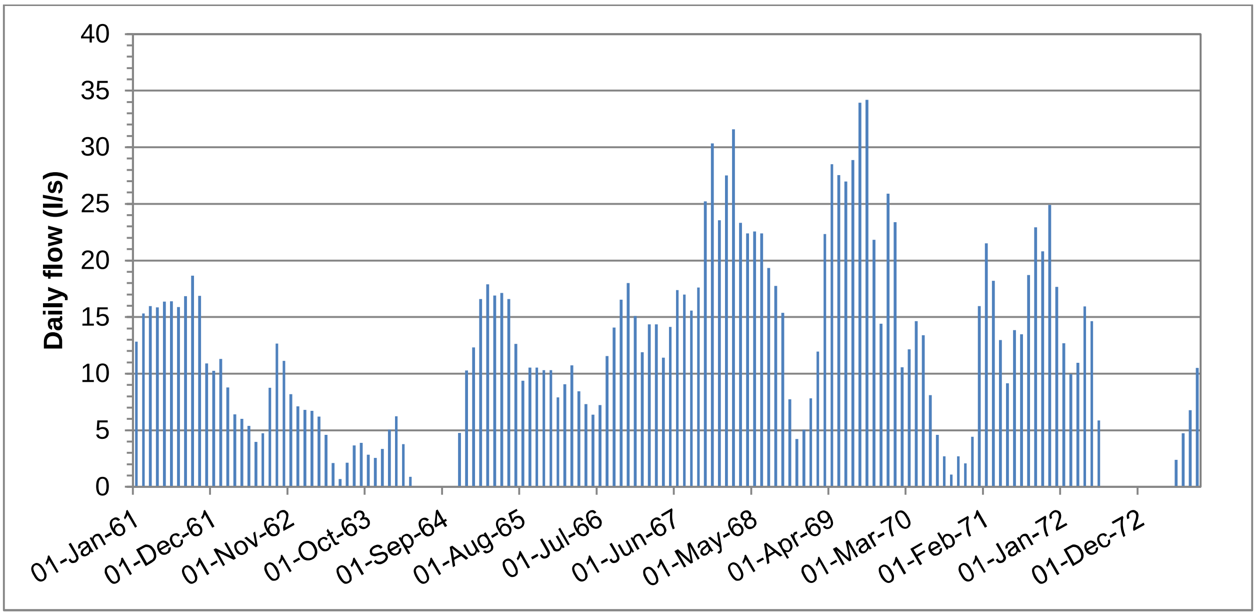


Figure 8: Daily flow for DWA flow station A2H103 Pipeline from Bierspruit Dam @ Nooitgedacht

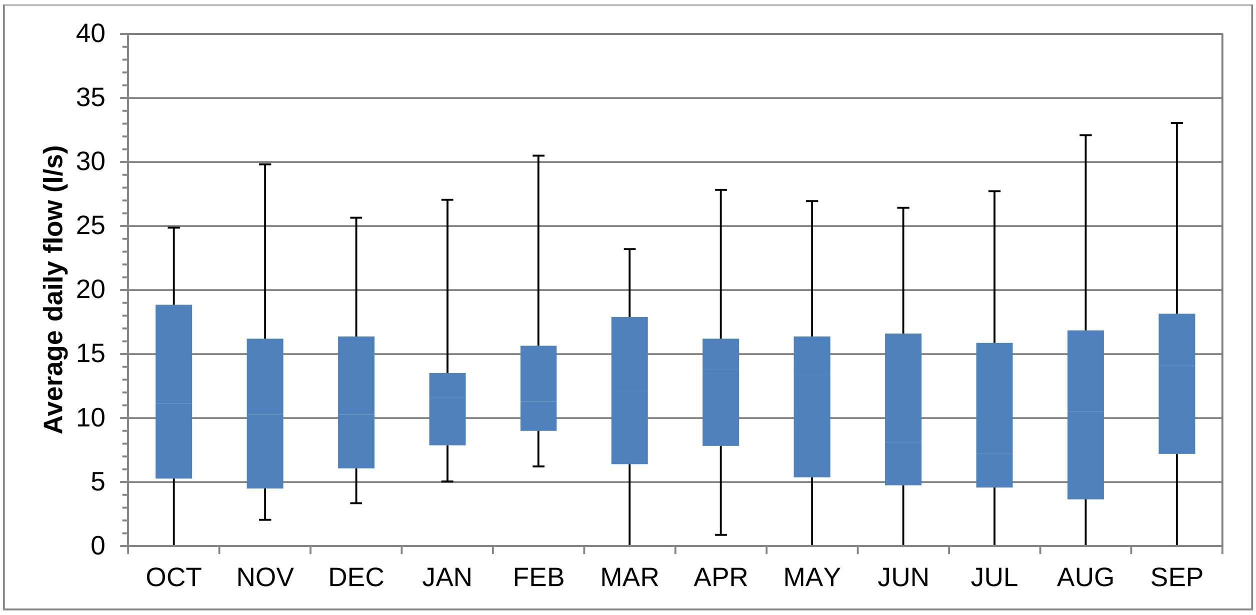


Figure 9: Average daily flow box plots for station A2H103 Pipeline from Bierspruit Dam @ Nooitgedacht

Figure 10 shows the flow and water quality stations for the Varkensvlei and Nooitgedacht farms. During the February 2013 site visit a flow and water quality monitoring station was setup on the Bofule River in the Varkensvlei farm the location of which appears in Figure 10 (FMWQ). Figure 11 shows the cross-section of the river and the data for the cross-section along with the photos of the setup appear in APPENDIX C.

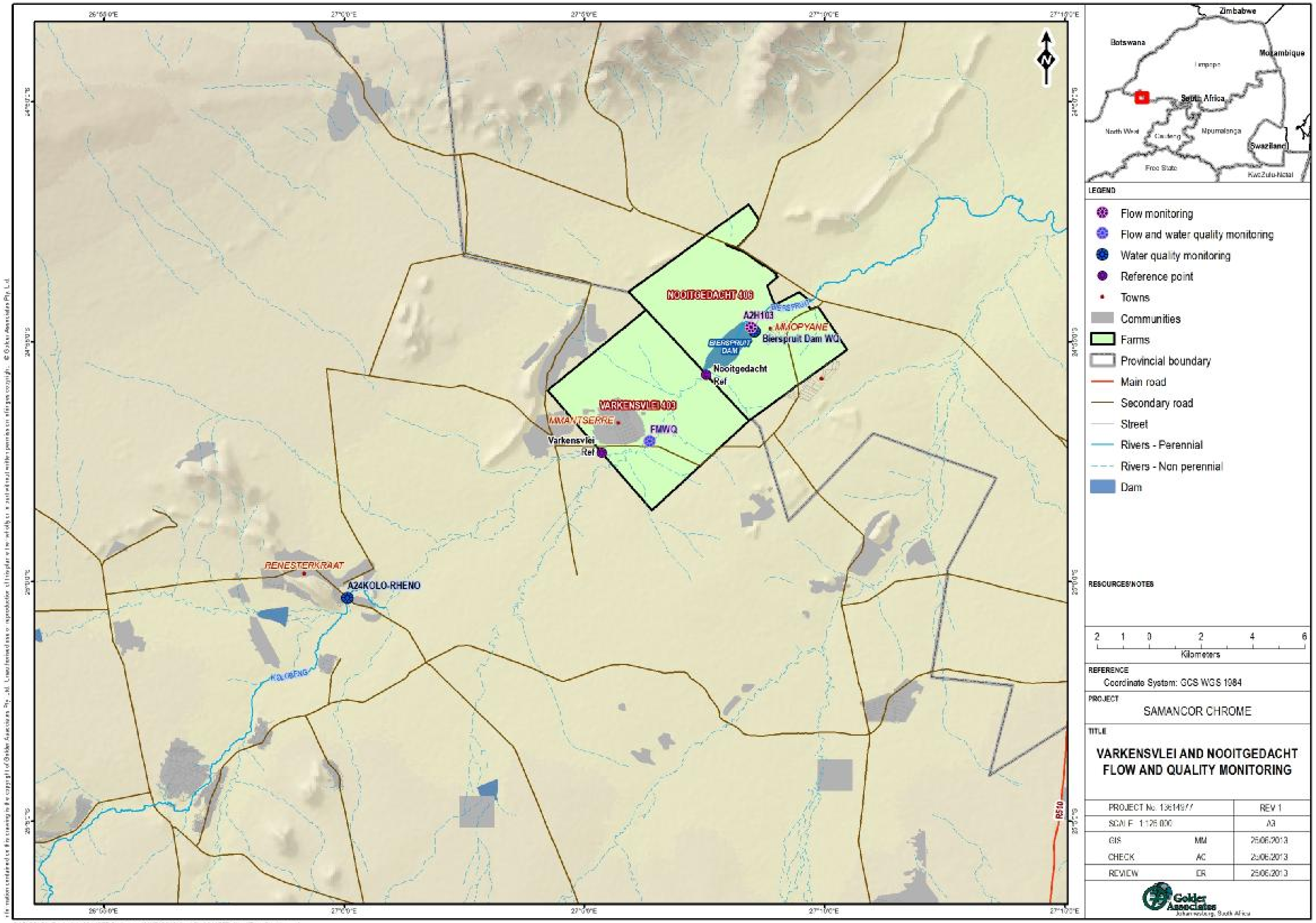


Figure 10: Flow and water quality monitoring stations for the Varkensvlei and Nooitgedacht area

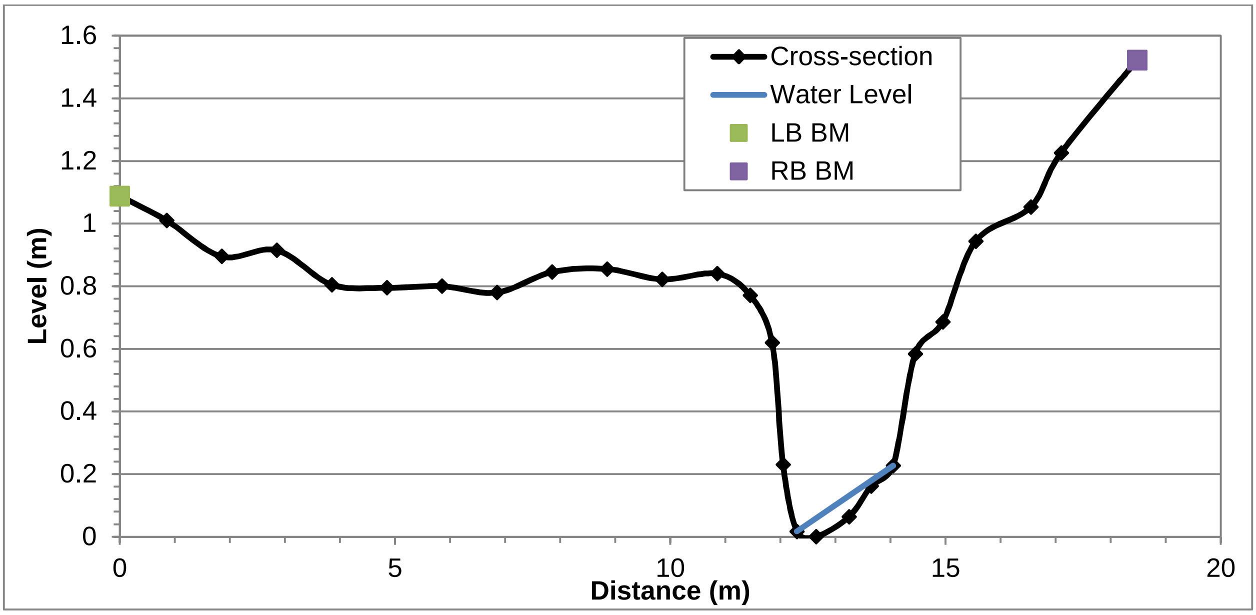


Figure 11: Cross-section of flow and water quality monitoring station on Bofule River

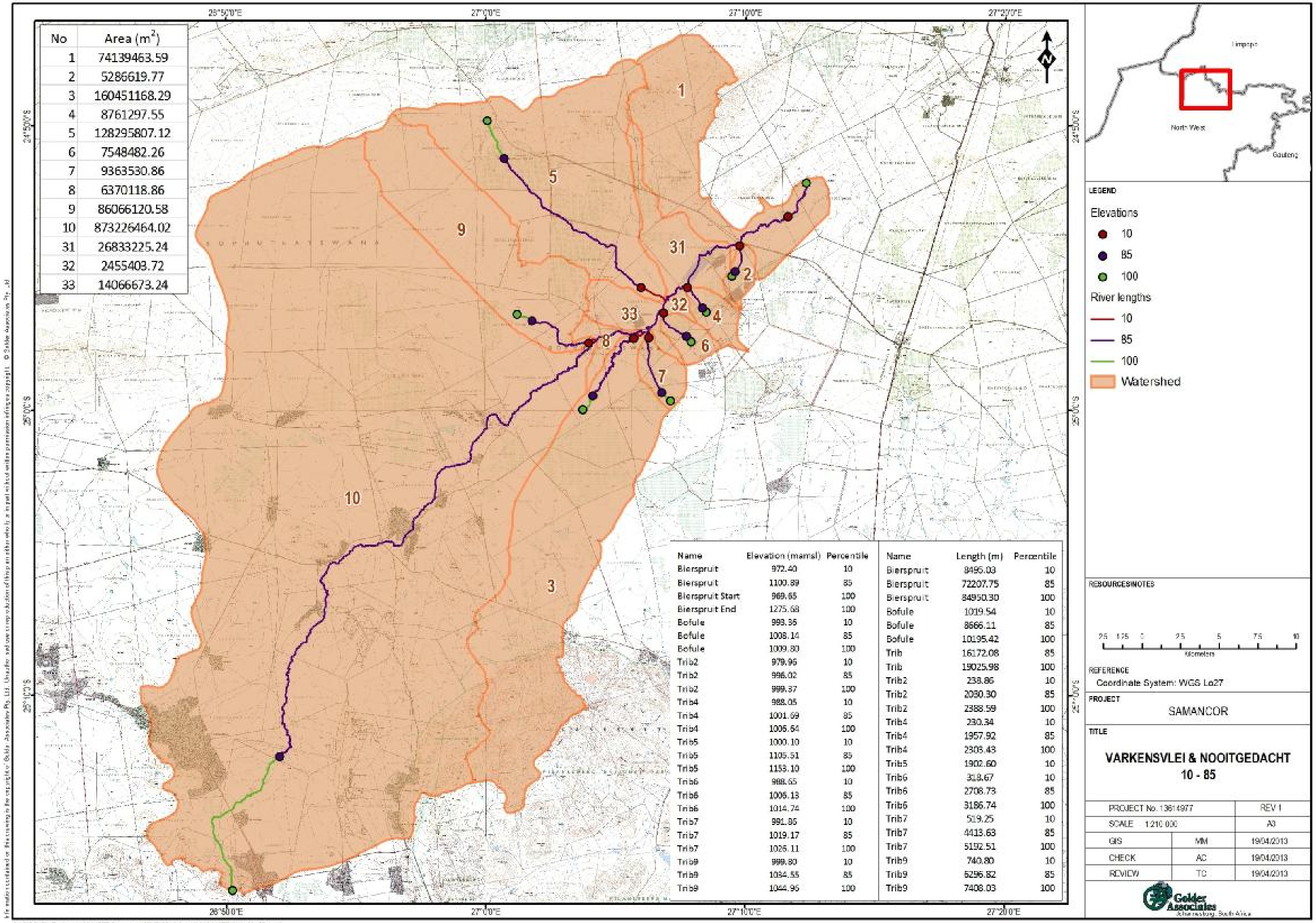
5.2 Floodline determination

The floodlines for the Varkensvlei and Nooitgedacht farms were determined. The following method was used for the determination of the floodlines:

- The site was visited to assess the site specific hydrological conditions;
- The catchment areas of the Varkensvlei and Nooitgedacht farms were delineated based on the 1:50 000 topographical maps;
- A flood peak analysis was undertaken to determine the different recurrence interval flood peaks for the watercourses within the area using various flood estimation methods;
- The flood peaks and the survey data of the study area were used as inputs to the HEC-RAS backwater programme to determine the surface water elevations for the 1: 50 and 1:100 year floods peaks;
- The floodlines were plotted on the available mapping;
- No flow and rainfall data against which the runoff calculations might be calibrated were available. The runoff volumes were therefore calculated theoretically using the various flood estimation methods;
- Since no flow data was available for estimation of the roughness coefficients, the Manning's *n* coefficients were estimated by comparing the vegetation and nature of the channel surfaces to published data (Webber, 1971).

5.2.1 Subcatchments

The total drainage area of the Varkensvlei and Nooitgedacht area was divided into 13 sub-catchments based on the topography of the area and the river reaches where flood lines were required. The catchment boundaries are shown in Figure 12.



No	Area (m²)
1	74139463.59
2	5286619.77
3	160451168.29
4	8761297.55
5	128295807.12
6	7548482.26
7	9363530.86
8	6370118.86
9	86066120.58
10	873226464.02
31	26833225.24
32	2455403.72
33	14066673.24

Name	Elevation (mamsl)	Percentile
Bierspruit	972.40	10
Bierspruit	1100.89	85
Bierspruit Start	969.65	100
Bierspruit End	1275.68	100
Bofule	993.35	10
Bofule	1008.14	85
Bofule	1009.80	100
Trib2	979.96	10
Trib2	996.02	85
Trib2	999.37	100
Trib4	988.05	10
Trib4	1001.69	85
Trib4	1006.54	100
Trib5	1000.10	10
Trib5	1105.51	85
Trib5	1153.10	100
Trib6	988.65	10
Trib6	1006.13	85
Trib6	1014.74	100
Trib7	991.86	10
Trib7	1019.17	85
Trib7	1026.11	100
Trib9	999.80	10
Trib9	1034.55	85
Trib9	1044.96	100

Name	Length (m)	Percentile
Bierspruit	8495.03	10
Bierspruit	72207.75	85
Bierspruit	84950.30	100
Bofule	1019.54	10
Bofule	8666.11	85
Bofule	10195.42	100
Trib	16172.08	85
Trib	19025.98	100
Trib2	238.86	10
Trib2	2030.30	85
Trib2	2388.59	100
Trib4	230.34	10
Trib4	1957.92	85
Trib4	2303.43	100
Trib5	1902.60	10
Trib6	318.67	10
Trib6	2708.73	85
Trib6	3186.74	100
Trib7	519.25	10
Trib7	4413.63	85
Trib7	5192.51	100
Trib9	740.80	10
Trib9	6296.82	85
Trib9	7408.03	100

Figure 12: Subcatchments of the floodline determination of the Varkensvlei and Nooitgedacht area

5.2.2 Flood peak calculation

The various flood estimation methods namely, the Rational Method using Point Precipitation (RM-PP), the Rational Method using TR102 (RM-TR_1), the Standard Design Flood method (SDF) and the Empirical Flood Estimation method or the Regional Maximum Flood method (RMF) was applied to the Varkensvlei Nooitgedacht area sub-catchments. The sub-catchment characteristics used in applying these methods are shown in Table 7 and the flood peaks for the 1 in 50 and 1 in 100 year flood are shown in Table 8.

Table 7: Subcatchment characteristics used in the flood estimation methods

Stream Name	Catchment	Quaternary Catchment	Area (km²)	River Length (m)	10-85 Slope (m/m)	Time of concentration (h)
Bierspruit	10	A24D	873.23	84.95	0.002017	22.126
Bofule	3	A24D	160.45	10.20	0.001933	4.395
Trib2	2	A24F	5.29	2.39	0.008961	0.797
Trib4	4	A24D	8.76	2.30	0.007893	0.813
Trib5	5	A24D	128.30	19.03	0.007387	4.241
Trib6	6	A24D	7.55	3.19	0.007316	1.075
Trib7	7	A24D	9.36	5.19	0.007014	1.592
Trib9	9	A24D	86.07	7.41	0.006254	2.187
Comb_1	9+10	A24D	959.29	84.95	0.002017	22.126
Comb_2	3+8+9+10	A24D	1 126.11	84.95	0.002017	22.126
Comb_3	3+7+8+9+10	A24D	1 135.48	84.95	0.002017	22.126
Comb_4	3+6+7+8+9+10	A24D	1 169.86	84.95	0.002017	22.126
Comb_5	3+6+7+8+9+10+31	A24D	1 298.15	84.95	0.002017	22.126
Comb_6	3+4+5+6+7+8+9+10+31+32	A24D	1 309.37	84.95	0.002017	22.126
Comb_7	All except 1 and 2	A24D+ A24F	1 323.44	84.95	0.002017	22.126
Comb_8	All except 1	A24D+ A24F	1 328.72	84.95	0.002017	22.126
Comb_9	All	A24D+ A24F	1 402.86	84.95	0.002017	22.126

Table 8: Computed 50 year and 100 year flood peaks

River	Peak Flow (m³/s)	
	1 in 50 year	1 in 100 year
Bierspruit	455	609
Bofule	207	290
Trib2	59	75
Trib4	61	80
Trib5	200	267
Trib6	50	65
Trib7	49	64
Trib9	158	220
Comb_1	462	622
Comb_2	524	706
Comb_3	528	711
Comb_4	540	728
Comb_5	587	791
Comb_6	591	797

Comb_7	596	804
Comb_8	598	806
Comb_9	625	842

Figure 13 shows the floodlines for the Varkensvlei and Nooitgedacht area. Due to the low resolution of contour data i.e. 5 m and the fact that during both site visits the rivers were dry these floodlines should not be used for infrastructural purposes. The HEC-RAS output file is shown in APPENDIX D.

5.3 Water Quality

Water quality data was obtained from the DWA (Resource Quality Studies) website for the area around the Varkensvlei and Nooitgedacht farms. Station A24KOLO-RHENO is situated approximately 11.3 km upstream of the western boundary of the Varkensvlei Farm and approximately 16.3 km upstream of the western boundary of the Nooitgedacht farm (see Figure 10). This water quality station contains only one measurement taken on 27 June 2006. The South African Water Quality Guidelines (Department of Water Affairs and Forestry, 2006) are presented in Table 9 for the various water users in the area. The water quality of Station A24KOLO-RHENO is presented in Table 10 and compared to the most sensitive case of the guidelines presented in Table 9. During a site visit conducted by three Golder Employees, Amanda Cassa, Eugeshin Naidoo and Xanthe Roux it was observed that the rivers running through these sites are completely dry except for one or two spots of ponding therefore no water quality samples were taken through the rivers. These rivers however do run through the Bierspruit Dam thus two samples of the Bierspruit Dam were taken and are presented in Table 11 along with an in-situ measurement of the dam and compared to the guidelines in Table 9

From Table 10 it is difficult to determine the quality of the water in the area as only one sample was taken and the area is often dry. Table 10 shows that for the most part the water quality was acceptable except for the Ammonia and Fluoride while these values are acceptable for domestic use they are over the limits for aquatic ecosystems.

From the sample taken during the site visits of the Bierspruit Dam it is clear from Table 11 that the water quality of the dam is poor. The Electrical conductivity has spiked higher than recommended for use in irrigation but is still well below the limits for domestic consumption. The Total Suspended Solids are very high to sustain aquatic ecosystems although there does seem to be life in and around the water. There are however dead fish on the edge of the dam as shown in Figure 14. There is a fluoride problem in the dam as the fluoride is well above the limits for both domestic and aquatic ecosystems and just below livestock and irrigation limits thus fluoride needs to be monitored before it becomes a serious problem. The Aluminium content is high for aquatic ecosystems but within limits of domestic use the second round of samples though indicated the Aluminium spiked higher than tolerable for domestic use thus needs to be monitored closely. Manganese and Chromium VI are above the limits for aquatic ecosystems but below the limits for domestic use. Phosphorus is higher than the limits for domestic use but below that of aquatic ecosystems. The chemical oxygen demand or COD in the dam is very high. This indicates large amounts of waste in the dam and it is at unacceptable limits for any use. This could be due to livestock or human intervention more investigation into the matter would have to be done.

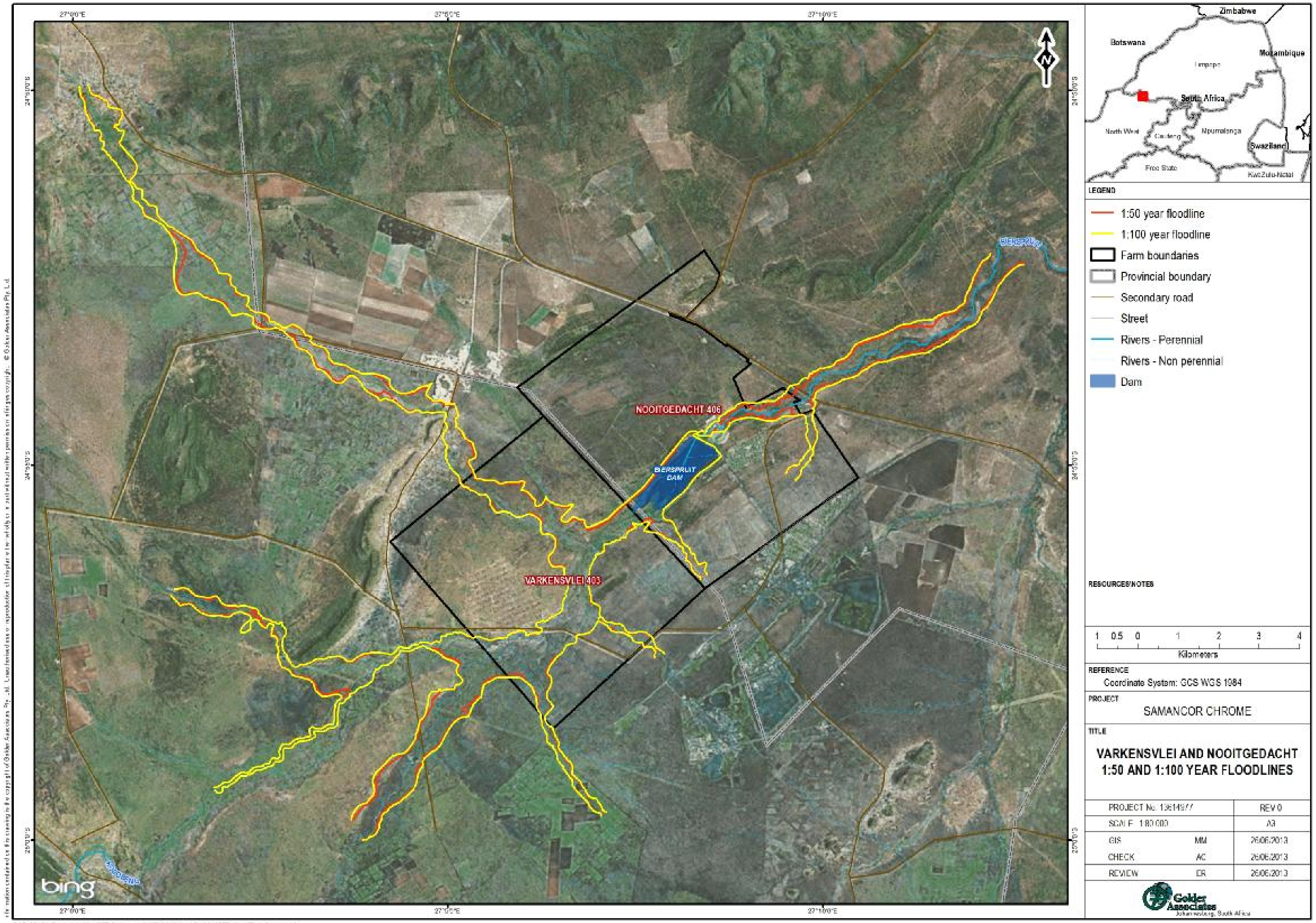


Figure 13: Floodlines for the Varkensvlei and Nooitgedacht area

Table 9: South African Water Quality Guidelines

Parameter	Unit	Domestic Use	Industrial Use: Category 3	Aquatic Ecosystems	Agricultural Use: Livestock Watering	Agricultural Use: Irrigation	Recreational Use
				Acceptable limits			
Calcium, Ca	mg/l	150			1500	1500	
Chloride, Cl	mg/l	200	150		1750	1750	
Total Dissolved Salts, TDS	mg/l	1000	800		2000	2000	
Electrical Conductivity, EC	mS/m	150	120			40	
Fluoride, F	mg/l	1		0.00075	4	4	
Potassium, K	mg/l	50					
Nitrogen, N	mg/l			2.5		2.5	
Magnesium, Mg	mg/l	100			700	700	
Sodium, Na	mg/l	200			2250	2250	
Ammonium, NH_4	mg/l	2		0.0007			
Nitrate + Nitrite	mg/l	10			200		
Nitrate	mg/l				250	250	
Nitrite	mg/l				150	150	
Phosphorus, P	mg/l	0.005		25			
pH (upper)		10	9			8.4	8.5
pH (lower)		4.5	5.75			6.5	5.75
Phosphate, PO_4	mg/l						
Silicon, Si	mg/l		85				
Sulphate, SO_4	mg/l	400	250		1250	1250	
Total Alkalinity as $CaCO_3$	mg/l		450				
Chromium IV, Cr VI	mg/l	1		0.0007	1.5	0.55	
E.coli (Faecal coliforms)	per 100 ml	1			600	600	1065
Iron, Fe	mg/l	1	6.5		30	30	
Aluminium, Al	mg/l	0.15			7.5	7.5	
Manganese, Mn	mg/l	0.4	6	0.00018	30	30	
Nickel, Ni	mg/l				3	3	

Parameter	Unit	Domestic Use	Industrial Use: Category 3	Aquatic Ecosystems	Agricultural Use: Livestock Watering	Agricultural Use: Irrigation	Recreational Use
Copper, Cu	mg/l	1.3		0.5	0.75	0.75	
Chromium, Cr	mg/l						
Mercury, Hg	mg/l			0.04	3.5	3.5	
DOC as C	mg/l	10					
COD as O_2	mg/l		50				
Total Suspended Solids, TSS	mg/l		20	100		50	
Hardness as $CaCO_3$	mg/l		375				
Tolerable limits							
Calcium, Ca	mg/l	300			2000	2000	
Chloride, Cl	mg/l	600	200		2000	2000	
Total Dissolved Salts, TDS	mg/l	2400	1600		3000	3000	
Electrical Conductivity, EC	mS/m	370	250			40	
Fluoride, F	mg/l	1.5		1.5	6	6	
Potassium, K	mg/l	100					
Nitrogen, N	mg/l			10		10	
Magnesium, Mg	mg/l	200			1000	1000	
Sodium, Na	mg/l	400			2500	2500	
Ammonium, NH_4	mg/l	10		0.015			
Nitrate + Nitrite	mg/l	20					
Nitrate	mg/l				400	400	
Nitrite	mg/l				200	200	
Phosphorus, P	mg/l	0.005		250			
pH (upper)		10.5	10			8.4	9
pH (lower)		4	5			6.5	5
Phosphate, PO_4	mg/l						
Silicon, Si	mg/l		150				
Sulphate, SO_4	mg/l	600	300		1500	1500	

Parameter	Unit	Domestic Use	Industrial Use: Category 3	Aquatic Ecosystems	Agricultural Use: Livestock Watering	Agricultural Use: Irrigation	Recreational Use
Total Alkalinity as $CaCO_3$	mg/l		600				
Chromium IV, Cr VI	mg/l	5		0.014	2	1	
E.coli (Faecal coliforms)	per 100 ml	10			1000	1000	2000
Iron, Fe	mg/l	5	10		50	50	
Aluminium, Al	mg/l	0.5			10	10	
Manganese, Mn	mg/l	4	10	0.00037	50	50	
Nickel, Ni	mg/l				5	5	
Copper, Cu	mg/l	2		1	1	1	
Chromium, Cr	mg/l						
Mercury, Hg	mg/l			0.08	6	6	
DOC as C	mg/l	20					
COD as O_2	mg/l		100				
Total Suspended Solids, TSS	mg/l		50	100		100	
Hardness as $CaCO_3$	mg/l		500				

Table 10: DWA water quality sample for station A2KOLO-RHENO

DWA ID			189038	
Station number			A2KOLO-RHENO	
Date Time sample taken			27/06/2006 09:17	
River			Kolobeng	
Upstream/Downstream			Upstream	
Distance from farm			16.31	
Farm			Nooitgedacht	
Preservative			HGCL2	
	Unit	**Determinants**	**Compared against acceptable limits**	**Compared against tolerable limits**
pH		physical and aesthetic	7.6	7.6
Total Dissolve Solids, TDS	mg/l	physical and aesthetic	100	100
Electrical Conductivity, EC	mS/m	physical and aesthetic	14.6	14.6
Total Alkalinity as $CaCO_3$	mg/l	physical and aesthetic	54.4	54.4
Fluoride, F	mg/l	chemical-macro	0.128	0.128
Chloride, Cl	mg/l	chemical-macro	4.9	4.9
(Nitrate and Nitrite) as N	mg/l	chemical-macro	0.04	0.04
Ammonia, NH4	mg/l	chemical-macro	0.046	0.046
Sulphate, SO_4	mg/l	chemical-macro	2	2
Sodium, Na	mg/l	chemical-macro	6.3	6.3
Calcium, Ca	mg/l	chemical-micro	11.8	11.8
Potassium, K	mg/l	chemical-micro	1.017	1.017
Magnesium, Mg	mg/l	chemical-micro	7.1	7.1
Orthophosphate as PO_4	mg/l	chemical-micro	0.068	0.068

Table 11: Water quality samples for Bierspruit Dam

ID			Bierspruitdam					
Station number			Bierspruitdam WQ					
Date Time sample taken			24/04/2013 14:44	20/05/2013 11:36	20/05/2013 11:42	24/04/2013 14:44	20/05/2013 11:36	20/05/2013 11:42
River			Bierspruit					
Upstream/Downstream			Downstream					
Distance from farm			2.52					
Farm			Nooitgedacht					
	Unit	Determinants	Compared against acceptable limits			Compared against tolerable limits		
pH		physical and aesthetic	7.4	7.6	7.8	7.4	7.6	7.8
Total Dissolve Solids, TDS	mg/l	physical and aesthetic	270	220	239	270	220	239
Electrical Conductivity, EC	mS/m	physical and aesthetic	37	57	0.0481	37	57	0.0481
Total Alkalinity as $CaCO_3$	mg/l	physical and aesthetic	132	174		132	174	
Total Suspended Solids, TSS	mg/l	physical and aesthetic	730	1112		730	1112	
Fluoride, F	mg/l	chemical-macro	3.6	3.8		3.6	3.8	
Chloride, Cl	mg/l	chemical-macro	9.3	12		9.3	12	
Nitrate	mg/l	chemical-macro	0.1	18		0.1	18	
Nitrite	mg/l	chemical-macro	0.5	0.5		0.5	0.5	
Sulphate, SO_4	mg/l	chemical-macro	30	47		30	47	
Sodium, Na	mg/l	chemical-macro	17	139		17	139	
Calcium, Ca	mg/l	chemical-micro	17	26		17	26	

Potassium, K	mg/l	chemical-micro	6.3	15		6.3	15	
Magnesium, Mg	mg/l	chemical-micro	15	27		15	27	
Iron, Fe	mg/l	chemical-micro	0.27	0.27		0.27	0.27	
Aluminium, Al	mg/l	chemical-micro	0.04	0.25		0.04	0.25	
Manganese, Mn	mg/l	chemical-micro	0.064	0.01		0.064	0.01	
Nickel, Ni	mg/l	chemical-micro	0.016	0.007		0.016	0.007	
Copper, Cu	mg/l	chemical-micro	0.0037	0.02		0.0037	0.02	
Mercury, Hg	mg/l	chemical-micro	0.0001	0.0001		0.0001	0.0001	
Hexavalent Chromium, Cr VI	mg/l	chemical-micro	0.01	0.04		<0.01	0.04	
Phosphorus, P	mg/l	chemical-micro		0.43			0.43	
Orthophosphate as PO_4	mg/l	chemical-micro	0.25	0.03		0.25	0.03	
Dissolved Organic Carbon, DOC	mg/l as C	Organic	5.6	22		5.6	22	
Chemical Oxygen Demand, COD	mg/l as O_2	Organic	104	157		104	157	
E. Coli	CFU/100ml	Organic	110	29		110	29	

Figure 14: Dead fish around the Bierspruit Dam

6.0 WATER BALANCE AND STORMWATER MANAGEMENT PLAN

For the chrome mine there will be little to no processing done on site therefore the water balance and stormwater management plan discussed in this section are at a very high conceptual level and must be updated when the infrastructure details and finalised and the groundwater studies are completed. Figure 15 shows the latest infrastructure layout as it stands which is basically the open pit, the stockpile and the plant office and haul roads. The site wide water balance at the Varkensvlei/Nooitgedacht mine will consist of the following:

- **Open Pit:** This open pit is to be mined to 40 m below ground level across the approximately 10.5 km length of the pit for a width of approximately 1.7 km;
- **Screen and Crusher:** The ore will then be piped to the crusher entering through a screen;
- **Stockpile:** The crushed ore will then be sent to the stockpile;
- **Trucks:** Trucks will be used to haul the ore away to be processed elsewhere;
- **Pollution Control Dam (PCD):** the dewatering of the pit will take place continuously throughout the life of the mine and this water will be pump to the PCD. Part of the water in the PCD will be used for dust suppression of the stockpile and some will be lost due to spillage but the rest must be stored or treated and released.

A schematic of this process is shown in Figure 16 along with the required stormwater management plan which will consist of a berm around the open pit to prevent any runoff water from coming into the pit. This water will be diverted around the pit to the nearest tributary. The other stormwater measure will be a channel running around the stockpile to catch any runoff of the stockpile and this water will be diverted to the PCD.

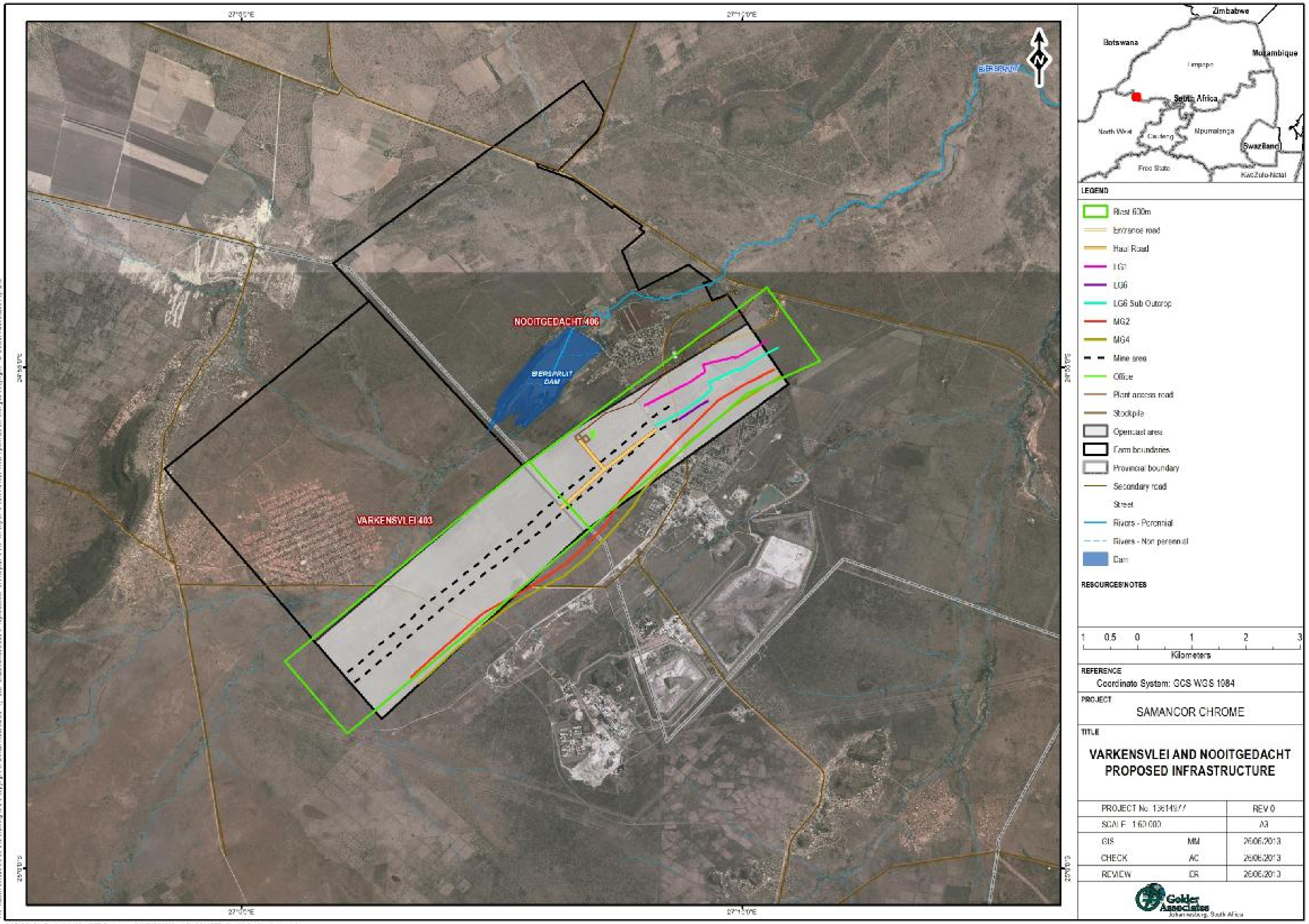


Figure 15: Infrastructure layout for Varkensvlei and Nooitgedacht mine

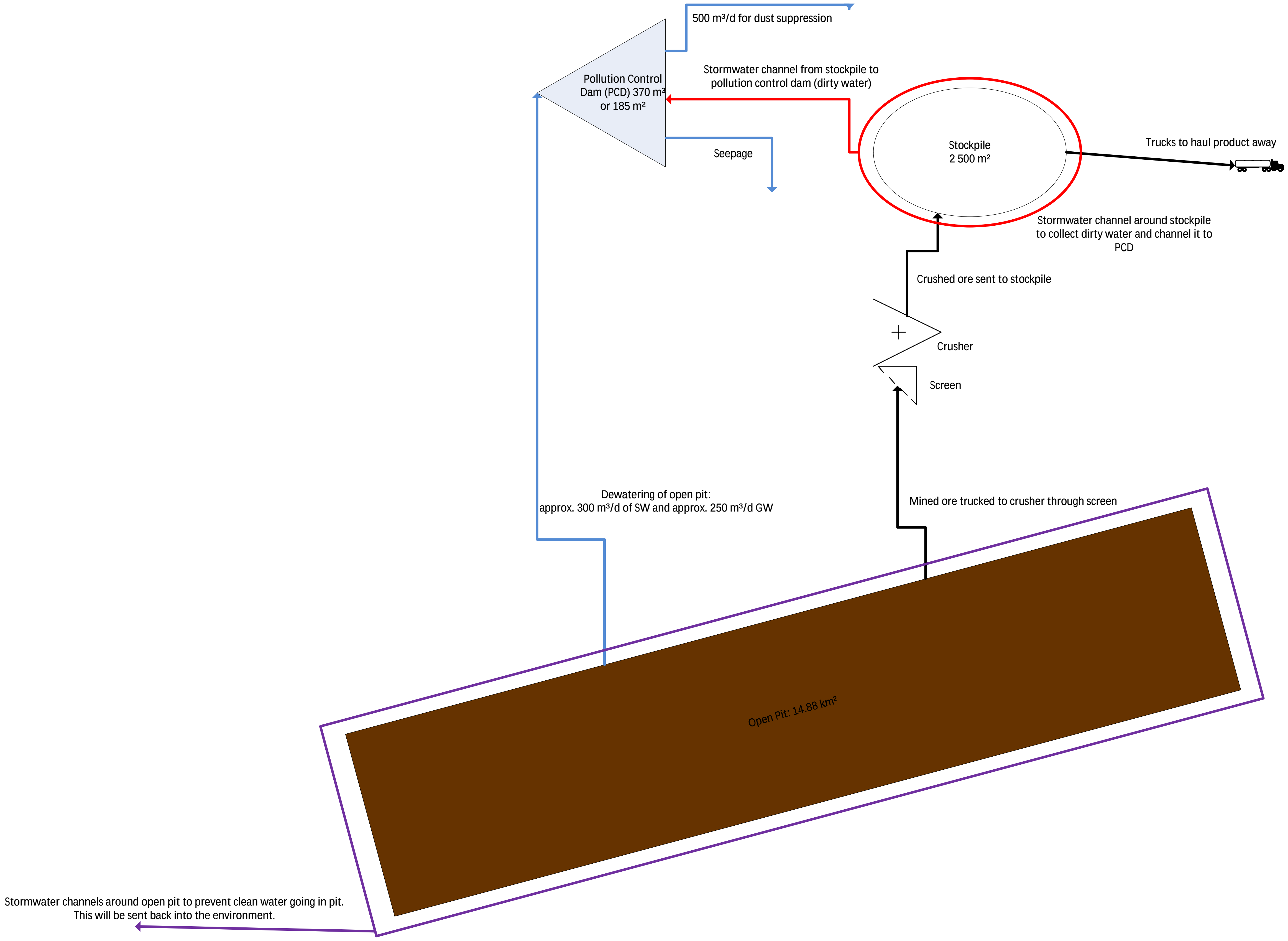


Figure 16: Water Balance and Stormwater Management Plan of Varkensvlei and Nooitgedacht mine

From the layout in Figure 16 it is possible to give an estimate of the size of the PCD required to have on site. The contribution of surface water (SW) is estimated by the following equation:

$$Q_{SW} = \frac{0.5 \times Area\ of\ pit \times MAP \times recharge}{365}$$

The area of the open pit at its fullest will be 14.88 km², the MAP is 642.73 mm, the recharge is assumed at 0.12 m³/d thus the flow expected from the surface is approximately 1570 m³/d. The contribution made by groundwater (GW) is estimated using Darcy's Law:

$$Q_{GW} = KS_f A$$

Where *K* is the hydraulic conductivity of the soil in *cm/s*, S_f is the slope of the water table and *A* is the saturated area of the pit. According to the groundwater specialists the area is a silty clay thus assuming a *K* value of 10^{-7} cm/s (Chow, et al., 1988) and an S_f of 1 which is likely to change over time but this would be the worst case, then the contribution made by GW is 450 m³/d.

The stockpile will also run into the PCD therefore the contribution made by the stockpile is:

$$Q_{Stock} = \frac{A \times MAP}{365}$$

Thus assuming the stockpile is 50 m by 50 m the runoff contribution by the stockpile is 4.55 m³/d. Taking evaporation into account by converting the MAE of 2337.2 mm to open water evaporation by using an average pan factor of 0.8, the loss due to evaporation is 5.59×10^{-3} m/d. Accounting for seepage assuming 1×10^{-10} m/s, it is possible to give a rough estimate of the size of PCD.

Assuming a 2 m high dam wall the required surface area for the PCD is 185 m². This number is based on rough calculations and will be updated when more investigations are done.

7.0 IMPACT ASSESSMENT

7.1 Potential surface water impacts

The potential surface water impacts from the project, both direct and indirect, are summarised in Table 12. In summary these potential impacts contribute to overall surface water impacts and include:

- Change in surface water catchment areas;
- Changes in surface water quality;
- Change in surface water runoff and erosion;
- Disruption and reduction in land due to construction of offices, stockpiles and roads.

The surface water quality impacts will ultimately impact on the downstream water users, including the provision of irrigation water when the water make becomes feasible for such use. The detailed impact assessment is outlined in Section 7.2.

Table 12: Summary of potential surface water impacts with respect to Varkensvlei/Nooitgedacht mine

Major aspect	Key Environmental Issues / Potential Impacts
Changes in surface water catchment areas	• Catchment areas are significantly reduced in the area due to the size of the open pit.
Changes in surface water quality	• The mobilisation of sediments in the open pit area during construction due to the ore being transported to and from the stockpile; • Spillage from equipment
Change in surface water runoff and erosion	• Erosion of the tributaries around the pits may occur to due increased runoff from open pit • Runoff impacts due to mining activities during operation and closure
Disruption and reduction in land due to construction of offices, stockpiles and roads	• Downstream water users will be disrupted by the construction of offices and stockpiles and roads and the extra water use can affect downstream users.

7.2 Surface Water Impact Assessment

7.2.1 Impact Assessment Methodology

The significance of the impacts during the impact assessment phase was determined using the approach described in Table 13 and provides the method for defining intensity, geographic extent and duration.

Table 13: Impact assessment criteria

CRITERIA	DESCRIPTION			
EXTENT	**National (4)** The whole of South Africa	**Regional (3)** Provincial and parts of neighbouring provinces	**Local (2)** Within a radius of 2 km of the construction site	**Site (1)** Within the construction site
DURATION	**Permanent (4)** Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact can be considered transient	**Long-term (3)** The impact will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter. The only class of impact which will be non-transitory	**Medium-term (2)** The impact will last for the period of the construction phase, where after it will be entirely negated	**Short-term (1)** The impact will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase
INTENSITY	**Very High (4)** Natural, cultural and social functions and processes are altered to extent that they permanently cease	**High (3)** Natural, cultural and social functions and processes are altered to extent that they temporarily cease	**Moderate (2)** Affected environment is altered, but natural, cultural and social functions and processes continue albeit in a modified way	**Low (1)** Impact affects the environment in such a way that natural, cultural and social functions and processes are not affected

PROBABILITY OF OCCURRENCE	**Definite (4)** Impact will certainly occur	**Highly Probable (3)** Most likely that the impact will occur	**Possible (2)** The impact may occur	**Improbable (1)** Likelihood of the impact materialising is very low

Low impact **(4 - 6 points)**	**A low impact has no permanent impact of significance. Mitigation measures are feasible and are readily instituted as part of a standing design, construction or operating procedure.**
Medium impact **(7 - 9 points)**	Mitigation is possible with additional design and construction inputs.
High impact **(10 - 12 points)**	The design of the site may be affected. Mitigation and possible remediation are needed during the construction and/or operational phases. The effects of the impact may affect the broader environment.
Very high impact **(13 - 16 points)**	Permanent and important impacts. The design of the site may be affected. Intensive remediation is needed during construction and/or operational phases. Any activity which results in a “very high impact” is likely to be a fatal flaw.

7.2.2 Surface Water Impacts

Table 14 sets out the detailed potential surface water impacts during construction, operation and at closure.

Table 14: Impact assessment during construction, operation and at closure

Aspect	Potential Impact	Extent	Duration	Intensity	Probability	Impact	Notes
CONSTRUCTION PHASE							
Run-off	• Spillage of fuels, lubricants and other chemicals; • Inadequate storm water management around the open pit and stockpile; the dumping of construction material, including fill or excavated material into, or close to surface water features that may then be washed into these features; • Construction equipment, vehicles and temporary workshop areas will be a likely source of pollution as a non-point source.	1	2	2	2	**7 medium**	It is expected that without mitigation a **medium** negative impact can be expected. Mitigation will include: • Bunded areas to store chemicals and/or fuel; • Clean-up of spills as soon as they occur; • Keep construction activities away from the Bierspruit River; and The significance of the impact after mitigation is likely to decrease to a **low** negative impact.
Construction of offices and roads	Potential impacts relating to the construction of offices and roads through the river bed could be: • Potential pollution transport via runoff after rainfall from disturbed areas along the road route during construction;	2	2	2	1	**7 medium**	A **medium** impact can be expected. In order to minimise impacts, construction needs to take place during the dry season (winter months). A Rehabilitation Plan will need to be developed upfront of any construction starting to accompany the Water Use Licence Application to Department of Water Affairs. Mitigation could reduce the impact to **low.**
OPERATIONAL PHASE							
Spillage of Pollution Control Dam PCD	Drop in water quality of area due to spillage of PCD	2	4	2	3	**11 high**	The likelihood of a PCD spilling is good but effective monitoring of the quantity and quality of the spillage can mitigate the matter. Mitigation could reduce the impact to **medium**.
Erosion of the watercourse due to discharge	Erosion of the watercourse due to discharge	1	1	1	1	**4 low**	The low flow dynamics at the site will unlikely cause any surface water erosion and thus a **low** impact rating can be expected.
Flood events and impact on infrastructure	Based on the flood line analyses, the proposed infrastructure for the Varkensvlei/Nootigedacht site does not lie within the 1:50 flood line.	1	3	1	1	**6 low**	It is likely that this impact will be **low** as long as future retrofitting of infrastructure is kept out of the two flood line recurrence intervals
CLOSURE PHASE							
Demolition activities	Decommissioning may leave large barren areas that may increase erosion, which might increase the amount of suspended solids in downstream surface water.	1	1	3	2	**6 low**	The total disturbed area of around 18 km² is relatively small and it is likely that the impact will be minimal upon closure. However, the topography of the area should be, where possible, returned to pre-construction state. Disturbed areas will be re-vegetated and thus the surface water flow regime will be primarily limited to seepage.

