DRAFT SCOPING REPORT

Bosveld Phosphates (Pty) Ltd – Magnetite Waste Site Disposal Facility

JULY 2022

Consulting

Purpose of Report

Bosveld Phosphates (Pty) Ltd requires a suitable waste disposal facility for the storage of magnetite waste for future use. Magnetite tailings are produced by two magnetite beneficiation plants on the Bosveld Phosphates (Pty) Ltd premises, where the beneficiation process entails the upgrading of magnetite (Fe_3O_4) from an average input feed to a concentrate. The upgraded magnetite concentrate is transported to clients off site. Non-magnetite tailings will be stored temporarily until it is processed through a copper flotation plant where copper mineral will be extracted. The waste produced from the copper extraction process needs to be disposed onto an authorised waste disposal facility.

Current value adding projects such as the pelletising of upgraded magnetite and developing of a Dense Medium Separation (DMS) product for the coal washing market is under investigation. If feasible, upgraded magnetite will be processed through these facilities before being transported off site.

This proposed project requires Environmental Authorisation (EA) in terms of the provisions of the National Environmental Management Act (NEMA) Act No. 107 of 1998, the National Environmental Management: Waste Act (NEMWA) Act No. 59 of 2008 as well as the National Water Act (NWA) Act No. 36 of 1998. Based on the nature of the proposed activities associated with this project, the necessary applications have to be supported *inter alia* by a Scoping and Environmental Impact Assessment and Reporting Process (S&EIR) as provided for in the Environmental Impact Assessment (EIA) Regulations (as amended 11 June 2021). In this regard an application for an EA in terms of the NEMA and an application for a Waste Management Licence (WML) in terms of the NEMWA will be made to the Limpopo Department of Economic Development, Environment and Tourism (LEDET) as the Competent Authority (CA). An application for the new water uses associated with this project (Water Use Licence (WUL)) will be submitted to the Department of Water and Sanitation (DWS).

This report represents the Scoping Report and Plan of Study compiled in support of the S&EIR Process as is provided for in the EIA Regulations. The content of this Scoping Report and Plan of Study gives full compliance with the requirements for a Scoping Report as detailed in Appendix 2 of the EIA Regulations.

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LIST OF ABBREVIATIONS AND ACRONYMS

AEL	**:**	Air Emission Licence
CARA	**:**	Conservation of Agricultural Resources Act 43 of 1983 (CARA)
CA	**:**	Competent Authority
CBA	**:**	Critical Biodiversity Area
CV	:	Curriculum Vitae
DEA	:	Department of Environmental Affairs
DFFE	:	Department of Forestry, Fisheries and the Environment
DWA	:	Department of Water Affairs
DWAF	:	Department of Water Affairs and Forestry
DWS	:	Department of Water and Sanitation
EA	:	Environmental Authorisation
EAP	:	Environmental Assessment Practitioner
EIA	:	Environmental Impact Assessment
EIS	:	Ecological Importance and Sensitivity
EMP	:	Environmental Management Plan
EMPR	:	Environmental Management Programme Report
ESA	:	Ecological Support Areas
FAII	:	Fish Assemblage Integrity Index
GN	:	Government Notice
GNR	:	Government Notice Report
GQM	**:**	Groundwater Quality Management
HDPE	**:**	High Density Polyethylene
HIA	**:**	Habitat Integrity Assessment
I&AP's	**:**	Interested and Affected Parties
IBA	**:**	Important Bird Area
IDP	:	Integrated Development Planning
IHAS	**:**	Invertebrate Habitat Assessment System
IUCN	:	The International Union for Conservation of Nature
IWULA	:	Integrated Water Use Licence Application
IWWMP	:	Integrated Water and Waste Management Plan
LED	:	Local Economic Development
LEDET	:	Limpopo Department of Economic Development, Environment and Tourism
LEMA	:	Limpopo Environmental Management Act (Act No. 7 of 2003)
MAMSL	**:**	Meters Above Mean Sea Level
MAP	:	Mean Annual Precipitation
MAR	:	Mean Annual Runoff
NBA	:	National Biodiversity Assessment
NEMA	:	National Environmental Management Act (Act No. 107 of 1998)
NEMAQA	:	National Environmental Management: Air Quality (Act No. 39 of 2004)
NEMBA	:	National Environmental Management: Biodiversity Act (Act No. 10 of 2004
NEMPAA	**:**	National Environmental Management: Protected Areas Act (Act No. 57 of 2003)
NEMWA	:	National Environmental Management: Waste Act (Act No. 59 of 2008)
NFA	:	National Forests Act (Act No. 84 of 1998)
NHRA	:	National Heritage Resources Act (Act No. 25 of 1999)
NWA	:	National Water Act (Act No. 36 of 1998)
PCD	:	Pollution Control Dam
PES	:	Present Ecological State
PPP	**:**	Public Participation Programme

LIST OF ABBREVIATIONS AND ACRONYMS (CONTINUED)

RQIS	**:**	Resource Quality Information Services
SACNASP	:	South African Council for Natural Scientific Professions
SAHRA	:	South African Heritage Resources Agency
SANS	:	South African National Standard
SA RHP	:	South African River Health Programme
SASS5	**:**	South African Scoring System – Version 05
SCC	**:**	Species of Conservation Concern (SCC)
S&EIR	:	Scoping and Environmental Impact Reporting
SQR	:	Sub-Quaternary catchment Reach
VEGRAI	:	Riparian Vegetation Response Assessment Index
WML	:	Waste Management Licence
WMS	:	Water Management System
WSA	:	Water Services Act (Act No. 108 of 1997)
WUL	:	Water Use Licence

EXECUTIVE SUMMARY

To be compiled after the Public Review Period.

1. INTRODUCTION AND OBJECTIVES

Bosveld Phosphates (Pty) Ltd (here after referred to as Bosveld Phosphates) is the owner of an industrial Phosphoric Acid Plant, situated just outside the town of Phalaborwa, in what is called the Phalaborwa Mining and Industrial Complex (PMIC), within the Limpopo Province of South Africa.

The site was established in the 1960's and has over the years been expanded and operated by a number of different owners. Bosveld Phosphates purchased the plant from Sasol Nitro (Pty) Ltd in 2011 and after having done some refurbishment, re-started the production of Phosphoric Acid in October 2012.

The plant primarily produces Phosphoric Acid, Sulphuric Acid, Mono-Ammonium Phosphate (MAP) as well as Granular Super Phosphate (GSP) which are transported by road and rail and exported mainly for use in the agricultural sector. Dry fertilizers are also mixed / blended at the plant according to the required demand specifications. Most of these operations are however currently inactive and large portions of the site are under lease agreements with tenants involved in the beneficiation and export of magnetite.

Two of these magnetite beneficiation plants, namely the Magnetite Dense Media Separation Plant (SAOB – South African Ore Beneficiation (Pty) Limited) and the Magnetite Drying Plant (MP2 - Mag Plant 2 (Pty) Ltd) have been constructed on the Bosveld Phosphates premises. The intention of these plants is to upgrade Magnetite (Fe_3O_4) from the adjacent Foskor (Pty) Ltd site (east of Bosveld Phosphates site), from an average input feed grade to a concentrate. The upgraded magnetite concentrate is transported to clients off site (see Figure 1(a)).

Current value adding projects such as the pelletising of upgraded magnetite and developing of a Dense Media Separation (DMS) product for the coal washing market is under investigation. If feasible, upgraded magnetite will be processed through these facilities before being transported off site.

Non-magnetite tailings will be stored temporarily until it is processed through a proposed copper flotation plant where copper mineral will be extracted. The waste produced from the copper extraction process needs to be disposed onto an authorised waste disposal facility. In support of these processes, Bosveld Phosphates requires a suitable authorised waste disposal facility (and associated infrastructure) where the waste produced from this copper extraction process can be disposed and stored for future use (see Figure 1(a)).

This proposed project requires Environmental Authorisation (EA) in terms of the provisions of the National Environmental Management Act (NEMA) Act No. 107 of 1998, the National Environmental Management: Waste Act (NEMWA) Act No. 59 of 2008 as well as the National Water Act (NWA) Act No. 36 of 1998.

Based on the nature of the proposed activities associated with this project, the necessary applications have to be supported *inter alia* by a Scoping and Environmental Impact Assessment and Reporting Process (S&EIR) as provided for in the Environmental Impact Assessment (EIA) Regulations of December 2014 (as amended). In this regard an application for an EA in terms of the NEMA and an application for a Waste Management Licence (WML) in terms of the NEMWA will be made to the Limpopo Department of Economic Development, Environment and Tourism (LEDET) as the Competent Authority (CA). An application for the new water uses (Water Use Licence (WUL)) associated with the project will be submitted to the Department of Water and Sanitation (DWS).

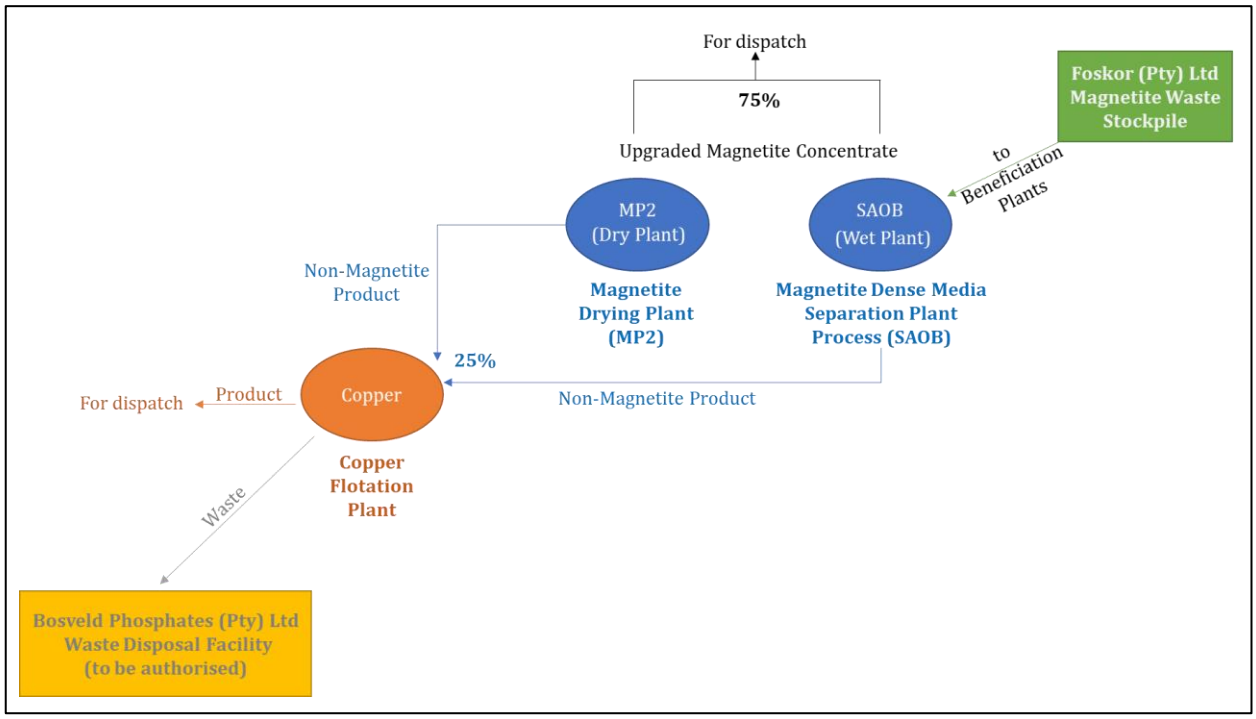

Figure 1(a): Process Flow Diagram illustrating the activities associated with the Magnetite Waste Site Disposal Facility to be authorised

This report represents the Scoping Report and Plan of Study compiled in support of the S&EIR Process as provided for in the EIA Regulations. The content of this Scoping Report and Plan of Study gives full compliance with the requirements for a Scoping Report as detailed in Appendix 2 of the said EIA Regulations.

The objective of the Scoping Process is to, through a consultative process:

(a) identify the relevant policies and legislation relevant to the activity;
(b) motivate the need and desirability of the proposed activity, including the need and desirability of the activity in the context of the preferred location;
(c) identify and confirm the preferred activity and technology alternative through an identification of impacts and risks and ranking process of such impacts and risks;
(d) identify and confirm the preferred site, through a detailed site selection process, which includes an identification of impacts and risks inclusive of identification of cumulative impacts and a ranking process of all the identified alternatives focusing on the geographical, physical, biological, social, economic, and cultural aspects of the environment;
(e) identify the key issues to be addressed in the assessment phase;

(f) *agree on the level of assessment to be undertaken, including the methodology to be applied, the expertise required as well as the extent of further consultation to be undertaken to determine the impacts and risks the activity will impose on the preferred site through the life of the activity, including the nature, significance, consequence, extent, duration and probability of the impacts to inform the location of the development footprint within the preferred site; and*

(g) *identify suitable measures to avoid, manage or mitigate identified impacts and to determine the extent of the residual risks that need to be managed and monitored.*

The overall S&EIR Process to be followed, the integration with the other authorisation processes, and the specific contribution by this Scoping Report and Plan of Study within the greater formal process, as well as the applicable timelines are shown graphically in Figure 1(b).

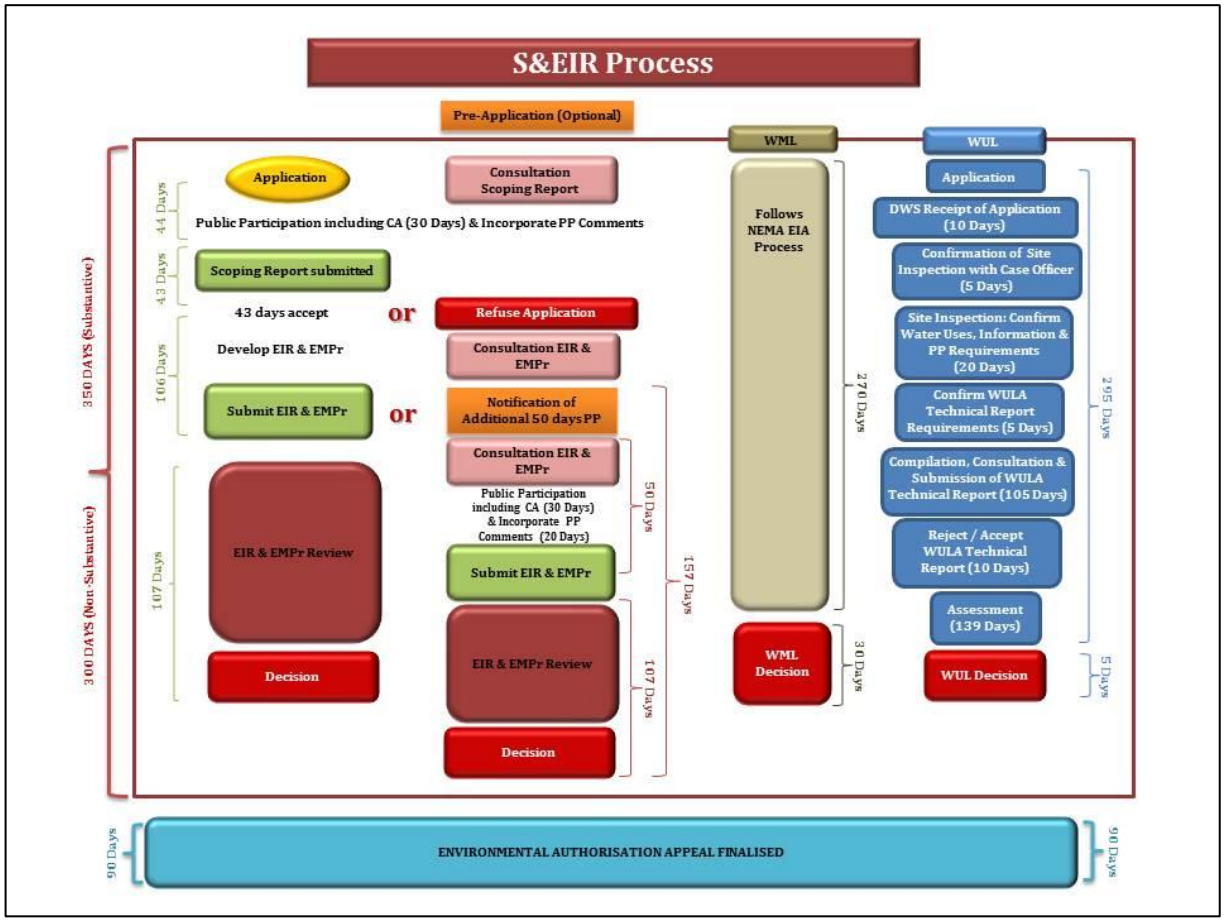

Figure 1(b): The Scoping Process Contextualized within the overall Environmental Authorisation Process and Timeline

2. DETAILS OF ENVIRONMENTAL PRACTITIONER (EAP)

2.1. DETAILS OF THE EAP WHO PREPARED THE REPORT

Table 2.1(a): Details of the Environmental Assessment Practitioner (EAP)

Project Consultancy	JMA Consulting (Pty) Ltd
Company Registration	2005/039663/07
Professional Affiliation	Environmental Assessment Practitioners Association of South Africa (EAPASA - EAP 2019/943); South African Council for Natural Scientific Professions (SACNASP – Pr.Sci.Nat. 400291/12)
Contact Person	Mrs René van Greunen (Pr. Sci. Nat.)
Physical Address	15 Vickers Street DELMAS 2210
Postal Address	P O Box 883 DELMAS 2210
Telephone Number	+27 13 665 1788
Fax Number	+27 13 665 2364
E-mail	rene@jmaconsult.co.za

2.2. EXPERTISE OF THE EAP

The Environmental Assessment Practitioner (EAP) for this project was Mrs René van Greunen (Pr. Sci. Nat.).

2.2.1. Qualifications of the EAP

René van Greunen holds the following degrees:

- B.Sc. from the University of Pretoria (2006) with major subjects in Ecology.
- B.Sc. (Hons) from the University of Pretoria (2007) with field of specialisation Ecology (Invasion Biology).
- M.Sc. (cum laude) from the University of Pretoria (2010) with field of specialisation Ecology (Invasion Biology).

René van Greunen is registered as an Environmental Assessment Practitioner (EAP 2019/943) with the Environmental Assessment Practitioners Association of South Africa (EAPASA) in accordance with the prescribed criteria of Regulation 15(1) of the Section 24H Registration Authority Regulations (Regulation No. 849, Gazette No. 40154 of 22 July 2016, of the NEMA, Act No. 107 of 1998, as amended).

In addition, she holds a Professional Registration with South African Council for Natural Scientific Professions (SACNASP) since 2012 – 400291/12. She is registered as a professional scientist in the following category:

- Ecological Science

2.2.2. Past Experience of the EAP

René van Greunen started her working career as an Intern at the South African National Biodiversity Institute (SANBI) Threatened Biodiversity Research Programme followed by being employed as an Environmental Practitioner at Clean Stream Scientific Services.

She was appointed as a Scientist at JMA Consulting (Pty) Ltd in 2012 and has been responsible for the compilation of Basic Assessment Reports (BAR), Scoping and Plan of Study Reports, Environmental Impact Assessment Reports (EIAR) and Environmental Management Programme (EMPr) Reports.

Subsequently, she is also assisting with the development of Integrated Water and Waste Management Plans (IWWMP) and External Audit Reports on Water Use Licences (WUL) and Waste Management Licences (WML). In addition, she facilitates the Stakeholder Engagement Programmes as required by Environmental Management Legislation.

2.3. CV OF THE EAP

A Synoptic CV of the EAP is attached as **APPENDIX 2(A)** to this report.

3. LOCATION OF THE ACTIVITY

3.1. ACTIVITY BACKGROUND

Bosveld Phosphates is the owner of an industrial Phosphoric Acid Plant, situated just outside the town of Phalaborwa, in what is called the Phalaborwa Mining and Industrial Complex (PMIC), within the Limpopo Province of South Africa. The site was established in the 1960's and has over the years been expanded and operated by a number of different owners. Bosveld Phosphates (Pty) Ltd purchased the plant from Sasol Nitro (Pty) Ltd in 2011 and after having done some refurbishment, re-started the production of Phosphoric Acid in October 2012.

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The non-magnetite tailings originating from this beneficiation processes will be temporarily stored on site until it is processed through a Copper Flotation Plant/process where Copper mineral will be extracted. In support of these processes, Bosveld Phosphates requires a suitable authorised waste disposal facility where the waste produced from this copper extraction process can be disposed and stored for future use.

3.2. CONTACT DETAILS

A summary of the relevant company details and the contact person is indicated in Table 3.2(a) and Table 3.2(b) respectively.

Table 3.2(a): Company Details

Name of Company	Bosveld Phosphates (Pty) Ltd
Trading Name	Bosveld Phosphates (Pty) Ltd
Registration Number	2004/020580/07
Date Established	2004/07/23
Country Established	South Africa
VAT Registration Number	4910218868
Physical Address	4th Floor, South Tower, Nelson Mandela Square, Corner of 5th & Maude Street, Sandton Farm Wegsteek, Station Road, Industrial Area, Phalaborwa, 1390

Table 3.2(b): Plant Manager

Contact Person	Mr Trevor Dunlop
Telephone Number	+27 15 781 6100
Cell phone Number	+27 83 447 4079
Email Address	trevor@bosveldafrica.co.za
Postal Address	Private Bag X01022 Phalaborwa 1390

3.3. REGIONAL SETTING AND LOCATION OF ACTIVITY

The Bosveld Phosphates site falls within the Ba-Phalaborwa Local Municipality which is located within the Mopani District Municipality of the Limpopo Province of the Republic of South Africa (Figure 3.3(a)). The central coordinates of the site are 23° 59' 22.9" S, 31° 05' 17.8" E (WGS84).

The regional topographical setting is depicted on Figure 3.3(b). Access to the site is gained via the R40 and/or the R71(that connects Tzaneen and Phalaborwa) with the nearest town to the site being Phalaborwa; see Figure 3.3(b). A summary of the regional and municipal information pertaining to the site is provided in Table 3.3(a).

Table 3.3(a): Summary of the Regional Setting and Location of the Activity

Central Coordinate of the Site	23° 59' 22.9" S ; 31° 05' 17.8" E
Nearest Town / City	Phalaborwa
Magisterial District	Phalaborwa
Local Municipality	Ba-Phalaborwa Local Municipality
District Municipality	Mopani District Municipality
Province	Limpopo Province
Country	Republic of South Africa

Bosveld Phosphates is situated within the Olifants River (B) Primary Catchment within the Olifants Water Management Area and the B72K quaternary catchment (Figures 3.3(c) and 3.3(d)). Water management on site is managed by the Olifants Catchment Management Agency.

The Bosveld Phosphates site is some 616 hectares (ha) in size and is located in a small sub-catchment area of the Ga-Selati River. The site is situated to the east of the Ga-Selati River and has a river frontage of some 4 000 meters. The land slopes from an elevation of 375 metres above mean sea level (mamsl) in the east, down towards the Ga-Selati River at an elevation of some 345 mamsl, in the west. The average topographic gradient across the site is 1.2%.

Surface water on site drains in a westerly to south-westerly direction towards the Ga-Selati River. Down-stream from Bosveld Phosphates, the Ga-Selati River flows past Foskor and then eventually into the Olifants River. The Olifants River then flows into and through the Kruger National Park and discharges into the Limpopo River.

The tertiary catchment reference within which the site resides is B72 with the site occupying less than 0.1 % of the total Selati Catchment (2 340 km^2).

A summary of the regional surface water catchments and drainage areas relevant to the site is depicted in Table 3.3(b).

Table 3.3(b): Regional Surface Water Catchment and Drainage Areas

Receiving Stream	Ga-Selati River
Quaternary Catchment	B72K
Primary Catchment	Olifants River (B) Primary Catchment
Water Management Area	Olifants Water Management Area

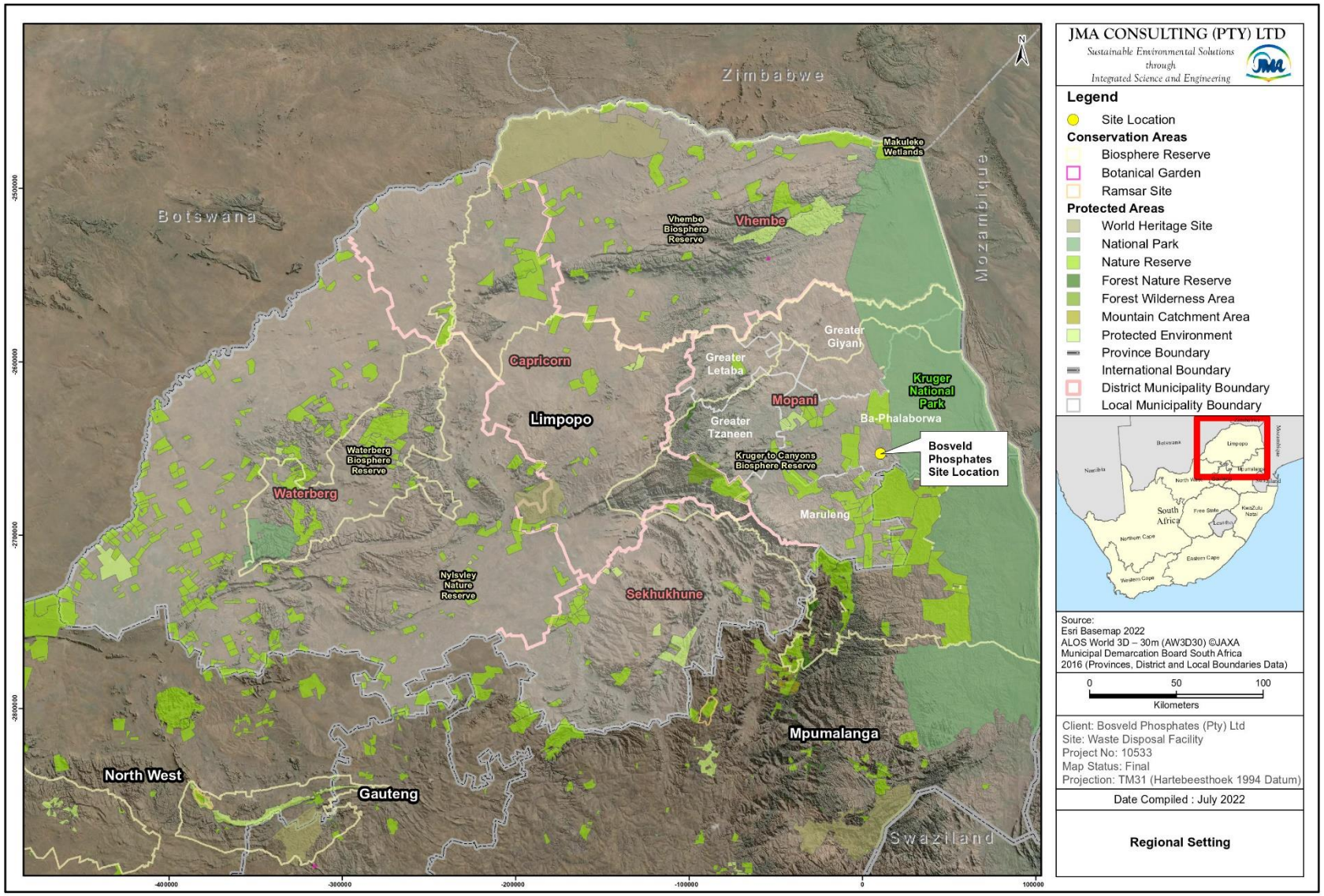


Figure 3.3(a): Regional Setting and Location of the Activity

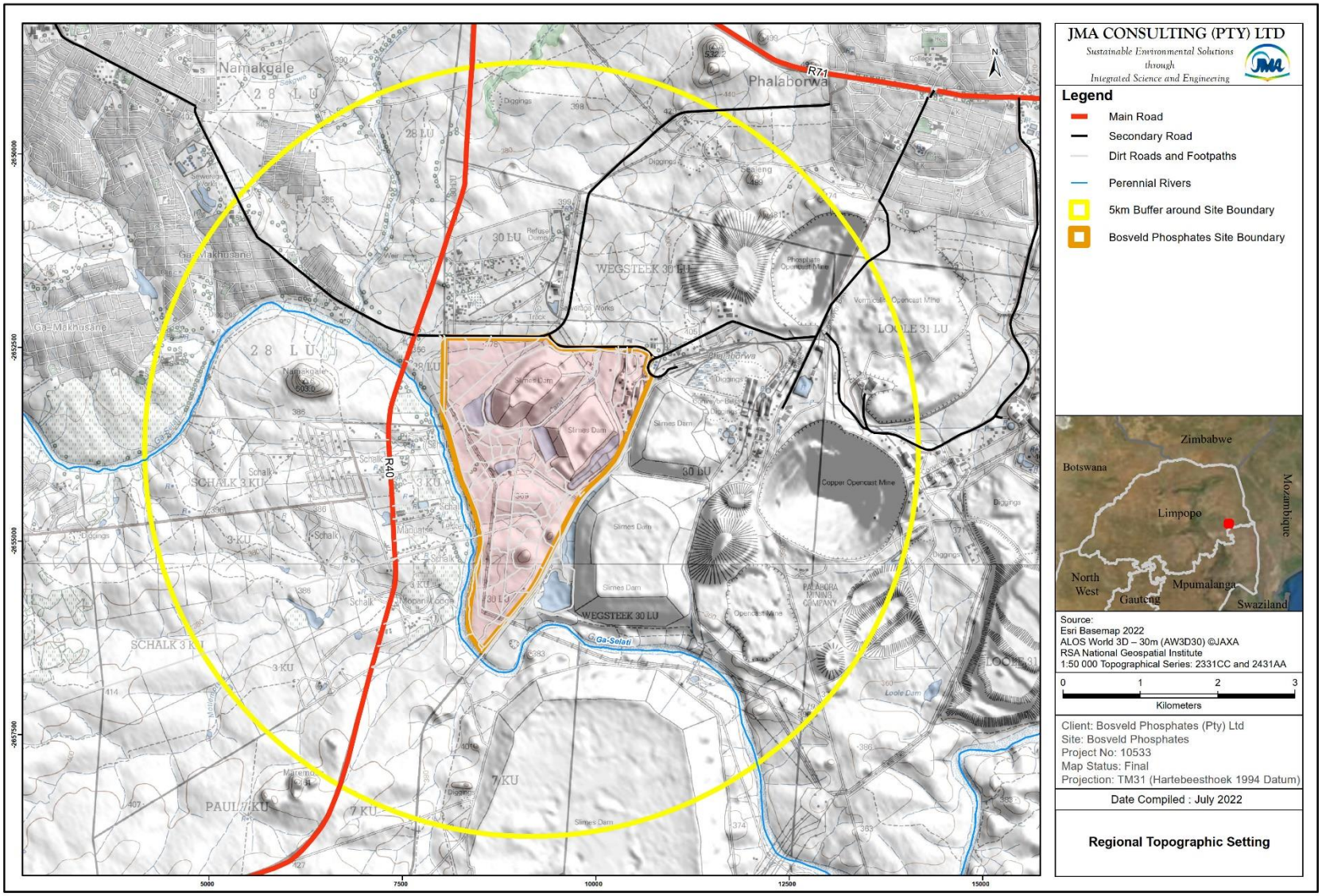


Figure 3.3(b): Regional Topography (Topographical Map 2331CC and 2431AA)

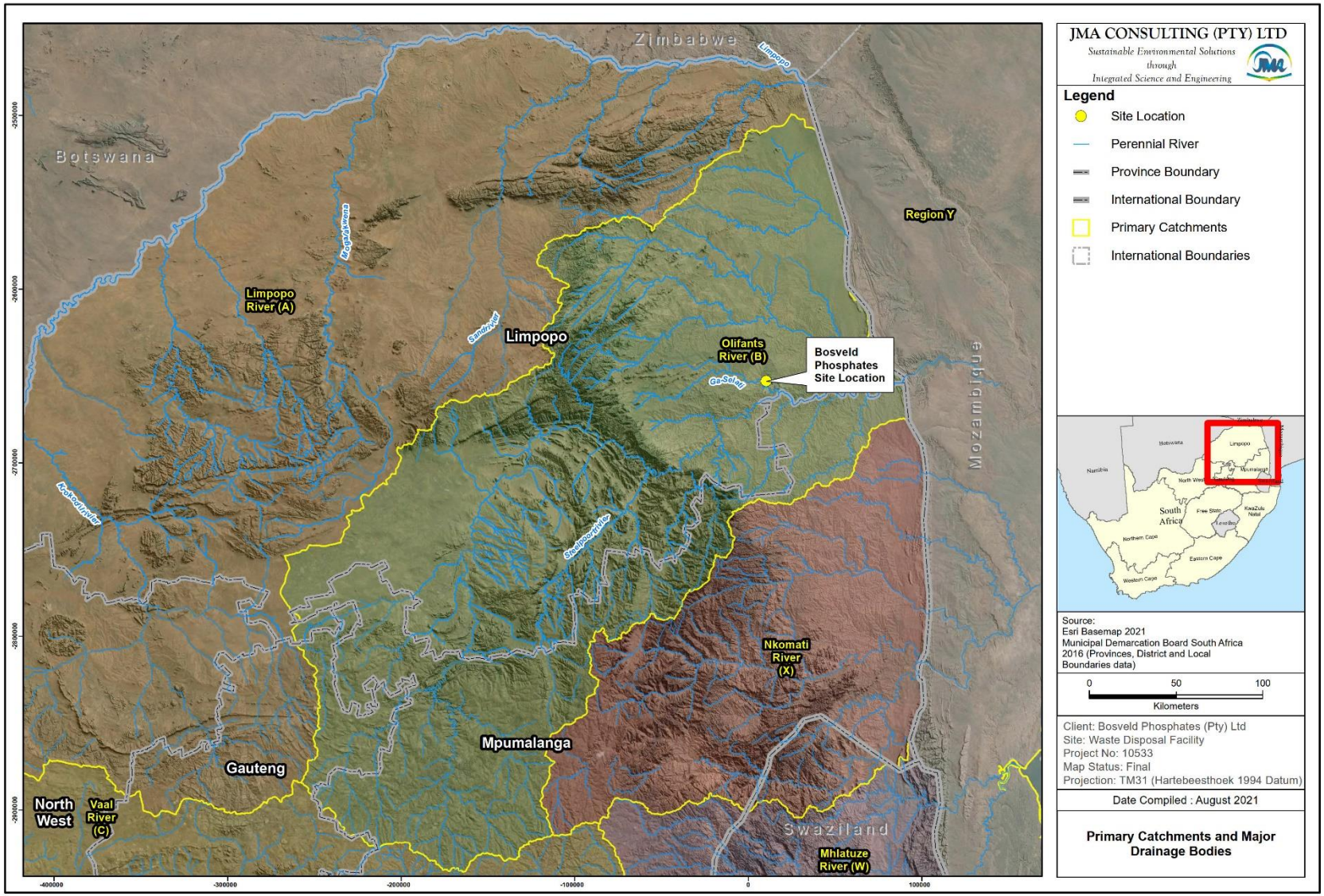


Figure 3.3(c): Primary Catchments and Major Surface Water Drainage Bodies

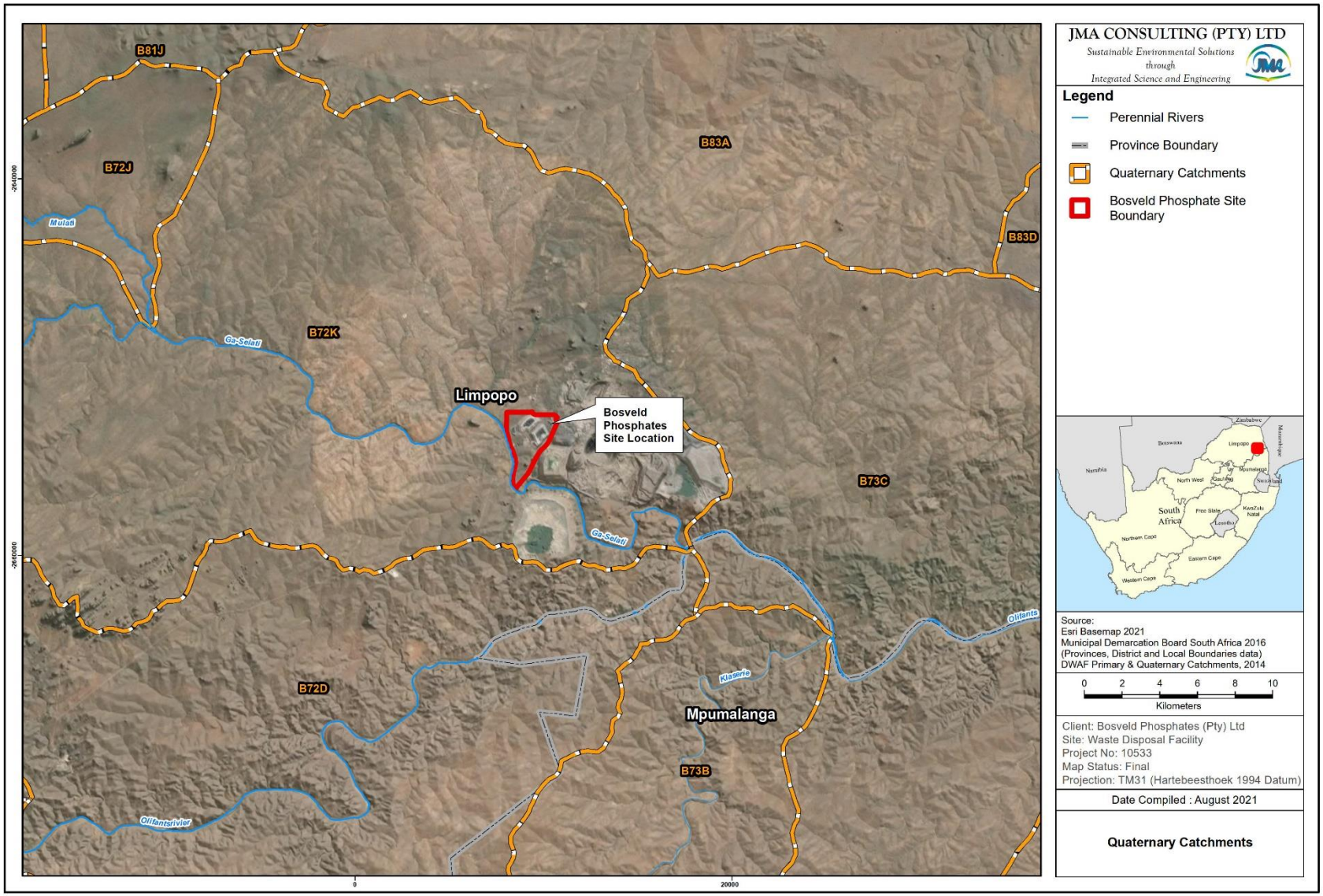


Figure 3.3(d): Delineated Quaternary Catchments

3.4. PROPERTY DESCRIPTION

Refer to Figure 3.4(a) showing the property layout of the Bosveld Phosphates site. The proposed waste disposal facility(and associated infrastructure) will be located in the north western corner of the site on the property with Surface Right Number 175/1976 (RMT O 240/1974); Re-registered on 18/11/2005 under permit number 4383/2005. The Copper Flotation Plant will be located on the property with Surface Right Number 92/1969 (RMT O 211/1968) DT: 05/2013.

Details pertaining to the said properties is relayed in Table 3.4(a).

Table 3.4(a): Details pertaining to the properties relevant to the project activities

Farm Name	21 Digit Surveyor General Code
Farm Wegsteek 30, Registration Division LU.	TOLU 0000 00000030 00000

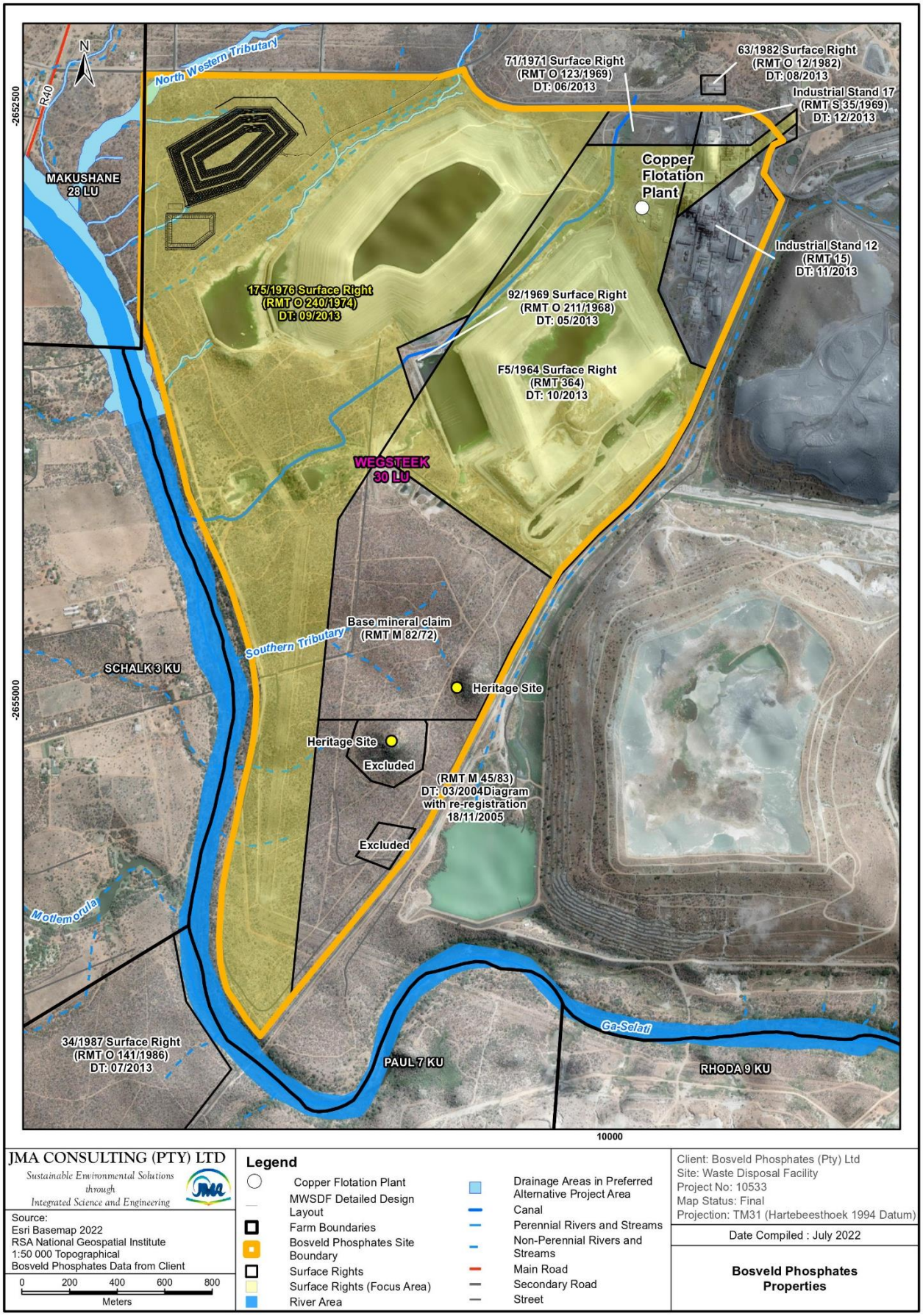


Figure 3.4(a): Layout of the Properties at Bosveld Phosphates

3.5. DETAILS OF RELEVANT MUNICIPALITY

Table 3.5(a): Information of District Municipality and Contact Person

District Authority	Mopani District Municipality
Contact Person	Mr SR Monakedi
Postal Address	Private Bag X 9687, Giyani, 0826
Telephone Number	+27 15 811 6300
Email Address	lekoapel@mopani.gov.za; Kgatlaq@mopani.gov.za; monakedir@mopani.gov.za; basa@mopani.gov.za

Table 3.5(b): Information of Local Municipality Details and Contact Person

Local Authority	Ba-Phalaborwa Local Municipality
Contact Person	Majee Seduma/ Clr de Beer
Postal Address	Private Bag X 01020, Phalaborwa, 1390
Cellular Phone	+27 15 780 6347/ +27 15 780 6300/ +27 76 657 5771/ +27 83 668 3213
Email Address	sedumam@ba-phalaborwa.gov.za; mabuzaz@ba-phalaborwa.gov.za

3.6. DETAILS OF RELEVANT GOVERNMENT AUTHORITIES

3.6.1. National Authorities/Agencies/Institutions

Department of Forestry, Fisheries and the Environment (DFFE)

National Department	Department of Forestry, Fisheries and the Environment- Head Office - Pretoria
Directorate	The Director: Licensing/ Systems Management
Contact Person	Lucas Mahlangu
Postal Address	Private Bag X 447, Pretoria, 0001
Telephone Number	+27 12 399 9791
Email Address	lmahlangu@dffe.gov.za

Department of Water and Sanitation (DWS)

National Department	Department of Water and Sanitation - Head Office - Pretoria
Postal Address	Private Bag X313, PRETORIA, 0001
Telephone Number	+27 12 336 7500
Facsimile Number	+27 12 336 8664

3.6.2. Provincial/Regional Authorities/Agencies/Institutions

Limpopo Department of Economic Development, Environment and Tourism (LEDET)

Regional Department	Limpopo Department of Economic Development, Environment and Tourism
Contact Person	Ms Mamabolo
Postal Address	Private Bag X9484, POLOKWANE, 0700
Telephone Number	+27 15 293 8300
Cellular Phone	+27 79 527 8329
Email Address	mamabolotm@ledet.gov.za

Regional Department of Water and Sanitation (DWS)

Regional Department	Lydenburg Regional Office
Water Management Area	Olifants WMA
Contact Person	Portia Munyai
Physical Address	TPA Building, Cnr Schurink and Rossouw Streets, LYDENBURG, 1120
Telephone Number	+27 13 235 4206
Cellular Phone	+27 82 328 8805
Email Address	MunyaiP2@dwa.gov.za

3.6.3. Other Authorities/Agencies/Institutions

South African Heritage Resources Agency (SAHRA)

Provincial Department:	Polokwane Limpopo
Contact Person	Nokukhanya Khumalo
Postal Address	Private Bag x 9549, POLOKWANE, 0700
Telephone Number	+27 15 284 4000
Facsimile Number	+27 15 284 4510
Email Address	litholek@sac.limpopo.gov.za; info@sahra.org.za; nkhumalo@sahra.org.za

4. SCOPE OF ACTIVITY

4.1. SUMMARY OF OVERALL ACTIVITIES AND PROCESSES

Bosveld Phosphates is the owner of an industrial Phosphoric Acid Plant. The site was established in the 1960's and has over the years been expanded and operated by a number of different owners. Bosveld Phosphates (Pty) Ltd purchased the plant from Sasol Nitro (Pty) Ltd in 2011 and after having done some refurbishment, re-started the production of Phosphoric Acid in October 2012.

The plant primarily produces Phosphoric Acid, Sulphuric Acid, Mono-Ammonium Phosphate (MAP) as well as Granular Super Phosphate (GSP) which are transported by road and rail and exported mainly for use in the agricultural sector. Dry fertilizers are also mixed / blended at the plant according to the required demand specifications. Most of these operations are however currently inactive and large portions of the site are under lease agreements with tenants involved in the beneficiation and export of magnetite.

Two of these magnetite beneficiation plants, namely the Magnetite Dense Media Separation Plant (SAOB – South African Ore Beneficiation (Pty) Limited) and the Magnetite Drying Plant (MP2 - Mag Plant 2 (Pty) Ltd) have been constructed on the Bosveld Phosphates premises. The intention of these plants is to upgrade Magnetite (Fe_3O_4) from the adjacent Foskor (Pty) Ltd site (east of Bosveld Phosphates site), from an average input feed grade to a concentrate. The upgraded magnetite concentrate is transported to clients off site.

Current value adding projects such as the pelletising of upgraded magnetite and developing of a Dense Media Separation (DMS) product for the coal washing market is under investigation. If feasible, upgraded magnetite will be processed through these facilities before being transported off site.

Non-magnetite tailings will be stored temporarily until it is processed through a proposed copper flotation plant where copper mineral will be extracted. The waste produced from the copper extraction process needs to be disposed onto an authorised waste disposal facility. In support of these processes, Bosveld Phosphates requires a suitable authorised waste disposal facility where the waste produced from this copper extraction process can be disposed and stored for future use.

The sections below provide a brief description of the activities and processes associated with the plant (see Figure 4.1(a)).

4.1.1. Phosphoric Acid Production

Phosphoric acid (H_3PO_4), is a colourless, crystalline compound, which is readily soluble in water. The main product is phosphoric acid with a commercial concentration of 52 – 54 % phosphorus pentoxide (**P_2O_5**). Sulphuric - and phosphoric acid are worldwide the most important mineral acids in terms of volume and value.

Two processes using different raw materials can be used in the manufacturing of Phosphoric Acid:

- Thermal processes which use elemental phosphorus as the raw material. Here, elemental phosphorus is produced from phosphate rock, coke and silica in an electrical resistance furnace.
- Wet processes where phosphate minerals are used, which are decomposed with an acid.

There are three possible subgroups of wet processes depending on which acid is used for the acidulation, i.e. nitric acid (HNO_3), hydrochloric acid (HCl) or sulfuric acid (H_2SO_4).

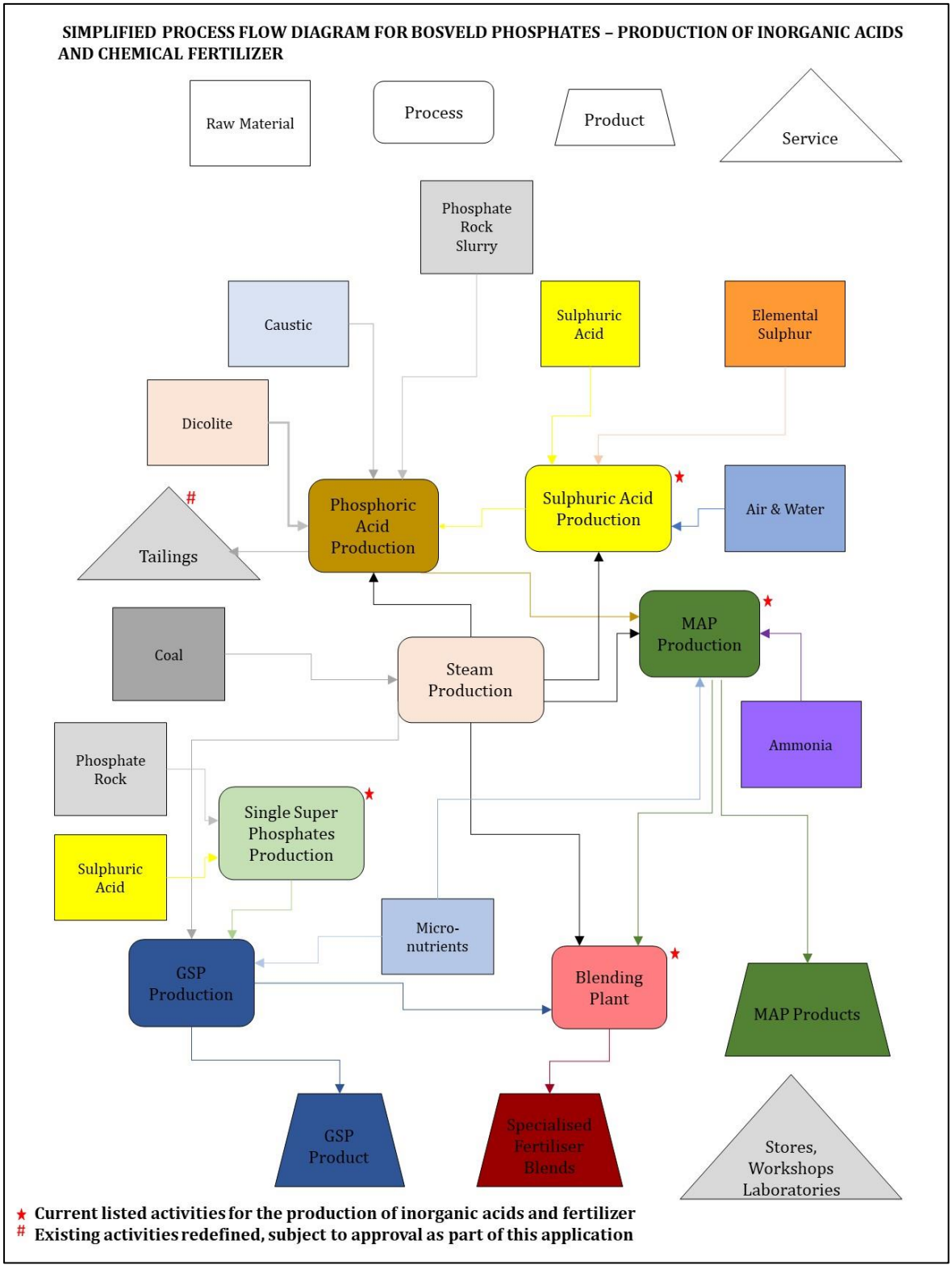


Figure 4.1(a): Simplified Process Flow Diagram for Bosveld Phosphates

The wet digestion of phosphate rock with sulfuric acid is the preferred process in terms of volume and is the process used at Bosveld Phosphates.

Figure 4.2.1(a) gives an overview of the production of phosphoric acid. The tri-calcium phosphate from the phosphate rock reacts with concentrated sulfuric acid to produce phosphoric acid and the insoluble salt calcium sulphate.

$$Ca_3(PO_4)_2 + 3H_2SO_4 \rightarrow 2H_3PO_4 + 3CaSO_4$$

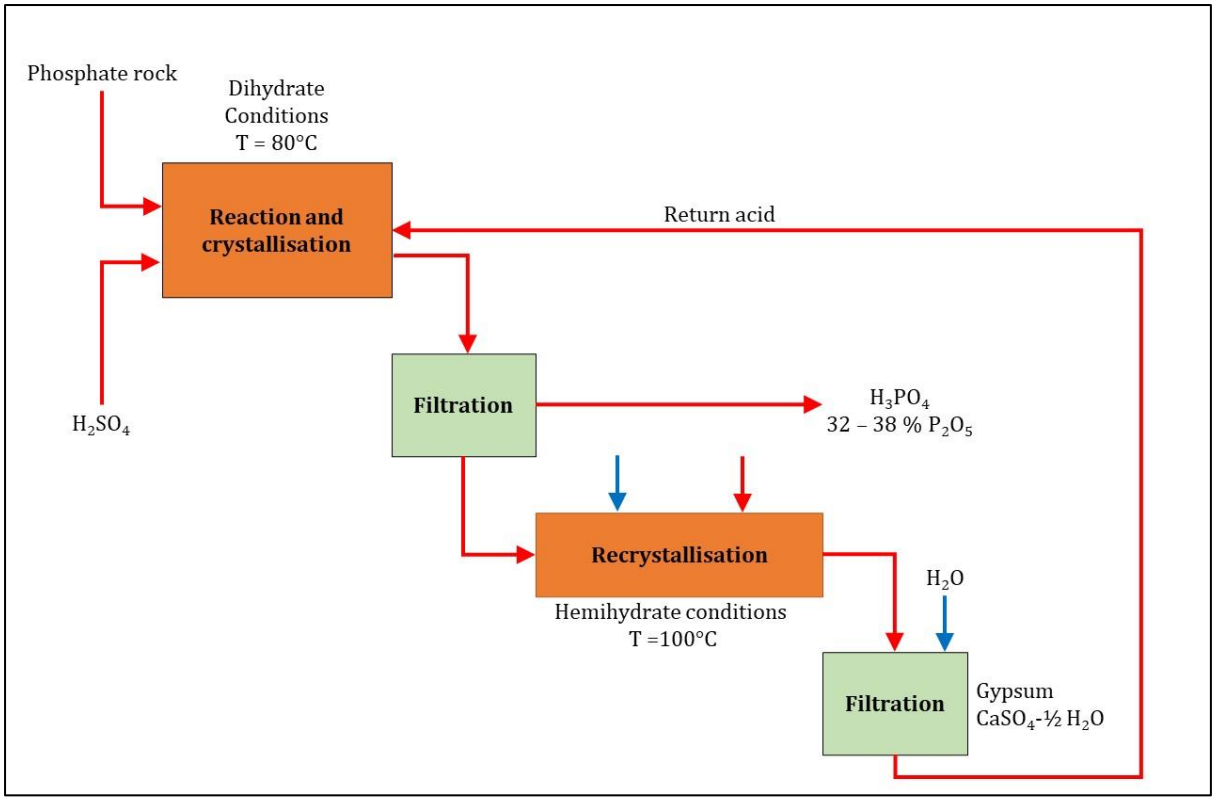


Figure 4.2.1(a): Overview of di-hemihydrate recrystallisation process with double-stage filtration

The insoluble calcium sulphate is filtered from the phosphoric acid. The reaction between phosphate rock and sulfuric acid is restricted by an insoluble layer of calcium sulphate which forms on the surface area of the rock. This restriction is minimised by contacting the phosphate rock with recirculated phosphoric acid, thereby converting as much of it as possible to the soluble mono calcium phosphate, followed by precipitation as calcium sulphate with sulfuric acid.

$$Ca_3(PO_4)_2 + 4H_3PO_4 \rightarrow 3Ca(H_2PO_4)_2$$

$$3Ca(H_2PO_4)_2 + 3H_2SO_4 \rightarrow 3CaSO_4 + 6H_3PO_4$$

Calcium sulphate exists in a number of different crystal forms depending particularly on the prevailing conditions of temperature, phosphorus pentoxide concentration and free sulphate content.

The operating conditions ensures that the calcium sulphate is precipitated as the dihydrate form, i.e. 26 – 32 % phosphorus pentoxide at 70 – 80 °C during the first stage precipitation and 40 – 52 % phosphorus pentoxide at 90 – 110 °C for the hemihydrate second stage precipitation.

Circulation of the reactor contents provides the necessary mixing. The reaction system consists of a series of separate agitated reactors. The slurry temperature is controlled by the use of a flash cooler. This also de-gases the slurry making pumping easier.

The filtration stage separates the phosphoric acid from the calcium sulphate. About four to five tonnes of gypsum are generated for every tonne (phosphorus pentoxide equivalent) of acid produced. Bosveld Phosphates utilises tilting pan (vacuum assisted), traveling belt (vacuum assisted) and filter press filtration equipment for the various filtration stages. The filter medium is moved in sequence through the various stages for continuous operation.

The initial separation is followed by stages of washing, which ensures that all the soluble phosphorus pentoxide is recovered.

Following the first filtration stage the product is concentrated through an evaporative process (see Figure 4.2.1(b)). The forced circulation evaporator consists of a heat exchanger, vapour or flash chamber and condenser.

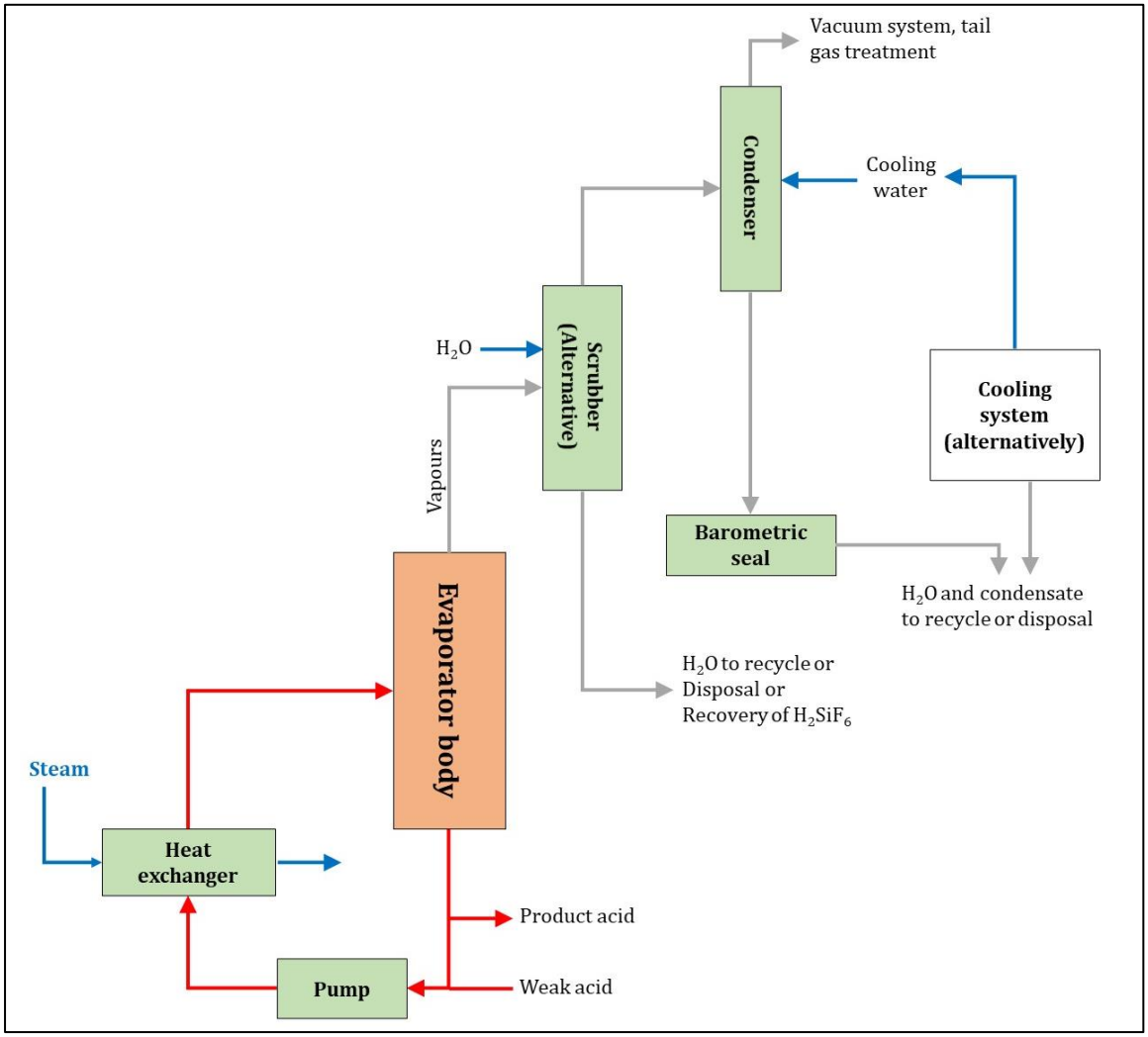


Figure 4.2.1(b): Forced circulation evaporator for the concentration of Phosphoric Acid

Recrystallisation is performed to improve the phosphorus pentoxide yield prior to final filtration to achieve a 54% product.

4.1.2. Sulphuric Acid Production

For an overview of the production of sulfuric acid, see Figure 4.2.2(a). Sulfuric acid is produced at Bosveld Phosphates from sulphur dioxide (SO_2), which is derived from elemental sulphur.

Elemental sulphur is derived from desulphurisation of natural gas or crude oil by the Claus process. Sulphur in liquid form (at temperatures of 140 – 150 °C), delivered via road tankers, accounts for 30% of the intake and sulphur in the form of solid prills about 70%.

Sulphur in prill form is delivered via rail and stockpiled. The solid sulphur is melted at 130°C and filtered prior to combustion at 1 000 to 1 100°C to produce sulphur dioxide.

Sulphur dioxide is then converted into sulphur trioxide (SO_3) in a gas phase chemical equilibrium reaction, using a catalyst:

$$SO_2 + ½\ O_2 \leftrightarrow SO_3 \qquad \Delta H0 = -99\ kJ/mole$$

The conversion rate is defined as follows:

Conversion rate = (SO_2 in – SO_2 out) / SO_2 in x 100 (%)

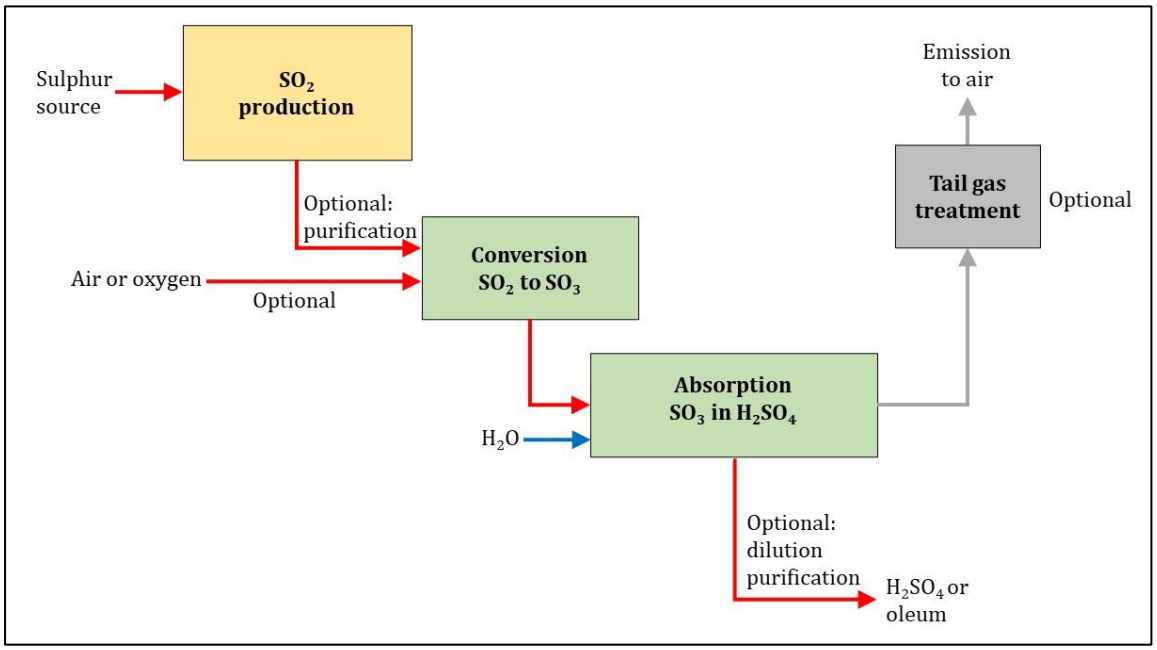


Figure 4.2.2(a): Sulphuric acid production process overview

Both thermodynamic and stoichiometric considerations are taken into account of maximising the formation of sulphur trioxide.

The Lechatelier-Braun principle - when an equilibrium system is subjected to stress, the system will tend to adjust itself in such a way so as to partly relieve the stress - needs to be considered for optimisation of the equilibrium.

The stresses are, for instance, variations of temperature, pressure, or the concentration of a reactant.

For SO_2/SO_3 systems, the following methods are available to maximise the formation of sulphur trioxide:

- as this is an exothermic process, a decrease in temperature by removal of the heat will favour the formation of sulphur trioxide
- increased oxygen concentration
- sulphur trioxide removal (as in the case of the double absorption process)
- increased pressure
- catalyst selection, to reduce the working temperature (equilibrium)
- longer reaction time

Only vanadium compounds, platinum and iron oxide have proven to be technically satisfactory when tested for catalytic activity for sulphur dioxide oxidation. At present, vanadium pentoxide is used almost exclusively.

In industrial practice, the lower temperature range is 410 – 440 ºC for conventional catalysts and 380 – 410 ºC for caesium treated catalysts.

The upper temperature range is 600 – 650 ºC, above this, catalytic activity can be permanently lost due to internal surface area reduction. The average operating life for the catalyst is approximately 10 years.

Operating life is generally determined as a result of catalyst losses during screening of the catalyst, which has to be carried out periodically to remove dust.

Optimising the overall system behaviour requires a balance between reaction velocity and equilibrium. However, this optimum also depends on the sulphur dioxide concentration in the raw gas and on its variability.

Consequently, each process is more or less specific for a particular sulphur dioxide source.

Two general converter types have been in use extensively in the past:

- the brick-arch support and
- the cast iron beams and columns design (still very popular in North America)

Newer converter types are:

- central core tube converters
- converters with one or more integrated heat exchangers (with the heat exchanger placed in the core tube or “wrapped” around the outer shell of the converter vessel)

Figure 4.2.2(b) illustrates the essential difference in design of brick-arch and core tube converters.

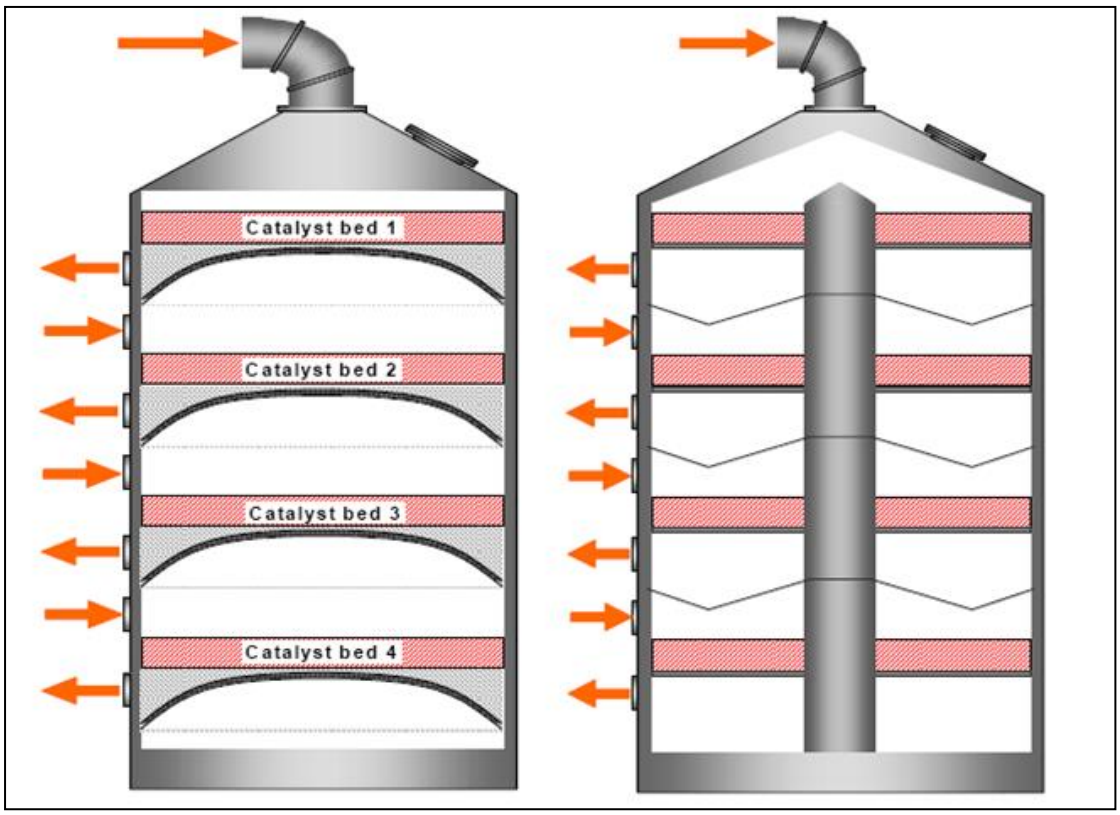


Figure 4.2.2(b): Schematic of a brick arch converter (left) and a core tube converter (right)

Finally, sulphuric acid is obtained from the absorption of sulphur trioxide and water into sulfuric acid (with a concentration of at least 98 %). For an example of a final absorber, see Figure 4.2.2(c).

The efficiency of the absorption step is related to:

- the sulfuric acid concentration of the absorbing liquid (98.5 – 99.5 %)
- the temperature range of the liquid (normally 70 – 120 ºC)
- the technique of acid distribution
- the raw gas humidity (mist passes the absorption equipment)
- the mist filter
- the temperature of incoming gas
- the co-current or counter current character of the gas stream in the absorbing liquid

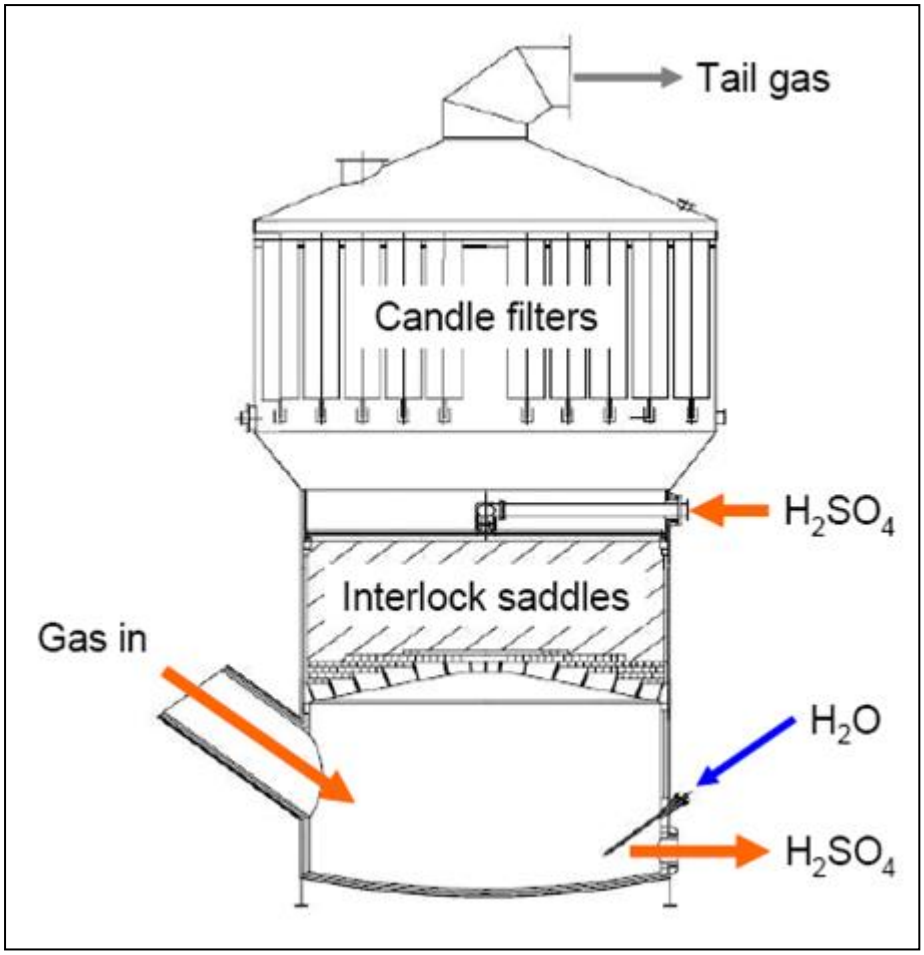


Figure 4.2.2(c): Schematic of a typical final absorber

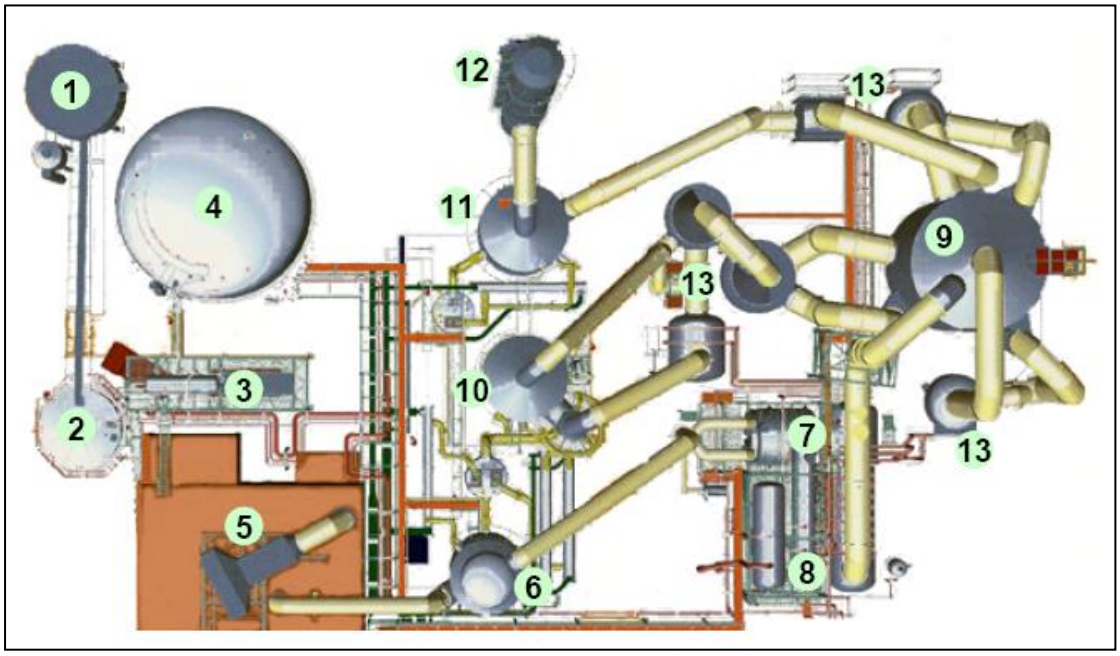


Figure 4.2.2(d): Schematic of a typical sulphuric acid plant layout

Figure 4.2.2(d) gives an impression of a sulphuric acid plant similar to the operation at Bosveld Phosphates. The example shows a double contact/double absorption plant based on sulphur combustion:

1. solid sulphur storage
2. sulphur melting
3. liquid sulphur filtration
4. liquid sulphur storage
5. air filter and silencer
6. air dryer
7. sulphur combustion, five burners with individual air supply
8. steam drum, feed-water tank, waste heat boiler
9. converter
10. intermediate absorber
11. final absorber
12. stack
13. heat exchangers, economisers and superheater.