8.0 CONCLUSIONS

The following conclusions can be made as a result of this study:

- The available climate and rainfall data was analysed to describe the baseline conditions on the site. The 24 hour rainfall depths for different recurrence intervals were generated for use in infrastructure design. A daily rainfall and average monthly evaporation records were produced for use in the feasibility studies;
- The Northam (POL) weather station was used as the data for this study which is located 15.9 km east of this study;
- A monitoring programme has been set up to collect flow and water quality data on the project area. Although the area is very dry water quality samples were taken from the Bierspruit Dam;
- The water quality and flow data collected by DWA was sourced and assessed. The water quality results from the monitoring programme are presented in the report. The results show that the water has undesirable standards of TSS to sustain aquatic ecosystems although there is evidence of wildlife. The fluoride levels in the dam are very high and approach the limits from livestock and irrigation which is unacceptable for domestic consumption. Aluminium content in the dam is high for aquatic ecosystems and can be high for domestic use. Phosphorus is high for domestic consumption. The COD in the dam is unacceptable and indicates large amounts of waste in the dam;
- The 50 year and 100 year flood peaks and floodlines have been determined for the rivers crossing the Varkensvlei and Nooitgedacht farms. The analysis shows that the open pit is located within the floodlines of four of the tributaries;
- A high level conceptual water balance was done based of the infrastructure information available. The size of the PCD was estimated according to rough values by the specialists;
- A conceptual stormwater management plan was made based on the above information of the water balance.

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Amanda Cassa	Trevor Coleman
Water Resource Engineer	Senior Water Resource Engineer

AMC/TJC/amc

APPENDIX A

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APPENDIX B

24 hour Storm Rainfall Depths Statistical Analysis

Table B1 shows the data used in the Reg Flood program, (Alexander, et al., 2003) to produce the 24 hour rainfall depths for the 1 in 2, 1 in 5, 1 in 10, 1 in 20, 1 in 50, 1 in 100 and 1 in 200 recurrence intervals at the Northam (POL) station.

Table B1: Daily recorded maximum's for every year

Year	Daily recorded maximum rainfall (mm)
1903	10.1
1904	12.1
1905	9.7
1906	11.5
1907	11.7
1908	11.5
1909	21.2
1910	15.8
1911	13.6
1912	13.8
1913	14
1914	20.9
1915	20.8
1916	13.3
1917	17.2
1918	13.9
1919	16.4
1920	15.8
1921	16.2
1922	11.5
1923	16.5
1924	12.7
1925	13.8
1926	18.6
1927	11.1
1928	15.9
1929	12.8
1930	13.4
1931	15.3
1932	15.8
1933	13.1
1934	21.4
1935	19.5
1936	16
1937	18.4
1938	18.5
1939	26
1940	41.1
1941	14.6
1942	33.6
1943	22.3
1944	37.7
1945	30.1
1946	21.3
1947	28.6
1948	14.4

1949	36.7
1950	38.8
1951	68
1952	81
1953	40.9
1954	30.6
1955	52.6
1956	56.4
1957	40
1958	35.3
1959	40.8
1960	45.3
1961	73.1
1962	27.7
1963	77
1964	42.1
1965	51.1
1966	23.2
1967	80.5
1968	109.3
1969	130.5
1970	53.5
1971	68
1972	60
1973	57
1974	60
1975	47
1976	48.5
1977	49
1978	99
1979	74
1980	50
1981	47.5
1982	67
1983	52
1984	53
1985	43
1986	58
1987	27
1988	52.5
1989	67.5
1990	46.5
1991	88
1992	45.5
1993	80
1994	104
1995	163
1996	63.5
1997	95
1998	50
1999	54
2000	88

In order to determine the likely magnitude of storm events, a statistical approach, using the Reg Flood program (Alexander, et al., 2003), was applied to the available recorded daily rainfall depths. The maximum 24 hour rainfall depth for each year was analysed. This method statistically analyses the maximum daily rainfall depths for each year to determine the different recurrence interval daily rainfall depths. The best fit is the Log Pearson distribution which resulted in the 24 h storm rainfall depths. Figure B1 shows the Log Pearson graph.

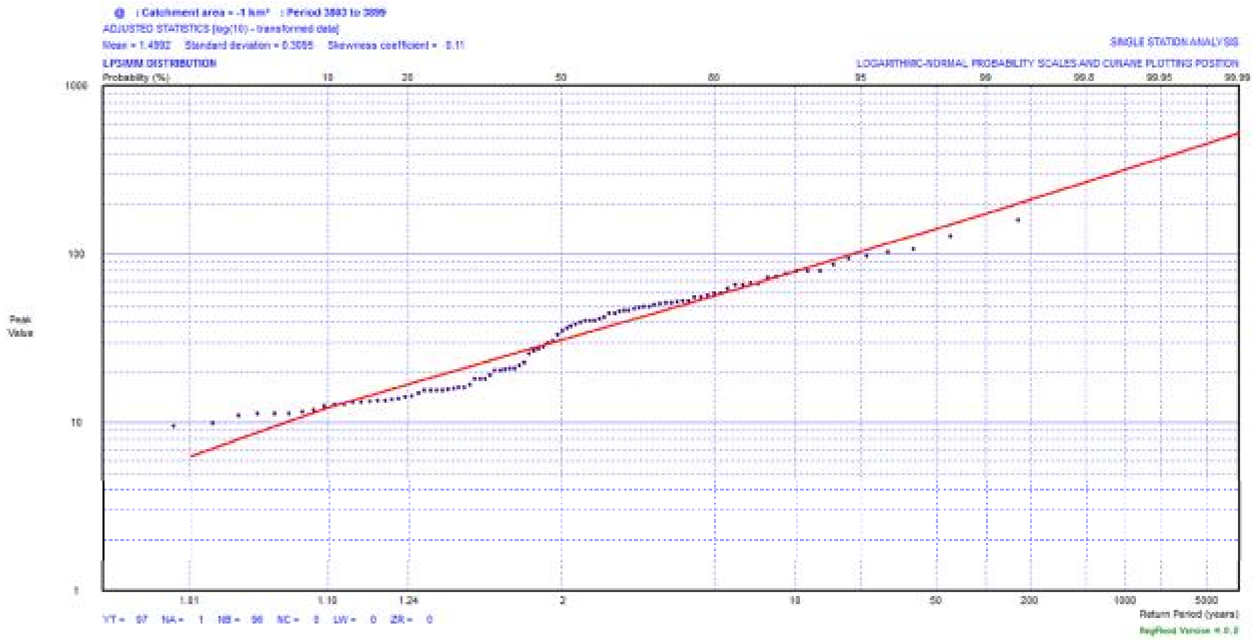

Figure B1: Log Pearson distribution curve

APPENDIX C

Cross-section setup of flow and water quality monitoring station along the Bofule River

Project:	**Samancor Chrome**	**Benchmark coordinates:**	
Project number:	13614977	**LB BM:**	24° 57' 4.5" S
Date:	20/02/2013		27° 6' 22" E
Time:	12:21	**Accuracy:**	
Site:	Varkensvlei	**Elevation:**	
River/Stream:	Bofule River	**RB BM:**	24° 57' 5.1" S
Coordinates:	24° 57' 4.8" S		27° 6' 22.4" E
	27° 6' 22.8" E	**Accuracy:**	
Accuracy:		**Elevation:**	
Elevation:	989.757		

Distance (m)	**Level (m)**	**Distance (m)**	**Level (m)**	**Comments**
0.15	1.347	0	1.088	LB BM
1	1.425	0.85	1.01	
2	1.54	1.85	0.895	
3	1.52	2.85	0.915	
4	1.63	3.85	0.805	
5	1.64	4.85	0.795	
6	1.635	5.85	0.8	
7	1.655	6.85	0.78	
8	1.59	7.85	0.845	
9	1.58	8.85	0.855	
10	1.613	9.85	0.822	
11	1.595	10.85	0.84	
11.6	1.664	11.45	0.771	
12	1.815	11.85	0.62	
12.2	2.205	12.05	0.23	
12.45	2.418	12.3	0.017	Riverbed
12.8	2.435	12.65	0	Riverbed
13.4	2.371	13.25	0.064	Riverbed
13.8	2.273	13.65	0.162	Riverbed
14.2	2.208	14.05	0.227	Riverbed
14.6	1.851	14.45	0.584	
15.1	1.749	14.95	0.686	
15.7	1.491	15.55	0.944	
16.7	1.382	16.55	1.053	
17.25	1.209	17.1	1.226	
18.63	0.913	18.48	1.522	RB BM

Water Level	**12.45**	**2.418**	**12.30**	**0.017**
Water Level	14.20	2.208	14.05	0.227

Slope calculation		
Upstream, US:	**Top**	2.36
	Middle	2.29
	Bottom	2.22
	Length	13.70
Downstream, DS:	**Top**	2.10
	Middle	2.01
	Bottom	1.91
	Length	18.40
	Channel Length	4.70

Description of reference pt:
Reference point is lone tree on right bank

Angle from RB BM to a reference pt (°)
60

Figure C1: View of cross-section in Bofule River

Figure C2: Looking upstream of cross-section in Bofule River

Figure C3: Looking downstream of cross-section in Bofule River

Figure C4: View of riverbed at cross-section in Bofule River

Figure C5: View of dumpy level and reference point (tree) on the right bank at cross-section in Bofule River

APPENDIX D

HEC-RAS output for Varkensvlei and Nooitgedacht floodlines

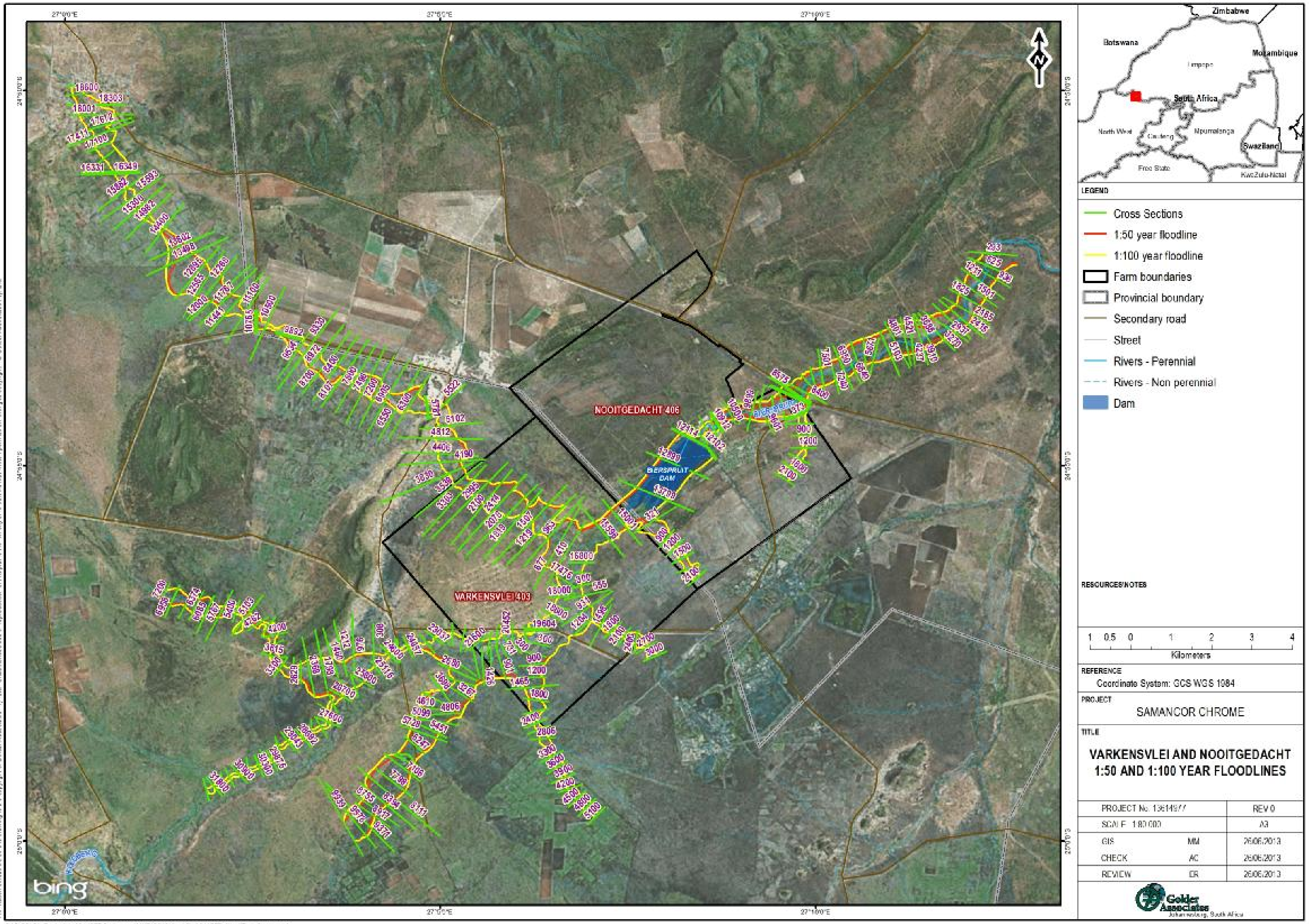

Figure D1: Floodlines and Cross-sections for the Varkensvlei and Nooitgedacht area

BIERSPRUIT – MAIN PROFILE OUTPUT TABLE

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Main	32224.42	1 in 50	309.01	970.4	989	974.81	989.01	0.000212	0.43	718.08	66.52	0.04
Main	32224.42	1 in 100	438.25	970.4	990.56	975.57	990.58	0.000293	0.53	825.55	70.84	0.05
Main	31800	1 in 50	309.01	970.46	988.91	975.03	988.92	0.000216	0.43	725.95	70.5	0.04
Main	31800	1 in 100	438.25	970.46	990.44	975.8	990.45	0.000296	0.52	837.66	75.45	0.05
Main	31438.41	1 in 50	309.01	970.4	988.84	974.89	988.85	0.00018	0.39	786.51	76.42	0.04
Main	31438.41	1 in 100	438.25	970.4	990.34	975.64	990.35	0.000247	0.48	905.26	81.43	0.05
Main	31200	1 in 50	309.01	970.52	988.8	974.6	988.81	0.000149	0.37	844.49	79.9	0.04
Main	31200	1 in 100	438.25	970.52	990.29	975.28	990.3	0.000208	0.45	967.37	85.05	0.04
Main	30900	1 in 50	309.01	971.1	988.69	976.92	988.72	0.000861	0.73	421.87	46.16	0.08
Main	30900	1 in 100	438.25	971.1	990.13	977.87	990.17	0.001164	0.89	491.66	50.43	0.09
Main	30600	1 in 50	309.01	970.28	988.6	974.55	988.61	0.000169	0.38	806.78	78.11	0.04
Main	30600	1 in 100	438.25	970.28	990.02	975.27	990.03	0.000239	0.48	920.79	83.23	0.05
Main	30300	1 in 50	309.01	970.4	988.55	974.76	988.56	0.000181	0.39	783.35	76.12	0.04
Main	30300	1 in 100	438.25	970.4	989.94	975.48	989.96	0.000255	0.49	892.51	80.8	0.05

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Main	30053.64	1 in 50	309.01	970.02	988.53	972.85	988.54	0.000055	0.25	1248.33	102.92	0.02
Main	30053.64	1 in 100	438.25	970.02	989.91	973.37	989.92	0.000082	0.31	1393.95	107.72	0.03
Main	29876.34	1 in 50	309.01	970.31	988.51	974.48	988.52	0.000167	0.38	809.79	78.07	0.04
Main	29876.34	1 in 100	438.25	970.31	989.88	975.19	989.9	0.000237	0.48	920.19	82.77	0.05
Main	29359.18	1 in 50	309.01	970.07	988.45	973.79	988.45	0.0001	0.31	990.87	89.94	0.03
Main	29359.18	1 in 100	438.25	970.07	989.79	974.4	989.8	0.000146	0.39	1115.07	94.82	0.04
Main	29043.35	1 in 50	309.01	970.62	988.4	974.54	988.41	0.000172	0.39	797.56	76.55	0.04
Main	29043.35	1 in 100	438.25	970.62	989.73	975.24	989.74	0.000248	0.49	901.88	80.98	0.05
Main	28877.74	1 in 50	309.01	970.18	988.37	974.58	988.38	0.00018	0.39	783.45	75.92	0.04
Main	28877.74	1 in 100	438.25	970.18	989.69	975.29	989.7	0.00026	0.49	885.86	80.27	0.05
Main	28692.25	1 in 50	309.01	970.49	988.34	974.64	988.35	0.000197	0.41	752.58	73.09	0.04
Main	28692.25	1 in 100	438.25	970.49	989.63	975.36	989.65	0.000286	0.52	849.97	77.27	0.05
Main	28200	1 in 50	309.01	970.08	988.24	974.6	988.25	0.000192	0.41	762.93	74.19	0.04
Main	28200	1 in 100	438.25	970.08	989.49	975.31	989.51	0.000281	0.51	858.35	78.27	0.05
Main	27900	1 in 50	309.01	970	988.19	974.36	988.2	0.000164	0.38	822.94	80.84	0.04

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Main	27900	1 in 100	438.25	970	989.42	975.06	989.43	0.000241	0.47	924.98	85.44	0.05
Main	27600	1 in 50	309.01	970.16	988.15	973.73	988.15	0.000126	0.34	906.67	84.91	0.03
Main	27600	1 in 100	438.25	970.16	989.36	974.38	989.37	0.000189	0.43	1011.88	89.43	0.04
Main	27300	1 in 50	309.01	970.37	988.11	974.33	988.11	0.000143	0.35	877.33	86.86	0.04
Main	27300	1 in 100	438.25	970.37	989.3	974.99	989.31	0.000212	0.45	983.32	91.68	0.04
Main	27045.61	1 in 50	309.01	970.09	988.08	973.25	988.09	0.000081	0.29	1081.88	95.95	0.03
Main	27045.61	1 in 100	438.25	970.09	989.26	973.81	989.26	0.000124	0.37	1197.06	100.25	0.03
Main	26700	1 in 50	309.01	970.35	988.04	974.17	988.05	0.00016	0.37	837.45	83.39	0.04
Main	26700	1 in 100	438.25	970.35	989.19	974.85	989.21	0.000239	0.47	936.3	88.09	0.05
Main	26325.82	1 in 50	309.01	970.23	988	973.46	988	0.000086	0.29	1066.11	97.6	0.03
Main	26325.82	1 in 100	438.25	970.23	989.13	974.03	989.14	0.000131	0.37	1179.11	102.1	0.03
Main	26100	1 in 50	309.01	970.01	987.98	973.84	987.98	0.000124	0.34	920.06	87.54	0.03
Main	26100	1 in 100	438.25	970.01	989.09	974.48	989.1	0.000183	0.43	1020.46	91.86	0.04
Main	25800	1 in 50	309.01	970.33	987.94	973.83	987.95	0.000115	0.33	942.66	88.32	0.03
Main	25800	1 in 100	438.25	970.33	989.04	974.44	989.05	0.000177	0.42	1042.12	92.32	0.04

Reach	River Station	Profile	Q Total (m³/s)	Minimum Channel Elevation (m)	Water Surface Elevation (m)	Critical Water Surface (m)	Energy Gradient Elevation (m)	Energy Gradient Slope (m/m)	Velocity Channel (m/s)	Flow Area (m²)	Top Width (m)	Froude No Channel
Main	25561.27	1 in 50	309.01	970.5	987.9	974.35	987.91	0.000172	0.38	814.35	82.28	0.04
Main	25561.27	1 in 100	438.25	970.5	988.99	975.03	989	0.000255	0.48	905.88	86.79	0.05
Main	25115.77	1 in 50	309.01	970.33	987.84	974.11	987.84	0.000145	0.35	873.71	87.03	0.04
Main	25115.77	1 in 100	438.25	970.33	988.88	974.78	988.89	0.000222	0.45	967.22	91.58	0.04
Main	24600	1 in 50	296.35	970.54	987.76	974.19	987.77	0.000139	0.34	862.81	87.19	0.03
Main	24600	1 in 100	429.21	970.54	988.77	974.89	988.78	0.000223	0.45	952.62	91.44	0.04
Main	24328.72	1 in 50	296.35	970.66	987.72	974.42	987.73	0.000151	0.35	845.23	88.44	0.04
Main	24328.72	1 in 100	429.21	970.66	988.7	975.13	988.72	0.000242	0.46	934.24	92.95	0.05
Main	24313.64	1 in 50	296.35	970.7	987.72	974.47	987.73	0.000166	0.37	807.02	84.37	0.04
Main	24313.64	1 in 100	429.21	970.7	988.7	975.2	988.71	0.000268	0.48	891.76	88.68	0.05
Main	24300	1 in 50	296.35	970.21	987.72	974.42	987.72	0.000172	0.37	791.57	82.08	0.04
Main	24300	1 in 100	429.21	970.21	988.69	975.15	988.71	0.000278	0.49	873.86	86.23	0.05
Main	24284.78	1 in 50	296.35	970.29	987.71	974.4	987.72	0.000174	0.38	785.31	80.84	0.04
Main	24284.78	1 in 100	429.21	970.29	988.69	975.14	988.7	0.000281	0.5	866.16	84.82	0.05

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Main	24056.76	1 in 50	296.35	970.17	987.68	974.31	987.68	0.000164	0.37	805.82	82.58	0.04
Main	24056.76	1 in 100	429.21	970.17	988.63	975.03	988.64	0.000266	0.48	886.34	86.49	0.05
Main	23885.72	1 in 50	296.35	970.32	987.65	974.18	987.66	0.00015	0.36	830.77	83.68	0.04
Main	23885.72	1 in 100	429.21	970.32	988.59	974.88	988.6	0.000246	0.47	910.81	87.41	0.05
Main	23400	1 in 50	296.35	970.47	987.59	974.01	987.6	0.000103	0.31	968.31	100.58	0.03
Main	23400	1 in 100	429.21	970.47	988.49	974.65	988.5	0.000167	0.41	1061.04	105.79	0.04
Main	23037.15	1 in 50	296.35	970.03	987.57	972.16	987.58	0.000031	0.19	1560.74	135.52	0.02
Main	23037.15	1 in 100	429.21	970.03	988.46	972.61	988.47	0.000052	0.26	1683.6	141.21	0.02
Main	22800	1 in 50	296.35	970.55	987.55	974.72	987.56	0.000217	0.42	707.87	76.14	0.04
Main	22800	1 in 100	429.21	970.55	988.42	975.47	988.44	0.000353	0.56	776.21	80.64	0.05
Main	22500	1 in 50	296.35	970.24	987.51	973.65	987.52	0.000094	0.29	1026.27	103.56	0.03
Main	22500	1 in 100	429.21	970.24	988.36	974.28	988.37	0.000155	0.39	1116.12	108.3	0.04
Main	22149.65	1 in 50	296.35	970.07	987.48	973.21	987.49	0.000077	0.26	1119.7	110.89	0.03
Main	22149.65	1 in 100	429.21	970.07	988.31	973.81	988.32	0.000132	0.35	1213.6	115.87	0.03
Main	21900	1 in 50	296.35	970.13	987.47	972.68	987.47	0.000039	0.2	1468.93	144.11	0.02

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Main	21900	1 in 100	429.21	970.13	988.29	973.18	988.3	0.000066	0.27	1590.13	151.6	0.03
Main	21600	1 in 50	296.35	970.14	987.46	972.81	987.46	0.000059	0.24	1239.65	116.5	0.02
Main	21600	1 in 100	429.21	970.14	988.27	973.36	988.27	0.0001	0.32	1335.67	120.83	0.03
Main	21300	1 in 50	296.35	970.09	987.44	972.86	987.44	0.000051	0.22	1353.64	133.74	0.02
Main	21300	1 in 100	429.21	970.09	988.24	973.39	988.24	0.000086	0.29	1462.85	139.91	0.03
Main	21084.79	1 in 50	296.35	970.07	987.43	972.72	987.43	0.000057	0.24	1246.29	115.07	0.02
Main	21084.79	1 in 100	429.21	970.07	988.22	973.26	988.22	0.000099	0.32	1338.87	119.37	0.03
Main	20700	1 in 50	296.35	970.02	987.41	972.2	987.41	0.000051	0.23	1299.04	117.82	0.02
Main	20700	1 in 100	429.21	970.02	988.18	972.69	988.19	0.00009	0.31	1392.09	122.49	0.03
Main	20451.76	1 in 50	296.35	970.21	987.39	973.65	987.39	0.000081	0.28	1082.32	119.6	0.03
Main	20451.76	1 in 100	429.21	970.21	988.15	974.28	988.16	0.000137	0.38	1176.52	127.92	0.04
Main	19993.82	1 in 50	341.4	970.28	987.34	973.55	987.34	0.000074	0.28	1286.45	146.12	0.03
Main	19993.82	1 in 100	494.47	970.28	988.05	974.18	988.06	0.000125	0.38	1395.27	157.5	0.04
Main	19604.24	1 in 50	341.4	970.43	987.28	974.56	987.29	0.0003	0.48	711.16	76.09	0.05
Main	19604.24	1 in 100	494.47	970.43	987.95	975.34	987.97	0.000513	0.65	763.74	79.79	0.07

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Main	19589.21	1 in 50	341.4	970.15	987.27	974.6	987.28	0.000269	0.46	737.34	81.04	0.05
Main	19589.21	1 in 100	494.47	970.15	987.94	975.39	987.96	0.000463	0.63	793.38	85.54	0.06
Main	19573.18	1 in 50	341.4	970.37	987.27	974.52	987.28	0.000237	0.45	774.43	86.44	0.05
Main	19573.18	1 in 100	494.47	970.37	987.94	975.29	987.96	0.000407	0.6	833.96	91.33	0.06
Main	19557.38	1 in 50	341.4	970.56	987.27	974.63	987.27	0.000229	0.43	802.22	93.8	0.04
Main	19557.38	1 in 100	494.47	970.56	987.93	975.41	987.95	0.000393	0.58	867.02	100.3	0.06
Main	18900	1 in 50	341.4	970.08	987.2	973.24	987.2	0.000063	0.26	1365.75	148.21	0.02
Main	18900	1 in 100	494.47	970.08	987.82	973.83	987.82	0.00011	0.35	1459.93	155.65	0.03
Main	18600	1 in 50	341.4	970.35	987.18	973.76	987.18	0.00008	0.29	1229.02	144.7	0.03
Main	18600	1 in 100	494.47	970.35	987.78	974.39	987.79	0.00014	0.4	1319.39	155.17	0.04
Main	18300	1 in 50	341.4	970.23	987.15	973.82	987.15	0.000092	0.31	1157.04	132.55	0.03
Main	18300	1 in 100	494.47	970.23	987.73	974.46	987.74	0.00016	0.42	1236.73	140.65	0.04
Main	18000	1 in 50	341.4	970.25	987.12	973.84	987.13	0.000097	0.31	1144.5	132.3	0.03
Main	18000	1 in 100	494.47	970.25	987.68	974.49	987.69	0.000174	0.43	1221.06	140.37	0.04

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Main	17700	1 in 50	341.4	970.05	987.1	973.04	987.1	0.000068	0.27	1324.87	146.14	0.03
Main	17700	1 in 100	494.47	970.05	987.64	973.64	987.65	0.000123	0.37	1406.87	155.99	0.03
Main	17475.56	1 in 50	341.4	970.26	987.08	973.87	987.09	0.000078	0.29	1370.59	253.42	0.03
Main	17475.56	1 in 100	494.47	970.26	987.61	974.52	987.62	0.000133	0.39	1505.86	255.38	0.04
Main	17071.93	1 in 50	342.89	970.1	987.02	973.63	987.02	0.000101	0.31	1138.35	126.85	0.03
Main	17071.93	1 in 100	496.79	970.1	987.49	974.29	987.5	0.000184	0.42	1198.82	131.77	0.04
Main	16800	1 in 50	342.89	970.26	986.99	973.83	987	0.000093	0.31	1166.96	135.18	0.03
Main	16800	1 in 100	496.79	970.26	987.44	974.48	987.45	0.000169	0.43	1228.47	140.78	0.04
Main	15596.46	1 in 50	366.79	970.15	986.89	973.37	986.9	0.000072	0.28	1369.3	160.06	0.03
Main	15596.46	1 in 100	533.85	970.15	987.25	973.97	987.26	0.000136	0.39	1427.75	168.24	0.04
Main	15001.48	1 in 50	366.79	970.28	986.84	973.89	986.85	0.000092	0.31	1396.97	292.46	0.03
Main	15001.48	1 in 100	533.85	970.28	987.16	974.56	987.17	0.000172	0.43	1493.01	318.82	0.04
Main	13799.49	1 in 50	382.07	970.21	986.71	973.95	986.71	0.000113	0.34	1210.46	155.07	0.03
Main	13799.49	1 in 100	553.55	970.21	986.89	974.63	986.9	0.000224	0.48	1239.55	159.8	0.05
Main	12899.29	1 in 50	382.07	970.08	986.61	973.92	986.61	0.000111	0.34	1306.09	286.27	0.03

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Main	12899.29	1 in 100	553.55	970.08	986.69	974.58	986.7	0.000226	0.48	1330.37	296.99	0.05
Main	12125.15	1 in 50	382.07	970.15	986.52	973.53	986.53	0.000105	0.33	1295.75	182.42	0.03
Main	12125.15	1 in 100	553.55	970.15	986.52	974.16	986.53	0.00022	0.48	1294.69	182.4	0.05
Main	12120		Inl Struct									
Main	12113.83	1 in 50	382.07	970.2	981.97	973.61	981.99	0.000492	0.57	694.72	103.67	0.07
Main	12113.83	1 in 100	553.55	970.2	983.2	974.25	983.23	0.000643	0.7	828.71	114.41	0.08
Main	12101.94	1 in 50	382.07	970.08	981.97	973.66	981.98	0.000507	0.56	690.86	103.41	0.07
Main	12101.94	1 in 100	553.55	970.08	983.2	974.3	983.22	0.000657	0.69	824.03	113.59	0.08
Main	11700	1 in 50	382.07	970.29	981.75	973.76	981.76	0.000598	0.56	683.15	109.14	0.07
Main	11700	1 in 100	553.55	970.29	982.92	974.41	982.94	0.000718	0.69	818.64	122.25	0.08
Main	11443.06	1 in 50	382.07	970.27	981.61	973.79	981.62	0.000516	0.52	765.11	161.76	0.07
Main	11443.06	1 in 100	553.55	970.27	982.75	974.41	982.77	0.000622	0.62	978.59	212.09	0.07
Main	11100	1 in 50	382.07	970.04	981.49	972.91	981.49	0.000268	0.4	1010.04	204.5	0.05
Main	11100	1 in 100	553.55	970.04	982.6	973.44	982.62	0.000335	0.5	1269.28	332.16	0.05

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Main	10959.19	1 in 50	382.07	970.02	981.46	972.3	981.47	0.000151	0.31	1253.86	188.62	0.04
Main	10959.19	1 in 100	553.55	970.02	982.57	972.76	982.58	0.000202	0.38	1532.47	313.48	0.04
Main	10911.99	1 in 50	382.07	970.2	981.45	973.51	981.46	0.000216	0.35	1127.65	188.15	0.04
Main	10911.99	1 in 100	553.55	970.2	982.56	973.92	982.57	0.000268	0.42	1408.97	309.12	0.05
Main	10900.45	1 in 50	382.07	970.54	981.45	974.72	981.45	0.000333	0.39	989.71	187.79	0.05
Main	10900.45	1 in 100	553.55	970.54	982.55	975.16	982.56	0.000381	0.47	1269.76	307.29	0.06
Main	10883.86	1 in 50	382.07	970.94	981.42	975.76	981.44	0.001333	0.62	643.49	185.1	0.1
Main	10883.86	1 in 100	553.55	970.94	982.53	976.64	982.55	0.001158	0.67	916.64	301.89	0.09
Main	10692.81	1 in 50	382.07	970.45	981.19	974.5	981.21	0.001088	0.66	583.36	118.9	0.09
Main	10692.81	1 in 100	553.55	970.45	982.28	975.21	982.31	0.001359	0.77	756.42	208.93	0.1
Main	10500	1 in 50	382.07	970.14	980.77	975.76	980.83	0.00448	1.12	343.61	90.32	0.18
Main	10500	1 in 100	553.55	970.14	981.88	976.68	981.92	0.00329	1.02	652.9	250.75	0.15
Main	10200	1 in 50	382.07	970.58	980.53	976.17	980.54	0.00038	0.39	1046.04	252.19	0.05
Main	10200	1 in 100	553.55	970.58	981.64	976.63	981.65	0.000403	0.45	1399.77	372.44	0.06
Main	9899.443	1 in 50	382.07	970.03	980.36	973.55	980.38	0.000808	0.61	675.3	164.62	0.08

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Main	9899.443	1 in 100	553.55	970.03	981.47	974.18	981.49	0.000704	0.64	1161.7	426.24	0.08
Main	9600.554	1 in 50	382.07	970.2	980.19	973.15	980.21	0.000438	0.5	982.28	291.78	0.06
Main	9600.554	1 in 100	553.55	970.2	981.3	973.71	981.31	0.000491	0.51	1491.74	512.15	0.06
Main	9300	1 in 50	393.73	970.03	980.04	973.12	980.06	0.000556	0.56	757.9	181.56	0.07
Main	9300	1 in 100	571.54	970.03	981.13	973.68	981.15	0.000592	0.63	1189.73	491.73	0.07
Main	9082.09	1 in 50	393.73	970.18	979.89	973.45	979.91	0.000798	0.62	723.16	307.81	0.08
Main	9082.09	1 in 100	571.54	970.18	980.99	974.04	981.01	0.000728	0.66	1145.1	415.83	0.08
Main	8650.264	1 in 50	400.99	970.1	979.64	973.02	979.65	0.000483	0.5	859.52	199.13	0.06
Main	8650.264	1 in 100	580.92	970.1	980.77	973.54	980.78	0.000417	0.52	1610.65	698.02	0.06
Main	8633.859	1 in 50	400.99	970.13	979.63	973.01	979.64	0.000472	0.49	865.78	196.29	0.06
Main	8633.859	1 in 100	580.92	970.13	980.76	973.52	980.77	0.000405	0.51	1626	698.89	0.06
Main	8630		Culvert									
Main	8621.33	1 in 50	400.99	970.07	979.59	972.98	979.61	0.000476	0.49	861.79	196.22	0.06
Main	8621.33	1 in 100	580.92	970.07	980.69	973.5	980.71	0.000421	0.52	1591.02	691.6	0.06

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Main	8604.084	1 in 50	400.99	970.13	979.59	973.07	979.6	0.000478	0.49	958.61	385.94	0.06
Main	8604.084	1 in 100	580.92	970.13	980.69	973.6	980.7	0.000436	0.52	1586.01	693.73	0.06
Main	8574.551	1 in 50	400.99	970.13	979.56	973.2	979.58	0.000669	0.58	727.88	163.26	0.07
Main	8574.551	1 in 100	580.92	970.13	980.67	973.75	980.68	0.000525	0.58	1514.54	709.71	0.07
Main	8559.972	1 in 50	400.99	970.12	979.55	973.19	979.57	0.000682	0.59	717.06	158.91	0.08
Main	8559.972	1 in 100	580.92	970.12	980.66	973.75	980.68	0.000537	0.58	1500.31	709.37	0.07
Main	8550		Bridge									
Main	8548.229	1 in 50	400.99	970.05	979.14	973.24	979.16	0.000877	0.65	650.36	144.72	0.08
Main	8548.229	1 in 100	580.92	970.05	979.91	973.79	979.94	0.001191	0.82	773.41	183.48	0.1
Main	8533.828	1 in 50	400.99	970.1	979.13	973.26	979.15	0.00089	0.65	653.83	148.9	0.08
Main	8533.828	1 in 100	580.92	970.1	979.89	973.82	979.92	0.001203	0.82	780.53	188.04	0.1
Main	8400.272	1 in 50	400.99	970.14	979.01	973.12	979.03	0.000835	0.63	676.47	153.42	0.08
Main	8400.272	1 in 100	580.92	970.14	979.73	973.67	979.77	0.001156	0.8	797.88	188.17	0.1
Main	8042.645	1 in 50	400.99	970.04	978.84	972.37	978.85	0.000356	0.43	1045.75	292.31	0.05
Main	8042.645	1 in 100	580.92	970.04	979.49	972.82	979.5	0.000507	0.55	1276.4	432.16	0.07

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Main	7800	1 in 50	400.99	970.09	978.73	972.79	978.75	0.000496	0.47	957.76	304.41	0.06
Main	7800	1 in 100	580.92	970.09	979.35	973.27	979.37	0.000653	0.58	1253.04	482.11	0.07
Main	7501.034	1 in 50	400.99	970.61	978.49	975.16	978.51	0.001659	0.64	833.61	411.29	0.11
Main	7501.034	1 in 100	580.92	970.61	979.06	976.48	979.08	0.001761	0.72	1082.31	464.51	0.11
Main	7239.744	1 in 50	400.99	970.26	977.89	974.59	977.92	0.003201	0.81	661.97	408.07	0.14
Main	7239.744	1 in 100	580.92	970.26	978.46	975.33	978.48	0.003026	0.88	914.03	485.36	0.14
Main	6949.554	1 in 50	400.99	970.34	977.09	974.84	977.11	0.002501	0.66	778.53	446.98	0.13
Main	6949.554	1 in 100	580.92	970.34	977.77	975.49	977.79	0.001983	0.68	1101.56	502.61	0.12
Main	6649.458	1 in 50	400.99	970.03	976.82	971.96	976.83	0.000506	0.44	1142.77	474.42	0.06
Main	6649.458	1 in 100	580.92	970.03	977.49	972.34	977.5	0.000583	0.51	1494.33	565.97	0.07
Main	6394.837	1 in 50	400.99	970.09	976.67	972.41	976.68	0.000645	0.46	1194.48	573.83	0.07
Main	6394.837	1 in 100	580.92	970.09	977.34	972.81	977.34	0.000661	0.51	1603.02	657.45	0.07
Main	6046.774	1 in 50	400.99	970.04	976.47	972.31	976.48	0.000611	0.47	1184	564.91	0.07
Main	6046.774	1 in 100	580.92	970.04	977.13	972.72	977.14	0.000646	0.53	1584.35	649.83	0.07

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Main	5671.459	1 in 50	400.99	970.08	976.31	971.69	976.31	0.000354	0.32	1527.48	588.54	0.05
Main	5671.459	1 in 100	580.92	970.08	976.95	972.02	976.96	0.000381	0.37	1920.67	619.27	0.05
Main	5102.946	1 in 50	400.99	970.01	976.05	972.44	976.06	0.000771	0.51	1164.29	603.19	0.08
Main	5102.946	1 in 100	580.92	970.01	976.69	972.85	976.7	0.000749	0.55	1576.2	670.67	0.08
Main	4800.742	1 in 50	400.99	970.07	975.82	972.35	975.83	0.000798	0.51	1171.72	657.56	0.08
Main	4800.742	1 in 100	580.92	970.07	976.48	972.79	976.49	0.000737	0.54	1636.83	748.66	0.08
Main	4521.373	1 in 50	400.99	970.02	975.62	971.85	975.63	0.000629	0.46	1218.36	629.5	0.07
Main	4521.373	1 in 100	580.92	970.02	976.29	972.2	976.3	0.000635	0.51	1684.82	764.24	0.07
Main	4236.817	1 in 50	400.99	970.01	975.43	972.13	975.44	0.000819	0.48	1157.26	629.26	0.08
Main	4236.817	1 in 100	580.92	970.01	976.11	972.65	976.12	0.000778	0.52	1638.86	796.07	0.08
Main	3909.799	1 in 50	400.99	970.01	975.12	972.16	975.13	0.001207	0.57	958.73	523.56	0.09
Main	3909.799	1 in 100	580.92	970.01	975.82	972.56	975.83	0.001138	0.62	1414.36	770.51	0.09
Main	3685.616	1 in 50	400.99	970.01	974.91	971.59	974.92	0.00083	0.48	999.48	451.93	0.08
Main	3685.616	1 in 100	580.92	970.01	975.6	971.85	975.61	0.000895	0.56	1405.88	714.32	0.08
Main	3270.093	1 in 50	400.99	970.03	974.49	972.08	974.51	0.001435	0.6	897.84	452.87	0.1

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Main	3270.093	1 in 100	580.92	970.03	975.16	972.42	975.18	0.001486	0.68	1249.98	635.62	0.1
Main	2937.375	1 in 50	400.99	970	974.27	970.96	974.28	0.00044	0.36	1433.43	565.94	0.06
Main	2937.375	1 in 100	580.92	970	974.93	971.19	974.93	0.000492	0.42	1831.5	653.75	0.06
Main	2720.667	1 in 50	400.99	969.99	974.17	970.89	974.18	0.000483	0.38	1345.43	503.41	0.06
Main	2720.667	1 in 100	580.92	969.99	974.81	971.1	974.82	0.000553	0.44	1687.91	564.79	0.06
Main	2414.963	1 in 50	400.99	970	974.04	970.9	974.04	0.000503	0.38	1326.27	498.69	0.06
Main	2414.963	1 in 100	580.92	970	974.66	971.11	974.66	0.000585	0.45	1653.67	558.23	0.07
Main	2164.841	1 in 50	400.99	970	973.87	971.02	973.88	0.000808	0.46	1087.16	432.7	0.08
Main	2164.841	1 in 100	580.92	970	974.47	971.24	974.48	0.000931	0.54	1358.66	482.37	0.08
Main	1825.009	1 in 50	400.99	970	973.61	970.87	973.61	0.000768	0.43	1181.81	502.84	0.07
Main	1825.009	1 in 100	580.92	970	974.16	971.08	974.17	0.000886	0.51	1475.75	559.8	0.08
Main	1501.064	1 in 50	400.99	970	973.36	970.89	973.37	0.000879	0.44	1164.77	537.99	0.08
Main	1501.064	1 in 100	580.92	970	973.88	971.09	973.89	0.001006	0.52	1459	599.49	0.08
Main	1211.478	1 in 50	400.99	970	973.07	970.87	973.08	0.001139	0.47	1091.07	551.18	0.09
Main	1211.478	1 in 100	580.92	970	973.55	971.07	973.56	0.001294	0.56	1368.92	613.91	0.09

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Main	936.0118	1 in 50	400.99	970	972.74	970.77	972.75	0.00136	0.48	1057.56	577.73	0.09
Main	936.0118	1 in 100	580.92	970	973.17	970.94	973.18	0.001552	0.57	1318.83	634.99	0.1
Main	625.3508	1 in 50	400.99	969.99	972.32	970.6	972.33	0.001623	0.47	1030.18	614.28	0.1
Main	625.3508	1 in 100	580.92	969.99	972.69	970.75	972.7	0.001921	0.56	1263.85	667.24	0.11
Main	292.949	1 in 50	400.99	969.59	971.19	970.66	971.21	0.010014	0.78	657.35	771.44	0.22
Main	292.949	1 in 100	580.92	969.59	971.41	970.76	971.44	0.010006	0.86	828.64	782.13	0.23

BOFULE –TRIB PROFILE OUTPUT TABLE

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	2100	1 in 50	52.63	996.61	997.72	997.15	997.73	0.005486	0.44	141.22	250.44	0.15
Trib	2100	1 in 100	67.14	996.61	997.82	997.2	997.83	0.005607	0.48	167.28	268.03	0.16
Trib	1800	1 in 50	52.63	993.74	994.77	994.33	994.79	0.021794	0.76	73.16	129.93	0.29
Trib	1800	1 in 100	67.14	993.74	994.88	994.4	994.91	0.020618	0.81	89.04	149.52	0.29
Trib	1500	1 in 50	52.63	990.89	992.36	991.53	992.37	0.004169	0.45	124.7	150.44	0.14

Trib	1500	1 in 100	67.14	990.89	992.51	991.6	992.52	0.004187	0.5	148.26	162.7	0.14
Trib	1200	1 in 50	52.63	988	989.16	988.84	989.24	0.059653	1.22	43.08	66.23	0.48
Trib	1200	1 in 100	67.14	988	989.28	988.93	989.37	0.060871	1.31	51.2	72.18	0.5
Trib	900	1 in 50	52.63	984.89	986.06	985.4	986.06	0.004206	0.42	146.55	222.36	0.14
Trib	900	1 in 100	67.14	984.89	986.18	985.46	986.19	0.004183	0.46	175.11	238.17	0.14
Trib	600	1 in 50	52.63	982.79	984.32	983.8	984.34	0.008371	0.51	111.69	167.11	0.19
Trib	600	1 in 100	67.14	982.79	984.44	983.85	984.46	0.008478	0.54	132.22	177.77	0.19
Trib	373.2911	1 in 50	52.63	980.95	981.88	981.49	981.9	0.0135	0.6	101.89	221.84	0.23
Trib	373.2911	1 in 100	67.14	980.95	981.97	981.54	981.99	0.013663	0.65	121.47	240.41	0.24
Trib	353.1833	1 in 50	52.63	980.73	981.61	981.24	981.63	0.013563	0.59	105	237.59	0.23
Trib	353.1833	1 in 100	67.14	980.73	981.69	981.29	981.71	0.013766	0.64	125.31	264.02	0.24
Trib	336.1273	1 in 50	52.63	980.56	981.38	981.02	981.4	0.012929	0.57	110.96	270.53	0.23
Trib	336.1273	1 in 100	67.14	980.56	981.46	981.07	981.48	0.012848	0.61	133.65	294.1	0.23
Trib	317.4241	1 in 50	52.63	980.36	981.17	980.79	981.18	0.009999	0.51	127.44	307.85	0.2
Trib	317.4241	1 in 100	67.14	980.36	981.26	980.83	981.27	0.010009	0.55	153.34	335.3	0.2

TRIB2 –TRIB PROFILE OUTPUT TABLE

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Trib	2100	1 in 50	41.99	1003.12	1003.94	1003.56	1003.95	0.011567	0.52	91.03	199.12	0.21
Trib	2100	1 in 100	58.05	1003.12	1004.03	1003.62	1004.05	0.013093	0.61	109.54	213.02	0.23
Trib	1800	1 in 50	41.99	999.88	1000.42	1000.16	1000.43	0.012263	0.41	111	315.61	0.2
Trib	1800	1 in 100	58.05	999.88	1000.51	1000.19	1000.52	0.010849	0.44	142.36	331.21	0.2
Trib	1500	1 in 50	41.99	997.26	998.49	997.78	998.5	0.003885	0.4	120.07	201.98	0.13
Trib	1500	1 in 100	58.05	997.26	998.65	997.86	998.66	0.00397	0.45	154.35	236.62	0.14
Trib	1200	1 in 50	41.99	994.01	994.55	994.55	994.72	0.298775	1.82	23.49	74.35	0.98
Trib	1200	1 in 100	58.05	994.01	994.64	994.64	994.84	0.274714	1.98	30.36	82.43	0.97
Trib	900	1 in 50	41.99	990.54	991.97	991.02	991.97	0.001345	0.26	181.54	214.47	0.08
Trib	900	1 in 100	58.05	990.54	992.16	991.09	992.17	0.001388	0.29	225.13	233.12	0.08
Trib	320.8817	1 in 50	41.99	988.02	989.13	989.13	989.28	0.294437	0.85	24.46	78.33	0.8
Trib	320.8817	1 in 100	58.05	988.02	989.21	989.21	989.39	0.294017	1.04	31	86.97	0.84

TRIB3 –TRIB PROFILE OUTPUT TABLE

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Trib	3000	1 in 50	35.91	1011.26	1012.09	1011.64	1012.1	0.006151	0.36	109.05	227.24	0.15
Trib	3000	1 in 100	49.36	1011.26	1012.2	1011.69	1012.21	0.006195	0.41	135.22	247.23	0.16
Trib	2700	1 in 50	35.91	1005.66	1006.23	1006.23	1006.39	0.329922	1.79	20.04	62.61	1.01
Trib	2700	1 in 100	49.36	1005.66	1006.32	1006.32	1006.5	0.315125	1.91	25.8	70.55	1.01
Trib	2400	1 in 50	35.91	1001.42	1002.23	1001.7	1002.23	0.0036	0.29	128.93	222.27	0.12
Trib	2400	1 in 100	49.36	1001.42	1002.35	1001.74	1002.35	0.003836	0.33	156.48	234.65	0.12
Trib	2100	1 in 50	35.91	998.25	998.8	998.76	998.92	0.212422	1.55	23.93	78.86	0.83
Trib	2100	1 in 100	49.36	998.25	998.92	998.84	999.03	0.142017	1.51	34.8	93.86	0.71
Trib	1800	1 in 50	35.91	995.22	996.37	995.65	996.38	0.002575	0.33	125.34	190.5	0.11
Trib	1800	1 in 100	49.36	995.22	996.53	995.72	996.54	0.002662	0.37	156.45	210.05	0.11
Trib	1497.963	1 in 50	35.91	993.19	993.6	993.6	993.72	0.35777	1.57	22.82	92.04	1.01
Trib	1497.963	1 in 100	49.36	993.19	993.66	993.66	993.81	0.337631	1.68	29.36	102.88	1
Trib	1203.839	1 in 50	35.91	990.9	991.04	991.04	991.04	0.000457	0.02	346.69	599.57	0.03
Trib	1203.839	1 in 100	49.36	990.9	991.04	991.04	991.04	0.000863	0.03	346.69	599.57	0.04

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	931.2278	1 in 50	35.91	989.48	989.85	989.85	989.85	0.000782	0.03	296.77	703.77	0.04
Trib	931.2278	1 in 100	49.36	989.48	989.85	989.85	989.85	0.001478	0.05	296.77	703.77	0.05
Trib	554.7047	1 in 50	35.91	988.21	987.92	988.08	988.59	2.625633		9.96	51.61	0
Trib	554.7047	1 in 100	49.36	988.21	988.84	988.13	988.84	0.0014	0.11	246.79	345.77	0.07
Trib	300	1 in 50	35.91	988.02	987.27	987.27	987.46	0.322009		18.41	49.73	0
Trib	300	1 in 100	49.36	988.02	987.43	987.43	987.58	0.327177		28.41	92.36	0

TRIB4 –TRIB PROFILE OUTPUT TABLE

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	5100	1 in 50	35.99	1025.19	1025.52	1025.52	1025.61	0.336217	1.43	27.09	150.33	0.96
Trib	5100	1 in 100	49.3	1025.19	1025.57	1025.57	1025.68	0.303963	1.55	34.85	163.79	0.95
Trib	4800	1 in 50	35.99	1019.75	1020.71	1020.11	1020.72	0.003043	0.32	126.21	203.34	0.11
Trib	4800	1 in 100	49.3	1019.75	1020.86	1020.16	1020.86	0.003083	0.36	156.19	217.43	0.12
Trib	4500	1 in 50	35.99	1017.87	1018.75	1018.38	1018.78	0.021752	0.75	52.71	104	0.29
Trib	4500	1 in 100	49.3	1017.87	1018.89	1018.46	1018.92	0.021268	0.82	67.15	116.22	0.3

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	4200	1 in 50	35.99	1015.19	1016.23	1015.61	1016.24	0.004533	0.37	104.56	167.25	0.14
Trib	4200	1 in 100	49.3	1015.19	1016.37	1015.68	1016.38	0.004571	0.42	129.21	181.85	0.14
Trib	3900	1 in 50	35.99	1012.47	1013.39	1013.04	1013.43	0.029341	0.86	44.27	85.77	0.34
Trib	3900	1 in 100	49.3	1012.47	1013.52	1013.13	1013.57	0.028728	0.95	56.52	98.64	0.34
Trib	3600	1 in 50	35.99	1009.37	1010.43	1009.77	1010.44	0.004913	0.43	99.38	160.5	0.15
Trib	3600	1 in 100	49.3	1009.37	1010.61	1009.85	1010.62	0.004847	0.44	130.82	191.39	0.15
Trib	3300	1 in 50	35.99	1007.51	1008.59	1008.02	1008.61	0.007878	0.48	80.45	137.5	0.18
Trib	3300	1 in 100	49.3	1007.51	1008.71	1008.09	1008.73	0.008646	0.55	97.46	154.83	0.19
Trib	2806.263	1 in 50	35.99	1004.17	1005.18	1004.62	1005.19	0.006162	0.43	91.84	175.43	0.16
Trib	2806.263	1 in 100	49.3	1004.17	1005.33	1004.69	1005.34	0.005603	0.47	120.44	198.35	0.16
Trib	2567.7	1 in 50	35.99	1002.81	1004.09	1003.31	1004.1	0.003458	0.37	107.49	150.82	0.12
Trib	2567.7	1 in 100	49.3	1002.81	1004.26	1003.38	1004.27	0.003616	0.41	134.25	168.54	0.13
Trib	2400	1 in 50	35.99	1001.92	1002.8	1002.44	1002.82	0.027994	0.76	47.82	92.57	0.32
Trib	2400	1 in 100	49.3	1001.92	1002.92	1002.53	1002.95	0.028067	0.85	59.53	102.18	0.33

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	2100	1 in 50	35.99	999.9	1000.69	1000.23	1000.69	0.003188	0.29	143.3	280.89	0.11
Trib	2100	1 in 100	49.3	999.9	1000.81	1000.27	1000.81	0.003205	0.33	176.56	294.58	0.12
Trib	1800	1 in 50	35.99	998.09	998.79	998.5	998.81	0.018622	0.59	72.41	240.46	0.26
Trib	1800	1 in 100	49.3	998.09	998.86	998.56	998.88	0.019792	0.67	91.11	270.3	0.27
Trib	1465.136	1 in 50	35.99	995.44	995.95	995.61	995.95	0.00494	0.27	143.23	388.47	0.13
Trib	1465.136	1 in 100	49.3	995.44	996.04	995.64	996.05	0.004739	0.3	180.48	419.54	0.13
Trib	1200	1 in 50	35.99	994.37	995	994.58	995	0.002725	0.23	179.48	468.58	0.1
Trib	1200	1 in 100	49.3	994.37	995.08	994.61	995.08	0.002865	0.26	220.99	529.18	0.11
Trib	900	1 in 50	35.99	993.15	993.8	993.51	993.81	0.006463	0.35	145.51	555.76	0.15
Trib	900	1 in 100	49.3	993.15	993.87	993.55	993.88	0.006138	0.37	186.41	595.85	0.15
Trib	600	1 in 50	35.99	991.93	992.54	992.19	992.55	0.002861	0.22	174.89	433.46	0.1
Trib	600	1 in 100	49.3	991.93	992.63	992.21	992.64	0.002886	0.24	214.92	463.28	0.1
Trib	300	1 in 50	35.99	990.57	991.1	990.79	991.11	0.010015	0.38	103.13	309.84	0.18
Trib	300	1 in 100	49.3	990.57	991.19	990.84	991.19	0.010015	0.43	131.49	354.77	0.19

TRIB5 –TRIB PROFILE OUTPUT TABLE

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Trib	9939.092	1 in 50	171.17	1009.44	1010.27	1010.27	1010.38	0.210975	1.8	126.72	500.05	0.86
Trib	9939.092	1 in 100	244.23	1009.44	1010.34	1010.34	1010.47	0.209514	1.98	163.5	543.35	0.87
Trib	9577.564	1 in 50	171.17	1008.61	1010.63	1009.45	1010.63	0.001336	0.34	762.2	963.67	0.08
Trib	9577.564	1 in 100	244.23	1008.61	1010.74	1009.53	1010.75	0.001534	0.38	1072.25	1461.44	0.09
Trib	9371.285	1 in 50	171.17	1008.15	1010.31	1008.9	1010.31	0.001745	0.33	613	638.77	0.09
Trib	9371.285	1 in 100	244.23	1008.15	1010.48	1009.02	1010.48	0.001012	0.28	1248.61	1525.09	0.07
Trib	8917.171	1 in 50	171.17	1007.1	1009.63	1008.16	1009.64	0.001678	0.43	495.8	394.32	0.1
Trib	8917.171	1 in 100	244.23	1007.1	1009.96	1008.3	1009.97	0.001829	0.5	638.79	485.69	0.1
Trib	8755.307	1 in 50	171.17	1006.74	1009.29	1007.83	1009.31	0.002532	0.55	413.85	402.67	0.12
Trib	8755.307	1 in 100	244.23	1006.74	1009.6	1008.02	1009.61	0.002689	0.62	551.66	504.03	0.13
Trib	8394.174	1 in 50	171.17	1005.94	1007.94	1007.03	1007.96	0.006622	0.73	337.13	526.07	0.19
Trib	8394.174	1 in 100	244.23	1005.94	1008.09	1007.22	1008.12	0.00804	0.86	427.72	627.75	0.21
Trib	8110.85	1 in 50	171.17	1005.23	1006.68	1005.89	1006.69	0.003349	0.46	514.06	751.26	0.13
Trib	8110.85	1 in 100	244.23	1005.23	1006.88	1005.99	1006.88	0.002874	0.47	796.17	1189.08	0.12

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Trib	7798.14	1 in 50	171.17	1004.57	1006.11	1005.17	1006.12	0.001244	0.3	756.96	839.69	0.08
Trib	7798.14	1 in 100	244.23	1004.57	1006.36	1005.25	1006.36	0.001197	0.33	962.49	857.64	0.08
Trib	7105.681	1 in 50	171.17	1002.9	1005.09	1003.85	1005.1	0.002476	0.5	488.81	586.78	0.12
Trib	7105.681	1 in 100	244.23	1002.9	1005.36	1003.98	1005.37	0.002522	0.55	679.49	783.35	0.12
Trib	6900	1 in 50	171.17	1002.41	1004.61	1003.37	1004.62	0.002343	0.5	484.61	511.27	0.11
Trib	6900	1 in 100	244.23	1002.41	1004.88	1003.56	1004.89	0.002392	0.55	626.31	554.53	0.12
Trib	6758.646	1 in 50	171.17	1002.07	1004.21	1003.06	1004.22	0.003642	0.59	391.11	440.43	0.14
Trib	6758.646	1 in 100	244.23	1002.07	1004.46	1003.24	1004.48	0.003822	0.66	509.94	501.67	0.15
Trib	6752.022	1 in 50	171.17	1002.04	1004.18	1003.05	1004.2	0.003724	0.6	387.17	435.26	0.14
Trib	6752.022	1 in 100	244.23	1002.04	1004.43	1003.22	1004.45	0.003913	0.67	503.61	491.5	0.15
Trib	6747.031	1 in 50	171.17	1002.03	1004.16	1003.03	1004.18	0.003778	0.61	384.67	430.78	0.14
Trib	6747.031	1 in 100	244.23	1002.03	1004.41	1003.21	1004.43	0.003983	0.68	499.63	486.42	0.15
Trib	6246.827	1 in 50	171.17	1000.72	1002.5	1001.49	1002.51	0.003652	0.52	396.57	431.28	0.14
Trib	6246.827	1 in 100	244.23	1000.72	1002.79	1001.63	1002.8	0.003426	0.57	532.05	492.5	0.14
Trib	5728.169	1 in 50	171.17	999.64	1001.58	1000.34	1001.58	0.001161	0.32	652.63	576.45	0.08

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	5728.169	1 in 100	244.23	999.64	1001.85	1000.44	1001.86	0.001251	0.37	819.67	628.14	0.08
Trib	5450.675	1 in 50	171.17	999.23	1001.27	1000.14	1001.27	0.001354	0.34	646.8	622.85	0.08
Trib	5450.675	1 in 100	244.23	999.23	1001.52	1000.24	1001.53	0.001445	0.39	814.97	678.99	0.09
Trib	5098.688	1 in 50	171.17	998.76	1000.7	999.61	1000.71	0.002478	0.47	515.82	637.75	0.12
Trib	5098.688	1 in 100	244.23	998.76	1000.96	999.76	1000.97	0.002352	0.5	689.71	704.54	0.12
Trib	4805.942	1 in 50	171.17	998.32	1000.38	999.15	1000.38	0.000769	0.26	870	910.11	0.06
Trib	4805.942	1 in 100	244.23	998.32	1000.67	999.26	1000.67	0.000705	0.27	1139.5	966.68	0.06
Trib	4610.481	1 in 50	171.17	998.17	1000.24	999.15	1000.24	0.000948	0.28	737.25	693.96	0.07
Trib	4610.481	1 in 100	244.23	998.17	1000.53	999.26	1000.54	0.00091	0.31	958.04	792.8	0.07
Trib	4146.305	1 in 50	171.17	997.3	999.96	998.15	999.97	0.000655	0.27	777.51	570.43	0.06
Trib	4146.305	1 in 100	244.23	997.3	1000.25	998.33	1000.25	0.00076	0.3	966.71	817.75	0.07
Trib	3698.316	1 in 50	171.17	996.92	999.54	998.17	999.55	0.001847	0.4	551.57	550.43	0.1
Trib	3698.316	1 in 100	244.23	996.92	999.78	998.47	999.79	0.001946	0.45	686.94	598.13	0.1
Trib	3267.456	1 in 50	171.17	996.28	998.4	997.26	998.42	0.004959	0.62	370.35	537.04	0.16
Trib	3267.456	1 in 100	244.23	996.28	998.63	997.45	998.65	0.004896	0.66	501.67	590.72	0.16

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Trib	3014.511	1 in 50	171.17	996	997.33	996.58	997.34	0.003717	0.39	438.15	463.92	0.13
Trib	3014.511	1 in 100	244.23	996	997.55	996.66	997.56	0.003802	0.44	542.63	474.23	0.13
Trib	2680.163	1 in 50	171.17	995.53	996.52	995.65	996.52	0.002046	0.25	600.66	686.59	0.09
Trib	2680.163	1 in 100	244.23	995.53	996.74	995.73	996.74	0.002018	0.29	754.81	705.83	0.1
Trib	2408.971	1 in 50	171.17	995.13	996.14	995.26	996.15	0.0014	0.23	722.24	922.15	0.08
Trib	2408.971	1 in 100	244.23	995.13	996.38	995.33	996.38	0.00129	0.26	941.76	922.15	0.08
Trib	1839.013	1 in 50	171.17	994.34	995.59	994.46	995.59	0.000902	0.17	793.42	761.82	0.06
Trib	1839.013	1 in 100	244.23	994.34	995.83	994.54	995.84	0.000944	0.21	978.97	761.82	0.07
Trib	1425.684	1 in 50	171.17	994.21	995.39	994.04	995.4	0.000785	0.15	823.91	792.77	0.06
Trib	1425.684	1 in 100	244.23	994.21	995.61	994.17	995.62	0.000915	0.19	1003.27	836.66	0.06
Trib	1202.771	1 in 50	171.17	993.3	995.15	994.33	995.15	0.00113	0.2	721.96	739.29	0.07
Trib	1202.771	1 in 100	244.23	993.3	995.32	994.45	995.32	0.001448	0.25	851.01	775.48	0.08
Trib	901.1014	1 in 50	171.17	993.37	995.02	993.61	995.02	0.000331	0.09	1046.69	770.69	0.04
Trib	901.1014	1 in 100	244.23	993.37	993.72	993.72	993.94	0.285684	0.32	119.16	274.82	0.62

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Trib	731.1812	1 in 50	171.17	993.16	994.93	993.37	994.94	0.000736	0.15	792.59	617.44	0.05
Trib	731.1812	1 in 100	244.23	993.16	993.48	993.48	993.69	0.279198	1.06	119.81	275.47	0.83
Trib	300	1 in 50	171.17	992.05	994.15	993.2	994.18	0.010007	0.83	213.82	162.09	0.22
Trib	300	1 in 100	244.23	992.05	993.4	993.4	993.73	0.218199	2.61	98.65	147.1	0.95

TRIB6 –TRIB PROFILE OUTPUT TABLE

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Trib	7200	1 in 50	138.84	1041.43	1042.94	1042.42	1043	0.02497	1.12	136.12	165.7	0.34
Trib	7200	1 in 100	194.8	1041.43	1043.1	1042.56	1043.19	0.029019	1.33	164.35	179.48	0.38
Trib	6957.656	1 in 50	138.84	1038.8	1040.37	1039.56	1040.38	0.005948	0.63	286.3	379.24	0.17
Trib	6957.656	1 in 100	194.8	1038.8	1040.61	1039.69	1040.63	0.005347	0.67	383.87	420.63	0.17
Trib	6612.564	1 in 50	138.84	1036.1	1037.95	1037.06	1037.97	0.008362	0.76	206.38	228.11	0.21
Trib	6612.564	1 in 100	194.8	1036.1	1038.13	1037.21	1038.17	0.010079	0.9	250.17	255.13	0.23
Trib	6374.266	1 in 50	138.84	1034.54	1036.07	1035.35	1036.09	0.007419	0.67	257.49	329.41	0.19
Trib	6374.266	1 in 100	194.8	1034.54	1036.39	1035.48	1036.4	0.00562	0.68	369	389.18	0.17

Reach	River Station	Profile	Q Total (m³/s)	Minimum Channel Elevation (m)	Water Surface Elevation (m)	Critical Water Surface (m)	Energy Gradient Elevation (m)	Energy Gradient Slope (m/m)	Velocity Channel (m/s)	Flow Area (m²)	Top Width (m)	Froude No Channel
Trib	6085.46	1 in 50	138.84	1032.71	1034.6	1033.58	1034.61	0.00377	0.55	337.32	429.76	0.14
Trib	6085.46	1 in 100	194.8	1032.71	1034.64	1033.72	1034.66	0.006546	0.74	354.59	437.64	0.19
Trib	5767.077	1 in 50	138.84	1030.13	1030.83	1030.77	1030.98	0.159843	1.85	85.69	203.99	0.78
Trib	5767.077	1 in 100	194.8	1030.13	1031.45	1030.89	1031.49	0.016855	0.98	242.2	297.97	0.28
Trib	5400	1 in 50	138.84	1025.03	1027.73	1026.06	1027.74	0.002805	0.57	267.21	166.39	0.13
Trib	5400	1 in 100	194.8	1025.03	1027.58	1026.25	1027.61	0.007264	0.88	243.14	159.49	0.2
Trib	5102.562	1 in 50	138.84	1023.06	1024.59	1024.59	1024.98	0.233798	2.79	49.69	61.49	0.99
Trib	5102.562	1 in 100	194.8	1023.06	1025.79	1024.83	1025.81	0.005236	0.65	449.36	665.56	0.17
Trib	4761.731	1 in 50	138.84	1020.31	1021.16	1020.95	1021.26	0.079997	1.42	101.67	183.33	0.56
Trib	4761.731	1 in 100	194.8	1020.31	1021.33	1021.08	1021.44	0.070323	1.55	135.34	227.77	0.55
Trib	4500	1 in 50	138.84	1014.44	1016.81	1015.58	1016.85	0.007087	0.83	185.8	155.34	0.2
Trib	4500	1 in 100	194.8	1014.44	1017.18	1015.78	1017.22	0.006945	0.92	251.35	216.65	0.2
Trib	4200	1 in 50	138.84	1013.08	1015.58	1014.03	1015.59	0.002829	0.55	291.14	217.79	0.13
Trib	4200	1 in 100	194.8	1013.08	1015.92	1014.2	1015.94	0.002982	0.63	373.1	262.3	0.13

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	3900	1 in 50	138.84	1011.56	1013.34	1012.81	1013.45	0.040559	1.47	97.36	101.95	0.44
Trib	3900	1 in 100	194.8	1011.56	1013.63	1013.01	1013.75	0.037011	1.58	136.09	153.6	0.43
Trib	3615.199	1 in 50	138.84	1009.39	1011.26	1010.06	1011.27	0.002982	0.5	294.74	212.66	0.13
Trib	3615.199	1 in 100	194.8	1009.39	1011.59	1010.18	1011.61	0.002997	0.57	367.59	223.52	0.13
Trib	3602.484	1 in 50	138.84	1009.29	1011.23	1009.98	1011.24	0.002679	0.47	307	218.03	0.12
Trib	3602.484	1 in 100	194.8	1009.29	1011.56	1010.1	1011.57	0.002725	0.54	381.54	228.94	0.12
Trib	3300	1 in 50	138.84	1007.87	1009.97	1008.79	1009.99	0.007979	0.77	188.77	146.93	0.2
Trib	3300	1 in 100	194.8	1007.87	1010.15	1008.97	1010.2	0.010245	0.95	218.29	166.48	0.23
Trib	3000	1 in 50	138.84	1005.64	1006.76	1006.22	1006.79	0.015218	0.82	189.88	254.02	0.26
Trib	3000	1 in 100	194.8	1005.64	1007.07	1006.33	1007.1	0.01048	0.81	274.23	288.25	0.23
Trib	2628.959	1 in 50	138.84	1003.48	1006.04	1004.02	1006.04	0.00094	0.24	490.08	362.02	0.07
Trib	2628.959	1 in 100	194.8	1003.48	1006.28	1004.18	1006.28	0.001183	0.31	582	398.53	0.08
Trib	2368.426	1 in 50	138.84	1003.32	1005.91	1003.49	1005.92	0.000386	0.16	851.49	917.69	0.04
Trib	2368.426	1 in 100	194.8	1003.32	1006.13	1003.66	1006.13	0.000456	0.19	1048.1	921.58	0.05
Trib	1797.88	1 in 50	138.84	1003.72	1005.56	1004.75	1005.56	0.002461	0.37	490.12	783.98	0.11

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	1797.88	1 in 100	194.8	1003.72	1005.74	1004.83	1005.75	0.002355	0.4	633.12	788.57	0.11
Trib	1459.52	1 in 50	138.84	1002.45	1004.26	1003.47	1004.28	0.007518	0.68	276.9	503.91	0.19
Trib	1459.52	1 in 100	194.8	1002.45	1004.38	1003.67	1004.4	0.0094	0.81	337.48	552.29	0.22
Trib	1212.366	1 in 50	138.84	1001.28	1001.92	1001.44	1001.94	0.013264	0.46	228.71	337.37	0.22
Trib	1212.366	1 in 100	194.8	1001.28	1002.19	1001.55	1002.21	0.008912	0.48	321.98	356.98	0.19
Trib	976.3454	1 in 50	138.84	1000.09	1001.46	1000.21	1001.46	0.000884	0.22	570.12	464.92	0.07
Trib	976.3454	1 in 100	194.8	1000.09	1001.77	1000.28	1001.77	0.000885	0.26	717.18	496.41	0.07
Trib	308.1715	1 in 50	138.84	997.83	1000.09	999.01	1000.12	0.010005	0.87	169.07	153.07	0.23
Trib	308.1715	1 in 100	194.8	997.83	1000.39	999.21	1000.43	0.010002	0.97	221.55	190.38	0.23

TRIB7 –TRIB PROFILE OUTPUT TABLE

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	18826.53	1 in 50	131.43	1148.68	1150.11	1149.71	1150.17	0.03396	1.18	126.2	172.15	0.39
Trib	18826.53	1 in 100	183.87	1148.68	1150.32	1149.84	1150.38	0.035777	1.21	164.15	200.01	0.4

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	18600	1 in 50	131.43	1144.36	1145.09	1144.51	1145.12	0.015046	0.42	181.01	238.62	0.22
Trib	18600	1 in 100	183.87	1144.36	1145.31	1144.63	1145.34	0.014499	0.46	237.03	281.17	0.22
Trib	18302.57	1 in 50	131.43	1140.14	1138.29	1137.97	1138.33	0.041558		138.58	237.7	0
Trib	18302.57	1 in 100	183.87	1140.14	1138.41	1138.07	1138.47	0.045666		169.22	254.04	0
Trib	18001.35	1 in 50	131.43	1131.71	1130.33	1129.98	1130.35	0.018939		242.65	534.87	0
Trib	18001.35	1 in 100	183.87	1131.71	1130.45	1130.05	1130.47	0.017867		308.09	562.1	0
Trib	17612.33	1 in 50	131.43	1124.18	1125.31	1124.81	1125.32	0.00976	0.56	287.01	543.82	0.2
Trib	17612.33	1 in 100	183.87	1124.18	1125.43	1124.9	1125.44	0.010194	0.63	354.36	575.94	0.21
Trib	17411.33	1 in 50	131.43	1121.03	1121.8	1121.56	1121.83	0.042159	0.92	167.76	414.32	0.4
Trib	17411.33	1 in 100	183.87	1121.03	1121.91	1121.65	1121.95	0.038809	1	215.78	442.41	0.39
Trib	17100	1 in 50	131.43	1115.55	1117.34	1116.55	1117.36	0.007174	0.63	271.13	395.14	0.19
Trib	17100	1 in 100	183.87	1115.55	1117.51	1116.71	1117.53	0.007299	0.69	338.96	413.58	0.19
Trib	16800	1 in 50	131.43	1109.89	1110.81	1110.81	1111.09	0.251398	2.36	56.96	108.21	0.98
Trib	16800	1 in 100	183.87	1109.89	1110.97	1110.97	1111.29	0.222797	2.53	75.68	123.9	0.95
Trib	16385.02	1 in 50	131.43	1107.01	1107.44	1107.44	1107.44	0.000234	0.04	923.08	607.6	0.03

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	16385.02	1 in 100	183.87	1107.01	1107.44	1107.44	1107.44	0.000458	0.06	923.08	607.6	0.04
Trib	16369.18	1 in 50	131.43	1106.9	1107.27	1107.27	1107.27	0.00026	0.04	891.96	603.19	0.03
Trib	16369.18	1 in 100	183.87	1106.9	1107.27	1107.27	1107.27	0.00051	0.06	891.96	603.19	0.04
Trib	16349.48	1 in 50	131.43	1106.73	1107.05	1107.05	1107.05	0.000308	0.04	844.16	597.87	0.03
Trib	16349.48	1 in 100	183.87	1106.73	1107.05	1107.05	1107.05	0.000603	0.06	844.16	597.87	0.04
Trib	16331.47	1 in 50	131.43	1106.59	1106.82	1106.82	1106.82	0.000406	0.04	769.82	590.27	0.03
Trib	16331.47	1 in 100	183.87	1106.59	1106.82	1106.82	1106.82	0.000795	0.05	769.82	590.27	0.04
Trib	15882.27	1 in 50	131.43	1102.16	1102.63	1103.11	1105.82	8.306787	7.9	16.63	63.04	4.91
Trib	15882.27	1 in 100	183.87	1102.16	1102.77	1103.27	1105.24	4.64346	6.96	26.4	78.23	3.83
Trib	15593.35	1 in 50	131.43	1099.39	1100.4	1100.4	1100.43	0.048215	0.68	184.26	599.01	0.39
Trib	15593.35	1 in 100	183.87	1099.39	1100.4	1100.4	1100.45	0.09436	0.95	184.26	599.01	0.54
Trib	15299.96	1 in 50	131.43	1096.49	1097.87	1097.46	1097.95	0.040921	1.28	113.51	172.7	0.42
Trib	15299.96	1 in 100	183.87	1096.49	1097.63	1097.63	1097.94	0.208675	2.5	78.16	130.18	0.93
Trib	14981.6	1 in 50	131.43	1093.99	1095.34	1095.12	1095.34	0.003419	0.29	474.4	790.03	0.12
Trib	14981.6	1 in 100	183.87	1093.99	1095.12	1095.12	1095.14	0.014323	0.52	315.31	628.48	0.23

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	14400.07	1 in 50	131.43	1089.84	1089.42	1089.42	1089.67	0.290788		59.51	122.7	0
Trib	14400.07	1 in 100	183.87	1089.84	1089.56	1089.57	1089.85	0.276595		77.94	140.17	0
Trib	13802.11	1 in 50	131.43	1085.29	1085.5	1085.5	1085.5	0.000223	0.02	1120.12	933.08	0.02
Trib	13802.11	1 in 100	183.87	1085.29	1085.5	1085.5	1085.5	0.000437	0.03	1120.12	933.08	0.03
Trib	13498.44	1 in 50	131.43	1082.8	1083.3	1083.49	1085.06	4.651536	5.87	22.41	85.97	3.67
Trib	13498.44	1 in 100	183.87	1082.8	1083.44	1083.49	1084.84	2.437533	5.28	35.66	117.89	2.8
Trib	12895.3	1 in 50	131.43	1078.38	1080.02	1079.24	1080.02	0.002236	0.33	576.52	1003.13	0.1
Trib	12895.3	1 in 100	183.87	1078.38	1079.72	1079.38	1079.81	0.051222	1.47	146.27	208.6	0.48
Trib	12564.63	1 in 50	131.43	1076.52	1077.43	1077.43	1077.69	0.246576	2.28	58.53	119.8	0.96
Trib	12564.63	1 in 100	183.87	1076.52	1077.61	1077.49	1077.61	0.002811	0.29	577.16	688.96	0.11
Trib	12267.77	1 in 50	131.43	1074.72	1075.72	1075.05	1075.73	0.00336	0.3	443.44	700.16	0.12
Trib	12267.77	1 in 100	183.87	1074.72	1075.17	1075.17	1075.3	0.294763	0.97	118.99	460.34	0.83
Trib	12000	1 in 50	131.43	1072.9	1073.69	1073.69	1073.72	0.035612	0.78	185.24	439.51	0.36
Trib	12000	1 in 100	183.87	1072.9	1073.69	1073.69	1073.74	0.069695	1.09	185.24	439.51	0.5

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Trib	11767.21	1 in 50	131.43	1070.23	1071.88	1070.68	1071.89	0.002544	0.35	367.05	357.8	0.11
Trib	11767.21	1 in 100	183.87	1070.23	1072.33	1070.84	1072.34	0.001757	0.37	548.35	458.8	0.1
Trib	11441.08	1 in 50	131.43	1068.65	1070.87	1069.81	1070.88	0.003975	0.55	353.59	609.78	0.14
Trib	11441.08	1 in 100	183.87	1068.65	1070.02	1070.02	1070.37	0.242221	2.63	69.89	98.06	0.99
Trib	11100	1 in 50	131.43	1066.08	1068	1067.31	1068.07	0.026471	1.18	112.51	107.54	0.35
Trib	11100	1 in 100	183.87	1066.08	1068.2	1067.51	1068.3	0.029967	1.38	136.07	119.96	0.39
Trib	10786.46	1 in 50	131.43	1063.89	1065.83	1064.92	1065.84	0.003123	0.41	378.88	474.18	0.12
Trib	10786.46	1 in 100	183.87	1063.89	1066.04	1065.14	1066.04	0.003028	0.45	478.1	489.69	0.12
Trib	10764.58	1 in 50	131.43	1063.76	1065.77	1064.89	1065.77	0.003368	0.45	362.91	468.48	0.13
Trib	10764.58	1 in 100	183.87	1063.76	1065.97	1065.07	1065.98	0.003238	0.49	462.49	486.67	0.13
Trib	10749.45	1 in 50	131.43	1063.63	1065.71	1064.83	1065.72	0.003486	0.47	356.29	468.13	0.13
Trib	10749.45	1 in 100	183.87	1063.63	1065.92	1064.97	1065.93	0.003329	0.51	456.74	487.63	0.13
Trib	10733.45	1 in 50	131.43	1063.52	1065.65	1064.68	1065.66	0.003561	0.51	346.44	461.62	0.13
Trib	10733.45	1 in 100	183.87	1063.52	1065.87	1064.83	1065.88	0.003422	0.55	446.63	484.45	0.14
Trib	10500	1 in 50	131.43	1062.08	1063.94	1063.23	1064	0.021764	1.09	125.53	127.55	0.32

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	10500	1 in 100	183.87	1062.08	1064.17	1063.41	1064.24	0.022441	1.25	156.95	146.22	0.34
Trib	9959.961	1 in 50	131.43	1058.87	1060.68	1059.85	1060.69	0.00276	0.35	427.59	567.57	0.11
Trib	9959.961	1 in 100	183.87	1058.87	1060.86	1060	1060.86	0.002815	0.39	527.68	578.74	0.12
Trib	9930.595	1 in 50	131.43	1058.77	1060.6	1059.95	1060.6	0.003799	0.36	386.81	544.06	0.13
Trib	9930.595	1 in 100	183.87	1058.77	1060.77	1060.09	1060.78	0.00368	0.41	483.45	558.3	0.13
Trib	9911.224	1 in 50	131.43	1058.68	1060.29	1059.7	1060.3	0.007448	0.42	305.11	498.24	0.17
Trib	9911.224	1 in 100	183.87	1058.68	1060.52	1059.76	1060.53	0.005367	0.44	420.45	533.96	0.15
Trib	9891.623	1 in 50	131.43	1058.56	1060.2	1059.31	1060.2	0.002617	0.35	381.52	378.38	0.11
Trib	9891.623	1 in 100	183.87	1058.56	1060.43	1059.39	1060.44	0.002502	0.39	494.81	527.98	0.11
Trib	9533.903	1 in 50	131.43	1056.73	1058.8	1057.79	1058.82	0.007472	0.73	200.43	207.73	0.2
Trib	9533.903	1 in 100	183.87	1056.73	1059.06	1057.97	1059.09	0.007531	0.82	258.17	236.9	0.2
Trib	9330.27	1 in 50	131.43	1055.67	1057.38	1056.5	1057.4	0.006501	0.68	229.87	248.58	0.18
Trib	9330.27	1 in 100	183.87	1055.67	1057.62	1056.64	1057.64	0.006628	0.77	294.08	280.32	0.19
Trib	8972.223	1 in 50	131.43	1053.53	1055.52	1054.46	1055.53	0.004283	0.57	298.51	392.12	0.15
Trib	8972.223	1 in 100	183.87	1053.53	1055.74	1054.62	1055.76	0.004303	0.62	394.4	461.23	0.15

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	8700	1 in 50	131.43	1051.83	1053.35	1052.76	1053.4	0.018444	0.95	151.32	211.63	0.29
Trib	8700	1 in 100	183.87	1051.83	1053.55	1052.89	1053.6	0.018763	1.07	201.32	299.91	0.3
Trib	8400	1 in 50	131.43	1049.84	1051.49	1050.57	1051.49	0.00321	0.48	353.96	408.49	0.13
Trib	8400	1 in 100	183.87	1049.84	1051.74	1050.67	1051.74	0.003084	0.52	462.72	464.63	0.13
Trib	8106.986	1 in 50	131.43	1047.83	1049.76	1048.87	1049.8	0.013675	0.91	148.87	135.92	0.26
Trib	8106.986	1 in 100	183.87	1047.83	1050.07	1049.05	1050.12	0.013172	0.99	195.37	168.15	0.26
Trib	7800	1 in 50	131.43	1045.26	1047.25	1046.18	1047.27	0.005504	0.67	223.67	214.9	0.17
Trib	7800	1 in 100	183.87	1045.26	1047.51	1046.32	1047.53	0.005855	0.76	282.09	241.17	0.18
Trib	7496.496	1 in 50	131.43	1044.06	1046.34	1045.19	1046.35	0.001936	0.39	424.16	428.08	0.1
Trib	7496.496	1 in 100	183.87	1044.06	1046.67	1045.33	1046.67	0.00166	0.41	571.63	480.33	0.1
Trib	7200	1 in 50	131.43	1042.58	1045.48	1043.79	1045.51	0.004576	0.74	209.44	172.62	0.16
Trib	7200	1 in 100	183.87	1042.58	1045.85	1044.02	1045.87	0.005133	0.72	375.71	573.91	0.17
Trib	6904.972	1 in 50	131.43	1041.46	1043.36	1042.53	1043.4	0.012577	0.9	159.51	200.05	0.25
Trib	6904.972	1 in 100	183.87	1041.46	1043.62	1042.71	1043.66	0.011908	0.99	216.45	236.92	0.25

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	6549.75	1 in 50	131.43	1039.85	1041.47	1040.55	1041.48	0.002967	0.45	368.28	423.73	0.12
Trib	6549.75	1 in 100	183.87	1039.85	1041.69	1040.64	1041.7	0.003157	0.51	468.59	494.62	0.13
Trib	6300	1 in 50	131.43	1038.35	1040.32	1039.48	1040.34	0.008143	0.7	278.65	523.33	0.2
Trib	6300	1 in 100	183.87	1038.35	1040.51	1039.73	1040.53	0.007895	0.7	411.74	832.38	0.2
Trib	5804.922	1 in 50	131.43	1035.1	1036.18	1035.54	1036.2	0.008811	0.64	230.08	277.41	0.2
Trib	5804.922	1 in 100	183.87	1035.1	1036.37	1035.63	1036.39	0.009139	0.73	284.86	294.05	0.21
Trib	5792.747	1 in 50	131.43	1035.07	1036.05	1035.5	1036.07	0.012311	0.7	206.67	271.73	0.23
Trib	5792.747	1 in 100	183.87	1035.07	1036.24	1035.59	1036.26	0.01215	0.79	259.8	288.26	0.24
Trib	5780.922	1 in 50	131.43	1035.02	1035.83	1035.45	1035.87	0.024752	0.87	164.63	259.46	0.32
Trib	5780.922	1 in 100	183.87	1035.02	1036.04	1035.54	1036.08	0.019683	0.92	221.74	277.89	0.3
Trib	5522.373	1 in 50	131.43	1031.45	1033.74	1032.48	1033.76	0.004066	0.63	242.41	218.86	0.15
Trib	5522.373	1 in 100	183.87	1031.45	1034.04	1032.64	1034.07	0.004178	0.71	316.17	265.75	0.16
Trib	5102.328	1 in 50	131.43	1027.36	1028.07	1028.07	1028.27	0.251881	2.18	68.49	165.17	0.96
Trib	5102.328	1 in 100	183.87	1027.36	1028.17	1028.17	1028.42	0.256601	2.41	86.81	181.95	0.99
Trib	4811.721	1 in 50	131.43	1025.03	1025.47	1025.47	1025.61	0.266399	1.88	84.13	303.98	0.94

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	4811.721	1 in 100	183.87	1025.03	1025.55	1025.55	1025.71	0.253068	2.06	109.6	344.22	0.95
Trib	4406.329	1 in 50	131.43	1020.82	1021.51	1021.51	1021.69	0.248211	2.04	74.41	218.9	0.94
Trib	4406.329	1 in 100	183.87	1020.82	1021.72	1021.56	1021.73	0.002699	0.26	659.28	910.88	0.1
Trib	4189.69	1 in 50	131.43	1018.98	1019.63	1019.63	1019.76	0.232342	1.92	90.82	346.23	0.9
Trib	4189.69	1 in 100	183.87	1018.98	1019.69	1019.69	1019.86	0.276119	2.22	113.77	423.04	1
Trib	3829.841	1 in 50	131.43	1016.57	1017.83	1017.22	1017.84	0.008185	0.58	259.25	351.02	0.19
Trib	3829.841	1 in 100	183.87	1016.57	1018	1017.31	1018.02	0.008504	0.66	321.51	378.56	0.2
Trib	3539.09	1 in 50	131.43	1014.01	1015.49	1014.84	1015.5	0.008054	0.65	248.46	343.43	0.19
Trib	3539.09	1 in 100	183.87	1014.01	1015.7	1014.95	1015.72	0.007529	0.7	325.65	382.57	0.19
Trib	3303.086	1 in 50	131.43	1012.03	1013.68	1012.89	1013.7	0.00755	0.7	234.26	312.05	0.19
Trib	3303.086	1 in 100	183.87	1012.03	1013.86	1013.03	1013.88	0.008397	0.81	294.35	356.01	0.21
Trib	2994.599	1 in 50	131.43	1009.24	1010.13	1009.78	1010.15	0.019926	0.71	212.67	426.68	0.28
Trib	2994.599	1 in 100	183.87	1009.24	1010.28	1009.85	1010.31	0.017338	0.76	280.2	463.82	0.27
Trib	2700.202	1 in 50	131.43	1007.13	1008.32	1007.58	1008.32	0.003057	0.35	437	639.7	0.12
Trib	2700.202	1 in 100	183.87	1007.13	1008.48	1007.65	1008.48	0.003204	0.4	546.28	700.71	0.12

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m³/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m²)	(m)	
Trib	2414.107	1 in 50	131.43	1005.05	1005.3	1005.3	1005.37	0.354768	1.48	115.09	782.4	0.99
Trib	2414.107	1 in 100	183.87	1005.05	1005.34	1005.34	1005.42	0.332644	1.61	152.3	898.99	0.99
Trib	2078.236	1 in 50	131.43	1001.4	1001.48	1001.48	1001.48	0.000546	0.02	905.44	1046.55	0.03
Trib	2078.236	1 in 100	183.87	1001.4	1001.48	1001.48	1001.48	0.001068	0.02	905.44	1046.55	0.04
Trib	1818.594	1 in 50	131.43	999.31	998.78	999.02	1000.74	16.08045		21.23	190.42	0
Trib	1818.594	1 in 100	183.87	999.31	998.85	999.09	1000.28	7.823283		34.69	228.82	0
Trib	1507.194	1 in 50	131.43	996.9	996.42	995.49	996.43	0.002953		403.61	473.62	0
Trib	1507.194	1 in 100	183.87	996.9	996.61	995.58	996.62	0.003295		498.39	526.45	0
Trib	1218.66	1 in 50	131.43	994.69	995.32	994.3	995.32	0.005161	0.23	438.42	898.58	0.13
Trib	1218.66	1 in 100	183.87	994.69	995.45	994.42	995.46	0.005035	0.28	567.87	1007.4	0.13
Trib	962.6174	1 in 50	131.43	992.49	992.94	992.61	992.96	0.021915	0.45	220.34	488.73	0.26
Trib	962.6174	1 in 100	183.87	992.49	993.08	992.68	993.09	0.022906	0.59	302.3	665.49	0.28
Trib	676.743	1 in 50	131.43	990.21	990.64	990.27	990.64	0.004224	0.22	531.35	1248.57	0.12
Trib	676.743	1 in 100	183.87	990.21	990.74	990.31	990.74	0.004249	0.26	658.39	1288.84	0.12

Reach	River Station	Profile	Q Total	Minimum Channel Elevation	Water Surface Elevation	Critical Water Surface	Energy Gradient Elevation	Energy Gradient Slope	Velocity Channel	Flow Area	Top Width	Froude No Channel
			(m^3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m^2)	(m)	
Trib	410.3293	1 in 50	131.43	988.56	988.97	988.67	988.98	0.010014	0.3	373.8	1042	0.17
Trib	410.3293	1 in 100	183.87	988.56	989.06	988.72	989.07	0.01	0.36	472.55	1124.03	0.18

June 2013

SAMANCOR CHROME LIMITED

Social Impact Assessment Report for the Proposed Varkensvlei and Nooitgedacht Operations

Submitted to:
Heather Booysens
Group Environmental Manager
Samancor

Report Number. 13614977

REPORT

Executive Summary

Introduction

Golder Associates has been requested by Samancor Chrome to conduct an ESIA for the proposed mining of the Varkensvlei and Nooitgedacht chrome reserve. As part of the ESIA, an SIA has been undertaken. The ESIA will be submitted to the Department of Mineral Resources in support of a Mining Right Application for this reserve.

Samancor Chrome was established in 1975 as a result of a merger between SA Manganese Ltd (formed in 1926 to mine manganese ore in the Northern Cape) and Amcor Ltd. Samancor Chrome is one of the world's largest integrated producers of ferrochrome, producing more than a million tons of charge chrome, about 70 thousand tons of intermediate carbon ferrochrome, and some 40 thousand tons of low carbon ferrochrome per annum.

Methodology

The SIA study was developed through a predominantly qualitative research methodology, which involved data collection through desktop literature review and key informant interviews undertaken in April 2013. The information that was collected was analysed and interpreted to generate a baseline of the socioeconomic conditions for the communities surrounding the project. Social impacts were identified and assessed using professional experience and information obtained through the data collection. Mitigation measures were proposed for negative social impacts and enhancement measures were proposed for positive social impacts.

Regional study area

The proposed project area crosses the Moses Kotane Local Municipality (LM), within the Bojanala District Municipality (DM) in the Northwest Province, along with the Thabazimbi Local Municipality (LM) within the Waterberg District Municipality (DM) in the Limpopo Province. The Moses Kotane LM has a population of 242,554 and a population density of 42 people/km^2 which is more than double the population of Thabazimbi LM with a population of 85,234 and a population density of 76 people/km$^{2.}$ The Moses Kotane LM has a higher average household size 3.2 than Thabazimbi which is 2.8.

The largest percentage of the population across Provincial, DM and LM areas lies in the age range of 15-65 years old which is the economically active age. The Black African population is the highest ethnic population (over 40%) followed by a small population (approximate average of 6%) of white males and females. Majority of the population in the RSA (Regional Study Area) have attained some secondary education (36%).

The average employment rate across the RSA is 38% and the average unemployment rate is 16%. Over 60% of the RSA reside in farm house structures with the remaining population of the RSA residing in informal settlement / squatter areas. The most common sanitation facilities across the RSA are the flush system toilet and pit toilets without ventilation.

The main hospital in the Thabazimbi Municipal area is the Thabazimbi Hospital. Most other health facilities such as clinics and surgeons are situated in the town of Northam. Electricity is the most common source of energy used for lighting within the RSA. The most common source of piped water is that of piped water taps inside dwellings and inside yards. Majority of the population in the regional study area rely on their refuse disposal to be removed by local authorities.

The majority of the employed population (30% for Moses Kotane LM and 51% for Thabazimbi LM) is employed in the formal sector. In the North West Province mining and quarrying contributes 26% towards the provincial GGP, mining is therefore the most dominant sector within the local economy.

Local study area

The proposed project area is located on portions of the farm Varkensvlei 403KQ which is owned by the Bakgatlabakgafela traditional authority under Chief JM Pilane and the Jabuseku Community, and Nooitgedacht farm 406 KQ, owned by Anglo Platinum, Mr Reiner Guba and Mr Alan McGill.

The proposed mining area has a mixture of mining, agriculture, small businesses and settlements within its vicinity. The BCR operations are neighbouring on the north eastern side of the proposed mining area. Anglo Union Mine is also neighbouring to the south eastern side of the proposed mining area's border. The Anglo residential village and all its related infrastructure runs in a southerly direction across the proposed project area. The main access roads to the proposed mining area are the R510 and the R511 along with the Anglo access roads.

Project Impacts and Mitigation

The impact assessment section investigates the potential negative and positive socioeconomic impacts associated with the proposed Varkensvlei and Nooitgedacht mining operations.

Construction Phase Impacts

There will be a low positive impact arising from employment, and some limited economic benefits associated with the proposed project. Samancor will introduce a cadette scheme where community learners will benefit from skills development. The presence of construction workers will increase the local population but no significant negative socioeconomic impacts are expected to arise from this, given adequate mitigation. The influx of work seekers is currently expected to be unlikely. Both major access roads will be affected by opencast mining activities and will need to be realigned to avoid loss of access for the users.

Operational Phase Impacts

Employment opportunities are likely to be limited with preference being given by the project proponent to contract the work to a third party. The economic benefits associated with the proposed project are expected to be somewhat limited but nevertheless positive. The opencast mining activities will directly impact on a cultivated area and may result in loss of crops if the land is cropped at the time of mining and needs to be discussed with the landowners.

Decommissioning Phase

At mine closure, the potential losses of the estimated 120 jobs created from the opencast operations which will impact on the local communities. Samancor's rehabilitation should be followed as to their closure framework.

Conclusion

With appropriate mitigation measures, the proposed project can offer some positive socioeconomic benefits to the economy with limited negative impacts.

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Acronyms

Acronym	Description
BHP	Broken Hill Proprietary Company
BCR	Bushveld Chrome Resources
CRR	Comment Response Register
DM	District Municipality
EMP	Environmental Management Plan
EIA	Environmental Impact Assessment
ESIA	Environmental and Social Impact Assessment
ha	Hectare
IDP	Integrated Development Plan
IMR	International Mineral Resources
Km	Kilometre
LM	Local Municipality
LSA	Local Study Area
m	Metre
MWP	Mine work plan
Pty	Proprietary
SIA	Social Impact Assessment
RSA	Regional Study Area

1.0 INTRODUCTION

Samancor Chrome proposes to undertake opencast mining of the chrome reserve on the farms Varkensvlei and Nooitgedacht in the North West and Limpopo Provinces respectively. In accordance with the Mineral and Petroleum Resources Development Act (MPRDA) (Act No. 28 of 2002), Samancor are required to apply for a Mining Right Application. In support of this application, an Environmental and Social Impact Assessment (ESIA) has been undertaken by Golder Associates Africa (Pty) Ltd.

As part of the ESIA, a Social Impact Assessment (SIA) has been undertaken to assess the potential social impacts that may arise from the proposed project.

2.0 BACKGROUND

Samancor Chrome was established in 1975 as a result of a merger between SA Manganese Ltd (formed in 1926 to mine manganese ore in the Northern Cape) and Amcor Ltd. (established in 1937 to exploit mineral deposits for the steel industry and to process those minerals into ferroalloys). The Kermas Group acquired Samancor Chrome from BHP Billiton and Anglo American in June 2005. International Mineral Resources (IMR) became the majority shareholder in Samancor Chrome Limited in November 2009 through the acquisition of a 70% direct shareholding in the holding company, Samancor Chrome Holdings (Pty) Limited.

Samancor Chrome's corporate office is based in Sandton, Johannesburg. The Company's core business is the mining and smelting of chrome ore. The company's total chromite resources exceed 650 million tons and are expected to support current mining activity for well over 200 years at the current rate of extraction. More than 80% of Samancor Chrome's chrome ore output is consumed in the production of ferrochrome in South Africa. The remainder of the ore is exported.

Samancor Chrome is one of the world's largest integrated producers of ferrochrome, producing more than a million tons of charge chrome, about 70 thousand tons of intermediate carbon ferrochrome, and some 40 thousand tons of low carbon ferrochrome per annum. In addition, Samancor Chrome sells more than 700 thousand tons of chrome ore per annum on the export market. Ferrochrome is used in the production of stainless steel. The chrome content in stainless steel gives it its lustre and resistance to corrosion. Some 85% of South Africa's chrome alloy production is exported to stainless steel producers across the globe and South Africa currently supplies more than 50% of worldwide charge chrome demand.

Samancor Chrome operates the following two chrome ore mining complexes and three ferrochrome plants as separate business units:

- Western Chrome Mines in the Rustenburg area in the North West Province.
- Eastern Chrome Mines near the Lydenburg /Steelpoort area of the Limpopo Province.
- Ferrometals plant near eMalahleni, Mpumalanga Province.
- Middelburg Ferrochrome and Middelburg Technochrome plants near Middelburg, Mpumalanga Province.
- Tubatse Ferrochrome plant in the Lydenburg / Steelpoort area of the Limpopo Province.

2.1 Project Description

Samancor Chrome holds prospecting rights on portions 1, 2 and Remainder of the farms Varkensvlei 403 KQ and portions 2 and 10 of the farm Nooitgedacht 406 KQ, and has applied for a mining right for these portions. The project site lies across the border of the Northwest and Limpopo Provinces, 150km north of Pretoria and 130km east of Bela-Bela.

Sufficient chrome ore reserves have been proven to support opencast mining of the LG6 and LG6A chromitite seams to a depth of 50 meters over an area of about 1273 hectares. An additional area of about 12 ha will be required for surface infrastructure, roads and servitudes.

The chromitite seams occur over a strike length of nearly 6.9km across both farms with an average dip of 25^0, reaching a depth of 300 metres. With an average thickness of about 1 metre, there is a potential for underground mining of the LG6 seam. The LG6A layer lies about 12 metres above the LG6 layer and is only about 0.3 metres thick, too thin for economically viable underground mining.

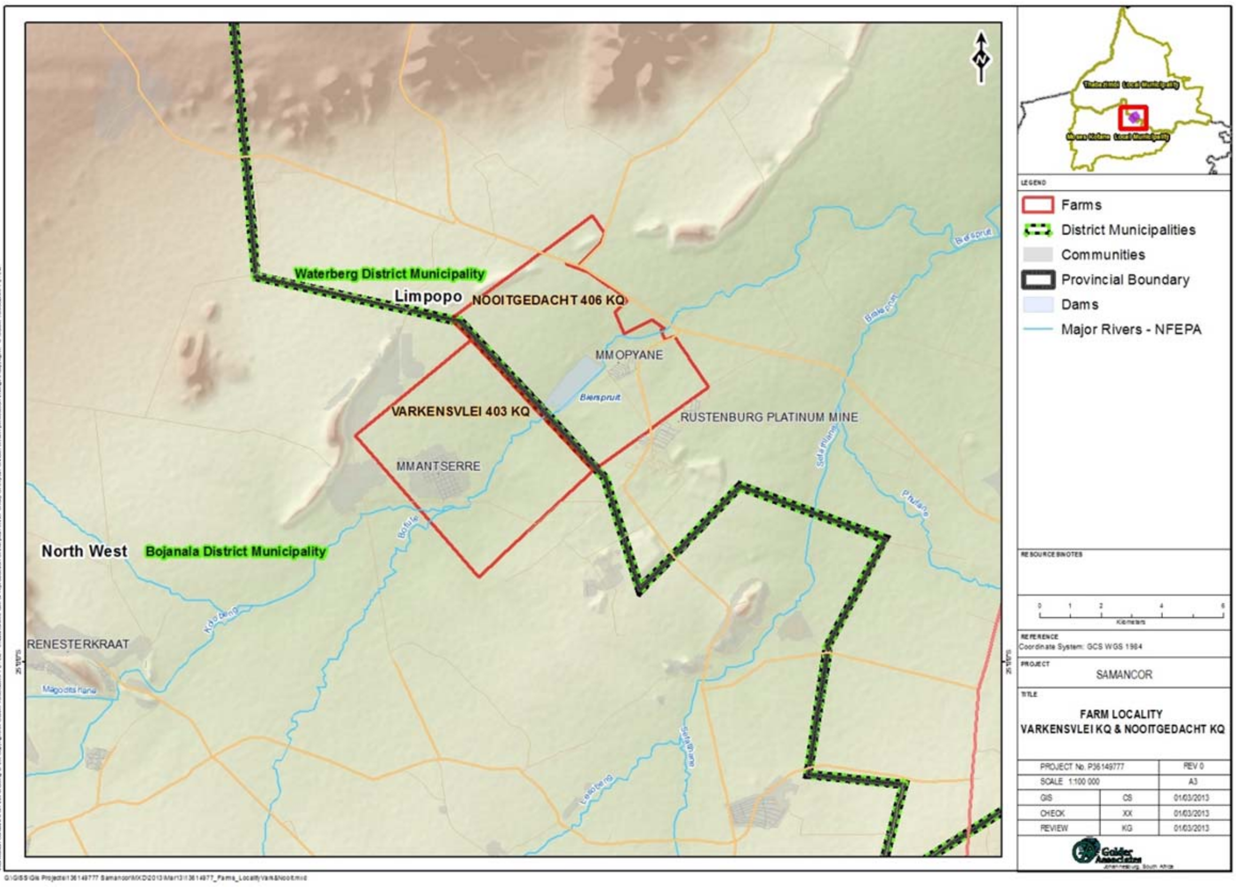

Figure 1: Locality map for the proposed Varkensvlei and Nooitgedacht mining areas

3.0 METHODOLOGY

The SIA study utilised a qualitative research methodology in order to gain an understanding of the affected communities, to collect community level baseline data and to identify positive and negative social impacts that may arise from the proposed project.