4.1.3. Phosphate Rock

Phosphate ores are found in two major geological origins: igneous or sedimentary. The phosphate minerals in both types of ore are of the apatite group, of which the most commonly encountered variants are fluorapatite $Ca_{10}(PO_4)_6(F,OH)_2$, and francolite $Ca_{10}(PO_4)_{6-x}(CO_3)_x(F,OH)_{2+x}$.

Fluorapatite predominates in igneous phosphate rocks and francolite predominates in sedimentary phosphate rocks.

Most phosphate ores have to be concentrated or beneficiated before they can be used. Different techniques may be used at the beneficiation stage, to treat the same ore for removal of the gangue and associated impurities. This gives rise to further variations in the finished ore concentrate product.

Phosphoric acid technology has to rely on raw materials of variable consistency and the technology needs to be constantly adapted to meet raw materials variations.

Bosveld Phosphates receives phosphate rock in a slurry from Foskor. A typical analysis of phosphate rock received from Foskor is provided below:

- 36.8 wt-% P_2O_5 - 0.1 wt-% Organics
- 52.1 wt-% CaO - 0.3 wt-% SrO
- 2.6 wt-% SiO_2 - 13 ppm As
- 2.2 wt-% F - 1 ppm Cr
- 3.5 wt-% CO_2 - 0.1 ppm Hg
- 0.2 wt-% Al_2O_3 - 11 ppm Pb
- 0.3 wt-% Fe_2O_3 - 2 ppm Ni
- 1.1 wt-% MgO - 6 ppm Zn
- 0.1 wt-% Na_2O - 134 ppm U_3O_8
- 0.1 wt-% K_2O - 102 ppm Cu
- 0.2 wt-% SO_3 - 1.3 ppm Cadmium

4.1.4. Phosphogypsum

Gypsum (calcium sulphate) is an unavoidable co-product in wet phosphoric acid production ("phosphogypsum"); for every tonne of phosphoric acid (P_2O_5) around 4 – 5 tonnes of gypsum is produced. Phosphate rock contains a range of impurities which are distributed between the product acid and the calcium sulphate.

Because of the volume of the gypsum production and the type and level of impurities in the gypsum, this co-product constitutes a major environmental challenge.

Gypsum for the agricultural market is currently mined from the dihydrate tailings dam A. The load-and-truck process involves the use of a front-end loader and a dump truck to transport the material to a designated dispatch point on site. Customers are responsible for the loading and transport of the gypsum from the site.

The redundant hemidihydrate tailings dam is presently used as a dumping site for dirty sulphur and boiler ash.

4.1.5. Fluorosilicic acid

Most phosphate rocks contain fluoride between 2 – 4 % w/w (solute/solution). This fluoride is released during acidulation as hydrogen fluoride, but reacts readily with excess silica forming fluosilicic acid (H_2SiF_6).

Magnesium and aluminium compounds also react with HF forming $MgSiF_6$ and H_3AlF_6. A proportion of the fluoride is released in the vapour, the amount depending on the reaction conditions, with the rest remaining in the acid solution.

Some of this residual amount may combine with other impurities at a sufficient rate for removal by filtration. The remaining amount will appear as sludge in the product acid. Volatile fluorine compounds can also be present in the release from the evaporator system.

4.1.6. Ammonia Gas

About 80 % of the ammonia worldwide is currently used as the nitrogen source in fertilisers, with the other 20 % being used in several industrial applications. Among the important inorganic products manufactured from ammonia are nitric acid, urea and sodium cyanide.

Anhydrous ammonia will be delivered to Bosveld Phosphates via road and rail tanker. The ammonia is transferred and stored in a horizontal, pressurized storage cylinder with a capacity of approximately 3 000 tons.

The high pressure storage tank and transfer system can be operated so that virtually no evaporative or working losses occur.

4.1.7. Mono Ammonium Phosphate (MAP)

When defining compound fertilisers, the large number of Nitrogen (N)/Phosphate (P)/ Potassium (K) – ratios and the numerous processes applied in their production must be taken into account. Product types are PK, NP (e.g. MAP), NK and NPK.

These products might contain:

- nitrogen, expressed as % of N, in ureic, ammoniacal and/or nitrate forms
- phosphorus, usually expressed as % of P_2O_5, in forms soluble in water and/or neutral ammonia citrate and/or mineral acids
- potassium, usually expressed as % of K_2O, in forms soluble in water
- secondary nutrients, as calcium (CaO), magnesium (MgO), sodium (Na_2O) and/or sulphur (SO_3)
- microelements (zinc, copper, boron, etc.)
- other elements.

Figure 4.2.7(a) gives an overview of the production of NPK fertilisers. Compound fertilisers can be produced in four, basically different, ways:

- production by the mixed acid route, without phosphate rock digestion
- production by the mixed acid route, with phosphate rock digestion
- production by the nitrophosphate route (ODDA process)
- mechanical blending or compactation of single or multi-nutrient components (not included in the figure).

Bosveld Phosphates applies direct neutralisation in a pipe reactor to produce mono ammonium phosphate (MAP). The efficient use of a pipe reactor provides a means of improving the water balance and the energy efficiency as well eliminating the need for a pre-neutralizing process.

A wide range of grades can be produced with this process. The heat of the reaction can also be used to evaporate the water contained in the phosphoric acid so the process can be operated at low recycle ratios and thus with low utilities consumption. The process using phosphoric acid can be written:

$$H_3PO_4 + 2NH_3 \text{ gas} \rightarrow (NH_4)2HPO_4 \text{ dry} + 46\text{kcal}$$

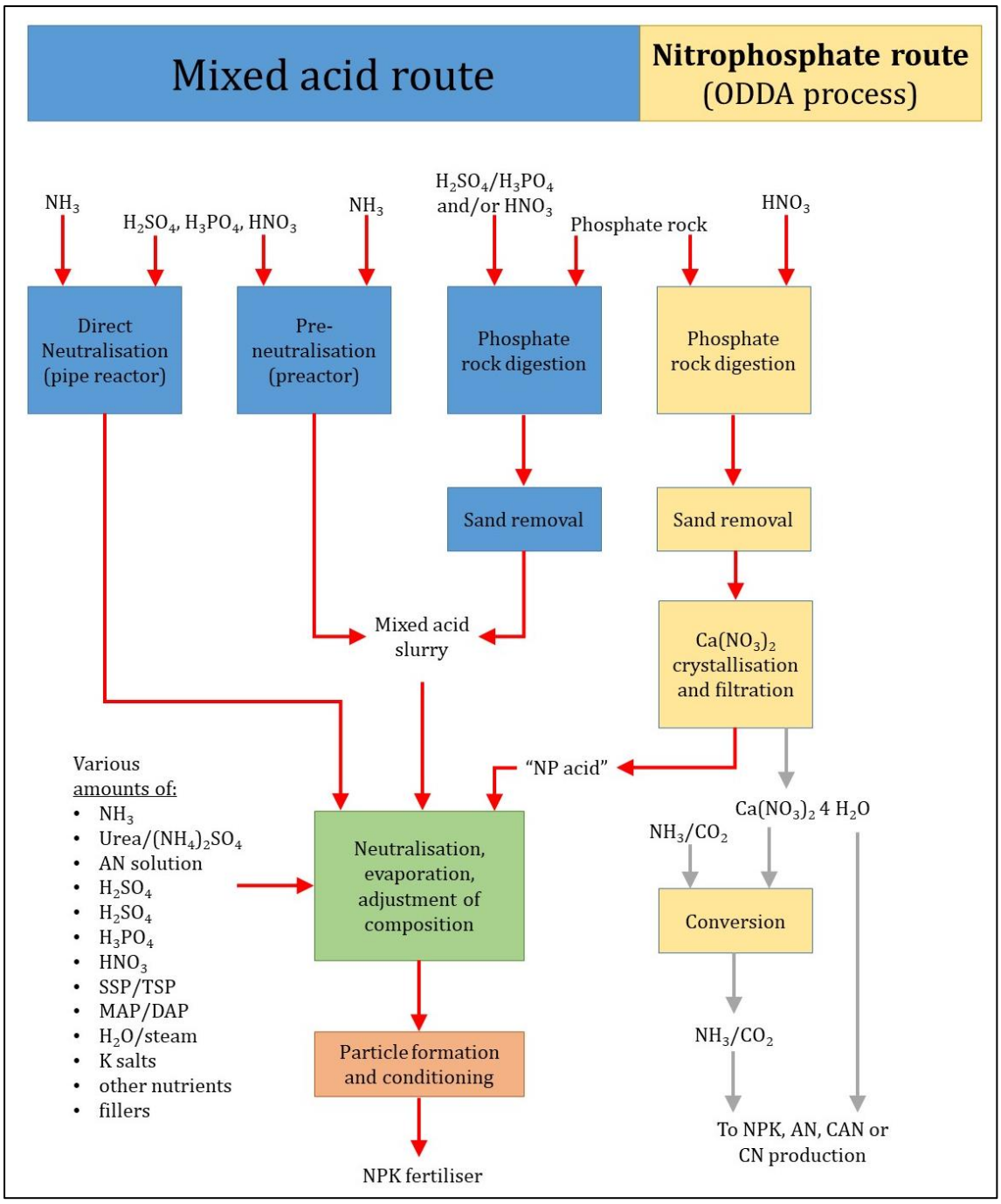


Figure 4.2.7(a): Overview of the production of NPK fertilisers from Phosphate Rock or Single Superphosphate (SSP)/ Triple Superphosphate (TSP)

A pipe reactor is, literally, just that – a length of pipe into which raw materials are introduced to react. The most common embodiment is the T-reactor (Figure 4.2.7(b)), which has a T-shaped mixer at one end. Alternatively, the mixed head may be cross shaped.

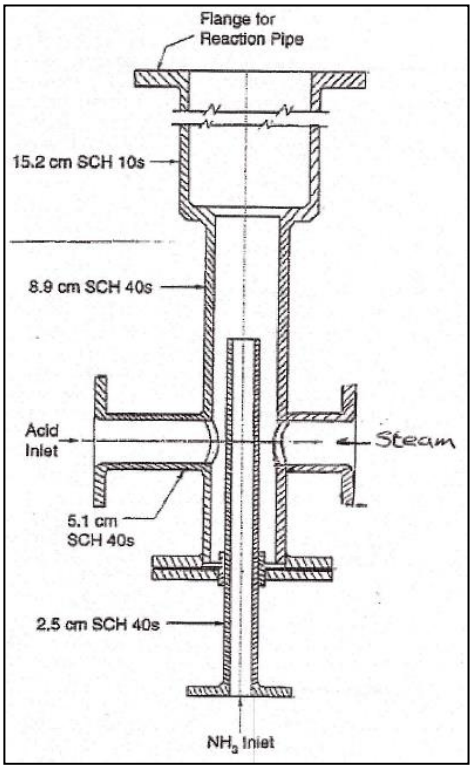


Figure 4.2.7(b): T-shaped Pipe Reactor

In a T-shaped reactor ammonia gas is introduced to the mixer in the direction of the horizontal axis, the other feed – phosphoric acid and sometimes small quantities of steam is added to the mixer head at a right angle to the ammonia (NH_3). While in the pipe, ammonia and the phosphoric acid react to produce a slurry, which is discharged from the end of the pipe to form a powder.

The next step in the process is particle formation and conditioning. The MAP powder is transferred to a granulation drum with the aid of a front-end loader. Some ammonia is reacted with phosphoric acid within the bed of solid raw and recycle material in the granulation drum. The process is very flexible and can produce a broad range of grades, including products with a low nitrogen content (see Figure 4.2.7(c)).

The required temperatures for particle formation and drying depend on the composition of the product. After particle formation, the product is dried and then screened. Fines and crushed oversize material are recycled back into the process. The commercial product is then cooled and coated in a rotating drum before storage in order to minimise the subsequent caking of the material.

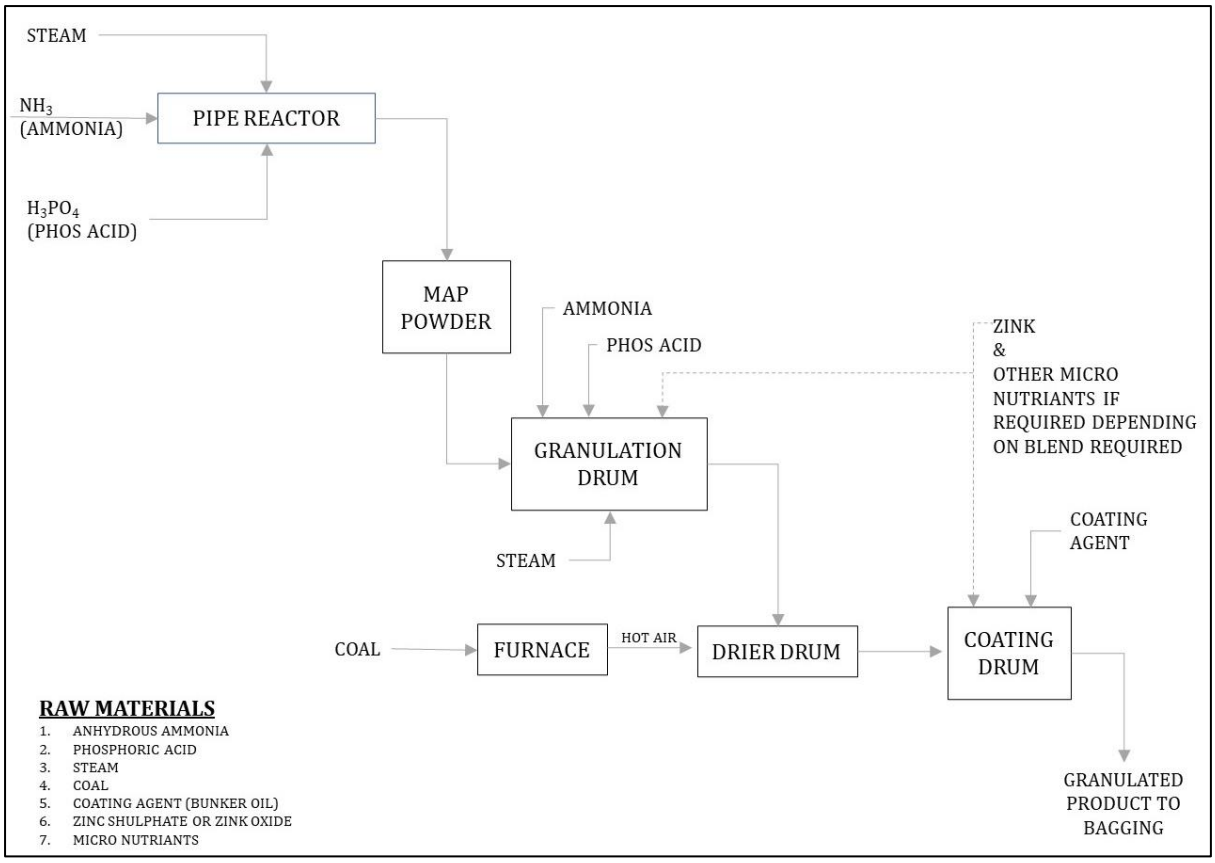


Figure 4.2.7(c): Bosveld Phosphates MAP process diagram

4.1.8. Granular Super Phosphate (GSP)

The phosphate fertiliser industry is divided into three segments: phosphoric acid and super phosphoric acid, normal and triple super phosphate, and granular ammonium phosphate (discussed in the previous section).

Superphosphates, i.e. single superphosphate (SSP) and triple superphosphate (TSP), account for one quarter of the world's phosphate fertiliser production. Normal super phosphate refers to fertiliser material containing 15 to 21 percent phosphorous as phosphorous pentoxide (P_2O_5).

Triple super phosphate, also known as double, treble, or concentrated super phosphate, is a fertiliser material with a phosphorus content of over 40 percent, measured as phosphorus pentoxide. Superphosphates are used as straight fertilisers (marketable products), but are also a feedstock for multinutrient fertilisers.

Single Superphosphate (SSP) fertiliser is currently produced at Farmfos on Erf 2040, Extension 5, Phalaborwa. Bosveld Phosphates is considering the relocation of the process to the company's main operations in order to streamline the production of granular super phosphate (GSP).

SSP fertiliser is prepared by reacting ground phosphate rock with 98 percent sulfuric acid. An important factor in the production of normal super phosphates is the amount of iron and aluminum in the phosphate rock. Aluminum (as Al_2O_3) and iron (as Fe_2O_3) above five percent imparts an extreme stickiness to the super phosphate and makes it difficult to handle.

Ground phosphate rock and acid are mixed in a reaction vessel, held in a semi-enclosed broadfield enclosure for about 30 minutes until the reaction is partially completed, and then transferred, via front-end loader, to a storage pile for curing (the completion of the reaction).

Following curing, the product can be used as a high-phosphate additive in the production of granular fertilizers. It can also be granulated for sale as granulated super phosphate or granular mixed fertilizer. The granulated super phosphate (GSP) material is stored under ambient conditions to allow natural drying from between 10 and 12% moisture to around 7 to 8%. The product is then dried to about 4% moisture in a rotary kiln before it is screened to specification and bagged.

4.1.9. Blending Plant

The straight fertilisers produced at Bosveld Phosphates, i.e. MAP and GSP may be marketed directly or could be used as feedstock in the production of specialised fertiliser blends incorporating a multitude of micronutrients. This activity takes place in the blending plant.

The raw materials are fed from a series of hoppers to a ribbon blender. After a brief blending process the final product passes over a weigh feeder to a bagging plant where 50 kg or bulk bags are filled.

The blending plant also features a 50 000 tons covered storage area and a rail loading facility.

4.1.10. Magnetite Dense Media Separation Plant (SAOB Plant)

Magnetite that has been reclaimed from the neighbouring Foskor stockpiles into trucks are dumped to a ground stockpile and a front-end loader transfers the dumped magnetite to a feed hopper. The top of the hopper is fitted with a static oversize grizzly to ensure that tramp material is prevented from entering the system. A variable frequency drive belt feeder discharges the material onto a plant feed conveyor. The plant feed conveyor discharges the material into the mill feed chute.

Pulping water and Landsky screen oversize are added to the fresh feed. The discharge from the wet ball mill is directed over a trommel screen. The screen serves to remove any scats from the mill or oversize contamination that may have been present in the feed stream. The oversize from the trommel screen is directed to a bin for disposal and the undersize is directed to the mill discharge sump. Water is added to the screen to ensure an efficient separation and to dilute the trommel screen undersize.

The material in the mill discharge sump is further diluted to the appropriate solids concentration before being pumped to the rougher magnetic separators which will consist of two machines operating in parallel. The non-magnetics discharge from the rougher magnetic separators is directed to the tailings collection tank while the magnetics discharge is directed to the Landsky screen feed sump.

Dilution water is added to the feed sump and the slurry is pumped to the Landsky screen. The oversize from the Landsky Screen is directed to the mill feed chute and undersize is directed to cleaner/recleaner magnetic separators. The cleaner/recleaner magnetic separators will be a two drum, double stage unit combined in a single frame. If required, the feed to the magnetic separators is diluted to the required slurry concentration. The non-magnetics discharge from the cleaner/recleaner magnetic separators is directed to the tailings collection tank while the magnetics discharge is directed to the magnetic classifier feed sump/ filter feed sump.

Dilution water is added to the magnetic classifier feed sump/ filter feed sump, if required to make up the requisite solids density. The slurry is then pumped to the four magnetic classifiers operating in parallel for the final stage of beneficiation. The overflow from the magnetic classifiers is directed to the tailings collection tank and the underflow gravitates to the product filters.

The underflow from the magnetic classifiers is directed to the product vacuum disk filter. The solids cake discharge from the filter will be directed to a product conveyor that will transport the material to a simple conical stockpile for reload onto trucks by front-end loader. The effluent discharge from the filter will be directed to the process water tank.

Non-magnetic tailings from the process are collected in the tailings collection sump and pumped to a tailing's thickener. From the tailing's thickener, the material is pumped to the copper flotation plant for processing.

4.1.11. Magnetite Drying Plant (MP2)

Refer to Figure 4.1.11(a) for a simplified flow diagram of the Magnetite Drying Plant. Magnetite (Fe_3O_4) is loaded into a feed hopper by a front-end loader at a rate of 100 tonnes per hour. The magnetite is transferred via a conveyor to the rotary drum dryer. The rotary drum drying is heated by two coal fired stokers (operating at 250kg/h each) supplement with a HFO burner (operating at a 200 l/h).

On exit the magnetite is cooled in a cooler rotary drum to 60°C and 0.5% moisture, before it is conveyed to a dry cooled holding bin. From the holding bin it is conveyed to the magnetic drum separation tower and screw fed into three magnetic separation units at a rate of 34 tonnes per hour.

Two stages of separation take place, the rougher stage and scavenging stage. The scavenging stage is gravity fed from the rougher stage for further winning of magnetite. Both the concentrate streams gravitate to the product conveyor for stockpiling. The upgraded magnetite concentrate is transported to clients off site.

The non-Magnetite Tailings / Product 2 is stored temporarily at a dedicated storage area from where it will be loaded by a front-end loader and trucked to the copper flotation plant feed bin stockpile.

4.1.12. Copper Flotation Plant

Refer to Figure 4.1.12(a) for a simplified flow diagram of the Copper Flotation Plant. Product 2 from the wet Magnetite plant will be pumped from the thickener underflow from the SAOB Plant into the flush floatation feed sump. Product 2 from the dry beneficiation (MP2) plant will be tipped into a feed bin by a front-end loader and fed via a variable speed conveyor onto the mill feed conveyor. Product is conveyed via a belt conveyor to a ball mill feed chute. Pulping water and Derek screens oversize is added to the fresh feed.

Reagent collectors (Pax and NaSH) is added at this point to allow for conditioning time before the flash flotation process. The discharge from the wet ball mill is directed over a trommel screen. The screen serves to remove any scats from the mill or oversize contamination that may have been present in the feed stream. The oversize from the trommel screen is directed to a bin for disposal and the undersize is directed to the mill discharge sump / or flush flotation feed sump. Feed from both the wet process as well as the dry magnetite beneficiation process is combined into the flush float sump from where it is pumped into the flush flotation cell.

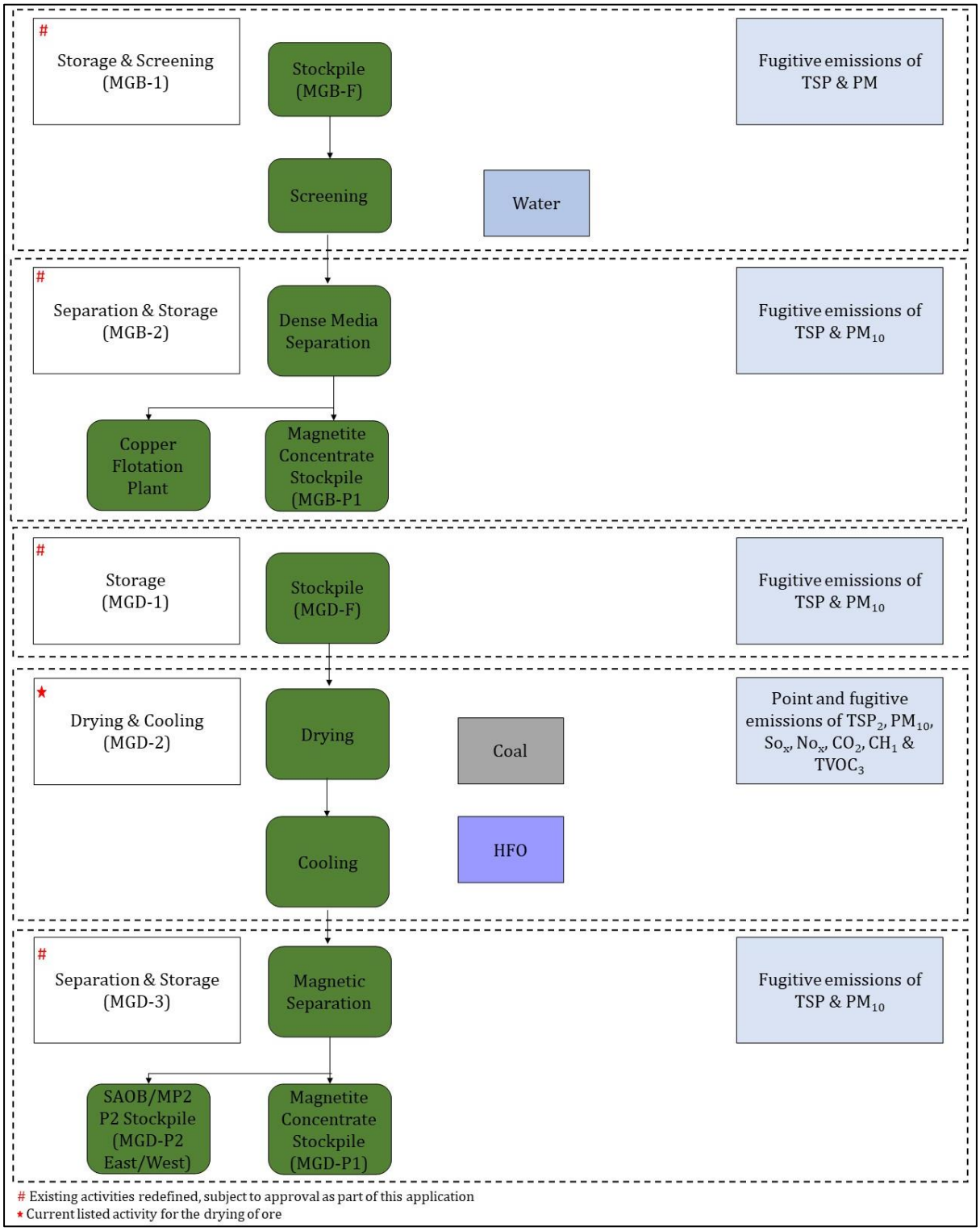


Figure 4.1.11(a): Simplified Block Diagram for Magnetite Beneficiation

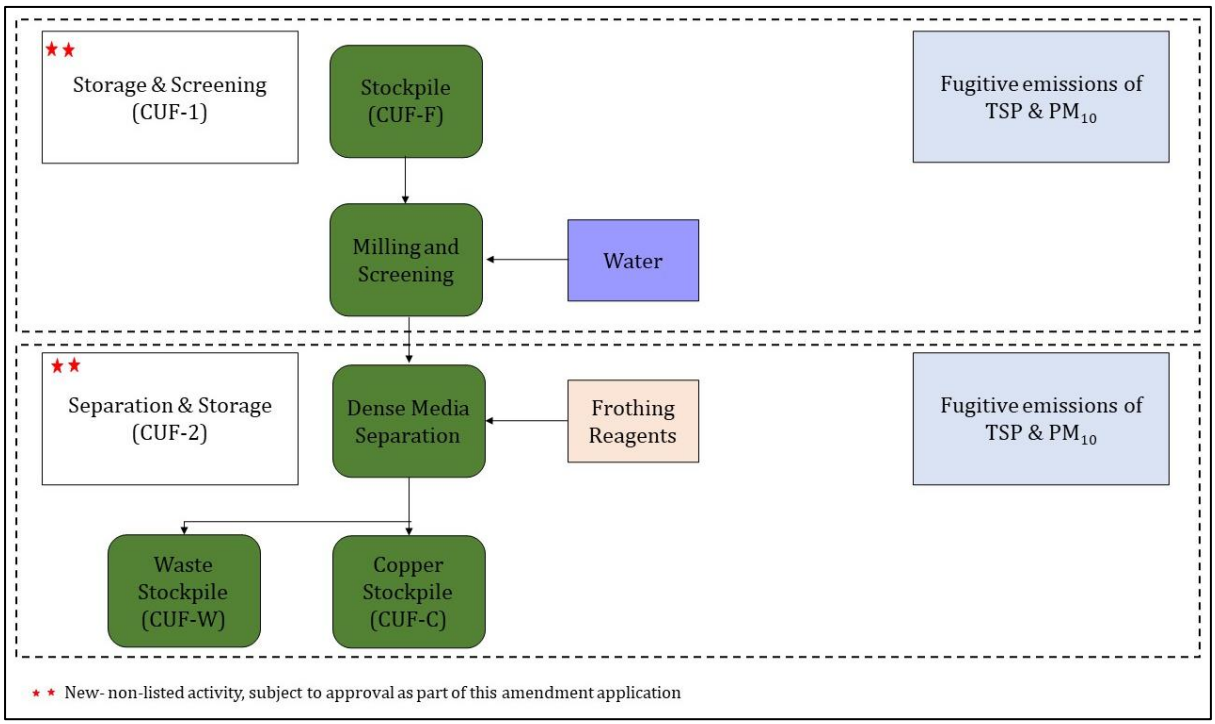


Figure 4.1.12(a): Simplified Block Diagram for the Copper Flotation Plant

Reagents such as a frother (Senfroth 200) reagents are added to the pulp to recover ultra-fine copper which is pumped to the copper flotation cleaner cells. Once the fines are recovered, product is dewatered to contain 30% solids and pumped through a Derek screen stacker. Oversize material is pumped to the mill for further liberation.

Under sized material is pumped to the conditioning tank where more reagents PAX, NaSH are added to the pulp. After conditioning, product is pumped into the rougher cell, where a frother, (Senfroth 200) is added.

The product is pumped through two rougher cells and another reagent (AM810) is added. Product is pumped through two more rougher cells and then discharged to a disk filter where water is extracted. From the disk filter, product is conveyed to a stockpile. Recovered water is pumped back to the thickener to be re-used. Concentrate recovered at the rougher stage is pumped to the cleaner and re-cleaner processes to upgrade product grade.

Concentrate produced are pumped to a press filter where excess water is removed and concentrate product deposited onto a stockpile. From the concentrate stockpile, material is fed into a bagging plant where it is bagged into 1-ton bags.

Waste material is loaded by a FEL / Excavator onto ADT's and transported to a dedicated waste site.

4.1.13. Steam Generation

Bosveld Phosphates operates four coal fired John Thomson Africa Economic boilers (Design Code BS 2790). The steam boilers are all manual feed, single chaingrate, bottom burning units.

A front-end loader is used to transfer bituminous coal from the coal stockpile yard into the individual feed hoppers of the boilers.

Ash is collected from the bottom of the boilers and conveyed via a submerged conveyor system to an ash pit.

Off-gases from the boilers are vented, via multi cyclone grit collectors.

4.1.14. Laboratories, Stores and Maintenance Workshops

The plant further incorporates a quality assurance laboratory, a research laboratory, consumable stores, decontamination facility and maintenance workshops including electrical, mechanical, instrumentation and auto electrical.

4.2. SUMMARY OF OVERALL ACTIVITY INFRASTRUCTURE

The Bosveld Phosphates site has been segregated into several operational management areas based on the geographical locality, site inventory and facilities as well as the processes and flow of material.

The following operational management areas at Bosveld Phosphates have been delineated and are illustrated on Figure 4.2(a):

- Operational Plant Management Area
- Gypsum Dam A Management Area
- Gypsum Dam B Management Area
- Emergency Dam Management Area
- North-Western Veld Management Area
- Southern Open Veld Management Area

Further details pertaining to this individual management areas are provided in the sections below.

Infrastructure associated with the greater Bosveld Phosphates site is relayed on Figure 4.2(b). Due to the nature of the operations at Bosveld Phosphates, most of the activities and infrastructure on site is constrained to the Operational Plant Management Area – see Figure 4.2(c).

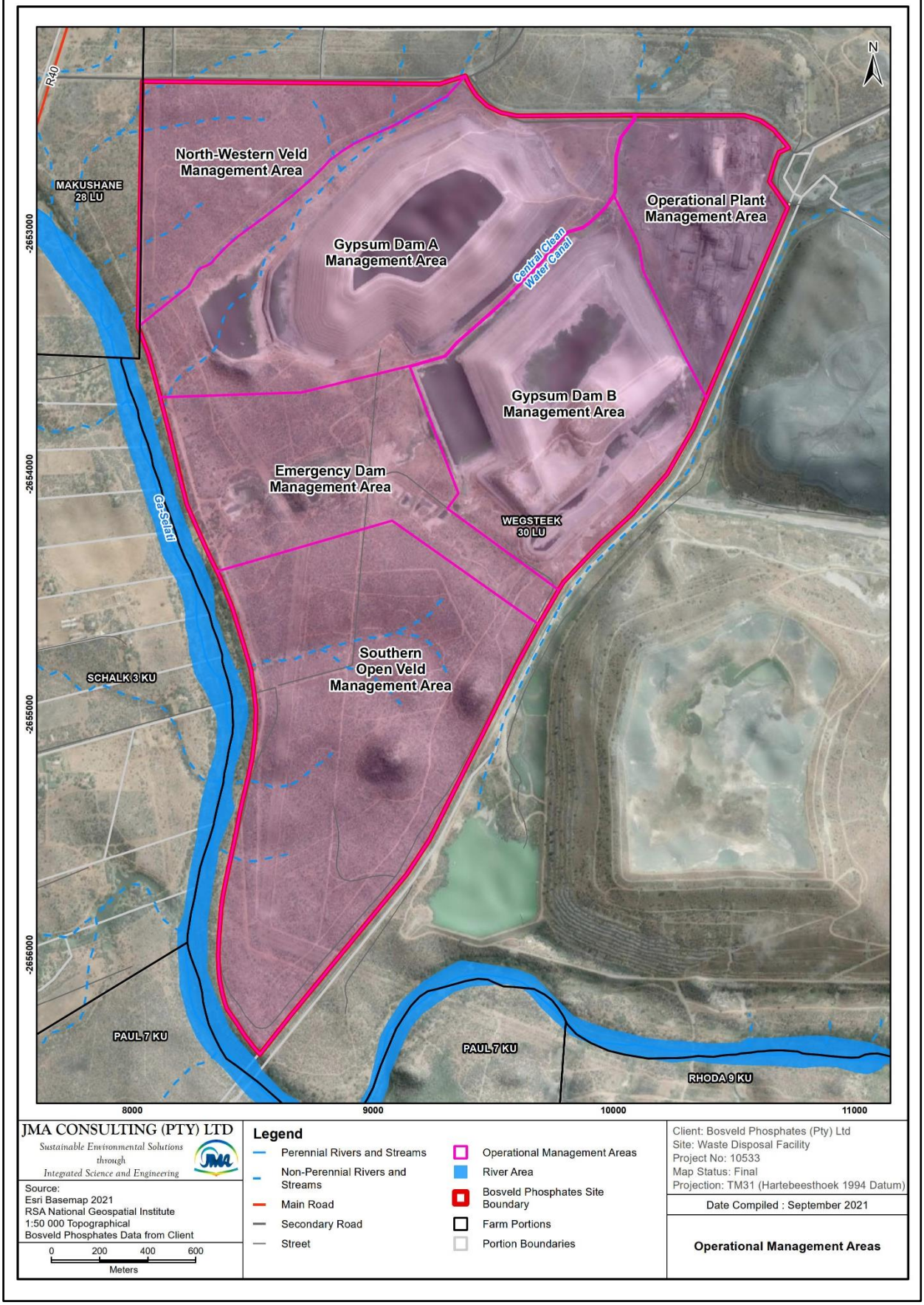


Figure 4.2(a): Delineated Operational Management Areas

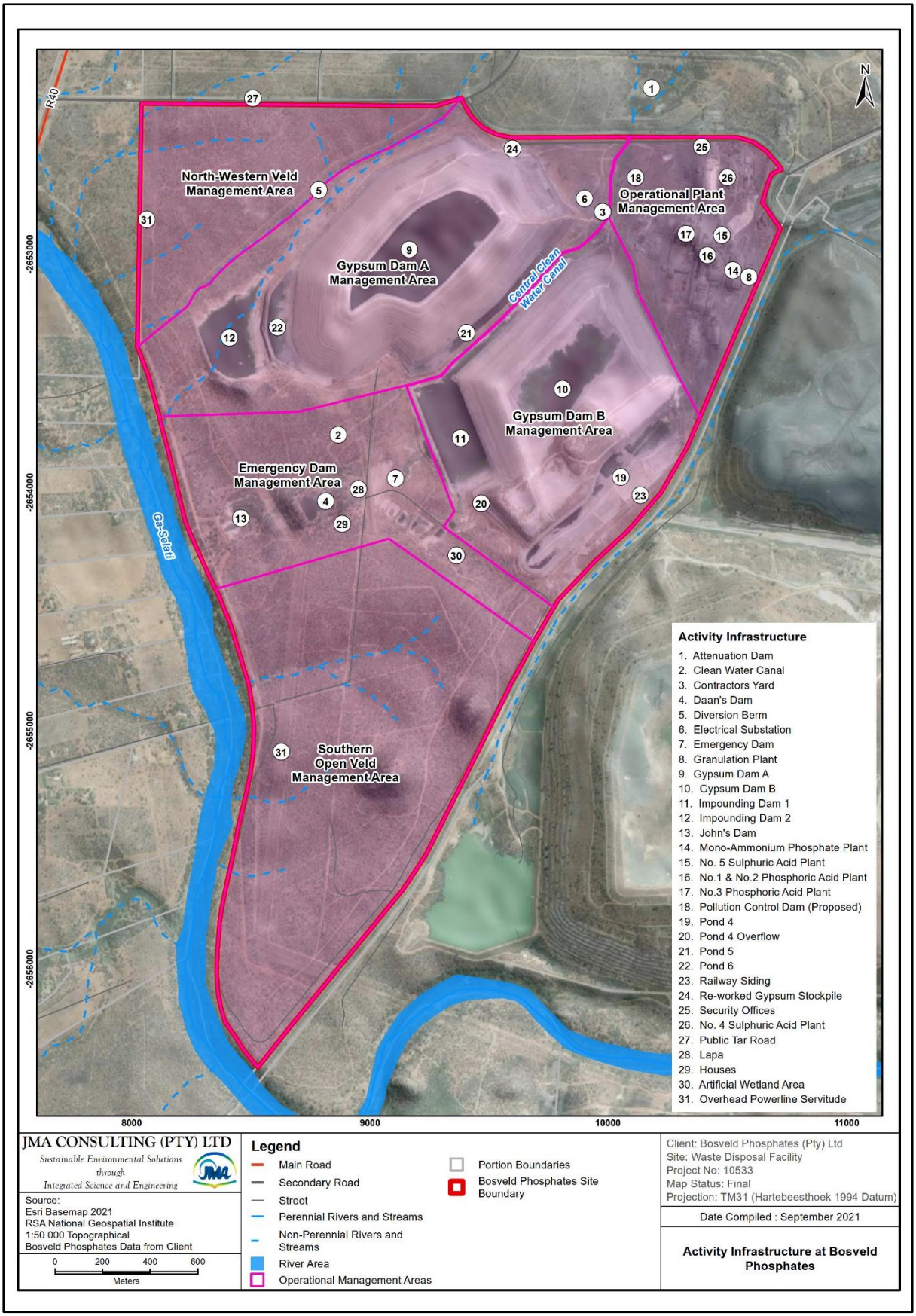


Figure 4.2(b): Activity Infrastructure at Bosveld Phosphates

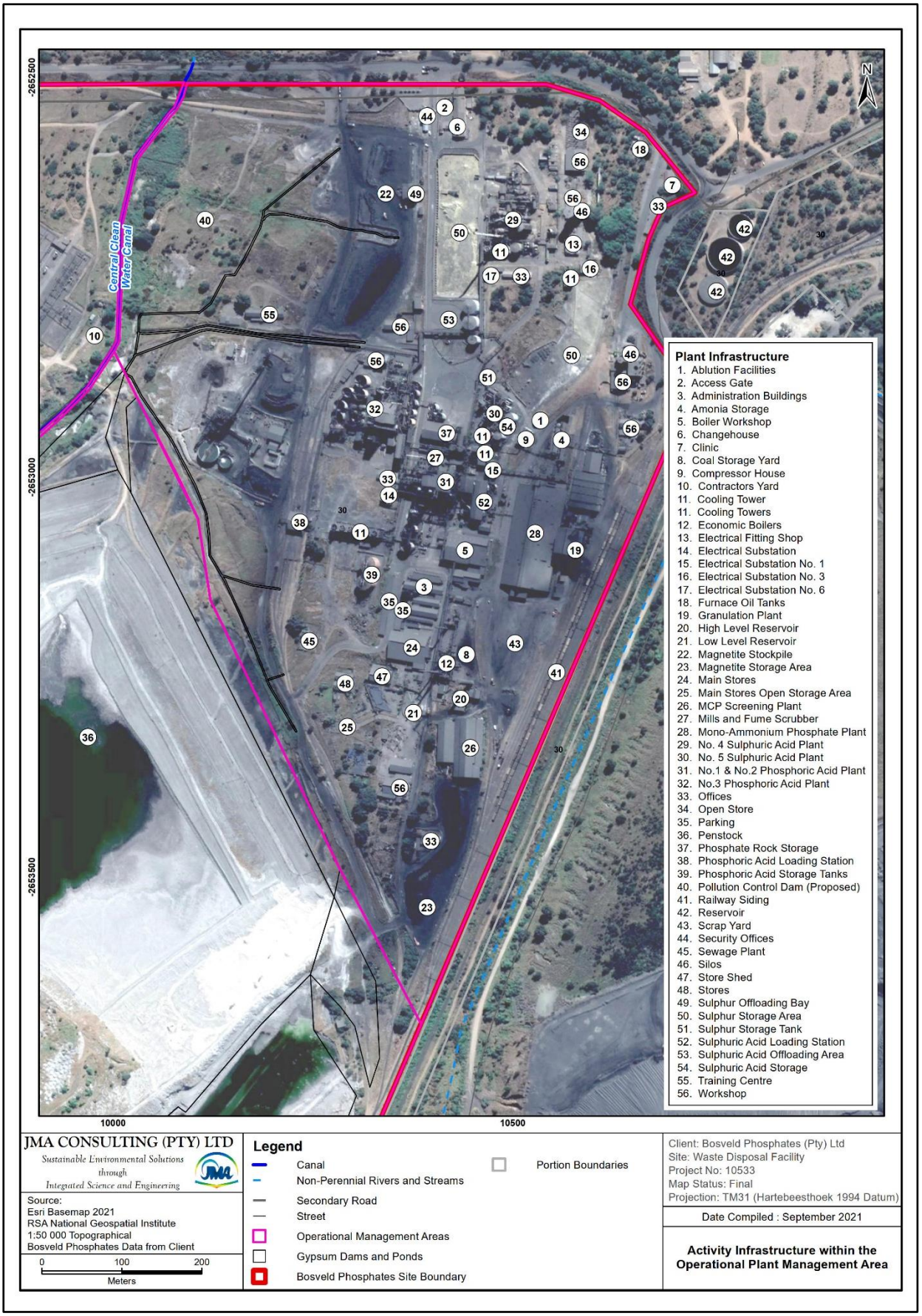


Figure 4.2(c): Activity Infrastructure within the Operational Plant Management Area

4.2.1. Operational Plant Management Area

The Operational Plant Management Area is situated within the north-eastern extent of the site and comprises of the entire plant area. A list of the major activity infrastructure within this management area is given below:

- Site Access Gate
- Security Offices
- Access Roads
- Railways and Sidings
- Weighbridge
- Change Houses
- Parking Areas
- Storage Tanks
- Stores
- Silos
- Conveyors
- Reservoirs
- Workshops
- Administration and Office Buildings
- Training Centre
- Raw Material and Final Product Loading Bays / Stations
- Magnetite Stockpile and Storage Areas
- Sulphur Stockpile and Storage Areas
- Cooling Towers
- Scrubbers
- Sulphuric Acid Plant (SAP) No. 4
- Sulphuric Acid Plant (SAP) No. 5
- Phosphoric Acid Plant (PAP) No. 1 & No.2
- Phosphoric Acid Plant (PAP) No.3
- Mono-Ammonium Phosphate (MAP) Plant
- Granulation Plant
- Screening Plant
- Sewage Plant
- Scrap Yard
- Storm Water Canals and Berms
- Pollution Control Dam

4.2.2. Gypsum Dam B Management Area

The Gypsum Dam B Management Area is situated to the west and south-west (down-gradient) of the Operational Plant Management Area. A list of the activity infrastructure within this management area is given below:

- Gypsum Dam B (Stack B)
- Hemi-Hydrate Dump
- Domestic Waste Disposal Facility
- Pond 4
- Pond 4 Overflow
- Impounding Dam 1
- Stormwater Canals and Diversion Berms
- Access Roads

- Railway Siding

4.2.3. Gypsum Dam A Management Area

The Gypsum Dam A Management Area is situated to the north-west of the Gypsum Dam B Management Area and to the West of the Operational Plant Management Area. A list of the activity infrastructure within this management area is given below:

- Gypsum Dam A (Stack A)
- Pond 5
- Pond 6
- Impounding Dam 2
- Reworked Gypsum Stockpile
- Electrical Substation
- Contractors Yard
- Stormwater Canals and Diversion Berms
- Access Roads
- Overhead Powerline

4.2.4. Emergency Dam Management Area

The Emergency Dam Management Area is located south-west of the Gypsum Dam B Management Area. A list of the activity infrastructure within this management area is given below:

- Emergency Dam
- Daan's Dam
- John's Dam
- Artificial Wetland Area
- Clean Water Canal
- Stormwater Diversion Berms
- Lapa
- Houses
- Access Roads
- Overhead Powerline

4.2.5. North-Western Open Veld Management Area

The North-Western Open Veld Management Area is situated to the west of the Gypsum Dam A Management Area (west of the clean water diversion berm). A list of the activity infrastructure within this management area is given below:

- Stormwater Diversion Berms
- Access Roads
- Overhead Powerline

4.2.6. Southern Open Veld Management Area

The Southern Open Veld Management Area is situated to the south of the Emergency Dam Management Area. A list of the activity infrastructure within this management area is given below:

- Access Roads
- Overhead Powerline

4.3. PROPOSED ACTIVITIES, INFRASTRUCTURE AND PROCESSES

Bosveld Phosphates requires a suitable authorised waste disposal facility where non-magnetite tailings can be stored for future use.

In summary, the proposed activities associated with this project will comprise of a Magnetite Waste Site Disposal Facility (MWSDF), an Access Road to the MWSDF and a Pollution Control Dam (PCD) including dirty water channels and a silt trap and a Copper Flotation Plant (see Figure 4.3(a)).

4.3.1. Magnetite Waste Site Disposal Facility

The proposed MWSDF will comprise the following design elements:

- A 1.5m high toe wall comprising of compacted colluvium soil founded on the residual gneiss, providing containment during the early deposition into the facility;
- A Class C barrier system beneath the MWSDF;
- A network of seepage collection drains constructed in the basin of the MWSDF; and
- A concrete lined solution trench to channel filter discharge and runoff from the outer slopes to the proposed PCD.

A summary of the design criteria and details is presented in Table 4.3.1(a).

Table 4.3.1(a): MWSDF Parameters

Parameter	Value
In-situ Dry Density	1.89 tonnes/m^3
Design Waste Tonnage	2 500 000 tonnes
Outer Slopes of Lifts	1:3 V:H
Bench Width	10m
Bench Height	10m
Final Elevation	400 mamsl
Maximum Height of MWSDF	31m
Capacity	1 510 759 m^3
Footprint Area	118 607 m^2 (11.86 ha)

The barrier system will be placed over 1:3 slopes.

The under-drainage layer will form part of the barrier system to collect any leakage resulting from rainfall that may penetrate the barrier system and any water seeping underneath the MWSDF.

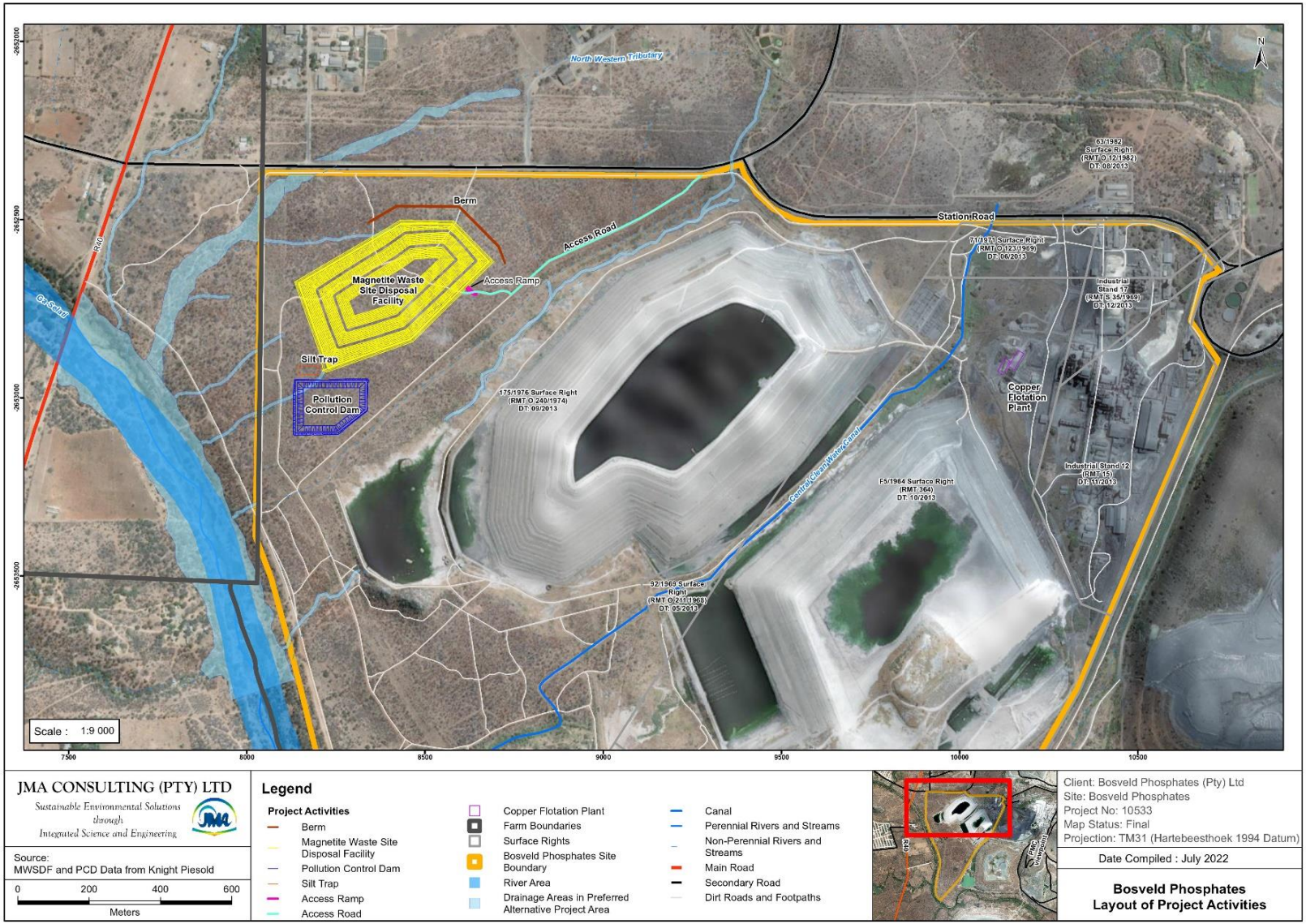


Figure 4.3(a): Layout of Proposed Activities

The under-drainage layer will comprise finger drains at 20 m centre to centre. The finger drains will be arranged in a herringbone system and the trenches will be 300 mm wide by 300 mm deep. The herringbone system will discharge into the solution trenches running outside the perimeter of the MWSDF monitoring the leakage rate and the efficiency of the barrier system. Dirty water channels will collect runoff along the perimeter of the MWSDF and the seepage from the MWSDF and convey it to the silt trap.

These channels will be sized to contain the 1:50 year flood peak in compliance with the GN 704, ensuring that the dirty water system does not spill into a clean water system more than once in 50 years. The channels shall be trapezoidal with a 1:1 slope and will be concrete lined. The properties of these channels are provided in Table 4.3.1(b).

Table 4.3.1(b): Dirty Water Trapezoidal Channel Hydraulic Properties

Channel	Design Discharge (m3/s)	Manning's n	Longitudinal Slope (%)	Base Width (m)	Flow Depth (m)	Velocity (m/s)	Froude Number	Free-board (m)	Design Depth (m)
Eastern	6.93	0.012	1.35	0.8	0.7	5.41	1.93	0.1	0.8
Western	6.93	0.012	1.30	0.8	0.7	5.41	1.93	0.1	0.8

A concrete silt trap will be placed between the MWSDF and PCD.

The size of the silt trap is dependant on the dimensions of the particles to be removed, the depth of the pond and the pond design inflow rate. It was assumed that:

- The pond shall be designed to settle out all particles coarser than 0.025 mm
- The design flow for the removal of the suspended solids was assumed to correspond with the 1:2 year, 24 hour flood flow and,
- The maximum pond depth is 1.0m

The silt trap is designed as a dual system, to facilitate the removal of sediment from one bay while the other remains in operation.

4.3.2. Pollution Control Dam (PCD)

The Pollution Control Dam (PCD) is designed to contain the 1:50 year storm event without spilling into the environment. The total volume of the PCD is 57 257.52 m^3 to a depth of 4 m (footprint area 29 502.5 m^2). The total volume comprises water received from direct precipitation and runoff from the catchment between the MWSDF and the PCD basin.

Outflows from the PCD are from evaporation and abstraction. For an average climatic year, in order to maintain a pool depth not exceeding 2.3 m, a minimum 80 m^3/day of pumping abstraction would be required during the rainy season from February to June. This pumping rate is also adequate to cater for an upset caused by a 1:50 year storm event. For a wet climatic year, in order to maintain a pool depth not exceeding 2.6 m, a minimum 200 m^3/day of pumping abstraction would be required over the months from November to July.

4.3.3. Access Road to the Magnetite Waste Site Disposal Facility

The waste will be delivered to the MWSDF via trucks on a perimeter access road around the site. The trucks will access the facility from the east and move around in a clockwise direction. A phased approach will be adopted where the first lift of the MWSDF will be placed, followed by the 2nd lift, followed by the 3rd lift. The perimeter road will be a 7 meter wide road.

The layers of the road are as follows:

- Topsoil and vegetation are stripped to a depth of 250 mm
- The base of the excavation is to be ripped and recompacted to a depth of 200 mm at 90% MOD AASHTO.
- A minimum depth of 300 mm G7 material to be placed in layers not exceeding 150 mm and compacted to 93% MOD AASHTO
- A 150 mm thick layer of G5 wearing course, compacted to 95% MOD AASHTO

4.3.4. Copper Flotation Plant

Refer to Figure 4.1.12(a) for a simplified flow diagram of the Copper Flotation Plant. Product 2 from the wet Magnetite plant will be pumped from the thickener underflow from the SAOB Plant into the flush floatation feed sump. Product 2 from the dry beneficiation (MP2) plant will be tipped into a feed bin by a front-end loader and fed via a variable speed conveyor onto the mill feed conveyor. Product will be conveyed via a belt conveyor to a ball mill feed chute. Pulping water and Derek screens oversize will be added to the fresh feed.

Reagent collectors (Pax and NaSH) will be added at this point to allow for conditioning time before the flash flotation process. The discharge from the wet ball mill will be directed over a trommel screen. The screen will serve to remove any scats from the mill or oversize contamination that may have been present in the feed stream. The oversize from the trommel screen will be directed to a bin for disposal and the undersize will be directed to the mill discharge sump / or flush flotation feed sump. Feed from both the wet process as well as the dry magnetite beneficiation process will be combined into the flush float sump from where it will be pumped into the flush flotation cell.

Reagents such as a frother (Senfroth 200) reagents will be added to the pulp to recover ultra-fine copper which will be pumped to the copper flotation cleaner cells. Once the fines are recovered, product will be dewatered to contain 30% solids and pumped through a Derek screen stacker. Oversize material will be pumped to the mill for further liberation.

Under sized material will be pumped to the conditioning tank where more reagents PAX, NaSH will be added to the pulp. After conditioning, product will be pumped into the rougher cell, where a frother, (Senfroth 200) will be added.

The product will be pumped through two rougher cells and another reagent (AM810) will be added. Product will be pumped through two more rougher cells and then discharged to a disk filter where water will be extracted. From the disk filter, product will be conveyed to a stockpile. Recovered water will be pumped back to the thickener to be re-used. Concentrate recovered at the rougher stage will be pumped to the cleaner and re-cleaner processes to upgrade product grade.

Concentrate produced will be pumped to a press filter where excess water will be removed and concentrate product deposited onto a stockpile. From the concentrate stockpile, material will be fed into a bagging plant where it will be bagged into 1-ton bags.

Waste material will be loaded by a FEL / Excavator onto ADT's and transported to the dedicated waste disposal facility proposed (MWSDF).

4.4. LISTED AND SPECIFIED ACTIVITIES TRIGGERED

The table below provides the details pertaining to the listed and specified activities triggered by the proposed activities associated with this project. The proposed activities are listed below:

- Magnetite Waste Site Disposal Facility
- Pollution Control Dam (PCD)
- Access Road to the Magnetite Waste Site Disposal Facility
- Copper Flotation Plant

The proposed activities related to this project, require authorisation in terms of NEMA, NEMWA and the NWA and the S&EIR Process as provided for in the EIA Regulations needs to be followed for this project. The relevant listed activities which may be triggered by the proposed project specified in Listing Notice 1 (LN1) - GNR 983 (as amended 2021), Listing Notice 2 (LN2) - GNR 984 (as amended 2021) or Listing Notice 3 (LN3) - GNR 985 (as amended 2021) of the EIA Regulations are relayed in Table 4.4(a).

Table 4.4(a): Listed and Specified Activities triggered by the Proposed Project Activities

Project Activity	Act	Listed Activity	Formal Process
Magnetite Waste Site Disposal Facility	**NEMA**	**LN1(12):** The development of infrastructure or structures with a physical footprint of 100 square meters or more, where such development occurs within 32 m of a watercourse.	**BA**
		LN1(27): The clearance of an area of 1 hectares or more, but less than 20 hectares of indigenous vegetation, except where such clearance of indigenous vegetation is required for— (i) the undertaking of a linear activity; or (ii) maintenance purposes undertaken in accordance with a maintenance management plan.	**BA**
		LN3(12): The clearance of an area of 300 square metres or more of indigenous vegetation except where such clearance of indigenous vegetation is required for maintenance purposes undertaken in accordance with a maintenance management plan. **e. Limpopo** **i)** Within any critically endangered or endangered ecosystem listed in terms of section 52 of the NEMBA or prior to the publication of such a list, within an area that has been identified as critically endangered in the National Spatial Biodiversity Assessment 2004; **ii)** Within critical biodiversity areas identified in bioregional plans; or **iii)** On land, where, at the time of the coming into effect of this Notice or thereafter such land was zoned open space, conservation or had an equivalent zoning.	**BA**
	NEMWA	**Category B -Disposal of waste on land** **B(8):** The disposal of general waste to land covering an area in excess of 200m^2 and with a total capacity exceeding 25 000 tons. **B(9):** The disposal of inert waste to land in excess of 25 000 tons, excluding the disposal of such waste for the purposes of levelling and building which has been authorised by or under other legislation.	**S&EIR for WML**
		Construction of facilities and associated structures and infrastructure **B(10):** The construction of a facility for a waste management activity listed in Category B of this Schedule (not in isolation to associated waste management activity)	
	NWA	**21(c):** Impeding or diverting the flow of water in a watercourse	**WULA**
		21(i): Altering the bed, banks, course or characteristics of a watercourse	**WULA**
		21(g): Disposing of waste in a manner which may detrimentally impact on a water resource	**WULA**
Access Road to Waste Disposal Facility	**NEMA**	**LN3(4):** The development of a road wider than 4 metres with a reserve less than 13,5 metres. **e. Limpopo** **i. Outside urban areas:** **(aa)** A protected area identified in terms of NEMPAA, excluding disturbed areas; **(bb)** National Protected Area Expansion Strategy Focus areas;	**BA**

Project Activity	Act	Listed Activity	Formal Process
		(cc) Sensitive areas as identified in an environmental management framework as contemplated in chapter 5 of the Act and as adopted by the competent authority; **(dd)** Sites or areas identified in terms of an international convention; **(ee)** Critical biodiversity areas as identified in systematic biodiversity plans adopted by the competent authority or in bioregional plans; **(ff)** Core areas in biosphere reserves; or **(gg)** Areas within 10 kilometres from national parks or world heritage sites or 5 kilometres from any other protected area identified in terms of NEMPAA or from the core areas of a biosphere reserve, excluding disturbed areas; or	
		LN3(12): The clearance of an area of 300 square metres or more of indigenous vegetation except where such clearance of indigenous vegetation is required for maintenance purposes undertaken in accordance with a maintenance management plan. **e. Limpopo** **i)** Within any critically endangered or endangered ecosystem listed in terms of section 52 of the NEMBA or prior to the publication of such a list, within an area that has been identified as critically endangered in the National Spatial Biodiversity Assessment 2004; **ii)** Within critical biodiversity areas identified in bioregional plans; or **iii)** On land, where, at the time of the coming into effect of this Notice or thereafter such land was zoned open space, conservation or had an equivalent zoning.	**BA**
		LN3(18): The widening of a road by more than 4 metres, or the lengthening of a road by more than 1 kilometre **e. Limpopo** **i. Outside urban areas:** **(aa)** A protected area identified in terms of NEMPAA, excluding conservancies; **(bb)** National Protected Area Expansion Strategy Focus areas; **(cc)** Sensitive areas as identified in an environmental management framework as contemplated in chapter 5 of the Act and as adopted by the competent authority; **(dd)** Sites or areas identified in terms of an international convention; **(ee)** Critical biodiversity areas as identified in systematic biodiversity plans adopted by the competent authority or in bioregional plans; **(ff)** Core areas in biosphere reserves; **(gg)** Areas within 10 kilometres from national parks or world heritage sites or 5 kilometres from any other protected area identified in terms of NEMPAA or from the core area of a biosphere reserve; or **(hh)** Areas within a watercourse; or within 100 metres from the edge of a watercourse; or	**BA**
Pollution Control Dam	**NEMA**	**LN1(12):** The development of dams or weirs, where the dam or weir, including infrastructure and water surface area, exceeds 100 square meters where such development occurs within 32m of a watercourse.	**BA**
		LN1(13): The development of facilities or infrastructure for the off-stream storage of water, including dams and reservoirs, with a combined capacity of 50 000 cubic metres or more, unless such storage falls within the ambit of activity 16 in Listing Notice 2 of 2014.	**BA**
		LN1(27): The clearance of an area of 1 hectares or more, but less than 20 hectares of indigenous vegetation, except where such clearance of indigenous vegetation is required for— (i) the undertaking of a linear activity; or (ii) maintenance purposes undertaken in accordance with a maintenance management plan.	**BA**
		LN2(6): The development of facilities or infrastructure for any process or activity which requires a permit or licence or an amended permit or licence in terms of national or provincial legislation governing the generation or release of emissions, pollution or effluent, excluding— (i) activities which are identified and included in Listing Notice 1 of 2014; (ii) activities which are included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) in which case the National Environmental Management: Waste Act, 2008 applies; (iii) the development of facilities or infrastructure for the treatment of effluent, polluted water, wastewater or sewage where such facilities have a daily throughput capacity of 2 000 cubic metres or less; or	**S&EIR**

Project Activity	Act	Listed Activity	Formal Process
		(iv) where the development is directly related to aquaculture facilities or infrastructure where the wastewater discharge capacity will not exceed 50 cubic metres per day.	
		LN3(12): The clearance of an area of 300 square metres or more of indigenous vegetation except where such clearance of indigenous vegetation is required for maintenance purposes undertaken in accordance with a maintenance management plan. **e. Limpopo** **i)** Within any critically endangered or endangered ecosystem listed in terms of section 52 of the NEMBA or prior to the publication of such a list, within an area that has been identified as critically endangered in the National Spatial Biodiversity Assessment 2004; **ii)** Within critical biodiversity areas identified in bioregional plans; or **iii)** On land, where, at the time of the coming into effect of this Notice or thereafter such land was zoned open space, conservation or had an equivalent zoning.	**BA**
		LN3(14): The development of dams or weirs where the or weir including infrastructure and water surface area exceeds 10 square meters where such development occurs within 32 meters of a water course	**BA**
	NWA	**21(c)** Impeding or diverting the flow of water in a watercourse	**WULA**
		21(i) Altering the bed, banks, course or characteristics of a watercourse	**WULA**
		21(g) Disposing of waste in a manner which may detrimentally impact on a water resource	**WULA**
Copper Flotation Plant	**NEMA**	**LN1(34):** The expansion [or changes to] of existing facilities or infrastructure for any process or activity where such expansion [or changes] will result in the need for a permit or licence or an amended permit or licence in terms of national or provincial legislation governing the release of emissions, effluent or pollution, excluding— **(i)** where the facility, infrastructure, process or activity is included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) in which case the National Environmental Management: Waste Act, 2008 applies; [or] **(ii)** the expansion of [or changes to] existing facilities or infrastructure for the treatment of effluent, wastewater, polluted water or sewage where the capacity will be increased by less than 15 000 cubic metres per day; or **(iii)** the expansion is directly related to aquaculture facilities or infrastructure where the wastewater discharge capacity will be increased by 50 cubic meters or less per day.	**BA**
		LN2(6): The development of facilities or infrastructure for any process or activity which requires a permit or licence or an amended permit or licence in terms of national or provincial legislation governing the generation or release of emissions, pollution or effluent, excluding— (i) activities which are identified and included in Listing Notice 1 of 2014; (ii) activities which are included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) in which case the National Environmental Management: Waste Act, 2008 applies; (iii) the development of facilities or infrastructure for the treatment of effluent, polluted water, wastewater or sewage where such facilities have a daily throughput capacity of 2 000 cubic metres or less; or (iv) where the development is directly related to aquaculture facilities or infrastructure where the wastewater discharge capacity will not exceed 50 cubic metres per day.	**S&EIR**
	NEMWA	**Category B – Reuse, recycling or recovery of waste** **B(3):** The recovery of waste including the refining, utilisation, or co- processing of the waste at a facility that processes in excess of 100 tons of general waste per day or in excess of 1 ton of hazardous waste per day, excluding recovery that takes place as an integral part of an internal manufacturing process within the same premises.	**S&EIR for WML**
		Construction of facilities and associated structures and infrastructure **B(10):** The construction of a facility for a waste management activity listed in Category B of this Schedule (not in isolation to associated waste management activity)	

5. POLICY AND LEGISLATIVE CONTEXT

All relevant Acts, Regulations, Formal Departmental Guidelines and Templates, as well as Formal Provincial and Municipal Regulatory Frameworks are considered routinely during the compilation of Scoping and EIA/EMP Reports.

After due consideration of the relevant Acts, Regulations, Formal Departmental Guidelines and Templates, Formal Provincial and Municipal Regulatory Frameworks, a Table was compiled to summarise the Policy and Legislative Context of the project which was considered in terms of the new activities that will be applied for.

The first column of this table references the Applicable Legislation and Guidelines used to determine the legislative background and context of the project. The second column gives a brief description of how, when and where it has been considered/applied during the Scoping and EIA Phases of the project and the third column describes how the project and associated activities will comply with and respond to the Policy and Legislative Context.

Table 5(a): Policy and Legislative Context of the Bosveld Phosphates project

Applicable Legislation and Guidelines used to Compile the Report	Reference where Applied	How does this development Comply with and Respond to the Policy and Legislative Context
Constitution of the Republic of South Africa, 1996 (Act No. 108 of 1996) Section 24 of the Constitution states that everyone has the right to an environment that is not harmful to their health or well-being; 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;* • *promote conservation; and* • *secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.*	All Application Forms, Documents and Reports (Draft and Final) compiled and submitted in support of the Scoping and Environmental Impact Assessment and Reporting (S&EIR) Process.	A comprehensive S&EIR Process will be undertaken, including the necessary public participation, to identify the potential impacts associated with the project. The prescribed reports, i.e. Scoping Report, Environmental Impact Assessment Report (EIAR) and an Environmental Management Programme (EMPr) will be compiled in support of this process. The EMPr will include mitigation measures as well as monitoring plans that will ensure that the relevant environment is managed in a sustainable manner to support the rights as enshrined in the Constitution.
National Environmental Management Act, 1998 (Act No. 107 of 1998) – NEMA Section 24 of the NEMA, headed "Environmental Authorisations" sets out the provisions which are to give effect to the general objectives of Integrated Environmental Management, and laid down in Chapter 5 of the NEMA. In terms of section 24(1), the potential impact on the environment of listed activities must be considered, investigated, assessed and reported on to the competent authority charged by the NEMA with granting of the relevant environmental authorisation. In terms of section 24F(1) of the NEMA no person may commence an activity listed or specified in terms of section 24(2)(a) or (b) unless the competent authority has granted an environmental authorisation for the activity. **NEMA Regulations** ▪ *Public Participation Guideline – GNR 807 of 10 October 2012* ▪ *Fees for consideration and processing of applications for environmental authorisations and amendments thereto – GN 141 of 28 February 2014* ▪ *Guideline on Need and Desirability of the Environmental Impact Assessment (EIA) Regulations – GN 891 of 20 October 2014* ▪ *EIA Regulations – GNR 982 of 2014 as amended* ▪ *EIA Regulations: Listing Notice 1 – GNR 983 of 2014 as amended* ▪ *EIA Regulations: Listing Notice 2 – GNR 984 of 2014 as amended* ▪ *EIA Regulations: Listing Notice 3 – GNR 985 of 2014 as amended* ▪ *National Exemption Regulations in terms of the National Environmental Management Act 1998 (Act No 107 of 1998) – GNR 994 of 08 December 2014* ▪ *National Appeal Regulations in terms of the National Environmental Management Act 1998 (Act No 107 of 1998) – GNR 993 of 08 December 2014* ▪ *Financial Provisioning Regulations – GNR 1147 of 20 November 2015 as amended*	All Application Forms, Documents and Reports (Draft and Final) compiled and submitted in support of the Scoping and Environmental Impact Assessment and Reporting (S&EIR) Process.	The S&EIR Process was undertaken in accordance with the principles of Section 24 of NEMA as well as with the EIA Regulations (as amended in 2021), promulgated in terms of NEMA. The Public Participation Programme was designed as recommended in the Public Participation Regulations and guidelines. Application fees relevant to the project were determined by the applicable regulations. The prescribed reports for the S&EIR Process, i.e. Scoping Report, Environmental Impact Assessment Report (EIAR) and an Environmental Management Programme (EMPr) was compiled according to the requirements in the amended EIA Regulations. The Listing Notices have been reviewed against the project activities to determine the listed activities triggered and for which an application for EA has been submitted. Costs/Financial Provisioning associated with the environmental management of all the life cycle phases of the project was considered following the Financial Provisioning regulations.

Applicable Legislation and Guidelines used to Compile the Report	Reference where Applied	How does this development Comply with and Respond to the Policy and Legislative Context
▪ *Notice of the Requirement to submit a report generated by the National Web based Environmental Screening Tool in terms of Section24(5)(h) of the National Environmental Management Act, 1998 and Regulation 16(1)(b)(v) of the Environmental Impact Assessment (EIA) Regulations (GNR 982 of December 2014 as amended) – GNR 960 of July 2019* ▪ *Procedures to be followed for the assessment and minimum criteria for reporting of identified environmental themes in terms of section 24(5)(a) and (h) of the National Environmental Management Act, 1998, when applying for environmental authorisation – GNR 320 of 20 March 2020* **Guidelines** ➢ *Need and Desirability Guideline in terms of the Environmental Impact Assessment Regulations 2017 - DFFE* ➢ *Public Participation Guideline in terms of National Environmental Management Act, 1998 Environmental Impact Assessment Regulations, 2017- - DFFE* ➢ *Species Environmental Assessment Guideline 2020 – SANBI*		The Need and Desirability of the Project were considered and discussed following the regulations and guidelines provided by DFFE.
National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) – NEMWA The objects of this Act are to protect health, well-being and the environment by providing reasonable measures for minimising the consumption of natural resources; avoiding and minimising the generation of waste; reducing, re-using, recycling and recovering waste; treating and safely disposing of waste as a last resort; preventing pollution and ecological degradation; securing ecologically sustainable development while promoting justifiable economic and social development; promoting and ensuring the effective delivery of waste services; remediating land where contamination is present, or may be present, a significant risk of harm to health or the environment; and achieving integrated waste management reporting and planning; to ensure that people are aware of the impact of waste on their health, well-being and the environment; to provide for compliance with the measures set out above and generally, to give effect to section 24 of the Constitution in order to secure an environment that is not harmful to health and well-being. **NEMWA Regulations** ▪ *Waste Classification and Management Regulations – GNR 634 of 23 August 2013* ▪ *National Norms and Standards for the Assessment of Waste for Landfill Disposal – GNR 635 of 23 August 2013*	All Application Forms, Documents and Reports (Draft and Final) compiled and submitted in support of the Scoping and Environmental Impact Assessment and Reporting (S&EIR) Process.	The Act, Regulations and Guidelines were considered when classifying and identifying the listed waste activities associated with the project for which authorisation is required. When proposing appropriate waste management objectives and management measures the Act, Regulations and Guidelines will be considered. The Act, Regulations and Guidelines will also be consulted when compiling the Integrated Water and Waste Management Plan (IWWMP) which will be submitted as part of the Water Use Licence Application (WULA).

Applicable Legislation and Guidelines used to Compile the Report	Reference where Applied	How does this development Comply with and Respond to the Policy and Legislative Context
▪ *National Norms and Standards for Disposal of Waste to Landfill – GNR 636 of 23 August 2013* ▪ *List of Waste Management Activities that have, or are likely to have, a detrimental effect on the environment – GNR 921 of 29 November 2013 as amended* ▪ *Norms and Standards for Storage of Waste –GNR 926 of 29 November 2013* ▪ *National Norms and Standards for the Remediation of Contaminated Land and Soil Quality – GN 331 in Government Gazette No. 37603 dated 2 May 2014* ▪ *Amendment to the List of Waste Management Activities that have, or are likely to have, a detrimental effect on the environment – GN 1094 of 13 February 2015* ▪ *Regulations regarding the Planning and Management of Residue Stockpiles and Residue Deposits from a Prospecting, Mining, Exploration or Production Operation – GNR 632 of 24 July 2015* ▪ *Amendments to the List of Waste Management Activities that have, or are likely to have, a detrimental effect on the environment – GNR 633 of 24 July 2015* ▪ *National Norms and Standards for the Sorting, Shredding, Grinding, Crushing, Screening and Bailing of General Waste – GN 1093 of 11 October 2017* ▪ *Amendment to the List of Waste Management Activities that have, or are likely to have, a detrimental effect on the environment – GN 1094 of 11 October 2017* **DFFE Guidelines** ➢ *The Waste Licensing Application Process in terms of the National Environmental Management: Waste Act 2008 (No. 59 of 2008)* ➢ *Framework for the Management of Contaminated Land of May 2010* **SANS Guideline** ➢ *South African National Standard, SANS 10234:2008, Edition 1.1, Globally Harmonized System of Classification and Labelling of Chemicals (GHS), SABS Standards Division*		
National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) – NEMAQA Section 21 read with section 22 of the NEMAQA states that the Minister responsible for Environmental Affairs may publish a list of activities which result in atmospheric emissions and which the Minister reasonably believes has or may have a significant detrimental effect on the environment. Section 22 of the NEMAQA states that no person may without a provisional atmospheric emission licence or an atmospheric emission licence conduct an activity listed on a national or provincial list published in terms of the Act.	The Air Quality Specialist Assessment for the proposed project considered a review of the relevant health legislation, ambient air quality guidelines and standards.	The Air Quality Specialist Assessment evaluated the potential sources and emissions of the proposed project against the relevant health legislation, ambient air quality guidelines and standards. An overview will be provided of possible pollutants of concern, possible impacts and impact areas. An assessment of the priority air quality issues will be performed and an air quality management strategy will be proposed.

Applicable Legislation and Guidelines used to Compile the Report	Reference where Applied	How does this development Comply with and Respond to the Policy and Legislative Context
The National Ambient Air Quality Standards were published on 24 December 2009 and provide *inter alia* for national ambient air quality standards for PM10. In addition to the above, the National Ambient Air Quality Standards for PM2.5 came into effect on 29 June 2012. While the NEMAQA does not require industry or mining companies to comply with the standards as published, Provincial and Local Authorities have the authority to ensure compliance with the standards. Section 19 and 20 of the NEMAQA provides for the management of priority areas. The national air quality officer, after consulting with the provincial and local air quality officer, must prepare an air quality management plan ("AQMP") in respect of a priority area. The AQMP must be submitted to the Minister for approval within 6 months after the declaration of the area as a priority area. Prior to approval of an AQMP the Minister must follow a consultative process as prescribed in section 56 and 57 of the NEMAQA. The Minister may prescribe regulations necessary for implementing and enforcing approved AQMPs, including: ▪ *funding arrangements;* ▪ *measures to facilitate compliance with such plans;* ▪ *penalties for any contravention of or any failure to comply with such plans; and* ▪ *regular review of such plans* **NEMAQA Regulations** ▪ *Listed Activities and Associated Minimum Emission Standards – GNR 893 of November 2013* ▪ *National Dust Control Regulations - GNR 827 of November 2013* ▪ *Atmospheric Emission Reporting Regulations – GNR 283 of April 2015* ▪ *Atmospheric Impact Report Regulations – GNR 747 of October 2013* ▪ *Air Dispersion Modelling Regulations - GNR 533 of July 2014* ▪ *Greenhouse Gas Regulations - GNR 275 of April 2017* ▪ *Declaration of Greenhouse Gases as Priority Air Pollutants – GNR 710 of July 2017* ▪ *National Pollution Prevention Plans Regulations – GNR 712 of July 2017* **Templates and Guidelines (e.g. published by DEA, SANS, Local Authority (by-laws) or other):** ➢ *Limpopo Provincial Air Quality Management Plan (October 2013).* ➢ *World Health Organisation Air Quality Guidelines (May 2015).*		

Applicable Legislation and Guidelines used to Compile the Report	Reference where Applied	How does this development Comply with and Respond to the Policy and Legislative Context
National Water Act, 1998 (Act No. 36 of 1998) – NWA The purpose of the NWA, as set out in Section 2 thereof, is to ensure that the country's water resources are protected, used, developed, conserved, managed and controlled, in a way which, *inter alia*, takes into account the reduction and prevention of pollution and degradation of water resources. The NWA states, in section 3 thereof, that the National Government is the public trustee of the Nation's water resources. The National Government must ensure that water is protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner for the benefit of all persons and in accordance with its constitutional mandate. **NWA Regulations** ▪ *Regulations requiring that a water use be registered – GNR 1352 of 12 November 1999* ▪ *Regulations on use of water for mining and related activities aimed at the protection of water resources – GNR 704 of 4 June 1999* ▪ *Replacement of General Authorisation in terms of Section 39 of the National Water Act, 1998 (Act No. 36 Of 1998) – GN 1199 of 18 December 2009* ▪ *Regulations regarding the safety of dams in terms of Section 123(1) of the National Water Act, 1998 – GNR 139 of 24 February 2012* ▪ *General Authorisation in terms of section 39 of the National Water Act, 1998 (Act No. 36 of 1998) for Water Uses as defined in section 21(c) or section 21(i) – GN 509 in Government Gazette No. 40229 dated 26 August 2016* ▪ *Revision of General Authorisation for the Taking and Storing of Water – GN 538 in Government Gazette No. 40243 of 2 September 2016* ▪ *New Nine (9) Water Management Areas of South Africa – GN 1056 in Government Gazette No. 40279 dated 16 September 2016* ▪ *Regulations Requiring that the Taking of Water for Irrigation Purposes be Measured, Recorded and Reported – GN 131 in Government Gazette No. 40621 of 17 February 2017* ▪ *Water Use Licence Application and Appeals Regulations, 2017 – GNR 267 in Government Gazette No. 40713 of 24 March 2017* ▪ *Requirements for the purification of waste effluents – Government Notice (GN) R 991 of May 1984* **DWS Guidelines** ➢ *DWAF, Second Edition, 1998. Waste Management Series. Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste.*	All Application Forms, Documents and Reports (Draft and Final) compiled and submitted in support of the Scoping and Environmental Impact Assessment and Reporting (S&EIR) Process.	Water Uses at the project site have been authorised in terms of the following authorisations issued by the Department of Water and Sanitation (DWS): A Water Use Licence (WUL) - The original WUL was issued to Bosveld Phosphates on 20 April 2011 (Licence No. 04/B72K/ACGI/866). This licence has subsequently been amended on 02 October 2017. On 12 October 2017, an additional WUL (Licence No. 06/B72K/G/6015) as issued to Bosveld Phosphates. A Water Use Licence Application (WULA) has been compiled and was/ will be submitted to the DWS for the new water uses associated with the project. Assessments conducted as part of the surface and groundwater specialist reports was done in terms of the relevant Best Practice Guidelines (BPG's) of the DWS as outlined in the specialist reports attached as appendices to this report. Proposed mitigation measures will be aligned with the provisions of the relevant BPG's and a detailed assessment of the measures against the relevant BPG's will be done when compiling the IWWMP, submitted as part of the WULA.

Applicable Legislation and Guidelines used to Compile the Report	Reference where Applied	How does this development Comply with and Respond to the Policy and Legislative Context
➢ *DWAF, Second Edition, 1998. Waste Management Series. Minimum Requirements for Waste Disposal by Landfill.* ➢ *DWAF, Second Edition, 1998. Waste Management Series. Minimum Requirements for Water Monitoring at Waste Management Facilities.* ➢ *Guidelines for the Utilization and Disposal of Wastewater Sludge – Volume 1: Selection of Management Options; 2006.* ➢ *Guidelines for the Utilization and Disposal of Wastewater Sludge – Volume 2: Requirements for the Agricultural Use of Sludge; 2006.* ➢ *Guidelines for the Utilization and Disposal of Wastewater Sludge – Volume 3: Requirements for the On-site and Off-site Disposal of Sludge; 2006.* ➢ *Guidelines for the Utilization and Disposal of Wastewater Sludge – Volume 4: Requirements for the Beneficial Use of Sludge; 2006.* ➢ *Guidelines for the Utilization and Disposal of Wastewater Sludge – Volume 5: Requirements for Thermal Sludge Management Practices and for Commercial Products Containing Sludge; 2006.* ➢ *Best Practice Guideline A1 – Small-Scale Mining (Standard format); 2006* ➢ *Best Practice Guideline A1.1 – Small-Scale Mining (User Format); 2006* ➢ *Best Practice Guideline G1 – Storm Water Management; 2006* ➢ *Best Practice Guideline G2 – Water and Salt Balances; 2006* ➢ *Best Practice Guideline H3 – Water Reuse and Reclamation; 2006* ➢ *External Guideline: Generic Water Use Authorisation Application Process, 2007* ➢ *Internal Guideline: Generic Water Use Authorisation Application Process, 2007* ➢ *Best Practice Guideline A3 – Water Management in Hydrometallurgical Plants; 2007* ➢ *Best Practice Guideline A4 – Pollution Control Dams; 2007* ➢ *Best Practice Guideline G3 – Water Monitoring Systems; 2007* ➢ *Best Practice Guideline H4 – Water Treatment; 2007* ➢ *Best Practice Guideline A2 – Water Management for Mine Residue Deposits; 2008* ➢ *Best Practice Guideline A5 – Water Management for Surface Mines; 2008* ➢ *Best Practice Guideline A6 – Water Management for Underground Mines; 2008* ➢ *Best Practice Guideline G4 – Impact Prediction; 2008* ➢ *Best Practice Guideline G5 – Water Management Aspects for Mine Closure; 2008* ➢ *Best Practice Guideline H1 – Integrated Mine Water Management; 2008* ➢ *Best Practice Guideline H2 – Pollution Prevention and Minimization of Impacts; 2008* ➢ *Operational Guideline: Integrated Water and Waste Management Plan, 2010* ➢ *Water Conservation and Water Demand Management Guideline for the Mining Sector in South Africa; DWA, 2011.*		

Applicable Legislation and Guidelines used to Compile the Report	Reference where Applied	How does this development Comply with and Respond to the Policy and Legislative Context
➢ *Internal Guideline: Section 21(a) and (b) Water Use Authorisation Application Process (taking and/or storing water)* ➢ *Internal Guideline: Section 21(c) and (i) Water Use Authorisation Application Process (impeding or diverting the flow of water in a watercourse and /or altering the bed, banks, course or characteristics of a watercourse)* ➢ *Internal Guideline: Section 21(e), (f), (g), (h) and (j) Water Use Authorisation Application Process (waste discharge related)* ➢ *Water Resources for the Olifants Catchment in terms of Government Notice (GN) No. 39943, 22 April 2016* ➢ *Development of an Integrated Water Quality Management Plan for the Olifants River System: Lower Olifants Sub-Catchment Plan. Study Report No. 9 Report No: P WMA 04/B50/00/8916/10, DWS 2016*		
National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) – NEMBA The purpose of the NEMBA is to provide for the management and conservation of South Africa's biodiversity within the framework of the NEMA so as to protect species and ecosystems that warrant national protection. The NEMBA gives effect to ratified international agreements affecting biodiversity to which South Africa is a party, and which bind the Republic. The NEMBA must be read together with the NEMA and in particular, must be guided by the principles set out in Section 2 of the NEMA, as set out above. It is important to note that the NEMBA will find applicability throughout the lifetime of a project, from the commencement of operations to the decommissioning. The NEMBA provides for the publishing of various lists of species and ecosystems by the Minister of Environmental Affairs as well as by the Member of an Executive Council ("MEC") responsible for the conservation of biodiversity of a province in relation to which certain activities may not be undertaken without a permit. In terms of Section 57 of the NEMBA, no person may carry out any restricted activity involving any species which has been identified by the Minister as "critically endangered species", "endangered species", "vulnerable species" or "protected species" without a permit. The NEMBA defines "restricted activity" in relation to such identified species so as to include, but not limited to, hunting, catching, capturing, killing, gathering, collecting, plucking, picking parts of, cutting, chopping off, uprooting, damaging, destroying, having in possession, exercising physical control over, moving or translocating.	All Application Forms, Documents and Reports (Draft and Final) compiled and submitted in support of the Scoping and Environmental Impact Assessment and Reporting (S&EIR) Process.	The Act and the Regulations were consulted as part of the Ecological specialist studies conducted as part of the project. Ecological specialist studies included a Plant and Animal Life Assessment, Wetlands and Aquatic Ecosystems Assessment. These Assessments were undertaken to determine the current status of the environment and to determine any potential ecological sensitivity to be avoided and mitigated. In addition, this legislation was consulted in order to determine if any permits, authorisations, licences and/or consents needed to be obtained in order to commence/continue with the project and relevant activities.

Applicable Legislation and Guidelines used to Compile the Report	Reference where Applied	How does this development Comply with and Respond to the Policy and Legislative Context
NEMBA Regulations ▪ *Publication of lists of critically endangered, endangered, vulnerable and protected species - GNR 151 of 23 February 2007* ▪ *Threatened and Protected Species Regulations – GNR 152 of 23 February 2007* ▪ *National List of Ecosystems that are Threatened and in need of Protection – GNR 1002 of 09 December 2011* ▪ *Publication of National List of Invasive Species – GNR 507of 19 July 2013* ▪ *Publication of Prohibited Alien Species – GNR 508 of 19 July 2013* ▪ *Alien and Invasive Species Regulations – GNR 598 of 01 August 2014* ▪ *Alien and Invasive Species Lists – GNR 864 of July 2016*		
National Environmental Management: Protected Areas Act, 2003 (Act No. 57 of 2003) - NEMPAA The objectives of this Act are to provide, within the framework of national legislation, including the National Environmental Management Act, for the declaration and management of protected areas; to provide for co-operative governance in the declaration and management of protected areas; to effect a national system of protected areas in South Africa as part of a strategy to manage and conserve its biodiversity; to provide for a diverse and representative network of protected areas on state land, private land, communal land and marine waters to promote sustainable utilisation of protected areas for the benefit of people, in a manner that would preserve the ecological character of such areas; to promote participation of local communities in the management of protected areas, where appropriate; and to provide for the continued existence of South African National Parks.	All Application Forms, Documents and Reports (Draft and Final) compiled and submitted in support of the Scoping and Environmental Impact Assessment and Reporting (S&EIR) Process.	The Act and the Regulations were consulted as part of the Ecological specialist studies conducted as part of the project, specifically to identify protected areas (legally gazetted) and conservation areas (managed for biodiversity conservation, but not legally declared) that are present within the landscape in which the study area is located.
Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983) - CARA The purpose of the Conservation of Agricultural Resources Act ("**CARA**") is to provide for the control over the utilisation of the natural agricultural resources of the Republic so as to promote the conservation of the soil, the water sources and the vegetation and the combating of weeds and invader plants. Biological control reserve is defined in GNR 1048 as "*an area designated by the executive officer in terms of regulation 15D of the regulations for the breeding of biological control agents*". **CARA Regulations** ▪ *Regulations – GNR 1048 of 25 May 1984* ▪ *Weed Control Scheme – GNR 1044 of 25 May 1984*	All Application Forms, Documents and Reports (Draft and Final) compiled and submitted in support of the Scoping and Environmental Impact Assessment and Reporting (S&EIR) Process.	Provisions of CARA will be taken into account in the soil and land capability specialist study in terms of the mitigation measures proposed to prevent the degradation of the agricultural potential of soil, to protect land against soil erosion and to prevent water logging and salinisation of soils by means of proposing suitable soil management objectives and measures.

Applicable Legislation and Guidelines used to Compile the Report	Reference where Applied	How does this development Comply with and Respond to the Policy and Legislative Context
National Forests Act, 1998 (Act No. 84 of 1998) - NFA In terms of section 15(3) of the National Forests Act ("NFA") four lists of protected trees belonging to a particular species under section 12(1)(d) of the Act have been published with the most recent list published on 13 September 2013. The effect of declaring these trees as protected is that in terms of section 15(1) of the NFA no person may cut, disturb, damage or destroy any protected tree or possess, collect, remove, transport, export, purchase, sell, donate or in any other manner acquire or dispose of any protected tree or forest product derived from a protected tree, except under a licence granted by the Minister to an applicant and subject to such period and conditions as may be stipulated. **NFA Regulations** ▪ *Schedule A of the National Forests Act (Act No. 84 of 1998); A List of All Protected Tree Species Under Section 12 of the National Forests Act, 1998 (Act No. 84 of 1998) – GNR 635 of 6 December 2019.*	All Application Forms, Documents and Reports (Draft and Final) compiled and submitted in support of the Scoping and Environmental Impact Assessment and Reporting (S&EIR) Process.	Schedule A of the National Forests Act (Act No. 84 of 1998) was used to identify protected tree species that occur or potentially occur in the study area. The Act makes provision for the protection and management of these species under the correct permit.
Limpopo Environmental Management Act (Act No. 7 of 2003) - LEMA The objectives of the Limpopo Environmental Management Act (Act No. 7 of 2003) are to: • Manage and protected the environment; • Secure ecologically sustainable development and responsible use of natural resources: • Generally, contribute to the progressive realisation of the fundamental rights contained in Section 24 of the South African Constitution; • Give effect to international agreements effecting environmental management; • Amongst other provisions, the Act makes provision for the: o Declaration and management of provincial parks; o Declaration and management of sites of ecological importance; o Declaration or protected natural environments. Of relevance to the proposed Project are, *inter alia*: • Chapter 4 concerning activities and protection of wild animals listed as specially protected or protected under Schedule 2 and Schedule 3 of the Act; • Chapter 8 concerning restricted activities and protection of indigenous plants listed as specially protected or protected under Schedule 11 and Schedule 12 of the Act; • Chapter 15: concerning the issuing of permits for restricted activities.	All Application Forms, Documents and Reports (Draft and Final) compiled and submitted in support of the Scoping and Environmental Impact Assessment and Reporting (S&EIR) Process.	Schedule 2, Schedule 3, Schedule 11 and Schedule 12 of the Limpopo Environmental Management Act (Act No. 7 of 2003) were used to identify flora and fauna listed as Protected or Specially Protected that occur or potentially occur in the study area. The Limpopo Environmental Management Act (Act No. 7 of 2003) makes provision for the protection and management of these species under the correct permit. The Limpopo Conservation Plan was reviewed to assess the provincial conservation context of the study area. Based on literature review and a field programme, Specially Protected and Protected species of flora and fauna, as listed under the relevant Schedules, that occur or potentially occur in the study area or that may be affected by proposed Project activities, were identified. Recommendations concerning their management will be highlighted for inclusion in the proposed Project's Environmental Management Programme.

Applicable Legislation and Guidelines used to Compile the Report	Reference where Applied	How does this development Comply with and Respond to the Policy and Legislative Context
National Heritage Resources Act, 1999 (Act No. 25 of 1999) – NHRA The NHRA aims to, *inter alia*, promote good management of the national estate, and to enable and encourage communities to nurture and conserve their legacy so it may be bequeathed to future generations. The preamble to the NHRA states that our heritage is unique and precious and it cannot be renewed. The national estate means the "national estate" defined in section 3 of the NHRA. This section states that those heritage resources of South Africa which are of cultural significance or other special value for the present community and for future generations must be considered as part of the national estate and fall within the sphere of operations of heritage resources authorities. Section 3 (3) read with section 2 provides that cultural significance, for purposes of the NHRA, means aesthetic, architectural, historical, scientific, social, spiritual, linguistic or technological value or significance. Section 34 of the NHRA provides for a mechanism for protecting immovable property by providing for an outright prohibition on altering or demolishing any structure or part of any structure, which is older than 60 years, without a permit issued by the relevant provincial heritage resources authority. If a permit is refused, consideration must be given to designating the place concerned as a heritage site, or protected area or heritage area within three months of such refusal. An important provision in the NHRA is section 38 of the Act which states that any person who intends to undertake developments categorised in the section must at the very earliest stages of initiating such development, notify the responsible heritage resources authority and furnish it with details regarding the location, nature and extent of the proposed development.	All Application Forms, Documents and Reports (Draft and Final) compiled and submitted in support of the Scoping and Environmental Impact Assessment and Reporting (S&EIR) Process.	A Phase I Heritage Impact Assessment (HIA) study was done according to Section 38 of the National Heritage Resources Act (No 25 of 1999). The aims with the Phase I HIA study were to establish whether any of the types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (No 25 of 1999) do occur in the Project Area and, if so, to determine the nature and the extent of these remains. In addition, to establish whether any of the types and ranges of heritage resources which have been identified in the project area will be affected by the project operations and, if so, to establish appropriate mitigation and management measures for these heritage resources.

6. MOTIVATION FOR NEED AND DESIRABILITY

The need and desirability for the proposed project was provisionally considered during this Scoping Phase at the hand of the Integrated Environmental Management Guideline referenced as:

DEA (2017), Guideline on Need and Desirability, Department of Environmental Affairs (DEA), Pretoria, South Africa.

The Need and Desirability Assessment is presented in Tabular format, focussing on the two major aspects of importance namely:

- Securing ecological sustainable development and use of natural resources – Table 6(a).
- Promoting justifiable economic and social development - Table 6(b).

The objective of this assessment is to ensure that all the relevant considerations as provided in the said guideline have been taken into account during the Scoping Phase of the project and that key issues to be addressed during the following EIA Phase was identified.

In the event that additional assessments are required (indicated in column 3 of Table 6(a) and (b)), it will be considered during the EIA Phase of the project and will be described in the EIAR as well as the EMPr.

Table 6(a): Securing Ecological Sustainable Development and Use of Natural Resources

Need and Desirability Guideline Batch 1 Questions	Answer	Further Assessment Required in EIA (Yes/No)
1. How will this development (and its separate elements/aspects) impact on the ecological integrity of the area?	Ecological baseline assessments (terrestrial (plant and animal life), wetlands and aquatic ecosystems) were conducted by suitable and qualified ecologists during the Scoping Phase of the project. Ensuing comprehensive ecological impact assessments will be conducted during the EIA Phase. The outcome will be documented in the EIAR and the proposed mitigation/ management measures of the potential impacts will be provided in the EMPr.	-
1.1. How were the following ecological integrity considerations taken into account?	Ecological assessments was informed by relevant available databases which included (but was not limited to) the South African National Biodiversity Institute (SANBI), FitzPatrick Institute of African Ornithology (2021), the Vegetation of South Africa, Lesotho and Swaziland (Mucina and Rutherford 2011), National Web-based Environmental Screening Tool, the National Freshwater Ecosystem Priority Areas (NFEPA) database, the Limpopo Conservation Plan (Version 2), the South African Protected Area and Conservation Area Database (SAPAD 2021), the Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa (DWS 2014), The 2016 Red List of Mammals of South Africa, Swaziland and Lesotho, IUCN (International Union for the Conservation of Nature) Red List of Threatened Species (2021-1), NEMBA ToPS List (2007), Strategic Water Source Areas (SWSA) (2017), National List of Ecosystems that are Threatened and in Need of Protection, updated WET-Health Version 2.0.	-
1.1.1. Threatened Ecosystems,	The local study area is located in the Phalaborwa-Timbavati Mopaneveld (SVmp 7) vegetation type, of the savanna biome (Mucina and Rutherford, 2011). This vegetation type is well-conserved in formal protected areas, and is not considered a threatened ecosystem according to NEMBA (2011).	No
1.1.2. Sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure,	According to the SAPAD (2021), the site is located within the Kruger to Canyons Biosphere Reserve (This conservation area is 2,901,386 ha in extent and was formerly recognised as a biosphere in 2001 by UNESCO in 2011), and within the 10 km buffer zone of the Kruger National Park. The Kruger National Park is a critically important protected area in South Africa, that amongst other attributes, is recognised as an Important Bird Area. Flora species of conservation concern were recorded in the study area; five nationally protected trees as listed under the National Forests Act, (1998) and one species listed as protected in Limpopo Province and one species although not listed as a threatened or protected tree in South Africa, is globally recognised as a Near Threatened species by the IUCN (2021-1). The immediate landscape has a rich fauna community, that includes several conservation dependent species (i.e., species generally restricted to formal protected areas, such as the African Elephant). Mammal, bird and reptile species of conservation concern were recorded within the study area. Several water courses and related features were identified within the project study area and its immediate surroundings, with the most significant being the Ga-Selati River and associated riparian habitat. No natural wetland habitat was identified within the project study area or the 500m buffer.	Yes - Comprehensive impact assessments will be conducted during the EIA Phase of this project whereafter appropriate mitigation/ management measures will be proposed for each identified potential impact for inclusion in the EMPr.

Need and Desirability Guideline Batch 1 Questions	Answer	Further Assessment Required in EIA (Yes/No)
1.1.3. Critical Biodiversity Areas ("CBAs") and Ecological Support Areas ("ESAs"),	Critical Biodiversity Areas (CBA) are areas required to meet biodiversity targets for ecosystems, species and ecological processes, as per biodiversity plans. Ecological Support Areas (ESA) are not essential for meeting biodiversity targets but play an important role in supporting the ecological functioning of CBA and/or in delivering ecosystem services. These areas must be safeguarded in their natural or near-natural state owing to their importance and critical use for conserving biodiversity and maintaining ecosystem functioning. The site is located within a network of land designated as Critical Biodiversity Area 2 (CBA2), under the Limpopo Conservation Plan (V2). Land portions designated CBA2 have been selected to meet biodiversity pattern and/or ecological process targets. A Critical Biodiversity Area 2 (CBA2) – is considered *"Areas selected to meet biodiversity pattern and/or ecological process targets. Alternative sites may be available to meet targets"*. Mining and industrial land uses are generally incompatible with areas designated as CBA 2, however they do indicate that certain elements of these activities may be allowed, subject to detailed impact assessment. It is noted that that the Limpopo Conservation Plan delineations are conducted at a high level, and do not necessarily account for localised sites of disturbed/secondary habitat.	Yes - Comprehensive impact assessments will be conducted during the EIA Phase of this project whereafter appropriate mitigation/ management measures will be proposed for each identified potential impact for inclusion in the EMPr.
1.1.4. Conservation targets,	Land portions designated CBA2 have been selected to meet biodiversity pattern and/or ecological process targets. The assigned management objectives of CBA2 land include inter alia, maintenance in a natural state and minimising impact on threatened species.	
1.1.5. Ecological drivers of the ecosystem,	The Aquatic Ecosystems specialist assessed ecological drivers (habitat and water quality) of the aquatic ecosystems associated with the project area.	
1.1.6. Environmental Management Framework,	The Environmental Management Framework for the Olifants and Letaba Rivers Catchment Areas was and will be consulted during the course of the project.	
1.1.7. Spatial Development Framework (SDF), and	The goal of the Ba-Phalaborwa Municipal SDF (2019-2024) in terms of biodiversity and heritage is to promote development that protects and sustains the special environmental heritage of the municipality. The comprehensive impact assessments that will be conducted during the EIA Phase of this project whereafter appropriate mitigation/ management measures will be proposed for each identified potential impact for inclusion in the EMPr will address the objectives of the said SDF which is to protect environmentally sensitive areas.	
1.1.8. Global and international responsibilities relating to the environment (e.g. RAMSAR sites, Climate Change, etc.)	Impacts associated with the proposed new activities are expected to be localised, can be mitigated to an acceptable level and do not threaten any RAMSAR sites.	

Need and Desirability Guideline Batch 1 Questions	Answer	Further Assessment Required in EIA (Yes/No)
1.2. How will this development disturb or enhance ecosystems and/or result in the loss or protection of biological diversity?	Activities associated with the proposed project include the development of a magnetite waste site disposal facility and Pollution Control Dam (PCD). The footprints associated with these facilities will be disturbed and the impact on the biological diversity will be assessed during the EIA Phase of this project whereafter appropriate mitigation/ management measures will be proposed for each identified potential impact for inclusion in the EMPr to be authorised.	Yes - Comprehensive impact assessments will be conducted during the EIA Phase of this project whereafter appropriate mitigation/ management measures will be proposed for each identified potential impact for inclusion in the EMPr.
1.2.1. What measures were explored to firstly avoid these negative impacts?	A comprehensive alternatives assessment in terms of the following were considered (full details of this process are relayed in Section 7.1 of this report): • property on which or location where the activity is proposed to be undertaken • type of activity to be undertaken • design or layout of the activity • technology to be used in the activity • operational aspects of the activity • the option of not implementing the activity Proposed facilities will be designed by specialist civil engineers according to all legal and guideline requirements.	No
1.2.2. Where these negative impacts could not be avoided altogether, what measures were explored to minimise and remedy (including offsetting) the impacts?	Proposed facilities will be designed by specialist civil engineers according to all legal and guideline requirements. Comprehensive ecological impact assessments will be conducted during the EIA Phase. The outcome will be documented in the EIAR and the proposed mitigation/ management of potential impacts will be provided in the EMPr.	Yes
1.2.3. What measures were explored to enhance positive impacts?	No positive impacts are expected in terms of ecosystems/ biological diversity.	No
1.3. How will this development pollute and/or degrade the biophysical environment?	The potential impacts associated with the proposed activities were provisionally assessed by the EAP and the outcome of this assessment is relayed in section 7.5 of this report. Comprehensive ecological impact assessments will be conducted during the EIA Phase by each relevant specialist.	Yes

Need and Desirability Guideline Batch 1 Questions	Answer	Further Assessment Required in EIA (Yes/No)
	The outcome will be documented in the EIAR and the proposed mitigation/ management of potential impacts will be provided in the EMPr.	
1.3.1. What measures were explored to firstly avoid these impacts?	A comprehensive alternatives assessment in terms of the following were considered (full details of this process are relayed in Section 7.1 of this report): • property on which or location where the activity is proposed to be undertaken • type of activity to be undertaken • design or layout of the activity • technology to be used in the activity • operational aspects of the activity • the option of not implementing the activity Proposed facilities will be designed by specialist civil engineers according to all legal and guideline requirements.	No
1.3.2. Where impacts could not be avoided altogether, what measures were explored to minimise and remedy (including offsetting) the impacts?	Proposed facilities will be designed by specialist civil engineers according to all legal and guideline requirements. Comprehensive ecological impact assessments will be conducted during the EIA Phase. The outcome will be documented in the EIAR and the proposed mitigation/ management measures of the potential impacts will be provided in the EMPr.	Yes
1.3.3. What measures were explored to enhance positive impacts?	No positive impacts are expected in terms of ecosystems/ biological diversity.	No
1.4. What waste will be generated by this development?	General/ domestic waste might be generated during the construction of the proposed activities. These wastes can however be managed to negligible levels if general good housekeeping measures are developed and implemented by the approved service provider (construction contractor).	No
1.4.1. What measures were explored to firstly avoid waste?	Not Applicable	Not Applicable
1.4.2. Where waste could not be avoided altogether, what measures were explored to minimise, reuse and/or recycle the waste?	Not Applicable	Not Applicable
1.4.3. What measures have been explored to safely treat and/or dispose of unavoidable waste?	Not Applicable	Not Applicable
1.5. How will this development disturb or enhance landscapes and/or sites that constitute the nation's cultural heritage?	The Phase I Heritage Impact Assessment study conducted on the new development footprint revealed none of the types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (Act No. 25 of 1999).	No
1.5.1. What measures were explored to firstly avoid these impacts?	Not Required	No

Need and Desirability Guideline Batch 1 Questions	Answer	Further Assessment Required in EIA (Yes/No)
1.5.2. Where impacts could not be avoided altogether, what measures were explored to minimise and remedy (including offsetting) the impacts?	Not Required	No
1.5.3. What measures were explored to enhance positive impacts?	No positive impacts are expected in terms of the heritage resources within the project area.	No
1.6. How will this development use and/or impact on non-renewable natural resources?	None of the development elements will impact on any non-renewable natural resources.	No
1.6.1. What measures were explored to ensure responsible and equitable use of the resources?	Not Applicable	Not Applicable
1.6.2. How have the consequences of the depletion of the non-renewable natural resources been considered?	Not Applicable	Not Applicable
1.6.3. What measures were explored to firstly avoid these impacts?	Not Applicable	Not Applicable
1.6.4. Where impacts could not be avoided altogether, what measures were explored to minimise and remedy (including offsetting) the impacts?	Not Applicable	Not Applicable
1.6.5. What measures were explored to enhance positive impacts?	Not Applicable	Not Applicable
1.7. How will this development use and/or impact on renewable natural resources and the ecosystem of which they are part?	Ecological (terrestrial (plant and animal life), wetlands, aquatic ecosystems), surface water and groundwater baseline assessments were conducted by suitable and qualified scientists during the Scoping Phase of the project. Ensuing comprehensive ecological impact assessments will be conducted during the EIA Phase. The outcome will be documented in the EIAR and the proposed mitigation/ management measures of the potential impacts will be provided in the EMPr. Due to the stringent liner design and operational requirements to be developed for the magnetite waste site disposal facility and PCD (according to latest regulations), it is not expected that any of these will impact on the water resources or their associated ecosystems.	Yes - Comprehensive impact assessments will be conducted during the EIA Phase whereafter appropriate mitigation/ management measures will be proposed for each identified potential

Need and Desirability Guideline Batch 1 Questions	Answer	Further Assessment Required in EIA (Yes/No)
		impact for inclusion in the EMPr.
1.7.1. Will the use of the resources and/or impact on the ecosystem jeopardise the integrity of the resource and/or system taking into account carrying capacity restrictions, limits of acceptable change, and thresholds?	Ecological (terrestrial (plant and animal life), wetlands, aquatic ecosystems), surface water and groundwater baseline assessments were conducted by suitable and qualified scientists during the Scoping Phase of the project. Ensuing comprehensive ecological impact assessments will be conducted during the EIA Phase. The outcome will be documented in the EIAR and the proposed mitigation/ management measures of the potential impacts will be provided in the EMPr. Due to the stringent liner design and operational requirements to be developed for the magnetite waste site disposal facility and PCD (subject to current best practice and legal requirements), it is not expected that any of these will impact on the water resources or their associated ecosystems.	Yes - Comprehensive impact assessments will be conducted during the EIA Phase whereafter appropriate mitigation/ management measures will be proposed for each identified potential impact for inclusion in the EMPr.
1.7.2. What measures were explored to firstly avoid the use of resources?	No renewable natural resources will be used for the proposed project.	No
1.7.3. If avoidance is not possible, to minimise the use of resources?	No renewable natural resources will be used for the proposed project.	No
1.7.4. What measures were taken to ensure responsible and equitable use of the resources?	No renewable natural resources will be used for the proposed project.	No
1.7.5. What measures were explored to enhance positive impacts?	No renewable natural resources will be used for the proposed project.	No
1.7.6. Does the proposed development exacerbate the increased dependency on increased use of resources to maintain economic growth or does it reduce resource dependency (i.e. de-materialised growth)? *note: (sustainability requires that settlements reduce their ecological footprint by using less material and energy demands and reduce the amount of waste they generate, without compromising their quest to improve their quality of life)*	No renewable natural resources will be used (increased dependency) for the proposed project.	No

Need and Desirability Guideline Batch 1 Questions	Answer	Further Assessment Required in EIA (Yes/No)
1.7.7 Does the proposed use of natural resources constitute the best use thereof? In other words is the use justifiable when considering intra- and intergenerational equity, and are there more important priorities for which the resources should be used (i.e. what are the opportunity costs of using these resources for the proposed development alternative?)	No renewable natural resources will be used for the proposed project.	No
1.7.8 Do the proposed location, type and scale of development promote a reduced dependency on resources?	No renewable natural resources will be used for the proposed project.	No
1.8. How were a risk-averse and cautious approach applied in terms of ecological impacts?	A comprehensive set of baseline assessments were conducted for all the environmental components considered. The relevant specialists will, during the EIA Phase of this project, conduct impact assessments, compile management plans and provide inputs on monitoring requirements. The civil engineering design team will design the proposed facilities taking into consideration the specialists' recommendations and subject to current best practice and legal requirements.	Yes - Comprehensive impact assessments will be conducted during the EIA Phase whereafter appropriate mitigation/ management measures will be proposed for each identified potential impact for inclusion in the EMPr.
1.8.1. What are the limits of current knowledge (note: the gaps, uncertainties and assumptions must be clearly stated)?	This S&EIR Process is supported with comprehensive site specific investigations and assessments in order to minimise the limits in knowledge. Each specialist will document the gaps, uncertainties and assumptions in their respective specialist reports. The EIAR will contain a specific section on this matter.	Yes
1.8.2. What is the level of risk associated with the limits of current knowledge?	Due to the comprehensive and site specific baseline work conducted, the risks associated with the limits of current knowledge are deemed insignificant.	Yes
1.8.3. Based on the limits of knowledge and the level of risk, how and to what extent was a risk-averse and cautious approach applied to the development?	The comprehensiveness of the specialist studies to limit knowledge gaps and the application of best practice and legally founded design criteria adopted for this project, forms the foundation of the risk averse and cautions approach applied to the development.	Yes

Need and Desirability Guideline Batch 1 Questions	Answer	Further Assessment Required in EIA (Yes/No)
1.9. How will the ecological impacts resulting from this development impact on people's environmental right in terms following:	-	-
1.9.1. Negative impacts: e.g. access to resources, opportunity costs, loss of amenity (e.g. open space), air and water quality impacts, nuisance (noise, odour, etc.), health impacts, visual impacts, etc. What measures were taken to firstly avoid negative impacts, but if avoidance is not possible, to minimise, manage and remedy negative impacts?	A comprehensive set of baseline assessments were conducted for all the environmental components considered. The relevant specialists will, during the EIA Phase of this project, conduct impact assessments, compile management plans and provide inputs on monitoring requirements.	Yes - Comprehensive impact assessments will be conducted during the EIA Phase whereafter appropriate mitigation/ management measures will be proposed for each identified potential impact for inclusion in the EMPr.
1.9.2. Positive impacts: e.g. improved access to resources, improved amenity, improved air or water quality, etc. What measures were taken to enhance positive impacts?	No positive impacts are expected in terms of the natural resources within the project area.	No
1.10. Describe the linkages and dependencies between human wellbeing, livelihoods and ecosystem services applicable to the area in question and how the development's ecological impacts will result in socio-economic impacts (e.g. on livelihoods, loss of heritage site, opportunity costs, etc.)?	There is no indication at this stage of the Scoping Phase, that any of the proposed development activities will impact negatively on the social, economic, heritage or biophysical components of peoples' environmental rights. The comprehensive impact assessment to be conducted during the EIA phase of the project will result in the compilation of an EMPr that will effectively manage any significant negative impacts to acceptable levels.	Yes - Comprehensive impact assessments will be conducted during the EIA Phase whereafter appropriate mitigation/ management measures will be proposed for each identified potential impact for inclusion in the EMPr.
1.11. Based on all of the above, how will this development positively or negatively impact on ecological integrity objectives/targets/considerations of the area?	At this point in time it is our assessment that the significant negative impacts associated with proposed developments can effectively be managed to acceptable levels.	

Need and Desirability Guideline Batch 1 Questions	Answer	Further Assessment Required in EIA (Yes/No)
1.12. Considering the need to secure ecological integrity and a healthy biophysical environment, describe how the alternatives identified (in terms of all the different elements of the development and all the different impacts being proposed), resulted in the selection of the "best practicable environmental option" in terms of ecological considerations?	A comprehensive alternatives assessment in terms of the following were considered (full details of this process are relayed in Section 7.1 of this report): • property on which or location where the activity is proposed to be undertaken • type of activity to be undertaken • design or layout of the activity • technology to be used in the activity • operational aspects of the activity • the option of not implementing the activity	No
1.13. Describe the positive and negative cumulative ecological/biophysical impacts bearing in mind the size, scale, scope and nature of the project in relation to its location and existing and other planned developments in the area?	If the proposed project is managed as per the EMPr to be submitted and approved the cumulative impact on the bigger area can effectively be managed to acceptable levels.	Yes - A comprehensive cumulative impact assessment will be performed as part of the EIA Phase of this project.

Table 6(b): Promoting Justifiable Economic and Social Development

Need and Desirability Guideline Batch 2 Questions	Answer	Further Assessment Required in EIA (Yes/No)
2.1. What is the socio-economic context of the area, based on, amongst other considerations, the following considerations?	-	-
2.1.1. The IDP (and its sector plans' vision, objectives, strategies, indicators and targets) and any other strategic plans, frameworks of policies applicable to the area,	The 2021/22 IDP objective states the following: "*To Provide Quality Infrastructure and Affordable Services, Promote Sustainable Economic Growth, Financial Viability, Sound Administration and Accountable Governance.*" The recent IDP for the municipality focusses on five key economic sectors namely; agriculture, mining, manufacturing, tourism and property development.	No
2.1.2. Spatial priorities and desired spatial patterns (e.g. need for integrated of segregated communities, need to upgrade informal settlements, need for densification, etc.),	The project is close to a densely populated township - Mashukane township. Key spatial priorities and desired spatial patterns include: • Moving jobs and investment towards dense townships • Upgrade all informal settlements on suitable well-located land by 2030 • Better quality public transport	No
2.1.3. Spatial characteristics (e.g. existing land uses, planned land uses, cultural landscapes, etc.), and	Ward 2 where the project is situated, hosts several brownfield mining areas and mining infrastructure as well as a small section of townships to the north and west of the R40 including sections of the Mashukane township on the western outskirts of the town of Phalaborwa.	No
2.1.4. Municipal Economic Development Strategy ("LED Strategy").	The following broad strategic programs are proposed to serve as interventions to grow the economy of Ba-Phalaborwa: • Infrastructure development • Property and housing development • Recycling and alternative Green Economy development • Tourism development • *Mining reclamation of waste dumps, extended copper mining and Ilmenite mining* • Settlement of land claims • Scarce game breeding and cattle farming • Big game and trophy hunting and allied offshoot trades • Manufacturing and beneficiation of local commodities from mine dumps and agriculture • Retail, SMME and Informal trading support, • Consolidate the Phalaborwa CBD	No

Need and Desirability Guideline Batch 2 Questions	Answer	Further Assessment Required in EIA (Yes/No)
2.2. Considering the socio-economic context, what will the socio-economic impacts be of the development (and its separate elements/aspects), and specifically also on the socio-economic objectives of the area?	The proposed project is in line with development priorities to enhance the reclamation of mining areas in the Ba-Phalaborwa Municipality and, in general, to support the mining sector in the district and province.	No
2.2.1. Will the development complement the local socio-economic initiatives (such as local economic development (LED) initiatives), or skills development programs?	The proposed project is in line with development priorities to enhance the reclamation of mining areas in the Ba-Phalaborwa Municipality and, in general, to support the mining sector in the district and province.	No
2.3. How will this development address the specific physical, psychological, developmental, cultural and social needs and interests of the relevant communities?	Direct and flow-on of employment creation; reclamation of mining tailings.	Yes
2.4. Will the development result in equitable (intra- and inter-generational) impact distribution, in the short- and long-term?	Tax income generated, increase in public spending.	No
2.4.1. Will the impact be socially and economically sustainable in the short- and long-term?	Positive impacts will be medium term (10 years). Long term negative impacts should be neutralised through the development and implementation of a suitable closure plan/ rehabilitation program.	Yes
2.5. In terms of location, describe how the placement of the proposed development will:	-	-
2.5.1. Result in the creation of residential and employment opportunities in close proximity to or integrated with each other,	The proposed project is located within Ward 2 of on the Ba-Phalaborwa Municipality – close to a township and to the town of Phalaborwa.	No
2.5.2. Reduce the need for transport of people and goods,	Limited job opportunities during the operational phase. However the proposed project is close to a residential area and township associated with the town of Phalaborwa.	No
2.5.3. Result in access to public transport or enable non-motorised and pedestrian transport (e.g. will the development result in densification and the achievement of thresholds in terms public transport),	Employment numbers from the local communities might be too low to achieve scale and cost advantages for public transport.	No
2.5.4. Compliment other uses in the area,	The proposed project is situated within a brownfield mining area.	No
2.5.5. Be in line with the planning for the area,	The proposed project is in line with development priorities to enhance the reclamation of mining areas in the Ba-Phalaborwa Municipality and, in general, to support the mining sector in the district and province.	No
2.5.6. For urban related development, make use of underutilised land available with the urban edge,	Not Applicable	No
2.5.7. Optimise the use of existing resources and infrastructure,	Yes, the proposed project entails the further reclamation of mining tailings from the area.	No
2.5.8. Opportunity costs in terms of bulk infrastructure expansions in non-priority areas (e.g. not aligned with the bulk infrastructure planning for the settlement that reflects the spatial reconstruction priorities of the settlement),	No, no new bulk infrastructure expansion associated with the proposed project.	No

Need and Desirability Guideline Batch 2 Questions	Answer	Further Assessment Required in EIA (Yes/No)
2.5.9. Discourage "urban sprawl" and contribute to compaction/densification,	Not Applicable. The proposed project is situated within a brownfield mining area and will directly employ a small number of workers on site.	No
2.5.10. Contribute to the correction of the historically distorted spatial patterns of settlements and to the optimum use of existing infrastructure in excess of current needs,	No, limited job opportunities will result from the proposed project during the operational phase of the site.	No
2.5.11. Encourage environmentally sustainable land development practices and processes,	Yes, the proposed project entails the further reclamation of mining tailings from the area.	Yes
2.5.12. Take into account special locational factors that might favour the specific location (e.g. the location of a strategic mineral resource, access to the port, access to rail, etc.),	Yes, the proposed project is located close to other mines and mine tailings and have nearby access to rail transport.	No
2.5.13. The investment in the settlement or area in question will generate the highest socio-economic returns (i.e. an area with high economic potential),	Yes, the proposed project is situated within a brownfield mining area, close to mine tailings.	No
2.5.14. Impact on the sense of history, sense of place and heritage of the area and the socio-cultural and cultural-historic characteristics and sensitivities of the area, and	No, the proposed project is the expansion of an existing operation, therefore the sense of place should already have become accustomed to mining and related activities/ infrastructure.	No
2.5.15. In terms of the nature, scale and location of the development promote or act as a catalyst to create a more integrated settlement?	Not likely.	No
2.6. How were a risk-averse and cautious approach applied in terms of socio-economic impacts?	Impacts will be quantified as far as possible using the largest margins for the impacted communities. The risk rating methodology as well as interviews with local stakeholders during the EIA phase of the project should also add control mechanism in the Socio-Economic Impact Assessment (SEIA).	Yes
2.6.1. What are the limits of current knowledge (note: the gaps, uncertainties and assumptions must be clearly stated)?	Local socio-economic data is sometimes limited but will not materially affect the conclusion of the SEIA.	Yes
2.6.2. What is the level of risk (related to inequality, social fabric, livelihoods, vulnerable communities, critical resources, economic vulnerability and sustainability) associated with the limits of current knowledge?	Medium-Low.	No

Need and Desirability Guideline Batch 2 Questions	Answer	Further Assessment Required in EIA (Yes/No)
2.6.3. Based on the limits of knowledge and the level of risk, how and to what extent was a risk-averse and cautious approach applied to the development?	All possible socio-economic risks were highlighted. Impacts will be quantified as far as possible using the largest margins for the impacted communities. The risk rating methodology as well as interviews with local stakeholders during the EIA phase of the project should also add control mechanism in the Socio-Economic Impact Assessment (SEIA).	No
2.7. How will the socio-economic impacts resulting from this development impact on people's environmental right in terms following:	-	-
2.7.1. Negative impacts: e.g. health (e.g. HIV-Aids), safety, social skills, etc. What measures were taken to firstly avoid negative impacts, but if avoidance is not possible, to minimise, manage and remedy negative impacts?	Management measures will be formulated during the EIA Phase of the proposed project to reduce the nuisance factors, risks related to potential in-migration of people and to reduce dependency on the mining sector.	Yes
2.7.2. Positive impacts. What measures were taken to enhance positive impacts?	The following could be considered to enhance the positive impacts associated with the proposed project: • Local recruitment and procurement • Recruit unskilled labour from poor local communities adjacent to proposed project site. • Focus on communities adjacent to proposed project site in terms of LED programmes	Yes
2.8. Considering the linkages and dependencies between human wellbeing, livelihoods and ecosystem services, describe the linkages and dependencies applicable to the area in question and how the development's socio-economic impacts will result in ecological impacts (e.g. over utilisation of natural resources, etc.)?	Given the location of the proposed project, these risks are considered to be low.	Yes
2.9. What measures were taken to pursue the selection of the "best practicable environmental option" in terms of socio-economic considerations?	The management measures that will be developed during the EIA Phase of the proposed project will reduce the medium-low risks further while enhancing the substantial economic benefits associated with the proposed project.	No
2.10. What measures were taken to pursue environmental justice so that adverse environmental impacts shall not be distributed in such a manner as to unfairly discriminate against any person, particularly vulnerable and disadvantaged persons (who are the beneficiaries and is the development located appropriately)?	'The polluter shall pay' principle should protect the local community against external/environmental costs related to the proposed project. Development of preventative management measures will form part of the EIA Phase of the proposed project.	No

Need and Desirability Guideline Batch 2 Questions	Answer	Further Assessment Required in EIA (Yes/No)
2.10.1. Considering the need for social equity and justice, do the alternatives identified, allow the "best practicable environmental option" to be selected, or is there a need for other alternatives to be considered?	No, fair opportunities should exist for unskilled workers and poor communities through the LED programmes associated with the Ba-Phalaborwa Municipality. Socio-economic risks associated with the proposed project posed to poorer communities are considered to be low.	Yes
2.11. What measures were taken to pursue equitable access to environmental resources, benefits and services to meet basic human needs and ensure human wellbeing, and what special measures were taken to ensure access thereto by categories of persons disadvantaged by unfair discrimination?	No, fair opportunities should exist for unskilled workers and poor communities through the LED programmes associated with the Ba-Phalaborwa Municipality. Socio-economic risks associated with the proposed project posed to poorer communities are considered to be low.	Yes
2.12. What measures were taken to ensure that the responsibility for the environmental health and safety consequences of the development has been addressed throughout the development's life cycle?	A management plan with clear objectives and procedures will be developed during the EIA Phase of the proposed project as part of the SEIA.	Yes
2.13. What measures were taken to:	-	-
2.13.1. Ensure the participation of all interested and affected parties,	A comprehensive stakeholder engagement programme is compiled at the start of the project following the relevant available legislation and guidelines. • National Environmental Management Act, 1998 (Act No. 107 of 1998) – NEMA • Public Participation Guideline – GNR 807 of 10 October 2012 • Publication of the companion guideline on the implementation of the Environmental Impact Assessment Regulations, 2010 – GNR 805 of 10 October 2012 • Public Participation Guideline in terms of National Environmental Management Act, 1998 Environmental Impact Assessment Regulations, 2017 A formal Interested and Affected Party (I&AP) database is compiled at the start of the project and is updated/expanded as the process continues.	No
2.13.2. Provide all people with an opportunity to develop the understanding, skills and capacity necessary for achieving equitable and effective participation,	A comprehensive stakeholder engagement programme is followed as stipulated in the relevant and available legislation and guidelines above. People are provided with the opportunity to develop the understanding, skills and capacity necessary for achieving equitable and effective participation.	No
2.13.3. Ensure participation by vulnerable and disadvantaged persons,	A comprehensive stakeholder engagement programme is followed as stipulated in the relevant and available legislation and guidelines above. A	No

Need and Desirability Guideline Batch 2 Questions	Answer	Further Assessment Required in EIA (Yes/No)
	formal I&AP database is compiled at the start of the project and is updated/expanded as the process continues. Participation of all I&AP's are encouraged.	
2.13.4. Promote community wellbeing and empowerment through environmental education, the raising of environmental awareness, the sharing of knowledge and experience and other appropriate means,	A comprehensive stakeholder engagement programme is followed as stipulated in the relevant and available legislation and guidelines above. Information provided to the I&AP's with regards to the project, the impact on the environment and the management of these impacts are clear and concise. Opportunity is provided for I&AP's to raise any questions and to provide comments. The EAP/Applicant will provide feedback during the formal process to which the I&AP's will have access to.	No
2.13.5. Ensure openness and transparency, and access to information in terms of the process	A comprehensive stakeholder engagement programme is followed as stipulated in the relevant and available legislation and guidelines above. Information provided to the I&AP's with regards to the project, the impact on the environment and the management of these impacts are clear and concise. Opportunity is provided for I&AP's to raise any questions and to provide comments. The EAP/Applicant will provide feedback during the formal process to which the I&AP's will have access to.	No
2.13.6. Ensure that the interests, needs and values of all interested and affected parties were taken into account, and that adequate recognition were given to all forms of knowledge, including traditional and ordinary knowledge, and	A comprehensive stakeholder engagement programme is followed as stipulated in the relevant and available legislation and guidelines above. Information provided to the I&AP's with regards to the project, the impact on the environment and the management of these impacts are clear and concise. Opportunity is provided for I&AP's to raise any questions and to provide comments. The EAP/Applicant will provide feedback during the formal process to which the I&AP's will have access to.	No
2.13.7. Ensure that the vital role of women and youth in environmental management and development were recognised and their full participation therein were be promoted?	A comprehensive stakeholder engagement programme is followed as stipulated in the relevant and available legislation and guidelines above. A formal I&AP database is compiled at the start of the project and is updated/expanded as the process continues. Participation of all I&AP's are encouraged and provided for.	No
2.14. Considering the interests, needs and values of all the interested and affected parties, describe how the development will allow for opportunities for all the segments of the community (e.g.. a mixture of low-, middle-, and high-income housing opportunities) that is consistent with the priority needs of the local area (or that is proportional to the needs of an area)	The project is consistent with the job creation objective related to the reduction of mining waste dumps and has strong supply links to the local economy.	No

Need and Desirability Guideline Batch 2 Questions	Answer	Further Assessment Required in EIA (Yes/No)
2.15. What measures have been taken to ensure that current and/or future workers will be informed of work that potentially might be harmful to human health or the environment or of dangers associated with the work?	Protected under the Occupational Health and Safety Act (Act No. 85 of 1993).	No
2.15.1. What measures have been taken to ensure that the right of workers to refuse such work will be respected and protected?	Protected under South African Labour Relations Act (Act No. 66 of 1995) that protects workers against unfair dismissals.	No
2.16. Describe how the development will impact on job creation in terms of, amongst other aspects:	-	-
2.16.1. The number of temporary versus permanent jobs that will be created,	During the operational phase (10 years), job opportunities will be created for seven employees. The number of employment opportunities associated with the construction phase is still unknown at this stage.	Yes
2.16.2. Whether the labour available in the area will be able to take up the job opportunities (i.e. do the required skills match the skills available in the area),	There are sufficient skills in the Ba-Phalaborwa Municipal area.	Yes
2.16.3. The distance from where labourers will have to travel,	There is a large pool of unskilled labour close to the proposed project site.	No
2.16.4. The location of jobs opportunities versus the location of impacts (i.e. equitable distribution of costs and benefits), and	There is a large pool of unskilled labour close to the proposed project site.	No
2.16.5. The opportunity costs in terms of job creation (e.g. a mine might create 100 jobs, but impact on 1000 agricultural jobs, etc.).	Low risk	Yes
2.17. What measures were taken to ensure:		
2.17.1. That there were intergovernmental coordination and harmonisation of policies, legislation and actions relating to the environment, and	A comprehensive stakeholder engagement programme is followed as stipulated in the relevant and available legislation and guidelines above. All the relevant competent authorities form part of the formal I&AP database. Participation of all I&AP's are encouraged.	No
2.17.2 That actual or potential conflicts of interest between organs of state were resolved through conflict resolution procedures?	To date no conflict of interest between organs of state were noted. Should any conflict arise, it will be dealt with in the formal stakeholder engagement programme as prescribed by the relevant and available legislation and guidelines above.	No
2.18. What measures were taken to ensure that the environment will be held in public trust for the people, that the beneficial use of environmental resources will serve the public interest, and that the environment will be protected as the people's common heritage?	Management measures in line with best practice as well as with the applicable legislation governing this aspect will be developed during the EIA Phase.	Yes
2.19. Are the mitigation measures proposed realistic and what long-term environmental legacy and managed burden will be left?	Management measures in line with best practice as well as with the applicable legislation will be developed during the EIA Phase.	Yes

Need and Desirability Guideline Batch 2 Questions	Answer	Further Assessment Required in EIA (Yes/No)
2.20. What measures were taken to ensure that he costs of remedying pollution, environmental degradation and consequent adverse health effects and of preventing, controlling or minimising further pollution, environmental damage or adverse health effects will be paid for by those responsible for harming the environment?	Management measures in line with best practice as well as with the applicable legislation governing this aspect will be developed during the EIA Phase.	Yes
2.21. Considering the need to secure ecological integrity and a healthy bio-physical environment, describe how the alternatives identified (in terms of all the different elements of the development and all the different impacts being proposed), resulted in the selection of the best practicable environmental option in terms of socio-economic considerations?	No alternative considered – optimum use of existing operations/ site.	No
2.22. Describe the positive and negative cumulative socio-economic impacts bearing in mind the size, scale, scope and nature of the project in relation to its location and other planned developments in the area?	The numerous mines in the local area jointly result in an undiversified economy vulnerable to fluctuations in international commodity prices. It also jointly becomes an attractive hub for homeless and unskilled job-seekers from elsewhere to settle in the area that place pressure on public service delivery and infrastructure. It could impact negatively on safety and security related aspects in the local area.	Yes

7. CONSIDERATION OF ALTERNATIVES

The objective of this section is to determine the specific site layout having taken into consideration:

- the comparison of the originally proposed site plan,
- the comparison of this plan with the plan of environmental features and current land uses,
- the issues raised by interested and affected parties, and
- the consideration of alternatives to the initially proposed site layout as a result.

7.1. DETAILS OF ALTERNATIVES CONSIDERED

In terms of the different alternatives to be considered, reference is made to the definition for *alternatives* as contained in the EIA Regulations – GNR 982 of 2014 as amended.

"*alternatives*" in relation to a proposed activity, means different ways of meeting the general purpose and requirements of the activity, which may include alternatives to the -

(a) property on which or location where the activity is proposed to be undertaken
(b) type of activity to be undertaken
(c) design or layout of the activity
(d) technology to be used in the activity
(e) operational aspects of the activity
(f) the option of not implementing the activity

The following proposed activities at Bosveld Phosphates were identified for EA and alternatives associated with these activities have been considered where applicable:

- Magnetite Waste Site Disposal Facility (MWSDF)
- Access Road to Waste Disposal Facility
- Pollution Control Dam (PCD)
- Copper Flotation Plant

An Alternative Identification and Motivation Table (Table 7.1(a)) has been compiled which provides a summary of the outcome of the alternative's assessment. Refer to Figure 7.1(a) for the alternative positions considered in terms of the abovementioned activities and to Figure 7.1(b) for the site layout plan of the preferred alternative.

A large-scale version of the proposed site layout plan, indicating the preferred alternative is attached as **APPENDIX 7(A)** to this report.

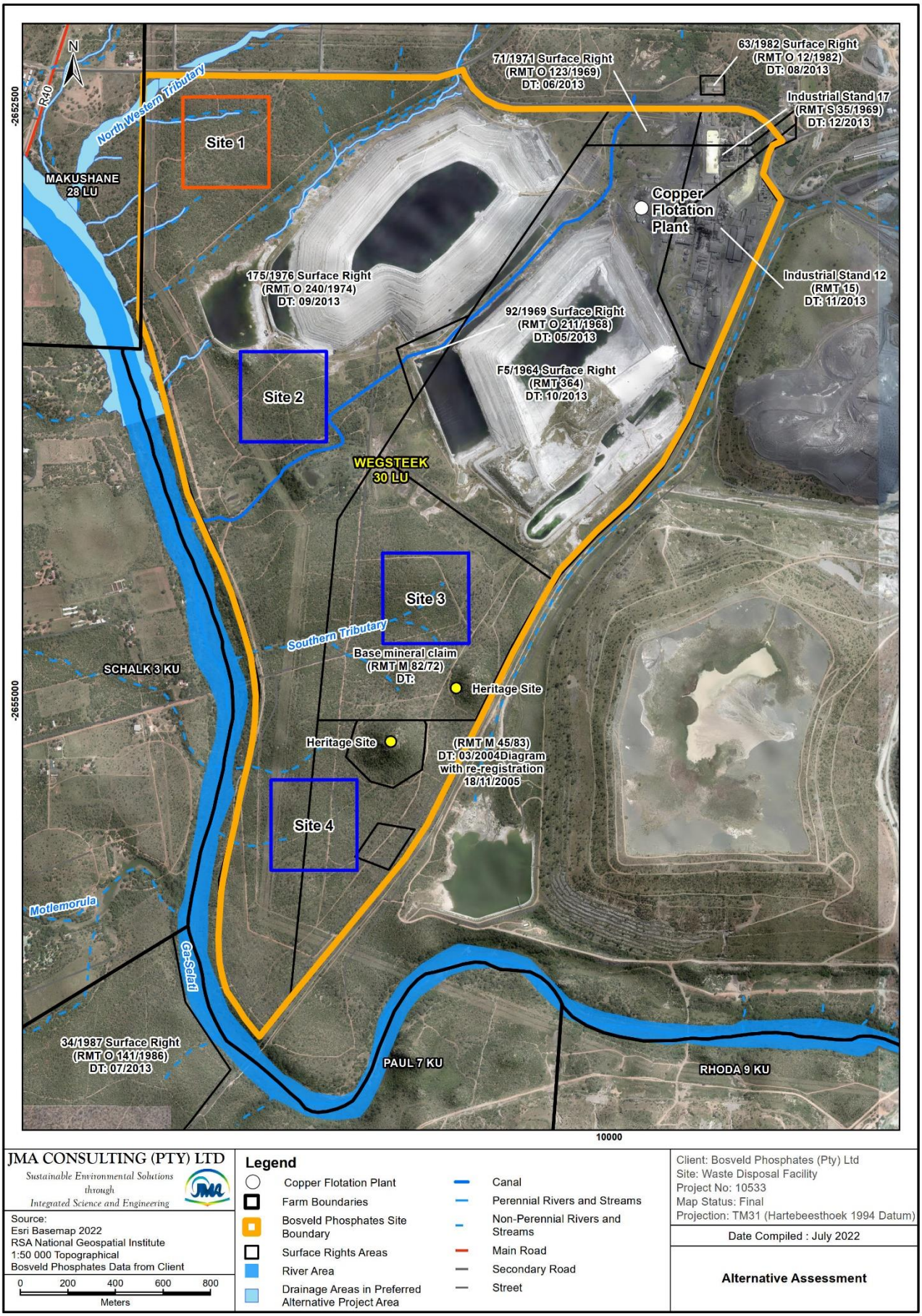


Figure 7.1(a): Proposed Site Layout Plan – Alternative Sites Considered

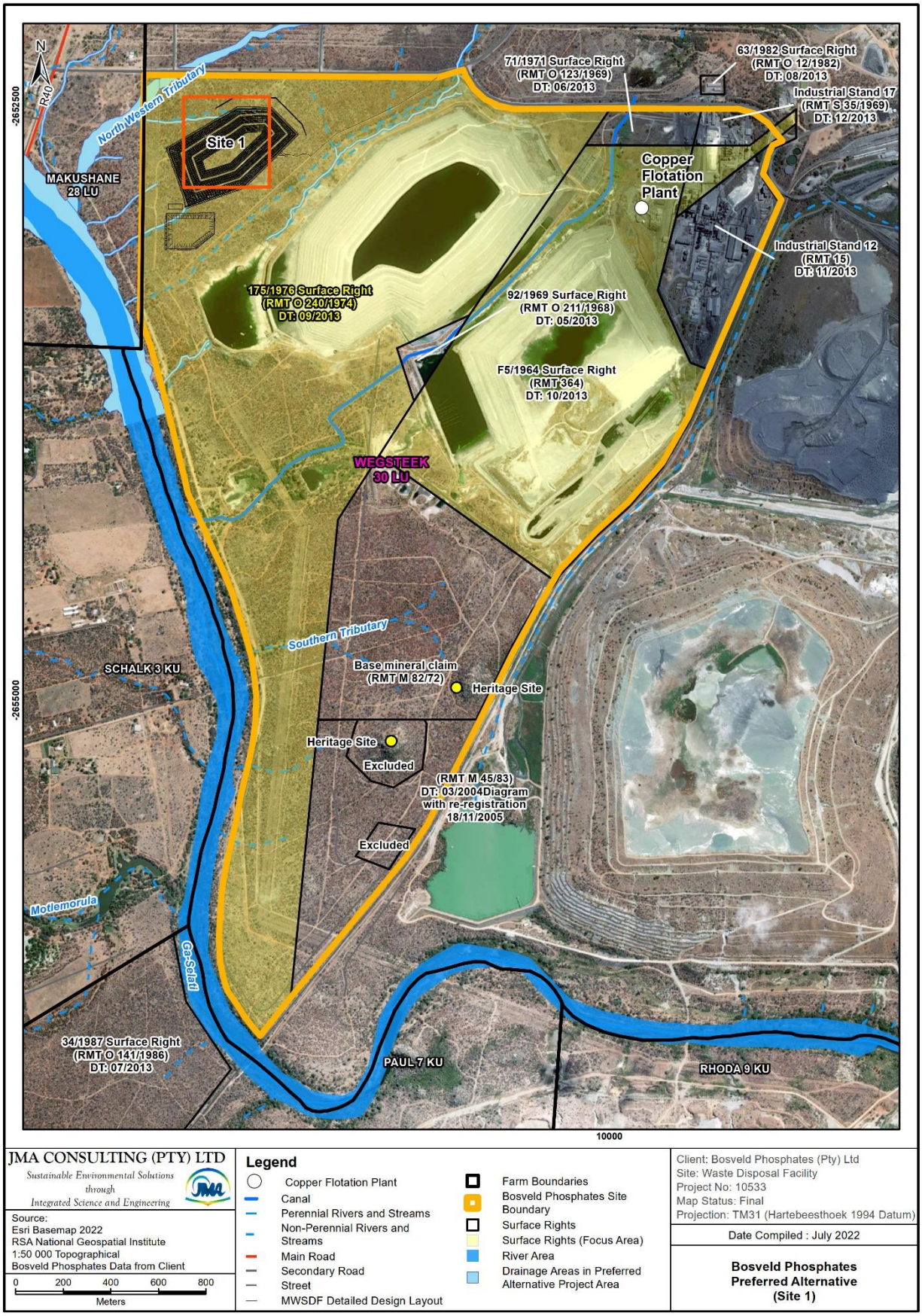


Figure 7.1(b): Proposed Site Layout Plan – Preferred Alternative

Table 7.1(a): Alternative Assessment Table

Activity	Alternative Property	Alternative Site	Alternative Type of Activity	Alternative Design/ Layout	Alternative Technology	Alternative Operational Aspects	No-Go Alternative
Magnetite Waste Site Disposal Facility (MWSDF)	Four sites were identified as alternatives. All four sites are located on the Farm Wegsteek 30, Registration Division L.U. **Site 1:** 175/1976 Surface Right belonging to Bosveld Phosphates **Site 2:** 175/1976 Surface Right belonging to Bosveld Phosphates **Site 3:** Unknown Surface Right **Site 4:** Partially located on175/1976 Surface Right belonging to Bosveld Phosphates & partially located on Base mineral claim (RMT M 45/83) DT: 03/2004 Diagram with re-registration 18/11/2005	**Site 1:** North West of Gypsum Dam A; North of Impounding Dam 2 **Site 2:** South-West of Gypsum Dam A; East of Impounding Dam 2 **Site 3:** South of the Emergency Dam Management Area; Northern corner of Southern Open Veld Management Area **Site 4:** South of the Emergency Dam Management Area; Southern corner of Southern Open Veld Management Area	A Waste Disposal Facility (disposal to landfill) is a primary requirement to cater for the disposal of tailings/ slimes generated from a beneficiation plant. The non-magnetite tailings will be stored temporarily on site until it is processed through a copper flotation plant where copper mineral will be extracted. The waste produced from this copper extraction process needs to be disposed onto an authorised waste disposal facility.	The design and layout of the proposed MWSDF is governed by the legal requirements as per the NEMWA and NWA Regulations, whilst the actual layout is a function of the site attributes where the facility will be located.	The development of the MWSDF will be done in compliance with current legal requirements and through standard best practice civil construction technologies which will be determined by the approved civil designs as well as site conditions.	The development of the MWSDF will be done in strict compliance with the DWS approved designs and the operation will be done in accordance with standard best practices and the operational plan/manual for the MWSDF.	Waste produced by a beneficiation process needs to be disposed onto an authorised waste disposal facility.
Preferred Alternative	**Sites 1, 2 and 4 are the preferred alternative sites –** Surface Rights belong to Bosveld Phosphates.	**Site 1 is the preferred alternative site –** Limited footprint available at Site 2 & 4.	**No Type of Activity Alternative.**	**No Design/ Layout Alternative**	**No Technology Alternative.**	**No Operational Aspects Alternative.**	**The no-go option will deter sustainable development.**
Access Road to the Magnetite Waste Site Disposal Facility	The Access Road is required to the new Magnetite Waste Site Disposal Facility which will be located on Bosveld Phosphates property.	There is no site alternative for the Access Road to the new Magnetite Waste Site Disposal Facility.	An Access Road for vehicular traffic is required.	The Access Road will be designed in accordance with standard best practice civil engineering requirements.	An Access Road for vehicular traffic is required.	The Access Road will be operated in compliance with the design, safety and environmental procedures as prescribed in the design report and the site EMP.	The access road is an operational requirement.
Preferred Alternative	**Access Road to Magnetite Waste Site Disposal Facility located at the preferred alternative Site 1 – Bosveld Phosphates property.**	**The locality of the new access road is dictated by the current infrastructure and the preferred alternative site for the new Magnetite Waste Site Disposal Facility - Site 1.**	**No Type of Activity Alternative.**	**No Design/Layout Alternative.**	**No Technology Alternative.**	**No Operational Aspects Alternative.**	**The no-go option is not feasible.**
Pollution Control Dam (PCD)	Property dictated by location of the actual Magnetite Waste Site Disposal Facility – Preferred Alternative Site 1.	Dam to be downslope of the new Magnetite Waste Site Disposal Facility.	A PCD is a basic requirement for process water recovery and reticulation during tailings/ slimes storage.	The layout for the new PCD is dictated by its functional requirements, the available footprint and the liner type design as legally prescribed.	The use of PCD's for the containment of affected storm water and contaminated leachate is current best practice in South Africa.	The new PCD will be operated in strict compliance with the operational procedures as specified in the design report which is prescribed by the DWS.	The new Magnetite Waste Site Disposal Facility cannot operate without a PCD.
Preferred Alternative	**Facility located at the preferred alternative Site 1 – Bosveld Phosphates property.**	**No Alternative Site. Facility at the preferred alternative Site 1.**	**No Activity Type Alternative.**	**No Design/ Layout Alternative.**	**No Technology Alternative.**	**No Operational Aspects Alternative.**	**The no-go option is not feasible.**

Activity	Alternative Property	Alternative Site	Alternative Type of Activity	Alternative Design/ Layout	Alternative Technology	Alternative Operational Aspects	No-Go Alternative
Copper Flotation Plant	Existing Operations on Properties where the Surface Rights belong to Bosveld Phosphates.	Optimal proximity to stockpile areas, favourable transport routes, ample footprint area and will not inhibit existing or future plant activities.	Optimisation of beneficial material on or close to the Bosveld Phosphates site which contribute to the economic/ value adding potential of the site.	The design and layout of the plant are dictated by spatial attributes and functional requirements related to the extraction of copper from the non-magnetite tailings. The new Plant design and layout was therefore optimized to fit into the existing materials flow of the Bosveld Phosphates site.	The technology used for Copper extraction is determined by the nature of the feed materials.	Plant will operate in accordance with approved design specifications.	Optimisation of beneficial material on or close to the Bosveld Phosphates site which contribute to the economic/ value adding potential of the site.
Preferred Alternative	**No Alternative Property.**	**No Alternative Site.**	**No Activity Type Alternative.**	**No Design/ Layout Alternative.**	**No Technology Alternative.**	**No Operational Aspects Alternative.**	**The no-go option will deter sustainable development.**

7.2. DETAILS OF PUBLIC PARTICIPATION UNDERTAKEN

A summary of the Public Participation Process (PPP) undertaken up to now in support of this project is provided in the sections below.

A Comprehensive PPP Report will be attached as an Appendix to the Draft/Final EIA Report. The PPP Report will provide the details and copies of all documents and information provided to Interested and Affected Parties (I&AP's) as well as proof of all the actions taken during the PPP in support of this project.

7.2.1. The Interested and Affected Party (I&AP) Database

The relevant regulations define I&AP's as:

- Any person, group of persons or organisation interested in, or affected by an activity
- Any organ of state that may have jurisdiction over any aspect of the activity

As per guidelines considered, I&AP's were deemed as the following:

- Landowners
- Lawful Land Occupier
- Landowners or Lawful Land Occupier on adjacent properties
- Municipal Councillor (Ward Councillor)
- The Local Municipality
- The District Municipality
- Traditional Authority/Leaders
- Host Communities
- The Department of Water and Sanitation (DWS)
- Department of Forestry, Fisheries and the Environment (DFFE)
- Limpopo Department of Economic Development, Environment and Tourism (LEDET)
- Other relevant Government Agencies and Institutions responsible for various aspects of the environment and for infrastructure

Having full regard for the above, a formal I&AP database was compiled at the start of this project. This database will continually be updated throughout the process. A copy of the current I&AP database is attached as **APPENDIX 7(B)** to this report**.**

7.2.2. Proof of Notifications to Landowners, Land Occupiers and I&AP's

During the Notice of Application and Scoping Phase, a Notification Letter was compiled to formally inform provisionally identified I&AP's of the project as well as the PPP to be followed. A copy of this Notification Letter is attached as **APPENDIX 7(C)** to this report.