The study investigates how the communities utilise the environment around them and what impacts the proposed project would have on the livelihoods of the communities.

The activities which were undertaken to collect and analyse the data for this study are listed below:

3.1 Delineation of Study Area

The regional study area for the SIA has been defined as the local municipalities, regional municipalities and provinces within the proposed project are located. The regional study area contextualises the social environment on a macro-perspective, specifically in terms of population demographic and economic trends such as population growth, concentration and movement, employment levels and sectors.

The local study area has been defined as the farm portions affected by the proposed mining rights application and the neighbouring properties, assuming that the residual biophysical impacts will not extend over these properties. The local study area contextualises the specific receiving social environment for the project, with the focus on households and communities living on these farm portions.

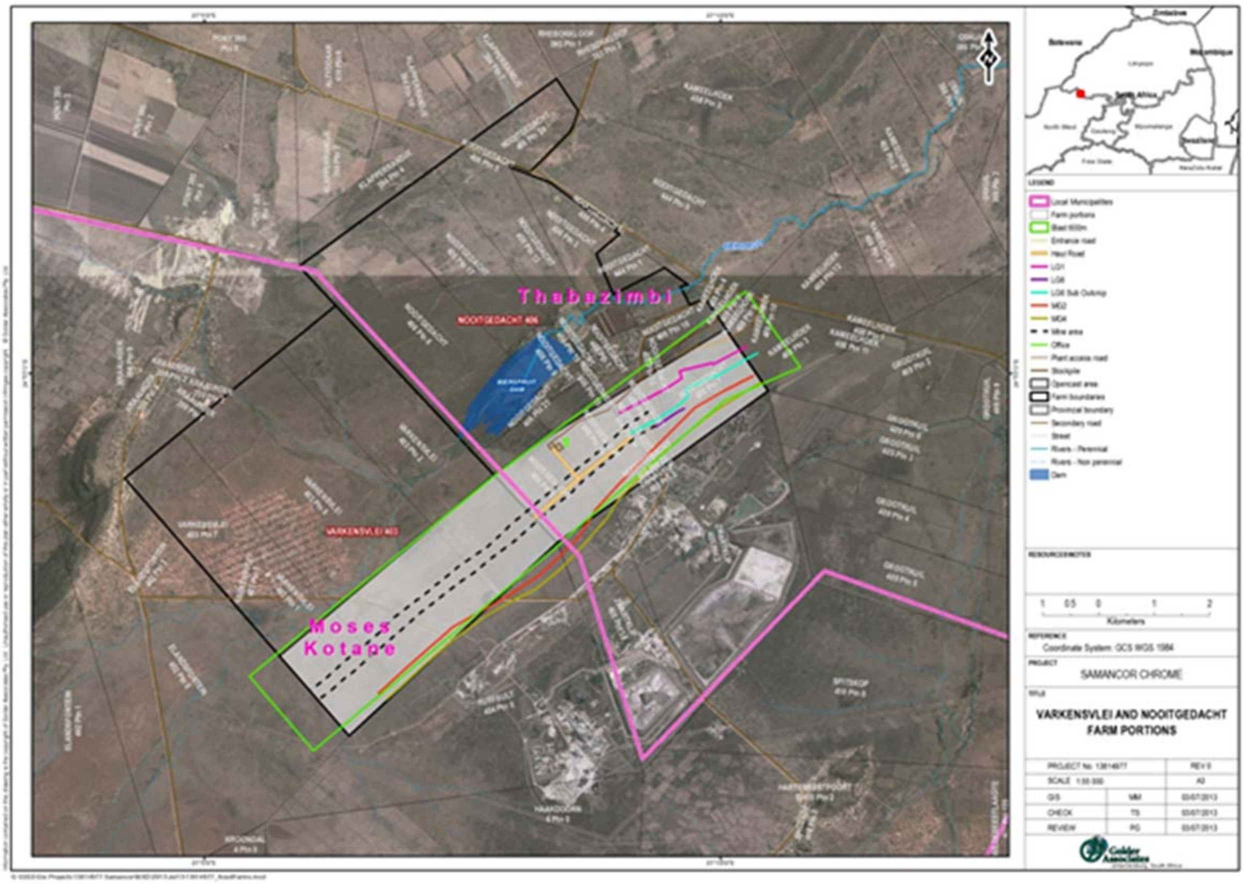

Figure 2: Delineation of study area

3.2 Desktop Study

The following documents were reviewed as part of the SIA:

- Local and regional municipal annual reports, spatial development frameworks and integrated development plans (IDP);
- Relevant socio-demographic and economic data obtained from SA Census 2012;
- Reports produced during the public participation process supporting the Environmental Impact Assessment (EIA), which provided details of key stakeholders identified and public expectations and concerns (such as comments and response report, CRR);
- Air Quality Impact Assessment[1];

[1]Air Quality Impact Assessment for the proposed Varkensvlei/Nooitgedacht Mining Rights Application, Golder Associates (Pty) Ltd. (March 2013).

- Closure Framework and Closure Costing[2];
- Visual Impact Assessment[3];
- Ground Water Specialist Report[4];
- Surface Water Specialist Report[5]
- Noise Specialist Report[6] and
- Documents relating to studies undertaken on other similar dated, current and proposed projects in South Africa and elsewhere describing the socio-economic impacts that have resulted from such projects.

3.3 Key Informant Interviews

Interviews were conducted with various potentially affected members within the local community.

The purpose of the interviews was to:

- Gain insight into the current situation with regard to social services and infrastructure and local administration of these services;
- Gain insights into social impacts as a result of demographic changes in the community (e.g. influx, presence of the workforce, governance constraints, and changes in social capital);
- Gain insight into local development objectives and community needs.

Interviews were held with the following stakeholders during the social team's field work and the public participation process In addition, comments were obtained through and these were reviewed and included in the SIA report. Specifically, comments were sought from:

Authorities:

- Local municipalities relative to the project area are listed in Table 1 :

Table 1: Authorities that were contacted:

Municipality	Ward Councillor	Date and Time
Moses Kotane Municipality	Dorcas Tau	Wednesday, 24 April, 10am
Thabazimbi Local Municipality	Manala Isaac, Mkanzi Themba, Sikhovari Mavuma	Wednesday, 17 April, 12h00

Tribal Authorities:

- The local tribal authority which were contacted as listed in Table 2,

Table 2: Tribal authorities which were contacted

Tribal Authority	Person contacted	Date and Time

[2] Closure Framework and Closure Costing for Samancor's Varkensvlei/Nooitgedacht Prospecting Area, as part of the EIA Informing the Mining Right Application, Golder Associates (Pty) Ltd. (April 2013).

[3] Visual Impact Assessment for the proposed Varkensvlei/Nooitgedacht Chrome mine, Golder Associates (Pty) Ltd. (March 2013)

[4] Groundwater Baseline and Impact Assessment Report for the Mining Rights Application (MRA), Golder Associates (Pty) Ltd. (June 2013).

[5] Surface Water Baseline and Impact Assessment Report for Varkensvlei and Nooitgedacht Chrome Mine, Golder Associates (Pty) Ltd. (June 2013).

[6] Environmental Impact Assessment for the EIA and EMP at the proposed Varkensvlei 403KQ and Nooitgedacht 406KQ, Northam, Limpopo Province, dBAcoustics, Barend van der Merwe, (June 2013).

Tribal Authority	Person contacted	Date and Time
Baphalane Ba Mantserre	Kgosi Modise, Tonse Ramokoka	11 June 2013

Local businesses:

- Local business in the area are listed in Table 3,

Table 3: Local businesses

Business	Owner	Date and Time
Rock Cottage Lodge	Mr Reiner Guba	Wednesday, 24 April, 4:30pm
Hunting Farm	Mr Allan and Mrs Sandy McGill	Wednesday, 24 April, 4:30pm

Local Landowners:

- Potentially affected local landowners, which are listed in Table 4.

Table 4: Varkensvlei and Nooitgedacht Landowners

Title	Full name	Farm Portions	Date and Time
Mr	Gerhard Young	Kameelhoek 406	Wednesday, 24 April, 4:30pm
Mr	Johan Young	Kameelhoek 406	Wednesday, 24 April, 4:30pm
Mrs	Sandra McGill	Varkensvlei 403 KQ portion 2	Wednesday, 24 April, 4:30pm
Mr	Alan McGill	Varkensvlei 403 KQ portion 2	Wednesday, 24 April, 4:30pm
Mr	Reiner Guba	Nooitgedacht 406 KQ	Wednesday, 24 April, 4:30pm

3.4 Assumptions and Limitations

This report assumed that potential impacts relating to noise, air quality and water quality and quantity will be addressed in specialist assessment reports. It is assumed that the recommendations that the specialists make will be implemented and will be effective to reduce the impacts to the levels identified within their various specialist assessments

Detailed information on employee numbers, salaries and wages were not available at the time of the writing of this report.

4.0 REGIONAL BASELINE

The socioeconomic conditions of the regional study area are provided below, focussing on population demographics, household characteristics, social infrastructure and economics.

4.1 Description of the District and Local Municipalities

The proposed project area includes the Nooitgedacht and Varkensvlei farms, and crosses provincial, district municipal and local municipal boundaries. The Varkensvlei farm area is located in the Moses Kotane Local Municipality (LM), within the Bojanala District Municipality (DM) in the Northwest Province. The

Nooitgedacht project area is located in the Thabazimbi Local Municipality (LM) within the Waterberg District Municipality (DM) in the Limpopo Province.

Land use within the Bojanala District Municipality is characterized by crop production and small scale farming as well as large scale mining operations. There are tourism activities from the Pilanesberg National Park and Sun City in the region. There is an abundance of agriculture and minerals (magnesium, chrome, nickel and platinum), (Bojanala IDP, 2012).

For the purposes of this baseline, the Regional Study Area (RSA) of Varkensvlei and Nooitgedacht consists of data broken into the municipal levels described in Table 5

Table 5: Focal areas of the baseline are:

Proposed Varkensvlei Mining Area	Proposed Nooitgedacht Mining Area
■ North West Province;	■ Limpopo Province;
■ Bojanala District Municipality (DM);	■ Waterberg District Municipality (DM);
■ Moses Kotane Local Municipality (LM).	■ Thabazimbi Local Municipality (LM)

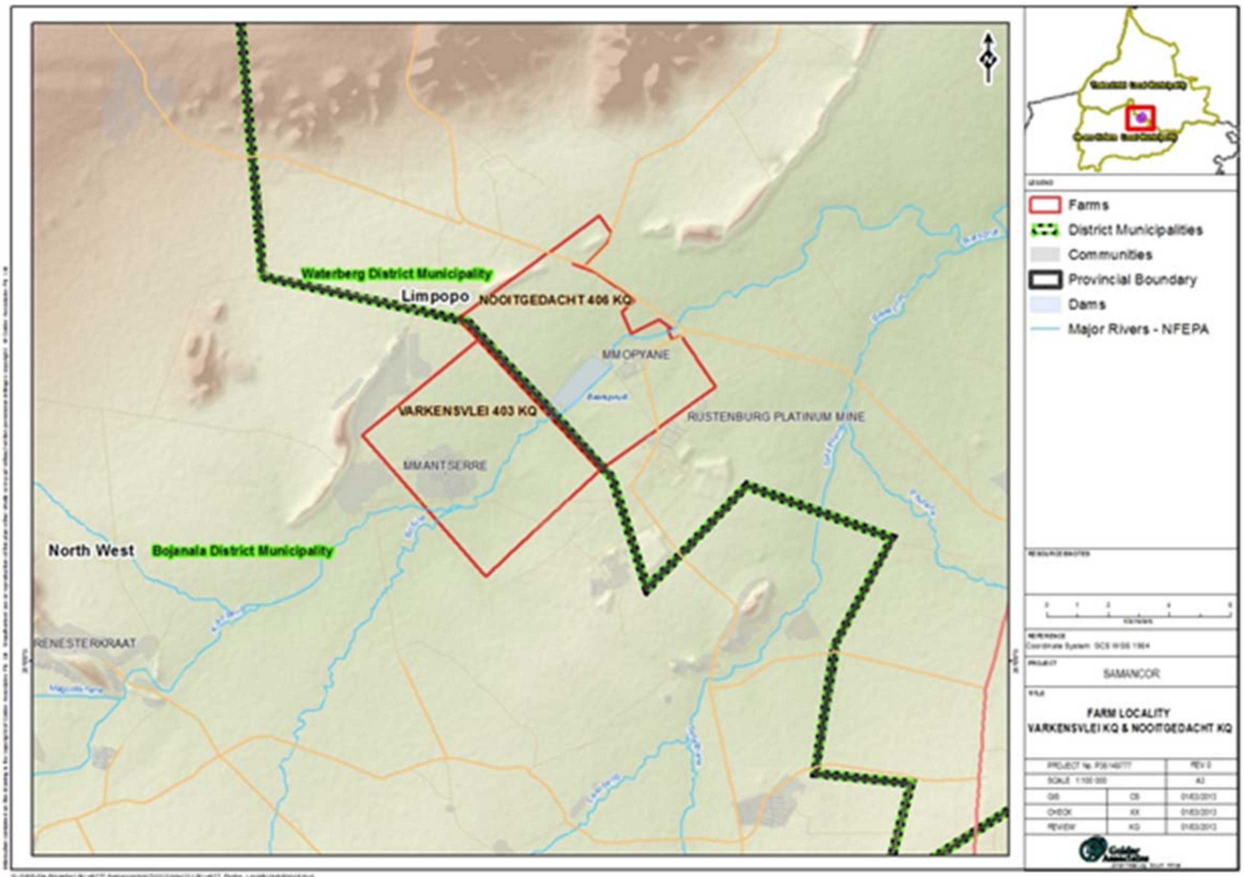

Figure 3: District and Local Municipalities

4.2 Population Demographics

4.2.1 Population Size

The population distribution on a Provincial, District and Local Municipal level are presented in Table 6 below. The Moses Kotane LM has a population of 242,554 and a population density of 42 people/km^2 which is more than double the population of Thabazimbi LM with a population of 85,234 and a population density of 76 people/km^2. At the DM level, population numbers show the Bojanala DM has a population of 1,507,505 a population density of 82 people/km^2 compared to the Waterberg DM with a population of 679,336 and a population density of 15 people/km^2.

In Limpopo Province there are a total number of 1,418,100 households with an average household size of 3.6. The Thabazimbi LM has 25,080 households and an average household size of 3.4. In the Varkensvlei RSA there are a total number of 1,638,889 households with an average household size of 3.1.The Moses Kotane LM has a 75,193 households with an average household size of 3.2. Although the average household size is bigger in Limpopo Province, the overall population of the North West Province is larger than the Limpopo Province.

Table 6: Population Distribution

Nooitgedacht					Varkensvlei				
Geographical Demarcation	**Population**	**Number of Households**	**Average Household Size**	**Population Density/ km^2**	**Geographical Demarcation**	**Population**	**Number of Households**	**Average Household Size**	**Population Density/ km^2**
Limpopo Province	5,404,868	1,418,100	3.8	43	North West Province	3,509,953	1,062,000	3.3	33
Waterberg DM	679,336	179,866	3.7	15	Bojanala DM	1,507,505	501,696	3.0	82
Thabazimbi LM	85,234	25,080	3.4	76	Moses Kotane LM	242,554	75,193	3.2	42

Source: SA Census 2011[7]

Overall the household numbers within the RSA are consistent with the above mentioned population numbers. Moses Kotane LM has 75,193 households and Thabazimbi LM has 25,080 households, therefore it is evident as shown in Table 7 that the Moses Kotane LM – has a 3 times larger population than the Thabazimbi LM. The average household size across theRSA is 3.2 but the Bojanala DM has a household size of 2.8 which is the same as the Thabazimbi LM but this isn't consistent with the number of households for Bojanala which is much larger than that of Thabazimbi.

Despite an increase in household numbers in the RSA between 2001 and 2011, the average household size has decreased in all municipal jurisdictions bar the Thabazimbi LM.which has increased from 2.5 to 2.8. Also the percentage of female headed households has decreased from 2001 to 2011 across the RSA.

The Moses Kotane LM has a higher average household size 3.2 than Thabazimbi which is 2.8. The Moses Kotane LM also has the highest percentage of female headed households (44.1%) at the LM level.

[7] South African National Population Census 2012.

Table 7: Household counts and sizes according to the municipal areas

		Households		Average household size		Female headed households (%)	
		2001	2011	2001	2011	2001	2011
Varkensvlei	**North West Province**	760,588	1,062,015	3.7	3.1	40.5	36.5
	Bojanala DM	324,616	501,969	3.4	2.8	38.9	32.1
	Moses Kotane LM	61,759	75,193	3.7	3.2	49.6	44.1
Nooit.edacht	**Limpopo Province**	1,117,818	1,418,102	4.2	3.7	54.2	50.4
	Waterberg DM	145,883	179,866	3.6	3.4	45.6	42.7
	Thabazimbi LM	20,734	25,080	2.5	2.8	29.4	24.7

Source: SA Census 2011- Municipal factsheet

4.2.2 Age Distribution

The overall trend in age distribution as of 2011 is that the largest percentage of the population across Provincial, DM and LM areas lies in the age range of 15-65 years old which is the economically active age group in a population (refer to Table 8). When comparing the percentages of the economically active age group between province, DM and LM, the percentages are very similar. Thabazimbi LM has the highest percentage (76.4%) of the population between the ages of 15-65 years old in comparison to the percentages across the RSA. There has been a growth in the economically active population within the RSA between 2001 and 2011 of 5.4%.The total population of the proposed RSA has declined by 40% from 2001 to 2011. The North- West Province population has grown by more than Limpopo Province from 2001 to 2011 (18% vs. 8.1%).

There has been a general decrease in the age group of 0-15 years of age between 2001 and 2011. Thabazimbi LM has a smaller proportion (21.1%) of young people between 0 and 15 years of age and an even smaller proportion (2.5%) of elderly people aged 65 and over when compared at a district and provincial level. This implies that at least one third of the population is children and/or elderly. This implies that for every one or two adults, there is at least one dependent just based on age.

Table 8: Age structure

	Population			Age Structure (%)					
				<15		15-65		65+	
	2001	**2011**	**% of total change**	**2001**	**2011**	**2001**	**2011**	**2001**	**2011**
Nooitgedacht									
Limpopo Province	4,995,462	5,404,868	8.1	39.1	34.0	55.2	59.8	5.7	6.3
Waterberg DM	604,938	679,336	12.2	35.1	29.9	59.3	64.3	5.6	5.8
Thabazimbi	65,533	85,234	30	26.0	21.1	71.5	76.4	2.5	2.4

LM									
Varkensvlei									
Northwest Province	2,984,098	3,509,953	18	31.1	29.6	63.7	64.7	5.2	5.6
Bojanala DM	1,189,360	1,507,505	27	29.0	26.4	65.8	68.3	5.2	5.3
Moses Kotane LM	237,175	242,554	2.3	32.4	29.2	60.7	63.1	6.9	7.7
Total Population	19,076,566	11,429,450	-40						

Source: SA Census 2011- Municipal factsheet

4.2.3 Gender and Ethnicity

The distribution of gender and ethnicity for the RSA is show in Figure 4. The Black African population is the highest ethnic population (over 40%) followed by a small population (approximate average of 6%) of White males and females across the RSA. The gender distribution is fairly uniform amongst the Black African population.

At the LM level, Thabazimbi has more of a white population representation (8%) than Moses Kotane (0%) but in the Moses Kotane LM the percentage of Black African population is higher than in Thabazimbi. The Black African male (49%) to female (50%) ratio is relatively uniform in the Moses Kotane LM as compared to the Black African male (50%) to female (34%) in the Thabazimbi LM. The predominant population are Black African males (47%) and females (45%).

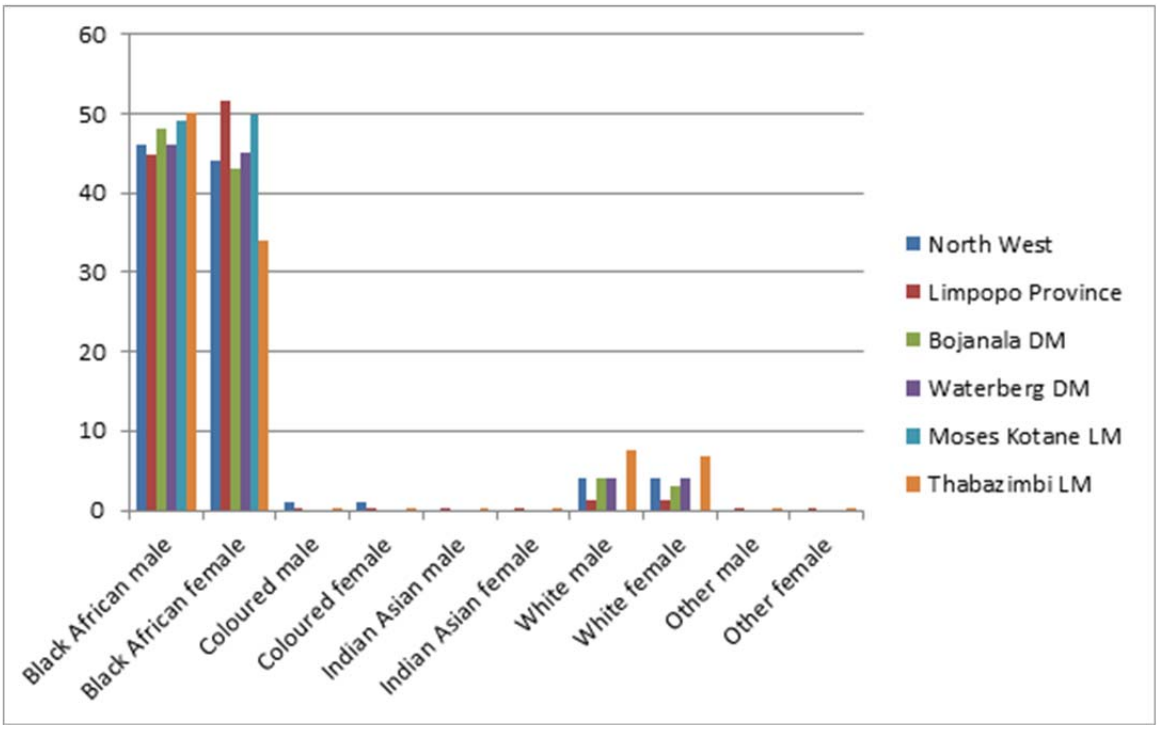

Figure 4: Gender Distribution, Source: SA Census 2011

4.2.4 Education

The majority of the population in the RSA have attained some secondary education, ranging from 34% to 38% of the population. Between 23% and 28% have completed secondary education, and between 5% and 8% have completed higher or tertiary education. A substantial proportion of the population have either no schooling, some primary or completed primary education, ranging between 28% and 34% (see Table 9).

Table 9: Education levels for adults in each administrative area

EDUCATION	Varkensvlei			Nooitgedacht		
	North West (%)	Bojanala DM (%)	Moses Kotane LM (%)	Limpopo Province (%)	Waterberg DM (%)	Thabazimbi LM (%)
No schooling	12	8	9	17	13	9
Some primary	17	15	17	12	14	14
Completed primary	5	5	5	4	5	6
Some secondary	34	37	36	36	37	38
Completed secondary	25	29	28	23	24	27
Higher	7	6	5	8	7	6
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**

Source: SA Census 2011

4.2.5 Employment

The average employment rate across the RSA is 38% and the average unemployment rate is 16%. Whilst the Limpopo province has an employment rate of 27%, the Waterberg DM has a higher proportion of the employed population (38%), with the Thabazimbi LM serving as the main employment hub for the Waterberg DM with 51% of the population employed. Thabazimbi therefore serves as an important supplier of employment for the population in the Limpopo Province. Conversely, employment levels in the Moses Kotane LM (30%) are lower than employment levels in the Bojanala DM (42%), indicating that the Moses Kotane LM is not the most significant employment contributor to the Bojanala DM and North West province (refer to Figure 5).

As seen in the age distribution section (4.2.2) the high percentage of economically active people will mean that there is a high availability for employment in the area. In the RSA the highest attained level of education is some secondary (36%) and 23% of the RSA have completed secondary school, therefore there is a semi-skilled labour force available to the mine for employment.

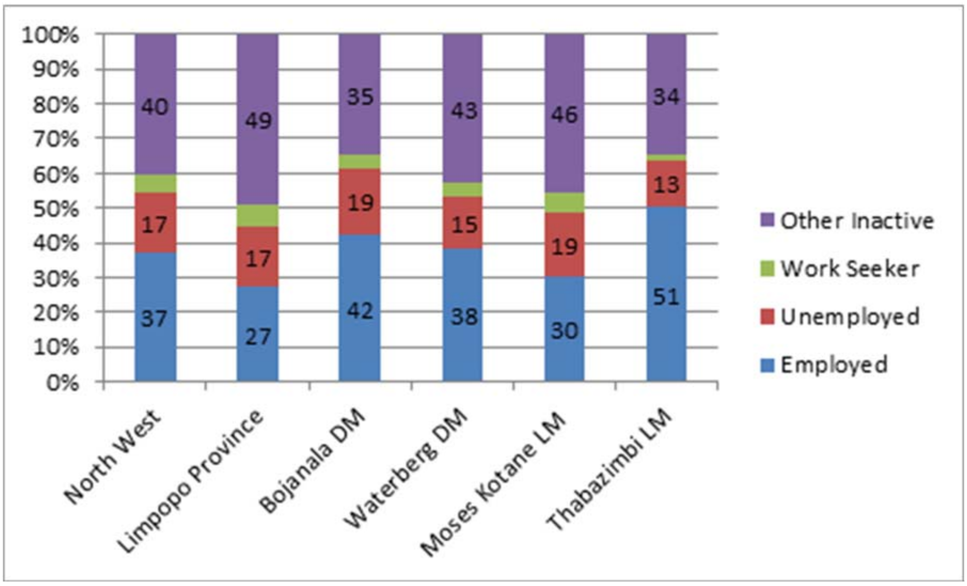

Figure 5: Employment, Source: SA Census 2011

4.2.6 Health

The prevalence of HIV and AIDS between 2004 and 2007 in Thabazimbi LM are presented in Table 10. The latest percentage levels for 2007 indicate that an estimated 8.06% of the population had contracted HIV and 0.65% suffered from AIDS. The estimated level of HIV has increased at an average of 0.52% from 2004 to 2007 per annum. The estimated AIDS level has increased at an average of 11.72% from 2004 to 2007 respectively. There was a shortage of health information on desktop view regarding the Moses Kotane LM (Thabazimbi LM IDP 2011-12).

The closest hospitals to the proposed project site are the George Stegmann District Hospital (27km away) and the Curamed Thabazimbi Hospital, situated 49km's away in Thabazimbi Town. Health infrastructure is discussed in section 4.3.2.

Table 10: HIV/AIDS- Thabazimbi LM

	2004	Total%	2005	Total%	2006	Total%	2007	Total%
HIV	5,801	8.5	5,805	8.38	5,803	8.26	5,729	8.06
AIDS	337	0.49	387	0.55	433	0.61	467	0.65
Population	68,238		69,264		70,216		71,057	

Source: Thabazimbi LM IDP 2012[8]

4.2.7 Housing

In Figure 6 over 60% of the RSA reside in farm house structures with the remaining population of the RSA residing in Informal settlement / squatter areas[9] (17%) and traditional dwellings (2%).

In Thabazimbi LM 64% of the population resides in farm housing, 14% residing in informal squatter and 12% in informal dwellings. In Moses Kotane LM 76% of the population reside in farm housing, 12% in informal squatter housing and 8% in informal dwellings.

[8] Thabazimbi Local Municipal Integrated Development Plan (IDP) 2011-2012.

[9] Stats SA defines an informal settlement refers to an area consisting mainly of informal dwellings. The term squatter areas is used as a synonym only for informal settlements. There are three types of squatter areas or informal settlements: those within municipal or local authority areas; those outside municipal or local authority boundaries; and those situated in rural areas.

With established towns and townships within the municipal area, there are sprawling informal settlements that are found adjacent to the nodes, especially where there are mining activities.

The existence of the informal settlements within the municipal area extends the service delivery backlogs in municipalities. In Thabazimbi municipality one informal settlement, Jabulane is found on a privately owned land and is comprised of 288 households without basic services (Waterberg IDP, 2013).

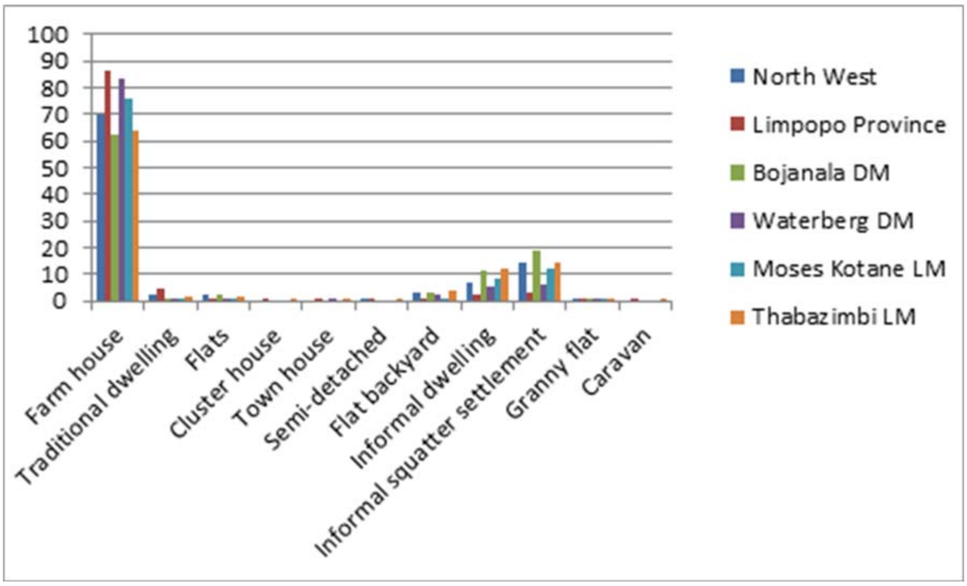

Figure 6: % distribution of Housing, Source: SA Census 2011

4.3 Social Infrastructure

The focal social infrastructure and service supply in the regional study area includes sanitation, water systems, places of convenience and waste disposal sites, electricity, telecommunications and health facilities.

4.3.1 Sanitation

As presented in Table 11 it is evident that across the RSA that the flush system toilet and pit toilets without ventilation are the most common sanitation facilities. The majority of the Thabazimbi population (63%) have flush toilet sanitation systems and only 18% have access to pit toilets without ventilation as compared across the RSA. Majority of the population in Moses Kotane LM have access to pit toilets without ventilation (68%) and only 12% of the population using flush toilet systems.

It is interesting that at a LM level, sanitation systems differ to such a degree that it can be deduced that the Moses Kotane LM has lower cost housing than the Thabazimbi LM.

Table 11: Toilet Facilities

TOILET FACILITIES	Varkensvlei			Nooitgedacht		
	North West (%)	Bojanala DM (%)	Moses Kotane LM (%)	Limpopo Province (%)	Waterberg DM (%)	Thabazimbi LM (%)
Flush toilet (connected to sewerage system)	42	33	12	20	44	63
Flush toilet with septic tank	3	4	2	2	4	5
Chemical toilet	1	1	1	1	1	1
Pit toilet with ventilation	11	11	14	15	10	3

TOILET FACILITIES	Varkensvlei			Nooitgedacht		
	North West (%)	Bojanala DM (%)	Moses Kotane LM (%)	Limpopo Province (%)	Waterberg DM (%)	Thabazimbi LM (%)
(VIP)						
Pit toilet without ventilation	34	44	68	53	35	18
Bucket toilet	1	1	0	1	1	1
Other	1	1	1	1	2	3
None	6	4	3	7	4	6
TOTAL	100	100	100	100	100	100

Source: SA Census 2011

4.3.2 Health Facilities

The main hospital in the Thabazimbi Municipal area is the Thabazimbi Hospital. Most other health facilities such as clinics and surgeons are situated in the town of Northam. There are an estimated number of 19 health facilities situated in the Thabazimbi LM.

The main hospital in the Moses Kotane LM is the George Stegman Hospital, which has 323 beds and 97 professional staff. It is estimated that there are 10 health facilities within the Municipality, which is less health infrastructure than Thabazimbi LM (refer to Table 12).

Table 12: Comparison of health facilities between local municipalities

Health facilities	No. of Facilities	
	Thabazimbi LM	Moses Kotane LM
Hospitals	5	4
Public Health Clinics	8	3
Satellite Clinic Offices	3	-
Mobile Health Service	3	3
Total	**19**	**10**

Source: Thabazimbi Municipality IDP 2011-12 & MKLM IDP 2011/2012[10]

4.3.3 Energy

Electricity is the most common source of energy used for lighting across the RSA as depicted in Figure 7 with over 75% of the RSA's population using electricity. The next most utilized source of energy for lighting is the use of candles (11%). On the LM level, Thabazimbi LM has 77% of the population utilizing electricity as the main source of energy for lighting, followed by 18% using candles as a source of light. Moses Kotane LM has 99% of the population utilizing electricity as the main source of energy for lighting, followed by only 1% of the population using candles as their primary source of light.

[10] Moses Kotane Local Municipal Integrated Development Plan (IDP) 2011-12

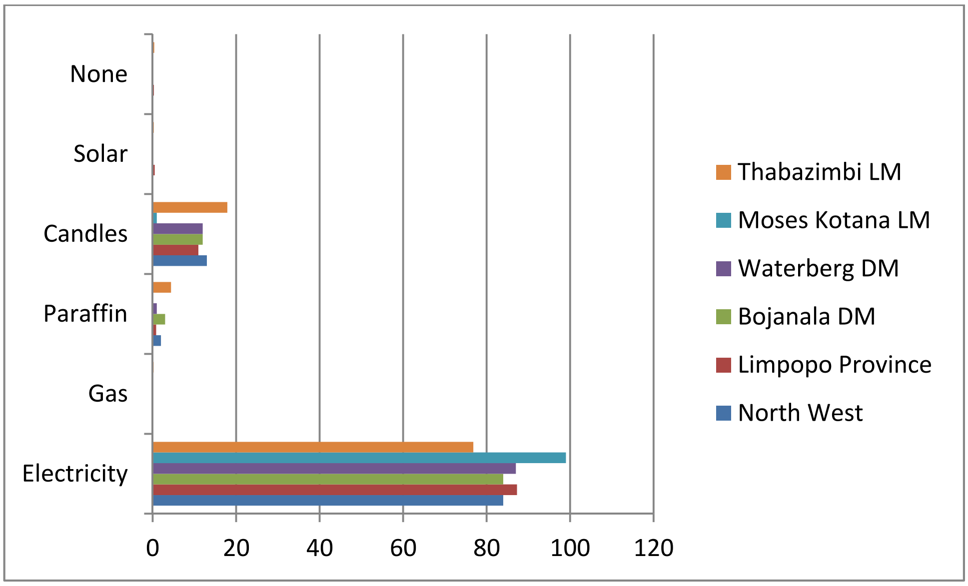

Figure 7 Energy sources for lighting, Source: SA Census 2012

Electricity is also the most commonly used energy source used for cooking in the RSA as presented in Figure 8. The second most commonly used source of energy to cook with is wood, which is extremely common in Limpopo where 43% of the population are using wood to cook.

On the LM level, Thabazimbi LM has 73% of the population using electricity as their primary source of energy to use to cook, followed by 16% of the population using paraffin as their primary source of energy used for cooking. Moses Kotane LM has 75% of the population using electricity as their primary source of energy to use to cook with, followed by 17% using wood as their primary source of energy to use to cook.

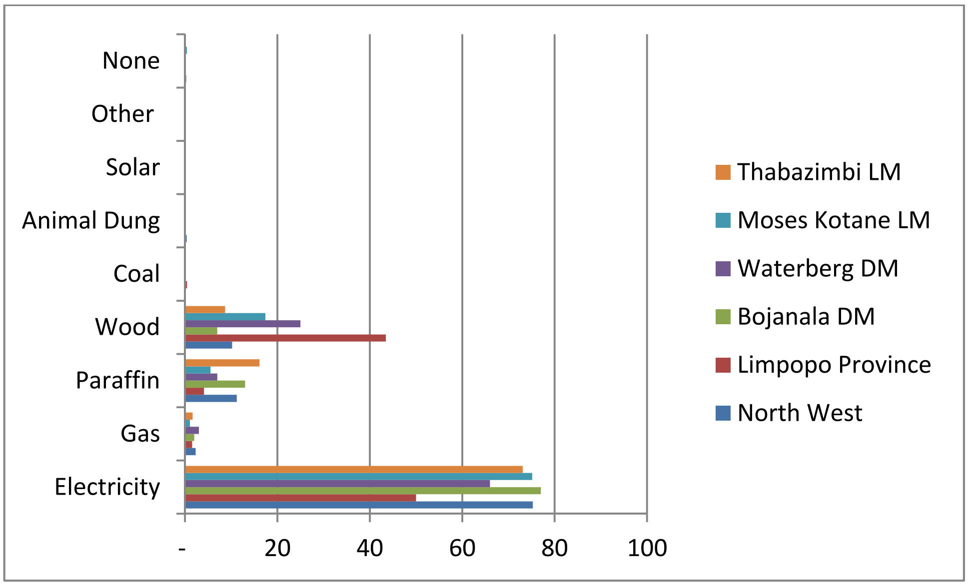

Figure 8 Energy used for cooking, Source: SA Census 2012

Electricity is the main mode of energy used for heating in all areas. Wood and paraffin are the second most common source of energy used for heating as illustrated in Figure 9. On the LM level, Thabazimbi has 68% of the population using electricity as the main source of energy to cook with, followed by 14% of the population using wood as the energy source for heating. Moses Kotane LM has 63% of the population using electricity as the main source of energy for heating, followed by 18% of the population using wood as the main source of energy for heating. As seen in the following statistics it is evident that the most prevalent source of energy used for all needs is electricity.

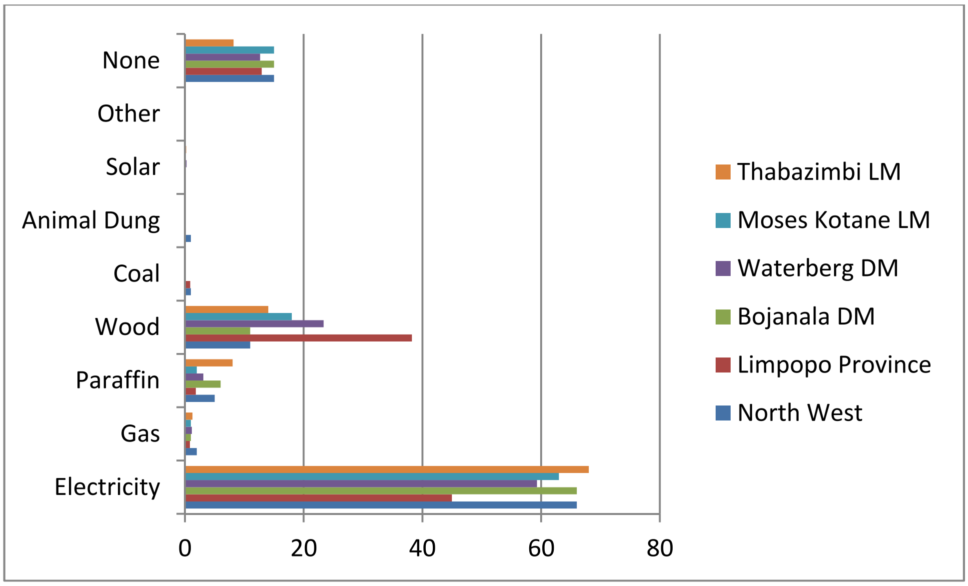

Figure 9 Energy used for heating, Source: SA Census 2012

4.3.4 Water

The most common source of piped water is that of piped water taps inside dwellings and inside yards. On the LM level, 47% of the Thabazimbi LM population have access to piped water inside their dwellings followed by 24% having access to piped water inside their yard. In the Moses Kotane LM the main source of piped water is piped water inside the yard (38%), followed by 25% of the population having piped tap water on a community stand (less than 200m away). It is reported that only around 10% of the local population do not have access to a piped water source as depicted below in Table 13.

Table 13: Piped Water

PIPED WATER	Varkensvlei			Nooitgedacht		
	North West (%)	Bojanala DM (%)	Moses Kotane LM (%)	Limpopo Province (%)	Waterberg DM (%)	Thabazimbi LM (%)
Piped tap water inside dwelling	29	26	19	18	31	47
Piped tap water inside yard	40	47	38	34	40	24
Piped tap water on community stand : distance less than 200m from	14	10	25	20	16	13

dwelling						
Piped tap water on community stand: between 200m and 500m from dwelling	5	4	8	7	5	5
Piped tap water on community stand: between 500m and 1000m (1km) from dwelling	2	2	3	4	2	3
Piped tap water on community stand greater than 1000m (1km) from dwelling	1	1	1	2	1	2
No access to piped water	8	10	7	14	6	6
TOTAL	100	100	100	100	100	100

Source: SA Census 2012

Communities in the regional study area are mostly supplied by water from a regional or local water scheme operated by the municipality or other water services (see Table 14). Thabazimbi LM has 64% of the population using municipal water and only 17% relying on boreholes as their main source of water and 15% relying on water tanker deliveries. Less than 5% of the population rely on another source of water. Moses Kotane LM has 80% of the population relying on municipal water as the main source of water, followed by 10% of the population using borehole water as the main source of water.

Table 14: Source of water

SOURCE OF WATER	Varkensvlei			Nooitgedacht		
	North West (%)	Bojanala DM (%)	Moses Kotane LM (%)	Limpopo Province (%)	Waterberg DM (%)	Thabazimbi LM (%)
Regional/ local water scheme operated by municipality or other water services provider	74	74	80	63	70	64
Borehole	15	12	10	15	19	17
Spring	0	0	0	2	0	0
Rain water tank	0	0	0	1	0	0
Dam/pool/stagnant water	0	1	1	4	1	0
River/stream	0	0	0	6	1	0
Water vendor	2	4	2	4	2	1
Water tanker	4	5	3	3	5	15
Other	3	4	3	3	2	2
TOTAL	100	100	100	100	100	100

Source: SA Census 2012

4.3.5 Refuse

The majority of the population in the regional study area rely on their refuse disposal to be removed by local authorities as characterized in Table 15. Only in Limpopo Province 66% of the population have their own refuse dumps. Less than 10% of the total population have no formal method of rubbish disposal.

The population in the Thabazimbi LM has 60% of the refuse removed by local authority, and 29% have their own refuse dumps and only 6% having no refuse disposal. Moses Kotane LM has 80% of the refuse also removed by local authorities and 13% of the population have their own refuse dumps.

Table 15: Refuse disposal

REFUSE DISPOSAL	Varkensvlei			Nooitgedacht		
	North West (%)	Bojanala DM (%)	Moses Kotane LM (%)	Limpopo Province (%)	Waterberg DM (%)	Thabazimbi LM (%)
Removed by local authority/ private company at least once a week	49	49	81	21	44	60
Removed by local authority/ private company less often	1	2	2	1	1	2
Communal refuse dump	2	2	1	1	2	2
Own refuse dump	40	39	13	66	45	29
No rubbish disposal	6	7	3	10	7	6
Other	1	1	1	1	1	1
TOTAL	100	100	100	100	100	100

Source: SA Census 2012

4.4 Economics

This economic section focuses on local employment and the various sector contributions. The mining, agriculture, farming, hunting and tourism sectors are the most dominant economic sectors in theses municipal areas.

4.4.1 Labour Force

The formal sector of the labour force is the main economic contributor for the RSA as presented in Table 16. The formal sector of the Thabazimbi LM contributes 72% to the local economy, with the informal sector only contributing to 12% of the economy. In Moses Kotane LM the formal sector contributes 76% to the local economy, with the informal sector only contributing to 13% of the local economy.

The majority of the employed population (30% for Moses Kotane LM and 51% for Thabazimbi LM) is employed in the formal sector. In Moses Kotane LM, 76% of the employed population is employed in the formal sector and 72% of the employed population in Thabazimbi LM are similarly employed.

Table 16: Labour force sectors

LABOUR FORCE SECTORS	Varkensvlei			Nooitgedacht		
	North West (%)	Bojanala DM (%)	Moses Kotane LM (%)	Limpopo Province (%)	Waterberg DM (%)	Thabazimbi LM (%)
Formal sector	68	71	76	66	68	72
Informal sector	15	13	13	18	16	12
Private household	15	13	9	14	14	13
Do not know	2	2	1	2	2	3
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**

Source: SA Census 2012

4.4.2 Income

The average annual national household income according to the IES 2010/2011[11] was R119 542. As presented in Table 17, the majority (50%) of all combined household populations earn between R9 601 and R76 400 per annum. Therefore, the majority of all income earning households within the RSA fall under the average national annual household income bracket. Less than 20% of the population in 2012 had no income.

Thabazimbi LM has the most households (20%) falling in the R38 201-R76 400 household income bracket followed by 16% of the population households earning between R19 601-R38 200 per annum. Moses Kotane LM has the most households (22%) falling in the R9 601-R19 600 income bracket and 17% earning in the R19 601-R38 200 bracket.

[11] Income and Expenditure survey (IES) 2010-2011, South African Statistics.

Table 17: Annual household Income

INCOME	Varkensvlei			Nooitgedacht		
	North West (%)	Bojanala DM (%)	Moses Kotane LM (%)	Limpopo Province (%)	Waterberg DM (%)	Thabazimbi LM (%)
No income	17	17	19	14	14	14
R1-R4 800	4	3	4	6	4	3
R4 801-R9 600	7	5	7	12	8	4
R9 601-R19 600	19	17	22	23	20	13
R19 601-R38 200	20	19	17	21	22	16
R38 201-R76 400	15	19	15	10	14	20
R76 401-R53 800	9	10	9	6	9	14
R153 801-R307 600	5	5	4	4	6	10
R307 601-R614 400	3	3	1	2	3	5
R614 001-R122 8800	1	1	0	1	0	1
R128 802-R245 7600	0	0	0	0	0	0
R2 457 601 or more	0	0	0	0	0	0
TOTAL	100	100	100	100	100	100

Source: SA Census 2012

4.4.3 Economic Sector Contributions

Northam is the closest town from the project area, located approximately 4 km to the east. It is mentioned in the Waterberg DM IDP (2013) that Northam is sustained around the local mining activities in the area and it is considered as a developing node. The future role of the node will increase in importance as mining activities shifts from iron ore to platinum. Thabazimbi is regarded as a developing area and is dominated by a single sector which is mining. The Waterberg DM is one of the major mining regions in South Africa where platinum, iron ore, coal and diamonds are mined. The Waterberg DM has both comparative and competitive advantages in agriculture, mining and tourism. The mining industry in the municipal area contributes to the economic development of the District and Province. The Waterberg DM is the largest production area of platinum in the Province. The municipal area still has the potential of expanding mining activities.

Mining plays an important role in the economy of the Bojanala region, and is the district's major source of employment. Most of the mining activities are concentrated in a band (the Merensky Reef) which stretches from west of the Pilanesberg, southwards through the Bafokeng area, and parallel to the Magaliesberg towards Marikana and Brits in the east. The mines along this belt have spawned many industries which manufacture supplementary products. Not only are chrome, lead, marble, granite and slate produced in the area, but the two largest platinum mines in the world are found in the Bojanala DM (Bojanala IDP, 2012).

According to the Bojanala DM IDP (2012) the Moses Kotane LM contributed 10.1% towards the Bojanala District Municipality GGP. Mining and quarrying contribute 41.8% towards the Bojanala DM's GGP and agriculture only 1.8%. In the North West Province mining and quarrying contributes 26% towards the provincial GGP, mining is therefore the most dominant sector within the local economy.

4.5 Description of local project area

The proposed project site lies across the border of the Northwest and Limpopo Provinces, 150km north of Pretoria and 130km east of Bela-Bela. The proposed project area is located on portions of the farm Varkensvlei 403KQ which is owned by the Bakgatlabakgafela traditional authority under Chief JM Pilane and Nooitgedacht farm 406 KQ, owned by Anglo Platinum, Mr Reiner Guba and Mr Alan McGill.

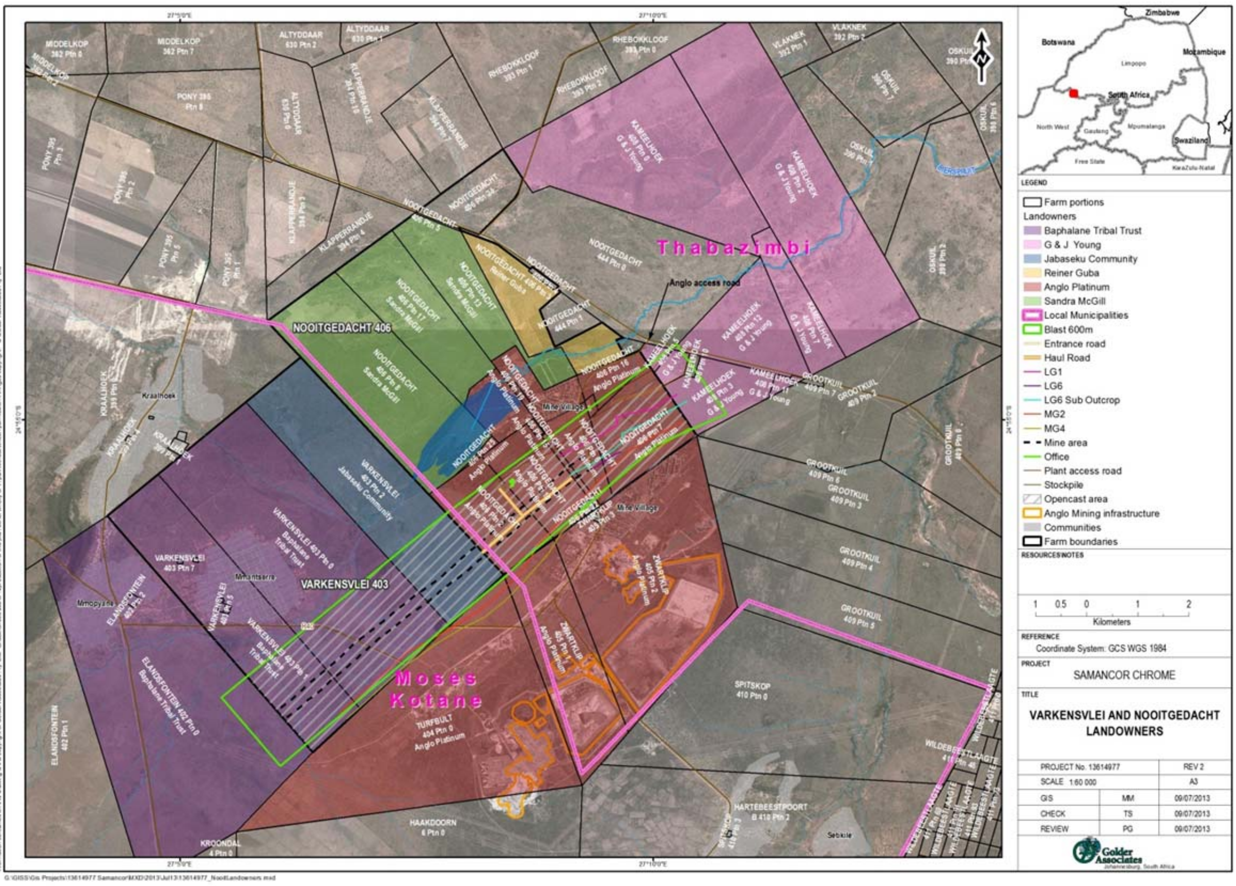

Figure 10: Local study area

Table 18: Farm portions in local study area

Portion number	Land owner	Portion description	Potential infrastructure
Kameelhoek 408 Portion 0, 3, 4, 7, 9, 10, 11, 12.	Mr Gerhard Young and Mr Johan Young	■ Open bushveld, agriculture and ■ Ben House mining contractors	None
Nooitgedacht 406 Portion 1	Anglo Platinum	■ Majority of the portion is Anglo's mining village residential area (houses and roads),	None

Portion number	Land owner	Portion description	Potential infrastructure
		■ a bed and breakfast, ■ open land and ■ The Bierspruit stream.	
Nooitgedacht 406 Portion 2	Anglo Platinum	■ Open grass land ■ A perennial stream which feeds into the Bierspruit Dam	■ Proposed mining lease area. ■ Samancor's proposed opencast operations will run from a NE to a SW direction. ■ The haul road and stockpiles will also be placed on this portion.
Nooitgedacht 406 Portion 7	Anglo Platinum	■ Currently being utilised by BCR mining where samples are being taken; ■ A perennial stream which feeds into the Bierspruit River; ■ Open land	■ The portion consists of the start of the proposed Samancor operations ■ Proposed opencast area; ■ The 600m blast radius also ends on this portion.
Nooitgedacht 406 Portion 6	Anglo Platinum	■ Anglo's main access road runs through this portion in a North to South direction; ■ Open grass area and ■ A small Anglo residential area.	■ Proposed Samancor opencast area; ■ The 600m blast radius also ends on this portion.
Nooitgedacht 406 Portion 12	Anglo Platinum	■ Open grass area and ■ A small Anglo residential area.	■ Proposed Samancor opencast area; ■ The 600m blast radius also ends on this portion.