7.2.3. Information provided to I&AP's

In support of this notification, a Background Information Document (BID) relaying the information pertaining to the project (including maps and diagrams) as well as the PPP to be followed was also compiled for distribution to I&AP's.

At the onset of the PPP, the Notification Letter and BID were e-mailed to I&AP's in cases where relevant details were available.

A Registration Form and Questionnaire were also e-mailed on this occasion where I&AP's were invited to provide general comments to the EAP but also specifically to provide details of any other I&AP not included in the provisional I&AP database which they deemed relevant to the project. To ensure that all I&AP's were notified, notifications were also sent via sms'e where contact numbers were available.

Newspaper advertisements as well as site notices were compiled by JMA Consulting relaying information pertaining to the project, the PPP to be followed as well as information regarding the Scoping Phase Public Meeting held on 21 July 2022.

A newspaper advertisement appeared on 7 July 2022 in the Phalaborwa Herald and on 8 July 2022 in the Far North Bulletin. This advertisement notified I&AP's of the Scoping Phase Public Meeting arranged for 21 July 2022 at the Cajori Hotel (Phalaborwa).

Site Notices were put up in advance of the Scoping Phase Public Meeting at the following sites:

- Bosveld Phosphates Main Entrance
- Bosveld Phosphates Notice Board
- SAOB Plant Site Notice Board
- Leboneng Public Library
- Rixile Education Centre – Lulekani
- Ba-Phalaborwa Municipality

The Draft Scoping Report, compiled in strict compliance with the NEMA EIA Regulations, were made available to I&AP's for review. Electronic copies of this report were made available on the JMA website http://www.jmaconsult.co.za/public participation/Bosveld Phosphates and CD's/ flash drives were also available and distributed to I&AP's on request. Notifications were e-mailed and sms'ed to all Registered I&AP's after distribution of reports in cases where relevant details were available. Time frames for commenting were clearly indicated to I&AP's and were set for a minimum 30-day period as required by the NEMA EIA Regulations.

The Draft Scoping Report was made available for comment on 21 July 2022 to I&AP's for a review period of 30 days until 22 August 2022.

The Draft Scoping Report was available for I&AP review at the following public venues:

- Bosveld Phosphates Main Entrance
- SAOB Plant Entrance
- Leboneng Public Library
- Rixile Education Centre – Lulekani
- Ba-Phalaborwa Municipality

A copy of the BID, Registration Form and Questionnaire, Newspaper Advertisements and Site Notices are provided in **APPENDIX 7(D).**

7.2.4. Public and other Meetings

The Scoping Phase Public Meeting was held on 21 July 2022 at the Cajori Hotel (Phalaborwa).

The EAP addressed the full agenda of the meeting in the format of a slide show and explained what the proposed project entailed. The contents of the Draft Scoping Report were discussed with the I&AP's and opportunity was provided to I&AP's to ask questions and to raise concerns regarding the proposed project.

I&AP's were informed that the Draft Scoping Report would be available for public review. Time frames in this regard were communicated to the I&AP's as well as the details on where the reports were available and how they could obtain a copy thereof.

The minutes of the Public Meeting will be circulated to all registered I&AP's and will be attached to the Final Scoping Report (**APPENDIX 7(E)**) to be submitted to the CA.

Focus Group Meetings are meetings that are usually on a smaller scale than the I&AP Public Meeting and has the function of providing additional opportunities for communication between the applicant and I&AP's in order to prevent any misunderstanding and/or to address sensitive issues that may arise during the formal public participation process.

7.2.5. The Public Participation Process (PPP) Report

The NEMA regulations were reviewed specifically for requirements relating to the PPP. These regulations were strictly adhered to during the PPP conducted for this project.

Several guideline documents are currently available to assist persons when conducting a PPP and all of these documents were extensively studied and incorporated into the planning of this PPP and subsequent report. However, the primary source of guidance was the NEMA Public Participation Guideline GNR 807 of 10 October 2012 –

The Guidelines describe the PPP as follows:

- Provide an opportunity for I&AP's, EAP's and the CA to obtain clear, accurate and understandable information about the environmental impacts of the proposed activity or implications of a decision;
- Provide I&AP's with an opportunity to voice their support, concerns and questions regarding the project, application or decision;
- Provide I&AP's with the opportunity of suggesting ways of reducing or mitigating any negative impacts of the project and for enhancing its positive impacts;
- Enable an applicant to incorporate the needs, preferences and values of affected parties into its application;
- Provide opportunities for clearing up misunderstandings about technical issues, resolving disputes and reconciling conflicting interests;
- It is an important aspect of securing transparency and accountability in decision-making; and
- It contributes towards maintaining a healthy, vibrant democracy.

A comprehensive PPP Report will be compiled in support of the S&EIR Process followed for this project.

This PPP Report will continually be updated during the project and will reflect and address all comments received during the I&AP review periods. The Draft and Final PPP Report will be submitted to the relevant authorities as an APPENDIX to the Draft and Final EIA Report (EIAR) respectively.

7.3. SUMMARY OF ISSUES RAISED BY I&AP'S

A concise description of the views on the preferred alternatives, views on the existing environment, views on potential impacts and mitigation is relayed in the sections below.

7.3.1. Views on Preferred Alternatives

Will be completed after the Public Review Period

7.3.2. Views on Existing Environment

Will be completed after the Public Review Period

7.3.3. Views on Impacts and Mitigation

Will be completed after the Public Review Period

7.3.4. Issues and Concerns Register

A formal Issues and Concerns Register will be compiled for this project and will be relayed in Table 7.3.4(a). This register will be completed/updated after every review period for this project, namely the Scoping Phase and EIA Phase, concluded. This register will also be included in the PPP Report.

7.3.5. Objections

Will be completed after the Public Review Period

Table 7.3.4(a): Issues and Concerns Register

Name of Individual	Community / Company	Consulted	Date of Comments Received	Issue / Concern Raised	Response from EAP	Consultation Status e.g. Consensus, Dispute, Not Finalised etc.)
SCOPING PHASE						

Will be completed after the Public Review Period

7.4. ENVIRONMENTAL ATTRIBUTES ASSOCIATED WITH ALTERNATIVES

In support of the requirement to submit a report generated by the National Web Based Environmental Screening Tool in terms of Section 24(5)(h) of the National Environmental Management Act, 1998 (Act No. 107 of 1998) and Regulation 16(1)(b)(v) of the Environmental Impact Assessment (EIA) Regulations (GNR 982 of December 2014 as amended), when submitting an application for environmental authorisation, the required report generated is attached as **APPENDIX 7(F).**

The abovementioned Screening Report identified several environmental features/ attributes to be assessed and to be included in the assessment report (this Scoping Report). Refer to the table below (Table 7.4(a)) for the list of these environmental features/ attributes as well as comments/ motivation provided by the EAP in this regard.

Environmental baseline information relayed in the following sections were obtained from various sources which were updated and/or supplemented with data generated during specialist studies conducted specifically in support of this project. The full list of environmental components considered, is listed below:

- Socio-Cultural and Socio-Economic Aspects
- Archaeology, Heritage and Palaeontology
- Climate and Meteorology
- Topography
- Soils
- Land Capability
- Land Use
- Groundwater
- Surface Water
- Terrestrial Ecology (Plant Life and Animal Life)
- Aquatic Ecosystems
- Wetlands
- Air Quality

Summaries/ extracts of the current environmental conditions (baseline descriptions) relevant to the proposed project area are provided in the following sections.

Table 7.4(a): Environmental Attributes identified in the Screening Report and comments from the EAP

Environmental Attribute/ Specialist Assessment	Comment/ Motivation by the EAP
Agricultural	The Agricultural Sensitivity of the project area will be assessed and confirmed as part of the Soils, Land Capability and Land Use Specialist Assessment in support of the S&EIR Process.
Archaeological and Cultural Heritage	An Archaeological and Cultural Heritage Impact Assessment will be performed, and a relevant specialist report will be compiled in support of this S&EIR Process.
Palaeontological	A Palaeontological Impact Assessment will be performed, and a relevant specialist report will be compiled in support of this S&EIR Process.
Terrestrial Biodiversity (Plant and Animal Life)	A Terrestrial Biodiversity (Plant Life and Animal Life) Impact Assessment will be performed and a relevant specialist report will be compiled in support of this S&EIR Process.
Aquatic Biodiversity	An Aquatic Biodiversity (Aquatic Ecosystems and Wetlands) Impact Assessment will be performed and a relevant specialist report will be compiled in support of this S&EIR Process.
Hydrology (Surface Water)	A Hydrology (Surface Water) Impact Assessment will be performed and a relevant specialist report will be compiled in support of this S&EIR Process.
Noise	Activities associated with this project will be confined to the Bosveld Phosphates site, which falls within the larger Phalaborwa Mining and Industrial Complex. Therefore, a noise impact assessment was not deemed required in support to this S&EIR Process as the proposed activities/ project will not negatively impact on the current (baseline) ambient noise conditions.
Traffic	Activities associated with this project will be confined to the Bosveld Phosphates site, which falls within the larger Phalaborwa Mining and Industrial Complex. Therefore, a traffic impact assessment was not deemed required in support to this S&EIR Process.
Geotechnical/ Seismicity	A Geotechnical Assessment inclusive of a seismicity assessment will be performed by the civil engineering/design team and a relevant design/specialist report will be compiled in support of this S&EIR Process.
Climate	Activities associated with this project will not have an effect on the local/regional climate. Therefore, a climate impact assessment was not deemed required in support to this S&EIR Process.
Health	Health impacts (human and animal) will be assessed simultaneously with all the other environmental aspects and will not be assessed as a separate aspect.
Socio-Economic	A Socio-Economic Impact Assessment (SEIA) will be performed, and a relevant specialist report will be compiled in support of this S&EIR Process.
Ambient Air Quality	An Ambient Air Quality Impact Assessment will be performed, and a relevant specialist report will be compiled in support of this S&EIR Process.

7.4.1. Socio-Cultural and Socio-Economic Aspects

Specialist consultants from Southern Economic Development (SED) were requested to conduct a detailed Socio-Cultural/Economic specialist study in support of the proposed project.

The relevant Specialist Report is:

Socio-Economic Baseline and Scoping Report for Bosveld Phosphates Pty (Ltd), Waste Disposal Facility, Ba-Phalaborwa Municipality, Limpopo Province; April 2022.

The information provided below represents a concise summary of the baseline description compiled for the greater project area.

The project is located directly east of the R40 (regional road) about 7 km south west of the Phalaborwa town centre in the larger Ba-Phalaborwa Local Municipality of the Mopani District in the Limpopo Province. The project site is situated in Ba-Phalaborwa Local Municipality Ward 2.

The 1 km radius zone around the site is mainly characterised by brownfield mining areas. Within the 2 km radius zone there are number of accommodation sites to the west of the Ga-Selati River (Hlolwa Lodge; Poona Lodge, Lebalela Lodge, Bafokeng Palace; Mopani Country Lodge and Mokhontlo Lodge). Within the 5 km radius zone there is the residential and business areas of Ben-Farm and Lulekani to the north as well as a township of Ga-Makoshane one of the larger Phalaborwa township areas to the west of the site (see Figure 7.4.1(a)).

In 2016, approximately 170 000 people resided in Ba-Phalaborwa. Ward 2 of the municipality hosts 7% (12 000 people) of the municipal population. Ward 2 hosts a number of brownfield mining areas and mining infrastructure as well as a small section of townships to the north and west of the R40 including sections of the Mashukane township on the western outskirts of the Phalaborwa town. Until 2016 the area was characterised by high in-migration rates which have abated since then due to a slow-down in mining activities in the area.

With regards to service delivery, access to municipal services is in general higher in the local municipality than national averages apart from the low access levels to improved sanitation and regular refuse removal. Water scarcity was highlighted as one of the primary barriers to rural development in the Mopani District.

When considering skill levels, the municipal area has lower levels when compared to national figures and the area also experience a relatively low number of educational institutions (primary, secondary and tertiary) as well as teachers/educators.

HIV/AIDS, Tuberculosis (TB) and Malaria are serious illnesses that are prevalent in the Ba-Phalaborwa Municipality. Within the municipal area there is a shortage of health facilities, coupled with low staff retention and high staff overload.

Per capita crimes in the municipal area are much lower than the national average, including both property-related crimes and violent crimes. The past year however has seen a steady escalation in violent community protest in the area mainly related to local frustration over local procurement and jobs opportunities in the mining sector.

The local municipality experiences challenges in terms of financial management, project management and over-staffing. The high vacancy rate of environmental compliance officers at Ba-Phalaborwa Municipality is a concern in light of the large role that the mining sector plays in the municipality.

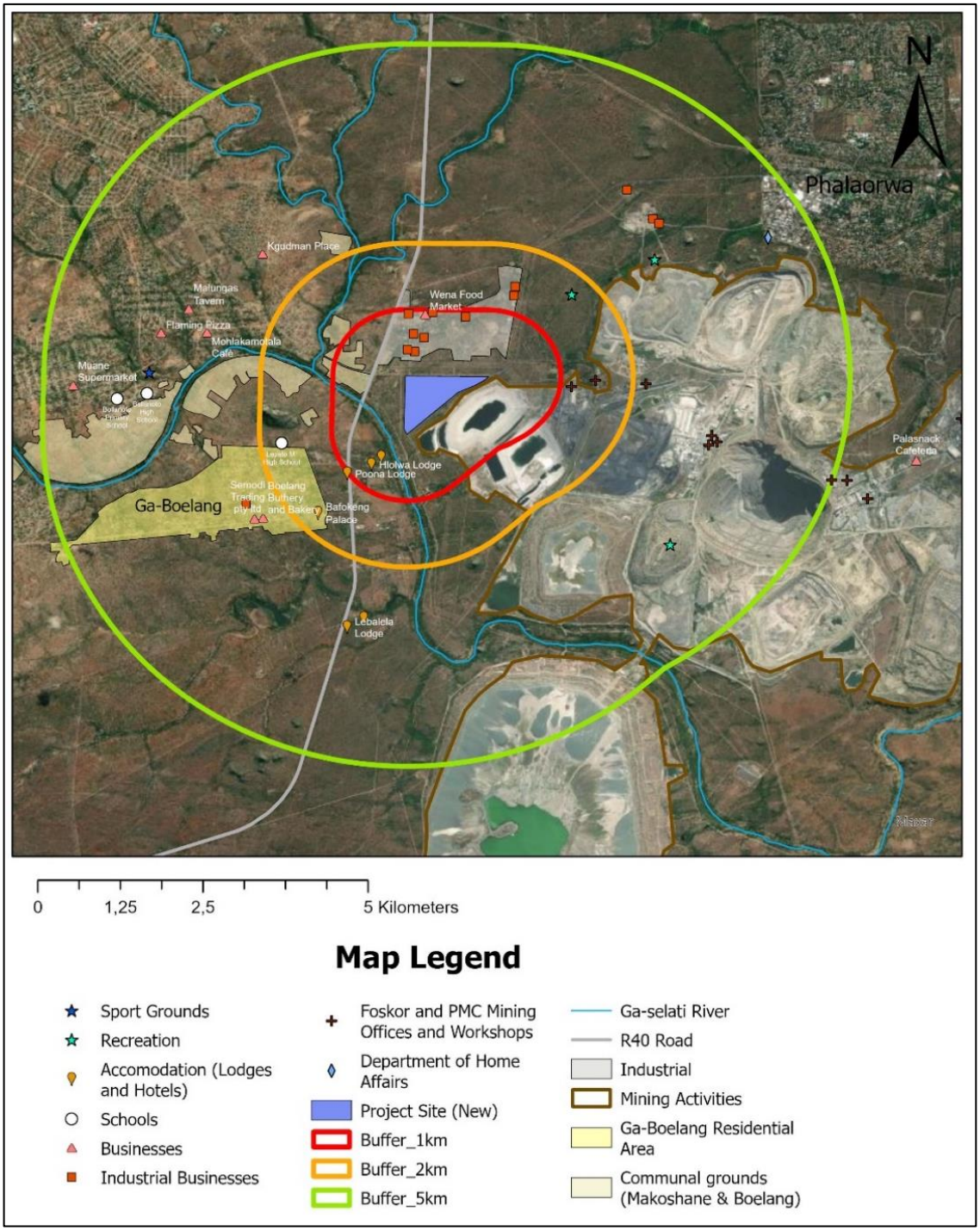


Figure 7.4.1(a): Socio- Economic Sensitive Areas Relevant to the Project Area

The COVID-19 pandemic could have exacerbated local governance challenges in the municipal area as municipal officials were required to work from home for long periods of time.

In terms of economic activity, mining overshadows all other sectors in the Ba-Phalaborwa Municipality's economy in terms of output (73%) but only made the second highest contribution (19%) towards employment after the services sector (including local government employment). Mining output and employment growth was sluggish (below 1% per annum) throughout the past decade.

The municipal area experiences low levels of new investment by both the public and private sectors. Most of the larger private sector investments are in the Ba-Phalaborwa Municipality mining sector and are mainly concentrated around the Palabora Copper Mine.

In terms of economic infrastructure, the municipal area faces challenges in terms of the low percentage of tarred roads (46%) and other road infrastructure and low levels of internet access.

The expanded unemployment rate (including discouraged job-seekers) in the Ba-Phalaborwa Municipality is slightly lower than the average for the Mopani District and provincial averages and a higher portion of the labour force is employed in the formal economy. In terms of larger national economy however, the Ba-Phalaborwa Municipality fared worse in terms of unemployment and formal employment.

Income poverty rates in the Ba-Phalaborwa Municipality are slightly below provincial and national averages. Social vulnerability is the highest in the eastern rural areas of the municipality. The distribution of income in the Ba-Phalaborwa Municipality is more unequal than the already unequal income distribution nationally. Ba-Phalaborwa stands out as an undiversified economy due to the dominant role that the mining sector plays.

The Ba-Phalaborwa Municipality economy is water and energy inefficient (low production relative to its resource use) due to the larger role that the primary sectors play (agriculture and mining).

Limpopo Province experienced the second lowest number of cases of the international COVID-19 pandemic that have hit the world since 2020, after the Northern Cape. The COVID-19 incidence case was around 2% of the Limpopo provincial population compared to the national average of 4%. Despite the relatively low number of cases, the province in general and the Ba-Phalaborwa Municipality's economy has been negatively affected by the pandemic mainly through the tourism, trade and services sectors and also due to the disruptions in the global supply chains and the negative impact on exporting sectors like mining.

The development of the mining sector as well as mining reclamation of waste dumps are development policy priority areas for the Mopani District as well as the Ba-Phalaborwa Municipality. Therefore, the proposed project is in line with the development priorities, and in general, to support the mining sector in the district and province.

7.4.2. Archaeology, Heritage and Palaeontology

7.4.2.1. Heritage Aspects

Specialist consultant Dr Julius Pistorius was requested to conduct a detailed Archaeological and Heritage specialist study in support of the proposed project.

The relevant Specialist Report is:

A Phase I Heritage Impact Assessment (HIA) study for a proposed Waste Disposal Facility for Bosveld Phosphates (Pty) Ltd on the farm Wegsteek 30 LU in Phalaborwa in the Limpopo Province; April 2022.

The information provided below represents an extract of the baseline description compiled with specific reference to the proposed project site.

The aims with the Phase I Heritage Impact Assessment (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 proposed Bosveld Phosphates Project.
- To propose mitigation measures for those heritage resources that may be affected by the proposed Bosveld Phosphates Project.

The Phase I HIA study for the Bosveld Phosphates' proposed Magnetite Waste Site Disposal Facility footprint revealed none of the types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (Act No. 25 of 1999) for the Project Area.

There is consequently no reason from a heritage point of view why the proposed Bosveld Phosphates project cannot proceed. Chance find procedures, will however be developed during the EIA Phase of this project to ensure that if any heritage resources of significance or graves are uncovered during the proposed Bosveld Phosphates project, that the negative impact on these resources can be mitigated. These measures and procedures will be incorporated into the EMPr.

7.4.2.2. Palaeontological Aspects

Specialist consultant Professor Bruce Rubidge was requested to undertake a desktop Palaeontological Impact Assessment specialist study in support of the proposed project.

The relevant Specialist Report is:

Desktop Palaeontological Impact Assessment Bosveld Phosphates (Pty) Ltd Development of Waste Disposal Facility and associated PCD; October 2021.

The information provided below represents a concise summary of the assessment performed in support of this project.

The proposed activities associated with this project, will not affect palaeontological heritage as the entire study area is underlain by Archaean igneous and metamorphic rocks of the Makhutswi Gneiss and syenites of the Phalaborwa Complex.

There is an unlikely possibility that the superficial Quaternary alluvial deposits could host fossils. It is considered that, from a palaeontological perspective, the proposed magnetite waste site disposal facility development should proceed. If fossils are uncovered in the Quaternary alluvial deposits in the course of construction activities, Bosveld Phosphates must immediately call in a qualified palaeontologist to assess the situation and, if necessary, undertake excavation of the fossils.

7.4.3. Topography and Land Use

The Mopani District is situated in the north-eastern part of the Limpopo Province. The District spans a total area of 20 011 km^2. The District Municipality is subdivided into five local municipalities, Greater Giyani, Greater Letaba, Greater Tzaneen, Ba-Phalaborwa and Maruleng (see Figure 7.4.3(a)).

Figure 7.4.3(a)): Local Municipalities of the Mopani District Municipality

The geomorphology of Mopani District Municipality is characterised by a variety of landscapes including, undulating landscapes, plains and lowlands with low to moderate relief. The geology of the district is not uniform and is characterised by sandstones, shale, grit, conglomerate, quartzite and basalt. The type of geology in the District is highly favourable for minerals such as Copper, Gold, Manganese etc. and this is confirmed by the existence of several mining activities taking place around Ba-Phalaborwa Local Municipality.

A part of the Kruger National Park forms part of the Mopani District Municipality.

There are other environmental conservation areas including the Wolkberg Wilderness area renowned as an important biodiversity hotspot, Debengeni Waterfalls, Modjadji Nature Reserve where prehistoric Cycads are found, Manombe Nature Reserve, Provincial Merensky Reserve, Letaba Ranch, geothermal springs in Hans Merensky Nature Reserve and Soutini Baleni (African Ivory Route in the district were traditional salt making activities takes place), Tingwadzi Heritage centre, Lekgalameetse and Muti wa Vatsonga. Apart from these natural areas, there are several private owned game farms and nature reserves around Ba-Phalaborwa and Maruleng Local Municipalities, such as Klasserie, Thorny Bush and Timbavati. Registered natural heritage sites include, Westfalia Estates, Manotsa and Madrid and Shiluvane.

Mopani District Municipality's economy is sustained by two major industries. The first is mining which is dominated by copper and phosphates. Copper is smelted in Phalaborwa while phosphates are transported as raw materials and processed in Richards Bay primarily for export. The second major industry is agriculture. The major focus is on sub-tropical fruit (tomatoes, bananas, mangoes, oranges and pineapples). The main focus of both these industries is to produce for export.

Mining is concentrated in the Ba-Phalaborwa region and the mines employ over 2 000 people and an additional 450 contractors and contribute an estimated 80% of Ba-Phalaborwa Municipality's Gross Domestic Product (GDP). Agriculture and forestry also play an important role in economic growth in the Mopani District Municipality.

The Bosveld Phosphates site is some 616 hectares (ha) in size and is located in a small sub-catchment area of the Ga-Selati River. The site is situated to the east of the Ga-Selati River and has a river frontage of some 4 000 meters. The land slopes from an elevation of 375 metres above mean sea level (mamsl) in the east, down towards the Ga-Selati River at an elevation of some 345 mamsl, in the west. The average topographic gradient across the site is 1.2%.

7.4.4. Climate and Meteorology

This section on Climate and Meteorology was extracted from information provided by the Surface Water Specialist (Knight Piezold) as well as the Air Quality Specialist (EHRCON).

The nature of local climate will determine what will happen to pollution when it is released into the atmosphere (Tyson and Preston-Whyte, 2000). Pollution levels fluctuate daily and hourly, in response to changes in atmospheric stability and variations in mixing depth. Similarly, atmospheric circulation patterns will have an effect on the rate of transport and dispersion of pollution.

The release of atmospheric pollutants into a large volume of air results in the dilution of those pollutants. This is best achieved during conditions of free convection and when the mixing layer is deep (unstable atmospheric conditions). These conditions occur most frequently in summer during the daytime. This dilution effect can however be inhibited under stable atmospheric conditions in the boundary layer (shallow mixing layer). Most surface pollution is thus trapped under a surface inversion (Tyson and Preston-Whyte, 2000).

Inversion occurs under conditions of stability when a layer of warm air lies directly above a layer of cool air. This layer prevents a pollutant from diffusing freely upward, resulting in an increased pollutant concentration at or close to the earth's surface. Surface inversions develop under conditions of clear, calm and dry conditions and often occur at night and during winter (Tyson and Preston-Whyte, 2000). Radiative loss during the night results in the development of a cold layer of air close to the earth's surface. These surface inversions are however, usually destroyed as soon as the sun rises and warms the earth's surface.

With the absence of surface inversions, the pollutants are able to diffuse freely upward. This upward motion may however still be prevented by the presence of elevated inversions. Elevated inversions occur commonly in high pressure areas. Sinking air warms adiabatically to temperatures in excess of those in the mixed boundary layer. The interface between the upper, gently subsiding air is marked by an absolutely stable layer or an elevated subsidence inversion. This type of elevated inversions is most common over Southern Africa (Tyson and Preston-Whyte, 2000).

The climate and atmospheric dispersion potential of South Africa is determined by atmospheric conditions associated with the continental high-pressure cell over the region. The continental high-pressure present over the region in the winter months results in fine conditions with little rainfall and light winds with a northerly flow. Elevated inversions are common in such high-pressure areas due to the subsidence of air. This reduces the mixing depth and suppresses the vertical dispersion of pollutants, causing increased pollutant concentrations (Tyson and Preston-Whyte, 2000).

Seasonal variations in the positions of the high-pressure cells have an effect on atmospheric conditions over the region. For most of the year the tropical easterlies cause an air flow with a north-easterly to north-westerly component. In the winter months the high-pressure cells move northward, displacing the tropical easterlies northward resulting in disruptions to the westerly circulation. The disruptions result in succession of cold fronts over the area in winter with pronounced variations in wind direction, wind speeds, temperature, humidity, and surface pressure. Airflow ahead of a cold front passing over the area has a strong north-north-westerly to north-easterly component, with stable and generally cloud-free conditions. Once the front has passed, the airflow is reflected as having a dominant southerly component (Tyson and Preston-Whyte, 2000).

Easterly and westerly wave disturbances cause a southerly wind flow and tend to hinder the persistence of inversions by destroying them or increasing their altitude, thereby facilitating the dilution and dispersion of pollutants. Pre-frontal conditions tend to reduce the mixing depth. The potential for the accumulation of pollutants during pre-frontal conditions is therefore enhanced (Tyson and Preston-Whyte, 2000).

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

Reference was made to Meteoblue Climate Diagrams, based on 30 years of hourly weather model simulations for Phalaborwa. This data provides a good indication of typical climate patterns and expected conditions (temperature, precipitation, sunshine and wind).

7.4.4.1. Regional Climate

The site is situated in the Lowveld Region of South Africa. The regional climate is highly seasonal with hot humid summers and warm dry winters. The average temperatures range between 18°C to 30°C during the summer months and between 10°C to 23°C during the winter months. The climate is dry and warm with daytime summer temperatures frequently exceeding 40°C. The rainfall predominantly occurs as thundershowers during the summer months. Hail is rare.

7.4.4.2. Temperature

Temperature affects the formation, action, and interactions of pollutants in various ways (Kupchella & Hyland, 1993). Chemical reaction rates tend to increase with temperature and the warmer the air, the more water it can hold and hence the higher the humidity. Temperature also provides an indication of the rate of development and dissipation of the mixing layer as well as determining the effect of plume buoyancy; the larger the temperature difference between the plume and ambient air, the higher the plume is able to rise.

Higher plume buoyancy will result in an increased lag time between the pollutant leaving the source and reaching the ground. This additional time will allow for greater dilution and ultimately a decrease in the pollutant concentrations when reaching ground level.

Humidity is the mass of water vapour per unit volume of natural air. When temperatures are at their highest the humidity is also high, the moisture is trapped inside the droplets of the water vapour. This makes the moisture content of the air high. When relative humidity exceeds 70%, light scattering by suspended particles begins to increase, as a function of increased water uptake by the particles (CEPA/FPAC Working Group, 1999). This results in decreased visibility due to the resultant haze. Many pollutants may also dissolve in water to form acids, as well as secondary pollutants within the atmosphere.

The climate is warm to hot and a fairly high humidity makes summer days very oppressive. Average daily maximum temperatures are of the order of 30°C in January and 23°C in July; extremes can reach 43°C in January and 35° in July, respectively. Average daily minima are about 18°C in summer and 8°C in midwinter, whilst extremes reach 7°C and -2°C, respectively. Frost is seldom experienced and is mainly confined to low-lying valleys.

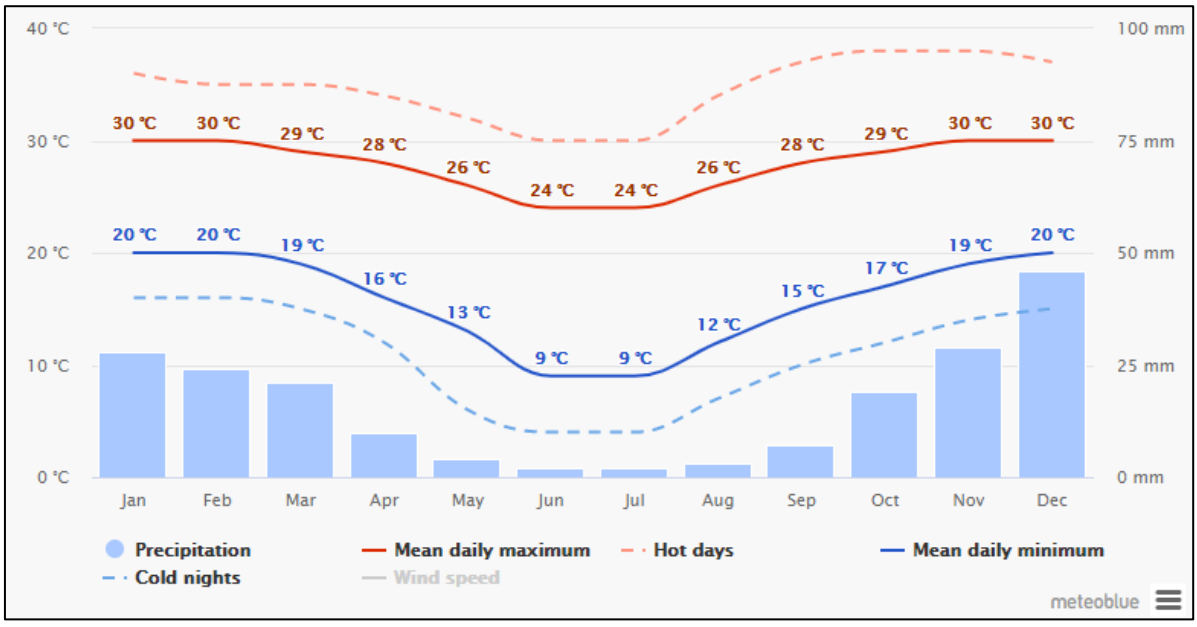


Figure 7.4.4.2(a): Phalaborwa Average Temperature and Precipitation for the Period 1990 – 2020

7.4.4.3. Mean Monthly and Annual Rainfall

The site is located in Olifants Water Management Area (WMA) and specifically within quaternary catchment B72K (WR2012). The rainfall time series used in the study was sourced from the Water Resources of South Africa 2012 Study for the B72K quaternary catchment. Mean annual precipitation (MAP) and S-pan evaporation (MAE) for the region, are 495 mm and 1 550 mm respectively, with a regional annual runoff (MAR) of 8.91 MCM.

The annual rainfall in the Phalaborwa area is relatively low but highly variable. The range is generally from 200 mm to 500 mm per annum, with an annual average of approximately 485 mm. Most rain falls over the period November to March with an average of about 94 rain days per year. Rainfall over the period May to September is generally very low and it is not uncommon to receive no rainfall at all during these months.

The monthly distribution is indicated in Figure 7.4.4.3(a). This record is from 1920 to 2004, Table 7.4.4.3(a) provides the 20th, 50th and 95thth percentiles used determine the dry, mean and wet year depths.

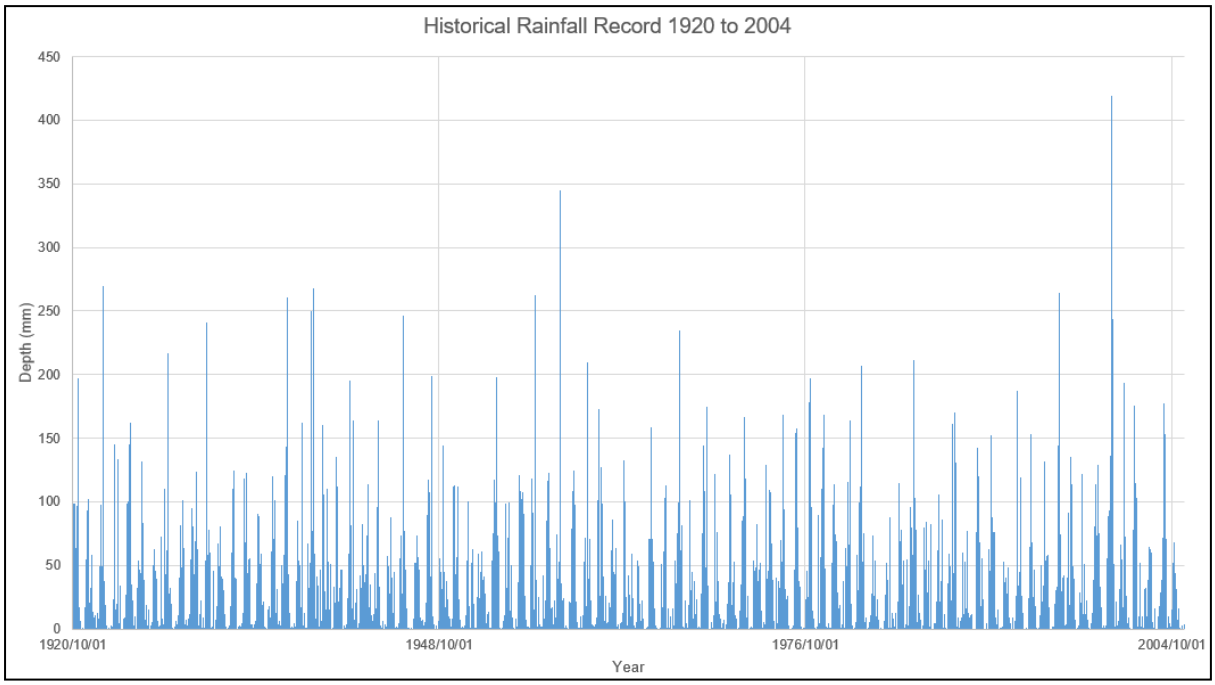


Figure 7.4.4.3(a): Historical Rainfall Record

Table 7.4.4.3(a): Dry, Mean, and Wet Monthly and Annual Precipitation (mm)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Dry year (20th percentile)	11	37	44	37	32	22	8	1	0	0	0	1	193
Average year (50th percentile)	27	59	83	76	57	53	23	6	2	1	2	5	394
Wet year (95th percentile)	78	134	177	213	261	165	74	32	24	41	14	58	1271

7.4.4.4. Maximum Rainfall Intensities

Storm data was taken from the South African Weather Bureau (SAWB) weather station data. Phalaborwa weather station 0681180 W is the closest station to the site and provides a 40-year daily record to determine the storm depths provided in Table 7.4.4.4(a).

Table 7.4.4.4(a): Site Specific Storm Depths (mm)

Duration (days)	Return Period (years)							
	2	5	10	20	50	100	200	PMP*
1	64	92	114	136	167	192	220	400
2	79	116	143	173	216	252	291	450
3	95	141	176	213	266	311	360	480
7	103	152	189	227	280	325	373	500

*PMP = Probable Maximum Precipitation

7.4.4.5. Mean Monthly Evaporation

The site is located within the B72K quaternary catchment. The mean S – pan evaporation indicated for this quaternary catchment according to the WR2012 study is 1 550 mm, however, according to Water Resources 1990 (WR90) study the mean S – pan evaporation is 1 650 mm. The WR 90 maps also show that the evaporation increases across the quaternary catchment and is highest in Phalaborwa (gauge number B7E005) where the mean S – pan evaporation is 1 725 mm. Consequently, a mean S – pan evaporation of 1 650 mm is considered more reasonable.

To account for lake evaporation for the water balance calculations, the WR90 conversion ratios were used to estimate the monthly lake evaporation, as shown in Table 7.4.4.5(a).

Table 7.4.4.5(a): Mean Lake Evaporation (mm)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
149	142	147	142	128	126	101	86	68	74	98	126	1 387

7.4.4.6. Surface Wind Field

Dispersion comprises vertical and horizontal components of motion. The wind field largely determines the horizontal dispersion of pollution in the atmospheric boundary layer. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume stretching. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction and the variability in wind direction, determine the general path pollutants will follow, and the extent of crosswind spreading.

Wind direction in the eastern parts is predominately from the South-Easterly sector. The wind across the Limpopo Province seldom exceeded 8.8 $m.s^{-1}$, most commonly within the range of 2.1 and 5.7 $m.s^{-1}$. The predominant wind directions within the Mopani District are from the east south-east. Wind speeds of between 5 and 18 km/h are generally observed.

Wind roses (see Figure 7.4.4.6(a)) comprise of 16 spokes which represents the direction from which the winds blew during the period under review.

The colours reflect the different categories of wind speeds (see also Figure 7.4.4.6(b)). The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories.

The value given in the centre of the circle describe the frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s.

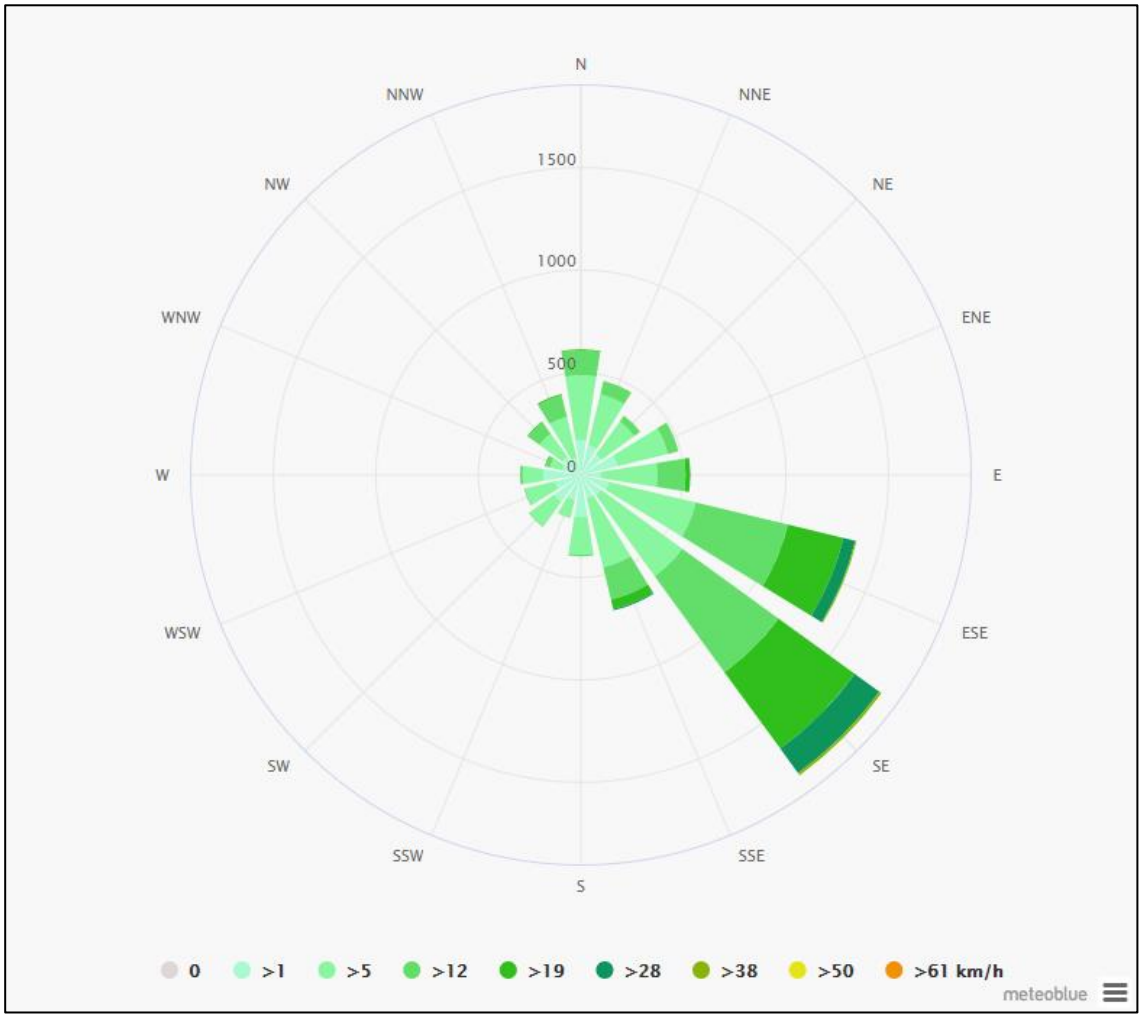


Figure 7.4.4.6(a): Phalaborwa Wind Rose for the Period 1991 – 2021

Atmospheric processes at meso-scale were considered in the characterisation of the atmospheric dispersion potential of the study area. For on-site data, hourly average Unified Model (UM) surface model data supplied by Meteoblue was used. Parameters that need to be considered in the characterisation of meso-scale ventilation potentials include wind speed, wind direction, extent of atmospheric turbulence, ambient air temperature and mixing depth.

Ground level concentrations were predicted for atmospheric conditions based on local meteorological data for the period 1 September 2020 to 31 August 2021. For the reporting period winds were mostly from the easterly sector 46.34%. Calm periods remained the exception (0.7%) but average wind speeds increased from light (16.5%), to moderate (39.6%), to brisk (43.2%).

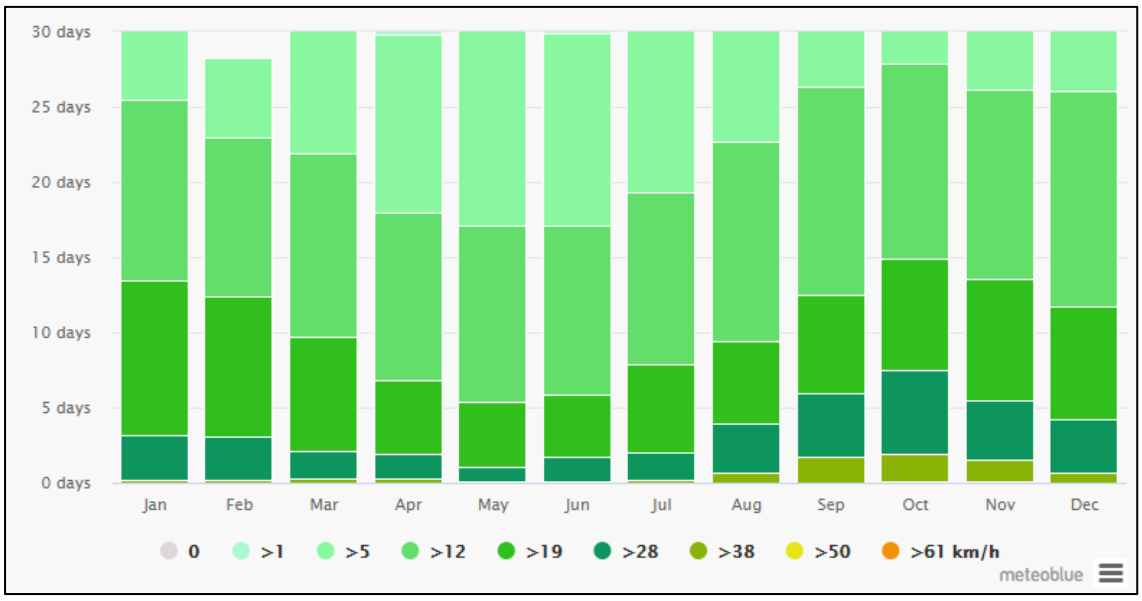


Figure 7.4.4.6(b): Phalaborwa Average Wind Speed for the period 1991 – 2021

An annual wind rose is presented in Figure 7.4.4.6(c).

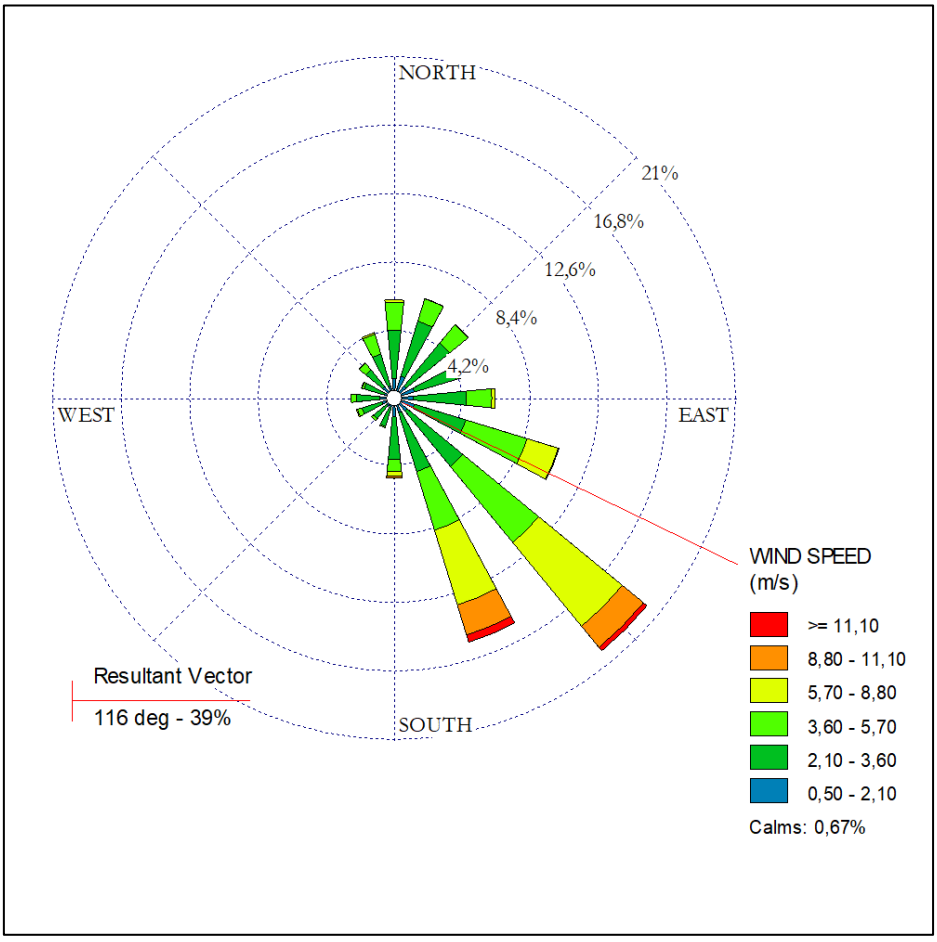


Figure 7.4.4.6(c): Phalaborwa - Period Wind Rose 1 September 2020 to 31 August 2021

7.4.5. Soils and Land Capability

Specialist consultants from Earth Science Solutions (ESS) were requested to conduct a detailed Soils and Land Capability Specialist Assessment in support of the proposed project.

The relevant Specialist Report is:

Bosveld Phosphates (Pty) Ltd Waste Disposal Facility Baseline Specialist Investigation Soils and Land Capability Studies, March 2022.

The information provided below represents a concise extract of the baseline description compiled for the study area.

7.4.5.1. Soil Characterisation

The soils encountered can be broadly categorised into two dominant groupings, with a number of sub dominant groups (Figure 7.4.5.1(a)).

The major soil forms are closely associated with the lithologies from which the soils are derived (in-situ formation) as well as with the topography and general geomorphology of the site, the effects of slope, altitude of the landforms and the pedogenetic processes involved which affects the soil formation.

The dominant soils classified are described in terms of their physical and chemical similarities and to some extent their topographic position and resultant pedogenisis.

The flat to undulating topography has resulted in the in-situ formation of soils, with some downslope transportation and accumulation of colluvial derived material in the valley bottoms and lower slope positions.

The soils encountered in the study area range from shallow fine grained sandy loams and silty loam soils to moderately deep sandy loams with an average rooting depth of between 30cm and 60cm.

The soils returned red to red brown and brown, fine grained loamy topsoil's on red and yellow brown silty loams to sandy loam subsoils often with 20% 30% gravel and pebbles, moderate to good drainage (rapid permeability), and at best moderate and more often poor water holding characteristics.

The pebble layer varies in thickness from a few (20cm - 40cm) centimetres to well over 60 and in places 120cm of rounded to sub rounded (transported) alluvial derived quartz materials that are founded on firm to hard saprolite or hard rock granite gneiss or dolerite.

Pockets (too small to delineate) of very shallow sub-outcrop and Mispah form soils were also noted across the site. These areas are significant as they are denude of a meaningful soil cover and form areas of high site sensitivity.

The drainage lines within the study area are characterised by moderately deep wet based soils.

When considering the sensitivity of a soil, aspects including the depth of soil, the wetness of the soil and the geomorphology (ground roughness, geology, microclimate and landform) were also considered and recorded.

As with any natural system, the transition from one system to another is often complex with multiple facets and variations that change over a relatively small spatial area.

The following dominant soil groupings are considered of importance within the study area (Figure 7.4.5.1(a)):

- The slightly deeper sandier loams (40-60cm Glenrosa, Hutton and Clovelly form soils) are considered of the better potential materials and are distinguished by the better than average depth of relatively free draining soil to a depth of greater than 500mm. This group are recognisable by the lack of signs of any wetness within the top 500mm, and have a relatively thin pebble/stone layer within the profile. Their land capability rates for the most part as moderate or poor intensity grazing. These sites are of the less sensitive sites in the study area.
- In contrast, the shallower and lithocutanic materials are considered to be more ***sensitive*** and will require greater management if disturbed. This group of ***shallower and more sensitive soils*** (< 500mm) are associated almost exclusively with the sub outcropping of the parent materials at, or close to surface and with soils with a more dominant pebble/stone layer. This group of soils constitute the largest portion of the soils in the study area. These soil forms include the sub-outcrop to 40cm Mispah form soils as well as the 40cm to 60cm Glenrosa and shallow Clovelly form soils.
- The streams and waterways comprise for the most part slightly deeper colluvial derived and wet based soils of the Avalon and/or Glencoe form soils.

The findings of the study area assessment were delineated according to their soil classification nomenclature and soil depth (decimetres), while soils with similar physical and chemical characteristics have been grouped and delineated into dominant categories (Figure 7.4.5.1(a)).

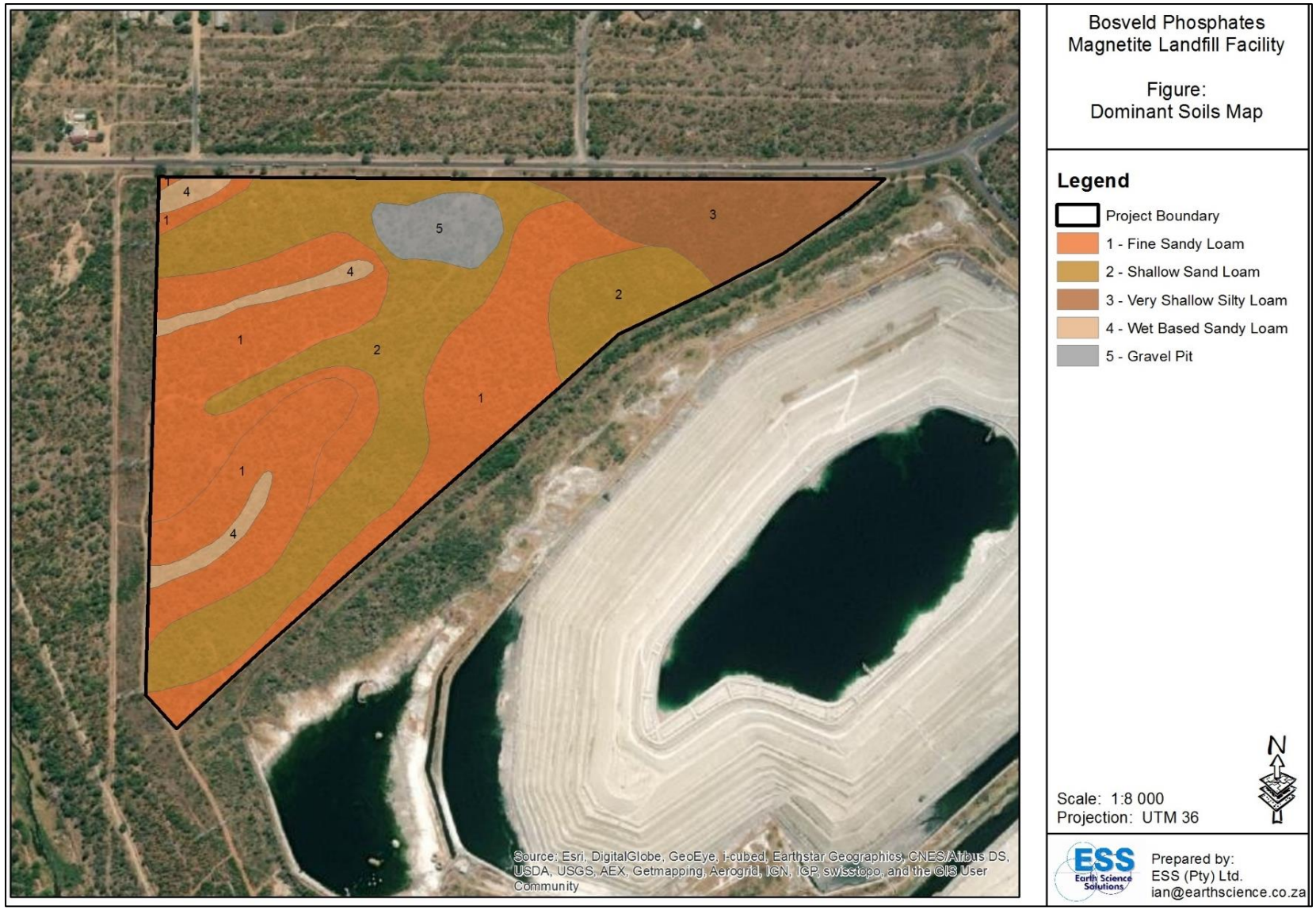


Figure 7.4.5.1(a): Dominant Soils Map

7.4.5.2. Soil Chemical and Physical Characteristics

A number of representative samples from the differing soil forms within the study area were taken and sent for analyses for both chemical and physical parameters. Refer to Table 7.4.5.2(a).

Table 2.1.4.1(a): Analytical Results

Sample Name	pH	Resistance	P (Ambic I)	K	Na	K	Ca	Mg	Cu	Al	Zn	Mn	Fe	Na	K	Ca	Mg	T-Value	EC	Clay	Silt	Sand	Cl	Na	Ca	Mg
	(KCl)	(ohm)	(mg/kg)	(mg/kg)	Exchangeable cations (cmol/kg)				mg/kg					Base saturation (%)				(cmol/kg)	mS/cm	%			mg/kg			
	5.2-6.5		20-80	>40					1-10	<30	2-10	10-250	10-250	<2.0	6-10	55-75	18-30								>200	>60
PB1	5,93	1594	6,5	162	0,17	0,42	7,29	1,42	8,81	<1	0,38	7,9	25,7	1,83	4,48	78,44	15,26	9,30	0,108	16	8	76	5,0	39	1458	170
PB2	6,69	1192	29,6	181	0,17	0,46	15,22	1,28	58,98	<1	0,95	20,5	50,9	0,97	2,70	88,86	7,47	17,13	0,173	6	20	74	13,0	38	3044	154
PB3	6,84	886	22,2	215	0,22	0,55	15,26	1,52	50,16	<1	0,98	10,9	48,2	1,26	3,14	86,96	8,65	17,55	0,280	9	24	67	18,5	51	3053	182
PB4	6,64	2139	108,6	58	0,21	0,15	3,76	0,72	3,65	<1	0,82	8,6	22,8	4,29	3,07	77,69	14,95	4,83	0,067	2	5	93	1,0	48	751	87
PB5	6,54	1156	195,0	187	0,17	0,48	9,21	1,94	9,06	<1	1,96	13,2	17,7	1,46	4,07	78,02	16,46	11,81	0,182	13	13	74	0,5	40	1842	233

7.4.5.3. Soil Chemical Characteristics

The analytical results are representative of the pre-construction conditions and indicative of the baseline conditions encountered, which will be disturbed if the proposed development takes place.

In general, the pH ranges from slightly acid at 6.01 to 6.75, nutrient levels reflecting generally acceptable levels of most of the required nutrients and metals, but deficiencies in the levels of Zinc, Magnesium, and Potassium and in some places Manganese, with higher than recommended concentrations of Copper and Phosphate encountered.

The growth potential on soils with these nutrient characteristics is at best moderate and additions of nutrient and organics (compost) will be necessary if vegetative cover is to be propagated on these soils (rehabilitation). They are at best moderate to poor grazing lands, with the majority of the study area classifying as having a land capability rating of wilderness status.

Geophysically, the laboratory analysis returned a variety of materials that range from very well sorted sandy loams with lower-than-average nutrient stores and moderate clay percentages (13% and 16% - B2/1) to soils with a silty sand texture and single grained structure and lower than recommended nutrients, metals and poor organic carbon stores.

7.4.5.4. Soil Erosion and Compaction

Erodibility is defined as the vulnerability or susceptibility of a soil to erosion. It is a function of both the physical characteristics of a particular soil as well as the way in which the soil is treated.

The resistance to, or ease of erosion of a soil is expressed by an erodibility factor ("K"), which is determined from soil texture/clay content, permeability, organic matter content and soil structure. The Soil Erodibility Nomograph (Wischmeier et al., 1971) was used to calculate the "K" value.

The index of erosion (I.O.E.) for a soil can then be determined by multiplying the "K" value by the "slope" measured as a percentage. Erosion problems may be experienced when the I.O.E is greater than 2.

The majority of the soils delineated within the study area can be classified as having a moderate to high erodibility index in terms of their organic carbon content (low) and clay content (moderate to low), while the topography will temper the erosion index from moderate to low, with undulating to flat slopes for the majority of the study area under review.

However, the vulnerability of the "B" horizon to erosion once the topsoil and/or vegetation is removed must not be underestimated when working with or on these soils. These horizons (B2/1) are vulnerable and rate as high when exposed.

The concerns around erosion and *inter alia* compaction, are directly related to the disturbance of the protective vegetation cover and topsoil that will be disturbed during any construction and operational phases of the development. Once disturbed, the effects and actions of wind and water are increased.

7.4.5.5. Pre-Construction Land Capability

Based on a well-developed and scientifically founded baseline of information, the South African Chamber of Mines (1991) Land Capability Rating System has been used as the basis for the land capability analyses for the study area.

Using the above mentioned system, the potential land capability expected of the study area was classified into four distinctly different and recognisable classes; namely Wetlands, Arable Land, Grazing Land and Conservation of Land.

1) Criteria for Wetland
   Land with organic soils or supporting hygrophilous vegetation where soil and vegetation processes are water determined.

2) Criteria for Arable Land
   Land, which does not qualify as having wetland soils.
   The soil is readily permeable to a depth of 750mm.
   The soil has a pH value of between 4.0 and 8.4.
   The soil has a low salinity and SAR
   The soil has less than 10% (by volume) rocks or pedocrete fragments larger than 100mm in the upper 750mm.
   Has a slope (in %) and erodibility factor ("K") such that their product is <2.0
   Occurs under a climate of crop yields that are at least equal to the current national average for these crops.

3) Criteria for Grazing Land
   Land, which does not qualify as having wetland soils or arable land.
   Has soil, or soil-like material, permeable to roots of native plants, that is more than 250mm thick and contains less than 50% by volume of rocks or pedocrete fragments larger than 100mm.
   Supports, or is capable of supporting, a stand of native or introduced grass species, or other forage plants utilisable by domesticated livestock or game animals on a commercial basis.

4) Criteria for Conservation of Land
   Land, which does not qualify as having wetland soils, arable land or grazing land, and as a result is regarded as requiring conservation practise/actions.

7.4.5.6. Land Capability Description

The land capability classification as described herein used the soil and geomorphological aspects (ground roughness, geology, topography, climate etc.) as the information source and basis for the land capability rating.

The area to be disturbed by the proposed development is planned over a range of land capability classes. These include significant areas of wilderness land potential, and areas of moderate to poor grazing land capability (see Figure 7.4.5.6(a)).

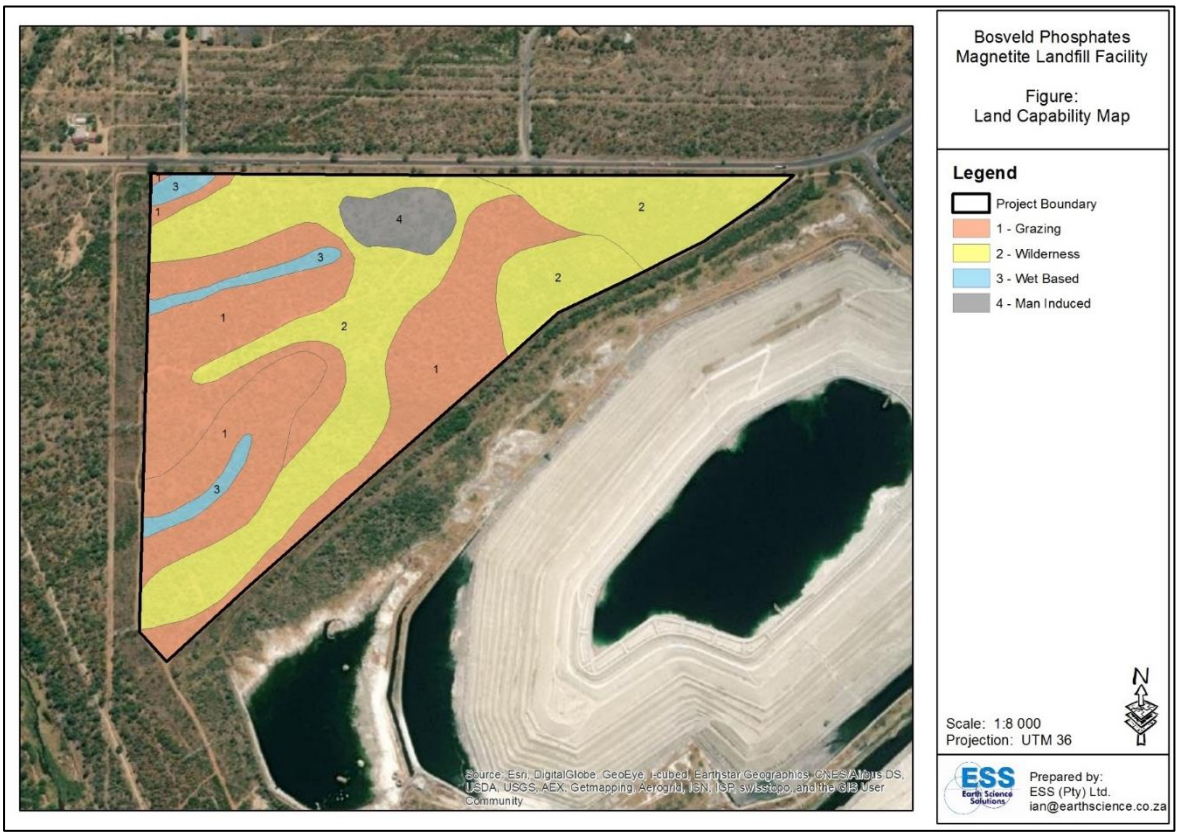


Figure 7.4.5.6(a): Land Capability Map

Wetland (Areas with wetland status soils)

There a number of areas associated exclusively with the drainage lines where wetness was noted at depth. None of these sites classify as wetlands, the wetness features occurring at depths greater than 500mm.

Arable Land

There are no sites that qualify as arable land capability status within the study area. Areas of red and yellow brown apedel soils were noted and , but none of these soils meet the required rooting depths (750mm).

Grazing Land

The classification of grazing land covers the shallower and transitional zone soils that are well drained. These soils are generally darker in colour, and although not always free draining to a depth of 750mm, they are capable of sustaining palatable plant species. A significant proportion of the sites mapped classify as moderate or poor potential grazing lands.

Wilderness / Conservation Land

The shallow rocky areas and soils with a lithocutanic structure or a preponderance of stone/pebble within the rooting profile classify as having a wilderness character and land capability rating. The majority of the study area classifies as having a wilderness land capability rating.

7.4.6. Geology and Groundwater

JMA Consulting (Pty) Ltd conducted a detailed Groundwater baseline specialist assessment in support of the proposed project.

The relevant Specialist Report is:

Groundwater Baseline Study Report; Bosveld Phosphates – June 2022

The information provided below represents a concise extract of the baseline description compiled for the study area.

7.4.6.1. Regional Geology

The regional geological setting of the Bosveld Phosphates site is shown on the map depicted in Figure 7.4.6.1(a).

Bosveld Phosphates is situated on Archaean gneiss, namely the Makhutswi Gneiss. The site is some 2 km east of the Phalaborwa Complex which consists of a main body of pyroxenite and related igneous rock, as well as a large number of syenite plugs intrusive into the surrounding Archaean gneiss.

The syenite forms conical hills up to 70 km distant along a north-east-tending belt and is distinct from a discontinuous fenite zone adjacent to the main body. Narrow, steeply dipping syenite dykes also cut through the pyroxenite and surrounding Archaean gneiss.

The Makhutswi Gneiss (Kaap Valley pluton) has a tonalitic composition, is intensely migmatized and exhibits in places schlieric amphibolite material which could represent mafic dykes.

Chemical analyses indicate the Kaap Valley pluton (tonalite gneiss) to have distinctive Na-rich TTG granitoid characteristics.

A number of Karoo dolerite dykes, part of a north-east trending dyke swarm, cut all the rocks of the Phalaborwa Complex as well as the surrounding Archaean gneiss. Dykes vary in width from a few centimeters to ± 50 m. Individual dykes tend to bifurcate, the off-shoots converging with other dykes.

The wider dykes are well jointed. Dykes become fine-grained towards their walls. Dyke contacts are sharp and marked in many places by shearing. No visible alteration of the wall rock (PMC's Old Copper Quarry - Loolekop) has taken place adjacent to the dykes (Lombard et al.). The dykes are normally less resistant than the granite gneiss host rock. Weathering, therefore, often creates negative topographic features which can be traced as linear structures along strike.

The main structural phenomena in the study area are the abundance of dolerite dykes, predominantly striking from north-east to south-west and a number of narrow, steeply dipping syenite dykes. Individual dykes tend to bifurcate, the off-shoots converging with other dykes. The wider dykes are well jointed. Dykes are weathered to depths varying between 2 m and > 30 m.

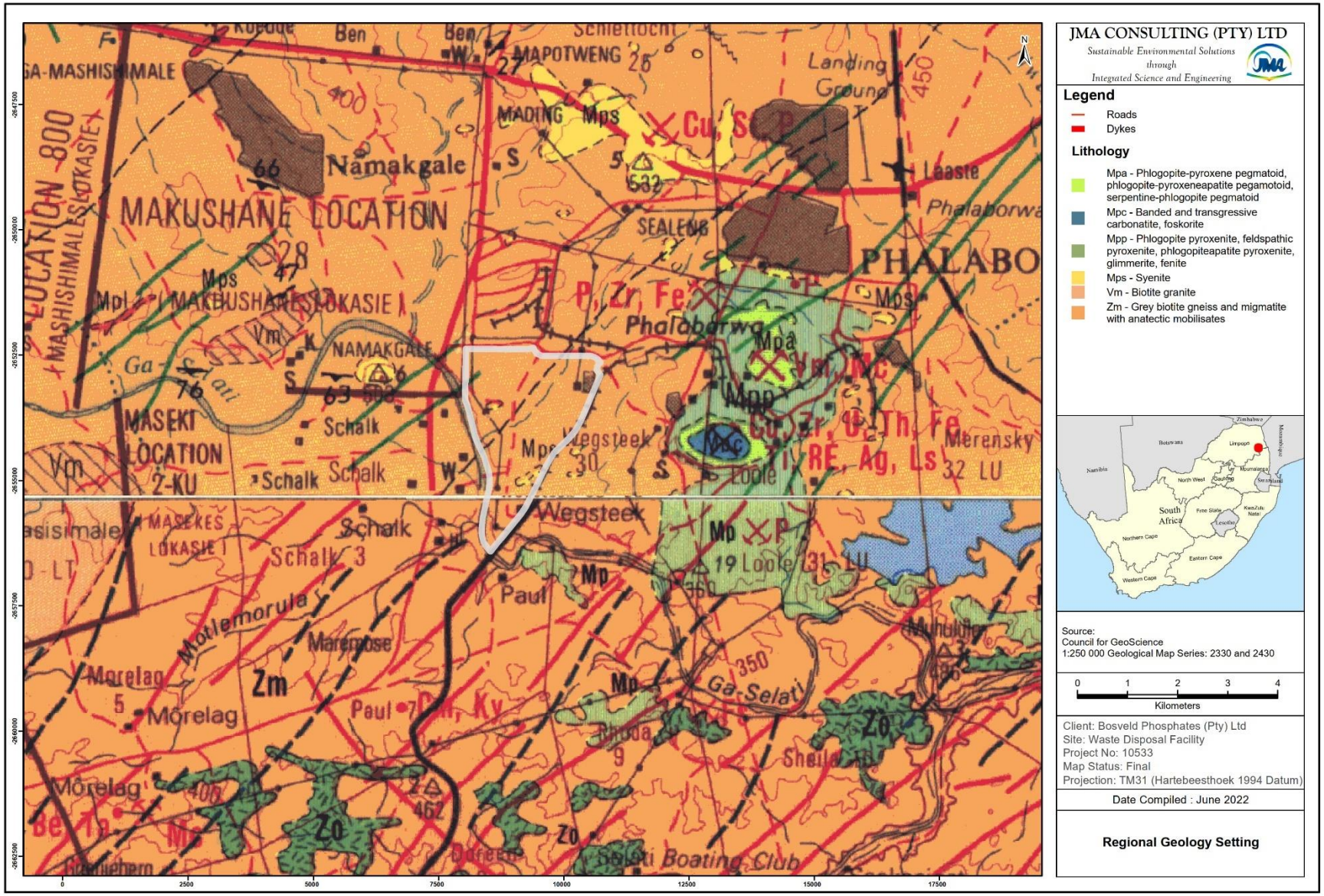


Figure 7.4.6.1(a): Regional Surface Geology

7.4.6.2. Regional Geohydrology

The regional geohydrology can be described with reference to DWAF's 1:500 000 Hydrogeological Map PHALABORWA 2330 as illustrated on Figure 7.4.6.2(a). The following regional characteristics are important:

The surface lithology for the region comprises predominantly meta-arenaceous rocks (quartzite, gneiss and migmatite).

Groundwater occurs in:

- Saturated unconsolidated alluvial deposits mainly along river systems.
- Fractured transitional zones between weathered and unweathered bedrock.
- Fractures along contact zones related to heating and cooling of host rock caused by the intrusion of dykes and sills.
- Basins of weathering occurring mostly in the crystalline rocks.
- Fractures related to tension or compressional stresses and off-loading.
- Faults and shear zones.

The aquifer type is indicated as an inter-granular and fractured type aquifer. The borehole yield class (median l/sec excluding dry boreholes) is indicated as ranging between 0.5 l/s and 2.0 l/s.

Groundwater quality, as represented by electrical conductivity, is indicated to range between 70 mS/m and 300 mS/m with some outliers ranging between 300 mS/m and 1000 mS/m. Fluoride concentrations are indicated to possibly be > 1.5 mg/l.

With reference to DWAF's map: Groundwater Resources of the Republic of South Africa, SHEET 2, 1995, the following regional characteristics are noteworthy:

- Mean annual recharge is indicated as ranging between 75 mm and 100 mm.
- The storage coefficient (order of magnitude only) is indicated as < 0,001.
- The mean depth to water table is indicated to range between 20 m - 30 m, while the standard deviation range from mean (m) is indicated as < 15 m.
- The mean annual (mm) groundwater component of base flow is indicated to range between 50 mm and 100 mm.

7.4.6.3. Physical Aquifer Description

The physical delineation and description of the aquifers within the study area is discussed with reference to the geological information generated during numerous site-specific quantitative field investigations. Over 150 geohydrological investigative boreholes have been drilled on site in the past and therefore a wealth of information is therefore available.

<u>Aquifer Matrix (Soil and Geological Matrix)</u>

Two aquifer zones exist, namely the shallow weathered zone and deep fractured aquifers. Extensive geological and geohydrological investigations have been performed by JMA Consulting on the shallow weathered zone aquifer as well as, although to a lesser degree on the deep fractured aquifer since 1993.

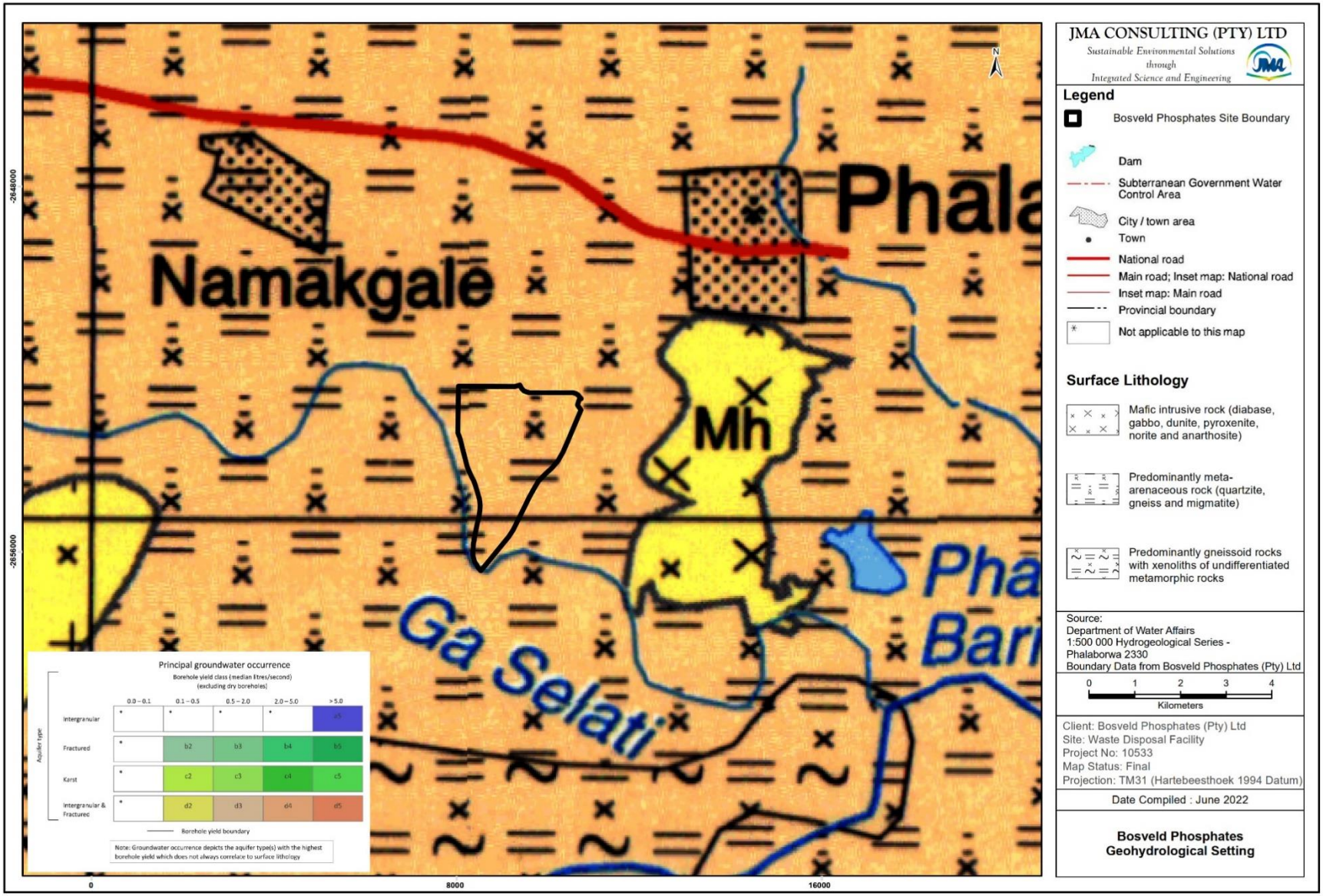


Figure 7.4.6.2(a): Regional Geohydrological Setting

Aquifer Types (Primary, Weathered, Fractured, Karst)

Two aquifer zones exist, namely the shallow weathered zone and deep fractured aquifers. Extensive geological and geohydrological investigations have been performed by JMA Consulting on the shallow weathered zone aquifer as well as, although to a lesser degree on the deep fractured aquifer since 1993.

Shallow Weathered Zone Aquifer

The shallow weathered zone aquifers(s) present in the study area, comprise initially of soil cover (colluvial gravel and residual gneiss soils), weathered gneiss with numerous pegmatite veins, syenite plugs (visible on surface as prominent kopjes) as well as syenite and dolerite dykes.

The soils vary in thickness (max. 2.38 m) with the alluvial soils extending to depths of ± 11 m (FGM-B28) in places. The weathering depth of the gneiss ranges between 10 m and 44.5 m, with an average weathering depth of 22.51 m. The syenite occurs as “plug like” intrusions and is considered a fresh non-porous rock and has a definite influence on groundwater flow directions.

Controlled Source Audio-frequency Magnetotellurics (CSAMT) data acquired along a 2 km traverse running along the Ga-Selati River eastern bank identified three broad conductive zones. Resistivity sections indicate the intrusion of dyke structures within the broader conductive zones. Below the depth of weathering, the resistive areas between the conductive zones can be interpreted as fresh non-porous rock.

The high density of dolerite dykes will result in the creation of pseudoflow tubes in a direction parallel to the strike of the dykes. The dykes run perpendicular to the Ga-Selati River, fronting the western boundary of the Bosveld Phosphates property, implying that several "flow tubes" intersect the river. Dykes predominantly act as groundwater barriers, thus compartmentalizing the aquifer, irrespective of the weathering depths. Groundwater through-flow mostly occurs at shallow depths.

Deep Fractured Zone Aquifer

During 2004 JMA Consulting undertook a study into the deep aquifer that comprised of a geophysical investigation, the drilling of 4 deep boreholes (GGM-B58D to FGM-B61D) and the subsequent testing and sampling of these boreholes to quantify relevant deep fractured aquifer attributes.

Borehole FGM-B58D was drilled to a depth of 130 m. Weathering in the borehole was recorded down to a depth of 34 m below the surface. Below the depth of weathering, the only fracturing of significance was recorded between 102 m and 108 m. This interval of recorded fracturing is associated with a syenite dyke and pegmatite intersection. A blow yield of 0.42 l/s was recorded along this intersection. Only one dolerite intersection was recorded and was recorded between 76.5 m and 81 m. No fracturing of significance was observed along this intersection. No fractures were recorded below 108 m.

Borehole FGM-B59D was drilled to a depth of 115 m. Weathering in the borehole was recorded down to a depth of 44.5 m. Below the depth of weathering, fractures were recorded between 51 m to 59 m and 83.5 m to 87.5 m. Both intervals of recorded fracturing are associated with dolerite intersections. A water strike with a blow yield of 1.03 l/s was recorded between 53.5 m and 56 m. Dolerite was again intersected in this borehole at a depth of 95.5 m. The contact was recorded as solid and the borehole was terminated in fresh dolerite at a depth of 115 m.

Borehole FGM-B60D was drilled to a depth of 130 m. Weathering in the borehole was recorded down to a depth of 29 m. Below the depth of weathering, fractures were recorded between 52.5 m to 65 m, 76 m to 81 m, 87 m to 91 m and 101 m to 103 m. These intervals of recorded fracturing are associated with pegmatite intersections, all of which made water. A total blow yield of 1.16 l/s was recorded for these intersections. No fractures were recorded below 103 m.

Borehole FGM-B61D was drilled to a depth of 130 m. Weathering in the borehole was recorded down to a depth of 27 m. Below the depth of weathering, fractures were recorded between 37 m to 46 m, 54 m to 56 m and 99 m to 101 m. The first interval of recorded fracturing is associated with a pegmatite intersection while the latter two intervals are both associated with amphibolite intersections. Water strikes with respective blow yields of 0.09 l/s, 0.13 l/s and 0.03 l/s were recorded along these intersections (in total 0.25 l/s). Dolerite was intersected in this borehole at a depth of 118.5 m. The contact was recorded as solid and the borehole was terminated in fresh dolerite at a depth of 130 m.

7.4.6.4. Hydraulic Aquifer Description

Borehole Yields

Blow yields were recorded during drilling of all investigative/monitoring boreholes on site in the past by JMA Consulting, whilst a hydro-census conducted during 1995, obtained yield information for the external users boreholes located on the western bank of the Ga-Selati River.

For the shallow weathered zone aquifer, 43 boreholes yielded water ranging between 0.01 l/s and 2.8 l/s, with an average yield of 0.31 l/s. Individual water intersections amounted to 53 in total and on average and ranged in depth between 14 m and 17 m below surface with an average yield of 0.26 l/s. At least 41.5 % of the water intersections are structure related. Structure related water intersections ranged between 0.01 l/s and 1.40 l/s, averaging at 0.31 l/s. Although not all the dyke contact zones yielded water, the higher yielding water intersections were recorded along these zones.

Water strikes were recorded in fractures below the depth of weathering in all four of the boreholes drilled into the deep fractured aquifer(s). Their blow yields ranged between 0.25 l/s and 1.16 l/s, with an average yield of 0.72 l/s. Individual water intersections amounted to nine in total and ranged in depth between 37 m and 108 m below surface with an average yield of 0.32 l/s. All the water intersections in the deep fractured aquifer(s) are structure related.

Aquifer Permeability

The hydraulic conductivity or permeability (k) of an aquifer is a measure of the ease with which groundwater can pass through the aquifer system. The permeability is defined as the volume of water that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area measured at perpendicular to the flow direction and is expressed in m/day.

A summary of the statistical analyses of the calculated aquifer permeabilities determined from 57 shallow weathered zone aquifer monitoring boreholes is indicated below:

k - Minimum	0.003 m/day
k - Maximum	6.046 m/day
k - Arithmetic Mean	0.359 m/day
k - Median	0.073 m/day
k - Harmonic Mean	0.031 m/day
k - Geometric Mean	0.090 m/day

Due to the heterogeneities inherent to weathered zone aquifers, statistical assessments indicate that the hydraulic parameter distribution will be log-normally distributed and that the actual k-value for the aquifer is bound by the calculated geometric and the harmonic means. Based on the analyses of the slug tests conducted a bulk hydraulic conductivity of around 0.04 m/day is assigned to the shallow weathered zone aquifers within the study area.

A summary of the statistical analyses of the calculated aquifer permeabilities determined from the 4 deep fractures aquifer(s) is indicated below:

k – Minimum	0.026 m/day
k - Maximum	1.157 m/day
k - Arithmetic Mean	0.086 m/day
k - Median	0.081 m/day
k - Harmonic Mean	0.058 m/day
k - Geometric Mean	0.072 m/day

Based on the analyses of the slug tests conducted a bulk hydraulic conductivity of around 0.06 m/day is assigned to the deep fractured aquifers within the study area.

Aquifer Transmissivity

The transmissivity (T) of an aquifer represents the groundwater flow potential through the entire saturated zone. The transmissivity is defined as the rate at which water is passed through a unit width of an aquifer under a unit hydraulic gradient.

A summary of the statistical analyses of the calculated aquifer transmissivities determined from 57 shallow weathered zone aquifer monitoring boreholes is indicated below:

T - Minimum	0.670 m^2/day
T – Maximum	9.700 m^2/day
T - Arithmetic Mean	2.856 m^2/day
T - Median	2.040 m^2/day
T - Harmonic Mean	1.488 m^2/day
T - Geometric Mean	1.981 m^2/day

A summary of the statistical analyses of the calculated aquifer transmissivities determined from the 4 deep fractures aquifer(s) is indicated below:

T - Minimum	0.800 m^2/day
T - Maximum	1.700 m^2/day
T - Arithmetic Mean	1.300 m^2/day
T - Median	1.400 m^2/day
T - Harmonic Mean	1.175 m^2/day
T - Geometric Mean	1.239 m^2/day

Aquifer Storativity

The storativity (S) of an aquifer is defined as the volume of water that an aquifer releases from, or takes into, storage per unit surface area of the aquifer per unit hydraulic gradient. Based on the interpretation of the data, the following range is proposed for storativity of the shallow weathered zone aquifers:

S - Minimum	0.0001
S - Maximum	0.005
S - Arithmetic Mean	0.015

Based on the interpretation of the data, the following range is proposed for storativity of the deep fractured zone aquifer(s):

S - Minimum	0.0000007
S - Maximum	0.000002
S - Arithmetic Mean	0.000005

Although the confined nature of the deep fractured aquifer implies low S values, the quantified S values still remain very low. This observation is in line with the observed fracturing status of this aquifer zone, which does not reflect fracturing of the bulk host rock – fracturing restricted to structural features.

Aquifer Porosity

The porosity of an aquifer is the ratio of the void space to the total volume of the aquifer. The porosity gives is an indication of the amount of water in the subsurface, but does not represent the volume that can be released from or taken into storage. The ratio between the volume of water that can be drained from the aquifer and the total volume of the aquifer is referred to as the effective porosity.

Porosity plays a governing role in groundwater seepage velocity, which relates to the rate with which not only water moves through an aquifer, but indeed also contaminants for which the migration mechanism is primarily advection. The effective porosity is the same as the specific yield for the unconfined shallow weathered zone aquifer. Testing indicated that both a primary and a secondary porosity exist. An average porosity will therefore be reflected by the groundwater level reaction during the pumping tests.

Based therefore on literature values, as well as quantification performed in similar geological environments, coupled with inverse approach modelling of groundwater seepage velocities, the following porosity ranges are suggested:

θ - Minimum	1%
θ - Maximum	5%
θ - Arithmetic Mean	10%

7.4.6.5. Aquifer Dynamics

Rainfall Recharge

During the calibration exercise for the groundwater abstraction assessment, the aquifer recharge was optimized using several methods.

The outcome of this exercise calculates annual rainfall recharge to the aquifer between 17.8 mm and 40.8 mm per year, which when calculated as a percentage of the mean annual rainfall of 494 mm/year, results in a percentage range between 3.6% and 8.3% of the mean annual rainfall. The most likely value for annual rainfall recharge to the aquifer is 30.6 mm/year or 6.2% of mean annual rainfall.

Groundwater Level Depths and Fluctuations

The groundwater levels are discussed with reference to the latest groundwater levels recorded in the shallow weathered zone and deep fractured aquifers during 2021 and 2022 (Table 7.4.6.5(a)).

The groundwater levels within the shallow weathered zone aquifer (and therefore the thickness of the unsaturated zone) ranges between 0.0 m and 12.69 m below ground level (mbgl) with an average depth to the water table of 4.95 mbgl assigned to the shallow weathered zone aquifer. The groundwater levels within the weathered zone aquifer are depicted on Figure 7.4.6.5(a).

The groundwater levels within the deep fractured aquifers range between 5.35 mbgl and 6.86 mbgl with an average depth to the water table of 6.11 mbgl. For all practical purposes this is similar to conditions observed for the shallow weathered zone aquifer in which the depth to water level averages at 4.95 mbgl.

Using the surveyed borehole collar elevations and the latest available groundwater levels recorded, the groundwater elevations were calculated. The groundwater elevations at Bosveld Phosphates range between 346 mamsl and 391 mamsl. The calculated groundwater elevations for the shallow weathered zone and deep fractured aquifers are depicted on Figure 7.4.6.5(b))

Table 7.4.6.5(a): Groundwater Water levels Recorded during 2021 and 2022

Site ID	Date WL	Collar Height (m)	Water Level (mbc)	Water Level (mbgl)	Water Level Elevation (mamsl)	Collar_Elev (mamsl)
Source Monitoring Boreholes						
FGM-B22 (SRCE-1)	2021/11/23 13:58	0.78	2.16	1.38	356.95	357.73
FGM-B23 (SRCE-2)	2021/11/23 14:14	0.52	2.63	2.11	361.67	362.19
FEGM-25 (SRCE-4)	2021/11/23 15:05	0.36	2.59	2.23	365.15	365.51
FGM-B32A (SRCE-5)	2021/11/23 15:05	0.39	2.59	2.20	374.82	375.21
FGM-B37 (SRCE-6)	2021/11/23 09:26	0.55	1.00	0.45	376.85	377.40
Plume Monitoring Boreholes						
FGM-B15 (PLUME-1)	2021/02/22 11:33	0.90	5.96	5.06	351.62	352.52
FGM-B19 (PLUME-2)	2021/11/23 14:39	0.75	0.69	-0.06	363.00	363.75
FGM-B27 (PLUME-3)	2021/11/23 10:34	0.70	6.41	5.71	346.86	347.56
FGM-B28A (PLUME-4)	2021/11/23 10:28	1.23	8.45	7.22	351.01	352.24
FGM-B30 (PLUME-5)	2021/11/23 10:41	0.29	5.17	4.88	355.05	355.34
FGM-B31 (PLUME-6)	2021/11/23 14:54	0.67	9.30	8.63	368.94	369.61
FGM-B45 (PLUME-7)	2021/11/23 15:16	0.53	6.44	5.91	363.08	363.61
FGM-B46 (PLUME-8)	2021/11/23 15:01	0.53	7.49	6.96	367.74	368.27

Site ID	Date WL	Collar Height (m)	Water Level (mbc)	Water Level (mbgl)	Water Level Elevation (mamsl)	Collar_Elev (mamsl)
FGM-B47 (PLUME-9)	2021/11/23 11:12	1.13	5.61	4.48	352.83	353.96
FGM-B50 (PLUME-10)	2021/11/23 14:21	1.07	12.00	10.93	362.84	363.91
FGM-52 (PLUME-11)	2021/11/23 10:52	1.23	6.00	4.77	359.56	360.79
AFB-1 (PLUME-13)	2021/11/23 13:42	0.49	9.30	8.81	356.31	356.80
AFB-5 (PLUME-14)	2021/11/23 14:07	0.23	8.74	8.51	357.58	357.81
AFB-15 (PLUME-15)	2021/11/23 10:59	0.45	6.25	5.80	359.74	360.19
Perimeter Monitoring Boreholes						
FGM-B61S (NPER-1)	2021/11/23 08:10	0.68	5.85	5.17	376.65	377.33
FGM-B61D (NPER-2)	2021/11/23 08:09	0.47	5.82	5.35	377.02	377.49
FGM-B34 (EPER-1)	2021/11/23 09:19	0.40	2.96	2.56	383.87	384.27
FGM-B38A (EPER-3)	2021/11/23 09:37	0.47	1.38	0.91	369.63	370.10
FGM-B39 (EPER-4)	2021/11/23 09:46	0.41	7.99	7.58	364.67	365.08
FGM-B40 (EPER-5)	2021/11/23 09:52	0.27	12.96	12.69	359.66	359.93
FGM-B41 (EPER-6)	2021/11/24 08:32	0.40	8.30	7.90	346.04	346.44
FGM-B20 (WPER-1)	2021/11/23 13:34	0.61	7.61	7.00	361.58	362.19
FGM-B21 (WPER-3)	2021/02/22 11:13	0.70	7.36	6.66	350.22	350.92
FGM-B60D (WPER-4)	2021/11/23 11:04	0.43	6.29	5.86	350.10	350.53
FGM-B59D (WPER-5)	2021/11/23 10:22	0.41	6.76	6.35	350.17	350.58
FGM-B29 (WPER-6)	2021/11/23 10:17	0.49	7.30	6.81	347.13	347.62
FGM-B58D (WPER-7)	2021/11/23 10:11	0.31	7.17	6.86	348.34	348.65
FGM-B58S (WPER-8)	2021/11/23 10:12	0.45	8.00	7.55	348.41	348.86
FGM-B43 (WPER-9)	2021/11/23 10:03	0.44	7.80	7.36	348.27	348.71
Plant Monitoring Boreholes						
FGM-B62 (PLANT-1)	2021/11/23 07:49	0.67	2.29	1.62	384.26	384.92
FGM-B63 (PLANT-2)	2021/11/23 07:56	0.95	5.49	4.54	384.38	385.33
FGM-B64 (PLANT-3)	2021/11/23 08:56	0.84	1.60	0.76	384.72	385.56
FGM-B67 (PLANT-4)	2021/11/23 08:26	0.79	3.38	2.60	378.19	378.98
FGM-B70 (PLANT-6)	2021/11/23 08:39	0.53	1.31	0.78	376.85	377.38
FGM-B71 (PLANT-7)	2021/11/23 09:01	0.56	1.59	1.03	381.37	381.93
FGM-B72 (PLANT-8)	2021/11/23 07:38	1.06	5.29	4.23	389.47	390.53
FGM-B75 (PLANT-10)	2021/11/23 07:41	0.81	8.68	7.88	388.94	389.75
FGM-B76 (PLANT-11)	2021/11/23 08:44	0.65	9.32	8.66	380.30	380.95
Groundwater Abstraction Monitoring Boreholes						
FGM-B49 (GRAB-1)	2019/06/19 11:48	1.06	11.90	10.84	354.22	355.28

Site ID	Date WL	Collar Height (m)	Water Level (mbc)	Water Level (mbgl)	Water Level Elevation (mamsl)	Collar_Elev (mamsl)
FGM-B48 (GRAB-2)	**2022/04/28 08:37**	1.24	5.33	4.09	352.79	354.03
FGM-B55 (GRAB-3)	**2022/04/28 08:30**	1.25	2.61	1.36	366.63	367.88
FGM-B51 (GRAB-4)	**2022/04/28 07:52**	1.28	4.20	2.92	366.78	368.06
FGM-B53 (GRAB-5)	**2022/04/28 07:49**	1.14	2.20	1.06	363.69	364.83
FGM-B54 (GRAB-6)	**2022/04/28 08:01**	1.08	3.48	2.40	370.76	371.84

* *"D" Deep Fractured Zone Groundwater Monitoring Borehole*
* *"S" Shallow Weather Zone Groundwater Monitoring Borehole*

Groundwater Elevations, Gradients and Flow Direction

Based on the calculated groundwater elevations, the regional groundwater gradient, which is from east to west, varies between 0.015 and 0.029. Locally the groundwater gradient varies between 0.015 and 0.044.

The groundwater flow directions at Bosveld Phosphates (East of the Ga-Selati River) are predominantly from the east to west, towards the Ga-Selati River. The groundwater flow directions to the West of the Ga-Selati River is predominantly from the west to east, towards the Ga-Selati River.

The groundwater flow directions were interpolated using the calculated groundwater elevations and are depicted in Figure 7.4.6.5(c) below. The groundwater flow directions depicted in Figure 7.4.6.5(c) provide a regional first order indication of the natural regional groundwater flow directions within the study area. The groundwater flow directions will be more accurately quantified and depicted within the numerical groundwater flow model. The steady state groundwater flow directions will be incorporated in the Groundwater Specialist Study Report.

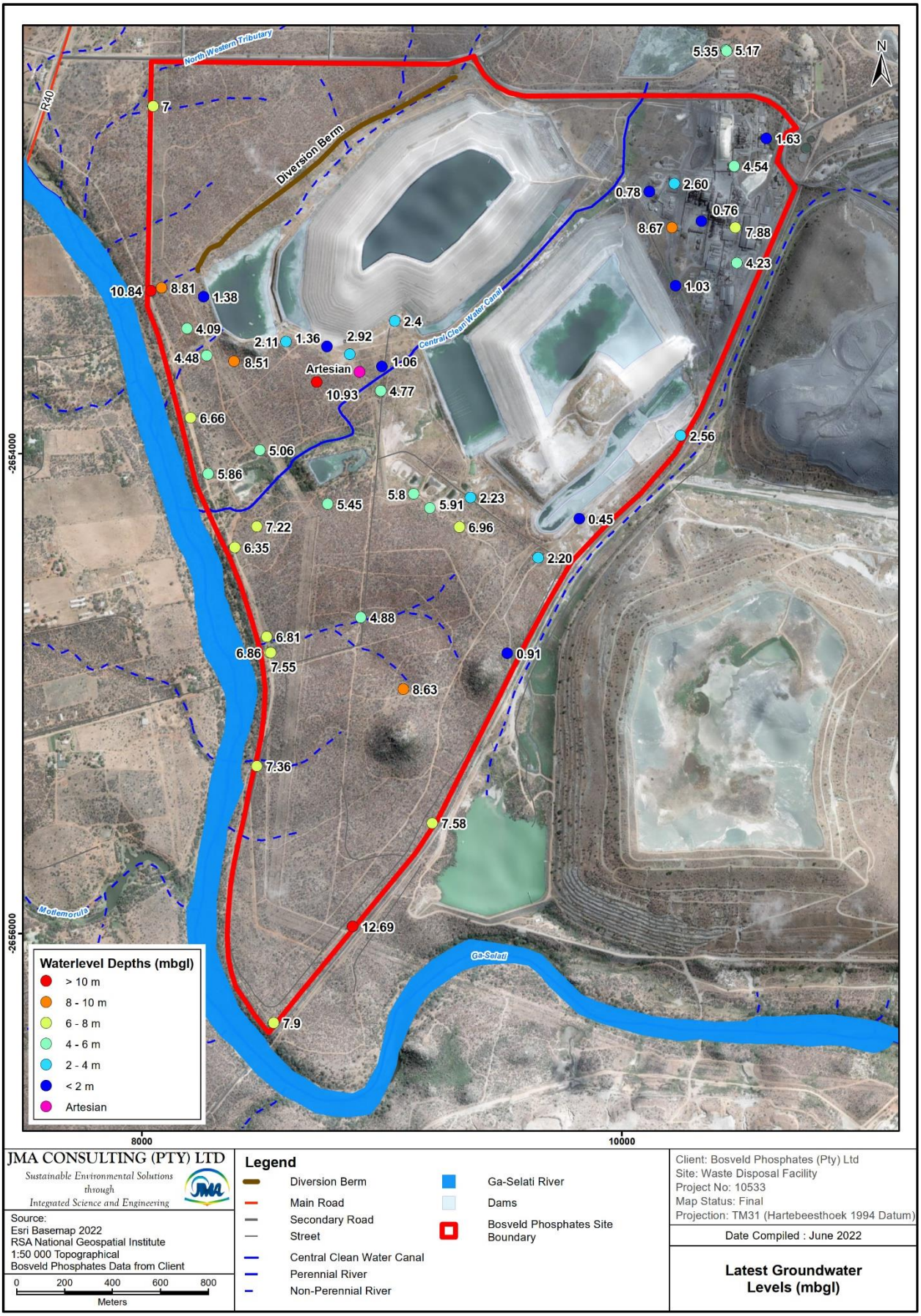


Figure 7.4.6.5(a): Groundwater Levels in the Shallow Weathered and Deep Fractured Zone Aquifers

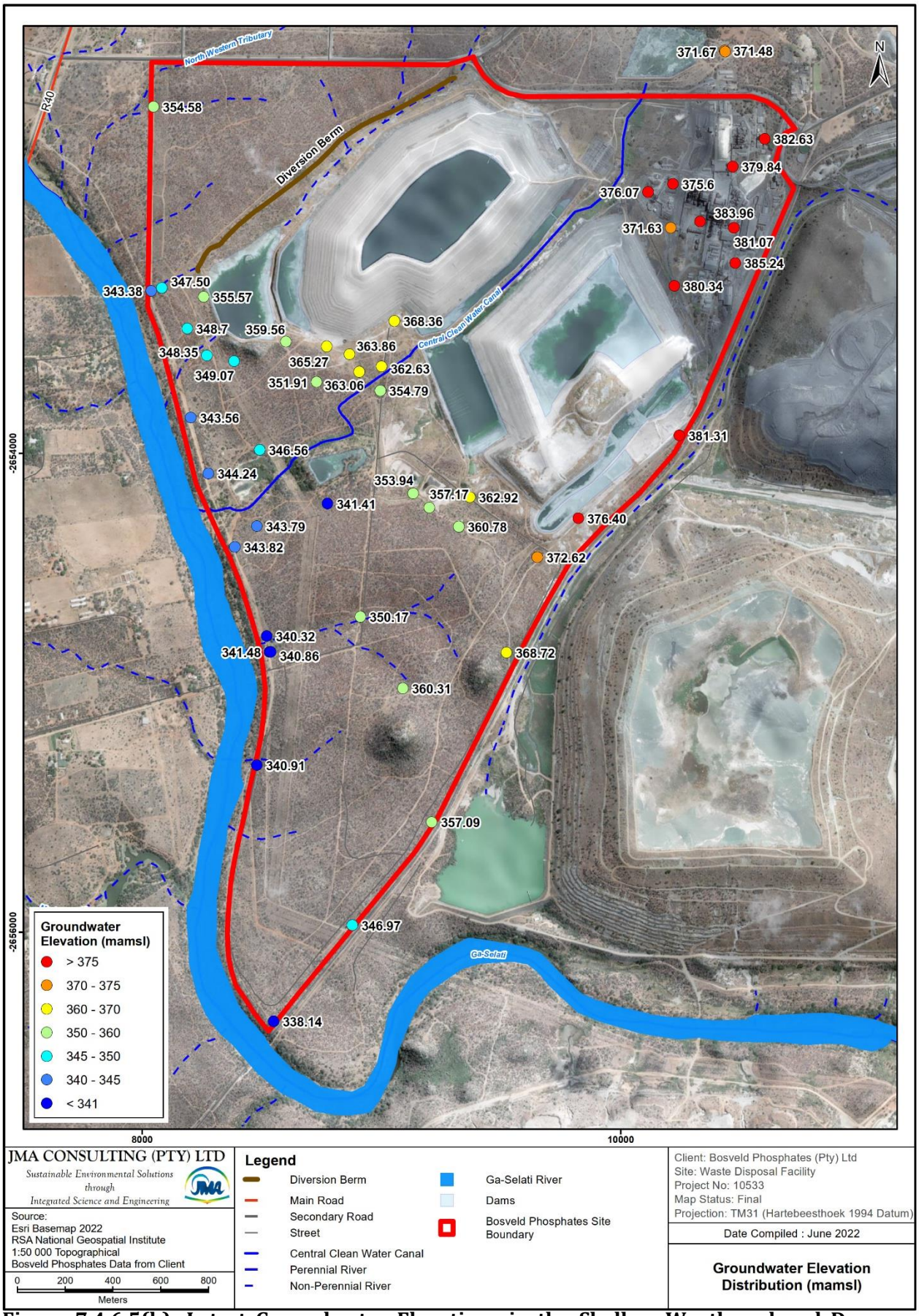


Figure 7.4.6.5(b): Latest Groundwater Elevations in the Shallow Weathered and Deep Fractured Zone Aquifers

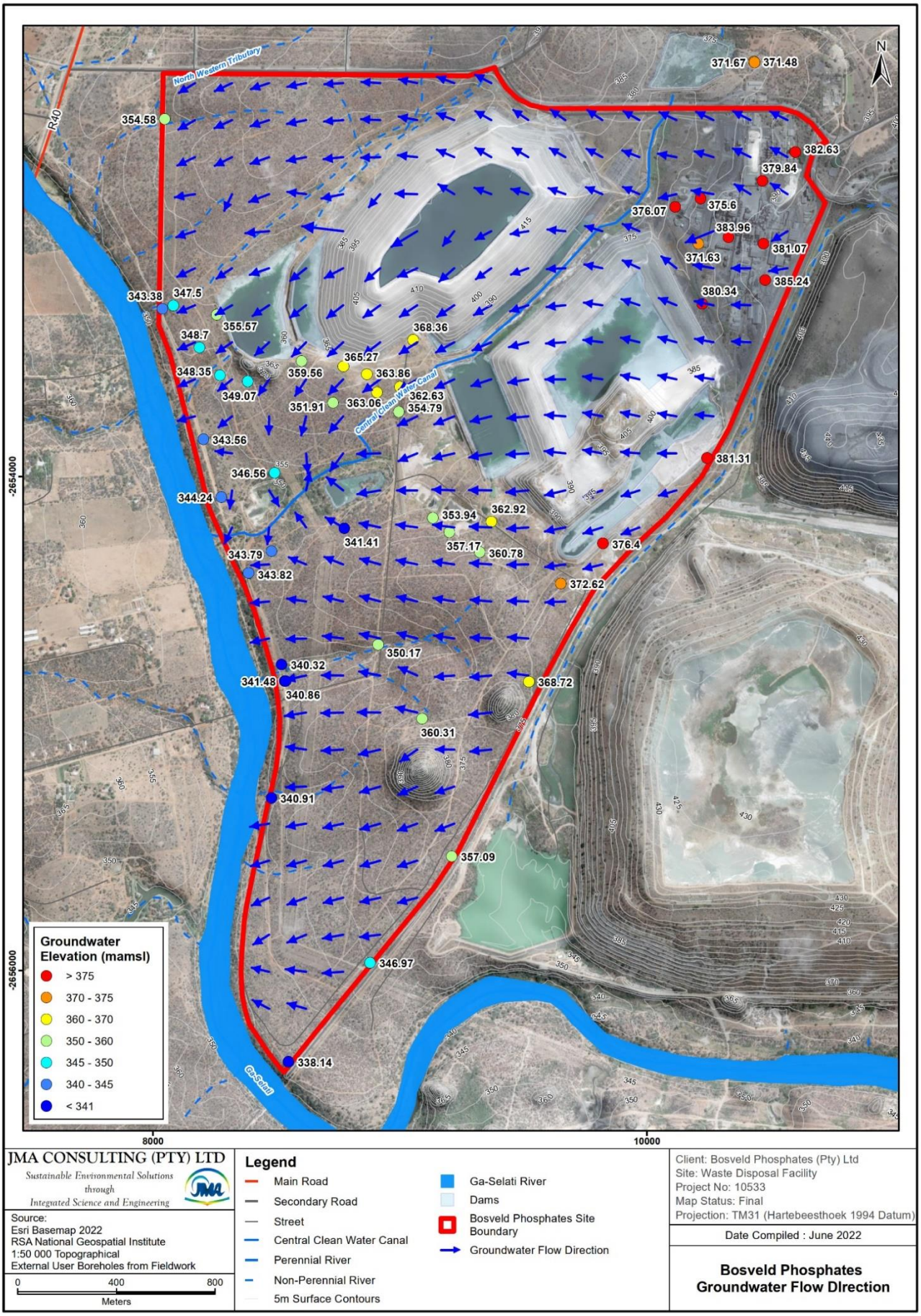


Figure 7.4.6.5(c): Interpolated Groundwater Flow Direction

7.4.6.6. Aquifer Hydrochemistry

The site represents a brown-fields situation, which implies that the quality and quantity of the groundwater in aquifers underlying the site have been exposed to potential contamination over the past 50 years.

The current groundwater monitoring system implemented at Bosveld Phosphates has continually been developed over the years, based on the various groundwater assessments conducted on site since the early 1990's and conditions of the boreholes. The groundwater monitoring system at Bosveld Phosphates is made up of 5 groups of boreholes, based on the locality of the boreholes and subsequently the purpose of the boreholes. These are namely (see Table 7.4.6.6(a):

- Source Monitoring Boreholes,
- Plant Monitoring Boreholes,
- Plume Monitoring Boreholes,
- Perimeter Monitoring Boreholes (includes the Deep Fractured Aquifer boreholes), and
- Abstraction Monitoring Boreholes.

Table 7.4.6.6(a): Groundwater Monitoring Borehole Groups

Site ID	Latitude	Longitude
Source Monitoring Boreholes		
FGM-B22 (SRCE-1)	23° 58' 57.2" S	31° 04' 52.5" E
FGM-B23 (SRCE-2)	23° 59' 02.8" S	31° 05' 04.3" E
FGM-B24 (SRCE-3)	23° 58' 41.9" S	31° 05' 07.4" E
FEGM-25 (SRCE-4)	23° 59' 24.2" S	31° 05' 31.6" E
FGM-B32A (SRCE-5)	23° 59' 32.0" S	31° 05' 41.7" E
FGM-B37 (SRCE-6)	23° 59' 26.9" S	31° 05' 47.9" E
FGM-B79 (SRCE-7)	23° 59'8.00"S	31° 05' 24.1" E
Plume Monitoring Boreholes		
FGM-B15 (PLUME-1)	23° 59' 17.8" S	31° 05' 01.1" E
FGM-B19 (PLUME-2)	23° 59' 07.0" S	31° 05' 15.4" E
FGM-B27 (PLUME-3)	23° 59' 25.2" S	31° 05' 10.5" E
FGM-B28A (PLUME-4)	23° 59' 28.4" S	31° 05' 00.9" E
FGM-B30 (PLUME-5)	23° 59' 40.0" S	31° 05' 15.5" E
FGM-B31 (PLUME-6)	23° 59' 50.1" S	31° 05' 22.4" E
FGM-B45 (PLUME-7)	23° 59' 25.4" S	31° 05' 25.4" E
FGM-B46 (PLUME-8)	23° 59' 28.0" S	31° 05' 29.7" E
FGM-B47 (PLUME-9)	23° 59' 04.9" S	31° 04' 52.8" E
FGM-B50 (PLUME-10)	23° 59' 08.2" S	31° 05' 08.9" E
FGM-52 (PLUME-11)	23° 59' 10.1" S	31° 05' 18.6" E
AFB-1 (PLUME-13)	23° 58' 55.7" S	31° 04' 46.8" E
AFB-5 (PLUME-14)	23° 59' 05.4" S	31° 04' 57.3" E
AFB-15 (PLUME-15)	23° 59' 23.7" S	31° 05' 23.4" E

Site ID	Latitude	Longitude
AFB-19 (PLUME-16)	23° 59' 29.9" S	31° 05' 32.9" E
AFB-20 (PLUME-17)	23° 59' 33.1" S	31° 05' 36.9" E
Perimeter Monitoring Boreholes		
FGM-B61S (NPER-1)	23° 58' 23.4" S	31° 06' 09.2" E
FGM-B61D (NPER-2)	23° 58' 23.3" S	31° 06' 09.1" E
FGM-B34 (EPER-1)	23° 59' 14.7" S	31° 06' 03.4" E
FGM-B33 (EPER-2)	23° 59' 24.5" S	31° 05' 56.0" E
FGM-B38A (EPER-3)	23° 59' 44.9" S	31° 05' 37.1" E
FGM-B39 (EPER-4)	24° 00' 09.1" S	31° 05' 25.5" E
FGM-B40 (EPER-5)	24° 00' 22.2" S	31° 05' 14.4" E
FGM-B41 (EPER-6)	24° 00' 34.8" S	31° 05' 02.4" E
FGM-B20 (WPER-1)	23° 58' 32.7" S	31° 04' 45.3" E
FGM-B10 (WPER-2)	23° 58' 58.8" S	31° 04' 45.5" E
FGM-B21 (WPER-3)	23° 59' 13.7" S	31° 04' 50.5" E
FGM-B60D (WPER-4)	23° 59' 21.0" S	31° 04' 52.9" E
FGM-B59D (WPER-5)	23° 59' 46.0" S	31° 05' 02.2" E
FGM-B29 (WPER-6)	23° 59' 43.7" S	31° 05' 01.9" E
FGM-B58D (WPER-7)	23° 59' 46.0" S	31° 05' 02.2" E
FGM-B58S (WPER-8)	23° 59' 46.1" S	31° 05' 02.4" E
FGM-B43 (WPER-9)	24° 00' 00.9" S	31° 05' 00.2" E
FGM-B42 (WPER-10)	24° 00' 11.6" S	31° 04' 56.9" E
Plant Monitoring Boreholes		
FGM-B62 (PLANT-1)	23° 58' 35.3" S	31° 06' 15.3" E
FGM-B63 (PLANT-2)	23° 58' 39.2" S	31° 06' 10.5" E
FGM-B64 (PLANT-3)	23° 58' 46.5" S	31° 06' 05.5" E
FGM-B67 (PLANT-4)	23° 58' 40.9" S	31° 06' 01.7" E
FGM-B68 (PLANT-5)	23° 58' 33.8" S	31° 06' 05.5" E
FGM-B70 (PLANT-6)	23° 58' 41.9" S	31° 05' 57.6" E
FGM-B71 (PLANT-7)	23° 58' 55.5" S	31° 06' 01.9" E
FGM-B72 (PLANT-8)	23° 58' 52.5" S	31° 06' 11.0" E
FGM-B74 (PLANT-9)	23° 58' 44.2" S	31° 06' 16.6"E
FGM-B75 (PLANT-10)	23° 58' 47.5" S	31° 06' 10.4" E
FGM-B76 (PLANT-11)	23° 58' 47.3" S	31° 06'01.2" E
Groundwater Abstraction Monitoring Boreholes		
FGM-B48 (GRAB-2)	23° 59' 01.3" S	31° 04' 49.9" E
FGM-B49 (GRAB-1)	23° 58' 55.9" S	31° 04' 44.8" E
FGM-B51 (GRAB-4)	23° 59' 04.8" S	31° 05' 13.9" E

Site ID	Latitude	Longitude
FGM-B53 (GRAB-5)	23° 59' 06.3" S	31° 05' 18.6" E
FGM-B54 (GRAB-6)	23° 58' 59.4" S	31° 05' 21.1" E
FGM-B55 (GRAB-3)	23° 59' 03.6" S	31° 05' 10.3" E

The localities of Groundwater Monitoring Boreholes are depicted on Figure 7.4.6.6(a) and have been colour coded according to the respective monitoring group.

The groundwater sampling frequencies are dependent on the nature of the monitoring boreholes. The groundwater abstraction boreholes are monitored on a monthly basis, whilst the groundwater monitoring boreholes are sampled on a 6-monthly basis.

The groundwater qualities, sampled at each of the monitoring boreholes for the 2021 and 2022 sampling period is given in Table 7.4.6.6(b).

The current groundwater chemistry results for Bosveld Phosphates are discussed with reference to the assigned monitoring groups of the boreholes.

Source Monitoring Boreholes:

- The pH of the boreholes ranges from 1.35 to 7.75, with FGM-B37 (SRCE-6) being the most acidic of the monitoring group averaging 1.53 during 2021 and 2022.
- The TDS concentration ranged between 11 129 mg/l to 139 135 mg/l with an average of 37 318 mg/l. The borehole FGM-B37 (SRCE-6) had the highest average TDS concentration in this monitoring group during 2021 and 2022 with 88 287 mg/l.
- The SO_4 concentration ranged between 2 743 mg/l to 45 995 mg/l with an average of 16 788 mg/l. The borehole FGM-B37 (SRCE-6) had the highest average SO_4 concentration in this monitoring group during 2021 and 2022 with 33 375 mg/l.
- The borehole FGM-B37 (SRCE-6) also had significantly higher PO_4 and Mn concentrations compared to the other boreholes with an average concentration of 38 492 mg/l and 166 mg/l compared to an average of 248 mg/l and 5.27 mg/l of the other boreholes.

Plume Monitoring Boreholes:

- The pH of the boreholes ranges from 4.11 to 8.82 with an average of 6.91.
- The TDS concentration ranged between 339 mg/l to 15 487 mg/l with an average of 5 773 mg/l.
- The SO_4 concentration ranged between 6.00 mg/l to 8 301 mg/l with an average of 2 888 mg/l.
- The boreholes FGM B19 (PLUME-2), FGM-45 (PLUME-7), FGM-B50 (PLUME-10), and FGM-B52 (PLUME-11) had average TDS concentration exceeding 10 000 mg/l and average SO_4 concentration exceeding 5 000 mg/l.
- The boreholes FGM-B19 (PLUME-2) and FGM-B50 (PLUME-10) had significantly higher PO_4 concentrations with an average of 1 682 mg/l compared to 108 mg/l of the rest of the boreholes.

Permitter Monitoring Boreholes:

- The pH of the boreholes ranges from 5.95 to 9.09 with an average of 7.50.
- The TDS concentration ranged between 86.8 mg/l to 5 425 mg/l with an average of 1 657 mg/l. The borehole FGM-B59D (WPER-5) had the highest average TDS concentration in this monitoring group during 2021 and 2022 with 4 608 mg/l.
- The SO_4 concentration ranged between 2.34 mg/l to 2 920 mg/l with an average of 468 mg/l. The borehole FGM-B59D (WPER-5) had the highest average SO_4 concentration in this monitoring group during 2021 and 2022 with 2 458 mg/l.
- The borehole FGM-B39 (EPER-4) had significantly higher Cl concentrations compared to the other boreholes with an average concentration of 1 498 mg/l compared to an average of 308 mg/l of the other boreholes.

Plant Monitoring Boreholes:

- The pH of the boreholes ranges from 2.50 to 9.59 with an average of 5.88.
- The TDS concentration ranged between 353 mg/l to 14 153 mg/l with an average of 3 543 mg/l. The borehole FGM-B67 (PLANT-4) had the highest average TDS concentration in this monitoring group during 2021 and 2022 with 11 042 mg/l.
- The SO_4 concentration ranged between 153 mg/l to 3 664 mg/l with an average of 1 456 mg/l.
- The borehole FGM-B67 (PLANT-4) had significantly higher PO_4 concentrations with an average of 6 217 mg/l compared to an average of 147 mg/l for the rest of the boreholes.

Abstraction Monitoring Boreholes:

- The pH of the boreholes ranges from 1.91 to 7.82 with an average of 4.78. The boreholes FGM-B51 (GRAB-4) and FGM-B53 (GRAB-5) had the lowest pH's with and average of 2.89 between them.
- The TDS concentration ranged between 3 805 mg/l to 25 615 mg/l with an average of 16 391 mg/l.
- The SO_4 concentration ranged between 729 mg/l to 14 873 mg/l with an average of 7 743 mg/l.
- The boreholes FGM-B51 (GRAB-4), FGM-B53 (GRAB-5) and FGM-B54 (GRAB-6) had significantly higher PO_4 concentrations with an average of 5 448 mg/l compared to an average of 293 mg/l for the rest of the boreholes.

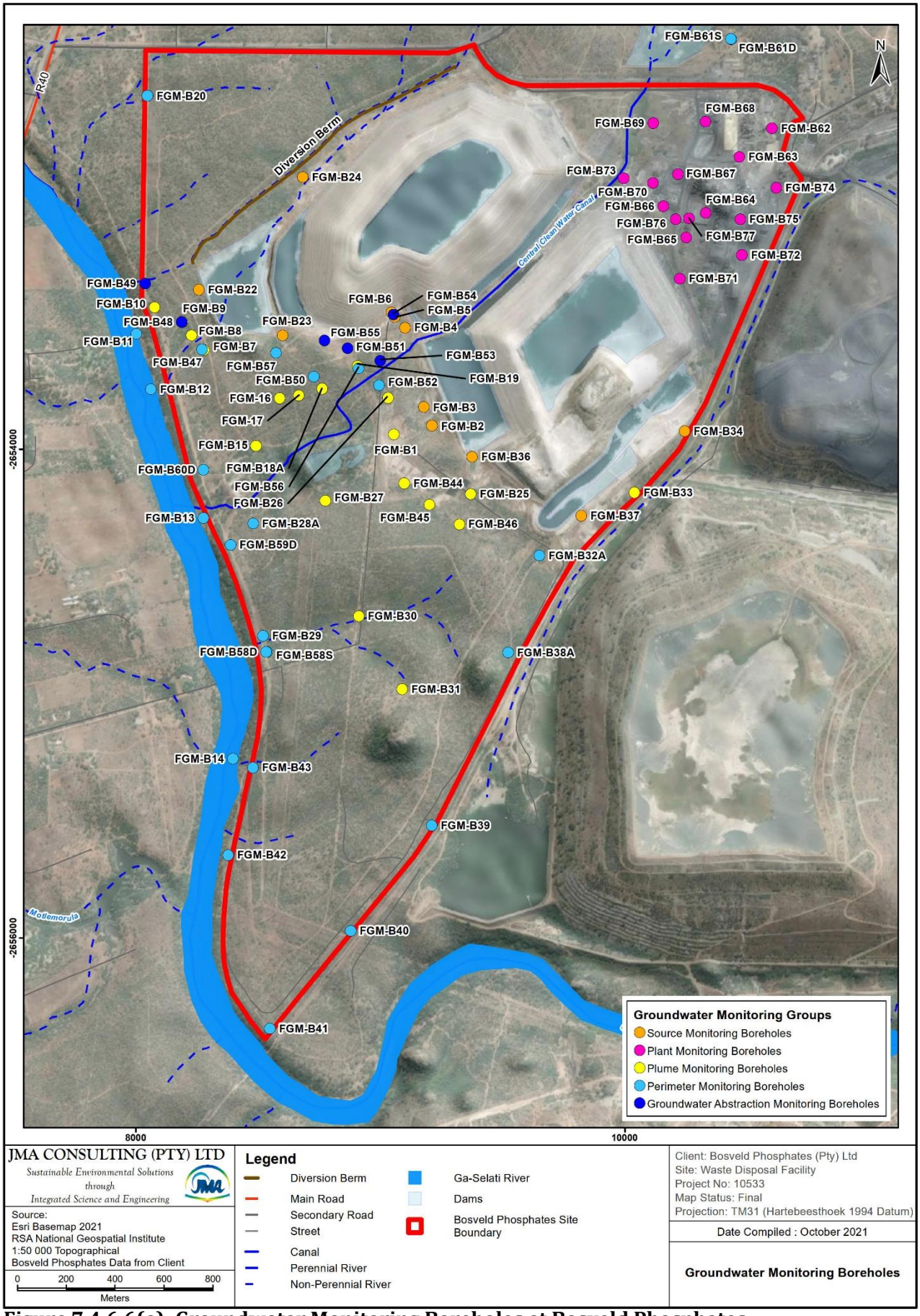


Figure 7.4.6.6(a): Groundwater Monitoring Boreholes at Bosveld Phosphates

Table 9.5(a): Groundwater Monitoring Quality Results of 2021 and 2022

Sample Description	Sampled	pH	EC	TDS	Tot Alk	Ca	Mg	Na	K	Si	Cl	SO_4	NO_3	NH_4	F	Al	PO_4	Cu	Fe	Mn
Source Monitoring Boreholes																				
FGM-B22 (SRCE-1)	2021/08/17 13:32	6.24	2 370	31 130	577	587	3 593	3 744	24.6	55.6	2 295	19 380	0.350	3.08	0.610	0.01	1153	0.020	0.120	1.87
	2021/11/23 13:58	6.37	2 480	29 092	623	619	3 492	3 431	17.8	71.0	2 631	17 170	0.350	2.09	0.130	0.01	1349	0.020	0.200	1.97
	2022/02/22 08:23	6.23	2 450	31 500	599	555	3 713	4 213	15.0	55.8	2 739	18 331	0.350	2.75	0.090	0.01	1567	0.010	0.080	1.07
FGM-B23 (SRCE-2)	2021/02/18 02:03	5.94	1 760	12 603	112	999	859	2 204	22.3	8.52	5 546	2 896	0.35	1.24	0.090	0.010	3.80	0.010	1.77	3.07
	2021/05/17 09:11	4.83	1 720	12 842	8.65	539	750	3 199	29.6	0.450	5 410	2 871	0.35	0.450	2.29	1.03	33.7	0.050	0.040	1.05
	2021/08/17 13:44	5.58	1 655	11 925	34.1	546	883	2 306	30.9	0.220	5 304	2 809	1.16	1.60	0.180	0.010	16.5	0.010	0.170	0.450
	2021/11/23 14:14	6.61	1 642	11 649	34.0	471	869	2 323	35.3	0.100	5 186	2 743	0.35	0.450	0.090	0.010	0.429	0.010	0.010	0.430
	2022/02/22 08:33	6.67	1 397	11 129	39.4	434	690	2 677	23.2	0.100	4 407	2 865	0.35	2.14	0.090	0.010	4.75	0.010	0.020	0.370
FGM-25 (SRCE-4)	2021/02/23 09:53	6.71	1 199	99 50	387	727	1 128	919	27.9	12.1	2 508	4 396	0.97	1.87	0.090	0.010	3.59	0.010	0.050	1.13
	2021/05/18 09:10	7.63	2 590	28 665	379	550	4 368	2 815	55.1	0.290	5 224	15 401	0.35	15.5	1.22	0.010	1.99	0.010	0.060	1.78
	2021/08/17 14:10	5.80	2 520	27 950	320	545	3 370	2 960	65.7	0.340	4 549	16 239	0.35	11.9	0.090	0.010	11.47	0.010	0.420	1.34
	2021/11/23 15:05	7.47	2 470	24 813	243	503	3 048	2 791	70.2	0.100	4 486	13 750	0.35	10.8	2.69	0.010	0.215	0.010	0.020	1.82
	2022/02/23 14:35	7.75	1 826	21 173	868	486	2 138	3 171	43.1	16.7	2 296	12 451	3.65	4.77	0.090	0.010	43.85	0.010	0.190	0.79
FGM-B32A (SRCE-5)	2021/02/22 03:24	6.89	2 040	25 251	770	506	2 394	3 427	27.5	20.5	91	18 297	0.350	2.94	18.70	0.010	0.644	0.010	0.050	23.2
	2021/05/18 09:01	6.82	2 050	26 343	809	472	3 132	3 317	32.0	16.0	351	18 531	0.350	1.49	10.80	0.010	0.859	0.010	0.030	9.52
	2021/08/18 10:52	6.85	2 020	23 837	899	528	2 432	3 413	37.3	20.6	340	16 512	0.350	4.08	12.60	0.010	2.45	0.010	0.040	14.6
	2021/11/23 09:30	6.87	2 060	23 835	677	525	2 327	3 306	58.7	26.8	341	16 585	0.350	6.07	21.40	0.010	233	0.040	0.050	15.0
	2022/02/22 11:18	6.94	1 984	25 818	677	478	2 309	4 196	39.9	18.7	308	18 015	0.350	4.51	8.78	0.010	34.0	0.010	0.290	15.4
FGM-B37 (SRCE-6)	2021/02/23 02:54	2.01	2 820	35 490	0.000	443	2 024	2 866	445	122	1803	16 015	2.45	243	732	227	10543	7.93	32.0	25.6
	2021/05/19 01:10	1.38	7 560	80 271	0.000	833	8 129	6 870	1610	435	0.480	45 995	0.350	0.450	0.090	2516	12619	115	1438	248
	2021/08/18 10:59	1.35	7 420	139 135	0.000	793	7 443	7 079	1644	331	174	39 435	0.350	1518	21.0	2353	76624	139	1278	249
	2021/11/23 09:26	1.38	6 320	93 123	0.000	643	4 883	4 795	1579	650	384	31 877	0.600	0.450	130	1894	46409	89.9	270	179
	2022/02/22 09:46	1.52	5 680	93 417	0.000	764	4 698	4 689	1207	859	0.480	33 555	2.23	0.450	164	1693	46265	62.1	176	130
Plume Monitoring Boreholes																				
FGM-B15 (PLUME-1)	2021/08/18 13:41	8.37	458	3 248	425	8.35	360	571	25.6	0.260	754	1 240	1.35	16.1	2.65	0.010	5.83	0.010	0.010	0.060

Sample Description	Sampled	pH	EC	TDS	Tot Alk	Ca	Mg	Na	K	Si	Cl	SO_4	NO_3	NH_4	F	Al	PO_4	Cu	Fe	Mn
	2022/02/23 08:51	8.82	449	3 233	512	4.60	360	557	26.5	0.100	778	1 184	1.54	1.49	0.940	0.010	5.37	0.010	0.050	0.040
FGM-B19 (PLUME-2)	2021/02/18 02:15	5.94	1 082	10 948	255	258	1 271	1330	35.3	64.0	671	5 963	0.350	0.450	0.740	0.010	1 260	0.020	0.020	4.02
	2021/05/18 01:38	5.88	1 084	10 889	264	250	1 217	1454	40.2	54.4	685	6 008	0.350	0.910	0.530	0.010	1 070	0.010	0.020	3.86
	2021/08/18 14:52	5.85	1 069	11 546	290	283	1 411	1491	39.0	55.9	685	5 874	0.350	0.720	0.540	0.010	1 582	0.010	0.030	5.17
	2021/11/23 14:39	6.02	1 085	11 686	260	279	1 465	1556	48.4	64.5	704	5 928	0.350	0.450	0.400	0.010	1 542	0.010	0.020	4.26
	2022/02/23 09:36	5.97	1 075	12 159	265	276	1 444	1674	43.0	61.2	693	6 115	0.350	0.490	0.090	0.010	1 748	0.010	0.340	3.80
FGM-B27 (PLUME-3)	2021/02/23 08:21	7.64	797	6 680	547	98.2	641	1253	23.8	1.68	1256	3 073	0.350	1.51	0.090	0.010	4.20	0.010	0.020	0.220
	2021/05/18 02:52	8.59	771	5 768	495	58.8	584	955	33.0	0.200	1063	2 769	1.18	0.450	0.180	0.010	2.85	0.010	0.010	0.010
	2021/08/18 13:23	8.54	749	6 002	492	55.8	590	995	32.8	0.370	1048	2 977	0.440	0.450	0.690	0.010	5.92	0.010	0.010	0.010
	2021/11/23 10:34	8.24	769	5 992	407	42.9	558	1106	39.8	0.500	1033	2 905	0.860	1.24	4.31	0.020	50.3	0.010	0.010	0.130
	2022/02/23 10:13	8.50	767	6 106	593	41.6	613	1034	34.3	0.320	1045	2 976	0.460	0.450	0.090	0.010	3.96	0.010	0.040	0.050
FGM-B28A (PLUME-4)	2021/02/22 02:28	7.09	427	3 429	288	380	371	184	7.65	7.87	566	1 742	0.35	1.01	0.090	0.010	1.66	0.010	0.030	2.51
	2021/05/17 02:42	7.05	393	3 132	46.1	127	450	214	7.97	0.420	583	1 717	1.06	0.450	0.090	0.010	0.092	0.010	0.010	0.970
	2021/08/18 09:56	7.93	364	2 439	426	29.2	342	210	16.7	1.45	590	925	2.80	42.40	0.410	0.010	2.51	0.010	0.020	0.840
	2021/11/23 10:28	8.15	347	2 265	299	19.7	318	218	17.3	0.430	574	885	3.03	30.00	0.300	0.010	0.828	0.010	0.010	0.590
	2022/02/22 14:11	7.44	360	2 361	361	14.5	330	252	18.4	0.830	577	889	4.48	32.70	0.090	0.010	0.491	0.010	0.060	0.400
FGM-B30 (PLUME-5)	2021/02/23 08:33	6.82	64.7	346	325	53.8	31.0	24.1	14.9	10.1	11.5	9.6	0.350	0.770	1.49	0.010	2.02	0.010	1.52	0.150
	2021/05/18 10:08	6.79	325	2 161	741	100	116	521	8.2	22.0	324	644	0.350	0.450	0.820	0.010	0.61	0.010	0.100	0.400
	2021/08/18 13:16	6.99	353	2 438	751	123	159	483	6.9	23.7	385	814	1.96	1.90	1.41	0.010	2.09	0.010	1.77	0.260
	2021/11/23 10:41	7.51	64.4	339	116	24.2	21.6	55.4	10.2	4.08	36.1	80.0	8.03	0.450	1.35	0.030	4.66	0.030	0.080	0.010
	2022/02/23 10:21	7.09	60.7	339	208	28.8	25.8	52.7	9.27	6.57	29.2	49.2	3.79	0.450	1.17	0.010	1.32	0.010	0.040	0.010
FGM-B31 (PLUME-6)	2021/02/23 08:43	7.32	92.2	512	462	70.8	47.5	41.8	25.9	13.8	11.1	33.5	0.350	0.480	1.82	0.010	1.87	0.010	0.010	0.010
	2021/05/18 09:58	7.02	90.6	494	443	63.0	44.7	45.2	24.9	8.44	14.8	29.7	0.600	0.450	0.950	0.010	1.07	0.010	0.020	0.860
	2021/08/18 13:08	7.36	80.5	451	392	50.4	45.4	49.0	23.4	5.96	24.3	12.7	0.670	0.450	2.24	0.010	5.70	0.010	0.090	0.010
	2021/11/23 14:54	7.47	104	617	369	48.6	49.9	90.5	25.2	5.61	45.7	128	0.350	0.450	0.810	0.010	7.02	0.010	0.050	0.010
	2022/02/23 10:28	7.32	106	605	448	50.2	45.3	100	20.5	7.18	43.1	72.3	0.610	0.450	1.22	0.010	0.21	0.010	0.430	0.080

Sample Description	Sampled	pH	EC	TDS	Tot Alk	Ca	Mg	Na	K	Si	Cl	SO_4	NO_3	NH_4	F	Al	PO_4	Cu	Fe	Mn
FGM-B45 (PLUME-7)	2021/02/23 09:32	5.38	910	10 183	132	346	1 434	931	213	83.3	500	4712	0.350	6.35	2.42	0.010	1944	0.070	0.090	9.64
	2021/05/18 09:33	5.51	1234	13 650	72	570	1 542	1 322	152	61.0	970	8235	0.350	25.9	0.340	0.010	779	0.020	0.060	2.46
	2021/08/19 09:14	6.69	1731	12 818	80	578	1 079	1 598	167	10.0	956	8301	8.49	36.1	0.140	0.010	5.98	0.010	0.680	0.700
	2021/11/23 15:16	7.10	1047	8 560	106	427	725	1 194	150	0.800	1093	4847	9.01	11.4	0.090	0.010	0.337	0.010	0.100	1.62
	2022/02/23 14:27	7.29	1005	10 213	152	449	701	1 830	140	0.890	1176	5729	18.0	8.74	0.090	0.010	3.86	0.010	0.140	1.39
FGM-B46 (PLUME-8)	2021/02/23 09:20	6.86	162	924	680	34.1	63.4	221	19.7	2.93	88.9	70.7	0.350	1.26	2.37	0.010	13.7	0.010	0.010	0.010
	2021/05/18 09:19	8.01	167	1 054	618	24.8	63.4	294	21.1	1.26	132	141	0.680	0.450	2.66	0.010	0.981	0.010	0.010	0.010
	2021/08/18 13:02	6.41	227	1 438	341	14.7	111	328	26.6	4.37	188	334	2.90	6.25	23.0	0.060	186	0.080	0.020	0.800
	2021/11/23 15:01	7.48	229	1 451	849	17.1	98.1	384	24.5	2.72	226	187	0.350	0.980	2.30	0.010	0.337	0.010	0.720	0.030
	2022/02/23 10:43	7.66	256	1 496	1036	14.2	100	414	27.4	3.76	222	82.2	1.36	3.56	2.60	0.010	0.859	0.010	0.570	0.050
FGM-B47 (PLUME-9)	2021/02/22 10:42	6.81	985	8 116	943	429	728	1 189	36.7	10.5	1 199	3 961	0.350	0.700	0.090	0.010	5.21	0.010	0.280	1.63
	2021/05/17 02:15	6.84	963	8 108	894	629	678	1 005	41.1	22.5	1 191	4 022	0.350	0.450	0.090	0.010	3.01	0.010	0.190	1.79
	2021/08/18 13:56	6.28	930	8 613	932	778	761	1 030	45.3	23.1	1 258	4 165	1.04	1.05	0.090	0.010	7.15	0.010	0.230	2.21
	2021/11/23 11:12	6.98	938	8 221	928	759	742	933	43.8	25.8	1 172	4 007	0.350	0.450	0.090	0.010	0.276	0.010	0.320	2.16
	2022/02/23 08:35	6.90	946	8 375	1036	586	740	1 071	48.6	19.2	1 213	4 089	0.350	0.450	0.090	0.010	0.583	0.010	0.760	1.81
FGM-B50 (PLUME-10)	2021/08/18 14:58	5.56	1 231	14 585	232	349	1 753	1 846	43.9	66.4	812	7 692	0.350	1.42	0.830	0.010	1 938	0.010	0.040	7.44
	2021/11/23 14:21	5.75	1 208	14 272	241	388	1 677	1 770	52.0	76.1	884	7 257	0.350	0.600	0.370	0.010	2 088	0.020	0.020	6.91
	2022/02/23 09:29	5.28	1 206	15 487	241	365	1 808	1 919	47.3	68.5	849	8 118	0.350	0.870	0.090	0.010	2 226	0.010	0.180	5.39
FGM-52 (PLUME-11)	2021/08/18 13:34	5.09	1 113	11 390	248	648	981	1 401	33.3	55.7	767	7 178	0.350	0.660	0.140	0.010	228	0.010	0.200	4.34
	2021/11/23 10:52	6.71	1 133	11 129	278	685	967	1 497	40.9	57.0	830	6 850	0.350	2.52	0.090	0.010	82.8	0.010	0.050	3.39
	2022/02/23 09:52	6.35	1 151	13 611	226	814	1 147	1 971	38.5	67.4	884	8 126	0.350	0.450	0.090	0.010	488	0.010	0.270	4.16
AFB-1 (PLUME-13)	2021/08/18 15:17	6.77	371	2 163	192	23.7	225	429	7.25	0.370	940	395	1.12	1.22	0.780	0.010	20.3	0.010	0.010	0.040
	2021/11/23 13:42	6.51	333	2 031	304	25.1	175	486	9.71	0.140	1 027	75.3	0.350	0.450	1.07	0.010	48.5	0.010	0.010	0.080
	2022/02/23 08:17	6.68	410	2 304	278	58.1	171	546	10.9	1.23	1 097	239	0.350	2.40	0.800	0.010	11.3	0.010	0.150	0.130
AFB-5 (PLUME-14)	2021/08/19 10:12	6.65	62.1	339	166	14.9	19.5	84	2.91	0.680	73.7	39.7	0.350	0.450	0.610	0.010	4.14	0.010	0.010	0.010
	2021/11/23 14:07	6.89	104	600	241	24.6	53.0	119	3.06	0.98	147	103	0.350	0.450	0.190	0.010	5.95	0.010	0.020	0.010

Sample Description	Sampled	pH	EC	TDS	Tot Alk	Ca	Mg	Na	K	Si	Cl	SO_4	NO_3	NH_4	F	Al	PO_4	Cu	Fe	Mn
	2022/02/23 09:00	6.84	107	573	362	28.0	49.6	120	3.73	1.10	141	6.46	0.350	3.82	0.360	0.010	1.04	0.010	0.330	0.060
AFB-15 (PLUME-15)	2021/08/19 13:12	4.11	1273	12 119	0.000	427	1 359	1 315	143.0	42.5	966	6 553	0.350	14.0	48.5	18.0	1254	0.040	0.140	15.0
	2021/11/23 10:59	7.78	454	3288	490	6.14	361	580	30.5	0.100	866	1 147	0.350	0.540	0.430	0.010	1.63	0.010	0.010	0.060
Perimeter Monitoring Boreholes																				
FGM-B61S (NPER-1)	2021/08/18 08:14	6.68	30.6	169	81.7	8.71	6.92	42.5	2.45	1.85	39.8	9.89	0.520	0.930	0.510	0.010	5.37	0.010	0.090	0.010
	2021/11/23 08:10	7.87	29.9	152	79.4	10.2	6.96	37.6	2.53	1.23	42.1	3.75	0.350	0.450	0.190	0.010	0.859	0.010	0.070	0.010
	2022/02/23 13:33	8.53	34.8	150	74.2	9.05	5.72	39.1	2.20	0.820	45.7	2.34	0.350	0.520	0.180	0.010	0.491	0.010	0.150	0.010
FGM-B61D (NPER-2)	2021/02/18 08:16	6.67	21.0	86.8	30.6	11.1	6.35	7.49	2.42	0.680	9.90	27.5	0.410	0.450	0.130	0.010	1.69	0.010	0.020	0.040
	2021/05/17 01:39	7.13	127	841	83.9	27.0	103	99.3	3.29	1.00	79.6	476	0.350	0.450	0.230	0.010	1.96	0.010	0.050	0.050
	2021/08/18 08:13	6.71	111	704	55.3	14.7	73.2	94.2	4.33	1.49	75.6	400	0.350	0.870	0.860	0.010	6.10	0.010	0.170	0.080
	2021/11/23 08:09	8.44	98.8	639	100	10.3	62.3	93.7	4.82	0.100	82.9	322	0.590	0.450	0.200	0.010	0.613	0.010	0.020	0.010
	2022/02/23 12:57	8.59	97.8	570	97.6	10.1	57.0	91.6	3.54	0.550	92.9	255	0.350	0.590	0.090	0.010	0.368	0.010	0.030	0.010
FGM-B34 (EPER-1)	2021/02/18 09:18	6.98	195	1 352	256	147	119	106	22.2	24.9	81.1	703	0.350	0.450	11.3	0.010	8.31	0.040	0.100	0.260
	2021/05/18 03:02	7.54	281	2 126	246	228	193	161	22.8	2.08	164	1206	0.350	0.450	2.33	0.010	1.17	0.010	0.040	0.630
	2021/08/17 14:44	7.36	296	2 144	116	155	196	214	17.8	1.21	293	1144	0.770	0.450	5.67	0.140	42.6	0.010	1.55	0.280
	2021/11/23 09:19	7.55	332	2 379	137	119	216	316	20.5	0.300	383	1238	0.350	0.760	1.17	0.010	1.81	0.010	0.020	0.190
	2022/02/22 09:33	7.40	362	2 708	117	128	243	370	20.3	1.11	409	1436	1.17	0.470	2.61	0.010	22.1	0.010	0.050	0.300
FGM-B38A (EPER-3)	2021/02/23 09:11	6.57	162	805	372	16.1	70.9	186	6.64	9.18	263	31.9	0.520	0.650	2.52	0.010	2.05	0.010	0.070	0.010
	2021/05/18 08:54	7.21	162	843	49.7	34.4	72.9	158	5.36	12.9	384	125	0.350	0.450	1.01	0.010	32.8	0.010	0.020	0.010
	2021/08/18 10:45	5.95	174	913	40.5	45.7	85.9	165	4.09	14.7	456	120	0.350	0.450	0.090	0.010	12.3	0.010	0.050	0.010
	2021/11/23 09:37	7.65	166	790	104	33.9	75.1	161	4.31	14.4	390	45.7	0.350	0.560	1.00	0.010	15.7	0.010	0.010	0.020
	2022/02/22 13:30	6.57	163	764	170	26.8	67.9	167	4.95	10.2	363	26.0	0.350	2.19	0.28	0.010	1.81	0.010	0.010	0.010
FGM-B39 (EPER-4)	2021/02/23 08:55	6.88	429	2 451	468	109	204	508	32.8	1.38	1140	169	0.350	1.21	2.36	0.060	2.51	0.010	0.090	0.310
	2021/05/18 08:44	6.90	416	2 344	481	206	197	355	10.5	6.69	985	275	0.350	6.52	16.7	0.010	2.33	0.010	0.190	0.260
	2021/08/18 10:36	6.93	541	2 994	289	205	288	456	12.3	2.23	1550	277	1.65	3.41	1.23	0.010	18.8	0.010	1.55	0.070
	2021/11/23 09:46	6.90	581	3 180	272	150	320	557	14.2	0.700	1845	128	0.350	0.47	0.40	0.010	0.736	0.010	0.130	0.110

Sample Description	Sampled	pH	EC	TDS	Tot Alk	Ca	Mg	Na	K	Si	Cl	SO_4	NO_3	NH_4	F	Al	PO_4	Cu	Fe	Mn
	2022/02/22 13:35	7.54	614	3 362	276	135	326	620	13.9	0.650	1972	53.1	0.700	2.72	2.46	0.010	66.5	0.010	0.460	0.120
FGM-B40 (EPER-5)	2021/02/22 03:08	5.95	64.1	328	192	41.2	24.8	41.0	8.36	18.2	37.3	51.5	0.350	0.840	0.220	0.010	6.38	0.010	0.310	0.230
	2021/05/18 08:33	7.31	71.0	378	252	44.8	30.7	47.5	7.98	19.4	39.9	53.0	0.350	0.710	0.850	0.010	0.552	0.010	0.340	0.160
	2021/08/18 10:28	6.33	75.2	432	293	49.8	34.6	54.4	9.51	19.2	42.7	61.7	0.350	0.450	0.580	0.010	2.67	0.010	0.640	0.010
	2021/11/23 09:52	6.58	81.0	429	306	49.5	33.0	58.3	10.4	21.2	42.4	48.8	0.350	1.46	0.430	0.010	0.276	0.010	0.530	0.150
	2022/02/22 13:39	6.49	95.6	479	326	53.7	34.9	67.7	10.9	21.7	59.0	47.3	1.01	1.16	1.21	0.010	1.38	0.010	0.740	0.550
FGM-B41 (EPER-6)	2021/02/23 10:41	6.91	381	1 842	971	23.5	81.7	405	48.6	9.36	504	23.1	0.350	131	0.470	0.060	3.47	0.010	0.130	0.050
	2021/05/17 11:15	7.84	365	1 973	1 064	26.9	76.8	428	48.4	8.03	536	12.6	5.38	138	0.650	0.010	2.97	0.010	0.030	0.030
	2021/08/18 09:30	7.54	387	2 052	1 145	26.7	79.3	432	59.9	8.11	541	4.11	6.05	143.0	0.760	0.010	9.14	0.010	1.13	0.020
	2021/11/24 08:32	7.99	386	2 292	1 174	27.1	94.7	455	67.1	8.57	525	107	6.95	149.0	0.490	0.010	86.8	0.020	0.130	0.440
	2022/02/23 14:49	7.28	396	2 163	1 270	19.9	77.5	434	62.7	8.23	522	46.2	0.460	178.0	0.680	0.020	4.35	0.010	1.08	0.070
FGM-B20 (WPER-1)	2021/08/18 14:23	8.92	468	2 889	829	5.97	205	731	21.0	0.280	807	594	2.73	2.58	0.520	0.010	11.8	0.010	0.010	0.010
	2021/11/23 13:34	8.61	503	3 013	892	2.97	206	862	27.4	0.100	874	502	0.350	0.450	0.380	0.010	1.41	0.010	0.010	0.010
	2022/02/23 08:06	8.76	516	2 994	961	3.82	187	866	25.8	0.100	938	389	0.350	3.15	0.200	0.010	1.53	0.010	0.030	0.010
FGM-B21 (WPER-3)	2021/02/22 11:13	7.39	389	2 865	448	186	252	395	22.5	7.74	470	1257	1.25	0.97	0.740	0.010	4.57	0.010	0.030	1.19
FGM-B60D (WPER-4)	2021/02/22 11:21	6.65	401	2 615	207	6.28	202	562	27.7	0.300	595	1096	0.350	0.620	0.230	0.010	1.07	0.010	0.050	0.160
	2021/05/17 02:29	8.62	372	2 613	205	7.83	133	666	40.2	0.100	549	1090	0.580	0.450	0.240	0.010	1.04	0.010	0.040	0.010
	2021/08/18 13:45	9.09	376	2 583	218	8.78	183	547	29.3	0.100	581	1043	9.45	10.6	0.670	0.010	3.71	0.010	0.010	0.010
	2021/11/23 11:04	8.76	407	2 715	147	27.1	250	489	29.5	0.100	648	1158	5.25	0.450	0.220	0.010	1.44	0.010	0.010	0.020
	2022/02/23 08:46	8.40	411	2 718	157	25.0	266	527	26.4	0.100	646	1127	0.850	0.570	0.090	0.010	1.47	0.010	0.010	0.020
FGM-B59D (WPER-5)	2021/02/23 02:19	6.67	458	3 566	296	230	369	385	16.4	7.4	65.0	1911	0.510	1.50	0.090	0.010	1.9	0.010	0.120	5.76
	2021/05/17 02:36	6.74	498	4 163	337	358	382	395	19.4	17.5	556	2244	0.350	0.85	0.120	0.010	0.77	0.010	0.070	4.03
	2021/08/18 10:02	6.51	591	5 425	509	542	493	482	15.6	27.4	655	2920	0.880	1.37	0.250	0.010	5.06	0.010	0.290	0.760
	2021/11/23 10:22	6.87	592	4 870	506	489	428	429	19.5	31.9	659	2538	0.350	0.450	0.090	0.010	0.49	0.010	1.37	0.680
	2022/02/22 14:06	7.01	565	5 016	449	515	443	461	18.3	27.9	626	2675	0.430	0.850	0.250	0.010	2.79	0.010	0.330	1.32
FGM-B29 (WPER-6)	2021/05/17 08:15	7.14	89.8	463	421	85.6	35.5	43.3	2.71	10.7	18.1	23.8	0.350	0.450	0.630	0.0100	0.307	0.010	0.120	0.160