Portion number	Land owner	Portion description	Potential infrastructure
Nooitgedacht 406 Portion 16	Anglo Platinum	■ Anglo's main access road runs through this portion in an East to West direction; ■ A perennial stream which feeds into the Bierspruit River; ■ A small Anglo residential area.	■ The 600m blast radius also ends on this portion.
Nooitgedacht 406 Portion 14	Anglo Platinum	■ Majority of the portion is Anglo's mining village residential area (houses and roads)	■ Proposed Samancor opencast area; ■ The 600m blast radius also ends on this portion.
Nooitgedacht 406 Portion 10	Anglo Platinum	■ Open grass area and; ■ A small Anglo residential area.	■ Proposed Samancor opencast area; ■ The 600m blast radius also ends on this portion. ■ All proposed mining infrastructure will also fall on this portion (Offices, storerooms.)
Nooitgedacht 406 Portion 25	Anglo Platinum	■ Open grass area and; ■ A small Anglo residential area.	None
Nooitgedacht 406 Portion 9	Anglo Platinum	■ Open grass area and; ■ Anglo residential area; ■ Bierspruit Dam and recreational facilities.	None
Nooitgedacht 406 Portion 3	Mr Reiner Guba	■ Agricultural and;	None

Portion number	Land owner	Portion description	Potential infrastructure
		■ Open grass land.	
Nooitgedacht 406 Portion 13	McGill Family	■ Agricultural land (Lurcerne); ■ Open grass land	None
Nooitgedacht 406 Portion 8 and 17	McGill Family	■ Agricultural land; ■ Open grass land and; ■ Land also used for game hunting.	None
Varkensvlei 403 Portion 2	Jabuseku Community and Baphalane Tribal Trust	■ Open grazing land and; ■ A perennial stream which feeds into the Bierspruit Dam; ■ Scattered residential areas.	■ Bottom portion of the land will be used for the proposed opencast mining; ■ The 600m blast radius also ends on this portion.
Varkensvlei 403 Portion 0	Baphalane Tribal Trust	■ A perennial stream which feeds into the Bierspruit Dam; ■ Mantserre community; ■ R40 tar road	■ Bottom portion of the land will be used for the proposed opencast mining; ■ The 600m blast radius also ends on this portion.
Varkensvlei 403 Portion 1	Baphalane Tribal Trust	■ A perennial stream which feeds into the Bierspruit Dam; ■ Mantserre community; ■ R40 tar road	■ Bottom portion of the land will be used for the proposed opencast mining; ■ The 600m blast radius also ends on this portion.
Varkensvlei 403 Portion 5	Baphalane Tribal Trust	■ A perennial stream which feeds into the Bierspruit Dam ■ Mantserre community; ■ R40 tar road.	■ Bottom portion of the land will be used for the proposed opencast mining; ■ The 600m blast radius also ends on this portion.

Portion number	Land owner	Portion description	Potential infrastructure
Varkensvlei 403 Portion 7	Baphalane Tribal Trust	■ A perennial stream which feeds into the Bierspruit Dam ■ R40 tar road; ■ Mantserre community.	■ Bottom portion of the land will be used for the proposed opencast mining; ■ The 600m blast radius also ends on this portion.
Elandsfontein 402 Portion 2	Baphalane Tribal Trust	■ A perennial stream which feeds into the Bierspruit Dam; ■ Mopyane community residential area; ■ R40 tar road and a national main road; ■ Kraalhoek community also stars on the northern end of this portion.	■ None
Elandsfontein 402 Portion 0	Baphalane Tribal Trust	■ Scattered residential areas; ■ R40 tar road and a national main road; ■ Open grass land.	■ The proposed open cast mining also will come to an end on the border of this portion; ■ The 600m blast radius also ends on this portion.
Zwartklip 405 Portion 2	Anglo Platinum	■ Anglo Union mine mining infrastructure; ■ Main mine access road; ■ A perennial stream	■ None
Zwartklip 405 Portion 1	Anglo Platinum	■ A perennial stream; ■ Main mine access road.	■ The 600m blast radius ends on the border of this portion.
Turfbult 404 Portion 0	Anglo Platinum	■ R40 tar road; ■ A perennial stream;	■ The 600m blast radius ends on the border of this

Portion number	Land owner	Portion description	Potential infrastructure
		■ Main mine access road; ■ Open grass land.	portion.

The land owners on farm Nooitgedacht 406 KQ are Mr Reiner Guba and family. Land use in this area comprises of residential and small businesses consisting of Bed and breakfasts, there are restaurants and a small portion of agricultural land consisting of lucerne fields and a wetland area.

Mrs Sandra McGill and Mr Alan McGill are the land owners of Portion 13, 17 and 8 on Nooitgedacht 406 403 KQ. Land use on the Varkensvlei farm consists of agriculture, which is predominantly sunflower and lucerne farming; there are also game farms where hunting enterprises are run and a wetland area.

The Ba- Mantserre community are immediate landowners on the Varkensvlei farm 403KQ portions 1, 5, 7 and portion 0 which they co-own with the Jabaseku community. The land use of their land consists of residential and grazing land. The Mantserre settlement lies within the western edge of the proposed project area boundary on the Varkensvlei 403 KQ farm. There has been an estimated 1,081 households (assuming that each structure relates to one household) in the proposed project area (on Varkensvlei farm) according to an aerial image count. The Ba- Mantserre community are also immediate landowners of portions 0 and 2 of Elandsfontein 402 KQ where there are two neighbouring communities namely Kraalhoek (approximately 1 km from the northern Varkensvlei farm boundary) and Mopyane (approximately 500 meters - 1 km from the Varkensvlei farm's western boundary), these communities are estimated to be half the size of the Mantserre community.

Mr Gerhard Young and Mr Johan Young are landowners of Kameelhoek 406 KQ portions 4, 9, 10, 3, 11, 12, 7 and 0 which is north eastern side of the proposed project area and is predominantly open agricultural land, Ben House Mining also have small scale bulk sampling operations on portion 3. BCR (Bushveld Chrome Resources) are also utilizing Mr Young's land to do bulk chrome sampling on portions 3, 4, 9 and 10.

The proposed mining area has a mix of mining, agriculture and settlements within its vicinity. The BCR operations are situated on the north eastern side of the proposed mining area. Anglo Union Mine is also situated on the south eastern side of the proposed mining area's border. The Anglo residential village and all its related infrastructure runs in a southerly direction across the proposed project area which consists of housing, roads, schools, a hospital, sports fields and offices.

The main access roads to the proposed mining area are the R510 and the R511 along with the Anglo access roads and the R40.

5.0 IMPACT ASSESSMENT

5.1 Impact Assessment Methodology

The significance of the identified impacts will be determined using the approach outlined below (terminology from the Department of Environmental Affairs and Tourism Guideline document on EIA Regulations, April 1998). This approach incorporates two aspects for assessing the potential significance of impacts, namely occurrence and severity, which are further sub-divided as follows:

Occurrence		Severity	
Probability of occurrence	Duration of occurrence	Scale / extent of impact	Magnitude (severity) of impact

To assess each of these factors for each impact, the following four ranking scales are used:

Probability	Duration
5 - Definite/don't know	5 - Permanent
4 - Highly probable	4 - Long-term
3 - Medium probability	3 - Medium-term (8-15 years)
2 - Low probability	2 - Short-term (0-7 years) (impact ceases after the operational life of the activity)
1 - Improbable	1 – Immediate
0 - None	
SCALE	**MAGNITUDE**
5 - International	10 - Very high/don't know
4 - National	8 - High
3 - Regional	6 - Moderate
2 - Local	4 - Low
1 - Site only	2 - Minor
0 - None	

Once these factors are ranked for each impact, the significance of the two aspects, occurrence and severity, is assessed using the following formula:

SP (significance points) = (magnitude + duration + scale) x probability

The maximum value is 100 significance points (SP). The impact significance will then be rated as follows:

SP >75	Indicates high social significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 – 75	Indicates moderate social significance	An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated.
SP <30	Indicates low social significance	Impacts with little real effect and which should not have an influence on or require modification of the project design.
+	Positive impact	An impact that constitutes an improvement over pre-project conditions

The impact assessment section investigates the potential negative and positive impacts associated with the proposed Varkensvlei and Nooitgedacht mining operations.

Social impacts are the real and perceived impacts experienced by humans (at individual and higher aggregation levels) as a result of social change processes caused by planned interventions. Social impacts relate to all social and cultural consequences to human populations of any public or private actions that alter the ways in which people live, work, play and relate to one another (Becker and Vanclay, 2003)[12].

5.2 Project Phases

For the purposes of this impact assessment the project has been divided into three phases:

- Construction;
- Operational; and
- Decommissioning and Closure.

5.3 Construction Phase

It is assumed that the construction period of surface cleaning and construction of infrastructure for the proposed project will be spread over 2 to 3 months, commencing in January 2014.

5.3.1 Employment

According to information obtained through fieldwork and the public consultation process, there is a general expectation that a new mining operation will employ many of the local people. However, the proposed Varkensvlei and Nooitgedacht operations are anticipated to be small scale operations. Information presented in the baseline indicates that there is an ample potential workforce in the local area. The population within the regional study area are predominantly of working age and are spread quite evenly between men and women, presenting opportunities for equal employment. This population is predominantly unskilled or semi-skilled, and are currently unemployed and looking for work. The Mantserrre community lives in the local study area, from who Anglo Union Mine is currently sourcing some employees. This community therefore may have residents with the required mining-related skills.

At the time of the writing of this report, it is unknown how many employment opportunities will be created during the construction phase of the project. The specific skills requirements and the anticipated distribution of labour sending area (local, regional, national or expatriate) are also unknown.

Based on the need for specific numbers, the positive impact of employment opportunities cannot be assessed at this stage.

5.3.2 Economic Benefits

As this is a small scale operation, the economic benefits associated with the proposed project are expected to be somewhat limited but nevertheless positive. Within the regional study area, mining contributes to 26% of the GGP industry sector, and additional mining activities will enhance this contribution and is likely to have multiplier effects at regional and national level.

The construction phase of the project is estimated to involve the capital expenditure of approximately R206 million over the duration of the construction phase. Whilst it falls beyond the scope of this study to conduct a detailed economic impact assessment, these values indicate a positive impact to the economy on a local, regional and national level. These values are estimated values and serve only as indications of the potential economic contributions of this project.

5.3.3 Skills Development

Samancor will introduce a cadette scheme where community learners will be recruited and placed on a skills development program on a quarterly basis (for a period of 3 months), the program will enable community learners to undergo institutional and/or workplace training and assessment. The aim of the program is to give the community learners the opportunity to obtain the necessary skills and knowledge as per operational

[12] Becker, H.A and Vanclay, F. (2003) The International Handbook of Social Impact Assessment: Conceptual and Methodological Advances. Edward Elgar Publishing Ltd, Cheltenham, UK and Northhampton, MA, USA.

requirement, at the end of the program the community learners will receive a competency certificate, which will in return promote job creation and dilute unemployment.

This section should also include what is proposed within the SLP for training, skills development etc. (ABET; scholarships, bursaries etc)

5.3.4 Population increase from construction workers

Construction workers are expected to be housed either within current available housing in the area or a construction camp near the site with its own independent service supply (water, sanitation etc), details on this has not been provided at the time of writing of this report. Should additional housing or service supply be required, it is recommended that the construction contractor engages with the local municipality to ascertain availability of services.

5.3.5 Influx of work seekers

Any new mining operations in an area will attract additional labourers who are seeking employment from the mines. It is difficult to mitigate this impact as it is an on-going trend associated with mining projects in rural areas.

The potential growth in the population will result in added pressure on the existing social amenities at the town. Nothing major has been noted in the baseline to indicate that there will be a drastic population influx; there are existing mining operations around the project area and population influx has not been apparent before.

5.3.6 Loss of access

Currently, there is an access road used by the Mantserre and the Mopyane communities to travel to the Anglo Union Mine (for employment), and for further travel to Northam. A second road is used by Anglo employees to access the Anglo Union Mine from the Anglo employee village. According to the Mineral Resource Manager of Anglo Union Mine, these roads were built and are maintained by Anglo Union Mine as access and haul roads, and these roads connect to the R510 and R511 to Thabazimbi (approximately 65 km from site). Both of these access roads will be affected by opencast mining activities and will need to be realigned to avoid loss of access for the users. Samancor will need to reach an agreement with Anglo Union Mine to negotiate the realignment of these roads.

5.3.7 Impacts arising from biophysical components

Biophysical components such as air quality, noise, visual intrusion and water quantity and quality may give rise to socio-economic impacts during the construction phase on the surrounding landowners and communities. Stakeholders reported concern over the following impacts: dust and noise impacts related to the blasting activities at Varkensvlei and Nooitgedacht, increase in traffic and groundwater quality and quantity.

5.3.7.1 Water Quantity and Quality

The area's water is supplied through the Magaliesberg water pipeline, and Anglo has indicated that is has an agreement with the Municipality to allow Anglo to distribute water from the pipeline in the local area. Water to the proposed mining site will be obtained from Anglo Union Mine and through existing borehole water. Local landowners have stated that they are concerned that blasting can damage and contaminate the underlying aquifers which can damage borehole water and affect their irrigation. According to the Groundwater Specialist Report it is unlikely that the operations will have significant impacts on ground water. Therefore, no additional social mitigation measures are necessary.

5.3.7.2 Noise and Vibration Impacts

Construction activities may result in a temporary increase in noise, creating a nuisance factor to local residents and affecting the quality of life. The Noise Impact Assessment specialist study indicated that the anticipated noise levels during construction can be mitigated, therefore no additional social mitigation measures are recommended.

5.3.7.3 Dust impacts

Construction activities may result in an increase in dust, especially from vehicle entrainment from unpaved roads, which may result in potential health impacts and nuisance dust fall. The Air Quality Impact Assessment did not undertake a quantitative assessment for the construction phase given limited information, and air quality impacts relating to the construction phase are expected to be of low environmental significance and with appropriate mitigation measure, no social impacts are expected.

5.4 Operational Phase

Open pit mining operations are planned to last between 6 and 8 years. On-going operational expenditure of about R300 million is expected over the 8 year operational period.

5.4.1 Employment Opportunities

Approximately 120 jobs are expected to be required to support the Varkensvlei and Nooitgedacht mining operations. Employment opportunities are likely to be limited with preference being given by the project proponent to contract the work to a third party. Employment opportunities may arise for unskilled/semi-skilled and general labour positions. A potential workforce is available in the area, given the levels of unemployment and the age distribution of the population. With the Mantserre community being one of the communities where local labour is sourced from for the Anglo Union Mine, it is possible that semi-skilled and skilled employees could be present within this community.

According to the information contained in the Mine Works Programme, Samancor proposes that in the first year of operations 10% of the total workforce will be employed from the local community, by year 2 this will increase to 20% and at the end of year 3 this should be 30%, all related to non-key positions.

It is recommended, where possible that employment be sourced locally.

5.4.2 Economic Benefits

As this is a small scale operation, the economic benefits associated with the proposed project are expected to be somewhat limited but nevertheless positive. Within the regional study area, mining contributes to 26% of the GGP industry sector, and additional mining activities will enhance this contribution and is likely to have multiplier effects at regional and national level.

An estimated R57.4 million per annum will be spent on salaries and wages. With approximately 10% of this workforce being local within the 1st year of operations, this means an estimated R5.74 million per annum will be spent on salaries and wages in the local area. Whilst it falls beyond the scope of this study to conduct a detailed economic impact assessment, these values indicate a minimal positive impact to the economy on a local, regional and national level. These values are estimated values and serve only as indications of the potential economic contributions of this project.

5.4.3 Change in Land Use

Portions 1, 2 and Remainder of the farms Varkensvlei 403 KQ and portions 2 and 10 of the farm Nooitgedacht 406 KQ are the portions which Samancor is currently applying for a mining right on. Samancor has indicated that it has agreements in place with the various landowners (the Baphalane Tribal Trust/Ba-Manserre community, the Jabaseku Community and Anglo Platinum) to either buy or lease the land in the mine application area. Although requested from Samancor, Golder has not been able to verify any written agreement between the landowners.

The land on Varkensvlei 403 Portion 1, 2 and remainder is currently used for grazing and the Mantserre community lives on Portion 1 and remainder. Samancor will only utilise a section of the portion surface area for mining purposes. Therefore only a section of the Varkensvlei 403 properties will be utilised for mining and the remainder will continue to be available for grazing. According to Mr McGill, who is a neighbouring landowner on Nooitgedacht 406, there is an agreement between himself and the Ba-Manserre community to use a section of land on Varkensvlei 403 Portion 2 for sunflower farming. Golder was unable to obtain documentation around this agreement. The opencast mining activities will directly impact on the cultivated area and may result in loss of crops if the land is cropped at the time of mining. The land on Nooitgedacht

406 portions 2, 6 and 10 is currently owned by Anglo Platinum and is largely undeveloped, aside from some roads crossing the properties from the Anglo mine village.

5.4.4 Traffic Safety Impacts

During the operational phase of the project, it is anticipated as listed in the MWP that approximately 12 vehicles will be utilised to transport the material transport the ROM ore to the nearest available siding, where it is loaded onto rail trucks for railing down to Richards Bay Port. The R510 or the R511 will be used and most of the material will be trucked from site. A rail solution is still being considered.

The access roads near the facility are currently utilised by Anglo Platinum. Stakeholders have indicated that they are concerned for pedestrian and other vehicle safety during night time operations on the public roads.

The roads on which the transport vehicles will be travelling are primarily used to travel into the Swartklip mining and residential area and may be crossed by pedestrians and/or other road users travelling to work or to neighbouring communities, which poses a risk to safety of the other road users. It is recommended that Samancor adopts appropriate traffic safety measures.

5.4.5 Impacts arising from biophysical components

Biophysical components such as air quality, noise, traffic impacts visual intrusion and water quantity and quality may give rise to socio-economic impacts and health and safety impacts during the operations phase on the surrounding landowners and communities.

5.4.5.1 Air Quality

The air quality impacts that may arise from the operations phase of the proposed project is discussed in the EIA.

5.4.5.2 Water Quality

The local community's water sources are mainly bore holes and municipal water. The operational impacts associated with the proposed project are discussed in the EIA.

5.4.5.3 Noise and vibration impacts

The potential impacts that may arise from noise and vibration during the operational phase are discussed in the EIA.

5.4.5.4 Visual Intrusion

The potential visual impacts that may arise from operations phase of the proposed project is discussed in the EIA.

5.5 Decommissioning and Closure Phase

The following sections describe the potential impacts associated with the decommissioning and closure phase. This section assumes that all mine infrastructure will be removed or demolished and the disturbed areas backfilled and rehabilitated to a new land use agreed upon by the mine, the authorities and the communities.

5.5.1 Loss of Employment

At mine closure, the potential losses of the estimated 120 jobs created from the opencast operations which will impact on the local communities. Mine employees and others, as required, must either be allocated to other operations or reskilled and trained to pursue alternative livelihood opportunities, in line with commitments contained in the mine's Social and Labour Plan.

5.5.2 Rehabilitation and change in land use

Rehabilitation follows demolishing or removal of existing infrastructure. The area is stripped and rehabilitated to a land use which is discussed in further detail within the Environmental Impact Assessment report. It is recommended that the choice of land use be agreed upon by the mine in conjunction with the District

Assembly as well as the District Traditional Leaders. Samancor's rehabilitation should be followed as to their closure framework.

Mr Alan McGill a local land owner from the Nooitgedacht area stated in the CRR that "when they are finished mining, I want to be able to plant sunflowers again in decent topsoil. The depth of the topsoil must be noted beforehand". Mr Reiner Guba a Nooitgedacht landowner said "community members don't want big mine dumps when the mine leaves it needs to look the same as it looks now".

6.0 RECOMMENDED MITIGATION/MANAGEMENT MEASURES

6.1 Construction Phase

Employment and Economic measures

Employees should be sourced from local areas as far as possible.

Skills Development

Include local community skills development as part of the SLP.

Population increase from Construction Workers

Establish construction camp with independent service supply, and liaise with the local municipality around services should additional services be required.

Population Influx from Work Seekers

Early communication of real employment opportunities (or lack thereof) in the region has the potential to reduce the potential influx of job seekers into the area.

Loss of Access

Access roads should be realigned prior to mining of these areas to avoid disruptions to access.

6.2 Operational Phase

Employment Opportunities

Employ local labour as far as possible.

Economic Benefits

Maximise local procurement as far as possible.

Change in Land Use

This SIA assumes that agreements between Samancor and the landowners have been reached. Where losses of private assets are incurred, these should be negotiated with the asset owner.

6.3 Decommissioning and Closure Phase

Loss of Employment

A program of retrenchment and re-training during the operational phase, providing employees with clear, transparent information on planned activities and closure dates, offering full retrenchment packages or relocation to maintain employment at other operations sites where possible.

7.0 IMPACT RATINGS

The social impacts discussed in the previous section are rated according to the environmental rating matrix provided by the EIA team and described in the methodology section of this report (Section 5.1). Table 19, Table 20 and Table 21 summarises the impacts related to the Construction, Operational and Decommissioning and Closure Phases of the proposed project, and provides a significance rating for each impact before and after mitigation.

Table 19: Construction Phase Impact Ratings

POTENTIAL SOCIAL IMPACT: CONSTRUCTION PHASE	SOCIAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
1. Employment - Cannot be assessed due to lack of construction employee information												
2. Economic benefits	2	2	2	4	**24**	Low	4	2	2	5	40	Moderate
3. Skills development – Waiting for SLP to assess												
4. Population Increase from Construction Workers	1	2	1	5	**20**	Low	1	2	1	5	**20**	Low
5. Population Influx from Work Seekers	1	2	1	1	**4**	Low	1	2	1	1	**4**	Low
6. Loss of Access	4	5	2	5	**55**	Moderate	2	1	1	5	**15**	Low
7. Impacts arising from biophysical components - Assessed in EIA												

Table 20: Operational Phase Impact Ratings

POTENTIAL SOCIAL IMPACT: OPERATIONAL PHASE	SOCIAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
1. Employment Opportunities	2	3	2	5	35	Mod	2	3	2	5	**35**	Mod
2. Economic Benefits	2	3	2	5	35	Mod	4	3	2	5	**45**	Mod
3. Change in Land use	2	3	1	5	30	Mod	2	3	1	4	24	Low
4. Traffic Safety - Assessed in EIA												
4. Impacts arising from biophysical components - Assessed in EIA												

Table 21: Closure and rehabilitation phase impact ratings

POTENTIAL SOCIAL IMPACT: CLOSURE AND REHABILITATION PHASE	SOCIAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
1. Loss of Employment	8	3	2	4	42	Mod	4	2	2	2	16	Low
2. Impacts arising from biophysical components Assessed in EIA												

8.0 CONCLUSION

The proposed Varkensvlei and Nooitgedacht project has some positive benefits in its extension of employment opportunities and economic benefits with continued input into the mining sector, the largest economic contributor in the local municipality. The potential impacts for this project were presented in relation to the construction, operational and decommissioning phases of the proposed mining operations. Anticipated positive impacts of the proposed project include the creation of employment and the economic benefits of the mineral resource to the local, regional and national economy. Few negative socio-economic impacts from the proposed project will occur, considering that Samancor reports to have agreements in place with landowners to purchase or lease the land to be mined. Alternative access needs to be provided for the roads that will be affected by mining activities.

With appropriate mitigation measures, the proposed project can offer some positive benefits to the economy with limited negative impacts.

On-going monitoring, management and implementation of measures outlined in specialist reports will be critical to ensuring environmentally intrinsic impacts do not affect communities.

Prepared for:

Mr Etienne Roux

Golder Associates Africa (Pty) Ltd

PO Box 6001 Halfway House 1685

Tel 0112544970 Fax 0113150317

A PHASE I HERITAGE IMPACT ASSESSMENT STUDY FOR SAMANCOR'S PROPOSED MINING RIGHT APPLICATION FOR PORTIONS OF THE FARM VARKENSVLEI 403KQ AND NOOITGEDACHT 406KQ NEAR NORTHAM IN THE NORTH-WEST AND LIMPOPO PROVINCES

Prepared by:

Dr Julius CC Pistorius

Archaeologist and Heritage Consultant

352 Rosemary Street Lynnwood 0081

PO Box 1522 Bela Bela 0480

Tel and fax 0147362115

Cell 0825545449

March 2013

Member ASAPA

EXECUTIVE SUMMARY

A Phase I Heritage Impact Assessment (HIA) study as required in terms of Section 38 of the National Heritage Resources Act (Act 25 of 1999) was done for Samancor's proposed Mining Right Application (MRA) for portions of the farm Varkensvlei 403KQ and Nooitgedacht 406KQ near Northam in the North-West and Limpopo Provinces.

The aims with the Phase I HIA were the following:

- To establish whether any of the types and ranges of heritage resources ('national estate') as outlined in Section 3 of the National Heritage Resources Act (Act 25 of 1999) (except paleontological) remains do occur in the Project Area.
- To determine the significance of these heritage resources and whether they will be affected by the Mining Project.
- To propose mitigation measures for those heritage resources that may be affected by the proposed Mining Project.

The Phase I HIA study for the Project Area revealed the following types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (No 25 of 1999), namely:

- A formal graveyard in the village of Mantserre.
- No archaeological or pre-historical remains were recorded. Neither did this study provide for a paleontological study.

The graveyard was geo-referenced (Table 1) but not mapped as it is located in the village of Mantserre.

Possible impact on the heritage resources

It seems as if the Project Area is devoid of any conspicuous heritage resources. The most obvious to exist are stone walled sites and these may possible be found in the Mmopyane mountain range outside the northern border of the Project Area.

Mitigating heritage resources

The graveyard of Mantserre is located in the village itself. Although no mine plan is currently available it is unlikely that any significant heritage resources or the graveyard will be affected by the mining project.

Consequently, no mitigation measures for any heritage resources can be recommended.

Disclaimer

It is possible that this Phase HIA study may have missed heritage resources in the Project Area as heritage remains may occur in thick clumps of vegetation while others may lie below the surface of the earth and may only be exposed once the Mining Project commences.

If any heritage resources of significance is exposed during the Mining Project the South African Heritage Resources Authority (SAHRA) should be notified immediately, all development activities must be stopped and an archaeologist accredited with the Association for Southern African Professional Archaeologist (ASAPA) should be notify in order to determine appropriate mitigation measures for the discovered finds. This may include obtaining the necessary authorisation (permits) from SAHRA to conduct the mitigation measures.

CONTENTS

1 INTRODUCTION

This document contains the report on the results of the Phase I Heritage Impact Assessment (HIA) study that was done for Samancor's proposed Mining Right Application (MRA) for portions of the farm Varkensvlei 403KQ and Nooitgedacht 406KQ near Northam in the North-West and Limpopo Provinces.

Focused archaeological research has been conducted in the North-West and Limpopo Provinces for several decades. This research consists of surveys and of excavations of Stone Age and Iron Age sites as well as of the recording of rock art and historical sites in this area. The Limpopo and North-West Provinces have a rich heritage comprised of remains dating from the pre-historical and from the historical (or colonial) periods of South Africa. Pre-historical and historical remains in the Limpopo and North-West Provinces of South Africa form a record of the heritage of most groups living in South Africa today.

Various types and ranges of heritage resources that qualify as part of South Africa's 'national estate' (as outlined in the National Heritage Resources Act [No 25 of 1999]) occur in the North-West and Limpopo Provinces (see Box 1, next page).

Box 1: Types and ranges of heritage resources (the national estate) as outlined in Section 3 of the National Heritage Resources Act, 1999 (No 25 of 1999).

The National Heritage Resources Act (Act No 25 of 1999, Art 3) outlines the following types and ranges of heritage resources that qualify as part of the National Estate, namely:

(a) places, buildings structures and equipment of cultural significance;
(b) places to which oral traditions are attached or which are associated with living heritage;
(c) historical settlements and townscapes;
(d) landscapes and natural features of cultural significance;
(e) geological sites of scientific or cultural importance;
(f) archaeological and palaeontological sites;
(g) graves and burial grounds including-
  (i) ancestral graves;
  (ii) royal graves and graves of traditional leaders;
  (iii) graves of victims of conflict;(iv) graves of individuals designated by the Minister by notice in the Gazette;
  (v) historical graves and cemeteries; and
  (vi) other human remains which are not covered by in terms of the Human Tissues Act, 1983 (Act No 65 of 1983);
(h) sites of significance relating to the history of slavery in South Africa;
(i) movable objects, including -
(i) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens;
  (ii) objects to which oral traditions are attached or which are associated with living heritage;
  (iii) ethnographic art and objects;
  (iv) military objects;
  (v) objects of decorative or fine art;
  (vi) objects of scientific or technological interest; and
  (vii) books, records, documents, photographs, positives and negatives, graphic, film or video material or sound recordings, excluding those that are public records as defined in section 1(xiv) of the National Archives of South Africa Act, 1996 (Act No 43 of 1996).

The National Heritage Resources Act (Act No 25 of 1999, Art 3) also distinguishes nine criteria for places and objects to qualify as 'part of the national estate if they have cultural significance or other special value …'. These criteria are the following:

(a) its importance in the community, or pattern of South Africa's history;
(a) its possession of uncommon, rare or endangered aspects of South Africa's natural or cultural heritage;
(b) its potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage;
(c) its importance in demonstrating the principal characteristics of a particular class of South Africa's natural or cultural places or objects;
(e) its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group;
(f) its importance in demonstrating a high degree of creative or technical achievement at a particular period;
(g) its strong or special association with a particular community or cultural group for social, cultural or spiritual reasons; (h)
(h) its strong or special association with the life or work of a person, group or organisation of importance in the history of South Africa;
(i) sites of significance relating to the history of slavery in South Africa

2 AIMS WITH THIS REPORT

Samancor Chrome (Samancor) intends to apply for a Mining Right Application (MRA) for portions of the farms Varkensvlei 403KQ and Nooitgedacht 406KQ near Northam in the North-West and Limpopo Provinces. Samancor intends to establish open cast chrome mining activities on these farms. These mining activities may have an influence on any of the types and ranges of heritage resources which are listed in Section 3 of the National Heritage Resources Act (No 25 of 1999).

In order to comply with heritage legislation, Samancor requires knowledge of the presence, relevance and the significance of any heritage resources that may be affected by the Mining Project. Samancor needs this knowledge in order to take pro-active measures with regard to any heritage resources that may be affected, damaged or destroyed when the chrome mining project is implemented. Golder Associates Africa (Pty) Ltd (Golder), the environmental company responsible for compiling the Environmental Impact Assessment (EIA) report for the mining project therefore commissioned the author to undertake a Phase I HIA study for the Project Area.

The aims with the Phase I HIA were the following:

- To establish whether any of the types and ranges of heritage resources ('national estate') as outlined in Section 3 of the National Heritage Resources Act (Act No 25 of 1999) (except paleontological) remains do occur in the Project Area.
- To determine the significance of these heritage resources and whether they will be affected by the mining project.
- To propose mitigation measures for those heritage resources that may be affected by the proposed mining project.

3 METHODOLOGY

This Phase I HIA study was conducted by means of the following:

- Surveying the larger Project Area with a vehicle and spots in the Project Area on foot.
- Briefly surveying literature relating to the pre-historical and historical context of the Project Area.
- Consulting maps of the proposed Project Area.
- Consulting archaeological (heritage) data bases.
- Consulting spokespersons regarding the possible presence of graves and graveyards in the Project Area.
- Synthesising all information obtained from the data bases, fieldwork, maps and literature survey in this report.

3.1 Field survey

The Project Area was surveyed with a vehicle as it mainly comprises agricultural fields or areas which have been subjected to agriculture in the past. Relatively undisturbed bush and some cleared surface areas were surveyed on foot. However, the largest part of the Project Area is covered with agricultural fields.

The town of Mantserre occurs in the central part of Varkensvlei 403KQ. The expanding outskirts of the town, where new inhabitants are continuously constructing new dwellings, encompasses as much as twenty five present of the surface of the farm. This area as well as a buffer zone around the village will not be affected by the proposed mining activities. This area also has been severely affected in the past as a result of deforestation and over grazing.

The main environmental characteristic of the Project Area are the presence of dry land agricultural fields in the centre, south and east and a deforested and degraded area around the village of Mantserre. Some remaining indigenous bush occurs towards the north-east on both Varkensvlei 403KQ and Nooitgedacht 406KQ.

A reconstructed GPS track log outlines the main pathway that was recorded during the survey for the Project Area (Figure 00).

Figure 00- The survey for the Project Area followed the black dotted route indicated on the Google image (above).

3.2 Databases, literature survey and maps

Databases kept and maintained at institutions such as the Provincial Heritage Resources Agency (PHRA), the Archaeological Data Recording Centre at the National Flagship Institute (Museum Africa) in Pretoria and SAHRA's national archive (SAHRIS) were consulted to determine whether any heritage resources of significance has been identified during earlier heritage surveys in or near the Project Area.

The author is acquainted with the Project Area at large as he had done several heritage impact assessment studies near the project area (see Part 9, 'Select Bibliography').

Literature relating to the pre-historical and the historical unfolding of the Project Area was reviewed (see Part 5, ‘Contextualising the Project Area’).

Maps outlining the Project Area were studied (2427CC Middelwit 1: 50 000 topographical map and Pretoria 1 250 000 map).

3.3 Consulting spokespersons

Spokespersons living and working in the Project Area were consulted regarding the possible presence of graveyards within its boundaries (see Part 10, ‘Consulting spokespersons’).

3.4 Assumptions and limitations

It is possible that this Phase I HIA study may have missed heritage resources in the Project Area as heritage sites may occur in thick clumps of vegetation while others may lie below the surface of the earth and may only be exposed once development commences.

If any heritage resources of significance is exposed during the mining project the South African Heritage Resources Authority (SAHRA) should be notified immediately, all development activities must be stopped and an archaeologist accredited with the Association for Southern African Professional Archaeologist (ASAPA) should be notify in order to determine appropriate mitigation measures for the discovered finds. This may include obtaining the necessary authorization (permits) from SAHRA to conduct the mitigation measures.

3.5 Some remarks on terminology

Terms that may be used in this report are briefly outlined below:

- Conservation: The act of maintaining all or part of a resource (whether renewable or non-renewable) in its present condition in order to provide for its continued or future use. Conservation includes sustainable use, protection, maintenance, rehabilitation, restoration and enhancement of the natural and cultural environment.

- Conservation (*in-situ*): The conservation and maintenance of ecosystems, natural habitats and cultural resources in their natural and original surroundings.
- Cultural (heritage) resources: A broad, generic term covering any physical, natural and spiritual properties and features adapted, used and created by humans in the past and present. Cultural resources are the result of continuing human cultural activity and embody a range of community values and meanings. These resources are non-renewable and finite. Cultural resources include traditional systems of cultural practice, belief or social interaction. They can be, but are not necessarily identified with defined locations.
- Cultural (heritage) resource management: A process that consists of a range of interventions and provides a framework for informed and value-based decision-making. It integrates professional, technical and administrative functions and interventions that impact on cultural resources. Activities include planning, policy development, monitoring and assessment, auditing, implementation, maintenance, communication, and many others. All these activities are (or will be) based on sound research.
- Heritage resources: The various natural and cultural assets that collectively form the heritage. These assets are also known as cultural and natural resources. Heritage (cultural) resources include all human-made phenomena and intangible products that are the result of the human mind. Natural, technological or industrial features may also be part of heritage resources, as places that have made an outstanding contribution to the cultures, traditions and lifestyles of the people or groups of people of South Africa.
- Stone Age: Refers to the prehistoric past, although Late Stone Age peoples lived in South Africa well into the Historical Period. The Stone Age is divided into an Earlier Stone Age (3 million years to 150 000 thousand years ago) the Middle Stone Age (150 000 years to 40 000 years ago) and the Late Stone Age (40 000 years to 300 years ago).

- Iron Age: Refers to the last two millennia and 'Early Iron Age' to the first thousand years AD. 'Late Iron Age' refers to the period between the 16th century and the 19th century and can therefore include the Historical Period.
- Historical period: Refers to the first appearance or use of 'modern' Western writing in a particular area or region of the world.
- Pre-historical: Refers to the time before any historical documents were written or any written language developed in a particular area or region of the world.
- Recent past: Refers to the 20th century. Remains from this period are not necessarily older than sixty years and therefore may not qualify as archaeological or historical remains. Some of these remains, however, may be close to sixty years of age and may, in the near future, qualify as heritage resources.
- Maintenance: Keeping something in good health or repair.
- Preservation: Conservation activities that consolidate and maintain the existing form, material and integrity of a cultural resource.
- Protected area: A geographically defined area designated and managed to achieve specific conservation objectives. Protected areas are dedicated primarily to the protection and enjoyment of natural or cultural heritage, to the maintenance of biodiversity, and to the maintenance of life-support systems.
- Reconstruction: Re-erecting a structure on its original site using original components.
- Replication: The act or process of reproducing by new construction the exact form and detail of a vanished building, structure, object, or a part thereof, as it appeared at a specific period.
- Restoration: Returning the existing fabric of a place to a known earlier state by removing additions or by reassembling existing components.
- Sustainability: The ability of an activity to continue indefinitely, at current and projected levels, without depleting social, financial, physical and other resources required to produce the expected benefits.
- Translocation: Dismantling a structure and re-erecting it on a new site using original components.
- Project Area: refers to the area (footprint) where the developer wants to focus its development activities (refer to plan).

- Phase I studies refer to surveys using various sources of data in order to establish the presence of all possible types and ranges of heritage resources in any given Project Area.
- Phase II studies include in-depth cultural heritage studies such as archaeological mapping, excavating and sometimes laboratory work. Phase II work may include the documenting of rock art, engraving or historical sites and dwellings; the sampling of archaeological sites or shipwrecks; extended excavations of archaeological sites; the exhumation of human remains and the relocation of graveyards, etc. Phase II work involve permitting processes, require the input of different specialists and the co-operation and approval of SAHRA.

4 THE PROJECT AREA

4.1 Location

The Project Area comprises Portion 1, 2 and the Remainder of the farm Varkensvlei 403KQ and Portion 2 and 10 of the farm Nooitgedacht 406KQ north-west of Northam a mining town on the road that runs between the Pilanesberg mountain range and Thabazimbi. Although Varkensvlei 403KQ and Nooitgedacht 406KQ adjoins, Varkensvlei 403KQ occurs in the North-West and Nooitgedacht 406KQ in the Limpopo Province (Middelwit 2427CC 1: 50 000 topographical & 2426 Thabazimbi 1: 250 000 map) (Figures 1-3).

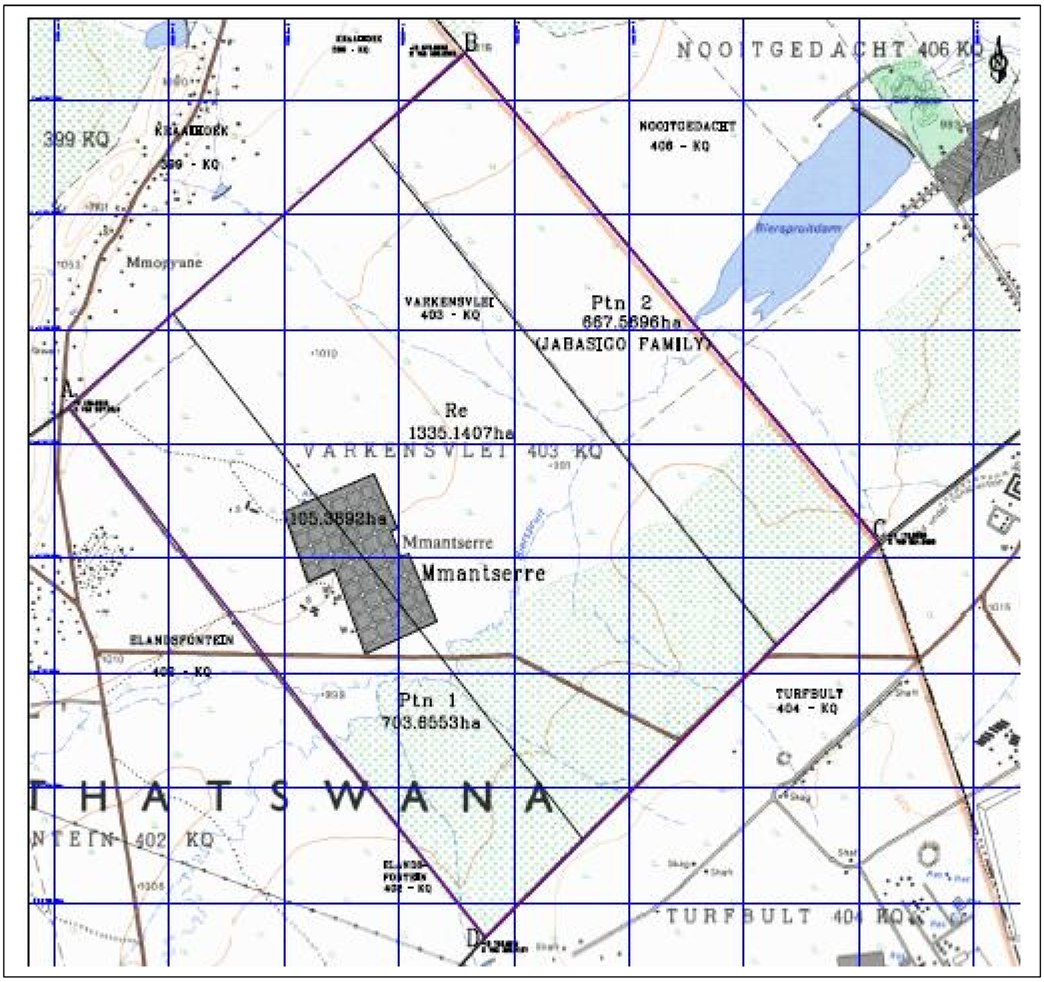

Figure 1 – The Project Area on portions of Varkensvlei 403KQ and Nooitgedacht 406KQ comprises two pieces of land to the west and to the east of the Bierspruit near Northam in the north-West and Limpopo Provinces. The Project Area mainly comprises agricultural fields (above).

Figure 2- The most outstanding features of the Project Area is the presence of agricultural fields, whether actively being utilized, laying foul waiting for the next season to be planted again or abandoned and now covered with vegetation which are regenerating. The natural vegetation that does occur is being depleted as a result of deforestation due to expanding populations in the villages of Mantserre and Mmopyane (above).

The Project Area is situated to the north of the Pilanesberg and to the south of the extensive ‘Vliegepoort’ and ‘Berg van Winde’ mountain range which is located to the south of Thabazimbi. The Project Area is a flat, outstretched homogenous eco-zone which is covered with acacia and other bushveld trees on mixed red and turf soils.

The mining town of Northam serves as a business hub for the booming platinum and chrome mining complex which have developed after Hans Merensky has discovered platinum bearing deposits at Swartklip in the early 20th century. Other economic interests in the area include dry land agriculture and wild game farming although the mining sector is gradually gaining the most prominent economic influence in the region.

Figure 3- The Project Area falls within the boundaries of Varkensvlei 403KQ and Nooitgedacht 406KQ, respectively located in the North-West and Limpopo Provinces. The Project Area is covered with older inactive and younger active agricultural fields whilst the last remaining indigenous bush closer to Mantserre and Mmopyane is being depleted for firing purposes (above).

4.2 The nature of the Project Area

The Project Area used to be covered with acacia and a wide range of bushveld trees and grass veld in the past. This tree and grass plain (savannah veld) was home to a wide range of antelope and other game. This flat landscape is broken in the north where the Mopyane range of kopjes is located outside the border of the Project Area.

The natural characteristic features of the Project Area have been transformed during the last decades, firstly as a result of dry land agriculture and in more recent times due to the establishment and expanding of the village of Mantserre as well as other villages in the area. The impact of platinum mining is prominent towards the south where the Swartklip Platinum Mine and town exist.

The Project Area cannot be described as a pristine piece of land any longer. It has largely being transformed except for some natural vegetation that still exists. This transformation was initially triggered by the occupation of the Project Area and the establishment of the village of Mantserre towards its centre. This was followed by large scale agriculture activities which resulted in the ploughing of the soil and the planting of agricultural crops. In general, however, it can also be said that the area is not rich in any particular heritage resources except stone walled sites which are mostly found at kopjes and randjes outside the larger Project Area.

4.3 The nature of the Mining Project

Samancor Chrome is currently preparing to apply for a Mining Rights Application and intends undertaking open cast chrome mining in the future. As such no mine plans are currently available for the future planned mining of chrome in the Project Area.

4.4 The heritage potential of the Project Area

The Project Area falls on a piece of land which is surrounded by areas which are characterised by cultural landscapes of significance, some of which have been researched and documented in the past. The immediate and larger Project Area has also been subjected to several heritage surveys, namely:

- Miller, S. 2007-2012. The heritage resources of Kumba Iron Ore Company, Thabazimbi, Limpopo Province of South Africa. Part 1 The archaeology, Part 2 The town and mine, Part 3 Human remains Part IV Heritage management plan.
- Pistorius, J.C.C. 2008. A Phase I Heritage Impact Assessment (HIA) study for Eskom's proposed new 132kV Simthabi power line running between the existing Thabazimbi Combined Substation and the proposed new Simthabi Substation in the Limpopo Province. Unpublished report prepared for EPA International.
- Pistorius, J.C.C. 2009. A Base line Heritage Assessment report for Eskom's Thabatsipi Substation and 132kV power line project near Amandelbult and

Thabazimbi in the Limpopo Province. Unpublished report prepared for EPA International.

- Pistorius J.C.C. 2011. Report on monitoring a seismic survey for heritage resources on several farms to the west of Northam in the Limpopo Province of South Africa. Unpublished report for Anglo Platinum.
- Pistorius, J.C.C. 2013a. A Phase I Heritage Impact Assessment study for Eskom's proposed Letlhabane Project near Northam in the Limpopo Province. Unpublished report prepared for URGENEG.
- Pistorius, J.C.C. 2013b. A Phase I Heritage Impact Assessment study for Samacor's proposed Mining Right Application on portions of the farm Haadoringdrift 473KQ in the Limpopo Province. Unpublished report prepared for Golder Associates Africa (Pty) Ltd.

These heritage surveys revealed that the larger Project Area is not rich in a wide range of heritage resources. The most common heritage resources which do occur are stone walled sites which date from the Late Iron Age. These heritage sites are mostly found along the base lines of kopjes and randjes in the region.

5 CONTEXTUALISING THE PROJECT AREA

The Project Area is located in a region that is wedged between Koedoeskop and Thabazimbi in the north and the Pilanesberg in the south and falls across the border of the North-West and Limpopo Provinces. The Project Area falls on a flat piece of land which is bisected by the Bierspruit which flows into the Bierspruitdam. The farm Varkensvlei 403KQ is situated to the west of this spruit whilst Nooitgedacht 407KQ is located to the east of the Bierspruit. The Mmopyane mountain range occurs to the north of the Project Area whilst Anglo Platinum's Swartklip mining village and associated mine infrastructure delineates its southern boundary (Middelwit 2427CC 1; 50 000 topographical map & 2426 Thabazimbi 1: 250 000 map).

Important historical and pre-historical centres occur around the Project Area. These include the Thabazimbi-Rooiberg area further to the north which is known for the presence of early tin mines (possibly Late Iron Age) in the Rooiberg as well as for Late Iron Age settlements which were occupied by specialist metal working groups who occupied the mountain range near Thabazimbi (Bauman 1912, Trevor 1919, Hall 1991). The Pilanesberg region to the south is where the Kgatla Kgafêla established a sphere of influence at capitals such as Moruleng and Boretele along the north-eastern perimeter of the Pilanesberg as early as the seventeenth century. Descendants of the original Kgatla Kgafêla clan who contributed to the historical and cultural significance of this group still occupy the larger area today (Breutz 1954, 1986; Schapera 1942, 1952).

Madibeng and Rustenburg further to the south-west and south-east were both home to various pre-historical and historical Tswana clans such as the Kwena and Kgatla (Breutz 1954, 1986) whilst some of these settlements, amongst others who were occupied by Mzilikazi's Ndebele, have been archaeological investigated (Pistorius 1997a, 1997b, 1998).

Ramakoka, east of the Project Area, today is still home to the Kwena Phalane a pre-historical and historical Tswana clan whose origins, earlier abodes and settlement history has not yet received any thorough attention from researchers (Breutz 1954, 1986). Members of the Kwena Phalane community are prominent occupants of the larger Project Area.

The Project Area itself is not known to contain a diverse range of heritage resources. The most common heritage resources in this region are the presence of Late Iron Age stone walled sites which occur near randjes and kopjes in the larger area.

The following brief overview of archaeological (pre-historical) and historical information will help to contextualise the Project Area within the context of the wider area.

5.1 Stone Age sites

Stone Age sites are marked by stone artefacts that are found scattered on the surface of the earth or that are parts of the deposits in caves and rock shelters. The Stone Age is divided into the Early Stone Age (ESA) (from 2.5 million years ago to 250 000 years ago), the Middle Stone Age (MSA) (from 250 000 years ago to 22 000 years ago) and the Late Stone Age (LSA) (from 22 000 years ago to about 2 000 years ago).

The LSA is associated with the rock paintings and engravings which were done by the San, Khoi Khoi and, in more recent times, by Negroid (Iron Age) farmers.

No significant recordings of Stone Age sites, rock paintings or engravings have been made near the Project Area, except for a few engravings near Maanhaarrand and Rustenburg whilst some rock paintings have been recorded in the Pilanesberg.

It can be expected that stone artefacts dating from the Stone Age may occur in the larger Project Area as stone tools also occur on the Springbokflats which represents a very similar environment or habitat as the Project Area.

5.2 Iron Age remains

It is highly unlikely that the Project Area was occupied by Early Iron Age (EIA) Bantu-Negroid people who lived elsewhere in the Limpopo, Mpumalanga, KwaZulu-Natal and North-West Provinces of South Africa during the 3rd to 9th centuries AD.