Sample Description	Sampled	pH	EC	TDS	Tot Alk	Ca	Mg	Na	K	Si	Cl	SO_4	NO_3	NH_4	F	Al	PO_4	Cu	Fe	Mn
	2021/08/18 10:07	7.39	80.9	461	408	72.8	35.1	56.1	3.89	5.87	26.2	18.8	0.350	0.450	1.14	0.0100	1.59	0.010	0.080	0.020
	2021/08/18 10:15	8.51	168	910	445	11.4	36.3	284	10.7	5.40	221	66	0.840	0.960	1.14	0.0100	7.97	0.010	0.010	0.010
	2021/11/23 10:17	7.31	111	594	447	59.2	39.8	119	7.09	3.87	91.1	8.75	0.350	0.450	0.460	0.0100	0.276	0.010	0.150	0.010
	2022/02/22 14:01	7.50	137	769	497	52.0	49.6	168	14.7	4.02	165	16.4	0.450	1.02	0.780	0.0100	0.276	0.010	0.320	0.030
FGM-B58D (WPER-7)	2021/02/22 02:45	8.47	150	839	381	9.7	30.2	259	12.9	0.760	235	58.1	0.530	0.450	0.490	0.010	3.68	0.010	0.010	0.010
	2021/05/18 08:22	8.87	142	791	373	2.37	26.2	263	13.3	0.370	208	53.3	0.350	0.450	0.460	0.010	0.613	0.010	0.030	0.010
	2021/08/18 10:12	8.81	141	744	354	4.45	24.2	243	12.4	1.31	203	42.9	0.350	0.450	0.860	0.010	0.828	0.010	0.010	0.010
	2021/11/23 10:11	8.48	150	832	402	11.5	45.5	245	13.0	10.1	240	27.3	0.350	0.450	0.610	0.010	7.61	0.010	0.010	0.010
	2022/02/22 13:53	8.54	146	827	406	11.2	40.2	244	10.9	8.82	249	22.9	0.350	0.670	0.860	0.010	2.91	0.010	0.110	0.010
FGM-B58S (WPER-8)	2021/02/22 02:44	8.74	192	1 114	599	3.64	32.6	374	12.6	2.30	251	75.8	0.350	0.45	0.74	0.060	3.93	0.010	0.040	0.010
	2021/05/18 08:21	8.63	185	1 045	521	6.96	26.4	358	13.8	3.64	236	88.4	0.360	0.45	0.68	0.010	0.828	0.010	0.010	0.010
	2021/11/23 10:12	8.19	170	1 034	504	19.8	46.6	304	12.6	7.94	230	116	0.350	0.45	0.66	0.010	1.26	0.010	0.070	0.010
	2022/02/22 13:56	7.93	194	1 057	522	34.6	54.9	282	11.3	11.3	239	110	1.31	0.92	1.02	0.010	2.73	0.010	0.380	0.010
FGM-B43 (WPER-9)	2021/02/22 02:54	7.22	152	817	526	144	56.4	89.8	3.11	31.2	86.0	121	0.350	0.450	0.560	0.010	1.41	0.010	0.010	0.010
	2021/05/17 03:11	6.95	183	1 086	518	154	60.7	173	4.47	37.8	238	131	0.350	2.33	5.78	0.010	5.61	0.010	0.090	0.290
	2021/08/18 10:21	6.99	175	1 064	524	98.0	68.3	182	5.58	36.7	231	131	3.59	8.09	1.50	0.010	5.61	0.010	0.030	0.240
	2021/11/23 10:03	7.13	173	1 037	493	90.7	67.2	194	6.93	39.8	220	160	0.350	0.450	0.760	0.010	0.429	0.010	0.320	0.290
	2022/02/22 13:48	6.43	168	982	498	89.9	62.7	176	5.94	38.9	214	127	0.350	3.60	1.42	0.010	0.613	0.010	0.220	0.290
Plant Monitoring Boreholes																				
FGM-B62 (PLANT-1)	2021/08/19 07:45	6.69	194	1 399	373	59.5	197	79.3	33.3	9.36	53.8	739	0.350	0.450	7.99	0.010	5.27	0.010	0.010	0.010
	2021/11/23 07:49	8.01	194	1 381	294	123	138	96.4	33.5	12.7	76.5	678	8.64	0.450	5.51	0.010	14.75	0.020	0.010	0.010
	2022/02/22 10:41	7.19	338	2 649	463	295	195	245	32.9	12.8	284	1310	0.350	0.840	4.08	0.010	4.29	0.010	0.120	0.010
FGM-B63 (PLANT-2)	2021/02/18 07:57	6.19	74.8	467	22.4	13.5	7.40	102	31.8	0.250	23.0	247	4.69	0.450	4.75	0.480	2.12	0.010	0.020	0.060
	2021/05/19 07:49	5.70	69.1	427	25.6	11.3	7.08	98.7	29.1	0.100	23.4	225	2.21	1.01	5.41	0.010	0.368	0.010	0.040	0.070
	2021/08/19 07:53	5.84	73.7	450	30.0	19.1	9.10	95.5	25.3	0.940	24.8	226	4.68	0.450	8.15	0.040	3.28	0.010	0.020	0.170
	2021/11/23 07:56	7.14	75.8	464	31.8	21.9	11.4	91.0	27.3	0.920	26.9	235	3.04	3.34	12.9	0.030	0.675	0.010	0.020	0.100

Sample Description	Sampled	pH	EC	TDS	Tot Alk	Ca	Mg	Na	K	Si	Cl	SO_4	NO_3	NH_4	F	Al	PO_4	Cu	Fe	Mn
	2022/02/22 10:36	6.68	62.4	353	46.2	7.96	4.71	85.9	23.8	0.230	22.7	153	4.84	0.920	2.63	0.010	2.48	0.010	0.080	0.010
FGM-B64 (PLANT-3)	2021/02/18 09:07	5.52	103	603	10.8	10.4	41.0	111	28.3	3.09	47.2	277	2.31	3.17	40.4	1.20	25.7	0.010	0.080	0.370
	2021/05/19 08:44	5.71	133	746	15.5	16.0	57.8	134	32.6	5.01	67.4	308	1.82	2.42	74.5	3.76	31.3	0.010	0.140	0.520
	2021/08/19 08:44	5.11	189	1 698	6.40	37.6	134	186	34.3	26.6	69.3	547	0.76	5.91	133	25.7	512	0.020	0.040	3.40
	2021/11/23 08:56	5.67	206	1 809	30.8	32.9	151	184	44.0	32.0	72.6	471	2.95	7.20	141	19.6	647	0.030	0.050	3.13
	2022/02/22 12:56	4.12	89.4	468	0.00	9.08	37.2	82.0	20.0	7.75	11.0	169	0.35	4.44	1.55	0.01	129	0.060	1.83	0.380
FGM-B67 (PLANT-4)	2021/02/18 08:44	2.50	752	10 500	0.000	579	561	389	308	59.2	10.1	2 038	12.9	22.3	203	142	6 151	1.91	16.4	10.9
	2021/05/19 08:13	2.54	835	13 167	0.000	611	778	512	354	70.7	48.5	2 591	10.6	24.5	0.09	190	7 970	1.95	12.8	12.7
	2021/08/19 08:14	2.94	863	13 105	0.000	603	677	557	378	59.2	64.7	3 593	14.1	33.7	0.09	149	6 946	1.80	7.66	14.6
	2021/11/23 08:26	2.71	932	14 153	0.000	650	836	603	409	53.2	52.3	3 278	12.3	34.1	0.81	171	8 007	0.860	16.7	16.0
	2022/02/22 13:04	3.17	317	4 283	0.000	315	178	146	90.6	43.4	21.2	1 374	15.5	11.4	0.09	60.3	2 009	0.330	0.88	2.92
FGM-B70 (PLANT-6)	2021/02/18 08:39	3.30	415	3 767	0.000	554	212	127	63.8	43.7	126	2 419	11.0	8.08	2.38	33.6	164	0.130	2.52	2.85
	2021/05/19 08:22	3.49	385	3 874	0.000	617	212	148	73.6	32.5	123	2 406	6.95	3.53	59.0	27.6	169	0.070	0.370	2.67
	2021/08/19 08:22	3.79	414	4 075	0.000	562	283	164	70.9	45.0	104	2 358	6.69	5.30	0.09	33.5	460	0.060	0.150	2.79
	2021/11/23 08:39	3.86	430	3 858	0.000	495	263	206	95.9	49.7	144	2 051	6.97	10.6	1.98	26.3	524	0.050	0.170	3.08
	2022/02/22 13:11	3.32	362	3 111	0.000	382	191	174	66.5	9.7	95	2 169	0.350	5.88	0.09	0.010	0.705	0.020	21.30	2.30
FGM-B71 (PLANT-7)	2021/02/18 08:59	6.85	367	3 117	230	455	187	235	33.9	28.3	165	1 643	50.9	0.450	4.34	0.010	30.6	0.010	0.010	0.390
	2021/05/19 08:35	6.31	393	3 420	303	344	271	287	33.0	33.8	209	1 649	94.3	0.450	4.94	0.010	21.9	0.010	0.010	0.960
	2022/08/19 08:39	5.90	389	3 332	290	346	251	301	37.9	31.9	210	1 660	72.3	0.450	5.28	0.010	26.5	0.010	0.030	0.640
	2021/11/23 09:01	7.16	323	2 996	128	558	123	122	41.4	11.3	67.2	1 871	23.2	0.450	4.85	0.010	27.8	0.010	0.010	0.150
	2022/02/22 13:20	6.82	333	3 237	112	567	146	144	48.5	5.98	95.3	2 050	21.4	0.610	8.69	0.010	14.6	0.010	0.010	0.030
FGM-B72 (PLANT-8)	2021/02/18 07:52	7.77	175	1 058	363	4.33	42.9	291	26.3	0.920	97.9	372	0.590	0.450	0.680	0.010	2.51	0.010	0.050	0.010
	2021/05/19 07:38	8.76	171	1 059	350	8.41	61.6	258	18.3	3.26	105	384	2.85	0.450	0.700	0.010	1.41	0.010	0.030	0.010
	2021/08/19 07:34	8.36	171	1 086	362	11.4	84.6	232	14.0	6.25	115	400	0.810	0.450	1.11	0.010	6.29	0.010	0.010	0.010
	2021/11/23 07:38	7.47	241	1 582	560	145	137	190	19.6	32.8	195	557	0.350	0.450	0.620	0.010	0.705	0.020	0.090	0.320
	2022/02/22 10:10	7.04	219	1 551	331	91.9	136	216	21.3	20.3	164	606	0.500	4.11	13.00	0.010	96.0	0.010	0.100	0.260

Sample Description	Sampled	pH	EC	TDS	Tot Alk	Ca	Mg	Na	K	Si	Cl	SO_4	NO_3	NH_4	F	Al	PO_4	Cu	Fe	Mn
FGM-B75 (PLANT-10)	2021/08/19 07:38	8.76	563	4 490	464	34.7	332	901	12.8	1.51	45.3	2 863	1.12	0.660	0.360	0.010	17.0	0.010	0.010	0.030
	2021/11/23 07:41	8.41	582	4 991	350	50.5	448	912	15.4	2.56	37.4	3 301	0.430	0.450	0.260	0.010	11.9	0.010	0.030	0.060
	2022/02/22 10:17	9.59	558	5 756	828	8.31	112	1 718	16.1	1.11	38.0	3 341	2.710	0.450	0.510	0.010	13.2	0.010	0.010	0.010
FGM-B76 (PLANT-11)	2021/08/19 08:28	6.34	376	3 226	290	202	320	279	22.4	41.5	187	1 342	116	4.52	12.0	0.010	164	0.010	0.020	1.96
	2021/11/23 08:44	6.50	384	3 098	255	191	315	274	23.9	46.4	228	1 223	129	0.450	9.17	0.010	106	0.020	0.010	2.27
	2022/02/22 13:15	5.96	611	7 365	173	249	1 074	692	25.0	51.4	145	3 664	13.5	2.01	0.09	0.060	1 337	0.020	0.060	10.2
Abstraction Monitoring Boreholes																				
FGM-B48 (GRAB-2)	2021/02/22 10:52	6.78	2 100	21 819	873	576	2 682	2 923	14.7	52.9	2 929	11 913	0.350	0.450	1.27	0.010	255	0.040	0.120	1.09
	2021/03/23 09:06	7.19	1 862	17 582	1 080	574	1 428	3 121	18.2	50.6	2 547	9 233	0.350	0.590	0.090	0.010	9.14	0.030	1.58	2.00
	2021/04/22 09:12	7.30	1 792	19 687	1 080	546	2 288	3 239	13.3	24.5	2 578	10 371	0.350	1.58	0.090	0.010	0.552	0.020	0.890	1.00
	2021/05/17 02:03	7.66	1 773	17 906	1 001	585	1 794	2 840	17.9	18.3	2 433	9 628	0.870	0.450	0.090	0.010	1.38	0.010	0.600	0.700
	2021/06/22 10:37	7.19	1 721	16 342	728	405	1 641	2 405	20.7	4.0	2 437	8 991	0.350	0.830	0.090	0.010	0.675	0.010	3.05	0.570
	2021/07/22 09:06	7.67	1 770	17 728	712	410	1 718	2 654	23.0	3.2	2 450	10 042	0.350	0.990	0.090	0.010	1.44	0.010	1.31	0.530
	2021/01/21 09:46	3.49	2 010	20 885	875	582	2 115	3 046	16.5	3.5	3 181	11 364	0.350	24.1	3.49	0.010	0.460	0.150	17.4	3.10
	2021/08/18 14:01	7.10	1 773	15 994	639	370	1 537	2 356	20.8	1.7	2 113	9 204	1.11	1.08	0.090	0.010	2.61	0.010	0.260	0.520
	2021/09/16 08:59	6.37	2 100	23 487	1 230	637	2 615	2 961	45.6	51.3	2 551	13 018	0.350	3.53	0.200	0.010	892	0.030	0.010	3.42
	2021/10/21 10:00	7.05	1 817	18116	1 327	715	1 801	2 546	35.7	52.5	2 311	9 862	0.350	0.880	0.090	0.010	42.9	0.010	0.52	1.30
	2021/11/22 14:03	6.40	1 625	14 749	244	615	1 498	2 045	28.2	37.3	2 073	8 320	0.350	2.12	0.090	0.010	0.184	0.010	6.11	1.83
	2022/01/20 09:52	7.82	1 862	18 001	1 072	707	1 826	2 585	25.5	54.6	2 612	9 490	1.95	1.04	0.090	0.010	88.0	0.010	0.170	0.43
	2022/02/23 08:27	6.47	2 060	25 615	1 326	636	2 935	3 512	46.5	69.2	2 558	14 873	0.350	3.99	0.090	0.010	249.3	0.010	0.090	4.70
	2022/03/23 09:12	6.26	2 110	25 538	1 375	621	2 924	3 725	40.4	53.7	2 289	14 133	0.350	0.470	0.090	0.010	975	0.010	0.040	3.17
	2022/04/28 08:37	6.68	1 919	22 067	1 262	751	2 506	2 767	42.5	54.9	3 095	11 776	0.350	2.80	0.090	0.010	337	0.010	0.030	3.60
FGM-B49 (GRAB-1)	2021/08/18 14:15	6.60	1 483	13 803	918	742	1 426	1 522	36.0	46.1	1 644	7 644	0.350	0.450	0.090	0.010	235	0.010	0.010	2.76
	2021/09/16 09:03	6.58	1473	14 317	718	683	1 608	1 677	45.3	51.5	1 847	7 839	0.350	0.480	0.090	0.010	173	0.020	0.010	2.94
	2021/10/21 10:06	6.72	1467	15 138	916	757	1 583	1 680	49.5	54.4	1 805	8 519	0.350	0.450	0.090	0.010	181	0.010	0.050	3.57
	2021/11/22 14:08	6.51	1499	14 505	874	723	1 521	1 597	46.8	54.0	1 782	8 091	0.350	0.940	0.090	0.010	205	0.010	0.010	3.48

Sample Description	Sampled	pH	EC	TDS	Tot Alk	Ca	Mg	Na	K	Si	Cl	SO_4	NO_3	NH_4	F	Al	PO_4	Cu	Fe	Mn
	2022/01/20 09:58	7.22	1495	14 762	923	702	1 589	1 674	43.7	54.3	1 869	8 106	1.53	0.450	0.090	0.010	205	0.010	0.040	3.46
	2022/02/23 08:13	6.70	1461	15 972	844	784	1 647	1 661	44.8	70.1	1 987	9 307	0.350	0.580	0.090	0.010	29.3	0.010	0.180	4.64
	2022/03/23 09:16	6.55	1400	16 293	883	735	1 742	2 199	40.1	54.8	1 525	9 303	0.350	0.450	0.090	0.010	207	0.010	0.100	3.06
	2022/04/28 08:40	6.99	1344	17 589	858	826	1 775	2 000	41.4	54.4	1 877	10 487	0.350	0.450	0.090	0.010	54.28	0.010	0.040	3.78
FGM-B51 (GRAB-4)	2021/02/18 01:33	3.05	1 269	16 960	0.000	348	1 559	1471	144.0	67.8	571	7 004	0.350	19.1	220	99.2	5 474	2.65	11.4	28.4
	2021/03/23 08:24	3.02	1 275	17 177	0.000	301	1 837	1490	129.0	88.8	723	8 161	0.350	14.7	191	81.9	4 204	2.64	10.1	23.2
	2021/04/22 08:28	2.68	1 391	18 657	0.000	420	1 683	1612	189.0	82.8	776	8 022	0.350	24.9	348	188	5 336	5.43	14.5	31.2
	2021/05/17 08:38	2.52	1 460	17 899	0.000	365	1 744	1781	223.0	86.4	717	7 836	0.350	25.4	25	153	4 968	4.8	26.9	23.4
	2021/06/22 09:58	2.52	1 450	18 327	0.000	350	1 728	1718	216.0	86.4	747	7 203	0.350	27.4	517	185	5 563	6.81	29.5	28.5
	2021/07/22 08:09	2.39	1 535	20 839	0.000	357	1 983	1926	230.0	87.7	624	8 140	0.350	36.0	547	164	6 759	5.95	31.8	23.2
	2021/01/21 08:53	2.84	1 330	20 036	0.000	402	1 746	1747	194.0	68.9	574	7 893	3.06	27.8	360	127	6 900	4.19	9.38	27.6
	2021/08/16 13:23	2.34	1 544	20 854	0.000	343	1 747	1881	228.0	81.5	686	7 169	0.350	35.5	596	241	7 847	6.67	34.6	27.7
	2021/09/15 08:11	2.35	1 482	22 925	0.000	413	1 944	1948	186.0	91.3	596	7 352	0.350	33.5	527	255	9 574	7.21	32.6	26.9
	2021/10/21 09:06	2.45	1 413	19 156	0.000	358	1 457	1511	245.0	93.3	656	7 374	0.350	25.2	410	189	6 860	6.25	25.3	28.3
	2021/11/22 13:15	2.86	1 053	11 937	0.000	451	900	1534	242.0	35.8	481	4 424	2.51	29.3	261	87.1	3 474	4.57	5.21	22.7
	2022/01/20 08:21	3.20	1 257	17 697	0.000	331	1 434	1498	169.0	66.8	669	7 446	2.27	18.9	280	136	5 646	3.08	16.3	27.4
	2022/02/22 08:40	3.06	1 191	17 513	0.000	326	1 455	1497	155.0	73.8	661	7 574	0.350	23.3	251	226	5 293	3.28	13.6	25.2
	2022/03/23 08:30	2.76	1 248	17 470	0.000	410	1 524	1654	175.0	69.1	696	7 311	0.350	21.3	0.500	157	5 462	3.07	19.4	23.4
	2022/04/28 07:52	2.17	1 364	18 852	0.000	434	1 594	1824	194.0	69.9	645	6 861	0.350	34.2	362	221	6 581	5.11	30.6	30.1
FGM-B53 (GRAB-5)	2021/02/18 01:36	3.80	285	3 805	0.000	75	202	419	78.3	57.5	41	729	0.730	8.90	157	92.3	1 990	1.39	0.290	3.57
	2021/03/23 08:21	3.37	581	6 461	0.000	213	391	674	150	60.7	208	2 411	0.640	19.6	300	146	1 929	1.70	0.460	9.52
	2021/04/22 08:24	3.47	702	9 663	0.000	301	634	950	178	78.0	306	3 608	0.350	20.7	336	205	3 097	4.71	0.390	17.6
	2021/05/17 08:34	3.55	743	9 670	0.000	288	665	897	184	58.9	325	3 846	0.350	24.3	348	173	2 895	3.95	0.410	14.0
	2021/06/22 09:54	3.20	828	10 854	0.000	342	682	998	201	66.0	378	4 270	0.350	29.2	434	216	3 269	5.04	1.05	20.7
	2021/07/22 08:04	2.80	985	13731	0.000	466	775	1056	236	81.0	447	5 070	0.350	40.7	1.58	346	5 253	3.71	0.010	21.2
	2021/01/21 08:56	2.78	422	4 979	0.000	123	257	642	84.4	47.3	67.0	1 615	2.25	12.3	170	65.6	1 923	0.71	0.140	5.38

Sample Description	Sampled	pH	EC	TDS	Tot Alk	Ca	Mg	Na	K	Si	Cl	SO_4	NO_3	NH_4	F	Al	PO_4	Cu	Fe	Mn
	2021/08/16 13:20	2.59	1 092	15 118	0.000	709	783	1071	259	92.6	442	5 033	0.350	40.4	749	479	5 477	4.88	30.0	29.00
	2021/09/16 08:08	1.91	1 552	22 842	0.000	1000	654	1062	448	305	162	4 271	0.800	75.4	1793	441	12 754	23.8	115	23.00
	2021/10/21 09:03	1.99	1 546	22 189	0.000	953	662	1055	528	315	24.1	4 452	0.650	53.1	1629	481	12 171	21.1	121	21.50
	2021/11/22 13:12	3.11	930	10 489	0.000	436	664	963	203	47.1	412	4 133	5.16	24.5	224	137	3 226	3.93	1.96	22.40
	2022/01/20 08:17	3.42	1 044	13 847	0.000	487	830	1342	265	62.1	467	4 564	0.990	39.4	426	234	5 130	6.47	3.29	28.50
	2022/02/22 08:37	3.07	910	11 603	0.000	419	764	1044	218	74.8	435	3 101	5.36	38.7	317	209	4 989	6.30	2.58	26.60
	2022/03/23 08:28	3.05	936	12 358	0.000	423	868	1533	287	70.5	455	3 997	1.79	36.3	0.090	238	4 462	3.72	3.82	21.80
	2022/04/28 07:49	4.10	1 488	18 259	0.000	892	604	870	399	209	166	4 422	1.01	72.5	1 450	388	8 795	15.7	135	22.3
FGM-B54 (GRAB-6)	2021/02/18 01:14	5.11	934	11 292	58.8	241	1 196	1261	35.5	71.4	354	5 377	0.350	1.57	26.7	3.75	2 748	0.410	0.290	8.71
	2021/03/23 08:33	3.50	1 095	12 502	0.000	287	1 192	1421	55.3	69.7	498	6 249	0.350	2.09	0.090	29.4	2 745	0.660	0.700	20.0
	2021/04/22 08:39	3.48	1 217	13 797	0.000	422	1 300	1518	66.9	53.8	592	5 870	0.350	13.9	120	59.0	3 744	1.54	40.3	40.5
	2021/05/17 08:47	5.42	1 281	16 282	0.000	530	1 502	1942	64.5	54.1	628	6 892	0.350	17.3	0.590	63.9	4 569	2.37	25.3	37.2
	2021/06/22 10:04	3.38	1 339	17 398	0.000	561	1 607	2103	130	53.0	693	6 581	0.350	26.0	1.27	93.8	5 455	4.29	75.2	57.8
	2021/07/22 08:19	3.83	1 472	20 983	0.000	536	2 387	2289	85.0	55.5	584	7 098	0.350	9.81	9.71	21.4	7 887	1.31	0.660	63.1
	2021/01/21 08:42	5.04	1 160	14 885	54.2	224	1 570	1639	41.5	74.9	638	7 604	0.350	0.860	23.7	1.71	3 094	0.110	0.360	10.3
	2021/08/16 13:33	4.10	1 461	22 018	0.000	342	2 524	2530	71.0	51.4	635	9 438	0.350	12.6	0.090	6.26	6 406	1.98	30.0	40.9
	2021/09/16 08:19	4.03	1 469	20 348	0.000	487	2 110	2104	88.1	59.2	813	7 963	0.350	15.2	0.090	7.32	6 679	0.540	0.260	46.7
	2021/10/21 09:18	4.14	1 466	20 210	0.000	538	1 967	1794	94.8	65.2	856	8 957	0.350	12.1	22.9	5.13	5 906	0.370	0.240	45.0
	2021/11/24 07:52	4.30	1 503	19 992	0.000	332	1 952	1774	89.6	64.9	879	9 739	0.350	12.2	29.5	4.36	5 124	0.200	0.270	43.6
	2022/01/20 08:31	3.41	1 454	20 500	0.000	541	2 036	2013	110	65.9	874	8 803	3.16	18.9	89.3	35.8	5 875	0.360	27.9	47.7
	2022/02/22 08:51	3.76	1 423	21 597	0.000	479	2 042	1987	102	82.4	1172	9 194	0.350	19.2	50.3	19.2	6 458	0.160	1.84	57.4
	2022/03/23 08:38	4.27	1 443	19 830	0.000	371	2 111	2077	85.2	70.7	957	9 162	0.350	16.9	0.090	0.010	4 980	0.010	16.9	37.4
	2022/04/28 08:01	4.38	1 554	20 823	0.000	379	2 255	2109	88.8	65.8	830	9 314	0.350	17.8	29.6	0.010	5 719	0.100	0.620	45.4
FGM-B55 (GRAB-3)	2021/02/18 02:09	6.75	772	8 101	224	545	706	927	75.4	25.1	408	5 192	0.350	0.450	2.06	0.010	110	0.050	0.030	0.770
	2021/03/23 08:46	6.70	1 113	11 108	164	595	908	1476	41.8	45.5	680	7 234	0.350	0.450	1.08	0.010	69.6	0.080	0.250	4.04
	2021/04/22 08:55	6.46	1 248	15 063	191	610	1 455	2128	57.1	36.1	818	9 787	0.350	0.640	1.59	0.010	84.0	0.040	4.24	3.81

Sample Description	Sampled	pH	EC	TDS	Tot Alk	Ca	Mg	Na	K	Si	Cl	SO_4	NO_3	NH_4	F	Al	PO_4	Cu	Fe	Mn
	2021/05/17 09:23	6.76	1 285	12 677	182	485	1 220	1863	66.5	41.7	904	7 919	0.350	1.54	1.48	0.010	104	0.020	0.020	2.23
	2021/06/22 10:22	6.61	1 266	12 013	172	496	1 152	1572	63.8	39.1	960	7 596	0.350	1.89	2.16	0.010	62.3	0.030	0.160	2.29
	2021/07/22 08:34	5.82	1 341	13 027	162	526	1 225	1692	68.5	40.7	995	8 355	0.350	1.59	2.59	0.010	62.6	0.020	0.040	1.69
	2021/01/21 09:06	4.95	908	9 416	122	571	812	1 104	64.3	26.7	672	6 046	0.350	0.450	1.43	0.010	72.1	0.090	0.060	0.190
	2021/08/16 13:56	5.11	1 330	13 153	180	512	1 238	1 697	61.8	33.0	1 039	8 399	0.350	3.52	1.89	0.010	90.5	0.040	0.020	1.62
	2021/09/16 08:49	6.55	1 333	12 985	159	526	1 251	1 733	74.9	35.8	1 006	8 254	1.32	1.81	2.03	0.010	31.3	0.030	0.150	1.91
	2021/10/21 09:50	7.40	1 327	13 033	121	520	1 266	1 814	79.5	35.2	1 078	8 188	0.350	1.46	1.52	0.010	4.97	0.020	0.310	1.94
	2021/11/22 13:54	5.78	1 369	13 635	23	615	1 206	1 727	76.8	30.1	1 093	8 891	0.350	1.72	1.33	0.010	2.73	0.020	0.730	2.17
	2022/01/20 09:13	6.31	1 504	18 228	261	523	1 969	2 233	53.4	64.9	1 328	10 820	1.35	1.56	0.55	0.010	1 125	0.010	0.420	3.39
	2022/02/23 09:45	5.84	1 479	18 534	270	575	2 252	2 046	54.3	80.9	1 407	10 384	0.350	1.96	0.090	0.010	1 644	0.010	0.500	4.58
	2022/03/23 09:04	5.78	1 417	18 424	263	526	2 059	2 495	42.5	76.3	1 164	10 128	0.350	1.01	0.590	0.010	1 837	0.010	0.780	3.46
	2022/04/28 08:30	5.84	1 090	18 531	285	562	2 146	2 253	46.9	69.2	1 216	10 410	0.350	1.47	0.720	0.010	1 708	0.010	0.280	4.62

7.4.6.7. Aquifer Classification

The aquifer classification is done in accordance with the formal DWAF protocol "South African Aquifer System Management Classification, December 1995." Special attributes of aquifers related to structural features (such as fracturing along dyke/fault contact zones, or karst development) have been incorporated into the classification through the "Second Variable Classification".

Classification is done in accordance with the following definitions for Aquifer System Management Classes:

Sole Aquifer System:

An aquifer which is used to supply 50 per cent or more of domestic water for a given area, and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.

Major Aquifer System:

Highly permeable formations, usually with a known, or probable, presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (less than 150 mS/m Electrical Conductivity).

Minor Aquifer System:

These can be fractured or potentially fractured rocks which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important for local supplies and in supplying base flow for rivers.

Non-Aquifer System:

These are formations with negligible permeability that are regarded as not containing groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, groundwater flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.

Aquifer System Management and Second Variable Classifications

Aquifer System Management Classification		
Class	**Points**	**Bosveld Aquifer**
Sole Source Aquifer System: Major Aquifer System: Minor Aquifer System: Non-Aquifer System: Special Aquifer System:	6 4 2 0 0 – 6	- - 2 - -
Second Variable Classification		
Class	**Points**	**Bosveld Aquifer**
High: Medium: Low:	3 2 1	- 2 -

Aquifer System Management Classification Points = 2

Groundwater Quality Management Classification

Aquifer System Management Classification		
Class	**Points**	**Bosveld Aquifer**
Sole Source Aquifer System: Major Aquifer System: Minor Aquifer System: Non-Aquifer System: Special Aquifer System:	6 4 2 0 0 – 6	- - 2 - -
Aquifer Vulnerability Classification		
Class	**Points**	**Bosveld Aquifer**
High: Medium: Low:	3 2 1	3 - -

Aquifer System Management Classification Points = 3

The indicated level of groundwater protection is derived from the Groundwater Quality Management Index (GQM Index).

GQM Index = Aquifer System Management Classification x Aquifer Vulnerability Classification
= 2 x 3
= **6**

Indicated Level of Groundwater Protection

GQM Index	Level of Protection	Bosveld Aquifer
<1	Limited	-
1 - 3	Low Level	-
3 - 6	Medium Level	6
6 - 10	High Level	-
>10	Strictly Non-Degradation	-

Aquifer Protection Classification

The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification, yield a Groundwater Quality Management Index of 6 for Bosveld Phosphates, indicating that **medium** level groundwater protection may be required.

7.4.6.8. Groundwater Use (Hydrocensus)

Two extensive groundwater hydrocensus have been performed adjacent to the Bosveld Phosphates operations, along the western bank of the Ga-Selati River. The two hydrocensus' were conducted in 1995 and 2010 respectively, with the 2010 hydrocensus serving as a follow-up assessment of the 1995 study.

A total of 36 boreholes were identified during the 1995 hydrocensus, and a total of 44 borehole localities were identified during the 2010 hydrocensus. The localities of the boreholes identified during the 1995 and 2010 hydrocensus' are illustrated in Figure 7.4.6.8(a) below.

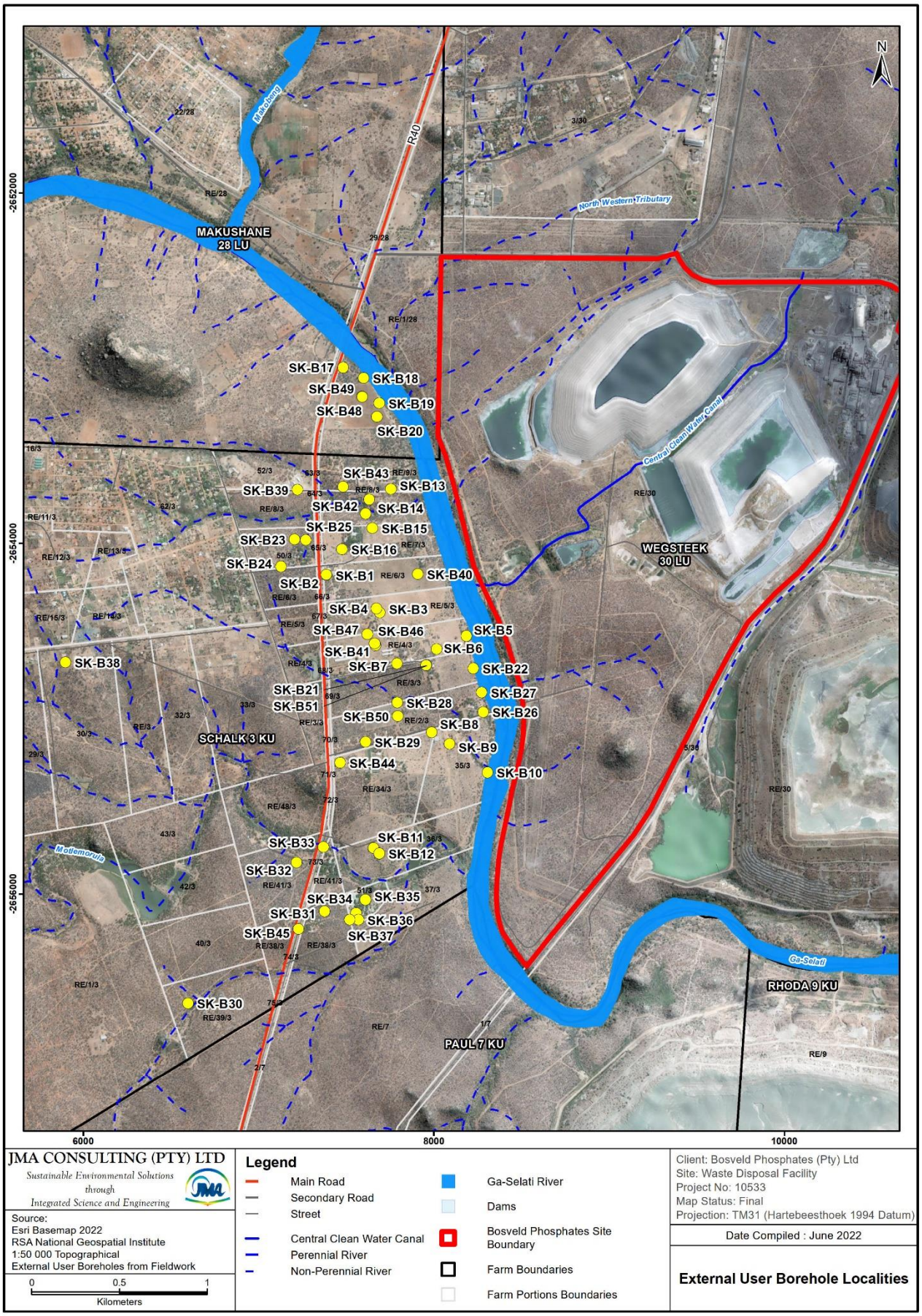
Of the 44 borehole localities identified during the 2010 groundwater hydrocensus:

- 7 were in use
- 32 were not in use, and
- 5 had been totally destroyed since the previous hydrocensus.

During the 2010 hydrocensus, 26 groundwater samples were collected and submitted to an accredited laboratory for analysis of the following parameters: pH, EC, TDS, Ca, Mg, Na, K, Si, T.Alk, F, Cl, SO_4, NO_3, NH_4, PO_4, Al, As, Cd, Cr (T), Cr^{6+}, Co, Cu, Fe, Hg, Mn, Ni, Pb, Th, U and Zn. The results of the analysis is presented in Table 7.4.6.8(a) below.

Based on the hydrochemistry results of the 2010 hydrocensus, the following conclusions were reached:

- Only 3 samples (SK-B5, SK-B7 and SK-B47) had no parameters that exceeded any of parameters provided in the SANS 2015-1: 2015 Drinking Water Standard.
- Of the 26 boreholes sampled, 10 boreholes had one or more parameters exceeding the Chronic Health threshold provided in the SANS 2015-1: 2015 Drinking Water Standard.
- The remaining 13 boreholes had parameters only exceeding the Aesthetic threshold provided in the SANS 2015-1: 2015 Drinking Water Standard.
- The parameters of most concern identified when comparing the water chemistry results to the SANS 2015-1: 2015 Drinking Water Standard is fluoride and manganese, however the magnitude of the elevation above the threshold is still within some margin and therefore only through continues monitoring could the extent of this elevation be determined.



JMA CONSULTING (PTY) LTD
Sustainable Environmental Solutions through Integrated Science and Engineering

Source:
Esri Basemap 2022
RSA National Geospatial Institute
1:50 000 Topographical
External User Boreholes from Fieldwork

0 0.5 1
Kilometers

Legend

- Main Road
- Secondary Road
- Street
- Central Clean Water Canal
- Perennial River
- Non-Perennial River
- Ga-Selati River
- Dams
- Bosveld Phosphates Site Boundary
- Farm Boundaries
- Farm Portions Boundaries

Client: Bosveld Phosphates (Pty) Ltd
Site: Waste Disposal Facility
Project No: 10533
Map Status: Final
Projection: TM31 (Hartebeesthoek 1994 Datum)

Date Compiled : June 2022

External User Borehole Localities

Figure 7.4.6.8(a): Borehole Localities identified during the 2010 Hydrocensus

Table 7.4.6.8(a): Groundwater Hydrocensus Chemistry Assessment with reference to the SANS 241-1:2015 Drinking Water Standard

BH No.	pH	EC	TDS	Ca	Mg	Na	K	F	Cl	SO4	NO3	NH4	Al	Cd	Cr (T)	Cu	Fe	Hg	Mn	Ni	Pb	Zn
		mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Operational	5.0 -9.7	-	-			-	-	-	-	-	-	-	0.30	-	-	-	-	-	-	-	-	-
Aesthetic	-	170	1 200			200	-	-	300	250	-	1.50	-	-	-	-	0.30	-	0.10	-	-	5
Acute Health	-	-	-			-	-	-	-	500	≤ 11	-	-	-	-	-	-	-	-	-	-	-
Chronic Health	-	-	-			-	-	1.50	-	-	-	-	-	0.003	0.05	2.00	2.00	0.006	0.40	0.07	0.01	-
SK-B2	6.95	160	967	40.1	24	313	3.46	2.52	273	136	0.81	<0.01	0.05	<0.003	<0.01	<0.01	0.37	<0.001	0.02	<0.01	<0.01	<0.01
SK-B5	7.93	43	265	32.7	18	29	3.37	0.39	41	80.9	0.58	<0.01	0.04	<0.003	<0.01	<0.01	0.06	<0.001	0.09	<0.01	<0.01	<0.01
SK-B6	7.17	279	1504	127	89	334	7.81	1.17	366	288	5.73	<0.01	0.02	<0.003	<0.01	<0.01	0.04	<0.001	0.01	<0.01	<0.01	<0.01
SK-B7	7.37	53	310	49.2	22	35	3.43	0.45	36	85.6	0.50	<0.01	0.05	<0.003	<0.01	<0.01	0.12	<0.001	<0.01	<0.01	<0.01	<0.01
SK-B8	7.40	331	1909	132	95	474	16.60	1.50	493	271	1.83	3.26	0.01	<0.003	<0.01	<0.01	0.12	<0.001	2.68	<0.01	<0.01	0.015
SK-B9	7.35	190	1221	118	65	270	8.51	1.36	224	203	4.77	0.06	0.01	<0.003	<0.01	<0.01	0.07	<0.001	0.07	<0.01	<0.01	<0.01
SK-B10	7.49	187	1089	94.2	49	274	9.82	1.62	342	83.9	3.37	0.26	0.01	<0.003	<0.01	<0.01	0.25	<0.001	0.28	<0.01	<0.01	<0.01
SK-B11	7.41	303	1779	123	107	417	13.30	1.72	466	315	6.34	<0.01	<0.01	<0.003	<0.01	<0.01	0.06	<0.001	0.02	<0.01	<0.01	0.045
SK-B15	7.28	361	2004	146	110	512	9.43	1.50	654	91.2	1.87	1.69	<0.01	<0.003	<0.01	<0.01	0.08	<0.001	<0.01	<0.01	<0.01	<0.01
SK-B18	7.40	183	1107	77.4	71	267	6.78	0.42	236	116	0.17	0.06	0.01	<0.003	<0.01	<0.01	0.16	<0.001	0.10	<0.01	<0.01	<0.01
SK-B24	7.00	128	730	54.9	32	201	15.20	0.92	132	18.6	3.23	1.81	0.02	<0.003	<0.01	<0.01	0.20	<0.001	0.55	<0.01	<0.01	<0.01
SK-B25	7.29	284	1720	126	67	476	11.60	1.04	508	62.9	0.41	1.55	0.01	<0.003	<0.01	<0.01	0.09	<0.001	0.09	<0.01	<0.01	<0.01
SK-B26	7.48	236	1484	155	84	298	9.03	1.32	410	305	3.99	0.03	0.03	<0.003	<0.01	<0.01	0.10	<0.001	0.56	<0.01	<0.01	0.012
SK-B31	7.63	228	1334	92.9	109	284	9.39	1.30	399	72.7	1.57	<0.01	0.01	<0.003	<0.01	<0.01	0.05	<0.001	0.02	<0.01	<0.01	<0.01
SK-B32	7.76	179	1063	72.1	71	275	8.11	1.45	259	51.9	0.23	<0.01	0.01	<0.003	<0.01	<0.01	0.05	<0.001	<0.01	<0.01	<0.01	<0.01
SK-B34	7.52	279	1639	121	139	331	10.20	1.03	496	166	4.55	<0.01	0.01	<0.003	<0.01	0.020	0.05	<0.001	0.48	<0.01	<0.01	<0.01
SK-B35	7.78	191	1177	99.4	78	254	8.23	1.11	210	138	5.59	<0.01	0.01	<0.003	<0.01	0.013	0.05	<0.001	0.09	<0.01	<0.01	0.019
SK-B40	7.69	256	1576	156	73	367	18.80	0.65	387	228	2.64	<0.01	<0.01	<0.003	<0.01	0.010	0.05	<0.001	<0.01	<0.01	<0.01	<0.01
SK-B41	8.16	288	1653	153	87	378	8.98	1.07	516	233	3.00	<0.01	0.01	<0.003	<0.01	0.016	0.05	<0.001	<0.01	<0.01	<0.01	0.057
SK-B42	7.72	236	1414	102	80	361	6.56	0.96	323	158	1.32	0.02	0.01	<0.003	<0.01	<0.01	0.08	<0.001	0.13	<0.01	<0.01	<0.01
SK-B43	6.91	92	560	28.8	23	155	1.46	0.45	199	69.7	0.14	0.29	0.49	<0.003	<0.01	<0.01	1.01	<0.001	0.23	<0.01	<0.01	<0.01

BH No.	pH	EC	TDS	Ca	Mg	Na	K	F	Cl	SO4	NO3	NH4	Al	Cd	Cr (T)	Cu	Fe	Hg	Mn	Ni	Pb	Zn
		mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	°C	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Operational	5.0 -9.7	-	-			-	-	-	-	-	-	-	0.30	-	-	-	-	-	-	-	-	-
Aesthetic	-	170	1 200			200	-	-	300	250	-	1.50	-	-	-	-	0.30	-	0.10	-	-	5
Acute Health	-	-	-			-	-	-	-	500	≤ 11	-	-	-	-	-	-	-	-	-	-	-
Chronic Health	-	-	-			-	-	1.50	-	-	-	-	-	0.003	0.05	2.00	2.00	0.006	0.40	0.07	0.01	-
SK-B45	7.63	227	1352	91.4	113	293	10.00	1.23	374	49.5	0.44	<0.01	0.02	<0.003	<0.01	<0.01	0.05	<0.001	0.01	<0.01	<0.01	0.041
SK-B46	7.88	306	1788	186	88	407	6.65	1.19	563	245	2.54	<0.01	<0.01	<0.003	<0.01	<0.01	0.05	<0.001	0.01	<0.01	<0.01	0.073
SK-B47	7.67	119	758	75.1	37	176	4.20	0.79	179	76.4	1.40	<0.01	0.01	<0.003	<0.01	<0.01	0.05	<0.001	0.01	<0.01	<0.01	0.016
SK-B49	7.84	135	842	85.8	50	186	1.07	0.28	214	61.0	0.15	<0.01	0.01	<0.003	<0.01	<0.01	0.10	<0.001	1.00	<0.01	<0.01	<0.01
SK-B51	7.66	294	1671	226	138	205	8.37	0.69	513	268	4.15	0.24	0.01	<0.003	<0.01	<0.01	0.06	<0.001	0.62	<0.01	<0.01	0.025

Note:
- Values indicated in **green** are less than the specified SANS 241-1:2015 limit.
- Values indicated in **yellow** exceed the specified SANS 241-1:2015 limit for operational risks.
- Values indicated in **brown** exceed the specified SANS 241-1:2015 limit for aesthetic risks.
- Values indicated in **purple** exceed the specified SANS 241-1:2015 limit for chronic health risks.
- Values indicated in **red** exceed the specified SANS 241-1:2015 limit for acute health risks.
- Values indicated in **black** do not have a specified SANS 241-1:2015 limit.
- Values indicated in grey measured below the detection limit.

7.4.7. Surface Water

Specialist consultants from Knight Piesold (Pty) Ltd were requested to conduct a detailed Surface Water Specialist Assessment in support of the proposed project.

The relevant Specialist Report is:

Bosveld Phosphates: Magnetite Waste Site Disposal Facility (MWSDF): Surface Water Specialist Report; June 2022

The information provided below represents a concise extract of the baseline description compiled for the study area.

7.4.7.1. Catchment characteristics

Bosveld Phosphates is situated within the Olifants River (B) Primary Catchment and Olifants Water Management Area and the B72K quaternary catchment. Water management on site is managed by the Olifants Catchment Management Agency.

Surface water on site drains in a westerly to south-westerly direction towards the Ga-Selati River. Down-stream from Bosveld Phosphates, the Ga-Selati River flows past Foskor and then eventually into the Olifants River. The Olifants River then flows into and through the Kruger National Park and discharges into the Limpopo River.

The quaternary catchment reference within which the site resides is B72K with total catchment area of 967 km^2 (WRC 2012). Of this total site area, the North-Western Veld Management Area which is the proposed site for the Magnetite Waste Site Disposal Facility (MWSDF) and the Pollution Control Dam (PCD) accounts for only 0.05% of the total quaternary catchment area. The Ga-Selati River is reportedly dry during the winter months and is regarded non perennial / ephemeral in nature, although a small baseflow past the site is reportedly maintained throughout the winter by discharges from sewage works at Phalaborwa, Namakgale and Makushane located further upstream in the catchment.

7.4.7.2. Site specific sub-catchments

The site-specific sub-catchments for the Bosveld Phosphates North-Western Veld Management Area are delineated in Figure 7.4.7.2(a). The public tar road on the northern side of the boundary forms a barrier against runoff through the site with runoff from the catchment North 01 being diverted around the site.

The runoff from catchment North 02 naturally flows away from the proposed MWSDF due to the gradual slope of the topography in that area. The existing storm water berm protects any contributing runoff from catchments South 01 and South 02 from entering the dirty water catchment of Impounding Dam 02.

Clean water diversion embankments are envisaged along the Northern perimeter of the MWSDF to guide clean water runoff away from the MWSDF and PCD draining naturally to the Ga-Selati.

The dirty water catchment for the proposed MWSDF encompasses the full surface area of the MWSDF together with a 5m wide perimeter around the MWSDF to incorporate runoff from the drainage channels and access roads. The dirty water catchment fully reports to the PCD on the southern side of the site.

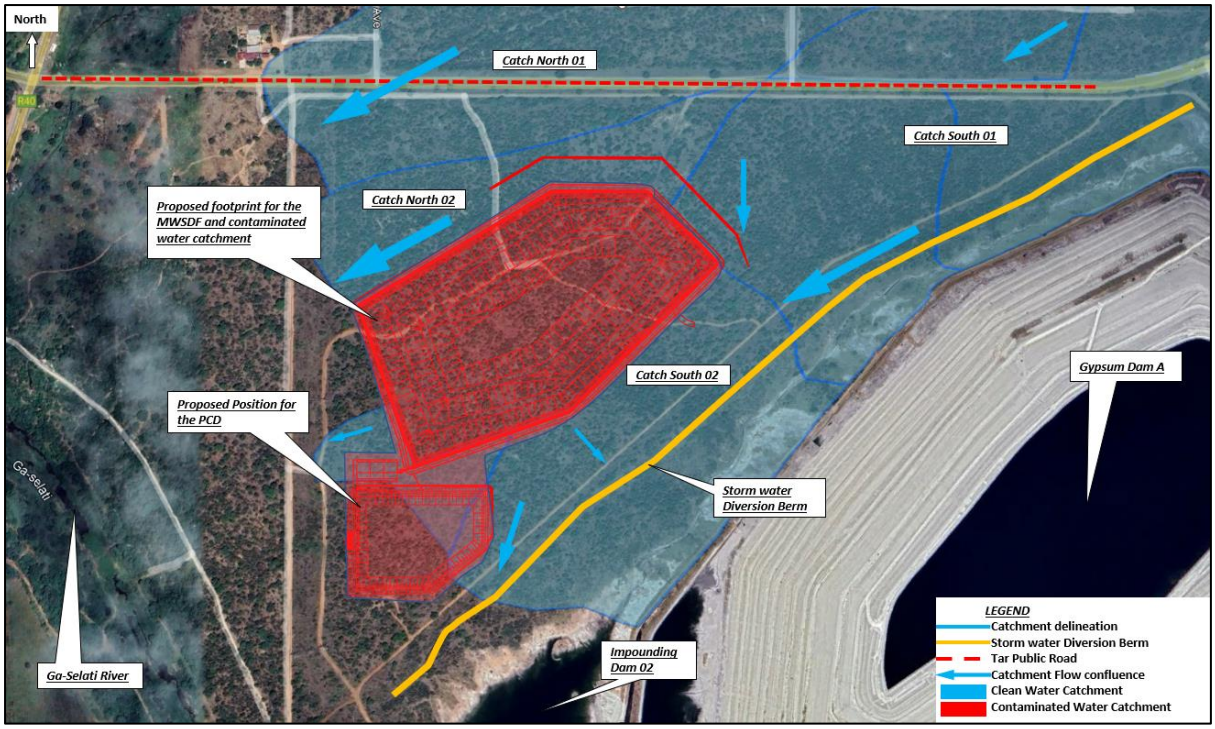


Figure 7.4.7.2(a): Site Specific sub-catchments

7.4.7.3. Existing storm water infrastructure

There is currently no existing infrastructure specifically used for surface water management with respect to the MWSDF site other than the existing stormwater berm along the toe of the Gypsum Dam A to protect any stormwater runoff from the North-Western Veld Management Area from entering the dirty water catchment of Impounding Dam 02. Any current clean water runoff from the site discharges naturally into the Ga-Selati river.

7.4.7.4. Water Regulating Authorities

The 1998 National Water Act clause 19 addresses prevention and remedying effects of pollution and requires that a land owner/occupier/user on which an activity or situation exists, which causes/has caused/or is likely to cause pollution of a water resource "must take all reasonable measures to prevent any such pollution from occurring, continuing or recurring".

The reasonable measures addressed in subsection 19 (2) include complying with any prescribed waste standard or management practice amongst other options of containing and remediating effects. To ensure compliance, the production plant is required to comply with the following norms and standards listed in Table 7.4.7.4(a).

Government Notice (GN) of 1999, on the minimum requirements for mine waste, regulates the discharge of dirty water systems into clean water systems. Based on these regulations, dirty water systems should be designed, constructed and maintained not to spill more than once in 50 years.

Table 7.4.7.4(a): Government Regulations

Act / Government Notice / Policy	Relevant Section(s)/ Regulations
National Water Act, 1998 (Act 36 of 1998)	19; 20; 21; 22; 23; 26; 27; 28; 29; 30; 31; 36; 39; 40 – 48; 49 – 52; 117 – 123; 145; 151 and 154
GN 704 of June 1999 Regulations on use of water for mining and related activities aimed at the protection of water resources	4; 5; 6; 7; 8; 12
GN R991 of May 1984	
The Dam Safety Regulations GN R139 of 24 February 2012	
Environment Conservation Act, 1989 (Act 73 of 1989)	20 (1); 21 and 22
GN R992 of 26 June 1970	2.10.14; 2.14.3; 5.1.1; 5.1.2; 5.5; 5.6.1; 5.6.2; 5.6.3; 5.9.1; 5.9.2 and 5.14.3
National Environmental Management (Act 107, 1998)	23; 24; 28; 30; 31; 32; 33 and 34
National Environmental Management Waste Act Regulations of 23 August 2013 on Classification, norms and standards – R636 Clause 3.1 and 3.2	
The Dam Safety Regulations (published in Government Notice R1560 of 25 July 1986)	

7.4.7.5. Receiving Water Body

The current Northwestern Veld Management area is undeveloped with only natural bush and trees occupying the site. All surface water on site within this catchment area is considered to be clean and uncontaminated and drains naturally via a sheet-wash in a westerly to south-westerly direction towards the Ga-Selati River.

The Ga-Selati River flows along the south-western border of the site in a south-easterly direction into the Olifants River which flows eastward through the Kruger National Park (KNP), through Mozambique and into the Indian Ocean.

The Ga-Selati is a perennial river and considered a type "C" channel according to the channel classification proposed by van Deventer, Teixeira-Leite & Macfarlane (2014) (Table 7.4.10.1(a) below). The river is characterised by a predominantly sandy, alluvial bed with occasional rock outcrops. A narrow active channel occurs within a large macro-channel, with the active channel mostly lined by dense stands of *Phragmites mauritianus*. Slow flowing, deeper pools are interspersed by shallow faster flowing sections with occasional rifles. Sand mining occurs in numerous locations along the river and discharges from sewage works at Phalaborwa, Namakgale and Makushane located further upstream in the catchment.

The design for the MWSDF and PCD will be such that it complies with the regulations as stipulated above.

7.4.7.6. Mean Annual Runoff (MAR)

The gross mean annual runoff (MAR) for quaternary sub-catchment B72K (in which the site area lies) is quoted in WR2012 as 8.91 million m^3. Average monthly runoff recorded in quaternary catchment B72K, over 84 years, was used to indicate the expected runoff volume from the site catchments draining into the Ga-Selati. The expected runoff was determined using area reduction for a wet climatic year (80th percentile), average climatic year (50th percentile) and a dry climatic year (20th percentile). The average monthly runoff volumes are summarized in Table 7.4.7.6(a) below.

The results suggest that a fraction of rainfall volume can be expected as runoff. The monthly runoff volumes vary with corresponding peaks in precipitation during the wet season (early December to April) and troughs during the dry season.

An average of 11 333 m^3 of rainfall can be expected as runoff per month on a wet rain year which equates to a net contribution of 0.13 % to the MAR of the B72K quaternary catchment area.

Table 7.4.7.6(a): Computed MAR reporting to Point 1 compared with reported MAR for quaternary sub-catchment B72K

	Area (km^2)	MAR (m^3)	% MAR to B72K
Dry (20th percentile) runoff site	0.48	303	0.0034
Average (50th percentile) runoff site	0.48	890	0.01
Wet (95th percentile) runoff site	0.48	11 333	0.13
Quaternary sub-catchment B72K	967*	8.91 million*	100

* WR2012 published values

Table 7.4.7.6(b) is summarised from the water balance to indicate the annual dirty water runoff from the MWSDF contaminated area for an average climatic year (50th percentile), a dry climatic year (20th percentile), and a wet climatic year (95th percentile). The runoff generated from the MWSDF is contained in the PCD with return water pumping back to the process plant. The results exclude the volume contained from the self-catchment area of the PCD itself.

Table 7.4.7.6(b): Annual Runoff Generated From WDF (dirty water catchment)

Climatic year	Volume (m^3/year)
Dry Weather Runoff	14 236
Average Weather Runoff	28 984
Wet Weather Runoff	94 060

7.4.7.7. Average Dry Weather Flows

An accepted definition of the dry weather flow in a stream is that flow in the stream that is equalled or exceeded for 70% of the time, a value which can readily be ascertained from an analysis of the flow-duration relationship. However, the Northwestern management veld area does not have any perennial or non-perennial tributaries or streams that traverse the site for which the average dry weather flows are to be analysed.

The Ga-Selati River that runs adjacent to the site and is the receiving water body which is reportedly dry during the winter months and is regarded non perennial / ephemeral in nature, although a small baseflow past the site is reportedly maintained throughout the winter by discharges from sewage works at Phalaborwa, Namakgale and Makushane located further upstream in the catchment.

7.4.7.8. Flood Peaks and Volumes

Peak flows were computed at four nodes/points of interest for which catchment areas were delineated as per Figure 7.4.7.2(a). These were located for the clean water runoffs for catchments North 02, South 01 and South 02 and for the contaminated water catchment of the MWSDF.

Catchment areas and slopes were determined from the aerial images and LiDAR survey as supplied by the Client. There are a multitude of methods available for the determination of peak flows. The applicability of each method largely depends on the catchment area, as well as the region in which the peak flow is being determined.

The methods used in this study were the Rational method. The peak flows calculated were evaluated for each node. The estimated peak flows for the 1:50, 1:100 year and 1:200-year recurrence interval, for each node, together with the catchment parameters, are presented in Table 7.4.7.8(a). Note that these represent the expected peak flows post to the development of the MWSDF and PCD. The facility is designed specifically to comply with GN704, where the facility is not likely to spill more than once in 50 years.

Table 7.4.7.8(a): Peak Flows determined for catchments within the site

Catchment	Area (km^2)	Catchment coefficient	Recurrence Interval	Flood Peaks (m^3/s)
Clean Water				
Catch North 02	0.14	0.357	50 year	3.3
			100 year	4.6
Catch South 01	0.3	0.357	50 year	7
			100 year	9.7
Catch South 02	0.08	0.357	50 year	1.9
			100 year	2.6
Contaminated Water				
WDF catchment only	0.12	0.6	50 year	4.8
			100 year	6.7

Contaminated runoff volumes only for the contaminated catchment area of the PCD for the various return periods and provided in Table 7.4.7.8(b).

Table 7.4.7.8(b): Runoff Volumes for Various Return Period Storms (m^3/day)

Duration (days)	50-year	100-year
1	12 479	14 325
3	19 791	23 115
7	20 825	24 149

7.4.7.9. Floodlines

As stated under section 7.4.7.7 above, the Northwestern management veld area does not have any perennial or non-perennial tributaries or streams that traverse the site for which the floodlines for the various storm recurrence intervals are needed to be analysed.

Figure 7.4.7.9(a) indicates the floodlines for the receiving Ga-Selati river over the section bounded by the site.

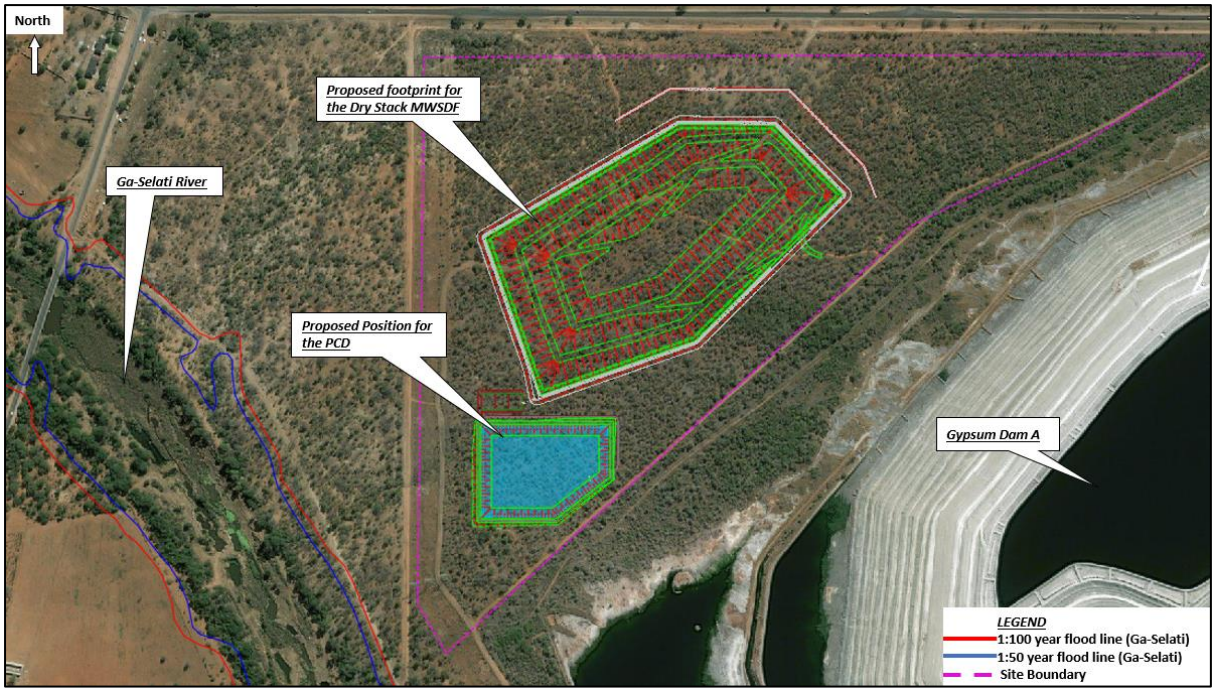


Figure 7.4.7.9(a): Ga-Selati Floodlines adjacent to site

7.4.7.10. Watercourse Alterations

Figure 7.4.7.10(a) below indicates the identified minor drainage lines that are located within the proposed site boundary.

The drainage lines can be classified as dry and non-perennial with no associated wetlands or riparian habitats.

Stormwater runoff from the contaminated catchment area will be collected and directed away from these identified drainage lines.

The proposed new infrastructure will have no impact on these minor drainage lines hence this project will not require any watercourse alterations and will not form part of the scope of work for this project.

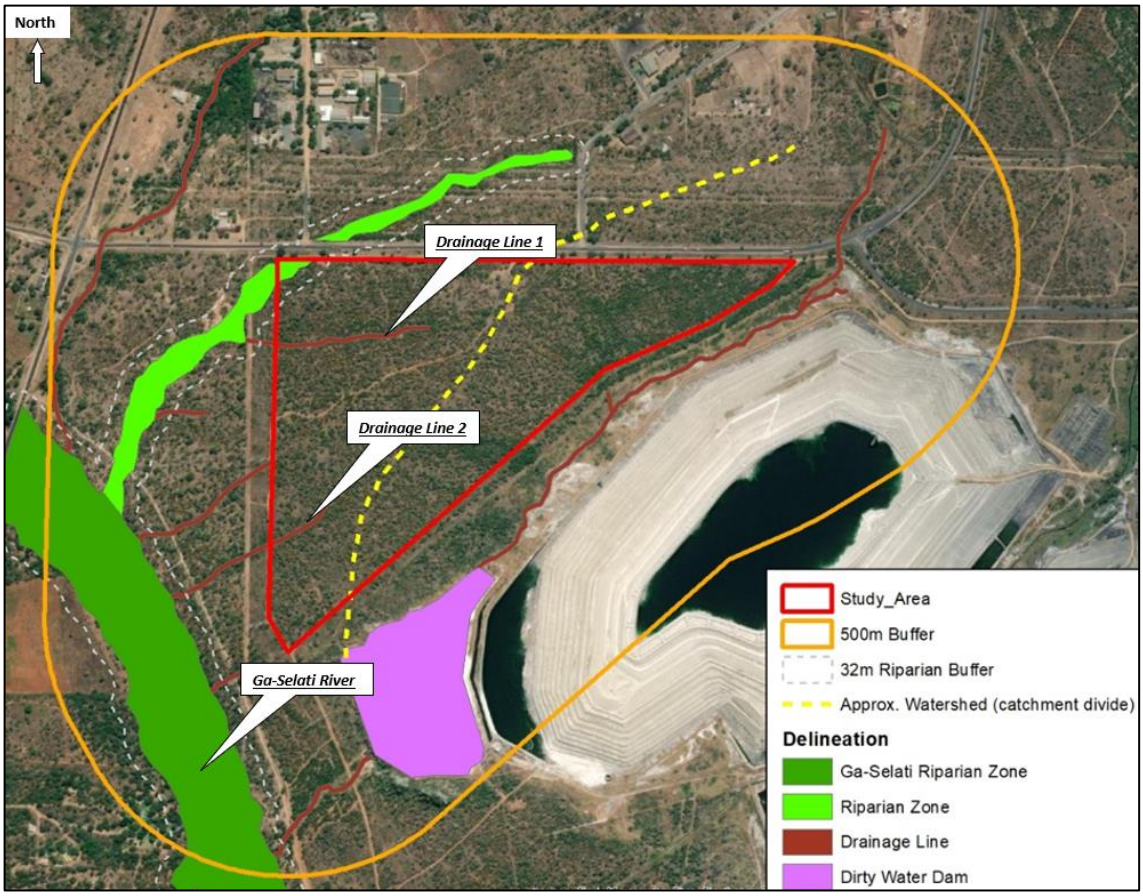


Figure 7.4.7.10(a): Drainage lines within the site boundary

7.4.7.11. Surface Water Use

The Ga-Selati River and its catchment are characterized by the demands for water by a large and poor rural population; by intensive irrigated agriculture; by the need for maintenance of river flows through private game reserves and the Kruger National Park for ecological and aesthetic reasons; and for improving the water quality of seepage and runoff from mines within the area.

The Lepelle Northern Water body extracts water from the Olifants River at the Phalaborwa barrage, upstream of the confluence of the Selati and Olifants Rivers. Water is sold by the Municipality to Phalaborwa, Namakgale and Lulekani residents.

7.4.7.12. Drainage Density

As previously stated, the Northwestern management veld area does not have any perennial tributaries or streams that traverse the site . Two minor drainage non-perennial segments have been identified with the site boundary, as indicated on Figure 7.4.7.10(a). The total length of the identified drainage lines approximates to 0.5 km. The calculation for the drainage density of the sub-catchments is 1km/km^2.

7.4.7.13. Climatic Water Balance

The Climatic Water Balance (B) in mm is calculated using only two components, namely Rainfall (R) in mm and Evaporation (E) in mm (S-pan x 0,88) and is defined by B = R – E. The value of B is calculated for the wettest six-month period of the year on record. E is thus the evaporation from a soil surface over the corresponding period for which R was calculated.

However, the historical evaporation record was not available therefore the average evaporation record was used as a constant over the 20 wettest years. The value is recalculated for successively drier years to establish whether B is positive for more or less than 20% of the time for which data is available.

During the period of consideration there were only two events that resulted in positive B-values for the site. See Table 7.4.7.13(a). The value for B has been consistently calculated as negative and the site therefore falls within an area that may have at least a seasonal water deficit under extreme conditions.

The calculation is conservative as it ignores run-off and thus assumes that all precipitation will infiltrate. The calculation also ignores the moisture storage capacity of the waste body or the cover.

Table 7.4.7.13(a): Climatic Water Balance (mm)

Year	R (mm)	E (mm)	B (mm)
1999	1038	734	304
1938	738	734	4
1995	566	734	-168
1924	610	734	-124
1984	627	734	-107
1952	616	734	-117
1936	661	734	-73
1966	562	734	-172
1975	588	734	-146
1922	617	734	-117
1971	594	734	-139
1920	607	734	-127
1977	573	734	-161
1960	535	734	-199
1968	577	734	-157
1955	577	734	-157
1941	540	734	-194
1954	566	734	-168
1957	571	734	-163
1980	577	734	-157

7.4.7.14. Surface Water Quality

A detailed Annual Water Monitoring Report for 2020/2021 had been undertaken by Golder Associates Africa for the full Bosveld Phosphates site. This section provides the summarised results extracted from the Golder report particularly for the surface water quality variables and limits.

Figure 7.4.7.14(a) provides a detailed layout for the locations of all the water quality sampling points at Bosveld Phosphates.

With respect to the surface water monitoring within the Northwestern open veld management area, position REM-R1 and REM-R2 are highlighted on Figure 7.4.7.14(a).

These positions relate to the Receiving Surface Water Resource of the Ga-Selati monitoring localities.

Table 7.4.7.14(a) provides the description and GPS coordinates for these specific locations.

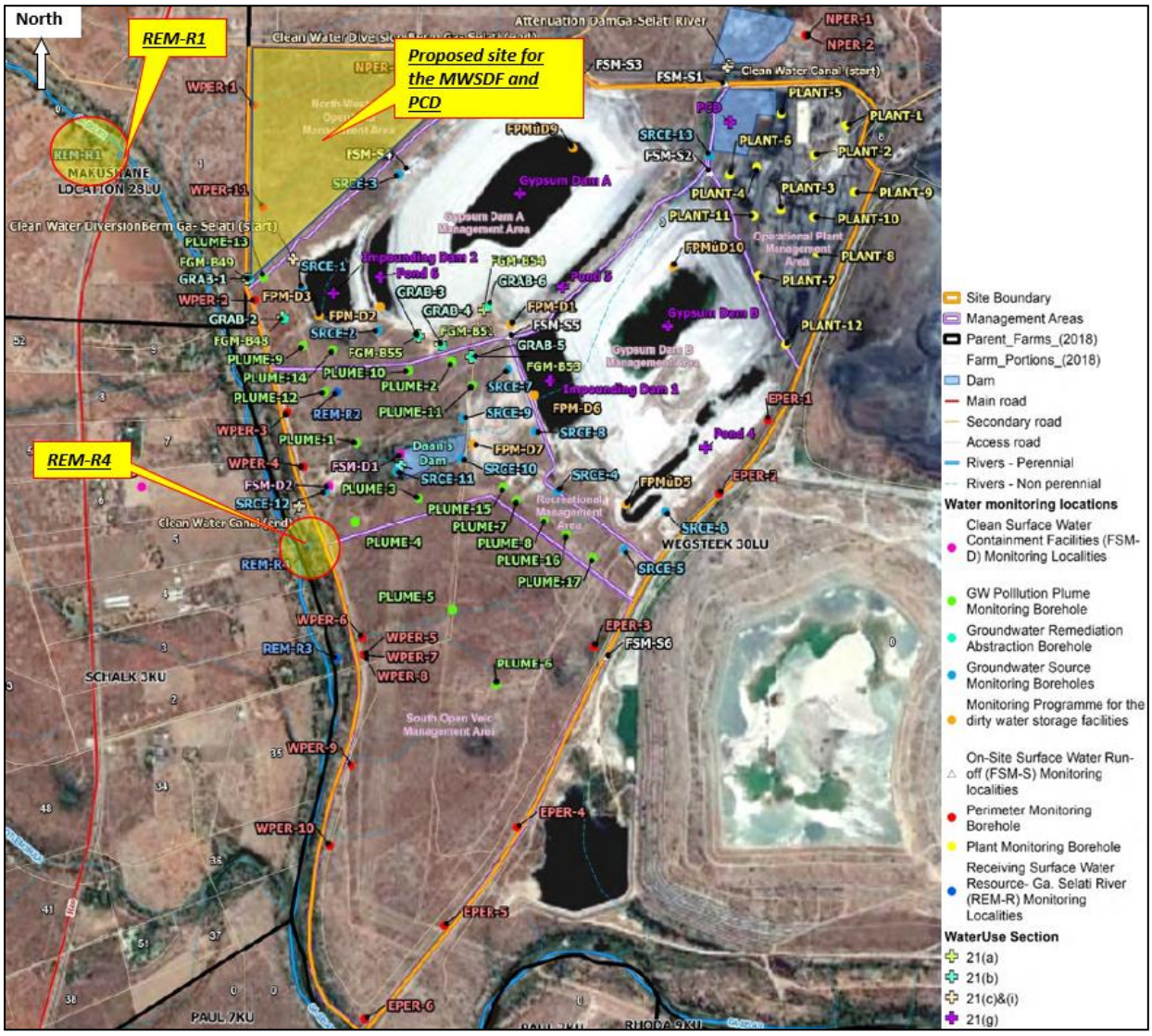


Figure 7.4.7.14(a): Water quality sampling points at Bosveld Phosphates

Table 7.4.7.14(a): GPS locations for sampling points on the Ga-Selati River at Bosveld Phosphates

Site No.	Description	Latitude (WGS84)	Longitude (WGS84)
REM-R1	Ga-Selati River Upstream from Bosveld Phosphates	23° 58'39.30" S	31° 04'25.10" E
REM-R4	Ga-Selati River downstream from Bosveld phosphates	23° 00'31.60" S	31° 04'53.60" E

7.4.7.15. Surface Water Quality Limits

The following tables were extracted from the Annual Water Monitoring Report for 2020/2021.

While there are no WUL limits specified for the upstream and downstream comparison of the impact of Bosveld, the Department of Water and Sanitation has determined water quality planning limits (WQPL) (DWS, 2018) which are used for comparison as well as the proposed classes and resource quality objectives of water resources for the Olifants catchment in terms of Government Notice (GN) No. 39943, 22 April 2016 (GN 39943).

The following WQPL limits are used (Table 7.4.7.15(a) and (b)).

Table 7.4.7.15(a): Water Quality Planning Limits (WQPL) (DWS, 2018)

Variable	Unit	Limits
pH		6.5 - 8.6
Electrical Conductivity (EC)	mSm	90
Total Dissolved Solids (TDS)	mg/L	500
Calcium (Ca)	mg/L	120
Sodium (Na)	mg/L	70
Magnesium (Mg)	mg/L	70
Potassium (K)	mg/L	30
Chloride (Cl)	mg/L	180
Sulphate (SO4)	mg/L	400
Nitrates (NO3-N)	mg/L	0.7
Fluoride (F)	mg/L	1.5
Aluminium (Al)	mg/L	0.01
Iron (Fe)	mg/L	0.1
Ortho-phosphate (PO4-3)	mg/L	0.3
Dissolved Oxygen (DO)	mg/L	9

Storm water quality variables and limits

Table 7.4.7.15(b): Quality Limits of Storm Water flowing into the Selati River from Bosveld Phosphates

Variable	Units	Quality of unpolluted storm water flowing into the Selati River from Bosveld Phosphates	10% increase in quality of storm water flowing into the Selati River from Bosveld Phosphates
pH		6.8 - 8	7.48 – 8.8
Electrical Conductivity	mS/m	10	11
Ortho-phosphate	mg/ℓ	0.05	0.055
Magnesium	mg/ℓ	10	11
Sodium	mg/ℓ	10	11
Nitrate	mg/ℓ	0.5	0.55
Calcium	mg/ℓ	10	11
Chloride	mg/ℓ	15	16.5
Sulphate	mg/ℓ	15	16.5
Fluoride	mg/ℓ	0.5	0.55

7.4.7.16. Surface Water Quality Analysis

The water quality results summary for monitoring points REM-R1 (Ga-Selati upstream from Bosveld Phosphates) and REM-R4 (Ga-Selati River downstream from Bosveld Phosphates) is presented below.

It must be noted that these results depict pre-development of the northwestern open veld management area for the proposed MWSDF and PCD.

These results were extracted verbatim from the Annual Water Monitoring Report for 2020/2021. All limits for this facility are compared either against the WQPL:2018 or the Olifants GN 39943 limits (whichever is the greatest).

The following is summarised:

- pH: Increase from 7.6 to 7.8 at the upstream and downstream points – within limits of 6.5 – 8.6;
- Electrical Conductivity (mS/m): Increase from 132 to 143 at the downstream monitoring point – above limit of 90;
- TDS (mg/L): Limit of 769 to 839 at the downstream monitoring point – above limit of 500;
- Calcium (mg/L): Increase from 51 to 54 at the downstream monitoring point – below limit of 120;
- Sodium (mg/L): Increase from 155 to 164 at the downstream monitoring point – above limit of 70;
- Magnesium (mg/L): Increase from 54 to 61 at the downstream monitoring point – below limit of 70;
- Potassium (mg/L): Same limit of 11 at the upstream and downstream point – within limit of 30;
- Chloride (mg/L): Increase from 179 to 193 at the downstream monitoring point – downstream point above limit of 180;
- Sulphate (mg/L): Increase from 80 to 123 at the downstream monitoring point – below limit of 400;

- Nitrate (mg/L): Decrease from 3.8 to 3.4 at the downstream monitoring point – above limit of 0.7;
- Fluoride (mg/L): Decrease from 0.6 and 0.4 at the downstream monitoring point – below limit of 1.5;
- Aluminium (mg/L): Same limit of 0.1 at the upstream and downstream point – above limit of 0.01;
- Iron (mg/L): Same limit of 0.1 at the upstream and downstream point – below limit of 0.1;
- Ortho-Phosphate (mg/L): Decrease from 5.1 to 2.6 at the downstream monitoring point – above limit of 0.3; and
- Dissolved Oxygen (mg O2/L): Increase from 6.6 to 6.7 at the downstream monitoring point – below limit of 9.

It can be noted that the Electrical Conductivity, Sodium, Chloride, Nitrate, Aluminium and Ortho-Phosphate levels are above the limits prior to any site development of the north western open veld management area.

7.4.7.17. Storm Water Management

Regulation GN704 of the National Water Act (36 of 1998) necessitates the collection and containment of dirty water in a system, separate from all clean water systems.

The proposed position of the MWSDF and the PCD is such to maintain only a contaminated catchment surrounding these facilities and to maintain the clean natural drainage paths of the area towards the Ga-Selati River. The MWSDF will be protected by diversion berms on the northern side to deflect any potential surface water runoff away from the MWSDF to avoid being contaminated.

The contaminated water catchment of the MWSDF and perimeter will be collected in concrete lined open trapezoidal channels collecting runoff from the MWSDF sloping embankments. These channels will lead to a silt trap that would settle any potential sediments before conveying the contaminated water into a PCD with return water pumping to the plant process.

The system will rely on there being adequate abstraction from the PCD to maintain a pond level that can provide adequate storage for storm events. The only abstractions envisaged from the PCD are for return water pumping back to the plant. Since the PCD will contain contaminated water, the usage for dust suppression will not be advisable since it would have a potential to contaminate ground water.

The PCD is sized to contain the 1:50 storm event without spilling into the environment. The PCD will have an emergency uncontrolled overflow weir spillway. The total volume of the PCD is 57 346 m^3 to a depth of 4.0 m.

7.4.7.18. Water Balance

Figure 7.4.7.18(a) provides the process flow diagram for the MWSDF and the PCD. As the MWSDF is intended to be a dry stack, any moisture in the material is assumed to be lost to interstitial lockup.

Precipitation events will result predominantly in runoff, with a small fraction infiltrating the MWSDF. This infiltration is assumed to be fully recovered by the drainage system, whereby it is drained into the solution trenches.

The solution trenches receive inflows via direct precipitation, infiltration and runoff from the MWSDF. The PCD receives water from direct precipitation and runoff from the catchment between the MWSDF and the PCD basin. Outflows from the PCD are from evaporation, abstraction, and an emergency spillway should a storm event greater than 1:50 years be experienced.

For an average climatic year, in order to maintain a PCD pool depth of 1.7 m, a minimum 80 m^3/day of pumping abstraction would be required during the rainy season from February to June. For a wet climatic year, in order to maintain a PCD pool depth of 2.6 m, a minimum 200 m^3/day of pumping abstraction would be required over the months from November to July.

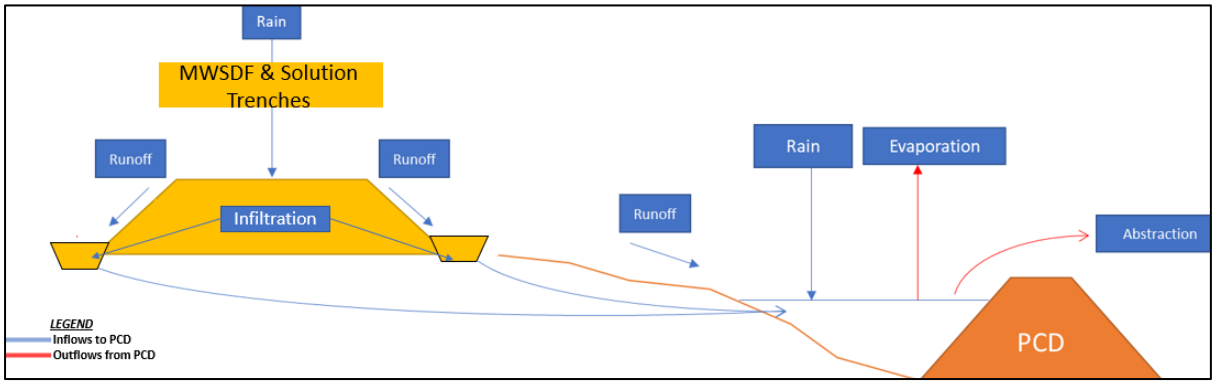


Figure 7.4.7.18(a): MWSDF and PCD Process Flow Schematic

Figure 7.4.7.18(b) to Figure 7.4.7.18(d) show the annual flows for average climatic conditions, a statistically wet year, and a statistically dry year. The system is sensitive to the target abstraction rate, but it is clear that for the combinations tested, the system is capable of containing the dirty water without experiencing spill events.

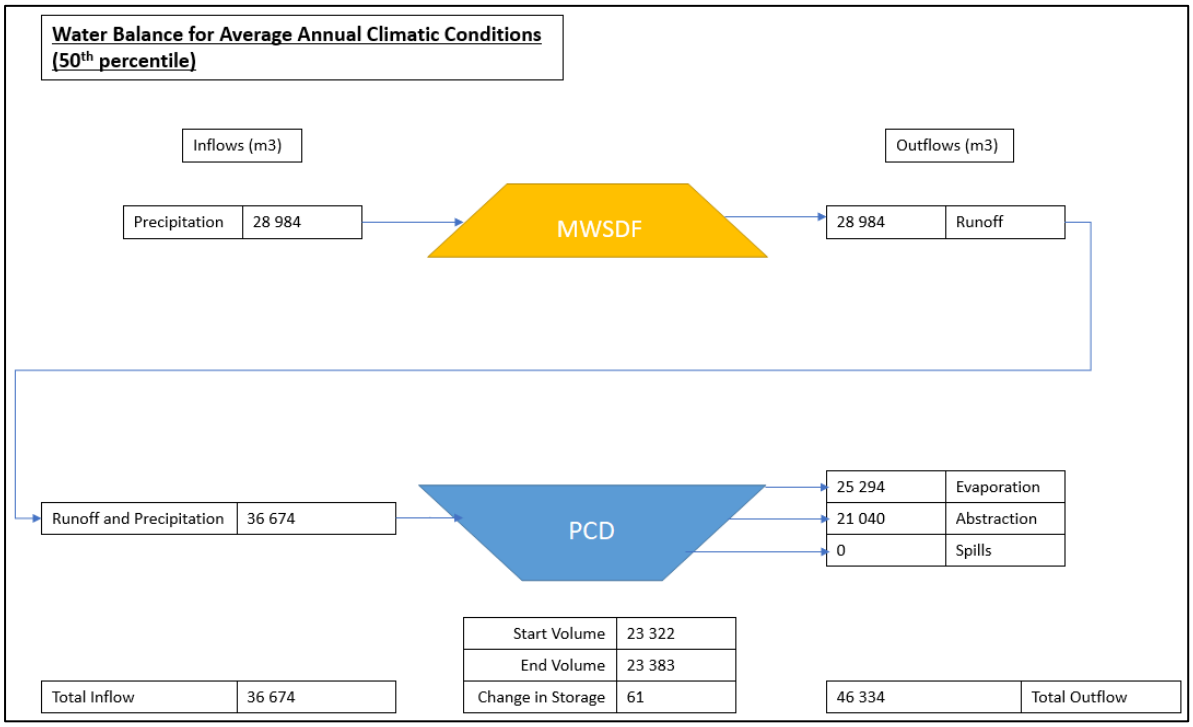


Figure 7.4.7.18(b): Water balance for Average Annual Climatic Condition (50th Percentile)

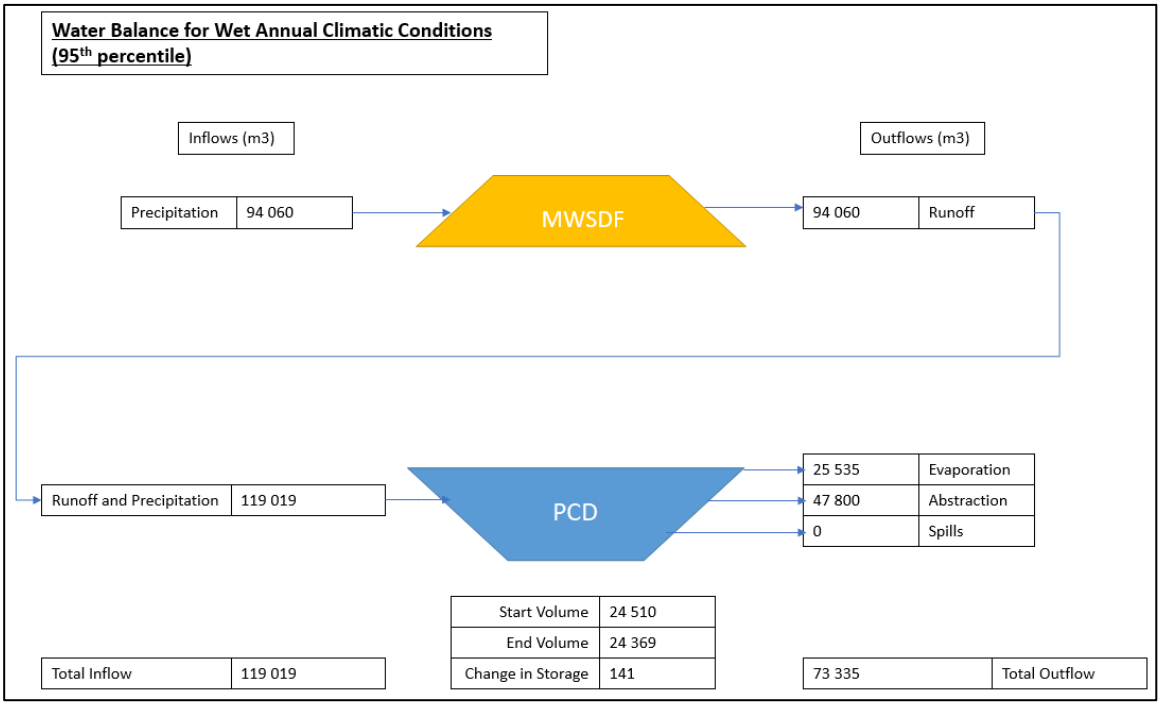


Figure 7.4.7.18(c): Water balance for Wet Annual Climatic Condition (95th Percentile)

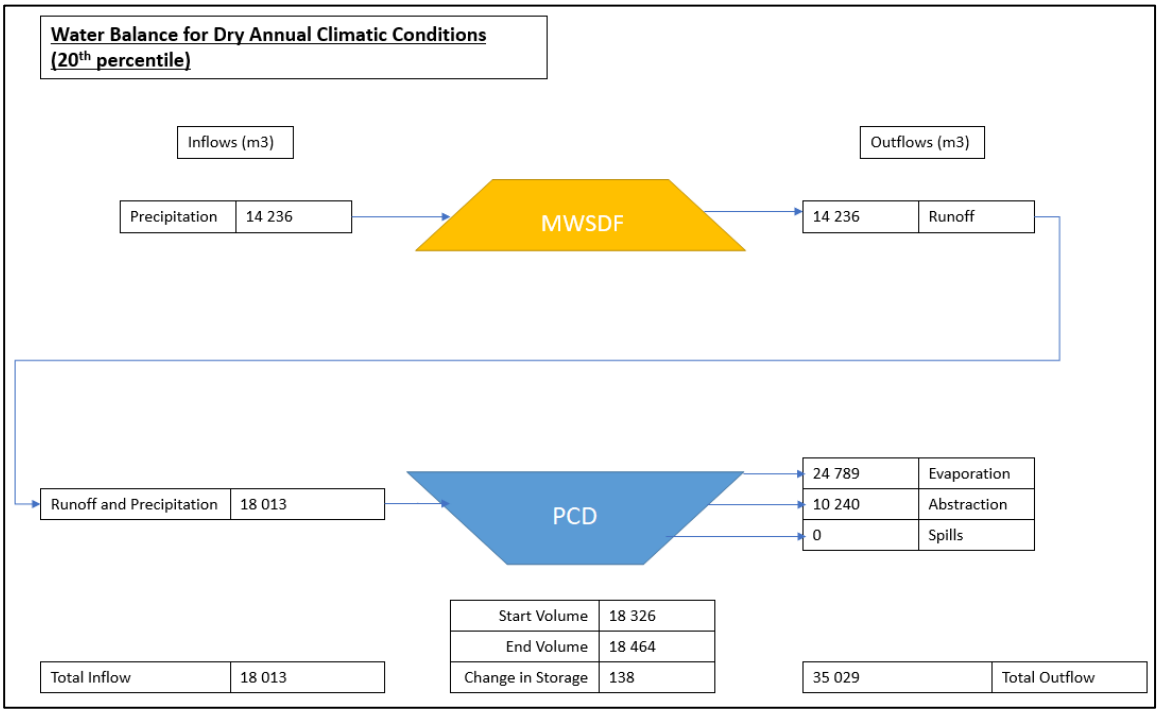


Figure 7.4.7.18(d): Water balance for Dry Annual Climatic Condition (20th Percentile)

7.4.8. Terrestrial Ecology (Plant and Animal Life)

Hawkhead Consulting's Specialist Consultant was requested to conduct a detailed Terrestrial Ecology (Plant and Animal Life) Assessment in support of the proposed project.

The relevant Specialist Report is:

Terrestrial Ecology Assessment for the Proposed Bosveld Phosphates (Pty) Ltd Magnetite Landfill Facility, April 2022.

The information provided below represents a concise summary of the baseline description compiled for the study area.

7.4.8.1. Regional Plant Life (Vegetation) Characteristics

The local study area is located in the Phalaborwa-Timbavati Mopaneveld (SVmp 7) vegetation type, of the Mopane Bioregion of the savanna biome (Mucina and Rutherford, 2011) – shown in Figure 7.4.8.1(a).

The savanna biome is the largest biome in South Africa, covering approximately 35% of the country's land surface (Scholes and Walker, 1993). Savannas are characterised by a dominant grass layer, over-topped by a discontinuous, yet distinct woody plant component. Primary determinants of savanna composition, structure and functioning are; fire, a distinct seasonal climate, substrate type, and browsing and grazing by large herbivores (Scholes and Walker, 1993).

Compositionally, Africa's savannas are distinguished as either fine-leafed savannas or broad-leafed savannas. The distribution of these forms is based primarily on soil fertility (Scholes and Walker, 1993); fine-leafed savannas occur on nutrient rich soils and are dominated by microphyllous woody species of the Fabaceae family (most commonly indigenous Acacia's). These savannas have a productive and diverse herbaceous layer that is dominated by grasses, and can support large populations of mammalian herbivores (Scholes and Walker, 1993). Conversely, broad-leafed savannas usually occur on nutrient poor soils and are dominated by macrophyllous woody species from the Combretaceae family (common genera: *Combretum* and *Terminalia*). Compared to fine-leafed savannas, broad-leafed savannas are less productive and support a lower herbivore biomass (Scholes and Walker, 1993).

Phalaborwa-Timbavati Mopaneveld occurs in a band stretching about 40 km east and west of Phalaborwa. Another patch occurs south of the Olifants River, along the boundary of the Kruger National Park and the Klaserie, Timbavati and Umbabat Private Game Reserves (Mucina & Rutherford, 2011).

Vegetation is characterised by open tree savanna on undulating plains. Sandy upland areas are dominated by *Combretum apiculatum*, *Terminalia sericea* and *Colophospermum mopane*, while low-lying areas are typically characterised by the emergence of *Senegalia nigrescens* and the increased dominance of *Colophospermum mopane* (Mucina & Rutherford, 2011). The field layer is generally well-developed. In terms of geology, quartz-feldspar rocks of the Makhutsi Gneiss dominate, while soils vary from sandy soils in upland areas to clayey soils in bottomlands (Mucina & Rutherford, 2011).

Mucina & Rutherford (2011) list the following flora species as being important or characteristic taxa in the Phalaborwa-Timbavati Mopaneveld vegetation type, amongst others:

Trees: *Colophospermum mopane, Combretum apiculatum, Combretum zeyheri, Terminalia sericea, Senegalia nigrescens, Vachellia exuvialis, Vachellia tortilis, Cassia abbreviata, Dalbergia melanoxylon, Peltophorum africana, Ozoroa engleri* and *Pseudolachnostylis maprouneifolia*.

Shrubs: *Combretum hereroense, Euclea divinorum, Grewia bicolor, Maerua parvifolia, Strychnos madagascariensis, Tephrosia polystachya, Clerodendrum ternatum, Commiphora africana, Hermannia glanduligera* and *Melhania forbesii*.

Graminoids: *Digitaria eriantha, Eragrostis rigidior, Pogonarthria squarrosa, Andropogon gayanus, Aristida congesta, Melinis repens, Panicum maximum, Perotis patens, Schmidtia pappophoroides* and *Themeda triandra*.

Herbs: *Evolvulus alsinoides, Heliotropium steudneri, Hemizygia elliotii, Ipomoea magnusiana* and *Kohautia virgata*.

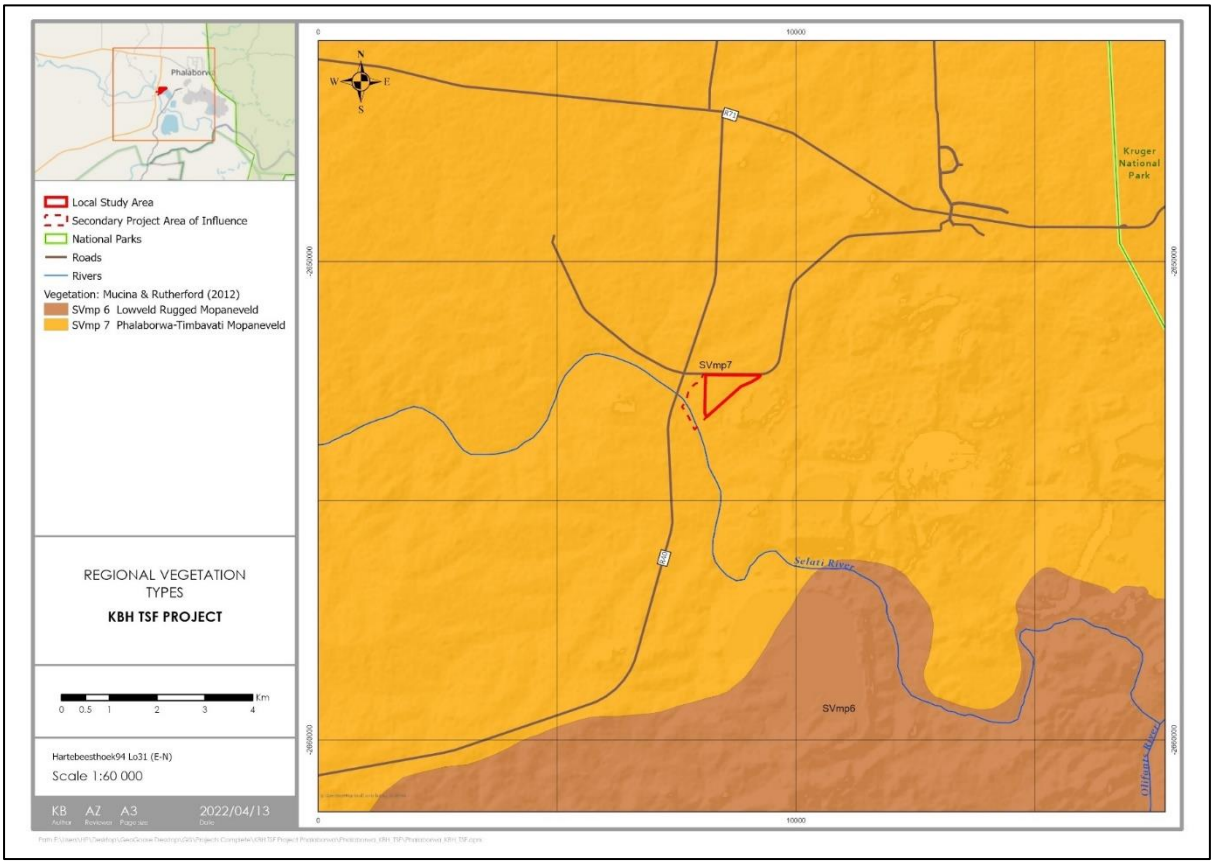


Figure 7.4.8.1(a): Local study area and secondary project area of influence (PAOI) in relation to Mucina and Rutherford's (2011) regional vegetation types.

7.4.8.2. Conservation Management Context

Nationally Threatened Ecosystems

Approximately 38% of the Phalaborwa-Timbavati Mopaneveld is formally conserved in the Kruger National Park, with smaller proportions conserved in the private game reserves bordering the park's western boundary. Accordingly, this vegetation type is considered 'well protected' on both the national and provincial protection rating levels (Desmet, et al., 2013).

Mucina & Rutherford (2011) regard this vegetation type as Least Threatened and this is reflected on the national list of threatened ecosystems (NEMBA Threatened Ecosystems, 2011), which also does not list Phalaborwa-Timbavati Mopaneveld as being a threatened ecosystem – refer to Figure 7.4.8.2(a).

Limpopo Conservation Plan

According to the Limpopo Conservation Plan (V2), the local study area is located within a network of land designated Critical Biodiversity Area 2 (CBA2) – shown in Figure 7.4.8.2(b). Land portions designated CBA2 have been selected to meet biodiversity pattern and/or ecological process targets (Desmet, et al., 2013). The assigned management objectives of CBA2 land include *inter alia*, maintenance in a natural state and minimising impact on threatened species (Desmet, et al., 2013). According to Desmet, et al., (2013), mining and industrial land uses are generally incompatible with areas designated as CBA 2, however they do indicate that certain elements of these activities may be allowed, subject to detailed impact assessment. It is noted that that the Limpopo Conservation Plan delineations are conducted at a high level, and do not necessarily account for localised sites of disturbed/secondary habitat.

Protected Areas and Conservation Areas

The local study area is embedded within a prominent wildlife conservation region of South Africa, known as the Kruger to Canyons Biosphere Reserve (SAPAD, 2021). This conservation area is 2,901,386 ha in extent and was formerly recognised as a biosphere in 2001 by UNESCO (UNESCO , 2021).

The western boundary fence of Kruger National Park is located about 8.9 km to the east of the local study area. The local study area is thus situated within the parks' 10 km buffer zone (SAPAD, 2021) (Figure 7.4.8.2(c)). Kruger National Park is a large and world-renowned protected area that is managed by the South African National Parks, and supports a high diversity of habitat types and an intact wildlife assemblage (Marnewick, et al., 2015). The Park is very important to biodiversity conservation in South Africa. Across the broader landscape, several smaller private game reserves are present, including amongst others; Solomon Private Game Reserve, Klaserie Private Game Reserve, Balule Private Game Reserve, Olifants West Private Game Reserve and Oliphants River Private Game Reserve (SAPAD, 2021) (Figure 7.4.8.4(c)).

Important Bird Areas

Kruger National Park and adjacent areas are recognised as a globally important bird area (IBA), with the following globally threatened trigger species; White-backed Vulture (*Gyps africanus*), Lappet-faced Vulture (*Torgos tracheliotos*), White-headed Vulture (*Aegypius occipitalis*), Cape Vulture (*Gyps coprotheres*), Hooded Vulture (*Necrosyrtes monachus*), Secretary bird (*Sagittarius serpentarius*), Martial Eagle (*Polemaetus bellicosus*), Kori Bustard (*Ardeotis kori*), Crowned Eagle (*Stephanoaetus coronatus*) and Bateleur (*Terathopius ecaudatus*) (Marnewick, et al., 2015). There are also numerous regionally threatened, range-restricted and biome-restricted bird species present (Marnewick, et al., 2015).

Hydrological Setting

The Ga-Selati River, which flows to the west of the local study area, joins the Olifants River downstream of the local study area before entering the Kruger National Park. This region, including the local study area, forms part of the Olifants Water Management Area and is mapped as part of the Phalaborwa Strategic Water Source Area (SWSA). In terms of the mapping data of the NFEPA, the local study area is located in a river FEPA (freshwater ecosystem priority area) (Fish FEPA) and a recognised fish sanctuary.

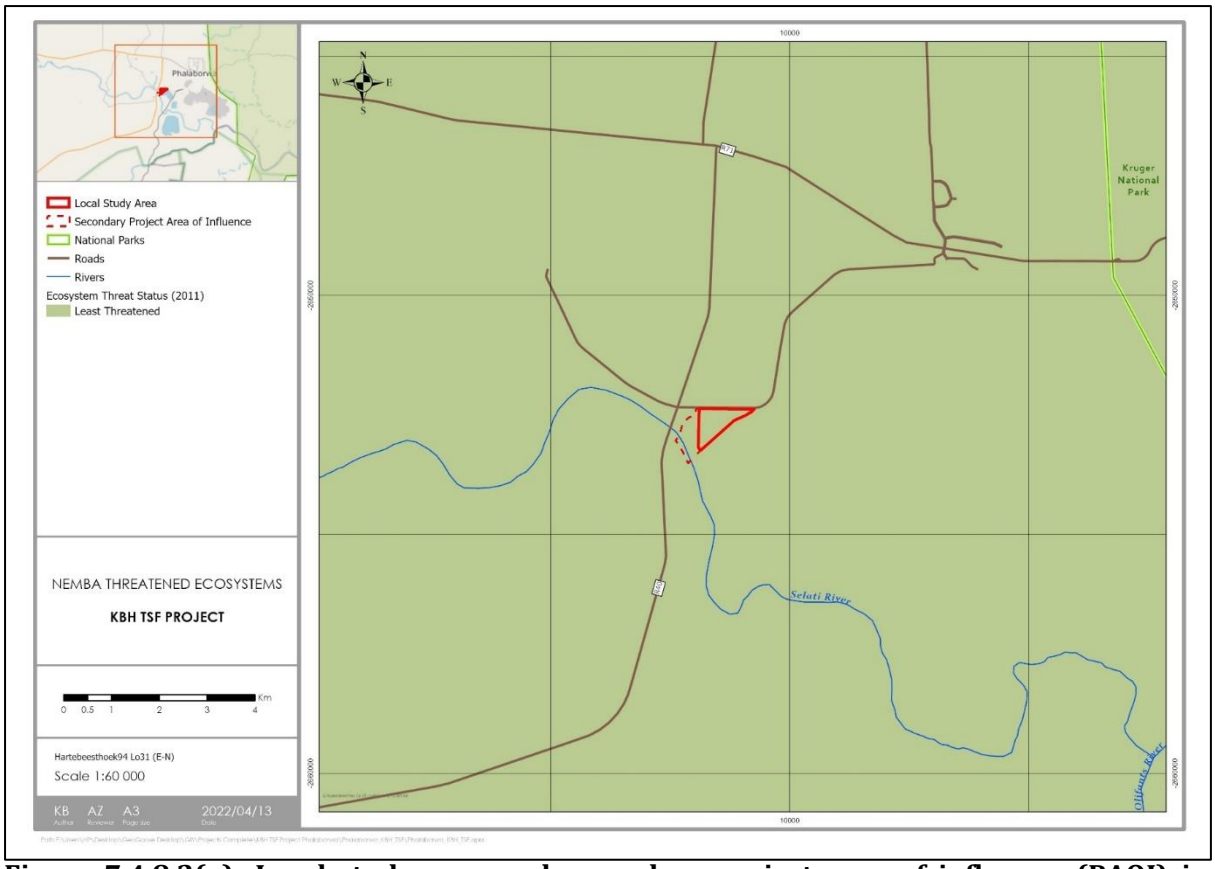


Figure 7.4.8.2(a): Local study area and secondary project area of influence (PAOI) in relation to national threatened ecosystems (2011).

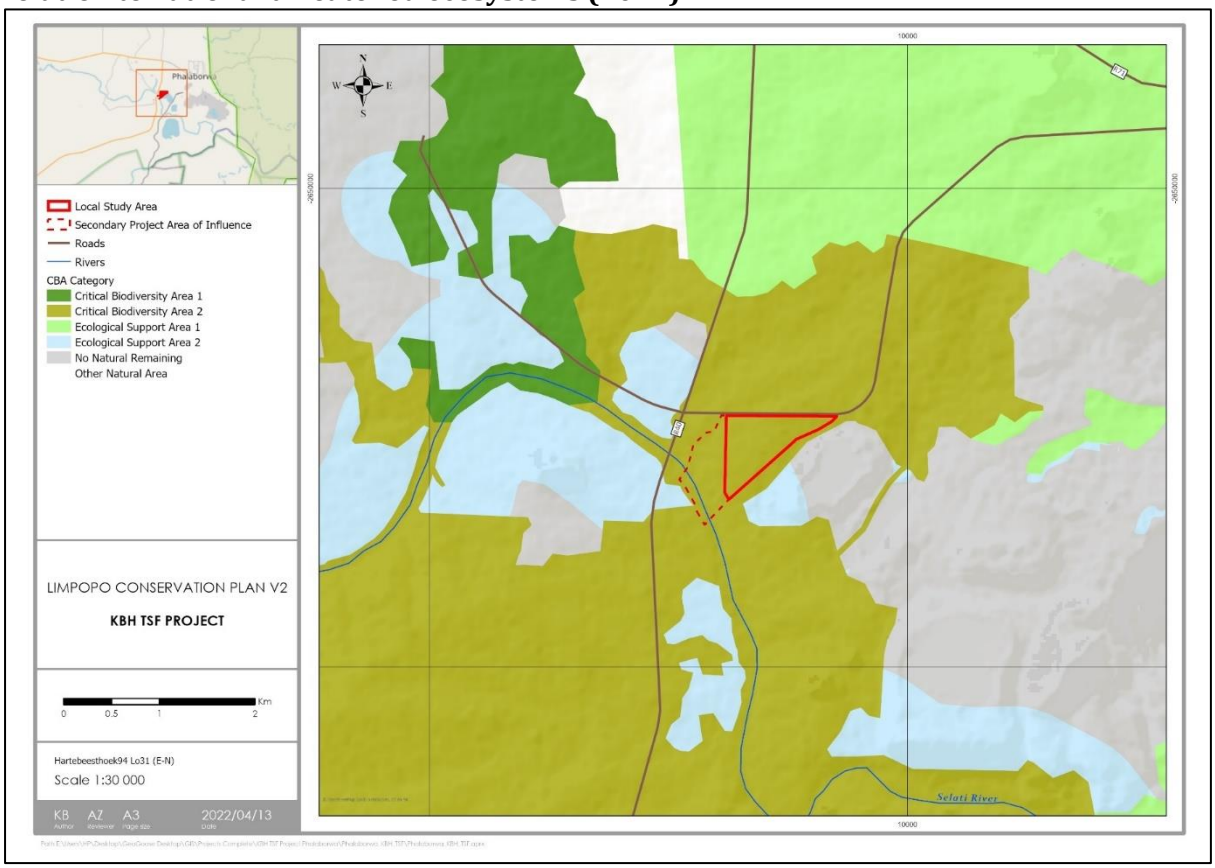


Figure 7.4.8.2(b): Limpopo Conservation Plan (2013) and the local study area and secondary project area of influence (PAOI).

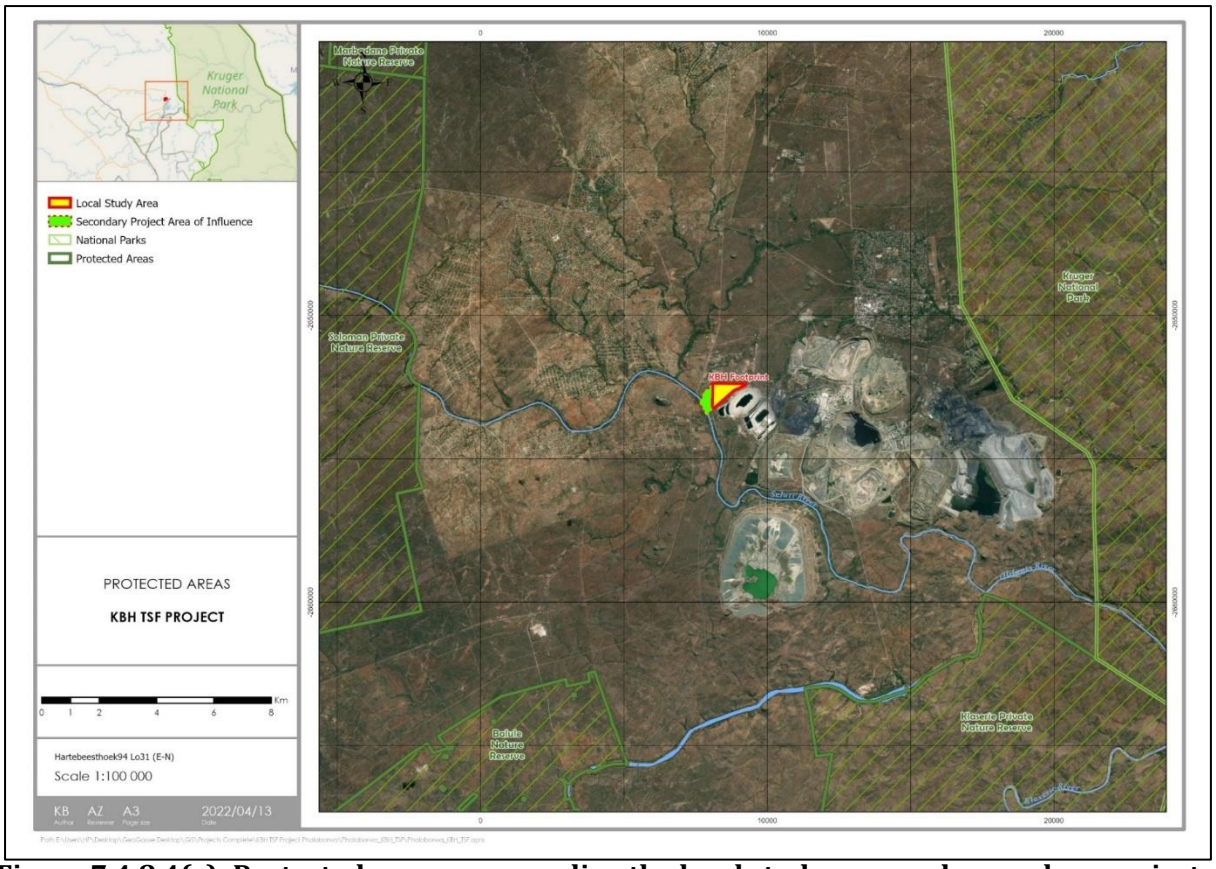


Figure 7.4.8.4(c): Protected areas surrounding the local study area and secondary project area of influence (PAOI).

7.4.8.3. Landscape Context and Existing Impacts

The following notes summarise the key features and character of the broader landscape surrounding the local study area/secondary project area of influence (PAOI), and any existing impacts or drivers of change:

- The broader landscape surrounding the local study area/secondary PAOI comprises a mosaic of natural and semi-natural habitat, and completely transformed land associated with various mining, agriculture and rural activities;
- The local study area is triangular in shape and positioned in an area of natural habitat that is partly enclosed by existing anthropogenic infrastructure and disturbances:
    - Land to the south and east of the local study area is mostly transformed and consists of tailings storage facilities associated with Bosveld Phosphates' operations;
    - Land to the immediate west of the local study area comprises an Eskom powerline servitude (which is maintained in a short, open shrubland form) and an electrified game fence (Figure 7.4.8.3(a)), beyond which lies an area of open savanna habitat and the Ga-Selati River;
    - The north of the site is bordered by a game fence and the tarred Makhushani Drive, which is an important arterial road linking the R40 provincial road to the town of Phalaborwa;
    - Important drainage features and habitats in the broader landscape include the Ga-Selati and Olifants Rivers. At its closest, the Ga-Selati River is located approximately 400 m to the west of the local study area, and flows on a north-south axis past the site. An electrified game fence is located between the Ga-Selati River and the local study area (Figure 7.4.8.3(b));

- A single small concrete water trough that is used to supply wildlife with drinking water is present in the local study area (Figure 7.4.8.3(c)). This is the only permanent water source on-site; and
- Land to the west of the Ga-Selati River is partly developed and consists of various farming operations, agricultural small holdings and the R40 provincial road. Beyond these, land is dominated by both developed land (rural residential) and undeveloped natural habitat that is under wildlife or conservation management.

Figure 7.4.8.3(a): A large Eskom powerline servitude and electrified game fence mark the western boundary of the local study area.

Figure 7.4.8.3(b): The Ga-Selati River corridor photographed upstream of the local study area from the R40 road bridge.

Figure 7.4.8.3(c): Small concrete water reservoir in the local study area is used to supply local wildlife with drinking water.

7.4.8.4. Ecological Context of the Ga-Selati River Corridor

The Ga-Selati River is located approximately 400m to the west of the local study area and has been included in the secondary PAOI based on its ecological sensitivity. Land between the river and the local study area comprises a strip of natural bushveld habitat and a belt of disturbed vegetation within the Eskom powerline servitude. The river corridor is bordered to the east by an electrified game fence and a gravel vehicle track. During the 2022 field visit, it was noted that the fence was in good condition. However, during the 2021 field visit, the fence was noted to be in various stages of disrepair as a result of elephant damage.

The river channel is characterised by open water pools, dense reedbeds of *Phragmites mauritianus,* as well as vegetated sandbanks Figure 7.4.8.3(b).

The river channel is fringed by well-developed riparian woodland. The Ga-Selati River acts as a highly functional and important ecological corridor, linking the Kruger National Park (which is an ecological source area) in the east, via the Olifants River, to areas of natural habitat across the broader landscape to the west.

The river corridor provides important habitat for fauna species that favour aquatic ecosystems (e.g., Hippopotamus *Hippopotamus amphibius*, and Sensitive species 2) or dense tall woodland vegetation (e.g., nesting raptors, Bushbuck *Tragelaphus scriptus*). Functionally, it also acts as a key resource area during the dry season and during droughts, when there is limited grazing and browsing resources available for herbivores in upland, terrestrial habitats. Natural habitat within and adjacent to the local study area forms part of the supporting/buffering habitat for the Ga-Selati River corridor system. In terms of species of conservation concern, several threatened, near and/or protected fauna and flora species occur or potentially occur in riparian habitat.

Common disturbances along the Ga-Selati River corridor include alien invasive species establishment (e.g., *Xanthium strumarium*), localised bush clearing, refuse dumping, and increased degradation, bank erosion and sedimentation caused by sand mining activities up- and downstream of the R40 bridge. Overall, however the functional integrity of the river corridor is rated very high, its conservation importance community is rated medium.

7.4.8.5. Vegetation Communities in the Local Study Area

This section presents descriptions of the vegetation communities identified within the local study area, and which are likely to be directly impacted by the proposed project activities.

Based on diagnostic woody species, vegetation structure and position in the landscape, one broad vegetation community, and one disturbed vegetation community were identified during the field visit. The natural vegetation community is *Colophospermum mopane – Combretum apiculatum* Bushveld, while the disturbed vegetation community is referred to as *Dichrostachys cinerea* Secondary Bushveld and occurs at an old borrow pit site.

A description of each community, along with representative photographs is presented in the sections below. A vegetation map of the local study area is shown Figure 7.4.8.5(a).

Colophospermum mopane – Combretum apiculatum Bushveld
Colophospermum mopane – Combretum apiculatum Bushveld is the dominant vegetation community in the local study area (approximately 45.58 ha, or 93% of the site), and is consistent with the Phalaborwa-Timbavati Mopaneveld vegetation type described by Mucina and Rutherford (2011).

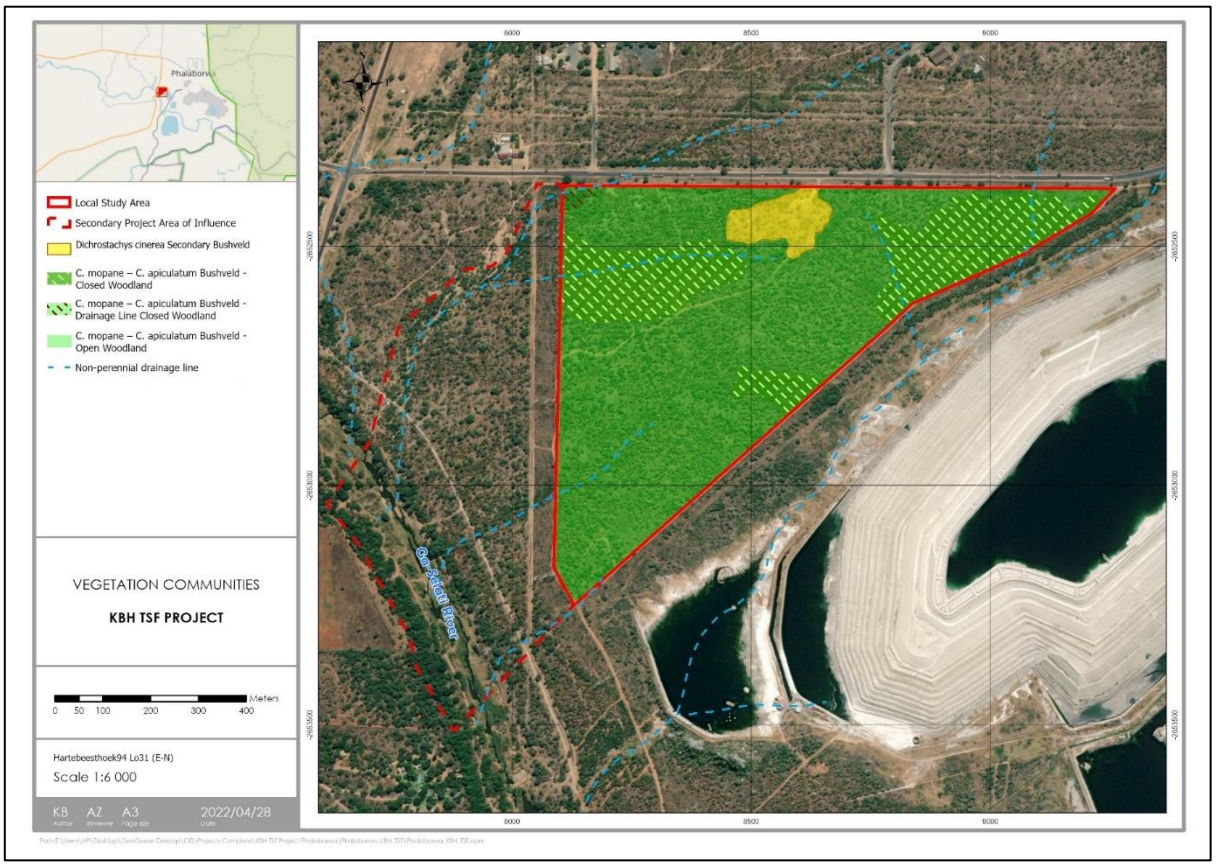


Figure 7.4.8.5(a): Map of vegetation communities identified in the local study area.

Vegetation structure is variable, and in line with Edwards (1983) structural classification, includes two main variations; a short-open woodland variation and a short-closed woodland variation. These structural variations are also associated with changes in the dominant woody species, which is likely linked to changes in soil characteristics (sandy vs loan and clay soils). *Combretum apiculatum* is generally more dominant in areas of open woodland (Figure 7.4.8.5(b)), while *Colophospermum mopane* is particularly dominant in areas of closed woodland (Figure 7.4.8.5(c)).

Figure 7.4.8.5(b): Open area of *Colophospermum mopane – Combretum apiculatum* Bushveld.

Figure 7.4.8.5(c): Semi-closed bushveld dominated by *Colophospermum mopane.*

Both variations of this broad community are characterised by defined lower and upper woody strata, which have similar species assemblages that are typically dominated by broad-leaf species, although fine-leaf species are also present. In terms of species composition, 102 flora species were recorded in this community.

Common woody species in the upper stratum (>5m) typically include *Colophospermum mopane, Combretum apiculatum, Combretum imberbe, Sclerocarya birrea* subsp. *caffra* and *Senegalia nigrescens*. Woody species prevalent in the lower woody stratum include *inter alia*, *Cordia monoica, Dichrostachys cinerea, Flueggea virosa, Grewia bicolor, Grewia flavescens, Grewia monticola, Gossypium herbaceum* and *Vachellia exuvialis*.

The herbaceous layer is well-developed and grass dominated but also comprises several forb species. In open woodland areas, several grass species are common including *Aristida adscensionis, Enneapogon scoparius, Eragrostis cylindriflora* and *Eragrostis trichophora*, while in closed wooded areas, the tall, shade tolerant grass *Panicum maximum* is dominant.

Other frequently recorded grasses include *inter alia*, *Cenchrus ciliaris, Heteropogon contortus* and *Urochloa mossambicensis*. Common small shrubs and herbs recorded include *Hermannia boraginiflora, Hibiscus micranthus, Hibiscus praeteritus* and *Melhania acuminata*.

Small ephemeral drainage features are located along the western boundary of the local study area. These range from poorly-defined depressed areas (Figure 7.4.8.5(d)) to a short more well-defined narrow drainage line (Figure 7.4.8.5(e)) – the latter is located in the north-west corner of the local study area.

For the most part, the flora composition along these drainage lines essentially mirrors that of adjacent areas of *Colophospermum mopane – Combretum apiculatum* Bushveld, with a few additional taxa recorded along the more defined drainage line in the north-west corner of the local study area.

Figure 7.4.8.5(d): Poorly defined drainage line, displaying little variation in vegetation from adjacent habitat.

Figure 7.4.8.5(e): Short, yet defined drainage line in the north-west corner of the local study area.

Additional woody species recorded include *Manilkara mochisia, Pappea capensis, Phyllanthus reticulatus, Searsia leptodictya, Sesbania bispinosa* and *Spirostachys africana*, while additional herbaceous species recorded at this site include *inter alia*; *Panicum deustum, Flaveria bidentis and Xanthium strumarium*. This drainage line is differentiated in the vegetation map in Figure 7.4.8.5(a).

Three declared alien invasive species were recorded in this community, namely *Flaveria bidentis, Tecoma stans* and *Xanthium strumarium*. *Flaveria bidentis* and *Xanthium strumarium* are small, annual herbaceous shrublets that are listed as NEMBA Category 1b invasive species and commonly invade riparian-type habitats.

Tecoma stans is a medium-sized tree that is also listed as a NEMBA Category 1b invasive species. This species is capable of establishing in a range of habitats, including dry terrestrial vegetation.

Four nationally protected trees were recorded in this vegetation community, namely *Boscia albitrunca, Combretum imberbe, Philenoptera violaceae* and *Sclerocarya birrea* subsp. *caffra* and one provincially protected tree, namely *Spirostachys Africana*. This vegetation community remains in good, stable condition. In line with the SANBI's (2020) evaluation protocol, its functional integrity is rated high, while its conservation importance community is rated medium.

<u>*Dichrostachys cinerea* Secondary Bushveld</u>
A small area (approximately 1.97 ha) in the central-north of the local study area was previously disturbed by borrow-pit operations, and is currently characterised by a secondary vegetation community.

Structurally, vegetation is characterised by open short bushveld. Woody vegetation dominated by the fine-leafed encroacher *Dichrostachys cinerea*, which grows to approximately 3 m, as well as several taller *Sclerocarya birrea* subsp. *caffra* trees. Other woody species recorded include *Albizia harveyi, Combretum apiculatum, Gossypium herbaceum, Vachellia tortilis* subsp. *heteracantha* and *Ziziphus mucronate* – see figure 7.4.8.5(f).

Despite the past disturbance, the herbaceous layer is relatively well developed and grass dominated (see Figure 7.4.8.5(g)), with *Aristida adscensionis*, *Enneapogon scoparius, Eragrostis cylindriflora, Heteropogon contortus*, and *Panicum maximum* all abundant. Common small shrubs and herbs include *Hermannia boraginiflora, Hibiscus praeteritus, Solanum panduriforme, Tephrosia purpurea and Tephrosia rhodesica var. rhodesica.* A total of 48 species were recorded in this community during the field visit.

Nationally protected trees recorded include *Combretum imberbe and Sclerocarya birrea subsp. Caffra*. Despite the secondary nature of this community, vegetation has recovered well, and habitat is stable and retains some of the functional attributes of undisturbed savanna habitat. In line with the SANBI's (2020) evaluation protocol, the functional integrity of *Dichrostachys cinerea* Secondary Bushveld is rated medium, while its conservation importance community is also rated low.

Figure 7.4.8.5(f): *Dichrostachys cinerea* Secondary Bushveld.

Figure 7.4.8.5(g): Recent disturbances to vegetation.

7.4.8.6. Flora Analysis

In total, 138 flora species, representing 35 families were recorded in the local study area during the 2021 field visit. The most represented family is the Poaceae with 31 species, followed by the Fabaceae with 22 species, and the Malvaceae with eight species and the Combretaceae and Tiliaceae with six species each.

As expected in areas of natural habitat, most (n=128) recorded species are indigenous, with 10 alien (exotic) taxa observed. Of these, three are declared invasive species (refer to Section 7.4.8.8). Trees are the most abundant growth form with 51 species, followed by the grasses and herbs with 32 and 30 species, respectively (Table 7.4.8.6(a)).

Table 7.4.8.6(a): Flora growth forms

Growth Form	No. of Species
Climber	10
Graminoid	32
Herb	30
Shrub	13
Succulent	2
Tree	51

7.4.8.7. Flora of Conservation Concern

Six protected flora species were recorded in the local study area during the field visit – refer to Table 7.4.8.7(a). These include five nationally protected tree species, as listed under the National Forests Act, (1998), and one species (viz. *Spirostachys africana*) listed as protected at a provincial level, under the Limpopo Environmental Management Act (2003).

Dalbergia melanoxylon was also recorded during the field visit. This species is not listed as a threatened or protected tree in South Africa, but it is globally recognised as a Near Threatened species by the IUCN (2021-1). This species is included in Table 7.4.8.7(a) for record purposes. Photographs of select protected tree species taken in the local study area are shown in Figure 7.4.8.7(a) - to Figure 7.4.8.7(d).

A review and cross-referencing of flora species documented on the BODATSA database for the broader Phalaborwa area indicates that an additional two species of conservation concern potentially occur in the local study area.

These are *Pterocarpus angolensis* and *Orbea rogersii* (Table 7.4.8.7(a)). Both are listed as protected in Limpopo Province, while *Pterocarpus angolensis* is further listed as a nationally protected tree. Neither species is considered threatened or near threatened on the national Red List.

Pterocarpus angolensis is a large tree that favours deep, well-drained sandy soils in open savanna (Van Wyk, 2000). This species is not well-represented in the Phalaborwa area and it is therefore considered unlikely that it is present in the local study area. *Orbea rogersii* is a small succulent that is known from Mopane woodland, and it is possible that this species is present in the local study area.

It is noted that the BODATSA database also lists *Kalanchoe longiflora* as having been recorded in the Phalaborwa area. This species is listed as Vulnerable on the national Red List. However, according to SANBI (2021), *Kalanchoe longiflora* is endemic to KwaZulu-Natal, where it has an estimated extent of occurrence of only 16 km^2 (Tugela Ferry to Muden) and is known from only five locations.

The BODATSA record for this species in the Phalaborwa area is therefore probably an error.

Table 7.4.8.7(a): Flora species of conservation concern recorded in the local study area

Family	Scientific Name	Regional Red List (2021)	National Forest Act (1998)	Limpopo Protected Status (2003)	Probability of Occurrence
Anacardiaceae	*Sclerocarya birrea* subsp. *caffra*	Least Concern	Protected	-	Recorded
Apocynaceae	*Orbea rogersii*	Least Concern		Protected	Possible
Capparaceae	*Boscia albitrunca*	Least Concern	Protected	-	Recorded
Combretaceae	*Combretum imberbe*	Least Concern	Protected	-	Recorded
Ebenaceae	*Diospyros mespiliformis*	Least Concern	Protected	-	Recorded
Euphorbiaceae	*Spirostachys africana*	Least Concern		Protected	Recorded
Fabaceae	*Philenoptera violaceae*	Least Concern	Protected	-	Recorded
Fabaceae	*Dalbergia melanoxylon*	Least Concern (Near Threatened*)	-	-	Recorded
Fabaceae	*Pterocarpus angolensis*	Least Concern	Protected	Protected	Unlikely
*Global IUCN (2021-1) Status					

Figure 7.4.8.7(a) : *Sclerocarya birrea*

Figure 7.4.8.7(b): *Combretum imberbe*

Figure 7.4.8.7(c): *Spirostachys africana*

Figure 7.4.8.7(d): *Boscia albitrunca*

7.4.8.8. Declared Alien Invasive Flora Species

Three flora species recorded in the local study area during the field visit are listed as declared alien invasive species under the NEMBA - Table 7.4.8.8(a). These were not abundant, and were mainly confined to scattered individual plants growing in drainage lines.

Table 7.4.8.8(a): Declared alien invasive species recorded in the local study area during the field visit.

Scientific Name	Common Name	NEMBA Category
Flaveria bidentis	Smelters Bush	1b
Tecoma stans	Yellow Bells	1b
Xanthium strumarium	Large Cocklebur	1b

7.4.8.9. Flora of Medicinal Value

Seven flora species recorded in the local study area have medicinal/traditional value. These are listed in Table 7.4.8.9(a), along with a brief description of their medicinal and traditional utility.

Table 7.4.8.9(a): Flora species with medicinal value recorded in the local study area.

Scientific Name	Medicinal use
Asparagus species	Rhizomes and fleshy roots are used for a variety of ailments including tuberculosis, kidney complaints and rheumatism.
Dichrostachys cinerea	Various parts of this plant are used to treat body pain, elephantiasis, syphilis and leprosy, amongst other afflictions.
Gomphocarpus fruticosus	Dried leaves are used as snuff and to treat headaches, tuberculosis and as an emetic to strengthen the body.
Sansevieria hyacinthoides	Used to treat ear infection, earache and toothache. Also used as a remedy to treat diarrhoea.
Sclerocarya birrea subsp. *caffra*	Various stomach and digestive ailments are treated with bark. The fruit of this tree is also widely eaten and used to produce both alcoholic and non-alcoholic beverages.
Terminalia sericea	Root decoctions are used to treat stomach disorders and diarrhoea. Other uses include eye lotion and as a treatment for pneumonia.
Ziziphus mucronata	Bark and leaves are used as an expectorant in coughs and chest ailments, while root extracts are used to treat diarrhoea and dysentery.
Source: Uses as described by Van Wyk *et al.* (2009).	

7.4.8.10. Mammals

Based on historic distribution ranges presented in Stuart and Stuart (2007), up to 112 mammal species are known from the region. Several of these are rare and conservation dependent taxa, that despite their historic ranges, are likely to be confined to formal conservation areas, such as the adjacent Kruger National Park.

Based on direct visual observations, camera- and Sherman trap data, and the identification of tracks and scats, 17 mammal species were recorded on the Bosveld Phosphates property during the 2022 and 2021 field visits (listed in Table 7.4.8.10(a)).

These are all free-roaming species that occur naturally in the area and/or have moved onto the property from Kruger National Park or other nearby conservation areas. They range from small taxa, such as the Tree Squirrel (*Paraxerus cepapi*) and Dwarf Mongoose (*Helogale parvula*), to large megafauna, such as the African Elephant (*Loxodonta africana*) and Giraffe (*Giraffa camelopardalis giraffa*). Refer to Figure 7.4.8.10(a) to Figure 7.4.8.10(c) for photographs of mammals taken during the field visits.

Considering the proximity of the Kruger National Park and the adjacent private reserves, the corridor habitat along the Ga-Selati and the character of on-site habitat, it is anticipated that several additional mammal species are likely to be present in the secondary project area of influence (PAOI), and may periodically move through the local study area.

Table 7.4.8.10(a): Mammals recorded in the local study area during the field visits.

Family	Scientific Name	Common Name
Bovidae	*Tragelaphus strepsiceros*	Kudu
Bovidae	*Tragelaphus scriptus*	Bushbuck
Bovidae	*Kobus ellipsiprymnus*	Waterbuck
Canidae	*Canis mesomelas*	Black-backed Jackal
Cercopithecidae	*Cercopithecus pygerythrus*	Vervet Monkey
Cercopithecidae	*Papio cynocephalus ursinus*	Chacma Baboon
Elephantidae	*Loxodonta africana*	African Elephant
Giraffidae	*Giraffa camelopardalis giraffa*	Giraffe
Herpestidae	*Helogale parvula*	Dwarf Mongoose
Herpestidae	*Galerella sanguinea*	Slender Mongoose
Herpestidae	*Mungos mungo*	Banded Mongoose
Hyaenidae	*Crocuta crocuta*	Spotted Hyaena
Leporidae	*Lepus saxatilis*	Scrub Hare
Muridae	*Mastomys sp.*	Multimammate Mouse
Sciuridae	*Paraxerus cepapi*	Tree Squirrel
Suidae	*Phacochoerus africanus*	Warthog
Viverridae	*Genetta maculata*	Large-spotted Genet

7.4.8.11. Mammals of Conservation Concern

Of species recorded during the field visits, three are of conservation concern:

- At a national level, the African Elephant is listed as Protected on the NEMBA ToPS List (2007), while at a provincial level this species is listed as Specially Protected, according to the Limpopo Environmental Management Act (2003). African Elephant are not listed as threatened on the mammal Red List. The Elephant observed in the study area are part of the greater Kruger National Park's Elephant population, which numbers between 20 000 and 30 000 individuals.
- The Spotted Hyaena (*Crocuta crocuta*) is listed as Near Threatened on the mammal Red List (Childs et al., 2016) and Protected on both the NEMBA ToPS List (2007) and the Limpopo Environmental Management Act (2003). Spotted Hyaena are considered free-roaming and individuals have probably moved up the Ga-Selati River from adjacent protected areas. No data are available on the region's Spotted Hyaena population; and
- Giraffe are listed as Protected, according to the Limpopo Environmental Management Act (2003). These Giraffe are free-roaming individuals that have also moved up the Ga-Selati River from adjacent protected areas.

An additional 28 mammal species that are potentially present in the Secondary PAOI (based on historic distribution ranges) are species of conservation concern. These are listed in Table 7.4.8.11(a), along with a probability of occurrence, predicated on habitat suitability.

The environmental screening tool highlighted the following mammals as potentially sensitive features with respects to the proposed Project: Cheetah (*Acinonyx jubatus*), African Wild Dog (*Lycaon pictus*) and Maquassie Musk Shrew (*Crocidura maquassiensis*). None of these species were recorded during the field visit. A brief discussion on each taxa is presented below:

- Cheetahs are listed as Vulnerable on the Mammal Red List (Childs et al., 2016). They favour a range of habitats including savanna and woodland (Skinner and Smithers, 1990). They occur in the Kruger National Park, as well as adjacent private protected areas, while free-roaming Cheetah also occur on private ranchlands across Limpopo Province. Although suitable habitat is present in the local study area, Cheetahs are sensitive to human activity and disturbances, and require large home-ranges with an abundant prey base. Considering that the local study area is small and bounded by fences, roads, and an existing tailings storage facility, it is unlikely that Cheetah will be present in the local study area, except possibly on a very transient basis as they disperse through the landscape;
- African Wild Dog are listed as Endangered. They are not territorial, range widely and inhabit open savanna and woodland. African Wild Dog occur in formal protected areas, as well part of free-roaming populations across Limpopo Province. Suitable habitat is present in the local study area, but, like the Cheetah, this species also requires large home-ranges with an abundant prey base. It is therefore unlikely-possible that African Wild Dog will be present on a transient basis in the local study area; and
- The Maquassie Musk Shrew is listed as Vulnerable. The habitat requirements of this species are poorly understood; however, it is believed they favour the dense matted vegetation of wetlands and moist grasslands (Stuart and Stuart, 2007). Suitable moist vegetation may be present along the Ga-Selati River, but little of this habitat is available in the local study area. It is therefore unlikely that this species is present in the local study area.

Figure 7.4.8.10(a): Warthog (*Phacochoerus africanus*)

Figure 7.4.8.10(b): African Elephant (*Loxodonta africana*)

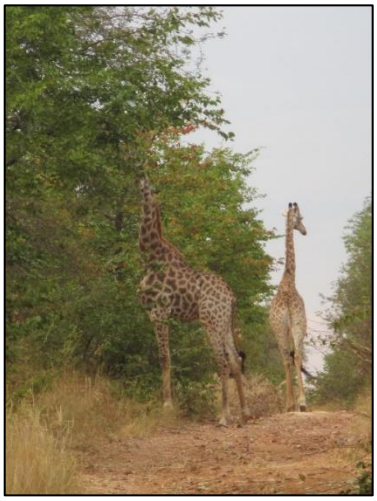


Figure 7.4.8.10(c): Giraffe (*Giraffa camelopardalis*)

Table 7.4.8.11(a): Mammal species of conservation concern potentially occurring in the Local Study Area and Secondary project area of influence (PAOI).

Family	Scientific Name	Common Name	Regional Red List Status (2016)	NEMBA ToPS Status (2007)	Limpopo Protected Status (2003)	Habitat Preferences*	Probability of Occurrence
Bovidae	*Damaliscus lunatus*	Tsessebe	Vulnerable	Endangered	Protected	Open savanna and grassland.	Unlikely – rare and conservation dependent species.
Bovidae	*Hippotragus equinus*	Roan Antelope	Endangered	Vulnerable	Specially Protected	Open savanna and grassland.	Unlikely – rare and conservation dependent species.
Bovidae	*Hippotragus niger*	Sable Antelope	Vulnerable	-	Protected	Open savanna and grassland.	Unlikely – rare and conservation dependent species.
Bovidae	*Oreotragus oreotragus*	Klipspringer	Least Concern	-	Protected	Rocky habitat.	Probable – small rocky hills located to the south-west of the local study area.
Bovidae	*Raphicerus campestris*	Steenbok	Least Concern	-	Protected	Range of habitat including savanna and grassland.	Probable – Suitable habitat present.
Bovidae	*Raphicerus sharpei*	Sharpe's Grysbok	Least Concern	Protected	Specially Protected	Low thicket and rocky hillsides.	Probable – Suitable habitat present. Previously observed by author along the Olifants River downstream of the local study area.
Bovidae	*Redunca arundinum*	Southern Reedbuck	Least Concern	Protected	Protected	Open grasses areas in savanna, close to water	Possible – Suitable habitat present.
Bovidae	*Redunca fulvorufula*	Mountain Reedbuck	Endangered	-	Protected	Mountainous and rocky areas	Unlikely – limited suitable habitat present.
Canidae	*Lycaon pictus*	African Wild Dog	Endangered	Endangered	Specially Protected	Open savanna and woodland	Unlikely/Possible – Suitable habitat present.
Canidae	*Canis adustus*	Side-striped Jackal	Least Concern	-	Protected	Open savanna and woodland	Possible – Suitable habitat present.
Elephantidae	*Loxodonta africana*	African Elephant	Least Concern	Protected	Specially Protected	Range of habitats, including Open savanna and woodland	Recorded
Felidae	*Leptailurus serval*	Serval	Near Threatened	Protected	Specially Protected	Range of habitats, including savanna and woodland	Possible – Suitable habitat present.

Family	Scientific Name	Common Name	Regional Red List Status (2016)	NEMBA ToPS Status (2007)	Limpopo Protected Status (2003)	Habitat Preferences*	Probability of Occurrence
Felidae	*Acinonyx jubatus*	Cheetah	Vulnerable	Vulnerable	Protected	Range of habitats, including savanna and woodland	Unlikely - Suitable habitat present, but rare species requiring large ranges, and sensitive to human disturbances.
Felidae	*Panthera leo*	Lion	Least Concern	Vulnerable	Protected	Range of habitats, including savanna and woodland	Possible – Suitable habitat present. Known to occur on mining properties downstream of the local study area.
Felidae	*Panthera pardus*	Leopard	Vulnerable	Vulnerable	Protected	Range of habitats, including savanna and woodland	Probable – Suitable habitat present.
Galagidae	*Galago moholi*	Southern Lesser Galago	Least Concern	-	Protected	Range of habitats, including savanna and woodland	Probable – Suitable habitat present.
Galagidae	*Otolemur crassicaudatus*	Thick-tailed Bushbaby	Least Concern	-	Protected	Range of habitats, including savanna and woodland	Probable – Suitable habitat present.
Giraffidae	*Giraffa camelopardalis giraffa*	South African Giraffe	Least Concern	-	Protected	Range of habitats, including savanna and woodland	Recorded
Herpestidae	*Paracynictis selousi*	Selous' Mongoose	Least Concern	-	Protected	Open woodland and grassland.	Possible – Suitable habitat present.
Hippopotamidae	*Hippopotamus amphibius*	Hippopotamus	Least Concern	-	Protected	Permanent water, including rivers, dams and lakes.	Probable – Suitable habitat present along the Ga-Selati River in Secondary PAOI. Potential to forage in the local study area.
Hyaenidae	*Crocuta*	Spotted Hyaena	Near Threatened	Protected	Protected	Range of habitats, including savanna and woodland	Recorded
Hyaenidae	*Parahyaena brunnea*	Brown Hyaena	Near Threatened	Protected	Protected	Savanna and desert habitats	Unlikely - Suitable habitat present, but a rare species in the region.

Family	Scientific Name	Common Name	Regional Red List Status (2016)	NEMBA ToPS Status (2007)	Limpopo Protected Status (2003)	Habitat Preferences*	Probability of Occurrence
Hyaenidae	*Proteles cristata*	Aardwolf	Least Concern	-	Protected	Range of habitats, including savanna and woodland	Unlikely - Suitable habitat present, but a rare species in the region.
Manidae	*Smutsia temminckii*	Ground Pangolin	Vulnerable	Vulnerable	Specially Protected	Savanna habitats	Possible - Suitable habitat present, but a rare species.
Muridae	*Dasymys incomtus*	African Marsh Rat	Near Threatened	-	-	Moist areas in savanna habitats	Possible - Suitable habitat present.
Mustelidae	*Aonyx capensis*	Cape Clawless Otter	Near Threatened	Protected	Protected	Riparian habitats	Probable – Suitable habitat present along the Ga-Selati River in Secondary PAOI. Potential to move through the local study area.
Mustelidae	*Hydrictis maculicollis*	Spotted-necked Otter	Vulnerable	Protected	-	Riparian habitats, but favours open water bodies.	Possible – Suitable habitat present along the Ga-Selati River in Secondary PAOI. Potential to move through the local study area.
Mustelidae	*Mellivora capensis*	Honey Badger	Least Concern	Protected	Protected	Savanna and grassland habitats	Probable - Suitable habitat present.
Orycteropodidae	*Orycteropus afer*	Aardvark	Least Concern	-	Specially Protected	Range of habitats, including savanna and woodland	Probable - Suitable habitat present.
Soricidae	*Crocidura maquassiensis*	Maquassie Musk Shrew	Vulnerable	-	-	Moist areas, with dense, matted vegetation.	Unlikely – Limited suitable habitat present.
Viverridae	*Civettictis civetta*	African Civet	Least Concern	-	Protected	Range of habitats, including savanna and woodland	Probable - Suitable habitat present.
Source: Habitat preferences as per Skinner and Smithers (1990) and Stuart and Stuart (2007).							

7.4.8.12. Birds

Based on South African Bird Atlas Project 2 (SABAP2) records, the broader landscape has a high bird species richness, with 351 species recorded in the pentads 2355_3100, 2355_3105, 2400_3105 and 2400_3100 that encompass the study area.

This high count is attributable to the presence of the various formal protected areas in the surrounding landscape and the high observer coverage that these areas will attract, compared to non-protected areas. The Kruger National Park and adjacent areas are recognised as a globally important bird area (IBA), and are home to several globally and regionally threatened species, as well as numerous range-restricted and biome-restricted bird species present (Marnewick, et al., 2015).

In total, 98 bird species were recorded during the field visits. The majority of these are fairly common taxa, with widespread distributions in savanna habitats in close proximity to the Kruger National Park and other protected areas.

7.4.8.13. Birds of Conservation Concern

The Marabou Stork is listed as Near Threatened, while the Cape Vulture, which was observed flying overhead during the field visit, is listed as Endangered on the national Red List (Taylor, et al., 2015). Based on SABAP2 records, an additional 23 bird species of conservation concern have previously been recorded in the encompassing pentads, and thus potentially occur in the secondary PAOI.

These are listed in Table 7.4.8.13(a), along with a probability of occurrence, based on habitat suitability in the Secondary PAOI. It is noted that, although several of these are unlikely to be frequently present in the local study area, they may have a transitory presence, based on inter alia, feeding opportunities.

The environmental screening tool highlighted Bateleur (*Terathopius ecaudatus*) and Hooded Vulture (*Necrosyrtes monachus*) as potentially sensitive features with respects to the local study area:

- Bateleur are listed as Endangered on the national Red List. This species favours a range of savanna habitats. This was not recorded during the field visit, but suitable habitat is present in the local study area and secondary PAOI. It is therefore probable that Bateleur may be present on-site on occasion; and
- Hooded Vulture are listed as Critically Endangered, and favour savanna habitats, particularly well-developed tall woodland. This was not recorded during the field visit, but suitable habitat is present in the local study area and secondary PAOI. It is therefore possible that Hooded Vulture have a transitory presence on-site in response to scavenging opportunities.

7.4.8.14. Herpetofauna

Based on the reptile distribution maps presented in Bates et al., 2014 and ReptileMAP records for the relevant QDS, up to 103 reptile species occur in the broader region and thus potentially occur in the Secondary PAOI.

Six reptile species were recorded during the field visits.
These are the Water Monitor (*Varanus niloticus*), Southern African Rock Python (*Python natalensis*), Black Mamba (*Dendroaspis polylepis*), Stripe-belled Sand Snake (*Psammophis*

subtaeniatus), Variable Skink (*Trachylepis varia*) and Rainbow Skink (*Trachylepis* cf. *margaritifer*). The Southern African Rock Python is of conservation concern. Considering the availability of suitable on-site habitat, it is likely that several additional reptile species are also present in the Secondary PAOI.

Based on the distribution maps in Du Preez and Carruthers (2009), and data reported on the FrogMAP database, at least 37 amphibian species are known to occur in the broader region. Of these, eight species were recorded during night-time surveys (listed in Table 7.4.8.14(a)). All recorded taxa are common, with widespread distributions.

Refer to Figure 7.4.8.14(a) to Figure 7.4.8.14(d) for select images of herpetofauna photographed during the field visits.

7.4.8.15. Herpetofauna of Conservation Concern

The Southern African Rock Python is of conservation concern. This species is listed as Protected according to the both NEMBA ToPS list (2007) and the Limpopo Environmental Management Act (2003). Based on historic distributions, two additional reptiles of conservation concern potentially occur in the in the local study area and Secondary PAOI, namely the Black File Snake (Gonionotophis nyassae) and Sensitive Species 2 :

- The Black File Snake is listed as protected in the province, according to the Limpopo Environmental Management Act (2003). It is not however, considered threatened or near threatened on the national reptile Red List (Bates et al., 2004). This species favours savanna habitats, where it is typically found under rocks or logs. There is suitable habitat in the in the Secondary PAOI, and it is therefore possible that the Black File Snake is present; and
- Sensitive Species 2 is listed as Vulnerable on the national reptile Red List (Bates et al., 2004). It is also listed as a protected species at a both national and provincial level according to the NEMBA ToPS list (2007) and the Limpopo Environmental Management Act (2003), respectively. There is no suitable habitat for Sensitive Species 2 in the local study area. This species is known to be present in the Ga-Selati River downstream of the local study area.

Two amphibians that potentially occur in the Secondary PAOI are of conservation concern; both the Giant Bullfrog (Pyxicephalus adspersus) and the African Bullfrog (Pyxicephalus edulis) are listed as Protected on the NEMBA ToPS List (2007), while the Giant Bullfrog is further listed as Protected at a provincial level, according to the Limpopo Environmental Management Act (2003).

African Bullfrog favour savanna habitats in low-lying areas, where they are typically found in seasonally flooded pans, but also along roadside furrows, dams and waterholes (Minter et al., 2004). These habitats are present in the study area and surrounding landscape, and it is therefore probable that this species is present. Unlike the African Bullfrog, the Giant Bullfrog is more regularly found at higher elevations, where they favour seasonal, shallow and grassy pans, as well as shallow waters on the margins of waterholes and dams (Minter et al., 2004). Although such habitats are present, considering the general distribution of this species, it is unlikely that it is present on-site.

Table 7.4.8.13(a): Bird species of conservation concern potentially occurring in the Local Study Area and Secondary PAOI.