The earliest Iron Age settlers who moved into the larger project area were Late Iron Age Sotho-speaking groups who belonged to the Moloko tradition. These Kgatla and Kwena communities are associated with stone walled settlements which date from AD1600 although earlier settlements, devoid of any stone walls, also probably occur in the region. Moloko sites have been recorded in Rooiberg, north of the Project Area (Hall 1991), at the Pilanesberg and in Madibeng and Rustenburg further to the south where these sites are associated with kopjes and randjes. Iron Age settlements occur in the Ben Alberts Nature Reserve and elsewhere in the Thabazimbi district (Miller 2007-2012).

The Rooiberg area is also renowned for early tin mining activities, possibly dating from the Late Iron Age. It seems as if large quantities of tin ore was mined from the Rooiberg and transported to an unknown destination. The abundance of iron ore in the area, particularly around Thabazimbi, also led to the smelting of these ores by local Late Iron Age people in order to manufacture products such as weapons (spears) and tools (hoes, axes, etc) (Bauman 1912, Trevor 1919, Hall 1991).

5.3 Historical period

The closest towns to the Project Area are Thabazimbi and Northam. Thabazimbi's name is derived from the Tswana words for 'mountain of iron'. This was due to the discovery of the exceptionally rich iron ore deposits at Vliegpoort ('defile of flies') by the geologists J.H. Williams in 1919. The South African government bought the ore body and production for the Iscor Iron Ore mine in 1928. The mine started with its operations in 1931

A branch railway line was built from Northam to Thabazimbi on the Pretoria-Middelwit line. The town of Thabazimbi was laid out on the farm Kwaggashoek and proclaimed on 4 May 1953. Millions of tons of iron ore are annually mined and hauled by train to Vanderbijlpark and New Castle (Erasmus 1995).

The town of Northam was laid out by E.H. Fulls on the farm Leeukoppie and formally proclaimed in 1946. This farm together with several others was owned by H. Herd who had purchased the properties from British soldiers to whom they have been allocated after the Anglo Boer War. Herd was allowed to choose the name for the new village which he called Northam after the village Northam in Devonshire, England (Erasmus 1995).

6 THE PHASE I HERITAGE SURVEY

6.1 The heritage field survey

The Phase I HIA is briefly described and illuminated with photographs according to the main environmental characteristics of the Project Area, namely agricultural fields in different stages of production and the outskirts of Mantserre.

Figures 4 & 5- Varkensvlei 403KQ is largely covered with agricultural fields in different stages of production, namely freshly ploughed and planted fields in the north, east and south (above) and agricultural fields that are laying foul for a season or longer in the southern and central parts of this farm. These fields are mainly covered with grass and no trees (above).

Figures 6 & 7- Abandoned agricultural fields where grass and trees have regenerated are found towards the central part of Varkensvlei 403KQ (above). Young foul laying agricultural fields on Nooitgedacht 407KQ with some indigenous bush along the northern fringe of the farm (below).

Figures 8 & 9- The south-western corner of Varkensvlei 403KQ looking towards Anglo Platinum's Swarklip Mine as well as a broad buffer zone around the village of Matserre is severely degraded as a result of deforestation and over grazing (above).

6.2 Types and ranges of heritage resources

The Phase I HIA study for the Project Area revealed the following types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (No 25 of 1999), namely:

- A formal graveyard in the village of Mantserre.
- No archaeological or pre-historical remains were recorded. Neither did this study provide for a paleontological study.

The graveyard was geo-referenced (Table 1) but not mapped as it is located in the village of Mantserre.

6.2.1 Formal graveyard in Mantserre

A large formal graveyard with hundreds of graves is located near the southern perimeter of the village of Mantserre. Many of the graves are older than sixty years.

Figure 10– A formal graveyard located in the village of Mantserre (above).

6.2.2 Table

Table outlining the coordinates and level of significance for the graveyard in the village of Mantserre.

Mantserre graveyard		**Coordinates**	**Significance**
No			
GY01	Large graveyard with hundreds of graves	24° 56 542S' 27° 06 113E'	**HIGH**

Table 1- Coordinates for graveyard in Mantserre and its level of significance (above).

7 THE HERITAGE IMPACT ASSESSMENT

7.1 Possible impact on the heritage resources

It seems as if the Project Area is devoid of any conspicuous heritage resources. The most obvious to exist are stone walled sites and these may possible be found in the Mmopyane mountain range outside the northern border of the Project Area.

7.2 Mitigating heritage resources

The graveyard of Mantserre is located in the village itself. Although no mine plan is currently available it is unlikely that any significant heritage resources or the graveyard will be affected by the mining project.

Consequently, no mitigation measures for any heritage resources can be recommended.

8 CONCLUSION AND RECOMMENDATION

The Phase I HIA study for the Project Area revealed the following types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (No 25 of 1999), namely:

- A formal graveyard in the village of Mantserre.
- No archaeological or pre-historical remains were recorded. Neither did this study provide for a paleontological study.

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Possible impact on the heritage resources

It seems as if the Project Area is devoid of any conspicuous heritage resources. The most obvious to exist are stone walled sites and these may possible be found in the Mmopyane mountain range outside the northern border of the Project Area.

Mitigating heritage resources

The graveyard of Mantserre is located in the village itself. Although no mine plan is currently available it is unlikely that any significant heritage resources or the graveyard will be affected by the mining project.

Consequently, no mitigation measures for any heritage resources can be recommended.

Dr Julius CC Pistorius
Archaeologist & Heritage Consultant
Member ASAPA

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10 SPOKESPERSONS CONSULTED

Daniel Jabasigo. Member of the Jabasido family and owners of Portion 2 of Varkensvlei 403LKQ.

March 2013

SAMANCOR CHROME LIMITED

Visual Impact Assessment for the Proposed Varkensvlei/Nooitgedacht Chrome Mine

Submitted to:
Samancor Chrome Limited

REPORT

Report Number. 13614977 - 11922 - 5

Distribution:

1 x Samancor Chrome Limited
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Golder Associates

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1.0 INTRODUCTION

1.1 Background

Samancor Chrome (Samancor) has appointed Golder Associates (Golder) to undertake a mining right application (MRA) for the farms Varkensvlei 403 KQ and Nooitgedacht 406 KQ (Varkensvlei/Nooitgedacht), as Samancor's current prospecting right for these properties is due to expire soon.

In terms of the Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA) process applicable to a MRA, a scoping report must be submitted within 30 days after the Department of Mineral Resources (DMR) notifies the applicant that the application form has been accepted, and the final documents must be submitted to the DMR within a further 150 days. This visual impact assessment (VIA) is one of the specialist studies conducted in support of the MRA submission.

1.2 Project description

The Nooitgedacht sector of Samancor comprises an area stretching over two farms, i.e. Varkensvlei 403 KQ and Nooitgedacht 406 KQ, as shown on Figure 1. These farms are located on either side of the provincial boundary between the North West Province and Limpopo Province, in the Magisterial Districts of Moses Kotane and Thabazimbi respectively, approximately 14 km west of Northam and 80 km north of Rustenburg.

The mineral to be mined at Varkensvlei/Nooitgedacht is chromite and in particular the LG6 chromitite seam. Open pit mining was selected to mine the shallow ore, so as to make ore available as early as possible. A conventional truck and shovel operation is planned. Mining will be done by means of drilling and blasting, using the single benching method.

The mine will include the following infrastructure and elements:

- Workshop;
- Administration office;
- Lighting of stockpile area, workshops and offices;
- Weighbridge;
- Mobile crushing and screening plant;
- Material (overburden, topsoil) dumps and product stockpiles; and
- Various items of machinery including drill rigs, excavators, dump trucks, bull dozers, graders and water bowsers.

There will be no beneficiation plant for this application as the process will consist of crushing and screening only to produce the various saleable products. Waste product will be deposited on waste rock dumps and later backfilled into the opencast void.

1.3 Project timeframes

Site establishment is scheduled to commence at the beginning of January 2014, with steady state production from opencast mining by January 2015. Open pit mining operations are planned to continue for 81 months or more, possibly followed by underground mining. Two alternative mining configurations have been considered for the opencast operations, with each one having a different life of mine (LoM):

- LG6 chromitite layer only, ending July 2020; or
- LG6 + LG6A chromitite layers, ending January 2021.

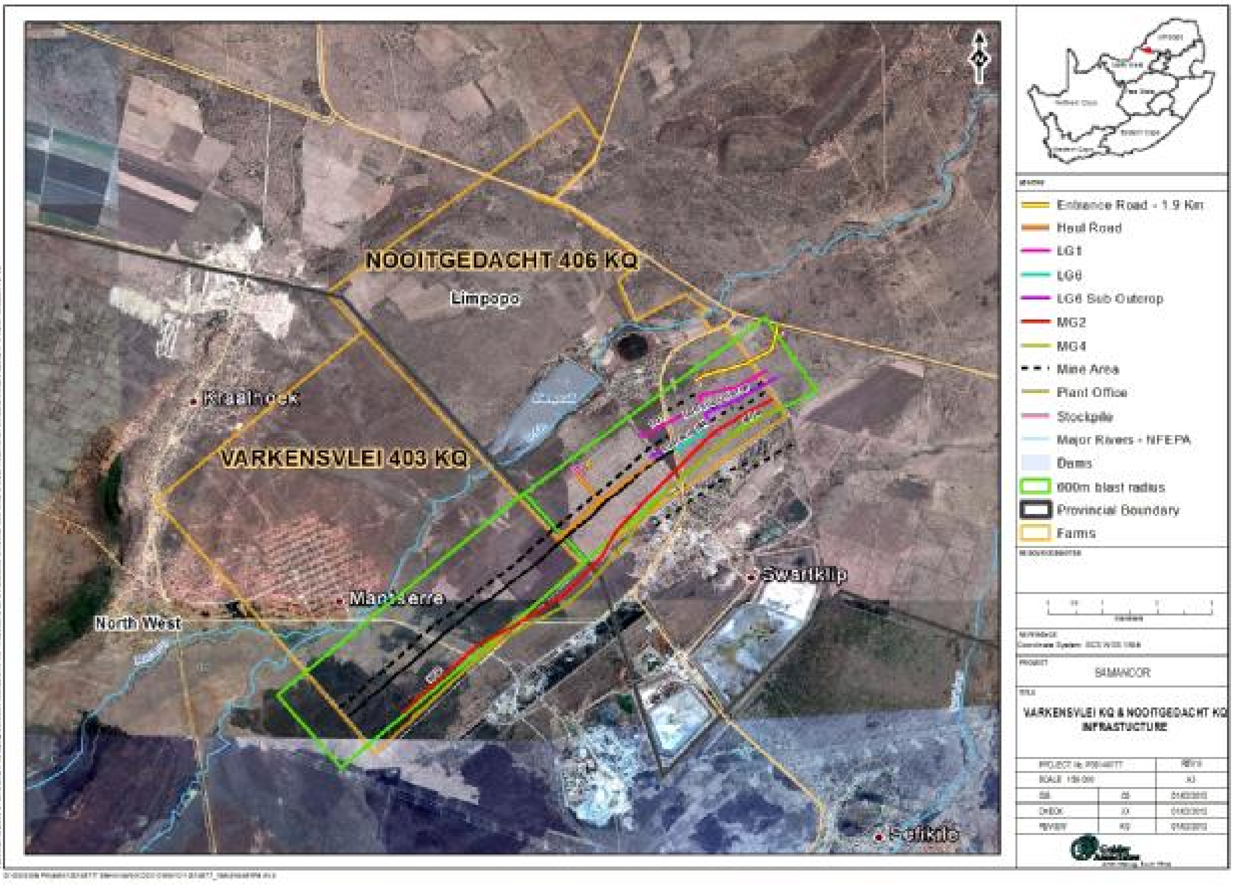

Figure 1: Layout of the proposed Varkensvlei/Nooitgedacht mine

2.0 TERMS OF REFERENCE

The terms of reference for the VIA were to determine the potential visual impacts of the proposed project on potential viewers or receptors in terms of the existing visual context; and to develop mitigation strategies to address these. In order to achieve this aim, the following four steps were followed:

- Describing the landscape as a visual resource, by way of a baseline investigation and subsequently characterising the nature and quality of the landscape and the visual sensitivity of the resource;
- Determining the change in the visual resource that would be brought about by key components of the proposed project and how visible this change will be from the surrounding areas;
- Describing the resultant visual impacts of these components of the proposed project; and
- Recommending mitigation measures to reduce the potential visual impacts of the project.

3.0 ASSUMPTIONS AND LIMITATIONS

The following assumptions and qualifications are relevant specifically to the field of VIA and the findings of this study:

- Determining the value, quality and significance of a visual resource or the significance of the visual impact that any activity may have on it, in absolute terms, is not achievable. The value of a visual resource is partly determined by the viewer and is influenced by that person's socio-economic, cultural and specific family background and is even subject to fluctuating factors such as emotional mood. This situation is compounded by the fact that the conditions under which the visual resource is viewed can change dramatically due to natural phenomena such as weather, climatic conditions and seasonal change. Visual impact cannot therefore be measured simply and reliably, as is for instance the case with water, noise or air pollution. It is therefore impossible to conduct a visual assessment without relying to some extent on the expert professional opinion of a qualified consultant, which is inherently subjective. The subjective opinion of the visual consultant is however unlikely to materially influence the findings and recommendations of this study, as a wide body of scientific knowledge exists in the industry of visual impact assessment, on which findings are based;

- The Digital Elevation Model (DEM) was developed for a 10 km radius around the open cast area. The DEM was developed from 5 m contour data;
- The viewshed was developed based on the position of the proposed open cast area. The viewshed was modelled on the above-mentioned DEM using Global Mapper 10® software. The receptor height was set to 1.5 m and the open cast area was set to ground level. The tailings facilities of the neighbouring Union Mine were used as obstruction at an elevation of 20 m above ground level;
- The viewshed analysis was carried out for the entire open pit mining footprint area and therefore indicates the entire extent to which the open pit may be visible during the LoM. Hence, the viewshed analysis illustrates a cumulative/worst-case scenario result and not the extent of the visual impact caused at any given point in time; and
- Due to the conceptual nature of the layout and designs used for the proposed project, the findings of this report are of a general nature and proposed mitigation may need to be reviewed and updated when final site layout drawings have been produced for the actual project implementation.

4.0 METHODOLOGY

The VIA specialist study conducted for the purposes of this EIA followed the following methodology (Figure 2):

- Describing the landscape character or visual baseline, based on the results of a site visit conducted on 20 February 2013; and a review of available aerial photography and topographical maps, in terms of:
  - Natural elements; and
  - Human-made elements.
- Determining the visual quality of the landscape in terms of:
  - The topographical character of the site and its surroundings and potential occurrence of landform features of interest;
  - The presence of water bodies within the study area;
  - The general nature and level of disturbance of existing vegetation cover within the study area; and
  - The nature and level of human disturbance and transformation evident.
- Determine the visual absorption capacity of the receiving visual landscape;
- Determining the receptor sensitivity to the proposed project;
- Determine the magnitude of the impact, by considering the proposed project in terms of aspects of VIA, namely:
  - Visibility;
  - Visual intrusion; and

  - Visual exposure.
- Assessing the impact significance by relating the magnitude of the visual impact to:
  - Its duration;
  - Severity; and
  - Geographical extent.
- To recommend mitigation measures to reduce the potential visual impacts of the project.

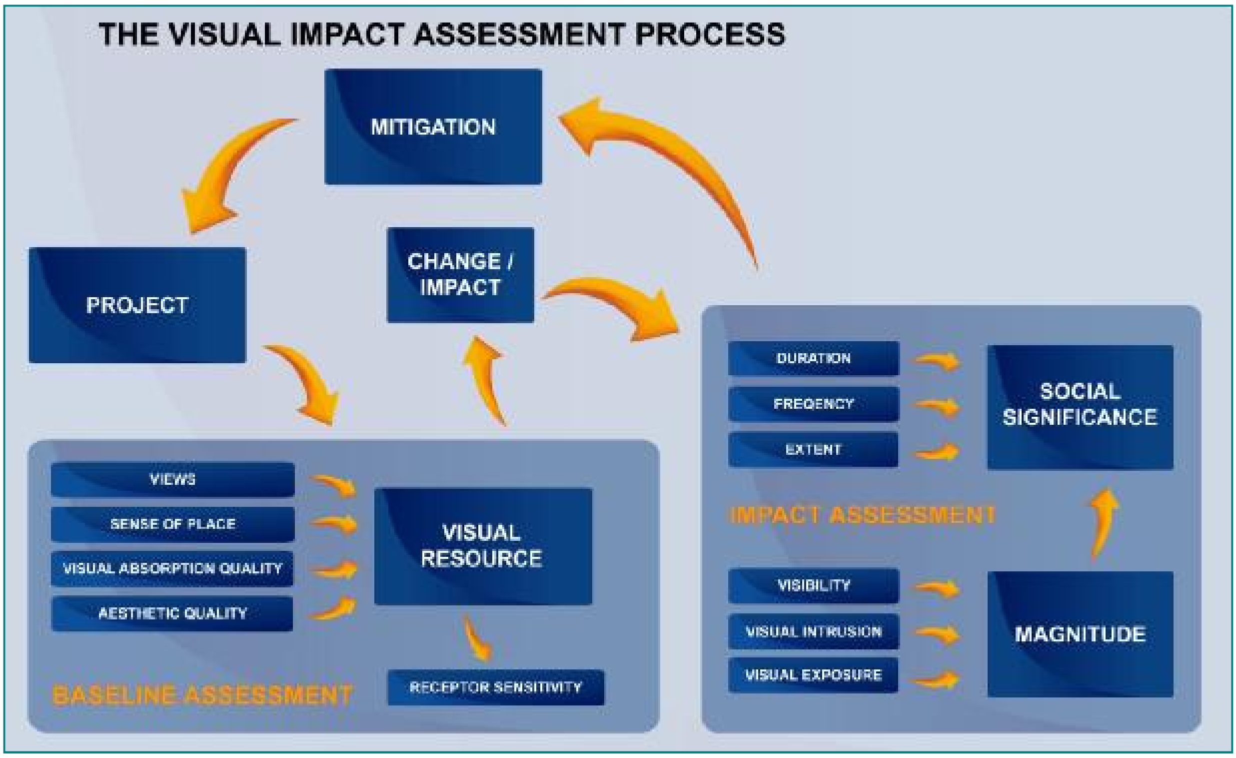

Figure 2: Methodology to conduct a Visual Impact Assessment

5.0 DEFINITION OF STUDY AREA

The study area for the VIA comprises the spatial extent of the project infrastructure footprint and related activities, as well as an associated buffer area. The construction activities, presence of visible infrastructural components and mining activity will all alter the physical appearance of the landscape and hence result in a visual impact.

For the purposes of the VIA, the study area was defined as a 10 km radius around the physical footprint of all surface components and activity areas of the project. The distance of 10 km was selected based on the assumption that the human eye cannot distinguish significant detail beyond this range. Even though the topography of the study area, which is largely flat and punctuated by a number of more prominent landforms, may make it possible to see over greater distances from some locations, structures that are this far away are no longer clearly discernible or are at most inconspicuous. For this reason, the visual impact beyond this range is considered negligible.

For the purposes of this VIA, the term “site” refers to the areas that the project infrastructure and activities will physically affect or alter; and includes all mining infrastructure and infrastructure on both the

Nooitgedacht and Varkensvlei properties. Similarly, the term “study area” refers to the area potentially visually affected by the project and indicates the 10 km radius buffer around the site.

6.0 BASELINE VISUAL CONDITIONS

6.1 Regional visual character

Landscape character is a description of the natural (physical and biological) and human-made (land use) attributes within the study area. This description is done primarily from an objective, visually orientated perspective and does not specifically address the underlying ecological or physical processes within the landscape.

The regional visual character is largely rural, consisting of wilderness/conservation and agricultural uses, contrasted in various locations by extensive mining, human settlements and linear infrastructure.

6.2 Study area visual character

The visual character of the study area is largely similar to that of the greater region; and is discussed in more detail and illustrated by Figure 3 below.

6.2.1 Topography

The largest part of the study area topography is slightly sloping to flat, but punctuated by several isolated ridges and outcrops, which are located northwest and southeast respectively of the Varkensvlei/ Nooitgedacht mining areas. Much larger landforms and mountain ranges are located further north outside of the study area, however they are not visually dominant due to their distance from the site.

In addition, various artificial landforms such as the tailings dams and slag dumps at the adjacent Anglo American Union mine tend to dominate short-range views. These largely geometric, mostly flat elements also contrast with the surrounding natural landforms due to their unnatural appearance.

6.2.2 Hydrology

There are no large watercourses located within the project study area, although the Bierspruit and several of its tributaries, which drain the project area, traverse the area directly north of the site. However, even the larger rivers and streams in the region are not particularly wide, and hence watercourses are rather identified in the landscape by taller and denser vegetation growing along them, than by visible water.

The largest surface water resource near the project area is the Bierspruit dam, located directly north of the Nooitgedacht section of the mine. However, both the dam and the Bierspruit itself were dry during the site visit, with no surface water in evidence, despite previous rain. A number of smaller pollution control and return water dams also occur within Union mine, although these are only visible in short-range views.

6.2.3 Vegetation cover

The vegetation cover in the study area consists largely of Acacia-dominated veld and has varying levels of visual density, depending on the growth forms and spacing of individual specimens. The appearance of the vegetation cover varies greatly across the study area, depending on the level of disturbance from human activity. Relatively large areas of intact natural vegetation still occur in parts of the study area; however, these are somewhat homogenous in appearance due to the limited diversity of the woody species component. By contrast, the outcrops and ridges are generally characterised by higher plant species and visual diversity.

Typically, the relatively undisturbed areas along ridges and watercourses have denser, larger trees and shrubs and a higher degree of visual screening, whereas areas disturbed by human settlement, mining and historic agriculture are usually characterised by smaller, more sparsely spaced plants.

6.2.4 Land cover and land use

The majority of the study area retains a rural sense of place, due to the low levels of transformation and limited levels of land use. However, the mine infrastructure at Union and adjacent operations southeast of the site, as well as a quarry located approximately 7 km north of the site, are visually prominent and intrusive in terms of the surrounding visual context. Furthermore, large areas have historically been degraded by agriculture and linear infrastructure, including high mast powerlines,asphalt and gravel roads that traverse the region.

The local topography is slightly sloping to flat, punctuated by several isolated ridges and outcrops, with more prominent landforms located further north of the study area

Artificial landforms such as tailings dams and slag dumps at the adjacent Anglo American Union mine dominate short range views

Watercourses are not visually prominent and are usually identifiable over distance by the taller and denser vegetation growing along them

The study area vegetation consists largely of Acacia dominated veld of varying visual density, which has in places been disturbed by human settlement, mining and agriculture

Large sections of the study area have a rural character, with low levels of development and transformation

The existing Union mine constitutes the most prominent human element within the study area

Figure 3: Visual character of the project study area

6.3 Study area aesthetic appeal and visual quality

Aesthetic appeal refers not only to the visual quality of elements of an environment but also to the way in which combinations of elements in an environment appeal to our senses; which determines the resultant visual resource value. Studies of perceptual psychology have shown human preferences for landscapes with a higher visual complexity, rather than homogeneous ones (NLA, 2004). Based on contemporary research (Crawford, 1994), landscape quality increases when:

- Prominent topography features and rugged horizon lines exist;
- Water bodies such as streams or dams are present;
- Untransformed indigenous vegetation cover dominates; and
- Limited presences of human activity or land uses that are not visually intrusive prevail.

Further to these factors, Table 1 indicates criteria used for visual resource assessment. The assessment combines visual quality attributes (views, sense of place and aesthetic appeal) with landscape character and gives the landscape a high, moderate or low visual resource value. When assessing the value of a landscape as visual resource, it is also necessary to consider the landscape in the context of where it is located. Although a visual landscape may be considered less impressive than others located far off or in other countries, it may be appealing because of its specific attributes compared to other landscapes nearby. In this way, what may be commonplace when placed in another visual context may be special or exceptional when viewed within its present setting.

Table 1: Visual resource value criteria

Visual Resource Value	Criteria
High	Pristine or near-pristine condition / little to no visible human intervention visible/ characterised by highly scenic or attractive features / Areas that exhibit a strong positive character with valued features that combine to give the experience of unity, richness and harmony. These are landscapes that may be considered to be of particular importance to conserve and which may be sensitive to change.
Moderate	Partially transformed or disturbed landscape / human intervention visible but does not dominate view / scenic appeal of landscape partially compromised / noticeable presence of incongruous elements / Areas that exhibit positive character but which may have evidence of degradation / erosion of some features resulting in areas of more mixed character. These landscapes are less important to conserve, but may include certain areas or features worthy of conservation.
Low	Extensively transformed or disturbed landscape / human intervention dominates available views / scenic appeal of landscape greatly compromised / visual prominence of widely disparate or incongruous land uses and activities / Areas generally negative in character with few, if any, valued features. Scope for positive enhancement frequently occurs.

Based on the findings of the baseline assessment and above criteria, the visual resource value of the study area is summarised as follows:

6.3.1 Topography

The isolated topographical features that contrast with the predominantly flat topography locally contribute to the visual resource value of the study area. Conversely, the large tailings dams and other mining landforms detract from the visual resource value, due to their unnatural, geometric shapes and contrasting colours.

6.3.2 Hydrology

The Bierspruit and Bierspruit dam are the only potentially significant hydrological features in the study area. However, as mentioned, the watercourse and dam appear to be dry most of the time, whilst the mine impoundments are artificial in appearance and located within an extensively transformed visual environment. Hence, these elements do not significantly contribute to the visual resource value of the study area.

6.3.3 Vegetation cover

The majority of the remaining semi-natural areas only contribute moderately to the visual resource value of the study area, due to their visually unvaried appearance. However the denser, more varied vegetation cover along the watercourses, ridges and outcrops have a higher level of visual resource value. By contrast, the vegetation cover of the old agricultural areas, mining and settlement areas are of limited to no visual resource value, as it is visibly disturbed or transformed and contrasts with that of the less disturbed surroundings.

6.3.4 Land cover and land use

The areas in which significant disturbance or visually prominent lands uses occur, including the mining, quarrying and human settlement, are visually intrusive and of limited to no visual resource value. Conversely, the areas where the land cover remains untransformed vary from moderate to high visual resource value, with the remaining parts of the study area being of limited resource value.

6.3.5 Visual resource value summary

When the results of the visual resource value assessment are mapped (Figure 4), it is evident that most of the areas with a high visual resource value are located several kilometres north, northwest and east of the proposed open pit mining site. The majority of the areas surrounding and especially south and east of the site are of low visual resource value, with large areas of moderate value occurring directly north of the site. The site itself is only of low to moderate visual resource value, with no proposed mining activity located within or adjacent to areas of high visual resource value.

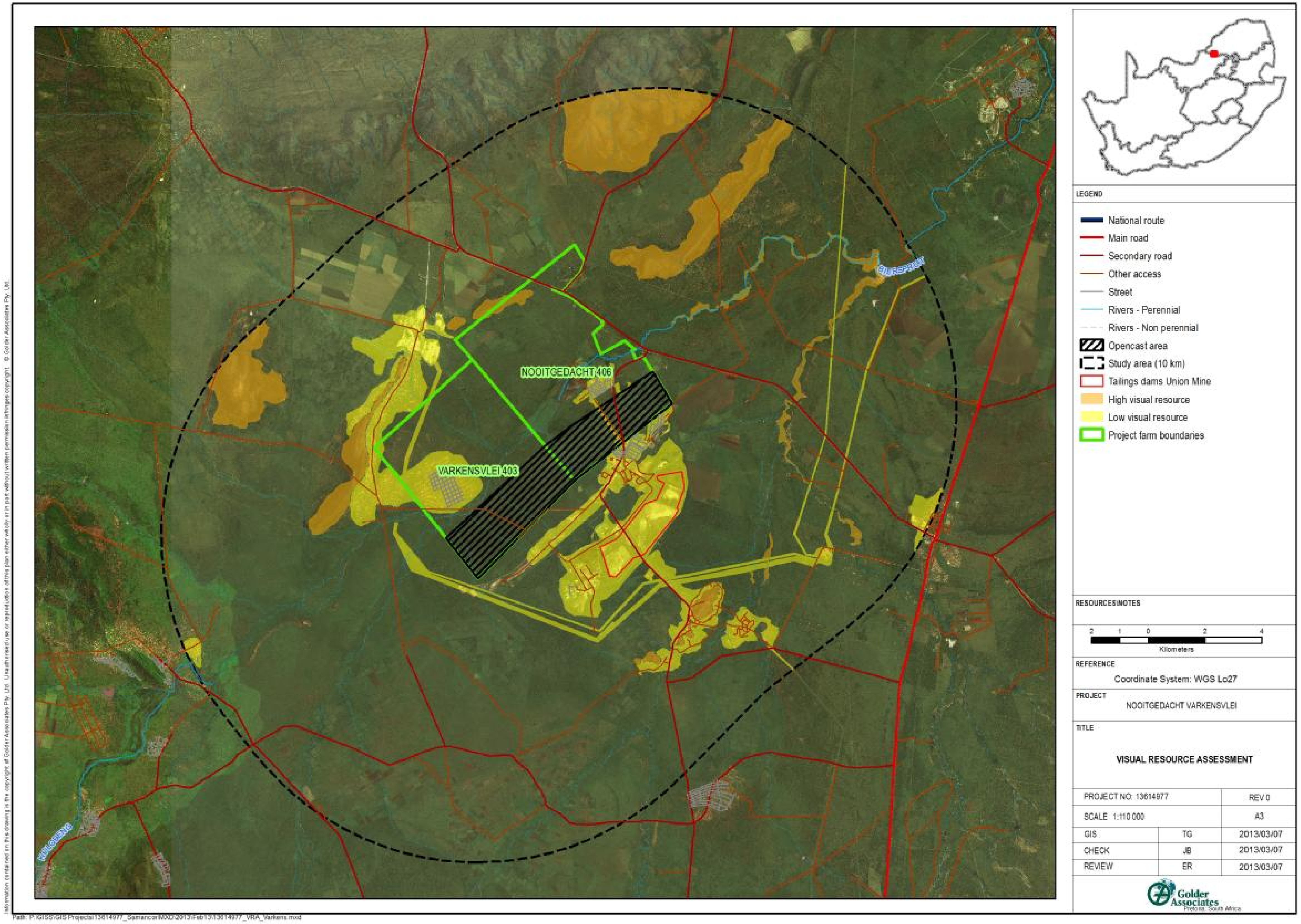

Figure 4: Visual resource value of the project study area

6.4 Visual receptors

6.4.1 Receptor groups

Potential viewers, or visual receptors, of the proposed mining development can broadly be categorised into two main groups (indicated on Figure 5), namely:

- People who live or work in the area and who will frequently be exposed to the project components (resident receptors); and
- People who travel through the area, and are only temporarily exposed to the project components (transient receptors).

The majority of receptors to the project will be resident, as the project area is not located near any major public roads or routes leading to major destinations such as tourist destinations, large towns or recreational areas. Furthermore, the majority of resident receptors living within proximity of the site are likely already employed at Union or one of the other mines in the region.

6.4.2 Receptor sensitivity

Receptor sensitivity refers to the degree to which an activity will actually impact on receptors and depends on how many persons see the project, how frequently they are exposed to it and their perceptions regarding aesthetics. The visual receptors can be classified for high, moderate or low visual sensitivity as indicated in Table 2.

Table 2: Visual receptor sensitivity criteria

Visual Quality Score	Site Specific Criteria
Number of people that will see the project (exposure factor):	
Large	Towns and cities, along major national roads (e.g. thousands of people).
Moderate	Villages, typically less than 1000 people.
Small	Less than 100 people (e.g. a few households).
Receptor perceived landscape value (sensitivity factor):	
High	People attach a high value to aesthetics, such as in or around a game reserve or conservation area, and the project is perceived to impact significantly on this value of the landscape.
Moderate	People attach a moderate value to aesthetics, such as smaller towns, where natural character is still plentiful and in close range of residency.
Low	People attach a low value to aesthetics, when compared to employment opportunities, for instance. Environments have already been transformed, such as cities and towns.

6.4.3 Receptor sensitivity weighting factor

To determine the magnitude of a visual impact, a weighting factor, which accounts for receptor sensitivity is determined (Table 3), based on the number of people that are likely to be exposed to a visual impact and their expected perception of the visual landscape and project, as set out in Table 2 above.

Table 3: Weighting factor for receptor sensitivity criteria

		Number of people that will see the project (exposure factor):		
		Large	Moderate	Small
Receptor perceived landscape value (sensitivity factor)	High	High (1.2)	High (1.2)	Moderate (1.0)
	Moderate	High (1.2)	Moderate (1.0)	Low (0.8)
	Low	Moderate (1.0)	Low (0.8)	Low (0.8)

The following weightings have therefore been applied to the visual receptor groups identified in Section 6.4.1:

- Resident receptors: moderate weighting. A relatively large number of people live adjacent to or near the site and may therefore be affected by the project. However, it is likely that the majority of these receptors will have a low level of sensitivity towards the project, as they have been living close to and are likely employed by one of the existing mines, or may view the proposed mine as an employment opportunity; and

- Transient receptors: low weighting. It is expected that the majority of people that travel in/through the study area are resident receptors, and that a small number of transient receptors will be affected by the project. Furthermore, as the site is not located on or near any areas of high visual resource value, it is likely that they will have a low level of sensitivity towards the study area.

For the purposes of this assessment, a worst-case scenario approach has been adopted; hence the overall receptor sensitivity to the project has been weighted as moderate.

7.0 IMPACT ASSESSMENT

7.1 Impact magnitude

7.1.1 Visibility

The zone of theoretic visibility (ZTV) is defined as the sections of the study area from which the proposed project may be visible. This area was determined by conducting a viewshed analysis and using Geographic Information System (GIS) software with three-dimensional topographical modelling capabilities, including viewshed and line-of-sight analyses (cross-sections). The footprint of the proposed open pit mining area was superimposed onto a DEM of the site, to produce a viewshed. The DEM as well as viewshed analysis results are then draped over a topo-cadastral map or aerial photograph, in order to increase the legibility of the results, indicated on Figure 5.

The results of the viewshed analysis indicate that the open pit will at some stage be visible from most of the northern half of the study area as it migrates/moves across the project area, but that the extent to which it will be visible in the southern half of the study area will be limited. The high degree of visibility to the north is attributed to the relatively flat local topography, whereas the slight natural rise south of the Bierspruit tributary and more prominent artificial topography of Union mine are responsible for the low levels of visibility to the south. Furthermore, as previously mentioned it is important to note that the actual extent to which the open pit will be visible at any point in time will be somewhat less than what is indicated by the viewshed analysis ZTV, which illustrates the cumulative visibility of the pit throughout the LoM. Based on the above results, the overall level of visibility of the open pit and mine infrastructure is rated as moderate.

During construction and especially operations, airborne dust is expected to occur from time to time, especially during dry and windy conditions. Dust plumes are also likely to be more visible than the activity causing them due to the height of the plume, as was observed at the existing quarry located north of the site. Hence, airborne dust is rated as having a high level of visibility.

Minimal light at night is expected during construction and also operations as it will be limited to the site establishment and mobile plant areas. Hence, the degree of visibility of night-time light sources will likely be somewhat limited at any given point in time and lighting is therefore rated as having low visibility.

7.1.2 Visual intrusion

Visual intrusion deals with how well the project components fit into the ecological and cultural aesthetic of the landscape as a whole. An object will have a greater negative impact on scenes considered to have a high visual quality than on scenes of low quality because the most scenic areas have the "most to lose".

The visual impact of a proposed landscape alteration also decreases as the complexity of the context within which it takes place, increases. If the existing visual context of the site is relatively simple and uniform any alterations or the addition of human-made elements tend to be very noticeable, whereas the same alterations in a visually complex and varied context do not attract as much attention. Especially as distance increases, the object becomes less of a focal point because there is more visual distraction, and the observer's attention is diverted by the complexity of the scene (Hull and Bishop, 1998).

The current visual context within which the project will take place is relatively complex, mainly because of the adjacent extensive Union mine infrastructure and settlements. The greater region also has a longstanding mining history, although only one other mine occurs within the project study area, namely the quarry located northwest of the site at Kraalhoek. Furthermore, the visible components of the proposed project will only consist of a single migrating open pit, a number of material and product stockpiles, mobile screening and crushing plant, machinery as well as offices and limited associated support infrastructure. The open pit will also be progressively backfilled and rehabilitated, which will limit the extent of the visually transformed areas at a given time. It is therefore unlikely that the proposed project will be considered highly intrusive by most receptors and this aspect has been rated as causing moderate visual intrusion.

The open pit mining will likely cause an increase in fugitive dust emissions, particularly as a result of blasting and windy conditions. Airborne dust is often visible over great distances and can be particularly bothersome, as it reduces visibility and alters visual amenities by settling on plants, crops and built structures in significant large quantities. Airborne dust is therefore expected to result in a moderate degree of visual intrusion.

Light at night can be one of the more objectionable impacts associated with any project or development as it can be highly intrusive, especially in areas with low levels of development. However, the proposed project is located in a highly developed area and adjacent to an existing mine. Furthermore, the project will not entail construction of a new beneficiation plant and includes limited additional infrastructure and will therefore not result in a substantial increase in ambient light levels. Hence, this aspect is expected to result in a low degree of visual intrusion.

During rehabilitation and closure, all surface infrastructures such as roads, fences and temporary building structures will be demolished and rehabilitated and mobile plant will be removed from site. Furthermore, the final open pit will be backfilled and all remaining disturbed areas rehabilitated, which will result in a positive visual impact. However, the majority of the rehabilitation will already have occurred during operations and hence the positive effect will be somewhat limited.

Furthermore, rehabilitation activities will involve a degree of earthworks which could result in airborne dust being generated, similar to what is expected during the construction phase, although the duration thereof will be limited.

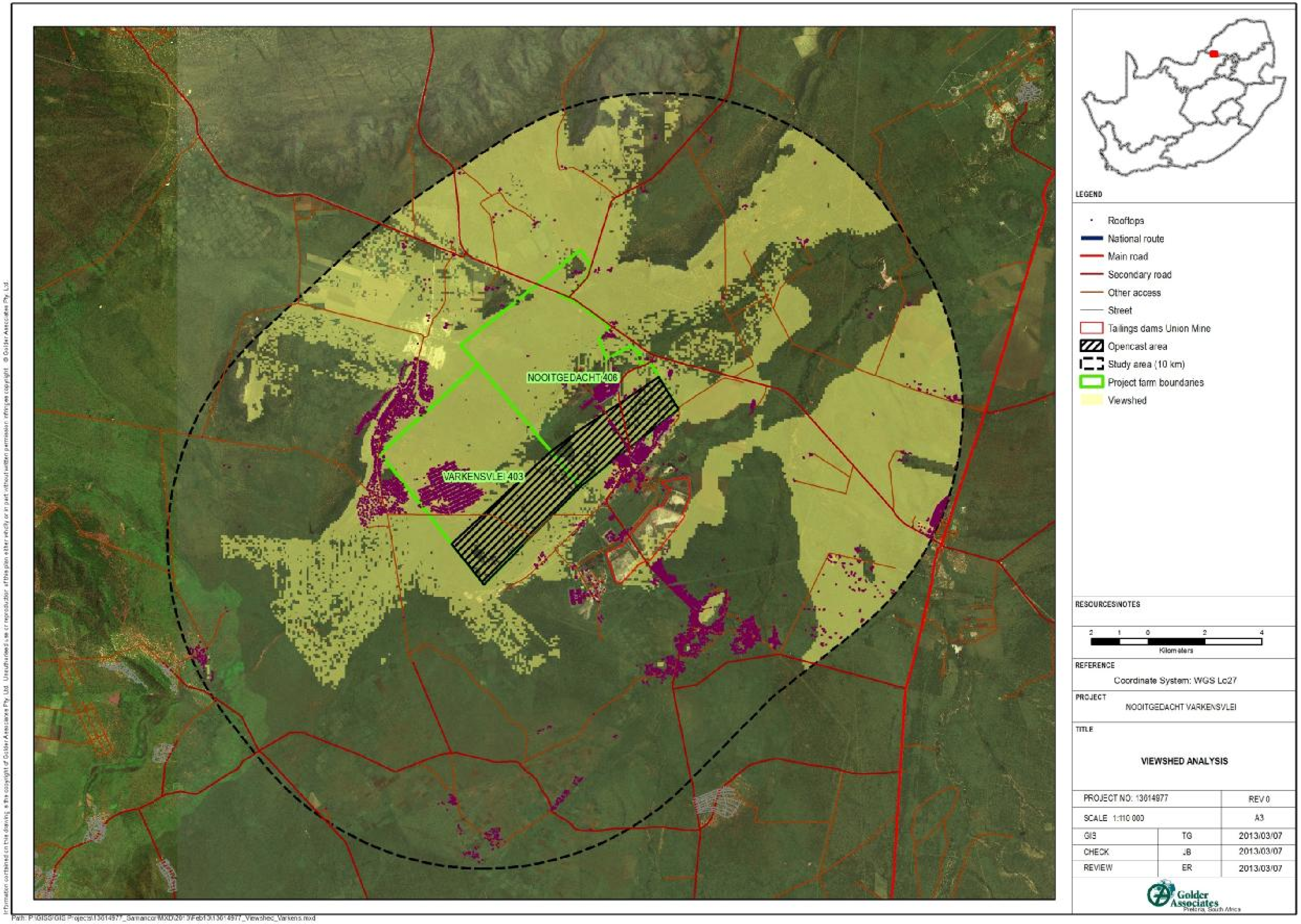

Figure 5: Zone of theoretical visibility and receptor locations in the project study area

The Varkenvlei/Nooitgedacht open pit mining will be similar in appearance to a number of other mines in the region

Although the open pit will be moderately intrusive in the visual landscape, its physical extent at any given time will be limited

Airborne dust can be particularly bothersome and more visible than its cause and will result in moderate visual intrusion

Lighting of the project at night is expected to be limited. The site is adjacent to the existing Union mine, and will therefore cause low levels of visual intrusion

Figure 6: Examples of project elements and associated levels of visual intrusion

7.1.3 Visual exposure

The visual impact of a development diminishes at an exponential rate as the distance between the observer and the object increases – refer to Figure 7. Relative humidity and fog in the area directly influence the effect. Increased humidity causes the air to appear greyer, diminishing detail. Thus, the impact at 1 000 m would be 25% of the impact as viewed from 500 m. At 2 000 m it would be 10% of the impact at 500 m. The inverse relationship of distance and visual impact is well recognised in visual analysis literature (Hull and Bishop, 1988) and was used as important criteria for this study.

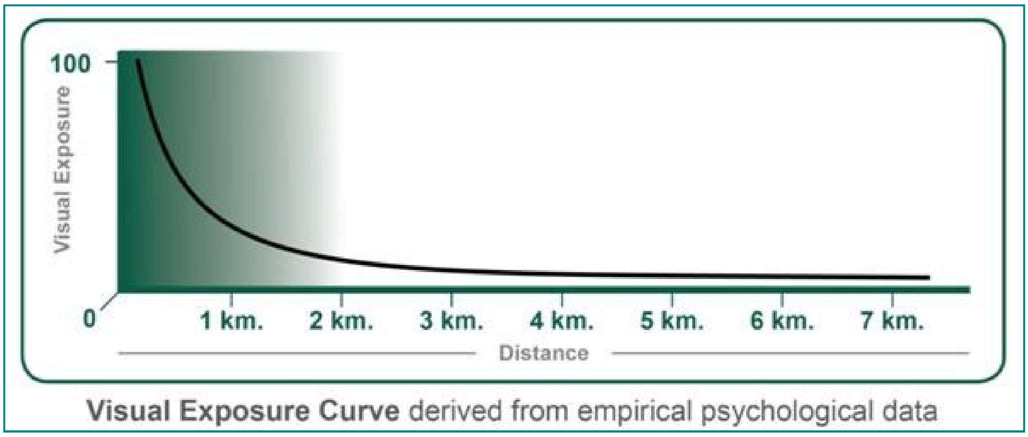

Figure 7: Visual Exposure Graph

Thus, visual exposure is an expression of how close receptors are expected to get to the proposed interventions on a regular basis. For the purposes of this assessment, close-range views (equating to a high level of visual exposure) are views over a distance of 500 m or less, medium-range views (equating to a moderate / medium level of visual exposure) are views of 500 m to 2 km, and long-range views are over distances greater than 2 km (low levels of visual exposure).

A number of resident receptors are located between 500 m and 2 km from the project site, with the majority of receptors located more than 2 km from the site. All of the major routes along which transient receptors pass through the study area are located more than 2 km from the site. Adopting a worst-case scenario, the level of visual exposure to the project was rated moderate.

7.1.4 Impact magnitude summary

The expected impact magnitude of the proposed project was rated, based on the above assessment of the visual resource value of the site alternatives, as well as level of visibility, visual intrusion, visual exposure and receptor sensitivity as visual impact criteria. The process is summarised below.

Magnitude = [Visual Quality of the site x (Visibility + Visual Intrusion + Visual Exposure)] x Receptor Sensitivity.

From the above equation the maximum magnitude point (MP) score is 32.4 points. Thus:

[1 x (1 + 1 + 2)] x Factor 1 = **4**

The possible range of MP scores is then categorised as indicated in Table 4 below.

Table 4: Impact magnitude point score range

MP Score	Magnitude rating
19+	High
13-18	Moderate
7-12	Low
≤6	Negligible

Table 5: Construction and operations phases - impact magnitude summary
(Where for: visual resource value, visibility, visual intrusion and visual exposure: high=3; moderate=2; low=1; and receptor sensitivity: high = factor 1.2; moderate = factor 1; low = factor 0.8.)

Visual impact	Visual resource value	Level of visibility	Visual intrusion	Visual exposure	Receptor sensitivity	Impact magnitude point score
Reduction in visual resource value due to presence of mining infrastructure and activity (moderate resource areas)	2	2	2	2	1	12 (low)
Visible dust plume	2	3	2	2	1	14 (moderate)
Light pollution at night	2	1	1	2	1	8 (low)

Table 6: Rehabilitation and closure phase - impact magnitude summary
(Where for: visual resource value, visibility, visual intrusion and visual exposure: high=3; moderate=2; low=1; and receptor sensitivity: high = factor 1.2; moderate = factor 1; low = factor 0.8.)

Visual impact	Visual resource value	Level of visibility	Visual intrusion	Visual exposure	Receptor sensitivity	Impact magnitude point score
Improvement in visual resource value due rehabilitation	2	2	1 (positive)	2	1	10+ (low positive)
Visible dust plume	2	3	2	2	1	14 (moderate)

7.2 Impact significance rating methodology

The significance of the identified impacts will be determined using the approach outlined in Table 7. This incorporates two aspects for assessing the potential significance i.e. occurrence and severity, which are further sub-divided as indicated. The impact ranking will be described for both pre and post implementation of mitigation/management measures conditions.

Table 7: Impact classification for impact assessment

Occurrence			Severity				Environmental significance
Direction	Probability	Duration	Magnitude	Geographic extent	Reversibility	Frequency	

- Direction of an impact may be **positive, neutral or negative** with respect to the particular impact (e.g., a habitat gain for a key species would be classed as positive, whereas a habitat loss would be considered negative);

- Probability of occurrence is a description of the probability of the impact actually occurring as **improbable** (less than 5% chance), **low probability** (5% to 40% chance), **medium probability** (40 % to 60 % chance), **highly probable** (most likely, 60% to 90% chance) or **definite** (impact will definitely occur). The probability of occurrence for visual impacts is determined by whether the project components will be visible or not. Hence, probability is not used for the purposes of this impact assessment as it is already factored into the magnitude determination;

- Duration refers to the length of time over which an environmental impact may occur: i.e. **transient** (less than 1 year), **short-term** (0 to 5 years [construction]), **medium term** (5 to 15 years [operational]), **long-term** (greater than 15 years with impact ceasing after closure of the project) or **permanent**;

- Magnitude is a measure of the degree of change in a measurement or analysis (e.g., the area of pasture, or the concentration of a metal in water compared to the water quality guideline value for the metal), and is classified as: **negligible**: no measurable effect (<1% change from current conditions); **low**: <10% change from current conditions; **moderate**: 10 to 20% change from current conditions; and **high**: >20% change from current conditions. The categorization of the impact magnitude may be based on a set of criteria (e.g. health risk levels, ecological concepts and/or professional judgment) pertinent to each of the discipline areas and key questions analysed. Each specialist study will attempt to quantify the magnitude and outline the rationale used;

- Scale/geographic extent refers to the area that could be affected by the impact and is classified as **site**; **local**: effect restricted to the local study area; **regional**: effect extends beyond the local study area into the RSA; and **beyond regional**: effect extends beyond the RSA site;

- Reversibility allows for the impact to be described as **reversible** or **irreversible**;

- Frequency may be **low**: occurs once; **medium**: occurs intermittently; or **high**: occurs continuously; and

- Environmental significance: The overall residual consequence for each effect will be classified as one of: **negligible**, **low**, **moderate** or **high** by evaluation of the rankings for magnitude, geographic extent and duration Table 8.

Table 8: Categories describing environmental significance

Category	Description
High	Of the highest order possible within the bounds of impacts that could occur. There is no possible mitigation that could offset the impact, or mitigation is difficult.
Moderate	Impact is real, but not substantial in relation to other impacts that might take effect within the bounds of those that could occur. Mitigation is both feasible and fairly easily possible.
Low	Impact is of a low order and therefore likely to have little real effect. Mitigation is either easily achieved or little mitigation is required, or both.
Negligible	Zero Impact.

Table 9 provides the method for combining the magnitude, geographic extent and duration of the impact, in order to determine the environmental significance. In this way, specific combinations of each of the three determining factors result in different environmental consequence ratings.

Table 9: Screening system for environmental significance

Magnitude	Geographic extent	Duration	Environmental significance
negligible	all	all	negligible
low	local	short-term	negligible
low	local	medium-term	low
low	local	long-term	low
low	regional	short-term	low
low	regional	medium-term	moderate
low	regional	long-term	moderate
low	beyond regional	short-term	low
low	beyond regional	medium-term	moderate
low	beyond regional	long-term	moderate
moderate	local	short-term	low
moderate	local	medium-term	low
moderate	local	long-term	moderate
moderate	regional	short-term	moderate
moderate	regional	medium-term	moderate
moderate	regional	long-term	high
moderate	beyond regional	short-term	moderate
moderate	beyond regional	medium-term	high
moderate	beyond regional	long-term	high
high	local	short-term	moderate
high	local	medium-term	high
high	local	long-term	high
high	regional	short-term	moderate
high	regional	medium-term	high
high	regional	long-term	high
high	beyond regional	short-term	high
high	beyond regional	medium-term	high
high	beyond regional	long-term	high

Table 10: Summary of construction and operations phases impacts and mitigation measures
Note: Construction and operational impacts have been considered collectively, as they will be similar in nature and largely indistinguishable from a visual perspective

Construction and operational phases impacts	Direction	Frequency	Reversibility	Significance before mitigation				Proposed mitigation measures (refer to Section 8 for greater detail)	Significance after mitigation			
				Magnitude	Extent	Duration	Significance		Magnitude	Extent	Duration	Significance
Reduction in visual resource value due to presence of mining infrastructure and activity (moderate resource areas)	negative	high / permanent	irreversible	low	local	medium term	low	Maintain visual appearance of site through good housekeeping	low	local	medium term	low
Visible dust plume	negative	medium	reversible	moderate	local	medium term	low	Implement dust suppression measures Avoid blasting during windy conditions	low	local	medium term	low
Light pollution at night	negative	High / permanent	reversible	low	local	medium term	low	Install directional lighting and fixtures Avoid unnecessary lighting	negligible	local	medium term	negligible

Table 11: Summary of rehabilitation and closure phases impacts and mitigation measures

Rehabilitation and closure phase impacts	Direction	Frequency	Reversibility	Significance before mitigation				Proposed mitigation measures (refer to Section 8 for greater detail)	Significance after mitigation			
				Magnitude	Extent	Duration	Significance		Magnitude	Extent	Duration	Significance
Improvement in visual resource value due rehabilitation	positive	high / permanent	not applicable	low (positive)	local	long term	low	Implement additional monitoring and rehabilitation measures	Moderate (positive)	local	long term	moderate
Visible dust plume		medium	reversible	moderate	local	short term	negligible	Implement dust suppression measures	low	local	short term	negligible

8.0 SUMMARY OF MITIGATION AND MONITORING MEASURES

8.1 Construction and operational phases

8.1.1 Reduction in visual resource value due to presence of mining infrastructure and activity

- Maintain the construction site in a neat and orderly condition at all times;
- Create designated areas for material storage, waste sorting and temporary storage, batching and other potentially intrusive activities and screen these off from the settlements/villages close to the site; and
- Limit the physical extents of areas cleared for material laydown, vehicular parking and the like as much as possible and rehabilitate these as soon as is feasible.

8.1.2 Visible dust plume

At the time of writing, an air quality assessment study for the project was not available. However, the following standard measures associated with mining activity must be implemented:

- Water down haul roads and large bare areas as frequently as is required to minimise airborne dust;
- Place a sufficiently deep layer of crusher rock or gravel at vehicle and machinery parking areas;
- Apply chemical dust suppressants if deemed necessary; and
- Implement a dust bucket and fallout monitoring system.

8.1.3 Light pollution at night

- During construction and operations, utilise security lighting (if feasible) that is movement activated rather than permanently switched on, to prevent unnecessary constant illumination;
- During the operational phase, plan the lighting requirements of the facilities and installations to ensure that lighting meets the need to keep the site secure and safe, without resulting in excessive illumination;
- Reduce the height from which floodlights are fixed as much possible whilst still maintaining the required levels of security illumination;
- Identify zones of high and low lighting requirements, focusing on only illuminating areas to the minimum extent possible to allow safe operations at night and for security surveillance;
- Avoid up-lighting of structures by rather directing lighting downwards and focused on the area to be illuminated; and
- Fit all security lighting with ‘blinkers’ or specifically designed fixtures, to ensure light is directed downwards while preventing side spill. Light fixtures of this description are commonly available for a variety of uses and should be used to the greatest extent possible.

8.2 Rehabilitation and closure phase

8.2.1 Improvement in visual resource value due rehabilitation

- Continuously assess condition of vegetation cover of rehabilitated areas for adequate cover density and species composition;
- Employ control measures to eradicate weedy and alien invader plant species as required; and
- Establish and maintain additional woody shrub and tree species in rehabilitated areas, to ensure that grassland conditions do not dominate, in consultation with a rehabilitation ecologist.

8.2.2 Visible dust plume

Due to the expected short duration of the rehabilitation phase it is not expected that extensive dust suppression will be necessary, however working areas and roads must be watered down as and when required.

8.3 Cumulative Impacts

The cumulative impact assessment considers this project within the context of other similar land uses, in the local and greater regional context.

Currently, several large chrome and platinum mines occur within the lower-lying parts of the greater region, with several open pit iron ore mines located in the mountains further north of the site. Furthermore, several of these mines are visible from the site, especially the adjacent Union mine. The Varkensvlei/Nooitgedacht open pit mine will therefore result in a cumulative visual impact within the study area. Other new open pit mining projects are also being applied for in the region and the degree to which visual impacts would accumulate would depend on the distances and topography between these projects, the degree to which the visual impacts of various projects can be mitigated, and the number of receptors.

In the light of the fact that mining has been in existence for a long period of time in the region, and the comparatively limited scale of the proposed project, it may be argued that any potential cumulative impact, although negative, is not likely to be of major significance.

9.0 CONCLUSION

In summary, it can be stated that the visual resource value of the study area varies significantly, based on the level of human transformation. The project site and immediate surroundings are of moderate to low value as a visual resource. The proposed project components will impact negatively on the visual environment, with the greatest impacts expected as a result of the open pit and airborne dust associated with operations. However, the visual impact during operations will be limited due to the fact that progressive backfilling and rehabilitation will be done; and hence these impacts are expected to be of low significance. Furthermore, during de-commissioning, all project infrastructures will be removed and the remaining mining void backfilled and the affected areas rehabilitated, which will largely eliminate potential residual impacts.

From a visual perspective it is therefore recommended that the project may proceed, provided that the recommended mitigation measures are implemented.

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Johan Bothma
Visual Assessment Specialist

Etienne Roux
Senior Reviewer

JB/ER/rb

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APPENDIX A

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GOLDER ASSOCIATES

REPORT ON:

SAMANCOR SPECIALIST SOIL ASSESSMENT

REPORT: P286

Submitted to:

Golder Associates

PO Box 6001

Halfway House

1685

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June 2015

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EXECUTIVE SUMMARY

Golder Associates requested during January 2013 a proposal for a baseline soil land use land capability wetland assessment at Varkenvlei, Nooitgedacht Rustenburg and Haakdoorn Thabazimbi for Samancor Mining Right Application. The total study area is approximately 2,112 ha in extent.

The objectives of the investigation included a soil survey and mapping of study area, measurement of the effective depth of the soil(s), assessment of agriculture potential of soils, assessment of the erodibility and misuse of soils, mapping of land use & land capability, formulation of a soil stripping guide and plan, determination of chemical, mineralogical and physical properties of representative soil forms, assessment of suitability of soils for rehabilitation purposes and an impact assessment of topsoil stripping on soils with recommendations to mitigate negative impacts.

From the assessment it is conclusive that the dominant soils according to the Taxonomical Soil Classification System of South Africa include Avalon, Bainsvlei, Mispah, Arcadia and Rensburg soils. The effective depth of the Avalon and Bainsvlei soils exceed 300mm inclusive of the *Orthic A and Yellow & Red Brown Apedalic B – Horizons*. The effective depths inclusive of the Orthic and Vertic A-Horizons of the Mispah, Arcadia and Rensburg soils are <300mm.

The agricultural potential under dry land and irrigation conditions is indicated in **Table 3** (**p13**). The agricultural potential of the Avalon and Bainsvlei soils is considered medium to high under dryland (650mm/y rainfall) and irrigation conditions (>10-15mm/week 33-1,500kPa plant available water). The Mispah, Arcadia and Rensburg soils are regarded as having low agricultural potential under dryland and irrigation conditions.

No evidence of soil erosion was observed on any of the soils during the investigation.

The current land use for Haakdoorndrift includes natural veld (285ha), plantation (9ha) and ploughed land (132ha). For Varkensvlei and Nooitgedacht the land use includes 1,270 ha of natural veld.. Land capability for Haakdoorndrift includes 285ha grazing, 9ha wilderness and 132ha arable. Varkensvlei and Nooitgedacht land capability includes 1,270 ha of grazing. .

A soil stripping stockpiling strategy is given on **p18 (Table 8)**. A total area of 1,899ha could potentially be covered 300mm thick @ bulk density 1,275 kg/m^3 during rehabilitation taking into consideration a 10% loss of topsoil from the 6,375,000 m^3 due to handling, compaction *etc*.

The soils are characterised by neutral pH values (5,3 and 7,2) and low electrical conductivity values (<250 mS/m). Under these conditions plant available nitrogen (15-20 mg/kg), phosphorus (10-15 mg/kg) and potassium (>50 mg/kg) are readily

available for plant uptake and sustainable plant growth. The *Orthic A-Horizon* is typically characterised by a low dense structure and texture distribution of approximately 65% sand, 20% silt and 15% clay with drainage properties in order of 10mm/h. The dominant clay mineral in the *Orthic A and Yellow Brown Apedalic B –Horizon* is kaolinite (*1:1 layer silicate*), with a low buffer capacity due to the low cation exchange capacity *(<10cmol+/kg*). The Vertic A-Horizon is typically characterised by clay content >25% with plasticity index>15% and cation exchange capacity >30cmol+/kg

The horizons specified in **Section 4.4 p11** of the soils (*except Soft Plinthic B and G -Horizons*) are suitable for rehabilitation purposes.

The potential impacts and reasons/activities with proposed mitigation measures on the soil due to construction activities include:

- ***Loss of topsoil***:

  This is due to stripping, handling and placement of the soil associated with the pre-construction land clearing and rehabilitation and it is recommended to strip all usable soil irrespective of soil depth.

- ***Change to soil's physical, chemical and biological properties***:

  There is a high probability that topsoil will be loss due to wind and water erosion, which will alter the soils properties. Stockpiling and subsequent mixing of soil layers during handling will ultimately have a negative effect on altering the basic soil properties. It is suggested to implement live management and placement of topsoil where possible, improve the organic content of the soils, and maintain fertility levels through fertilisation and to curb topsoil loss as much as possible.

- ***Cumulative effect on the soil***:

  Alteration of the natural surface topography due to re-profiling during construction after stripping will have a cumulative effect on the soils and careful consideration should be given to minimise compaction and ensure free drainage preferential surface water pathways.

SAMANCOR SPECIALIST SOIL ASSESSMENT

1 TERMS OF REFERENCE

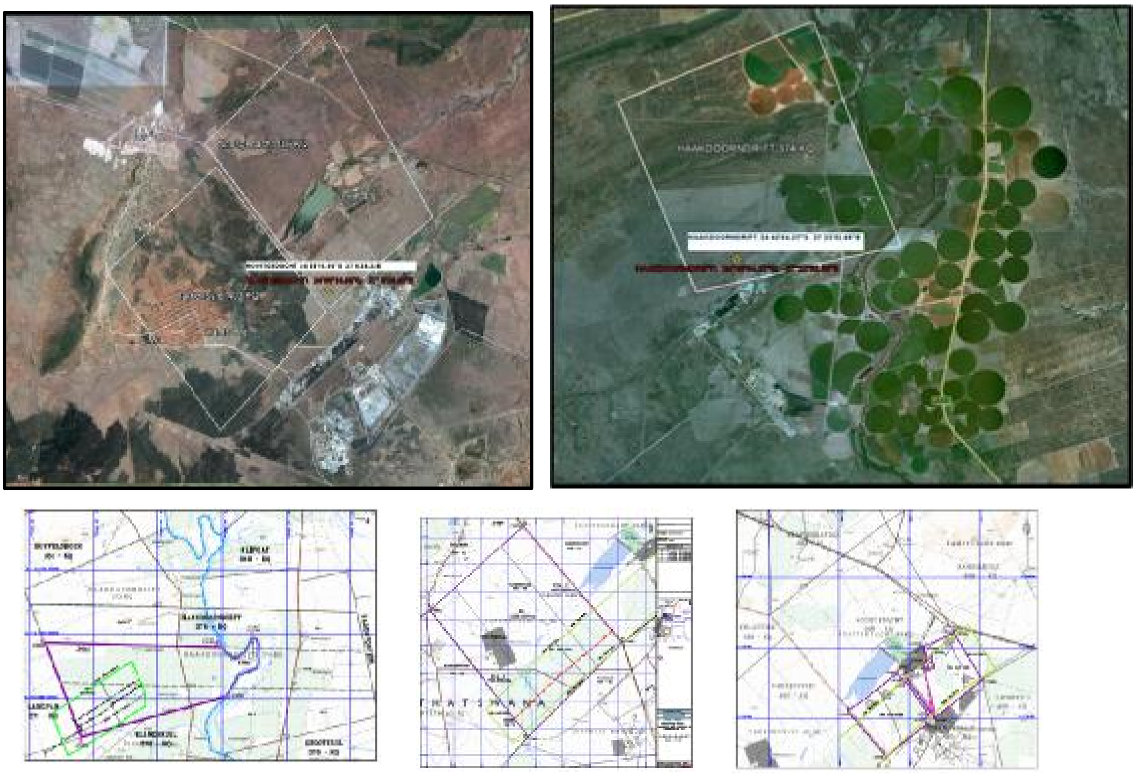


Figure 1. Investigation area.

During January 2013 Golder Associates requested a proposal for a baseline soil land use land capability wetland assessment at Varkenvlei, Nooitgedacht Rustenburg and Haakdoorn Thabazimbi for Samancor's Mining Right Application. The study area is approximately 2,112ha (**Figure 1**).

2 INVESTIGATION OBJECTIVES

The objectives of the investigation were interpreted as:

- **Objective 1:** *Soil survey and mapping of study area.*
- **Objective 2:** *Measurement of the effective depth of the soil(s).*
- **Objective 3:** *Assessment of agriculture potential of soils.*
- **Objective 4:** *Erodibility and misuse of soils.*
- **Objective 5:** *Land use & land capability.*
- **Objective 6:** *Soil stripping guide and plan*.

- **Objective 7:** *Determination of chemical, mineralogical and physical properties of representative soil forms.*

- **Objective 8:** *Assessment of suitability of soils for rehabilitation purposes.*

- **Objective 9:** *Impact assessment of topsoil stripping on soils with recommendations to mitigate negative impacts.*

3 METHOD OF INVESTIGATION

In order to meet the objectives of the investigation, the following scope of work was conducted:

- Collection of available information relevant to the study, *i.e.* GPS coordinates, map defining study area plotted on 1:50,000 tif image and aerial images.

- A desktop assessment for the draft scoping report.

- Interpretation of anticipated analytical data and field observations.

- Compilation of draft report.

- Internal review and submission of report.

3.1 Sampling Procedures

During the baseline assessment soil sampling was carried out according to the following procedures:

- Auger holes drilled with a 75 mm diameter 1,8 m mechanical steel auger.

- The ground surface at the position of the auger hole cleared of loose material. If present, surface vegetation will be carefully removed and the soil clinging to any roots left behind collected with the surface soil sample.

- The sampling interval in the auger holes was 150 mm and consolidated to one sample per auger hole.

- The auger was advanced to the required depth and then carefully removed from the hole. The hole was covered to prevent foreign material from entering.

- Approximately 1.5 kg of soil sample was taken from the hole raisings and soil material removed from the auger. The samples were quartered to produce a representative sample of suitable weight, *i.e.* 500 g.

- Prior to the taking of each sample both the steel auger and stainless steel trowel used to collect the soil samples were wiped clean of soil, washed with tap water, rinsed in a phosphate free detergent and finally sprayed with de-ionised water to prevent cross-contamination between sampling depths.

- The soil samples were placed directly in zip-lock freezer bags, clearly labelled in indelible ink with the name of the site, auger hole number and sampling date.

- The soil samples were stored in the shade prior to being transported to an air-conditioned environment awaiting transport to the analytical laboratory.

- Chain of custody forms accompanied the soil samples to the laboratory and the samples were verified and signed for by the laboratory chemist.

- All auger hole logs were geo-referenced (GPS: datum WGS1984, decimal degrees).

3.2 Inorganic Analyses

Table 1 shows the soil parameters for analysis during the baseline assessment.

TABLE 1. SOIL ANALYTICAL PARAMETERS

ELEMENT	METHOD
CHEMICAL	
Sample Preparation	Standard
pH (H_2O)	Standard
CEC+K+Na	NH_4Ac-extraction
EC+NO_3	Saturated distilled water extract
P	Bray 1-extract
Lime Requirement	Double Buffer Titration
MINERALOGY	
Clay fraction (<0.002mm) identification	XRD-scan (6 treatments)
PHYSICAL	
Particle size distribution (3 fractions-sand+silt+clay)	Hydrometer

3.3 Quality Assurance and Quality Control

The quality assurance/quality control procedure for the investigation entailed a combination of the following:

- Duplicate analyses on 5% of the samples submitted.

- Carry out additional checks using standard reference materials.

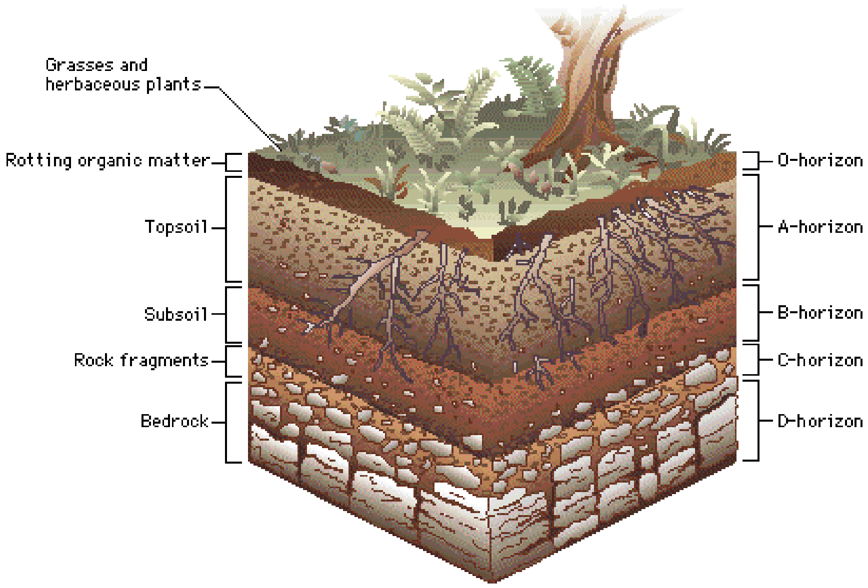
- Conduct multi linear regression techniques to ensure analytical equipment are properly calibrated.

- Double check calibrated equipment with spiked standards above highest standard and confirm with 10x dilution.

4 PROBLEM ANALYSIS

Section 4.1 is a brief description of basic soil forming principles to set a framework for evaluation of the baseline soil assessment:

4.1 Basic Soil Forming Principles



According to A Glossary of Soil Science (1995), soil (**Figure 2**) can be defined as:

"the unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for growth of plants, or, the unconsolidated mineral matter on the surface of the earth that has been subjected to and influenced by genetic and environmental factors of parent material, climate (including precipitation and temperature effects), macro- and micro-organisms and topography all acting over the period of time and producing a product – soil – that differs from the material, which is derived in many physical, chemical, biological and morphological properties and characteristics".

Soil is a thin surface covering the bedrock of most of the land area of the Earth. It is a resource that, along with water and air, provides the basis of human existence. Soil develops when rock is broken down by weathering and material is exchanged through interaction with the environment. Organic matter becomes incorporated into the soil as the result of the activity of living organisms. Soil also contains water, minerals, and gases. The soil system (**Figure 3**) is dynamic and it develops a distinct structure, often with recognizable layers or soil horizons arranged vertically through the soil profile.

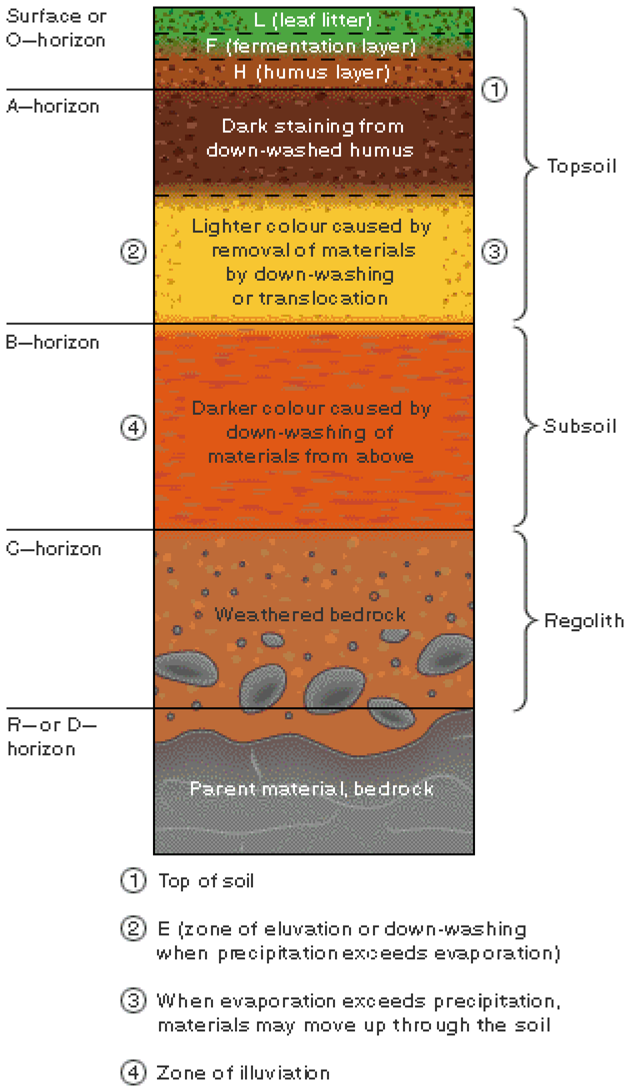


Figure 3. Soil system with different layers

Soil is essential for the development of most plants, providing physical support and nutrients. Plants are anchored in the soil by their roots. Nutrients, dissolved in soil water, are necessary for the plants' growth. Soil contains various organic matter, including dead material from plants and animals as well as animals that choose to live in the soil. The soil is therefore a store of major nutrients such as carbon and nitrogen and plays an important role in global nutrient cycles and in regulating hydrological cycles and atmospheric systems.

Soils vary from place to place due to various conditions such as climate, rock type, topography, and the local soil-forming processes. Over time soils develop characteristics specific to their location, which relate closely to the climate and vegetation of the area. The major world biomes reflect a clear association between vegetation and soil that has developed in response to the prevailing climate. Each soil type has a distinct combination of soil horizons and associated soil properties.

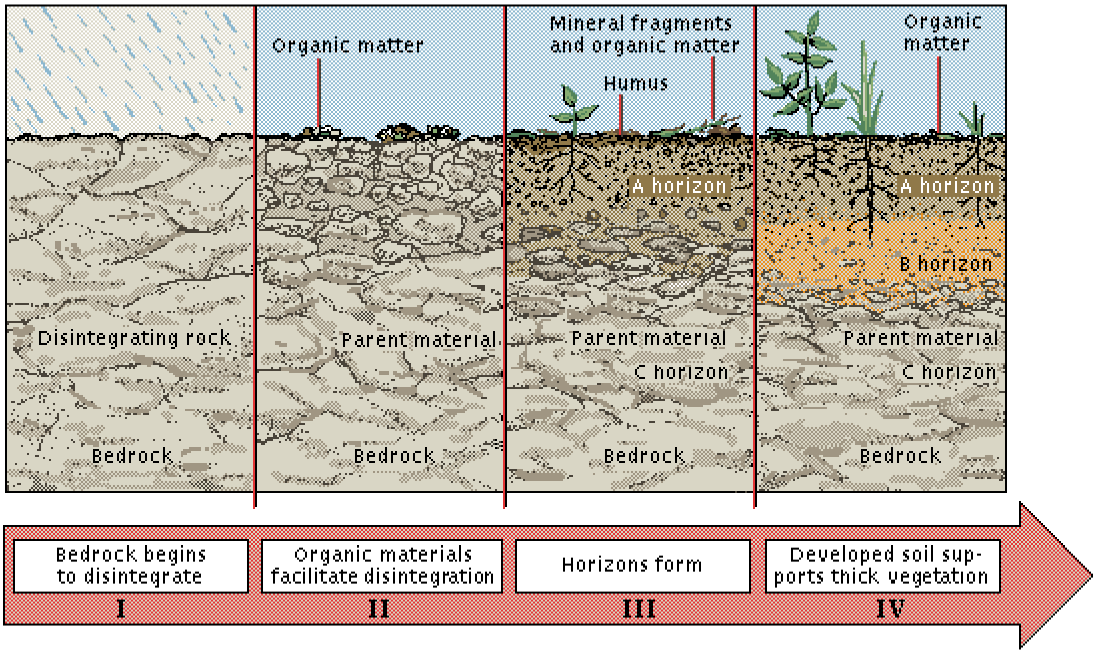


Figure 4. Different stages of soil formation

People depend on the soil for agriculture, and as such it is a valuable natural resource. Soils form continuously as the result of natural processes (**Figure 4**), and can therefore be regarded as a renewable resource. However, the soil-forming processes operate very slowly and the misuse or mismanagement of the soil may lead to damage or erosion, (**Figure 5**) or can disrupt the processes by which the soil forms.

Figure 5. Example of soil erosion (*not taken on site*)

If this happens the resource can be degraded or even lost and this is what should be prevented during topsoil stripping, stockpiling, replacement and rehabilitation. Many human activities cause damage to soils. These include bad farming techniques, overgrazing, deforestation, urbanization, construction, soil stripping, wars, contamination, pollution, and fires. The most critical result of these is soil erosion (**Figure 5**). With growing populations, the need for productive soils is increasing. Soil loss in many developing countries is a major cause for concern and will become a major issue in the future. The process of soil loss can have a detrimental effect on other systems as it produces sediment that can cause siltation of river systems and reservoirs, set off flooding downstream, and contribute to pollution and damage to estuaries, wetlands, and coral reefs. Soils need to be managed carefully in order to remain in good condition.

4.2 Abbreviated Legal Register for Rehabilitation

The following ***Acts*** focused on human rights, protection of the environment, accountability and financial provision should be considered with projects in South Africa:

- *Section 12 of the Minerals Act 50 of 1991.*
- *Sections 41, 42 and 43 of the Mineral & Petroleum Resources Development Act 28 of 2002, the M&PRD Regulations R527.*
- *Constitution of South Africa Act 108 of 1996.*
- *National Environmental Management Act 107 of 1998, and Amendments.*
- *National Water Act 36 of 1998 (Section 36), and Amendments, with specific reference to the NWA Regulations GN704 of 1999 and use of Water for Mining and Related Activities aimed at the Protection of Water Resources.*
- *The Water Services Act 108 of 1997.*
- *The Conservation of Agricultural Resources Act No. 43 of 1983 & Amendments (Govt. Gazette Vol. 429 No. 22166 of March 2001).*
- *National Forest Act 84 of 1998.*
- *Physical Planning Act of 1991.*
- *National Environmental Management Biodiversity Act of 2003.*
- *National Environmental Management Protected Areas Act of 2003.*

- *National Veld and Forest Fire Act 101 of 1998.*
- *Environment Conservation Act 73 of 1089.*
- *Environment Conservation Amendment Act 50 of 2003.*
- *Air Quality Act 39 of 2004.*
- *National Heritage Resources Act 25 of 1999.*
- *National Development Facilitation Act 67 of 1999.*
- *National Development Facilitation Act 67 of 1995.*
- *Promotion of Access to Information Act 2 of 2000.*
- *National Monuments Act 28 of 1969.*
- *Nuclear Energy Act 46 of 1999.*
- *National Nuclear Regulator Act 47 of 1999.*
- *Health Act 63 of 1997.*
- *Plant Improvement Act 53 of 1976.*
- *Occupational Health and Safety Act 85 of 1993.*
- *Agricultural Pests Act 36 of 1983.*
- *Fertilisers, Farm Feeds, Agricultural remedies and Stock Remedies Act 36 of 1947.*
- *Mine Health and Safety Act 29 of 1996.*
- *Hazardous Substances Act 15 of 1973.*
- *Land Survey Act 8 of 1997.*
- *SABS 0286: 1998 Code of Practice for Mine Residue.*
- *SABS: Water Quality.*

- *Chamber of Mines of SA Guidelines for Environmental Protection: Engineering Design, Operation & Closure of Metalliferous, Diamond & Coal residue deposits.*

- *Department of Mining & Energy Aide Memoir Guideline for the Peparation of EMPR'S.*

- *Department of Mining & Energy Mineral Policy in terms of Section 12 of the Minerals Act 1995.*

- *Department of Mining & Energy Policy on Financial Provision 1994.*

- *Guideline on the Compilation of a Mandatory Code of Practice on Mine Residue Deposits.*

- *Department of Water Affairs & Forestry Guideline on water & salt balances for TSF's.*

- *Chamber of Mines Guidelines for Vegetation of Mine Residue Deposits.*

- *Department of Water Affairs Policy and Guidelines for dealing with pollution from TFS's, and the containment and rehabilitation of abandoned TFS's, and prosecutions.*

- *Convention of Wetlands of International Importance especially as Waterfowl Habitat RAMSAR (in force in SA from 12 Dec 1975).*

- *International Cyanide Code.*

4.3 South African Environmental Soil Legislation

The following section outlines a summary of *South African Environmental Legislation* that needs to be considered for the proposed project with reference to management of soil:

- *The law on Conservation of Agricultural Resources (Act 43 of 1983) states that the degradation of the agricultural potential of soil is illegal.*

- *The Bill of Rights states that environmental rights exist primarily to ensure good health and well-being, and secondarily to protect the environment through reasonable legislation, ensuring the prevention of the degradation of resources.*

- *The Environmental right is furthered in the National Environmental Management Act (No. 107 of 1998), which prescribes three principles, namely* *the precautionary principle, the "polluter pays" principle and the preventive principle.*

- *It is stated in the above-mentioned Act that the individual/group responsible for the degradation/pollution of natural resources is required to rehabilitate the polluted source.*

- *Soils and land capability are protected under the National Environmental Management Act 107 of 1998, the Environmental Conservation Act 73 of 1989, the Minerals Act 50 of 1991 and the Conservation of Agricultural Resources Act 43 of 1983.*

- *The National Veld and Forest Fire Bill of 10 July 1998 and the Fertiliser, Farm Feeds, Agricultural Remedies and Stock Remedies Act 36 of 1947 can also be applicable in some cases.*

- *The National Environmental Management Act 107 of 1998 requires that pollution and degradation of the environment be avoided, or, where it cannot be avoided be minimized and remedied.*

- *The Minerals Act of 1991, MPRDA requires an EMPR, in which the soils and land capability be described.*

- *The Conservation of Agriculture Resources Act 43 of 1983 requires the protection of land against soil erosion and the prevention of water logging and salinisation of soils by means of suitable soil conservation works to be constructed and maintained. The utilisation of marshes, water sponges and water courses are also addressed.*

Sections 4.4 to 4.11 address the investigation objectives (*Section 2, p1*) for the project.

4.4 Objectives 1 and 2: Soil Classification and effective soil depth

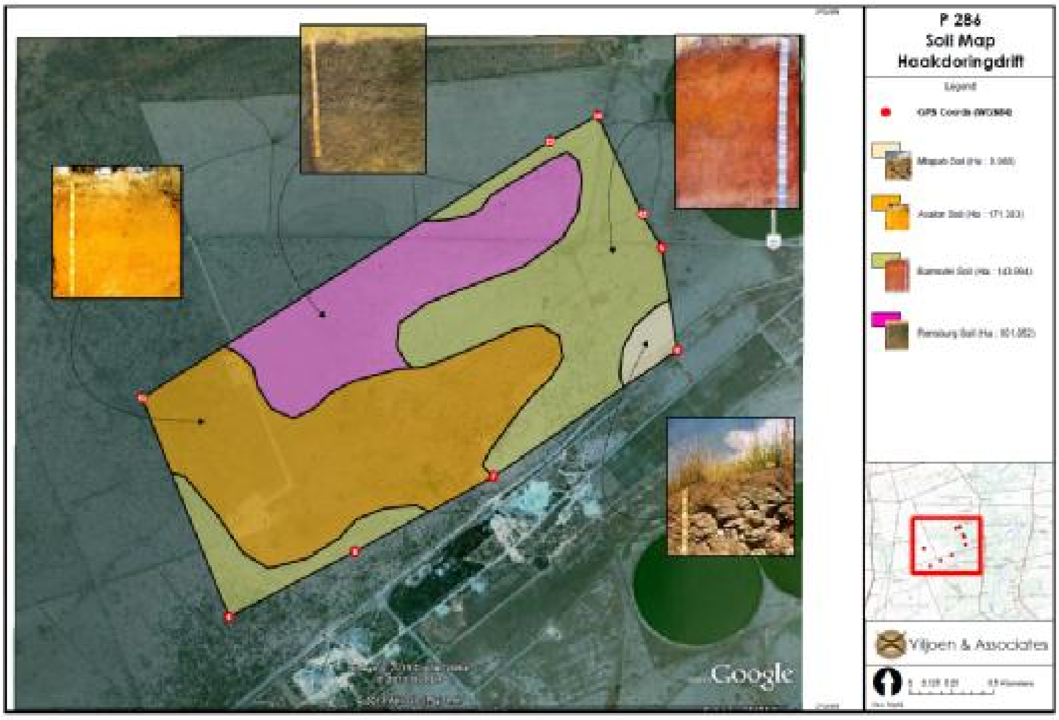


Figure 6. Haakdoorndrift Soil Types.

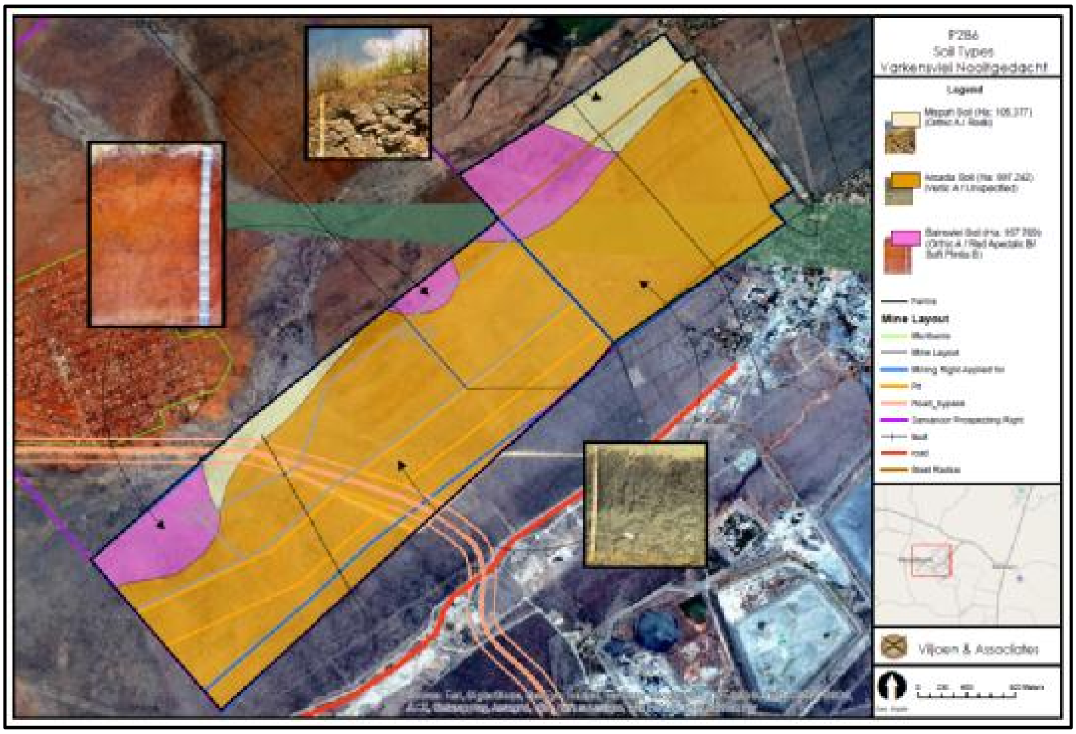


Figure 7. Varkensvlei and Nooitgedacht Soil Types.

Figures 6 and 7 show the distribution of soil types classified on the study area according to the latest version of the *South African Taxonomical Soil Classification System*.

Figure 8. Soil types: Bainsvlei, Arcadia, Avalon, Mispah and Rensburg soils (*left to right*).

Figure 8 shows the diagnostic horizons of the Bainsvlei, Arcadia, Avalon, Mispah and Rensburg soils classified according to the *South African Taxonomical Soil Classification System* summarised in **Table 2**:

TABLE 2. SOIL TYPES

SOIL TYPE	DIAGNOSTIC HORIZONS	EFFECTIVE DEPTH (MM)
Avalon	Orthic A – Horizon/Yellow Brown Apedalic B – Horizon/Soft Plinthic B – Horizon	>300
Arcadia	Vertic A – Horizon/G - Horizon	<300
Bainsvlei	Orthic A- Horizon/Red Apedalic B – Horizon/Soft Plinthic B –Horizon	>300
Rensburg	Vertic A – Horizon/G – Horizon	<300
Mispah	Orthic A – Horizon/Hard Rock	<300

4.5 Objective 3: Agricultural potential

The agricultural potential was assessed using the following formula as a function of various variables:

$$YIELD\ (kg\ ha^{-1}) = R/B \times ED/A \times C \times X$$

Where:

R – Rainfall (mm)

B - Species growth characteristics factor.

ED - Effective depth of the soil.

A - Soil wetness factor for textural classes of soil above effective depth.

C - Correction factor for aeration of soil.

X - Fixed coefficient for species.

The main variables determining the soil's agricultural potential (**Table 3**) include the **effective depth** (>300mm), **clay content** (15%) and **rainfall** (650mm).

TABLE 3. AGRICULTURAL POTENTIAL OF SOILS.

SOIL TYPE	AGRICULTURAL POTENTIAL	
	DRY LAND	IRRIGATION
Avalon	Medium	High
Arcadia	Low	Low
Bainsvlei	Medium	High
Rensburg	Low	Low
Mispah	Low	Low

4.6 Objective 4: Assessment of erodibility of soils and evidence of misuse

The exchangeable sodium percentage of the soils is anticipated to be below 15% of the cation exchange capacity, rendering the soils free of dispersion anomalies caused by the hydration of sodium and consequent soil erosion.

4.7 Objective 5: Land Use & Land Capability

Figure 9. Haakdoorndrift Land Use.

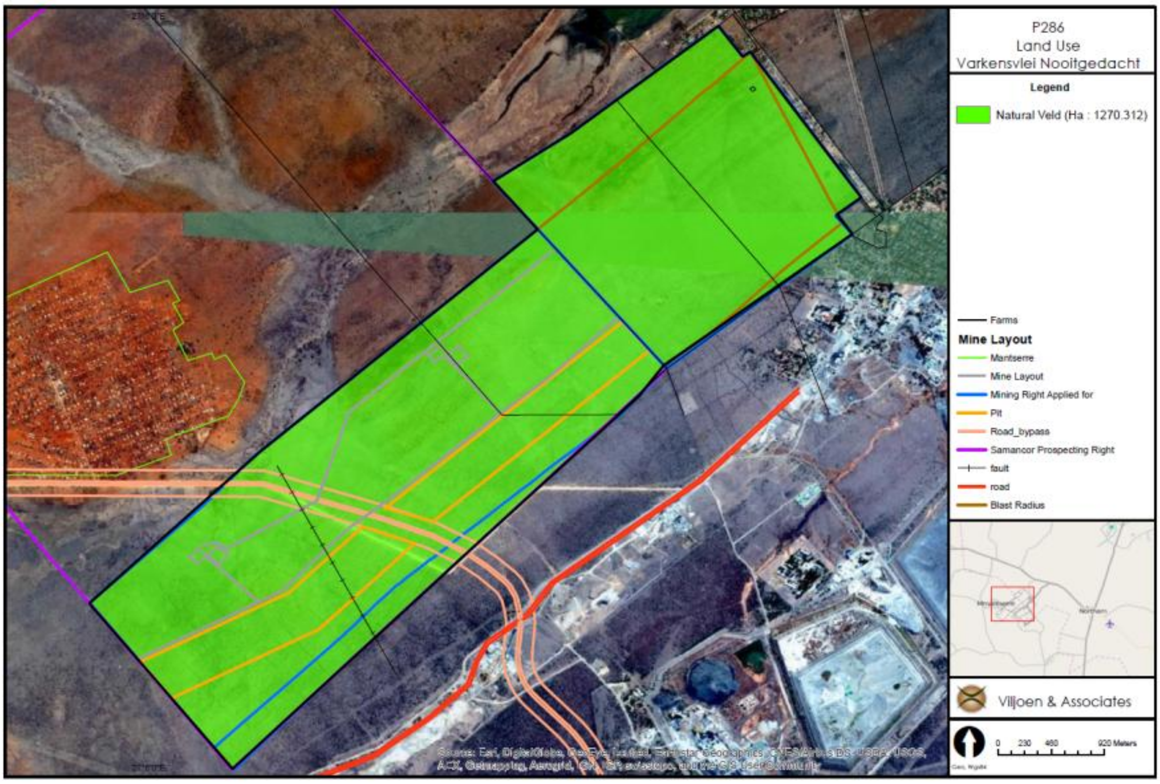


Figure 10. Varkensvlei and Nooitgedacht Land Use.

Tables 4 and 5 summarise the *land use* (**Figures 9** and **10**) of the areas investigated:

TABLE 4. HAAKDOORNDRIFT LAND USE

Area	Land Use	Surface Area (ha)	% of Total
Haakdoorndrift	Natural Veld	285	67
	Plantation	9	2
	Ploughed Land	132	31
	Total	**426**	**100**

TABLE 5. VARKENSVLEI AND NOOITGEDACHT LAND USE

Area	Land Use	Surface Area (ha)	% of Total
Varkensvlei and Nooitgedacht	Natural Veld	1,270	100
	Total	**1,270**	**100**

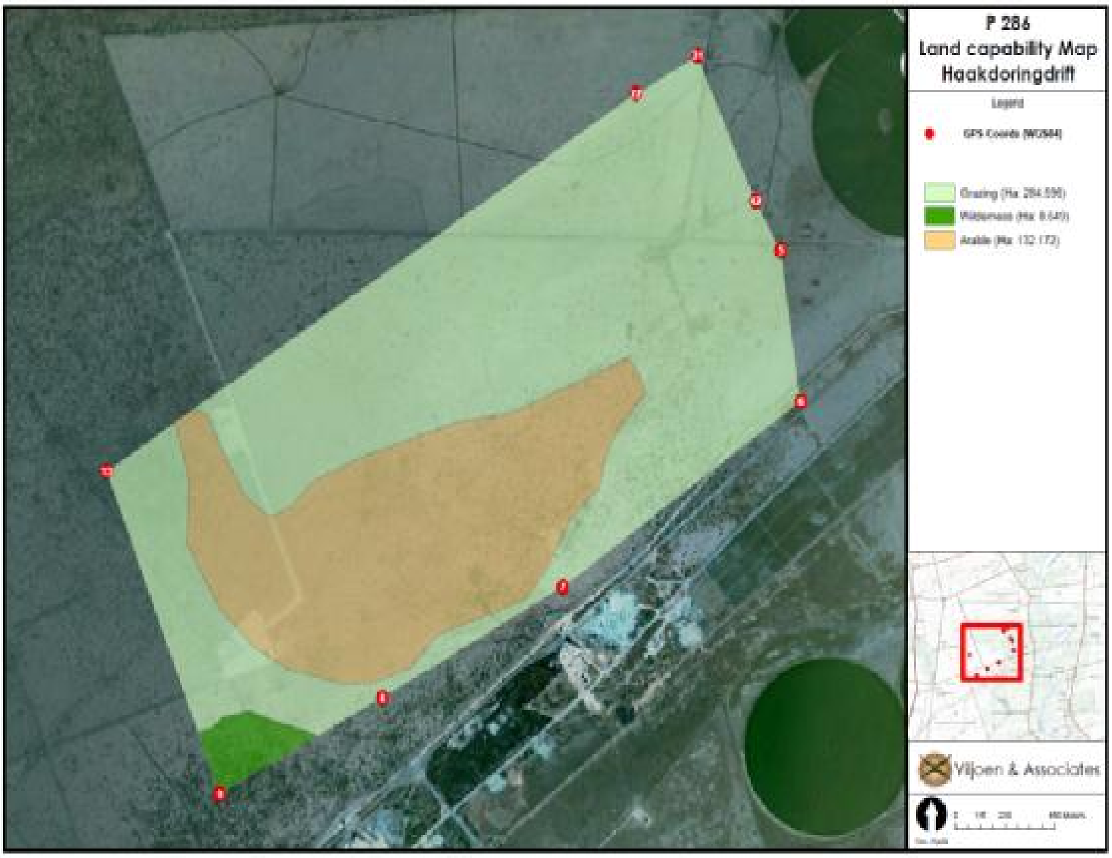


Figure 11. Haakdoorndrift Land Capability.

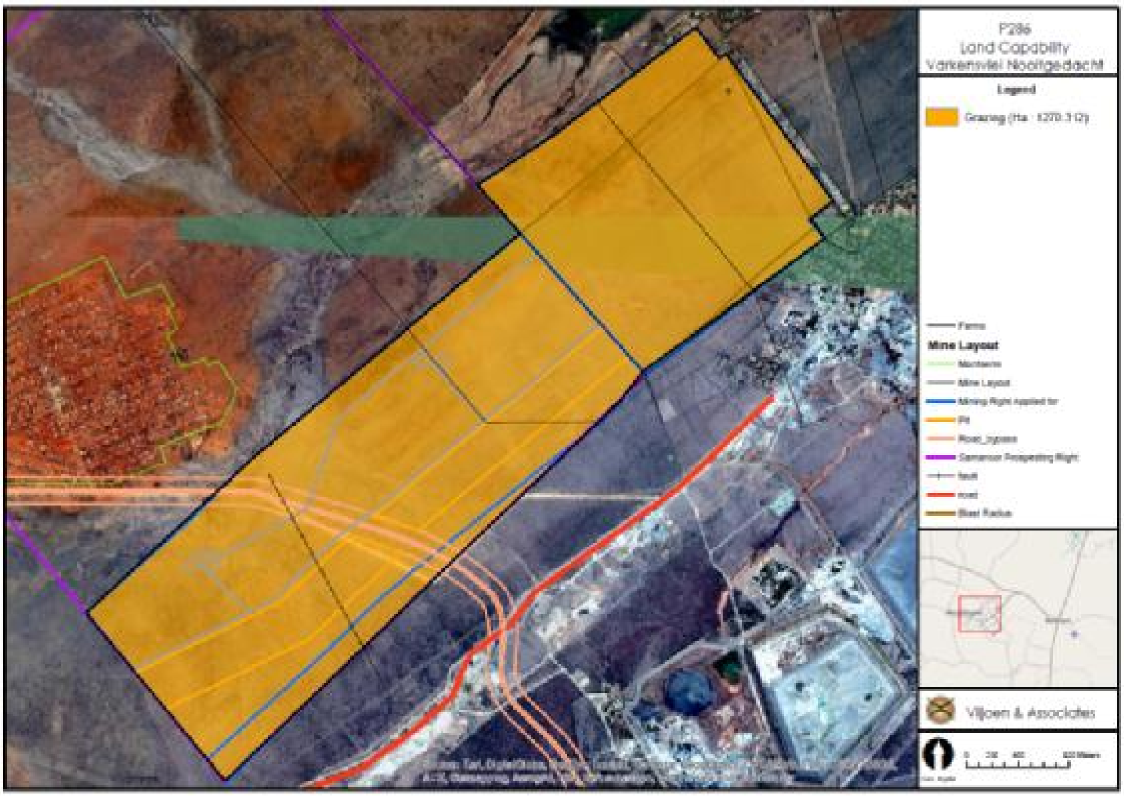


Figure 12. Varkensvlei and Nooitgedacht Land Capability.

Tables 6 and 7 summarises the *land capability* (**Figures 11 and 12**) of the area investigated:

TABLE 6. HAAKDOORNDRIFT LAND CAPABILITY

Area	Land Capability	Surface Area (ha)	% of Total
Haakdoorndrift	Arable	285	67
	Wilderness	9	2
	Arable	132	31
	Total	**425**	**100**

TABLE 7. VARKENSVLEI AND NOOITGEDACHT LAND CAPABILITY

Area	Land Capability	Surface Area (ha)	% of Total
Varkensvlei and Nooitgedacht	Grazing	1,270	100
	Total	**475**	**100**

4.8 Objective 6: Soil stripping utilisation guide and plan

It is recommended that all usable soil be stripped and stockpiled in advance of activities that might contaminate the soil.

The stripped soil should be stockpiled upslope of areas of disturbance or development to prevent contamination of stockpiled soils by dirty runoff or seepage. All stockpiles should also be protected by a bund wall to prevent erosion of stockpiled material and deflect surface water runoff.

Stockpiles can be used as a barrier to screen operational activities. If stockpiles are used as screens, the same preventative measures described above should be implemented to prevent loss or contamination of soil. The stockpiles should not exceed a maximum height of 6m and it is recommended that the side slopes and surface areas be vegetated in order to prevent water and wind erosion. If used to screen construction operations, the surface of the stockpile should not be used as a roadway as this will result in excessive soil compaction.

A conservative estimate of anticipated available topsoil to be stripped is summarised in **Table 8**.

TABLE 8. AVAILABLE TOPSOIL FOR REHABILITATION PURPOSES.

Soil Type & Average Effective Depth (mm)	Size (ha)	Available Volume (m^3)
Avalon (300)	171	513,000
Bainsvlei (300)	312	936,000
Rensburg (300)	101	1,596,000
Arcadia (300)	997	2,991,000
Mispah (300)	113	339,000
TOTAL		**6,375,000 @ BD: 1,275 kg/m^3**

A total area of 1,899ha could potentially be covered 300mm thick @ bulk density 1,275kg.m^3 during rehabilitation taking into consideration a 10% loss of topsoil from the 6,375,000m^3 due to handling, compaction *etc*.

4.9 Objective 7: Overview of basic soil chemical, physical and mineralogical properties of soils

The soils are characterised by neutral pH values (5,3 and 7,2) and low electrical conductivity values (<250 mS/m). Under these conditions plant available nitrogen (15-20 mg/kg), phosphorus (10-15 mg/kg) and potassium (>50 mg/kg) are readily available for plant uptake and sustainable plant growth.

The Orthic A-Horizon is typically characterised by a low dense structure and texture distribution of approximately 65% sand, 20% silt and 15% clay with drainage properties in order of 10mm/h.

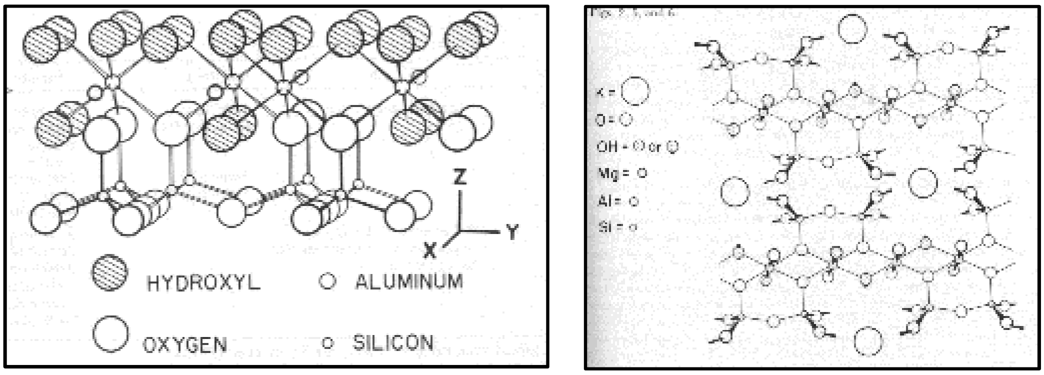


Figure 13. 1:1 Clay mineral (*left*) and 2:1 Clay mineral (*right*)

The dominant clay mineral (***Figure 13***) in the *Orthic A – Horizon, Red and Yellow Brown Apedalic B – Horizon* is kaolinite (*1:1 layer silicate*), with a low buffer capacity due to the low cation exchange capacity *(<10cmol+/kg*). The Vertic A-Horizon contains 2:1 clay minerals (***Figure 13***) with high buffer capacity and cation exchange capacity >30cmol+/kg.

4.10 Objective 8: Assessment of suitability of soils for rehabilitation purposes.

The soil horizons specified in *Section 4.4 p13* (*except Soft Plinthic B and G - Horizon*) are suitable for rehabilitation purposes.

When stockpiled soils have been replaced during rehabilitation, the soil fertility should be assessed to determine the level of fertilisation required to sustain normal plant growth. The fertility remediation requirements need to be verified at time of rehabilitation. The topsoil should be uniformly spread onto the rehabilitated areas and care should be taken to minimise compaction that would result in soil loss and poor root penetration.

When returning soil to the rehabilitation site care should be taken to place soil in a manner that will allow for levelling of soil to take place in a single pass. The soil profile should not be built up using a repeated tipping and levelling action to increase the soil depth.

Proper water control measures should be implemented to ensure a free-draining rehabilitated landscape.

Restoration of soil to its pre-mining capability is achievable to about 85% if topsoil was stockpiled in such a manner different horizons could be harvested and restored as close as possible to original state. Primary requisites include a bulk density between 1,275 – 1,850 kg/m^3, permeability 10 -15 mm/h, pH 5,3 – 7,2 (2:1 water : solid ratio), electrical conductivity <450 mS/m (saturated water extract), N (20 - 50mg/kg saturated water extract), P (10 – 15 mg/kg Bray 1 extract) and K (50 – 150 mg/kg 1N NH_4Ac extract). The effective depth should exceed 300 mm to allow for proper root penetration, water and nutrient storage. During stripping and stockpiling consideration should be given not to mix 1:1 and 2:1 layer silicates (fraction <0,002mm), *i.e.* kaolinite, oxides of Fe and Mn vs. vermiculite and smectite. The type of clay will be diagnostic to the specific horizon(s) stripped and stockpiled. During restoration this attribute will determine the water and nutrient retention of the restored soils, *i.e.* 1:1 layer silicates will result in 5 –20 and 2:1 clays >50 cmol(+)/kg cation exchange capacity (1N NH_4Ac extract). Careful consideration should be given to saturated and unsaturated water flow to ensure the water retention capabilities of the restored soil layers will sustain enough plant available water between 33 and 1,500 kPa for at least 50% of mean annual precipitation. Surface water drainage should be designed to prevent preferential seepage path ways causing soil loss due to soil erosion. From a pollution source/seepage pathway/ receptor continuum restored soils should be isolated from surrounding potential contamination.

4.11 Objective 9: Impact assessment

The potential significance of environmental impacts identified during topsoil stripping was determined by using a ranking scale, based on the following (the terminology is from the DEAT guideline document on EIA Regulations, April 1998):

Occurrence

Probability of occurrence (how likely is it that the impact may occur?), and duration of occurrence (how long may it last?)

Severity

Magnitude (severity) of impact (will the impact be of high, moderate or low severity?), and scale/extent of impact (will the impact affect the national, regional or local environment, or only that of the site?).

In order to assess each of these factors for each impact, the following ranking scales **(Table 9**) were used:

TABLE 9. RANKING SCALES FOR IMPACT ASSESSMENT

Probability:	**Duration**:
5 – Definite/don't know	5 – Permanent
4 – Highly probable	4 - Long-term (ceases with the operational life)
3 – Medium probability	3 - Medium-term (5-15 years)

2 – Low probability	2 - Short-term (0-5 years)
1 – Improbable	1 – Immediate
0 – None	
Scale:	**Magnitude**:
5 – International	10 - Very high/don't know
4 – National	8 – High
3 – Regional	6 – Moderate
2 – Local	4 – Low
1 – Site only	2 – Minor
0 – None	

Once the above factors had been ranked for each impact, the environmental significance of each was assessed using the following formula:

SP = (magnitude + duration + scale) x probability

The maximum value is 100 significance points (SP). Environmental effects were rated as either of high, moderate or low significance on the following basis:

- More than 60 significance points indicated high environmental significance.
- Between 30 and 60 significance points indicated moderate environmental significance.
- Less than 30 significance points indicated low environmental significance.

TABLE 10. IMPACTS ON SOIL

Environmental component	Potential impact	Activity/Reason	Environmental significance score						Criteria for magnitude	Mitigation measures
			P	D	S	M	Total	Rating		
Soil	• Loss of topsoil	• Stripping, handling and placement of soil associated with pre construction land clearing and rehabilitation	4 2	2 3	1 1	8 4	56 24	SBM SAM L	**High:** Loss of finite resource due to poor stripping **Low:** Recovery of as much usable soil material as possible	• *Strip all usable soil, irrespective of soil depth*
	• Change to soil's physical, chemical and biological properties	• Loss of topsoil through erosion. • Stockpiling of soils • Mixing of deep and surface soils during handling, stockpiling and subsequent placement	4 3	3 3	1 1	8 4	64 28	SBM SAM L	**High:** Soil properties are changed to such an extent that the associated agricultural potential cannot be maintained and/or realised. **Low:** Change to soil properties do not adversely affect land capability.	• *Implement live placement of soil where possible* • *Improve organic status of soils* • *Maintain fertility levels* • *Curb topsoil loss*
	• Cumulative effect on soil	• Change in natural surface topography due to reprofiling of surface after stripping	4	3	1	4	32	SBM L	**High:** Agricultural potential is compromised. **Low:** Pre-mining agricultural potential is maintained.	• *No specific measures are required. Stipulated remedial measures must be implemented*

4.11.1 Construction phase

Loss of topsoil and usable soil

Land transformation will lead to some losses of topsoil during construction and soil stripping.

Contamination of topsoil and stockpiled soil

Topsoil may be contaminated during the construction. Soil contamination is the result of surface runoff and seepage.

Contamination of stockpiled soil may occur due to seepage or contact with dirty surface water.

Soil erosion

Soil stockpiles may be exposed to erosion by surface water and wind. The aspect that would cause erosion is runoff.

4.11.2 Operational phase

Loss of topsoil and usable soil

During the construction usable soil may be lost due to inefficient stripping practices.

Contamination of soil

Seepage from contamination sources may contaminate stockpiled soil or *in situ* soil that has not yet been stripped.

Depending on the chemical composition of dust pollution, soil adjacent to the mining areas may be contaminated.

Leakages or spillages from conveyor may contaminate adjacent soils.

Soil erosion

Surface runoff leads to soil erosion. Soil stockpiles will be exposed to erosion activities during operation of the tailings dam, return water dam and concentrator areas.

4.11.3 Decommissioning and Closure phase

Loss of topsoil and replaced soil

Soil that has been used for rehabilitation purposes may be lost due to erosion caused by surface water runoff.

Soil erosion

The consumption of potable water during rehabilitation may lead to soil erosion if not done efficiently.

Contamination of soil

Depending on the content of the dust pollution, soil adjacent to construction areas may be contaminated.

The generation of hazardous and non-hazardous waste may pose a risk of soil contamination through seepage.

Potential incidents such as failure may cause contamination of topsoil if spills take place.

Visual impact

The use of stockpiled topsoil for rehabilitation purposes will have a positive visual impact.

4.11.4 Post-closure phase

Soil erosion

Soil erosion may occur due to surface water runoff across the rehabilitated construction sites.

Contamination of soil

Seepage from all construction and mining areas may contaminate surrounding soil.

5 CONCLUSIONS

- The dominant soils according to the Taxonomical Soil Classification System of South Africa are Avalon, Bainsvlei, Mispah, Arcadia and Rensburg soils.

- The effective depth of the Avalon and Bainsvlei soils exceed 300mm inclusive of the *Orthic A and Yellow & Red Brown Apedalic B – Horizons*. The effective depth inclusive of the Orthic and Vertic A-Horizons of the Mispah, Arcadia and Rensburg soils are <300 mm.

- The agricultural potential under dry land and irrigation conditions is available in **Table 3** (**p13**). The agricultural potential of the Avalon, Bainsvlei and soils is considered medium to high under dryland (*650mm/y rainfall*) and irrigation conditions *(>10-15mm/week 33-1,500kPa plant available water*). The Mispah, Arcadia and Rensburg soils are regarded low agricultural potentials under dryland and irrigation conditions.

- No evidence of soil erosion was observed on any of the soils during the investigation.

- The current land use for Haakdoorndrift includes natural veld (285 ha), plantation (9ha) and ploughed land (132 ha). For Varkensvlei and Nooitgedacht the land use includes 1,270 ha of natural veld.. Land capability for Haakdoorndrift includes 285 ha grazing, 9 ha wilderness and 132 ha arable. Varkensvlei and Nooitgedacht land capability include 1,270 ha of grazing .

- A soil stripping stockpiling strategy is given on **p18 (Table 8)**. A total area of 1,899 ha could potentially be covered 300 mm thick @ bulk density 1,275 kg/m^3 during rehabilitation, taking into consideration a 10% loss of topsoil from the 6,375,000 m^3 due to handling, compaction *etc*.

- The soils are characterised by neutral pH values (5,3 and 7,2) and low electrical conductivity values (<250 mS/m). Under these conditions plant available nitrogen (15-20mg/kg), phosphorus (10-15 mg/kg) and potassium (>50 mg/kg) are readily available for plant uptake and sustainable plant growth. The *Orthic A-Horizon* is typically characterised by a low dense structure and texture distribution of approximately 65% sand, 20% silt and 15% clay with drainage properties in order of 10 mm/h. The dominant clay mineral in the *Orthic A and Yellow Brown Apedalic B – Horizon* is kaolinite (*1:1 layer silicate*), with a low buffer capacity due to the low cation exchange capacity *(<10cmol+/kg*). The Vertic A-Horizon is typically characterised by clay content >25% with plasticity index>15% and cation exchange capacity >30cmol+/kg

- The soil horizons specified in **Section 4.4 p11** of the soils (*except Soft Plinthic B and G - Horizons*) are suitable for rehabilitation purposes.

- The potential impacts and reasons/activities with proposed mitigation measures on the soil due to construction activities include:

- ***Loss of topsoil***:

This is due to stripping, handling and placement of the soil associated with the pre-construction land clearing and rehabilitation and it is recommended to strip all usable soil irrespective of soil depth.

- ***Change to soil's physical, chemical and biological properties***:

There is a high probability that topsoil will be lost due to wind and water erosion, which will alter the soil properties. Stockpiling and subsequent mixing of soil layers during handling will ultimately have a negative effect by altering the basic soil properties. It is recommended to implement live management and placement of topsoil where possible, improve the organic content of the soils, and maintain fertility levels through fertilisation and to curb topsoil loss as much as possible.

- ***Cumulative effect on the soil***:

Alteration of the natural surface topography due to re-profiling during construction after stripping will have a cumulative effect on the soils and careful consideration should be given to minimise compaction and ensure free drainage preferential surface water pathways.

6 REFERENCES

VAN DER WATT H. AND VAN ROOYEN, T.H. 1990. A Glossary for Soil Science. V&R Printing Works (Pty) Ltd.

This investigation was done on available information and subsequent interpretation of data to reveal the properties on site with the techniques described.

***M.Sc. Pr. Sci. Nat*. SACNASP (400131/96)**

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South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Africa (Pty) Ltd.
PO Box 6001
Halfway House, 1685
Building 1 Maxwell Office Park
Magwa Crescent Waterfall City
cnr. Allandale Road & Maxwell Drive
Midrand
South Africa
T: [+27] (11) 254 4800

Golder Associates

April 2016

SAMANCOR CHROME (PTY) LTD.

Proposed Varkensvlei Mining Area: Bat Impact Assessment

Submitted to:
Heather Booysen
SHEQ Superintendent Environmental
Samancor Chrome (Pty) Ltd.

Report Number: 1416935

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REPORT

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1.0 INTRODUCTION

Samancor Chrome submitted an application for an Environmental Authorisation for a mining right and related infrastructural activities on the farm Varkensvlei 403 KQ (the Project), situated in the Thabazimbi district of the Waterberg Limpopo region (Figure 1), in September 2015. The Department of Mineral Resources' (DMR) Scoping Report acceptance letter dated 04 March 2016 requested that the impacts of the proposed facility on bats must be assessed in the Environmental Impact Assessment (EIA) phase. This report addresses this request, and provides details on the methods used, results obtained, and an assessment of potential impacts on bat species that may arise as a result of the proposed development.

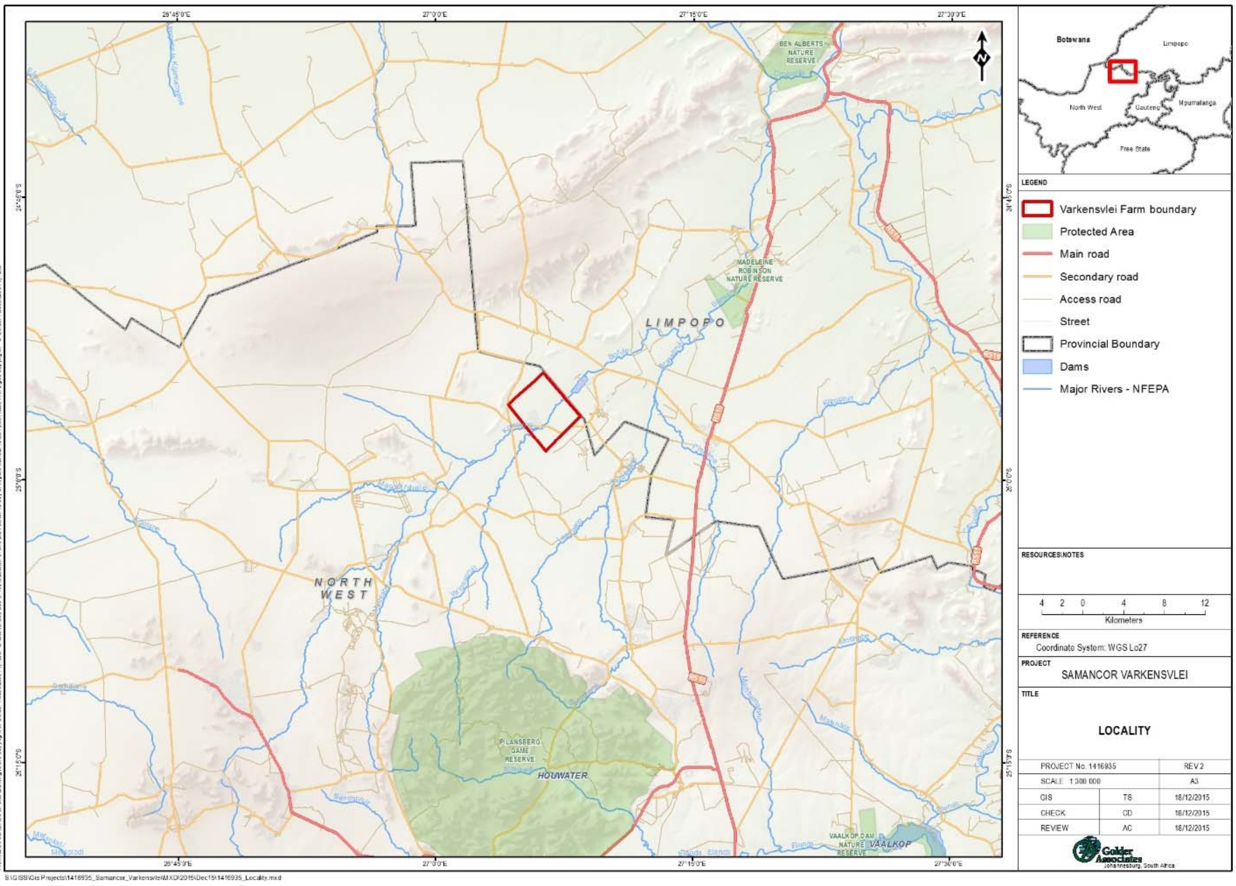


Figure 1: Project Locality

2.0 OBJECTIVES

The objectives of the bat baseline study and impact assessment were as follows:

- Identify sensitive habitats and terrain features on site that may constitute important roosting and/or foraging habitat for bat species;
- Conduct a short-term study of the bat species assemblage, diversity and spatial distribution of bat activity within the Study Area on site; and
- Assess the potential impacts of the Project on bat species within the Study Area, providing recommendations for application of mitigation measures where necessary.

3.0 APPROACH

The approach to the study and methods used are detailed in the sections that follow.

3.1 Study Area

The Study Area consists of disturbed, open savanna grassland; the original vegetation has previously been cleared for agricultural purposes. The primary predicted effect on bats arising from the Project is loss in extent of potential foraging and roosting habitat due to clearance of the existing habitat, in advance of construction works and mining activities; with secondary predicted impacts occurring during operation (e.g. disturbance as a result of site lighting).

The Study Area for this impact assessment was therefore defined as the general area where the Project infrastructure will be developed, as well as areas of suitable habitat in the vicinity of the Project site (Figure 2).

Figure 2: Study Area for bat assessment

3.2 Desktop Review

A literature review of available information on bat presence and diversity within the Study Area and general region was conducted. Reviewed data included biodiversity baseline data previously gathered within the Study Area (Golder Associates Africa, 2013). Other information that was reviewed included IUCN[1] and South African Red Data lists (Friedmann & Daly, 2004) for bat species present in the Waterberg region, bat species distribution maps for South Africa (Monadjem *et al.,* 2010), and any other available information on bat presence in these areas;

Sensitive bat species and bat-supporting habitats, as well existing threats to such species were identified through review of background biodiversity reports relating to the Project, available published literature, consideration of South Africa's national and provincial biodiversity legislation and policies as they pertain to

[1] International Union for the Conservation of Nature

bats, Non-Governmental Organisation (NGO) opinion and guidance documentation (Sowler & Stoffberg, 2014), and through application of the expertise of the bat survey and impact assessment team.

3.3 Baseline Bat Data Gathering

A site visit was conducted from 12 April 2016 – 14 April 2016 to assess the current extent of use of the Study Area by bat fauna.

Bat Habitat Suitability Assessment

Habitats within the Study Area were examined for the presence of features with bat roosting potential, such as rocky outcrops, cave systems, and mature and decaying trees. Daytime surveys of the Study Area also focussed on the identification of areas with good foraging potential for bats, including natural habitats with diverse structure/topography, and water sources, e.g. riparian areas.

Active Monitoring

Active monitoring was carried out with the use of a SM2BAT+ bat detector. The bat detector was mounted on a vehicle and a transect approximately 22.7 km in length was driven within the Study Area. The transect route was selected based on availability and accessibility of roads, with the aim of covering different habitats on site.

The detector was set to operate in continuous trigger mode during the active monitoring. When triggers are enabled, recording is suspended until a trigger event is detected. Recording then continues until no trigger event is detected for the specified period of time. For this survey, the trigger was set to record any sound whose frequency exceeds 16 KHz and 18 dB, for the duration of the sound plus 500 ms after the sound has ceased. All signals were recorded in WAC0 lossless compression format. Weatherproof ultrasound SMXU1 microphones were used.

The SM2+ was configured to commence recording from 15 minutes before sunset (17:45), for two hours, ceasing recording at 19:45. Active monitoring transects were conducted on two consecutive nights and followed the route shown on Figure 3. Temperatures ranged from approx. 28°C at the start of the surveys to approx. 23°C at their conclusion. Humidity was approximately 48% on both nights, and weather conditions were calm and dry. No limitations in term of climactic factors therefore affected the survey.

3.4 Impact Assessment

The significance of the identified impacts were determined using the approach outlined below (terminology from the Department of Environmental Affairs and Tourism Guideline document on EIA Regulations, April 1998). This approach incorporates two aspects for assessing the potential significance of impacts, namely probability of occurrence and severity, which are further sub-divided as follows:

Occurrence		Severity	
Probability of occurrence	Duration of occurrence	Scale/extent of impact	Magnitude (severity) of impact

To assess each of these factors for each impact, the following four ranking scales are used:

Probability	Duration
5 - Definite/don't know	5 - Permanent
4 - Highly probable	4 - Long-term
3 - Medium probability	3 - Medium-term (8-15 years)
2 - Low probability	2 - Short-term (0-7 years) (impact ceases after the operational life of the activity)
1 - Improbable	1 – Immediate
0 - None	
Scale	**Magnitude**

5 - International	10 - Very high/don't know
4 - National	8 - High
3 - Regional	6 - Moderate
2 – Local	4 - Low
1 - Site only	2 - Minor
0 - None	

Once these factors are ranked for each impact, the significance of the two aspects, occurrence and severity, is assessed using the following formula:

SP (significance points) = (magnitude + duration + scale) x probability

The maximum value is 100 significance points (SP). The impact significance will then be rated as follows:

Table 1: Impact significance categories

	Significance	Description
SP >75	Indicates high environmental significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 – 75	Indicates moderate environmental significance	An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated.
SP <30	Indicates low environmental significance	Impacts with little real effect and which should not have an influence on or require modification of the project design.
+	Positive impact	An impact that constitutes an improvement over pre-project conditions.

3.5 Assumptions and Limitations

- Distribution maps of South African bat species still require further refinement. Some bat species distributions have been included based on the models of expected occurrence shown in Monadjem *et al.,* (2010). If a species has a distribution marginal to the study area, it was assumed to occur in the area. The literature based table of species probability of occurrence therefore includes a higher number of bat species than that likely to actually be present.
- The number of call sequences recorded cannot be accurately used to estimate the actual numbers of individual bats present. The active monitoring surveys therefore do not provide an indication of bat abundance, and only indicates levels of bat activity at a particular point.
- It is not possible to confirm all southern African bat species with absolute confidence using sound analysis techniques, due to overlap in call signatures of bat species that share similar distributions, particularly amongst the Vespertilionidae family of bats. However it does provide a good estimation of bat activity, records bat species that are sometimes difficult to trap (e.g. the high-flying Molossidae), and is not invasive or traumatic to bats, unlike bat trapping.

4.0 BAT BASELINE ENVIRONMENT

4.1 Bat Species Potentially Present within Study Area

Based on the desktop review of available data, 39 bat species have distribution within the region; however suitable roosting and/or foraging conditions for all of these species may or may not be present within the Study Area. An assessment of likelihood of occurrence of each species, based on the habitat assessment conducted during the field survey, is presented in Table 2.

Table 2: Bat species potentially present within the Study Area and likelihood of roosting within the Study Area (Monadjem, 2010; Friedmann & Daly, 2004)

Species	Common Name	Regional IUCN Status[2]	Likelihood of occurrence
Pteropodidae – Fruit Bats			
Eidolon helvum	Straw-coloured fruit bat	NT	Unlikely – suitable roosting and/or foraging habitat (fruiting trees) is not available within the Study Area; in addition this species is a rare migrant to the Southern African region and its home distribution is concentrated in the region of Equatorial Africa.
Epomophorus gambianus	Gambian Epauletted fruit bat	DD	Unlikely – suitable roosting and/or foraging habitat is not available within the Study Area
Epomophorus wahlbergi	Wahlberg's Epauletted fruit bat	LC	Unlikely – suitable roosting and/or foraging habitat is not available within the Study Area
Rousettus egyptiacus	Egyptian fruit bat	LC	Unlikely – suitable roosting and/or foraging habitat is not available within the Study Area
Hipposideridae – Trident and Leaf-nosed bat			
Cleotis percivali	Short-eared trident bat	LC	Unlikely – typically a hollow-roosting species, and appears to be associated with woodland
Hipposideros caffer	Sundevall's leaf-nosed bat	DD	Unlikely – typically a hollow-roosting species, and closely tied to savanna woodland and riparian locations within the woodland
Rhinolophidae – Horseshoe bats			
Rhinolophus blasii	Blasius's horseshoe bat	VU	Possible – roosts in caves and mines; adjacent Anglo mine could potentially provide roosting habitat.
Rhinolophus clivosus	Geoffroy's horseshoe bat	NT	Possible – roosts in caves and mines; adjacent Anglo mine could potentially provide roosting habitat.
Rhinolophus darlingi	Darling's horseshoe bat	NT	Possible – roosts in caves and mines; adjacent Anglo mine could potentially provide roosting habitat.
Rhinolophus denti	Dent's horseshoe bat	NT	Unlikely – more closely associated with arid habitat with suitable cave roost sites.
Rhinolophus hildebranti	Hildebrandt's horseshoe bat	NT	Possible – roosts in caves and mines; adjacent Anglo mine could potentially provide roosting habitat.
Rhinolophus landeri	Lander's horseshoe bat	NT	Unlikely – associated with riparian woodland.

[2] Friedmann, Y. & Daly, D. eds., 2004. *Red Data Book of the Mammals of South Africa : A Conservation Assessment. Conservation Breeding Specialist Group (CBSG) South Africa (SSC/IUCN)*, Endangered Wildlife Trust

DD = Data Deficient; EN = Endangered; LC = Least Concern; NT = Near Threatened; VU = Vulnerable

Species	Common Name	Regional IUCN Status[2]	Likelihood of occurrence
Rhinolophus simulator	Bushveld horseshoe bat	LC	Possible - roosts in caves and mines; adjacent Anglo mine could potentially provide roosting habitat.
Emballonuridae – Sheath-tailed bats			
Taphozous mauritianus	Mauritian tomb bat	LC	Possible – roosts in variety of locations, including rock faces, tree trunks and walls
Nycteridae – Slit-faced bats			
Nycteris thebaica	Egyptian slit-faced bat	LC	Possible – roosts in a variety of shelters including caves, aardvark burrows, road culverts, trunks of large trees.
Molossidae – Free-tailed bats			
Chaerephon ansorgei	Ansorge's free-tailed bat	LC	Unlikely - Associates with dry woodland savanna in vicinity of rugged hills and mountain ranges with rocky cliffs and precipices
Chaerephon pumilis	Little free-tailed bat	LC	Unlikely – absent from elevations over 1000m
Mops condylurus	Angolan free-tailed bat	LC	Unlikely – the site is located at outer limit of its modelled range. It roosts in narrow crevices in rock faces and caves, and anthropogenic structures
Mops midas	Midas free-tailed bat	LC	Unlikely – roosts in narrow crevices in rock faces and caves, and anthropogenic structures. Associated with hot, low-lying river valleys
Sauromys petrophilus	Roberts's flat-headed bat	LC	Unlikely – roosts in narrow cracks under slabs of exfoliating rock, and is closely associated with rocky habitats, usually in dry woodland, mountain fynbos or arid scrub
Tadarida aegyptiaca	Egyptian free-tailed bat	LC	Possible – roosts in a variety of habitats including caves, rock crevices, in hollow trees, and behind bark of dead trees
Minopteridae – Long-fingered bats			
Minopterus fraterculus	*Lesser long-fingered bat*	NT	Unlikely – dependent on presence of caves for roosting.
Minopterus natalensis	*Natal long-fingered bat*	NT	Unlikely – dependent on presence of caves for roosting.
Vespertilionidae – Plain-faced bats			
Eptesicus hottentotus	Long-tailed serotine	LC	Unlikely – usually associated with rock outcrops supporting suitable cave or rock crevice roosting habitat
Glauconycteris variegatus	Variegated butterfly bat	NT	Unlikely – roosts in dense foliage, often associated with riparian forest
Hypsugo anchietae	Anchieta's pipistrelle	NT	Unlikely – habitat preference is thought to be riparian forest within savanna/woodland areas
Kerivoula argentata	Damara woolly bat	EN	Unlikely – closely associated with miombo woodland, riparian and coastal forest
Kerivoula lanosa	Lesser woolly bat	NT	Unlikely – may be associated with Afromontane forest
Laephotis botswanae	Botswana long-eared bat	VU	Unlikely – appears to be associated with open woodland and savanna habitat

Species	Common Name	Regional IUCN Status[2]	Likelihood of occurrence
Myotis bocagi	Rufous myotis	DD	Possible - Closely associates with wetlands, foraging over water
Myotis tricolor	Temminck's myotis	NT	Unlikely - roosts gregariously in caves, and is associated with mountainous areas that have caves
Neoromicia capensis	Cape serotine	LC	Probable. Roosts singly or in 2/3 individuals under bark of trees, at base of aloe leaves, under roofs of houses
Neoromicia nana	Banana bat	LC	Unlikely – banana plants/strelitzia which it roosts in are absent from the study area
Neoromicia zuluensis	Zulu serotine	LC	Unlikely – associates with woodland savanna, closely tied to riparian habitat
Pipistrellus hesperidus	Dusky pipistrelle	LC	Probable – appears to be associated with well-wooded locations such as riparian vegetation and forest patches, especially in proximity of water
Pipistrellus rueppellii	Rüppell's bat	LC	Unlikely – appears to be associated with large rivers and wetlands in dry savanna/woodland habitat
Pipistrellus rusticus	Rusty pipistrelle	NT	Possible - Occurs in savanna woodland, associated with open water bodies. May roost in crevices/hollows in trees
Scotophilus dingani	Yellow-bellied house bat	LC	Unlikely. Roosts in holes of trees and roofs of houses. Tied to presence of trees in habitat, avoids open habitat such as grassland
Scotophilus viridis	Green house bat	LC	Unlikely. Roosts in holes of trees and roofs of houses. Appears restricted to low-lying, hot savanna, avoiding open habitats such as grassland.

4.2 Bat Species Recorded during Active Monitoring

Overall, 89 sequences of bat calls were detected during the two nights of monitoring, which represents a relatively low level of bat activity throughout the study area. All bat echolocation calls recorded via the active monitoring survey were calls of the Molossidae and Vespertilionidae families. Of these, two bat species were confirmed; Cape serotine (*Neoromicia capensis*) and Egyptian free-tailed bat (*Tadarida aegyptiaca*) both of which are considered Least Concern in terms of regional conservation status. Some unidentified species were also detected. Based on the list of Molossid and Vesper species that are potentially present (Table 2), these species could potentially include Rusty pipistrelle (*Pipistrellus rusticus*) – Near Threatened, Dusky pipistrelle (*Pipistrellus hesperidus*), and Rufous myotis *(Myotis bocagi)* both of Least Concern.

4.3 Bat Activity Patterns within the Study Area

The bat activity calls recorded during the transects were grouped by family; the Free-tailed family Molossidae (Molossids) and the Plain-faced family Vespertilionidae (Vespers) – species within these family groups have relatively similar foraging and roosting habitat preferences. Vesper bats were recorded more frequently than Molossids overall.

Both groups were recorded more frequently in the northern parts of the study area (Figure 3), where mature *Acacia* woodland was recorded during daytime inspections, indicating that foraging habitat in this area is of greater value for bats than other parts of the Study Area.

Peaks in activity were also recorded in areas that held water, including the impounded area by the road to Mantserre, and in the moist grassland nearest to Bierspruit Dam.

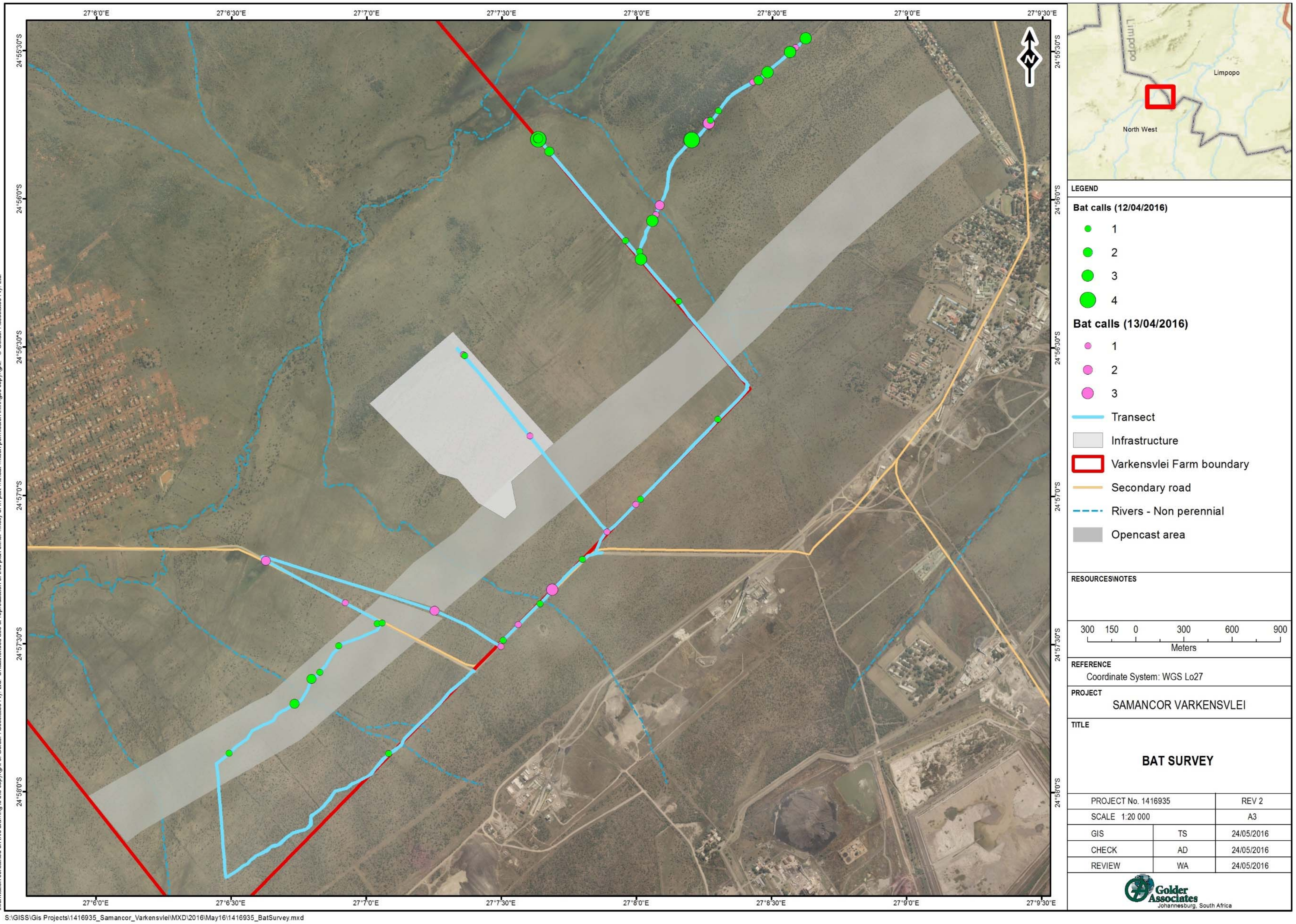
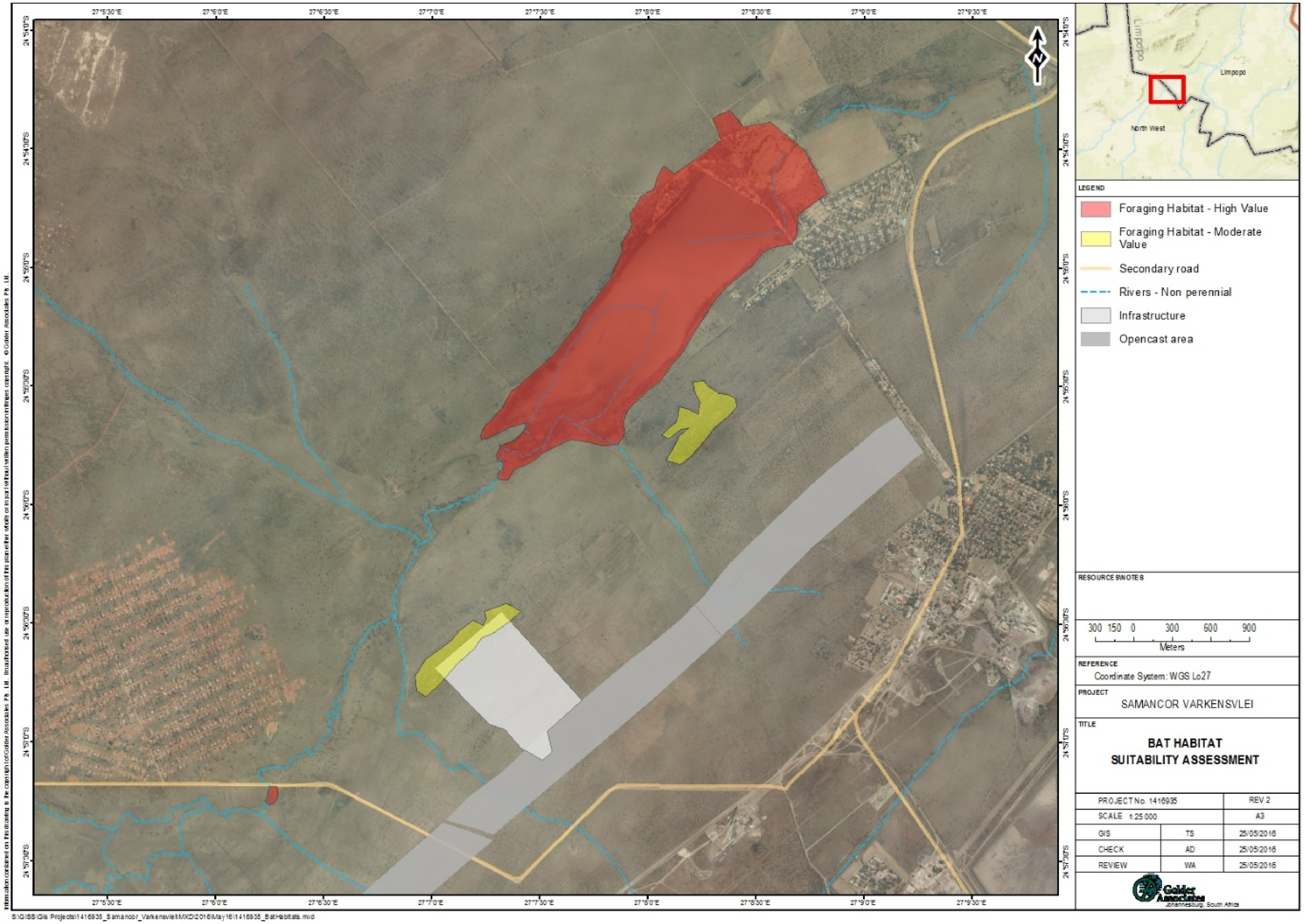


Figure 3: Bat activity patterns within the Study Area, April 2016



Service Layer Credits:

Figure 4: Bat Habitat Suitability Assessment

4.4 Sensitivity of bat habitat to development

Sensitive bat habitats were mapped based on the results of the bat activity survey and the habitat suitability assessment conducted in April 2016 (Figure 4).

The mature woodland consisting of *inter alia Acacia karroo*, *Acacia nilotica, Acacia tortilis* and *Ziziphus mucronata* trees in the northern region of the Study Area (Figure 5) provides moderate-value foraging habitat for bats. This woodland area may also provide some roosting opportunities for tree-roosting bats within the Study Area.

Figure 5: Acacia woodland in northern part of Study Area

The moist grassland in the vicinity of the Bierspruit Dam to the north of the Study Area is high-value foraging habitat for bats (Figure 6), as a result of its support of a greater abundance and diversity of flying macroinvertebrates compared to other habitats in the study area.

Figure 6: Moist grassland surrounding Bierspruit Dam

Areas where elevated bat activity was recorded included the impounded wet area located on the road to the Mantserre urban area (Figure 7), which is a source of drinking water and provides high-value foraging habitat particularly for high-flying bats, such as Molossids.

Figure 7: Impounded water near Mantserre, western part of the study area

The majority of the study area has been modified from its natural state through historic clearance for agricultural purposes (Figure 8). Although some bat calls were recorded in these areas, its foraging value for most bat species is considered low. The potential of these areas to support any significant bat roosts is considered low to negligible.

Figure 8: Modified habitat prevalent throughout the study area

4.5 Bat species of conservation importance

Both bat species confirmed during surveys are of Least Concern in terms of conservation status. Of those considered most likely to be present, one species of conservation importance, Rusty Pipistrelle (*Pipistrellus rusticus* – Near Threatened) may occur - its preferred foraging habitat is associated with open water bodies (Monadjem *et al.,* 2010). Its roosting habits are not well known, but it has been collected from tree crevices and cavities (Monadjem *et al.,* 2010), so it could potentially use the woodland in the northern area of the Study Area for roosting purposes.

5.0 IMPACT ASSESSMENT

5.1 Potential Impacts of the Project on bat species

Potential impacts of the Project on bat species were identified, based on review of available information on the effects of mines and mine infrastructure on bats, and South African guidance on assessment of potential impacts of wind energy facilities on bats (Sowler & Stoffberg, 2014), from which relevant information was distilled and applied to this assessment. The predicted impacts on bats for the construction, operational and closure phases of this Project are outlined in the following sections

5.1.1 Identified Impacts for the Construction Phase

The main impacts on bats during the construction phase arise from a) changes in land cover due to the proposed construction of the Project and all associated infrastructure, resulting in direct impacts on the extent and composition of vegetation communities and associated extent of provisioning of foraging and roosting areas for local bat populations; and b) direct impacts of injury/mortality should a day roost be disturbed by heavy site clearance machinery.

Specific project impacts on bats that are anticipated include:

- Direct loss/disturbance of bat species;
- Reduction in extent of foraging and roosting habitat for bats; and
- Injury/mortality of roosting bats during site clearance works.

5.1.2 Identified Impacts for the Operational Phase

Predicted impacts on bats during the operational phase of the Project chiefly relate to ongoing disturbance to some bat species due to presence of artificial site security lighting:

- Disturbance of typical bat foraging patterns caused by ongoing operation and maintenance activities at the facility (e.g. security lighting at night), and associated changes in insect foraging patterns in the vicinity of lighting structures;
- Possible mining effects on quantity and quality of the water resource at Bierspruit Dam and associated habitats that constitute sensitive bat foraging and drinking habitat.

5.1.3 Identified Impacts for the Decommissioning/Closure Phase

Predicted impacts on bats during the decommissioning and closure phase of the Project include the following:

- Possible contamination of aquatic ecosystems i.e. Bierspruit Dam and associated habitats that constitute high-value bat foraging and drinking habitat.

5.2 Impact Assessment for Project Phases

The Project components and activities potentially affecting bats are broken down by Phase and assessed individually as follows.

5.2.1 Construction Phase Impacts

Predicted impacts on bats during the construction phase of the Project relate to vegetation clearance within the Project boundary, resulting in direct effects on bats through potential injury/mortality of roosting bats during clearance works, and loss in extent of bat foraging habitat, as well as indirect effects on habitat integrity due to dust and sediment generation causing contamination of surface water systems. The impact assessment matrix summarises construction-phase related impacts to bats (Table 3); specific impacts are discussed in the paragraphs that follow.

Direct Loss/disturbance of bat species

Site clearance prior to construction could result in direct impacts including mortality and injury of bat species that may be roosting in the mature woodland in the northern region of the Study Area. This is considered to be an impact of moderate significance – although confirmed bat species within the Study Area are not of significant conservation concern, they contribute to the overall regional biodiversity and ecological integrity of the Study Area. Nevertheless, provided that the recommended mitigation measures (ref. Section 6.0) are put in place, the predicted impact can be reduced to one of low significance.

Reduction in extent of roosting habitat for bats

The woodland in the northern corner of the Study Area (Figure 5) provides roosting habitat for some tree-roosting bats. Reduction in the extent of this habitat is considered to potentially be of moderate significance due to its probable support of roosting bat species.

However, assuming that the application of recommended mitigation measures is adhered to i.e. woodland clearance is minimised, and felling of trees suspected to host bat roosts is supervised, the predicted effects can be reduced to low significance.

Reduction in extent of foraging habitat for bats

The loss of natural vegetation within the main Project footprint during site clearance will result in a reduction of available foraging habitat for bats, albeit largely relatively low value foraging habitat by comparison with the high-value moist grassland foraging habitat associated with the Bierspruit Dam, which is also the major drinking water source in the Study Area. However, some bat foraging habitat areas of moderate value are also present and may be affected by the Project.

The predicted reduction in extent of the vegetation types providing moderate-low value foraging habitat within the Study Area is considered to be of low magnitude in the context of the availability of large areas of prime foraging habitat in the surrounding area (moist grassland adjacent to Bierspruit Dam); the overall significance of predicted effects is rated as moderate.

The application of the recommended mitigation measures should ameliorate potential effects on bat foraging habitat to low significance.

Sediment loading of surface water runoff

Sediment is expected to be generated during construction activities and earthworks; sediment loading of surface water ecosystems can also affect the quality of riparian and wetland habitats through changes in water chemistry as a result of sedimentation and potentially embedded pollutants from heavy machinery etc. Changes in water quality in the Bierspruit Dam have the potential to affect bats that rely on this as a water source. The impact significance is predicted to be moderate prior to mitigation, due to the limited extent and duration of predicted effects, which would be greatest during seasonal rains.

With the application of the recommended mitigation measures (Section 6.0), the duration, extent and probability of impact can all be reduced, thereby reducing the resulting impact to one of low environmental significance post-mitigation.

Table 3: Bat impact rating - Construction Phase

Aspect	Impact	Rating – Pre mitigation				Total Rating	Significance Points	Rating – Post mitigation				Total Rating	Significance Points
		Magnitude	Duration	Scale	Probability			Magnitude	Duration	Extent	Probability		
Vegetation clearance in advance of construction works	Direct loss/disturbance of bat species	8	4	1	5	65	Moderate	8	4	1	2	26	Low
	Reduction in extent of roosting habitat	6	5	1	3	36	Moderate	4	2	0	2	12	Low
	Reduction in extent of foraging habitat	4	4	1	5	45	Moderate	4	4	1	2	18	Low
Soil erosion, dust and sediment generation from earthworks and vehicles	Contamination of surface water ecosystems	4	2	2	5	40	Moderate	4	1	2	2	14	Low

5.2.2 Operational Phase Impacts

Predicted operational phase impacts relate to disturbance of typical bat foraging patterns caused by ongoing activities at the facility (e.g. security lighting at night), and contamination risks for Bierspruit Dam and associated high-value bat foraging habitat. The impact assessment matrix summarises operational phase-related impacts to bats (Table 4); specific impacts are discussed in the paragraphs that follow.

Disturbance of bat activity patterns

The proposed mining development is likely to be well-lit at night for security reasons. This is expected to cause disturbance of bat species in surrounding areas. Disturbance may mean that some bat species are attracted to the lights to prey upon the insects that are attracted to the lights; other bat species may be deterred from well-lit areas. The magnitude of the effect is expected to be moderate, on a site only scale. The predicted impact is thus considered to be of moderate significance prior to mitigation.

Once the recommended mitigation measures are applied, the magnitude of effects on bats can be reduced, reducing the significance of the overall impact to low.

Effects on quality of Bierspruit Dam water and associated habitat that constitute bat foraging and drinking habitat

Pollution events associated with the proposed mine could potentially occur, affecting the quality of the Bierspruit dam water and its capacity to provide foraging and drinking habitat for bats. These potential impacts are considered to be of high magnitude and would occur at a local scale only, however it is considered improbable as the engineering designs of the proposed facility have been developed in such a way as to prevent such an occurrence. The predicted impact is therefore considered to be of moderate environmental significance prior to mitigation.

Providing that the specific mitigation measures outlined in the surface water assessment (Golder Associates Africa, 2016) are adhered to, the impact post-mitigation is considered to be of low environmental significance.

Table 4: Bat Impact Rating - Operational Phase

Aspect	Impact	Rating – Pre mitigation				Total Rating	Significance Points	Rating – Post mitigation				Total Rating	Significance Points
		Magnitude	Duration	Scale	Probability			Magnitude	Duration	Extent	Probability		
Site lighting and maintenance	Disturbance of foraging bats	6	4	2	5	60	Moderate	4	4	2	2	24	Low
Pollution events	Reduction in quality of water in Bierspruit Dam, and effects on invertebrate habitat availability (hence bat foraging opportunities)	2	4	1	5	35	Moderate	1	4	1	5	30	Low

5.2.3 Closure/Decommissioning Phase Impacts

Predicted impacts on bats during the decommissioning and closure phase of the project relate to contamination of surface water and aquatic ecosystems which bats use as water sources.

Contamination of surface water and aquatic ecosystems used as water sources by bats

Impacts on aquatic ecosystems during the decommissioning and closure period are mostly associated with soil erosion and sediment loading of surface water runoff and subsequently aquatic ecosystems, incorrect disposal of hazardous waste and possible surface water pollution due to the leaching of contaminants.

Provided the approved design principles and rehabilitation programme are implemented, no significant impacts on aquatic ecosystems and therefore drinking water quality for bats are expected after the closure phase of the site, thereby reducing the ranking to low.

Table 5: Bat Impact Rating: Decommissioning and Closure Phase

Aspect	Impact	Rating – Pre mitigation				Total Rating	Significance Points	Rating – Post mitigation				Total Rating	Significance Points
		Magnitude	Duration	Extent	*Probability*			Magnitude	Duration	Extent	*Probability*		

Removal of mining infrastructure, ground works for rehabilitation	Transportation of sediment from newly rehabilitated areas during intense rainfall events into surface water bodies may contaminate water sources for bats	8	5	3	5	80	High	6	5	3	1	14	Low

6.0 MITIGATION MEASURES

Mitigation measures to avoid/minimise effects on bats and their habitats, and restore affected areas are presented in the sections that follow.

6.1 Construction Phase Mitigation Measures

- Habitats identified as being of high foraging value, i.e. the moist grassland adjacent to Bierspruit Dam, should be avoided – no clearance or levelling works should take place in this area and a 100 m buffer between it and the cleared area should be retained;
- Loss of habitats identified as being of moderate foraging value, i.e. the woodland in the northern part of the study area, which may also support roosting bats, should be minimised wherever possible. Areas proposed for vegetation clearance should be clearly marked and no heavy vehicles should travel beyond the marked works zone;
  - Targeted searches for roosting bats should be conducted by an ecologist immediately prior to commencement of any clearance of the mature woodland in the northern part of the study area:
  - If a bat roost in a tree is suspected, the tree should be dismantled in sections and left on the ground for 24 hours to allow any roosting bats to escape.

6.2 Operational Phase Mitigation Measures

- Site lighting options should be managed to minimise effects on bats. Options that should be considered and applied where feasible include:
  - Use of security lighting that is movement-activated rather than permanently switched on;
  - Directional shading to prevent excessive light spillage;
  - Use of light bulbs that are not as attractive to insects (e.g. LED bulbs).
- Effective diversion of storm water and maintenance of the storm water management system should remain ongoing throughout the lifespan of the Project. The surface drainage management plan for the project should be strictly adhered to;
- Native species planting should be put in place around the Site boundary and in any areas which have exposed soils to aid in the reduction of soil erosion and additional loss of vegetation beyond the footprint of cleared areas; and
- Installation of artificial bat roosts on suitable trees and buildings within the surrounding area to encourage the presence of bats in the area and enhance the biodiversity value of the site is encouraged.

6.3 Closure/Decommissioning Phase Mitigation Measures

- Restoration/rehabilitation of the Project footprint should include consideration of compatible measures for habitat enhancement for bat species. Such measures include planting of native species of trees and shrubs; creation of drinking points e.g. ponds or dams; demarcation of rehabilitated areas as conservation areas only; and installation of artificial bat roosts in suitable locations.

7.0 SUMMARY AND CONCLUSION

Low levels of bat activity were recorded throughout the study area during the bat activity survey conducted in April 2016. Confirmed bat species are relatively common species that are of Least Concern in terms of conservation status. Of the three other bat species considered likely to occur, Rusty Pipistrelle is considered Near Threatened in the regional context.

The Study Area has been modified as a result of bush clearance for agriculture (livestock grazing). This has reduced the structural diversity of the site and as a result, limited the value of the majority of the Study Area for foraging and roosting bats. The woodland in the northern part of the study area has moderate value for foraging bats, and may support tree-roosting bat species in low numbers. The highest value habitat for foraging bats is the Bierspruit Dam and associated moist grassland, which will be largely unaffected by the Project.

The development of the Project will cause reduction in extent of mostly low-value foraging habitat and small areas of moderate-value foraging habitat for bats through vegetation clearance. The effects of which will reduce the extent of foraging habitat availability in the locality. Site clearance works may impact some individual bats through injury/mortality. Site security lighting throughout the lifetime of the Project will result in increased sensory disturbance of bats, which may reduce the area of effective foraging habitat available to some species, or attract other species that actively forage around site lighting.

Based on the results of the habitat suitability assessment and bat survey results, the significance of predicted effects on bats and bat habitat prior to mitigation are mostly moderate, and reducible to low significance with the application of the recommended mitigation measures. Provided that the recommended mitigation measures are incorporated into the Project's environmental management plan, and are enacted and reported upon to the relevant authority, the environmental significance of predicted impacts on bats and bat habitat can be reduced to environmentally acceptable levels.

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GOLDER ASSOCIATES AFRICA (PTY) LTD.

Aisling Dower
Terrestrial Ecologist

Etienne Roux
Project Manager

AD/

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APPENDIX A

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Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Africa (Pty) Ltd.
P.O. Box 6001
Halfway House, 1685
Building 1, Golder House, Magwa Crescent West
Maxwell Office Park, cnr.
Allandale Road and Maxwell Drive
Waterfall City
Midrand, 1685
South Africa
T: [+27] (11) 254 4800