Family	Common Name	Scientific Name	Regional Red List Status (2015)	NEMBA ToPS Status (2007)	Limpopo Protected Status# (2003)	Habitat Preferences*	Probability of Occurrence
Accipitridae	*Terathopius ecaudatus*	Bateleur	Endangered	Vulnerable	Specially Protected	Savanna habitats	Probable – suitable habitat present
Accipitridae	*Polemaetus bellicosus*	Martial Eagle	Endangered	-	Specially Protected	Range of habitats, including savanna	Probable – suitable habitat present
Accipitridae	*Aquila rapax*	Tawny Eagle	Endangered	Vulnerable	-	Savanna habitats	Probable – suitable habitat present
Accipitridae	*Aquila verreauxii*	Verreaux's Eagle	Vulnerable	-	-	Mountainous habitats	Unlikely/possible – limited suitable habitat present in the form of the small rocky hills located to the south-west of the local study area.
Accipitridae	*Gyps coprotheres*	Cape Vulture	Endangered	Endangered	Specially Protected	Savanna and grassland habitats	Recorded - flying overhead. Transitory presence.
Accipitridae	*Necrosyrtes monachus*	Hooded Vulture	Critically Endangered	Endangered	-	Savanna habitats, particularly well-developed tall woodland.	Possible – suitable habitat present. Transitory presence
Accipitridae	*Torgos tracheliotus*	Lappet-faced Vulture	Endangered	Endangered	-	Range of habitats, including savanna	Possible – suitable habitat present. Transitory presence
Accipitridae	*Gyps africanus*	White-backed Vulture	Critically Endangered	Endangered	-	Savanna habitats	Possible – suitable habitat present. Transitory presence
Accipitridae	*Trigonoceps occipitalis*	White-headed Vulture	Critically Endangered	Vulnerable	-	Semi-arid and broad-leaved woodland	Possible – suitable habitat present. Transitory presence
Accipitridae	*Stephanoaetus coronatus*	Crowned Eagle	Vulnerable	-	-	Tall, closed canopy forest, including riparian woodland.	Possible – suitable habitat present
Accipitridae	*Circus macrourus*	Pallid Harrier	Near Threatened	-	-	Open grasslands, floodplains, and croplands	Unlikely - no suitable habitat present.

Family	Common Name	Scientific Name	Regional Red List Status (2015)	NEMBA ToPS Status (2007)	Limpopo Protected Status# (2003)	Habitat Preferences*	Probability of Occurrence
Alcedinidae	*Alcedo semitorquata*	Half-collared Kingfisher	Near Threatened	-	-	Riparian woodland and forest, along flowing streams.	Possible – suitable habitat present
Bucorvidae	*Bucorvus leadbeateri*	Southern Ground-hornbill	Endangered	Protected	Specially Protected	Open grassland and woodland	Possible – suitable habitat present
Ciconiidae	*Ciconia nigra*	Black Stork	Vulnerable	Vulnerable	-	Riparian and wetland habitats – typically in mountainous regions.	Possible – suitable habitat present.
Ciconiidae	*Leptoptilos crumeniferus*	Marabou Stork	Near Threatened	-	-	Range of habitats, including savanna	Recorded
Ciconiidae	*Ephippiorhynchus senegalensis*	Saddle-billed Stork	Endangered	Endangered	Specially Protected	Large rivers in open savanna/	Probable - suitable habitat present.
Ciconiidae	*Mycteria ibis*	Yellow-billed Stork	Endangered	-	-	Wetland habitats	Probable - suitable habitat present
Ciconiidae	*Ciconia abdimii*	Abdim's Stork	Near Threatened	-	-	Range of habitats, including savanna	Possible – suitable habitat present.
Coraciidae	*Coracias garrulus*	European Roller	Near Threatened	-	-	Savanna habitats	Probable – suitable habitat present
Falconidae	*Falco biarmicus*	Lanner Falcon	Vulnerable	-	-	Range of habitats, including savanna	Possible – suitable habitat present
Falconidae	*Falco peregrinus*	Peregrine Falcon	Least Concern	Vulnerable	Specially Protected	Restricted to areas near high cliffs	Unlikely – limited suitable habitat present.
Pelecanidae	*Pelecanus rufescens*	Pink-backed Pelican	Vulnerable	Endangered	-	Wetland habitats	Unlikely - no suitable habitat present.
Phoenicopteriformes	*Phoenicopterus ruber*	Greater Flamingo	Near Threatened	-	-	Wetland habitats	Unlikely - no suitable habitat present.
Phoenicopteriformes	*Phoenicopterus minor*	Lesser Flamingo	Near Threatened	-	-	Wetland habitats	Unlikely - no suitable habitat present.
Rostrtulidae	*Rostratula benghalensis*	Greater Painted-snipe	Near Threatened	-	-	Vegetated habitats, alongside water with exposed mud	Possible – suitable habitat present.
#According to the Limpopo Environmental Management Act (2003), all bird species, excluding those listed as Specially Protected (Schedule 2) and those listed as common species (Schedule 3), are Protected in Limpopo Province.							
*Habitat preferences as per Roberts VII Multimedia.							

Table 7.4.8.14(a): Amphibian species recorded during the field visits.

Family	Scientific Name	Common Name
Bufonidae	*Amietophrynus garmani*	Eastern Olive Toad
Phrynobatrachidae	*Phrynobatrachus natalensis*	Snoring Puddle Frog
Phrynobatrachidae	*Phrynobatrachus mabiensis*	Dwarf Puddle Frog
Pipidae	*Xenopus muelleri*	Muller's Platanna
Ptychadenidae	*Ptychadena anchietae*	Plain Grass Frog
Ptychadenidae	*Ptychadena mossambica*	Broad-banded Grass Frog
Pyxicephalidae	*Cacosternum boettgeri*	Boettger's Caco
Pyxicephalidae	*Amieta angolensis*	Common River Frog

Figure 7.4.8.14(a): Water Monitor (*Varanus niloticus*).

Figure 7.4.8.14(b): Plain Grass Frog (*Ptychadena anchietae*).

Figure 7.4.8.14(c): Common River Frog (*Amieta angolensis*).

Figure 7.4.8.14(d): Muller's Platanna (*Xenopus muelleri*).

7.4.8.16. Invertebrate Screening

No baboon spider records for the relevant QDS are available on SpiderMAP (FitzPatrick Institute of African Ornithology, 2021). However, according to historic distribution maps in Dippenaar-Schoeman (2014), six baboon spider species from the Family Theraphosidae have been recorded in Limpopo Province. These are listed in Table 7.4.8.16(a). At a provincial level, baboon spiders are of conservation concern, according to Schedule 10 of the Limpopo Environmental Management Act (2003). No evidence (burrows) indicating the presence of these species was observed in the local study area. However, it is possible that some of these taxa are present.

Spiders that were frequently recorded in the local study area include Nephila senegalensis and Argiope lobata. Both these taxa are common and widespread species, and are not of conservation concern.

Table 7.4.8.16(a): Baboon spiders potentially occurring in the local study area.

Family	Scientific Name	Common Name
Theraphosidae	*Augacephalus breyeri*	Hectorspruit Golden Brown Baboon Spider
Theraphosidae	*Augacephalus junodi*	Junodi's Golden Brown Baboon Spider
Theraphosidae	*Brachionopus pretoriae*	no common name
Theraphosidae	*Ceratogyrus paleni*	Paulsen's Horned Baboon Spider
Theraphosidae	*Ceratogyrus darlingi*	South African Horned Baboon Spider
Theraphosidae	*Harpactira hamiltoni*	Golden Starbust Baboon Spider

7.4.8.17. Key Ecological Attributes of the Landscape

Despite large areas of transformation caused by various mine facilities (e.g., stockpiles, open pits, tailing storage facilities) and the presence of linear infrastructure, such as roads, powerline servitudes, railways and game fences, habitat connectivity across the broader landscape remains relatively high. This is evidenced by the observation of several large mammal taxa (such as elephants and giraffe) on the Bosveld Phosphates property during the field visits. These species are normally restricted to formal conservation areas, but they are 'free-roaming' in natural areas adjacent to the Kruger National Park.

The Ga-Selati and Olifants Rivers and the numerous nearby protected areas are key components of this landscape-scale connectivity. Both rivers act as highly functional and important ecological corridors, linking Kruger National Park (which is an ecological source area) in the east, to protected areas and other areas of natural habitat across the broader landscape to the west. Natural habitat in and adjacent to the local study area on the Bosveld Phospates property will form part of the supporting/buffering habitat for the Ga-Selati riparian corridor system.

An electrified game fence runs parallel to the river corridor to the west of the local study area. When intact and operational, the fence is likely to limit the direct movement of larger fauna between the river and the local study area. However, it was noted during the 2021 field visit that the fence is periodically damaged by elephants, which is likely to facilitate the free movement of larger taxa.

7.4.8.18. Processes and Drivers of Change

The following notes summarise the key processes and drivers of change that are likely to be present in the landscape and their possible influence on the character of the terrestrial ecology of the local study area.

Large herbivores (>5 kg) have an impact on natural resources that can either be positive or negative, depending on the intensity and frequency of resource use.

The effect of megaherbivores, such as elephant, on natural resources is particularly profound. Through the combined impact of feeding and breakage (e.g., debarking and pushing over of large trees), elephants are capable of drastically impacting the structure and composition of savanna habitat. At high densities, they are able to covert woodland and savanna into a mosaic of treeless grassland and/or coppicing shrubland (Scholes and Mennell, not dated).

It is also worth noting the important role that elephants play in maintaining open movement corridors in the landscape. Through their regular dismantling of the electric fences that have been primarily erected to restrict fauna movement, elephants promote local landscape connectivity.

Although evidence (faeces) of elephant was observed in the local study area, in comparison to land to the south of Bosveld Phosphates tailings storage facilities, which appear to be heavily utilised by elephant, the local study area is probably infrequently visited by elephant. This notwithstanding, through their impact on woody vegetation and their destruction of boundary fencing, elephants are considered a significant driver of change in the landscape and indeed the local study area.

Fire is considered a natural, albeit often human initiated, disturbance agent in both savanna and grassland ecosystems across Africa. Through the large-scale and periodic removal of plant material, fire influences tree-grass ratios and plant species mixes (fire tolerant vs fire intolerant species) and therefore plays a key role defining vegetation structure, composition and function (Du Toit et al., 2003).

It is understood that Bosveld Phosphates does not have a formal burning programme for their property. This notwithstanding, it is likely that accidental or intentional fires initiated on neighbouring land periodically spread onto the Bosveld Phosphates property. Fire is therefore considered a probable driver of change in the landscape and the local study area.

Three declared alien invasive species were observed in the study area during the field visit. These were recorded at very low densities in a drainage line in the local study area. It is noted that alien invasive species have the potential to rapidly colonise disturbed areas, and if not controlled, they can spread into adjacent undisturbed areas. Drainage lines and water courses are particularly susceptible to alien invasive species colonisation. Although there is currently little alien invasive species establishment in the local study area, dense stands of *Flaveria bidentis* were noted in drainage features at Bosveld Phospates. Alien invasive species establishment is therefore considered a potentially significant driver of change in the landscape.

7.4.8.19. Analysis of Site Ecological Importance

This section provides a summary comment on the ecological importance of affected and potentially affected habitats, as per the SANBI (2020) protocol. A map of ecological importance is shown in Figure 7.4.8.19(a).

Colophospermum mopane – Combretum apiculatum Bushveld is characterised by natural, savanna habitat that approximates reference habitat conditions. This variable community provides potential habitat for a variety of flora and fauna, several of which, are species of conservation concern. At a landscape scale, this community also provides a measure of supporting and buffering habitat for the Ga-Selati River ecological corridor.

In line with the SANBI (2020) rating criteria, the functional integrity of *Colophospermum mopane – Combretum apiculatum* Bushveld is rated high, while conservation importance is rated medium. Accordingly, the biodiversity importance of this communities is medium, while Resilience is considered low.

The ecological importance is thus rated high. This rating is extrapolated across the natural communities westward to the Ga-Selati River corridor (excluding the disturbed Eskom powerline servitude). This rating is consistent with the Limpopo Conservation Plan (V2) designation of this land as CBA2.

Dichrostachys cinerea Secondary Bushveld is a subclimax vegetation community that has regenerated following the cessation of borrow pit activities and rehabilitation of this site. Habitat is stable and retains some of the functional attributes of undisturbed habitat. This community is rated as having a medium functional integrity and low conservation importance. The biodiversity importance of *Dichrostachys cinerea* Secondary Bushveld is thus low. Receptor resilience is rated medium, resulting in an ecological importance rating of low. This rating is incongruous with the Limpopo Conservation Plan (V2) designation of the entire local study area, including this disturbed portion, as CBA2.

At a broader scale, within the secondary PAOI, the Ga-Selati River and its associated riparian habitat supports a variety of flora and fauna species, and forms an important landscape corridor, with high levels of connectivity to 1) surrounding patches of natural habitat, 2) the regionally important Olifants River, and 3) a network of protected areas.

Several fauna species conservation concern, including *inter alia*, Sensitive species 2 (Vulnerable), mammals such as Cape Clawless Otter (Near Threatened), Spotted-necked Otter (Vulnerable), and several bird taxa, are likely to occur or periodically utilise habitats within the river corridor. The functional integrity of the river corridor is rated very high, while its conservation importance is rated medium. Biodiversity importance is thus rated high. The resilience of this habitat is considered low, and accordingly, the ecological importance of the Ga-Selati River corridor is rated very high. This is consistent with the Limpopo Conservation Plan (V2) designation of this land as CBA2.

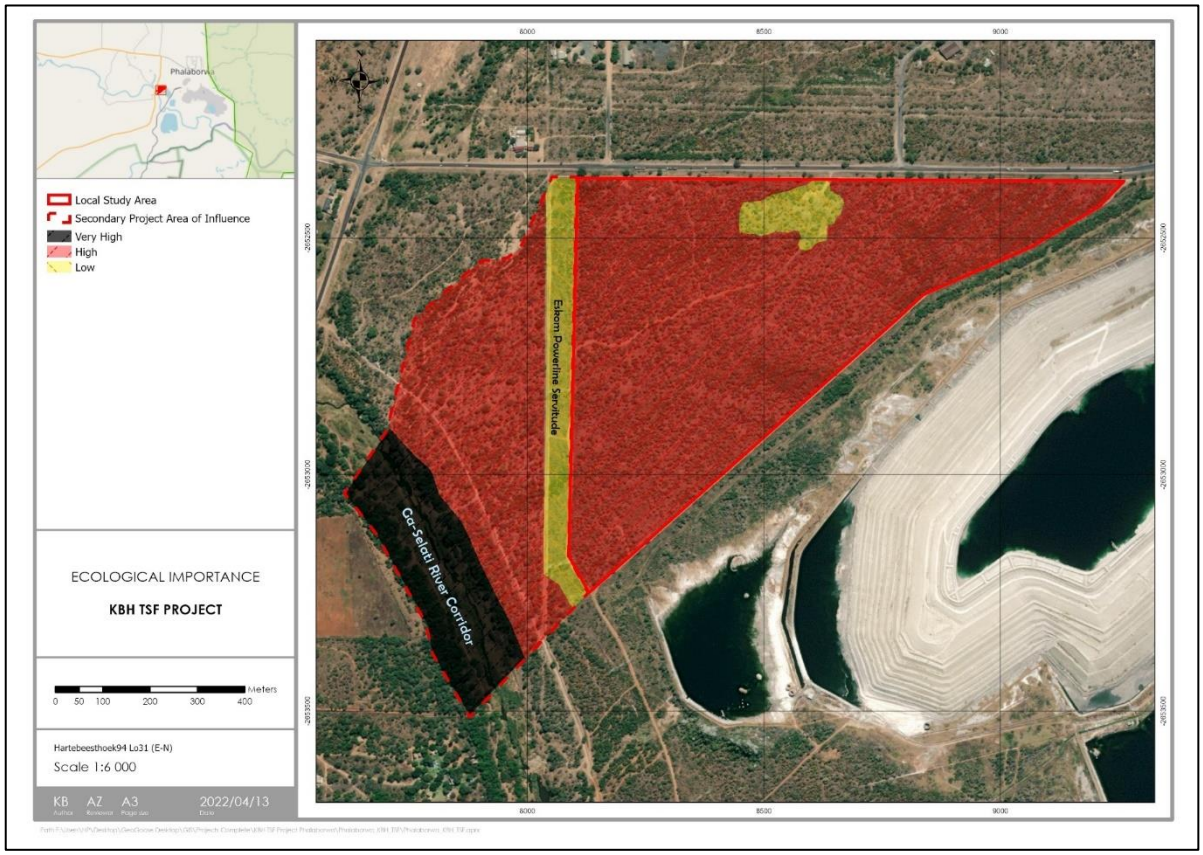


Figure 7.4.8.19(a): Ecological Importance of habitats in the local study area and the Ga-Selati River in the secondary PAOI.

7.4.9. Aquatic Ecosystems

Specialist consultants from Peridae Aquatic Consulting were requested to conduct a detailed Aquatic Ecology Specialist Assessment in support of the proposed project.

The relevant Specialist Report is:

Aquatic Ecology Baseline Assessment Report for Bosveld Phosphates Waste Disposal Facility Project, Phalaborwe, Limpopo Province; September 2021

The information provided below represents a concise summary of the baseline description compiled for the study area.

7.4.9.1. Background and Conclusions

The proposed study area is located on the eastern side of the adjacent Ga-Selati River, which flows past the study area in a south-easterly direction and which joins the confluence of the Olifants River further downstream. A wet season survey was undertaken from 28 to 30 April 2021.

The primary objective of the aquatic assessment was to:

- Characterise the biotic health and integrity of the aquatic ecosystem at the selected upstream and downstream sites along the Ga-Selati and Olifants rivers (see Figure 7.4.9.1(a));
- Evaluate the extent of site-related effects in terms of selected ecological indicators;
- Identify listed aquatic biota based on the latest IUCN rankings, or other pertinent conservation ranking bodies;
- Compare any differences in the results obtained in the aquatic ecosystem health in the project area;
- Identify trends in aquatic ecosystem health in the project area; and
- Identify impacts and associated mitigation hierarchy and controls that can be implemented to mitigate such impacts going forward.

As per the historical data of the study area, the Ga-Selati River continues to be under pressure and consequently its health and integrity is deteriorating temporally, owing to an increase in mining, industrial, agriculture and domestic practices within the catchment.

These activities continue to elevate the TDS concentrations and salinity, particularly within the Ga-Selati, which is of concern to the aquatic biota (fish and aquatic macroinvertebrates).

The Ga-Selati River is a major tributary for the Olifants River, and thus where it meets at the confluence of the Olifants River, it is known to be supplying impaired water quality into the main stem, as seen by the historical results.

The Olifants River System has been described as degraded and under threat, owing to cumulative upstream catchment impacts contributing to the heavy metal and chemical loads.

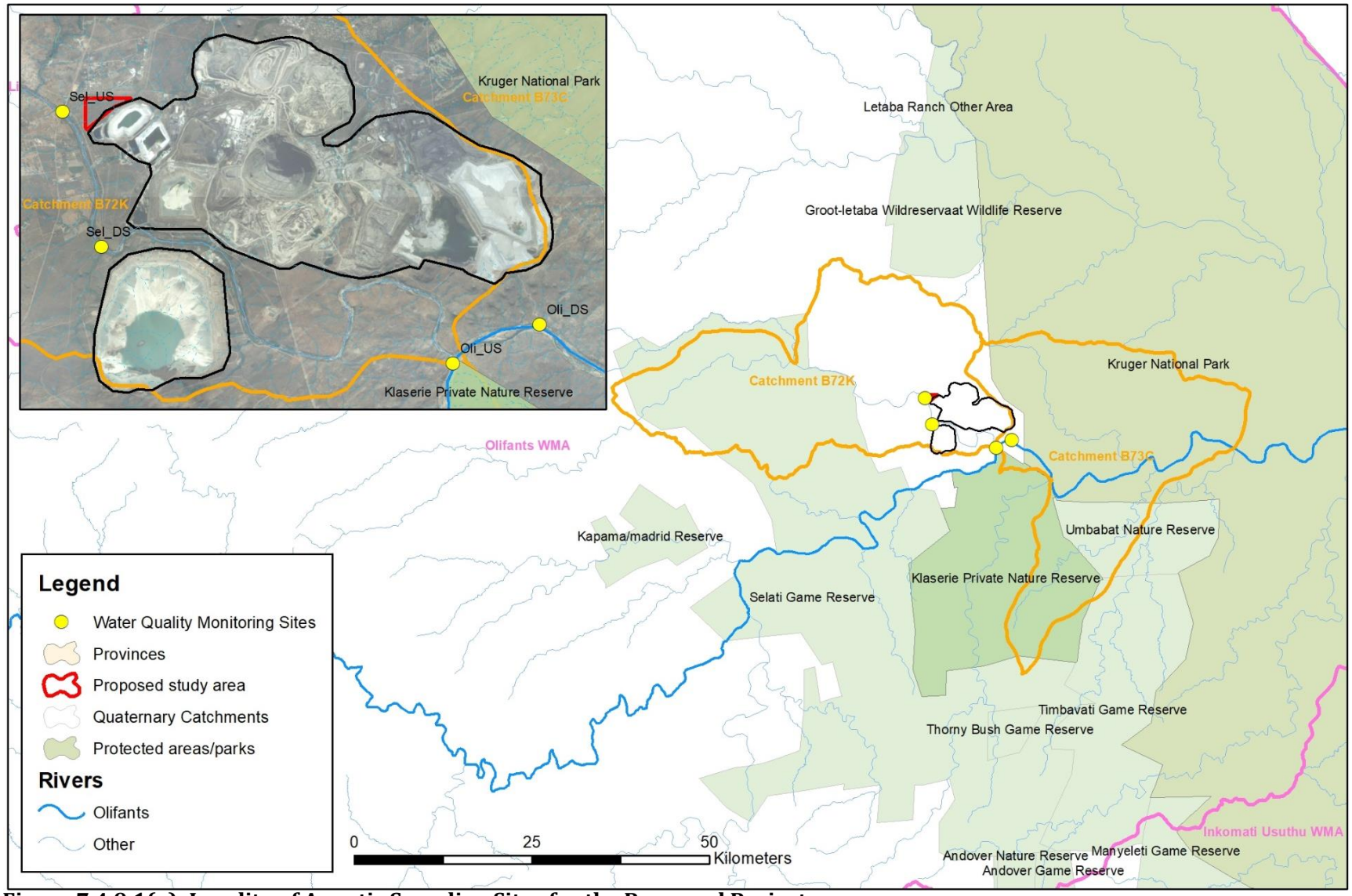


Figure 7.4.9.1(a): Locality of Aquatic Sampling Sites for the Proposed Project

Based on the ecoclassification process conducted for the baseline assessment in support of this proposed project, and the integrated ecological state (EcoStatus) calculated at each site, the following conclusions were reached:

- Overall, the EcoStatus for site Sel_US remains in a Class E (similar to the PES identified during the study conducted by DWS (2014)). There have been some changes to the upstream catchment in recent years with flow regime changes (lower runoff and increased abstraction), poor land-use practices, erosion and increased pollution from the catchment due to both increased mining and industrial activities. Consequently, owing to these continued threats, this site continues to be seriously modified.
- Further downstream at site Sel_DS, the integrated ecological state improved compared to study conducted by DWS (2014) to a Class C/D. However, this may have been attributed to better habitat diversity (large pools, downstream riffles and small rapids flowing through channels) with an abundance of overhanging habitat created by marginal reeds, providing adequate habitat for the aquatic biota. There is a good chance that fish migrating from the Olifants River are still able to reach this site. Tigerfish are present in the lower reaches of this river, just upstream from the Olifants River confluence. However, as this site is situated in the area described as a water quality barrier, the good flows associated with the cyclone Eloise, probably scoured the river and cleansed it notably, which explained the presence in some sensitive fish species identified at this site, and thus contributing to an improved ecological status.
- The integrated ecological status within the Olifants River, both upstream and downstream, have both improved compared to the study conducted by DWS (2014). Both sites indicated moderately modified (Class C) conditions, primarily influenced by the moderately modified (Class B/C) instream and riparian habitat integrity, including deep river runs, side channel pools, although limited marginal or overhanging vegetation. Unlike the Ga-Selati River, the rapids and deeper riffles within the Olifants River, particular at the downstream site, were however favourable habitat for all the rheophilic (flow-dependent) fish species, including *Chiloglanis pretoriae*, *Labeobarbus* and *Labeo* species, and aquatic macroinvertebrate taxa with specific velocity preferences namely Heptageniidae, Leptophlebiidae and Tricorythidae.
- Overall, the Ga-Selati River is in a more impaired state from both an aquatic biota and instream/riparian integrity, compared to the Olifants River, owing to this resource consistently and continually being under great threat from cumulative catchment impacts. However, as ecosystems respond in a knock-on effect, it will be vital to manage the Ga-Selati River, with the aim to improve its current ecological state towards the gazetted RQO's for quaternary catchment B72K.

7.4.9.2. Baseline Summary Results: Site Sel_US

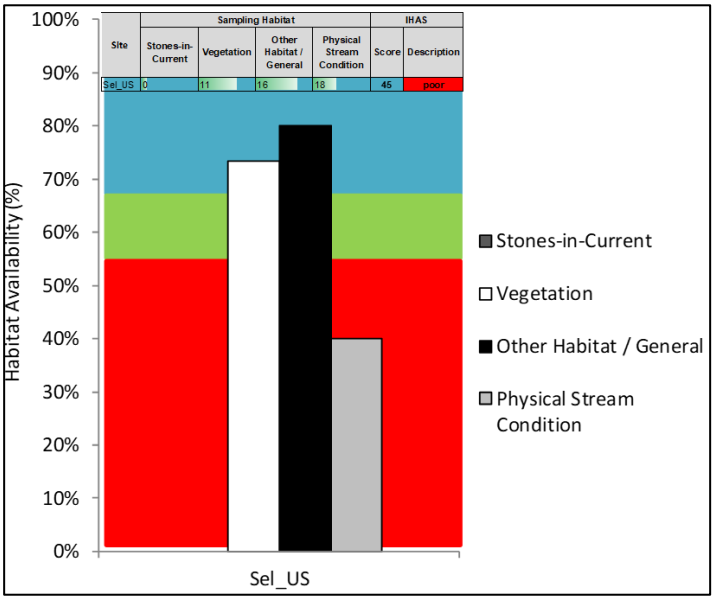
This site in the Ga-Selati River was selected as it is located upstream from the proposed study area. It is further located downstream of the Namakgale and Mashishimale townships, at the Lydenburg/Phalaborwa Road bridge.

See Table 7.4.9.2(a) for details pertaining to this sampling site. Table 7.4.9.2(b) relays the data results and the Present Ecological State (PES) results and Table 7.4.9.2(c) the Ecostatus results attained.

Table 7.4.9.2(a): Details of Sel_US Sampling Site

Water Management Area (WMA)	Olifants WMA 2
Quaternary Catchment	B72K
Level 1 Ecoregion	Lowveld
Level 2 Ecoregion	3.03
Latitude; Longitude	23°58'37.3080"S; 31°04'25.7880"E
Geomorphological Zone	E (lower foothills)
Altitude (m.a.s.l)	359
DWS, 2014 PES	**E (Seriously Modified)**
Ecological Importance (EI)	Moderate
Ecological Sensitivity (ES)	High
	
Upstream Photograph	**Downstream Photograph**

Table 7.4.9.2(b): Data results and Present Ecological State (PES)

Water Quality	**pH:** 7.3 **TDS:** 903.5 mg/l **Temperature:** 26.6 °C
Habitat Potential Assessment for Fish*	The upstream Ga-Selati site (Sel_US) consists of deeper pools (Figure 7.4.9.2(a) and (d)) and good overhanging reed and root wad habitats (Figure 7.4.9.2(b)). There are also limited shallow riffles (Figure 7.4.9.2(c)) and most of the bottom substrates consist of sandy alluvium.  **Figure 7.4.9.2: Site Sel_US**
Habitat Availability for Aquatic Macroinvertebrates (Integrated Habitat Assessment System, Version 2 [IHAS])	The habitat availability was *poor (IHAS%: 45%)*. The channel at this site was relatively narrow, although with some deep turbid pools, with limited flow conditions. There were no Stones-In-Current (SIC) biotope, poor stream condition (owing to illegal sand mining, erosion), but the site was characterised with good vegetation (although dominated by *Phragmites spp*.), Stones-Out-Of-Current (SOOC) and Gravel, Sand and Mud (GSM) availability (Figure 7.4.9.2(e)).  **Figure 7.4.9.2(e): IHAS results for site Sel_US**

<table>
<tr><td>IHI (Instream Habitat Integrity)</td><td>These assessments provide a high-level indication of the condition of the river reaches chosen for the purposes of this study. The IHI of site Sel_US was identified to be in a seriously modified state (Class E) (Score: 30). The main factors negatively influencing the instream habitat integrity included the following:
Flow modification;
Instream modification; and
Channel modification.
The serious modification to the above categories were frequently present and thus the habitat quality, diversity, size and variability, affected majority of the defined section, with only a small area where they were not influenced (upper left bank). These modifications were primarily owing to the on-going illegal sand mining activities in-stream at this site, a collapsed cross-over bridge (although providing additional habitat for aquatic biota) and erosion resulting in increased sedimentation at the site.</td></tr>
<tr><td>IHI (Riparian)</td><td>The riparian habitat integrity of site Sel_US was identified to be in a critical modified state (Class F) (Score: 3). The main factors negatively influencing the riparian habitat integrity included the following:
Vegetation removal;
Exotic vegetation encroachment;
Bank erosion; and
Channel modification.
The serious modification to the above categories were frequently present and thus the habitat quality, diversity, size and variability, affected the majority of the defined section, with only a small area where they were not influenced. These modifications were primarily owing to the on-going illegal sand mining activities within the riparian zone and banks at this site, erosion, cattle activity and trampling and clearing of the riparian zone on either side of the banks, in which to further conduct illegal sand mining for the local community. The alien invasive Xanthium strumarium species, is currently colonising within the degraded riparian zones, resulting in further modification of the riparian habitat integrity.</td></tr>
<tr><td>Macroinvertebrates</td><td>South African Scoring System, Version 5 (SASS5) Score: 97 (65% of the reference conditions)
Number of Taxa: 20
Average Score per Taxa (ASPT) Value: 4.9 (78% of the reference conditions)

SASS5 Summary according to Biotope
<table>
<tr><th rowspan="2">Aquatic Macroinvertebrates</th><th colspan="3">Sel - US</th></tr>
<tr><th>SIC</th><th>VEG (Vegetation)</th><th>GSM</th></tr>
<tr><td>SASS Score</td><td>0</td><td>56</td><td>96</td></tr>
<tr><td>Number of Taxa</td><td>0</td><td>14</td><td>19</td></tr>
<tr><td>ASPT</td><td>0.0</td><td>4.0</td><td>5.1</td></tr>
</table>
The SASS5 score was higher for the GSM biotope, although overall the aquatic macroinvertebrate assemblages preferred both the VEG and GSM biotopes (the SIC biotope was absent from this site). Of the aquatic macroinvertebrate assemblage sampled at the survey site, 45% were air-breathing families, which are not sensitive, resulting in a lower ASPT score. The overall sensitivity score ranged from 2 – 12.

From a Macroinvertebrate Response Assessment Index Model (MIRAI) perspective, the three-modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The model then derived the Ecological Category for the site. The macroinvertebrate Ecological Category is a D (57.7%).

This means the river (at this site) was in a largely modified ecological condition. A large loss of natural habitat, biota and basic ecosystem functions has occurred. The most impacted driver metric is that of flow modification at 23.6%, followed by water quality and habitat modifications at 22.7% and 22.2% respectively. The table below provides a summary of the data interpretation and the Ecological Category for the macroinvertebrates.

20 of the expected 47 taxa were recorded at this site. Taxa characterising this site in terms of abundance and sensitivity included: Baetidae 2 spp., Caenidae, and Hydropsychidae > 2 spp.</td></tr>
</table>

Macroinvertebrates

Reference taxa namely Simuliidae (FROC*5), Oligochaeta, Hydracarina, Corixidae, Naucoridae, Hydraenidae (FROC4), Baetidae >2spp, Leptophlebiidae, Corduliidae, Hydroptilidae, Leptoceridae, Elmidae, Hydrophilidae and Lymnaeidae (FROC3) were absent from the site.

Aquatic Macroinvertebrate Ecological Category, MIRAI

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC	% WEIGHT FOR METRIC GROUP
Flow Modification	FM	56.4	0.288	16.2775	3	75
Habitat	**H**	57.8	0.385	22.2222	1	100
Water Quality	**WQ**	57.4	0.308	17.6518	2	80
Connectivity & Seasonality	**CS**	80.0	0.019	1.53846	4	5
						260
Invertebrate EC				57.69		
Invertebrate EC Category				D		

The ASPT of this site was 4.9, indicative of the site being dominated by tolerant taxa, which prefer slow flowing to standing water, GSM and a low to very low requirements for unmodified physico-chemical conditions changed. A major adverse influence on the aquatic macroinvertebrate community along this upper reach is the presence of a water quality barrier further downstream. This barrier is created by poor water quality influences emanating from industrial and mining activities between this site and the confluence of the Ga-Selati with the Olifants River.

Fish

A summary of the habitats sampled and effort for site Sel_US in accordance with the flow velocity-depth classes sampled are provided below.

Sampling effort	Sel_US
Electro shocker (min) – riffles and overhanging vegetation in shallow water	20 minutes
Cast net (dimensions, efforts)	10 casts

Applying the Fish Response Assessment Index Model (FRAI) model resulted in a FRAI (%) score of 56.0%, placing it in an Ecological Category D (Largely modified).

The table below indicates the weight allocated to the different metric groups in the FRAI model for the site, and it is clear that the flows in the system (Velocity-depth and flow modification) play an important role at this site regarding the integrity of the fish populations. Reduced flows from upstream areas (flow modification) influence water quality and sediment washed down in the wet season, adds to the physico-chemical issues.

The weight allocated to the different metric groups in the FRAI model for Site Sel_DS

Metric Group	Weight (%)
Velocity-Depth	100,00
Cover	73,53
Flow Modification	97,06
Physico-Chemical	97,06
Migration	35,29
Impact of Introduced	26,47

Good overhanging vegetation provides favourable habitat to the barb (*Enteromius*) species, but the lack of good riffle habitats (partially due to sedimentation) reduces the habitat integrity of the river reach. Large pools with sandy bottoms supply good habitat to the larger fish species. Although there is some connection to the upstream system, a major adverse influence on the fish diversity at this upper site, is the presence of a water quality barrier further downstream.

This barrier is created by poor water quality influences emanating from industrial and mining activities between this site and the confluence of the Ga-Selati with the Olifants

Fish	River. The Olifants River is a major source of subtropical species, species that most probably are prevented from migrating upstream due to flow related issues and seepage adding pollutants to the surface water. Fish such as the subtropical Characidae family, which includes the tigerfish, imberi and silver robber, are examples of this issue, becoming very rare upstream in the Ga-Selati River but are reasonably abundant in the Olifants River.

** Habitat assessment refers to an evaluation of fish habitat potential (i.e. the potential that the habitat provides suitable conditions for a fish species to live there) at a site in terms of the diversity of velocity-depth classes present and the presence of various cover types at each of these velocity-depth classes. This provides a framework within which the presence, absence and frequency of occurrence of species can be interpreted. Habitat assessment includes a general consideration of impacts that may influence the condition or integrity of fish habitat at a site (Kleynhans, Louw, & Moolman, 2007).*

Table 7.4.8.2(c): EcoStatus Results

Driver Component	Score (%)	PES	Description
IHI: Instream	30	**E**	Seriously modified
IHI: Riparian	3	**F**	Critically modified
Response Component	**Score (%)**	**PES**	**Description**
Macroinvertebrates	57.7	**D**	Largely modified
Fish	56.0	**D**	Largely modified
Ecostatus	29.9	**E**	Seriously modified

7.4.9.3. Baseline Summary Results: Site Sel_DS

This site in the Ga-Selati River downstream of the proposed study and adjacent to the railway within the Bosveld Phosphates property, but still upstream from other industrial operators namely the Phalaborwa Industrial Complex.

See Table 7.4.9.3(a) for details pertaining to this sampling site. Table 7.4.9.3(b) relays the data results and the Present Ecological State (PES) results and Table 7.4.9.3(c) the Ecostatus results attained.

Table 7.4.9.3(a): Details of Sel_DS Sampling Site

Water Management Area (WMA)	Olifants WMA 2
Quaternary catchment	B72K
Level 1 Ecoregion	Lowveld
Level 2 Ecoregion	3.03
Latitude; Longitude	24°00'40.0284"S; 31°05'01.3560"E
Geomorphological zone	E (lower foothills)
Altitude (m.a.s.l)	348
DWS, 2014 PES	**E (seriously modified)**
Ecological Importance (EI)	Moderate
Ecological Sensitivity (ES)	High

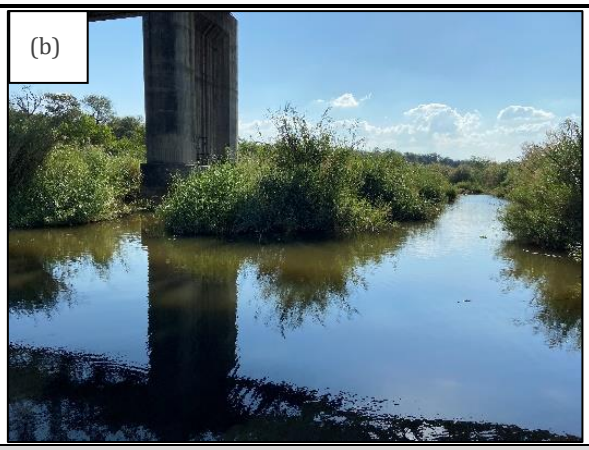
(a)	(b)
	
Upstream Photograph	**Downstream Photograph**

Table 7.4.9.3(b): Data results and Present Ecological State (PES)

Water Quality	**pH:** 7.3 **TDS:** 988.7 mg/l **Temperature:** 26.0°C
Habitat Potential Assessment for Fish	The downstream Ga-Selati site (Sel_DS) consisted of favourable riffles in anastomosing channels flanked by a dense growth of overhanging reeds, downstream of the bridge. The reed beds provide good overhanging and root wad habitats (refer to upstream site photograph (a) above). Upstream of the bridge, the damming effect of the low-level cement slab/bridge creates ample deep-water habitats with a number of inundated reed islands and good marginal overhanging vegetation (refer todownstream site photograph (b) above).
Habitat Availability for Aquatic Macroinvertebrates (IHAS)	The habitat availability was *adequate (IHAS%: 60%)*. The bridge crossing at the site, has resulted in inundation upstream and a deep pool and furthermore, modification downstream of the bridge. This contributed to the poor physical stream condition at this site. The SIC biotope was also poor, although good GSM and vegetation (although dominated by *Phragmites spp.)* – see Figure 7.4.9.3(a).

Site	Sampling Habitat				IHAS	
	Stones-in-Current	Vegetation	Other Habitat / General	Physical Stream Condition	Score	Description
Sel_DS	11	11	18	20	60	Adequate

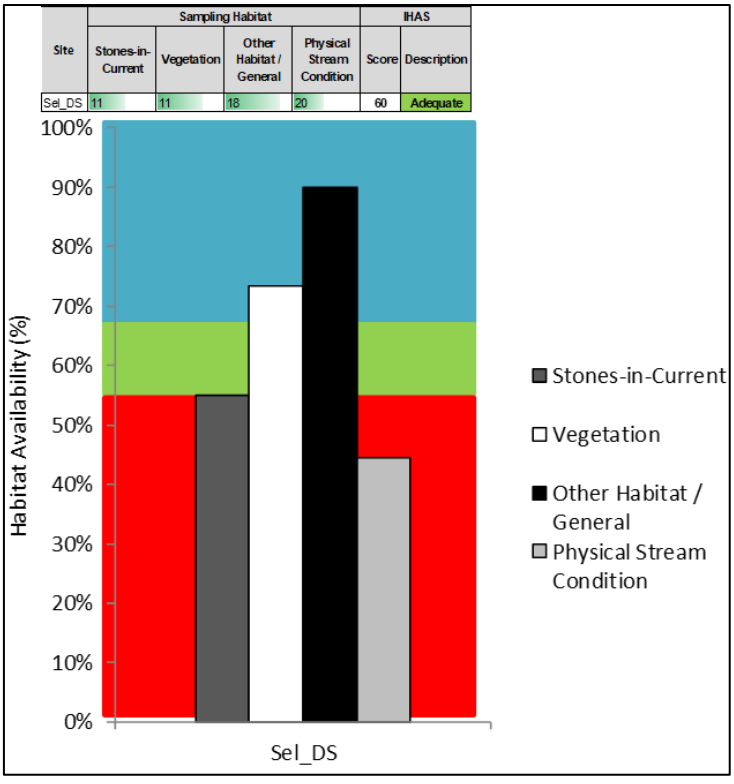


Figure 7.4.9.3(a): IHAS results for site Sel_DS

<table>
<tr><td>IHI (Instream)</td><td>These assessments provide a high-level indication of the condition of the river reaches chosen for the purposes of this study. The instream habitat integrity of site Sel_DS was identified to be in a largely modified state (Class D) (Score: 56). The main factors negatively influencing the instream habitat integrity included the following:
Inundation;
Instream modification; and
Channel modification.
The large modification to the above categories were generally present with a clearly detrimental impact on habitat quality, diversity, size and variability, although the larger area was not influenced. These modifications were primarily owing to the bridge over the river for Bosveld Phosphates employees to access either side of the river on their property. This bridge is resulting in upstream inundation and downstream channel and instream modification. The bridge however does not function as an instream barrier for fish migration upstream.</td></tr>
<tr><td>IHI (Riparian)</td><td>The riparian habitat integrity of site Sel_DS was identified to be in a moderately modified state (Class C) (Score: 63). The main factors negatively influencing the riparian habitat integrity included the following:
Channel modification.
The moderate modification to the above category was present at a small number of localities and the impact on habitat quality, diversity, size and variability was also limited. These modifications were primarily owing to local movement of wildlife within the riparian zone (i.e. hippo's, crocodiles, and various mammal species either inhabiting the river or utilising it as a water source).</td></tr>
<tr><td>Macroinvertebrates</td><td>SASS5 Score: 93 (62% of the reference conditions)
Number of Taxa: 18
ASPT Value: 5.2 (83% of the reference conditions)

SASS5 Summary according to Biotope
<table>
<tr><th rowspan="2">Aquatic Macroinvertebrates</th><th colspan="3">Sel-DS</th></tr>
<tr><th>SIC</th><th>VEG</th><th>GSM</th></tr>
<tr><td>SASS Score</td><td>58</td><td>52</td><td>40</td></tr>
<tr><td>Number of Taxa</td><td>10</td><td>12</td><td>9</td></tr>
<tr><td>ASPT</td><td>5.8</td><td>4.3</td><td>4.4</td></tr>
</table>
Aquatic macroinvertebrates had a preference for VEG, followed by SIC and then GSM. The sensitivity score of all families identified ranged from 1 – 12, with 33% being air-breathing families, which are not sensitive, resulting in a lower ASPT score.

From a MIRAI perspective, the three-modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The model then derived the Ecological Category for the site.

The macroinvertebrate Ecological Category is a D (56.9%). This means the river (at this site) is in a largely modified ecological condition. A large loss of natural habitat, biota and basic ecosystem functions has occurred over time.

The most impacted driver metric is that of flow modification at 25.0%, followed by habitat modification at 23.3% and water quality modifications at 22.6%. The table below provides the summary of the data interpretation and the Ecological Category for the macroinvertebrates.

18 of the expected 43 taxa were recorded at this site. Taxa characterising this site in terms of abundance and sensitivity included: Baetidae 2 spp., Caenidae Leptophlebiidae, Hydropsychidae > 2 spp and Hydraenidae. Reference taxa namely Belostomatidae, Gerridae, Dytiscidae, Tabanidae (FROC5), Hydracarina, Corixidae, Gyrinidae (FROC4), Heptageniidae, Corduliidae, Naucoridae, Nepidae, Leptoceridae, Ancylidae and Lymnaeidae (FROC3), were absent from the site.

The ASPT of this site was 5.2, indicative of the site being dominated by tolerant taxa, which prefer the moderately fast flowing water, cobbles, GSM and low requirements for unmodified physico-chemical conditions changed.

Aquatic Macroinvertebrate Ecological Category, MIRAI</td></tr>
</table>

Macroinvertebrates

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC	% WEIGHT FOR METRIC GROUP
Flow Modification	FM	55.0	0.288	15.8654	3	75
Habitat	**H**	56.7	0.308	17.4359	2	100
Water Quality	**WQ**	57.4	0.385	22.0648	1	80
Connectivity & Seasonality	**CS**	80.0	0.019	1.53846	4	5
						260
Invertebrate EC				56.9045		
Invertebrate EC Category				D		

A slightly more improved ASPT value of the aquatic macroinvertebrate community at this site is primarily owing to better habitat diversity, although this site is situated in the area described as a water quality barrier. The good flow dynamics at this site have improved the diversity of the community, although high abundances of the exotic Thiridae was noted within the GSM biotope. This is clearly resulting in immense competition for space with other macroinvertebrates with a preference for GSM.

Fish

A summary of the habitats sampled and effort for site Sel_US in accordance with the flow velocity-depth classes sampled are provided below.

Sampling effort	Sel_DS
Electro shocker (min) – riffles and overhanging vegetation in shallow water	25 minutes
Cast net (dimensions, efforts)	8 casts

Applying the FRAI model resulted in a FRAI (%) score of 60.6%, placing it in an Ecological Category C/D (Moderately to Largely modified). The table below indicates the weight allocated to the different metric groups in the FRAI model for the site, and it is clear that the water quality, in conjunction with flows in the system, plays an important role at this site regarding the integrity of the fish populations.

The weight allocated to the different metric groups in the FRAI model for Site Sel_US

Metric Group	Weight (%)
Velocity-Depth	97,14
Cover	71,43
Flow Modification	88,57
Physico-Chemical	100,00
Migration	34,29
Impact of Introduced	25,71

The habitat diversity at the site, which includes a large pool and many downstream riffles and small rapids flowing through channels, with abundant overhanging habitat created by marginal reeds, supply habitat to a number of fish species. Good overhanging vegetation provides favourable habitat to the barb (*Enteromius*) species, and the good riffle and other fast flowing habitats resulted in the presence of three *Chiloglanis* species. Although this site is situated in the area described as a water quality barrier, the good flows associated with the cyclone Eloise, probably scoured the river and cleansed it notably, which explains the presence of these sensitive species. There is a good chance that fish migrating from the Olifants River are able to reach this site. Tigerfish are present in the lower reaches of the river, just upstream from the Olifants River confluence.

Table 7.4.9.3(c): EcoStatus Results

Driver Component	Score (%)	PES	Description
IHI: Instream	56	**D**	Largely modified
IHI: Riparian	63	**C**	Moderately modified
Response Component	**Score (%)**	**PES**	**Description**
Macroinvertebrates	56.9	**D**	Largely modified
Fish	60.6	**C/D**	Moderately to largely modified
Ecostatus	60.8	**C/D**	Moderately to largely modified

7.4.9.4. Baseline Summary Results: Site Oli_US

Reference site located in the Olifants River, upstream of the Ga-Selati River confluence and downstream of the Phalaborwa Barrage.

See Table 7.4.9.4(a) for details pertaining to this sampling site. Table 7.4.9.4(b) relays the data results and the Present Ecological State (PES) results and Table 7.4.9.4(c) the Ecostatus results attained.

Table 7.4.9.4(a): Details of Oli_US Sampling Site

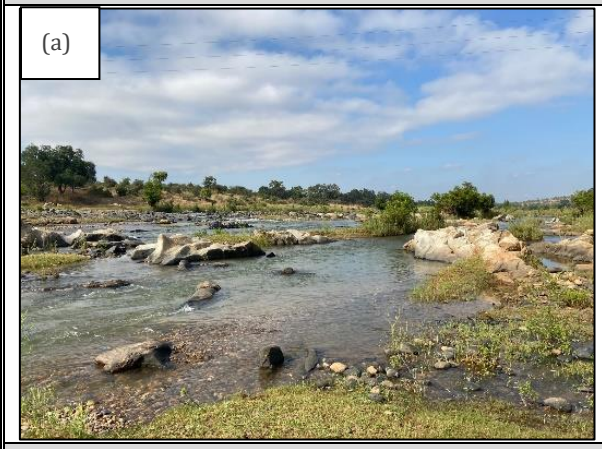
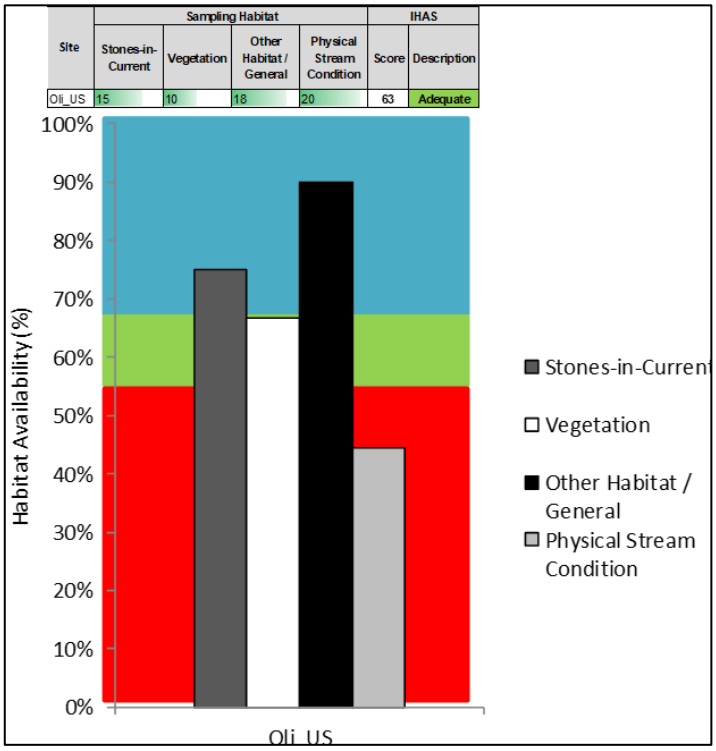
Water Management Area (WMA)	Olifants WMA 2
Quaternary catchment	B72K
Level 1 Ecoregion	Lowveld
Level 2 Ecoregion	3.03
Latitude; Longitude	24°02'25.5696"S; 31°10'20.1792"E
Geomorphological zone	E (lower foothills)
Altitude (m.a.s.l)	298
DWS, 2014 PES	**E (seriously modified)**
Ecological Importance (EI)	Moderate
Ecological Sensitivity (ES)	High
(a) 	(b) 
Upstream Photograph	**Downstream Photograph**

Table 7.4.9.4(b): Data results and Present Ecological State (PES)

Water Quality	**pH:** 7.5 **TDS:** 339.3 mg/l **Temperature:** 27.3°C
Habitat Potential Assessment for Fish	The upstream Olifants River site (Oli_US) consists of two major systems: • *Main channel of deep water and medium flows (refer to site photograph b above), and* • *Some slower flowing side channels, which form large slow-flowing pools interlinked with shallow riffles (refer to site photograph a above).* This site had a lack of marginal vegetation.
Habitat Availability for Aquatic Macroinvertebrates (IHAS)	The habitat availability was *adequate (IHAS%: 63%)*. The flow conditions and velocities varied at this site, of which further offered a diversity of aquatic biotopes. The SIC and other habitats i.e. GSM were rated good, with vegetation being adequate. Not only was the vegetation primarily dominated by *Phragmites spp*., but some instream vegetation could not be accessed (Figure 7.4.9.4(a)).  **Figure 7.4.9.4(a): IHAS results for site Oli_US**
IHI (Instream)	These assessments provide a high-level indication of the condition of the river reaches chosen for the purposes of this study. The instream habitat integrity of site Oli-US was identified to be in a moderate to largely natural state (Class C/B) (Score: 80). Although the instream integrity was moderate to largely natural, there were a few factors slightly influencing the instream habitat integrity which included: • *Channel modification; and* • *Physico-chemical.* The moderate modification to the above categories were present at a small number of localities and the impact on habitat quality, diversity, size and variability was also limited. These moderate modifications were primarily owing to the observed silt content covering the instream biotopes.
IHI (Riparian)	The riparian habitat integrity of site Oli-US was identified to be in a moderately modified state (Class C/B) (Score: 79). Although the riparian integrity was moderate to largely natural, the moderate modification to bank erosion was present at a small number of localities and the impact on habitat quality, diversity, size and variability was also limited. These modifications were primarily owing to local movement of wildlife within the riparian zone (i.e. hippo's, crocodiles, and various mammal species either inhabiting the river or utilising it as a water source).
Macroinvertebrates	**SASS5 Score:**137 (69% of the reference conditions) **Number of Taxa:** 21 **ASPT Value:** 6.5 (in-line with the reference conditions)

Macroinvertebrates

SASS5 summary according to biotope

Aquatic Macroinvertebrates	Oli_US		
	SIC	VEG	GSM
SASS Score	103	59	24
Number of Taxa	15	11	5
ASPT	6.9	5.4	4.8

Aquatic macroinvertebrates had a preference for SIC (hence the higher ASPT values for this biotope owing to more sensitive taxa being identified and mentioned further below), followed by VEG and only 5 identified in the GSM biotope. The sensitivity score of all families identified ranged from 3 – 13. Six taxa recorded within the SIC biotope had a sensitivity score of >8, elevating the ASPT score to 6.9 for this biotope, indicative of moderately tolerant taxa, with a preference for fast flowing water. Overall, this site recorded a higher overall ASPT value compared to the Ga-Selati River. Only 28.5% of the community were air-breathing taxa.

From a MIRAI perspective, the three-modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The model then derived the Ecological Category for the site.

The macroinvertebrate Ecological Category is a C (62.8%). This means the river (at this site) is in a moderately modified ecological condition. There has been loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.

The most impacted driver metric was that of flow modification at 25.9%, followed by water quality modification 18.5%, and least impacted was habitat modifications at 13.8%. The table below provides the summary of the data interpretation and the Ecological Category for the macroinvertebrates.

Aquatic macroinvertebrate Ecological Category, MIRAI

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC	% WEIGHT FOR METRIC GROUP
Flow Modification	FM	54.1	0.313	16.8962	1	100
Habitat	**H**	66.2	0.281	18.627	2	90
Water Quality	**WQ**	61.5	0.281	17.3107	2	90
Connectivity & Seasonality	**CS**	80.0	0.125	10	3	40
						320
Invertebrate EC				62.834		
Invertebrate EC Category				C		

21 of the expected 44 taxa were recorded at this site. Taxa characterising this site in terms of abundance and sensitivity included: Baetidae >2spp., Caenidae, Heptageniidae, Leptophlebiidae, Tricorythidae, Corduliidae and Hydraenidae.

Reference taxa namely Hydropsychidae >2spp, Tabanidae, Chironomidae, Corixidae, Sphaeridae (FROC*5), Turbellaria, Oligochaeta, Hirudinea, Elmidae (FROC4), Hydracarina, Belostomatidae, Notonectidae, Nepidae, Hydrophilidae, Athericidae, Culicidae, Muscidae, (FROC3) were absent from the site.

The ASPT of this site was 6.5, indicative of the site being dominated by tolerant to moderately tolerant taxa, which prefer very fast to fast flowing waters, cobbles and rocks (present at this site), GSM and a low requirement for unmodified physico-chemical conditions changed.

Fish

A summary of the habitats sampled and effort for site Oli_US in accordance with the flow velocity-depth classes sampled are provided below.

Fish

Applying the FRAI model resulted in a FRAI (%) score of 66.0%, placing it in an Ecological Category C (Moderately modified).

Sampling Effort	Oli_US
Electro shocker (min) – riffles and overhanging vegetation in shallow water	30 minutes
Cast net (dimensions, efforts)	10 casts

The table below indicates the weight allocated to the different metric groups in the FRAI model for the site, cover plays a significant role in the integrity of the Olifants River. The lack of ample marginal vegetation and the covering of rocky habitats with alluvial sediment, signifies that cover is an important metric in this river reach. Large floods tend to scour marginal vegetation on alluvial bars and banks, and the resulting sediment settles on the bottom substrates, including riffles and gravel beds.

During the dry season, it is clear that flows in the system (velocity-depth and flow modification) becomes more important, especially when water quality also becomes an issue.

The weight allocated to the different metric groups in the FRAI model for Site Oli_US

Metric Group	Weight (%)
Velocity-Depth	90,54
Cover	100,00
Flow Modification	97,30
Physico-Chemical	82,43
Migration	28,38
Impact Of Introduced	12,16

The habitat diversity at the site, which includes a deep river run and large side channel pools. The backwater pools are linked to each other with shallow riffles and small rapids. However, the lack of marginal or overhanging vegetation is very evident.

The three species of freshwater eels (*Anguilla*) disappeared from the system when their migration route from the sea was cut off by the large Massingir Dam in Mozambique. The scarcity of marginal vegetation explains the low numbers of barb (*Enteromius*) species encountered. The rapids and deeper riffles are however favourable habitat for all the rheophilic (flow-dependent) fish species, including *Labeobarbus* and *Labeo* species.

Table 7.4.9.4(c): EcoStatus Results

Driver Component	Score (%)	PES	Description
IHI: Instream	80	**B/C**	Moderately modified
IHI: Riparian	79	**B/C**	Moderately modified
Response Component	**Score (%)**	**PES**	**Description**
Macroinvertebrates	62.8	**C**	Moderately modified
Fish	66.0	**C**	Moderately modified
Ecostatus	71.6	**C**	Moderately modified

7.4.9.5. Baseline Summary Results: Site Oli_DS

Situated in the Olifants River approximately 1km downstream from the Ga-Selati River confluence.

See Table 7.4.9.5(a) for details pertaining to this sampling site. Table 7.4.9.5(b) relays the data results and the Present Ecological State (PES) results and Table 7.4.9.5(c) the Ecostatus results attained.

Table 7.4.9.5(a): Details of Oli_DS Sampling Site

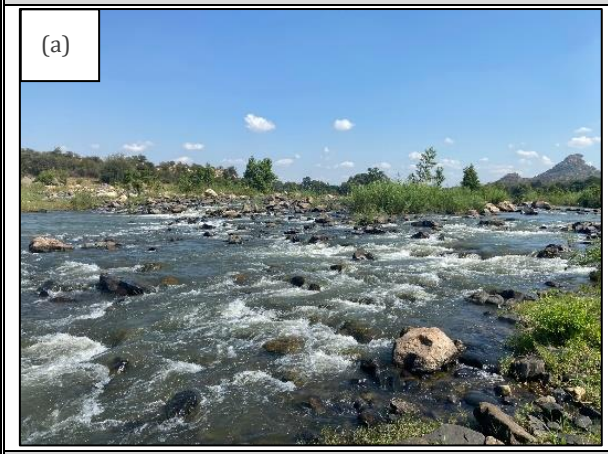
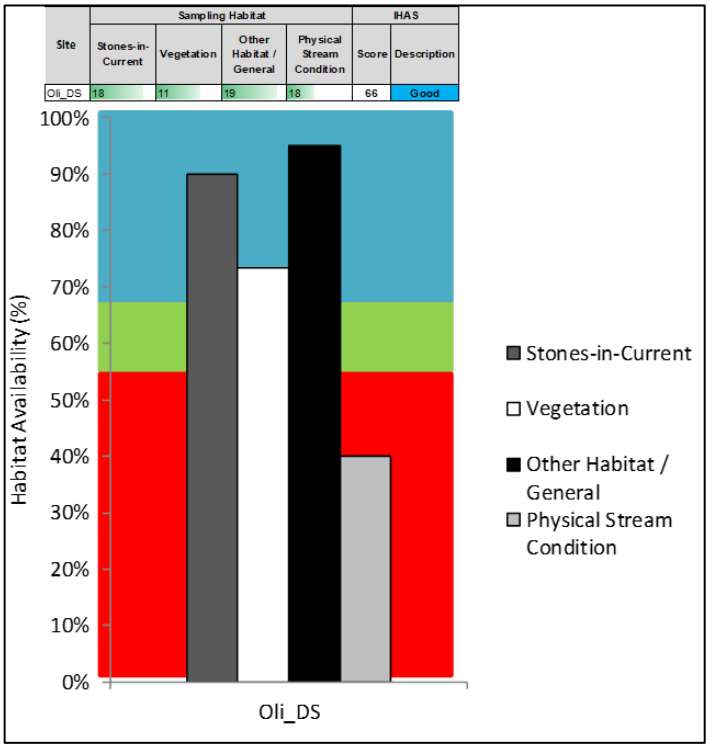
Water Management Area (WMA)	Olifants WMA 2
Quaternary catchment	B73C
Level 1 Ecoregion	Lowveld
Level 2 Ecoregion	3.03
Latitude; Longitude	24°01'50.4120"S; 31°11'38.6880"E
Geomorphological zone	E (lower foothills)
Altitude (m.a.s.l)	295
DWS, 2014 PES	**D (largely modified)**
Ecological Importance (EI)	High
Ecological Sensitivity (ES)	High
(a) 	(b) 
Upstream Photograph	**Downstream Photograph**

Table 7.4.9.5(b): Data results and Present Ecological State (PES)

Water Quality	**pH**: 7.7 **TDS:** 364.0 mg/l **Temperature:** 27.3°C
Habitat Potential Assessment for Fish	The downstream Olifants River site (Oli_DS) consists an upstream bedrock control that spans the width of the river and this creates extensive fast flowing habitats over rocky substrates. Excellent rocky rapids and cobble riffles supply favourable habitat to rheophilic fish species (refer to site photograph a above). Further downstream at this site, the river slows down into a medium deep but wide channel with a sandy bottom and some backwaters (refer to site photograph b above). Smaller side channels through reeds and other marginal vegetation, provide favourable habitat for smaller fish species (Figure 7.4.9.5(a)).

Habitat Potential Assessment for Fish	 **Figure 7.4.9.5(a): Site Oli_DS**
Habitat Availability for Aquatic Macroinvertebrates (IHAS)	The habitat availability was *good (IHAS%: 66%)*. The flow conditions and velocities varied at this site, of which further offered a diversity of aquatic biotopes. The SIC, vegetation and other habitats i.e. GSM were rated good, with the physical stream conditions rated poor. This was primarily owing to the high silt content at the site at the time of the survey (Figure 7.4.9.5(b)).  **Figure 7.4.9.5(b): IHAS results for site Oli_DS**
IHI (Instream)	These assessments provide a high-level indication of the condition of the river reaches chosen for the purposes of this study. The instream habitat integrity of site Oli_DS was identified to be in a moderate to largely natural state (Class C/B) (Score: 77). Although the instream integrity was moderate to largely natural, there were a few factors slightly influencing the instream habitat integrity which included: • *Channel modification; and* • *Physico-chemical.* The moderate modification to the above categories were present at a small number of localities and the impact on habitat quality, diversity, size and variability was also limited. These moderate modifications were primarily owing to the observed silt content covering the instream biotopes.

IHI (Riparian)

The riparian habitat integrity of site Oli_DS was identified to be in a moderately modified state (Class C/B) (Score: 77). Although the riparian integrity was moderate to largely natural, the moderate modification to bank erosion was present at a small number of localities and the impact on habitat quality, diversity, size and variability was also limited. These modifications were primarily owing to local movement of wildlife within the riparian zone (i.e. hippo's, crocodiles, and various mammal species either inhabiting the river or utilising it as a water source).

Macroinvertebrates

SASS5 Score:138 (69% of the reference conditions)
Number of Taxa: 22
ASPT Value: 6.3 (97% of the reference conditions)

SASS5 summary according to biotope

Aquatic Macroinvertebrates	Oli_DS		
	SIC	VEG	GSM
SASS Score	87	69	31
Number of Taxa	14	11	5
ASPT	6.2	6.3	6.2

Similar to the upstream site, aquatic macroinvertebrates had a preference for SIC, followed by VEG and then the GSM biotope. The sensitivity score of all families identified ranged from 3 – 13. Six taxa recorded within the SIC biotope had a sensitivity score of >8, elevating the ASPT score. The higher ASPT value for VEG was attributed from the single individual of Dixidae (Dixid midge) recorded with a sensitivity score of 10 out of 15. Only 22.7% of the community were air-breathing taxa.

There is a slight decrease in the ASPT value from the upstream site (6.5) to the downstream site (6.3) along the Olifants River. Consequently, the impaired water quality flowing in at the confluence of the Ga-Selati and Olifants river (just upstream from site Oli_DS), may thus be having an influence on the health and integrity of the downstream site on the Olifants River (Oli_DS) from both a driver and response perspective.

From a MIRAI perspective, the three-modification metrics of the MIRAI, namely flow modification, habitat and water quality, were each ranked and weighted and then rated according to change from the reference condition. The model then derived the Ecological Category for the site.

The macroinvertebrate Ecological Category is a C (62.3%). This means the river (at this site) is in a moderately modified ecological condition. There has been loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.

The most impacted driver metric was that of water quality modification at 24.4%, followed by flow modification 20.3%, and least impacted was habitat modifications at 15.9%. The table below provides the summary of the data interpretation and the Ecological Category for the macroinvertebrates.

Aquatic macroinvertebrate Ecological Category, MIRAI

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC	% WEIGHT FOR METRIC GROUP
Flow Modification	FM	59.7	0.313	18.6475	1	100
Habitat	**H**	64.1	0.281	18.0388	2	90
Water Quality	**WQ**	55.6	0.281	15.6331	2	90
Connectivity & Seasonality	**CS**	80.0	0.125	10	3	40
						320
Invertebrate EC				62.3195		
Invertebrate EC Category				C		

22 of the expected 46 taxa were recorded at this site. Taxa characterising this site in terms of abundance and sensitivity included: Baetidae >2spp., Caenidae Heptageniidae, Leptophlebiidae, Tricorythidae, Porifera, Corduliidae, Dixidae and Hydraenidae.

<table>
<tr><td>Macroinvertebrates</td><td>Reference taxa namely Corixidae (FROC*5), Dytiscidae, Elmidae, Gyrinidae, Hirudinea, Veliidae, Belostomatidae, Corbiculidae, Sphaeridae (FROC4), Hydracarina, Naucoridae, Nepidae, Notonectidae, Hydropsychidae >2spp, Ceratopogonidae, Culicidae, Ancylidae, Muscidae (FROC3) were absent from the site.

The ASPT of this site was 6.3, indicative of the site being dominated by tolerant to moderately tolerant taxa, which prefer very fast to fast flowing waters, cobbles and rocks, GSM and a low requirement for unmodified physico-chemical conditions changed. Similar to the upstream site.</td></tr>
<tr><td>Fish</td><td>A summary of the habitats sampled and effort for site Oli_DS in accordance with the flow velocity-depth classes sampled are provided below.

<table>
<tr><th>Sampling effort</th><th>Oli_DS</th></tr>
<tr><td>Electro shocker (min) – riffles and overhanging vegetation in shallow water</td><td>25 minutes</td></tr>
<tr><td>Cast net (dimensions, efforts)</td><td>15 casts</td></tr>
</table>

Applying the FRAI model resulted in a FRAI (%) score of 66.0%, placing it in an Ecological Category C (Moderately modified).

Table indicates the weight allocated to the different metric groups in the FRAI model for the site, cover again plays a significant role in the integrity of the Olifants River. Due to the proximity to the upstream site, the overall geomorphology and potential habitats are very similar to Site Oli_US. Lack of marginal vegetation and sediment deposition after floods are major aspects that influence the habitat integrity of the site. Flow related metrics become important during the dry season.

The weight allocated to the different metric groups in the FRAI model for Site Oli_DS
<table>
<tr><th>Metric Group</th><th>Weight (%)</th></tr>
<tr><td>Velocity-Depth</td><td>90,54</td></tr>
<tr><td>Cover</td><td>100,00</td></tr>
<tr><td>Flow Modification</td><td>97,30</td></tr>
<tr><td>Physico-Chemical</td><td>82,43</td></tr>
<tr><td>Migration</td><td>28,38</td></tr>
<tr><td>Impact Of Introduced</td><td>12,16</td></tr>
</table>

The broad bedrock control over the width of the river supplies this site with extensive rocky habitats, whereafter the water slows down in a large, medium deep pool on the downstream side. The species composition of the expected species is again similar to the upstream site in the Olifants River, thus the identical FRAI scores.</td></tr>
</table>

Table 7.4.9.5(a): EcoStatus Results

Driver Component	Score (%)	PES	Description
IHI: Instream	77	**B/C**	Moderately modified
IHI: Riparian	77	**B/C**	Moderately modified
Response Component	**Score (%)**	**PES**	**Description**
Macroinvertebrates	62.3	**C**	Moderately modified
Fish	66.0	**C**	Moderately modified
Ecostatus	70.5	**C**	Moderately modified

7.4.10. Wetlands

Specialist consultants WCS Scientific (Pty.) Ltd. were requested to conduct a detailed Wetland delineation and assessment specialist study in support of the proposed project.

The relevant Specialist Report is:

Baseline Wetland and Riparian Assessment for the Bosveld Phosphates (Pty) Ltd – Magnetite Landfill Facility; April 2022.

The information provided below represents an extract of the baseline description compiled with specific reference to the project area (proposed magnetite waste site disposal facility footprint).

7.4.10.1. Delineation & Typing of Wetlands and Riparian Habitats

To ensure due consideration of the 500m Regulated Area around wetlands (as required by GN509) the project study area together with a 500m buffer area (greater study area) was surveyed for wetlands, riparian habitat and watercourses, with specific emphasis on any of these habitats falling within the project study area (see Figure 7.4.10.1(a)). **No natural wetland habitat was identified within the project study area or the 500m buffer**.

However, several water courses and related features were identified within the project study area and its immediate surroundings. A map of identified water resource features is provided in Figure 7.4.10.1(a).

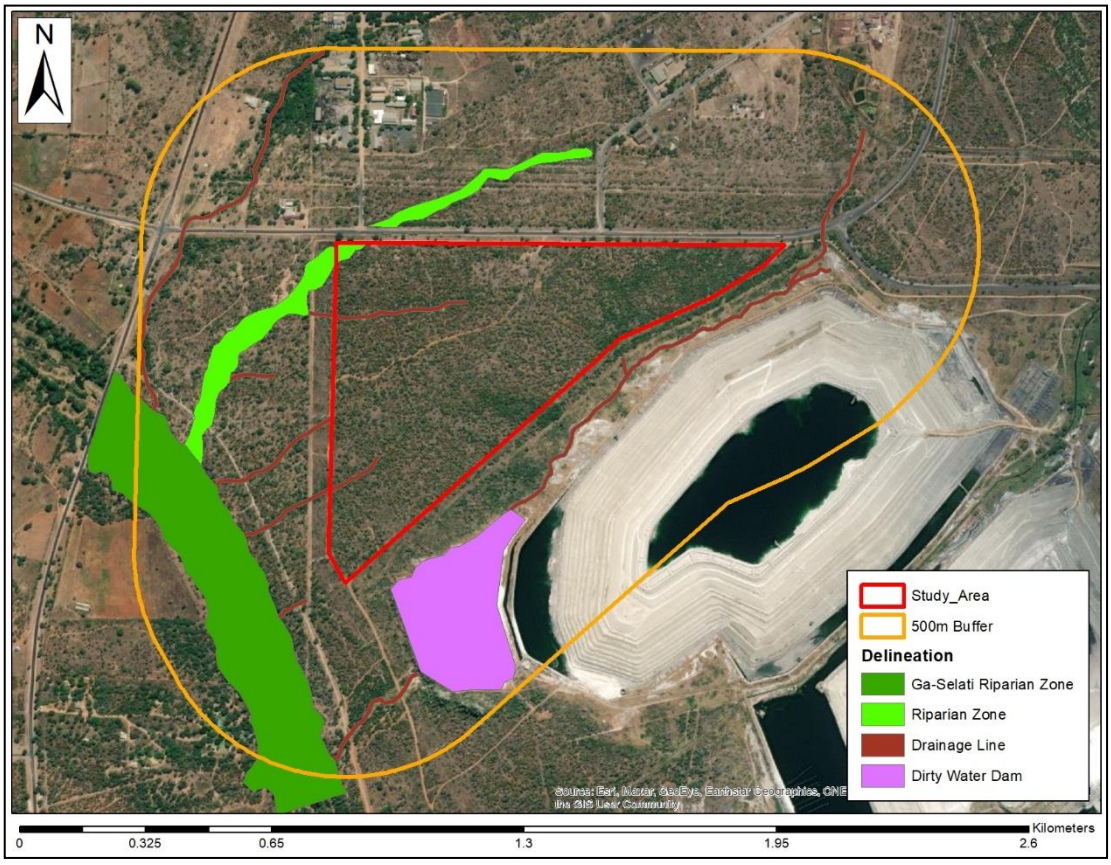


Figure7.4.10.1(a): Map of the delineated riparian zones and watercourses within the project study area

Identified features include the following:

- Ga-Selati River and associated Riparian habitat
- Riparian habitat associated with a small, non-perennial tributary of the Ga-Selati
- Several small, ephemeral Drainage Lines on and adjacent to the study area
- A large Dirty Water Dam area to the south of the proposed development site and associated with the existing Tailings Facilities

The most significant aquatic ecosystem within the greater project study area is considered to be the Ga-Selati River and associated riparian habitat. Adjacent to the project study area and approximately 200m to the west of the proposed development site the Ga-Selati River flows roughly from north to south – ***the Regulated Area[1] surrounding the Ga-Selati River does therefore not extend into the proposed development site***.

The Ga-Selati is a perennial river and considered a type "C" channel according to the channel classification proposed by van Deventer, Teixeira-Leite & Macfarlane (2014) (Table 7.4.10.1(a) below). The river is characterised by a predominantly sandy, alluvial bed with occasional rock outcrops. A narrow active channel occurs within a large macro-channel, with the active channel mostly lined by dense stands of *Phragmites mauritianus*. Slow flowing, deeper pools are interspersed by shallow faster flowing sections with occasional rifles. Sand mining occurs in numerous locations along the river.

Table 7.4.10.1(a): Classification of channels according to nature of flows (taken from van Deventer, Teixeira-Leite & Macfarlane, 2014).

	CHANNEL SECTION (CLASS)		
	"A" type	**"B" type**	**"C" type**
	Ephemeral systems	**Weakly ephemeral to seasonal systems**	**Perennial systems**
DESCRIPTION	A watercourse that has little to no riparian habitat and no soil hydromorphy (i.e. strongly ephemeral systems). Signs of wetness rarely persist in the soil profile	A watercourse with riparian vegetation/habitat and intermittent base flow (i.e., weakly ephemeral to non-perennial/seasonal systems). These channels show signs of wetness indicating the presence of water for significant periods of time.	A watercourse with permanent-type riparian vegetation/habitat, permanent base flow and permanent inundation (i.e., perennial systems).
HYDROLOGY	A-section channels are situated well above the zone of saturation (no direct contact between surface water system and ground water system) and hence do not carry base-flows. They do however carry storm water runoff following intense rainfall events (ephemeral), but this is generally short-lived.	Channel bed situated within the zone of the seasonally fluctuating regional water table (i.e., intermittent base flow depending on water table). Periods of no flow may be experienced during dry periods, with residual pools often remaining within the channel.	Water course is situated within the zone of the permanent saturation, meaning flow is all year round except in the case of extreme drought.
TOPOGRAPHICAL POSITION	Valley head (upper reaches of catchments). Channel type also linked to steep slopes which are	Mid-section of valley (middle reaches of catchments).	Valley bottom areas (middle to lower reaches of catchments).

[1] The Regulated Area of a watercourse in respect to riparian areas is defined in GN509 of 2016 as *(a) The outer edge of the 1 in 100 year floodline and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of the river, spring, natural channel, lake or dam. (b) In the absence of a determined 1 in 100 year floodline or riparian area the area within 100m from the edge of a watercourse where the edge of the watercourse is the first identifiable annual bank fill flood bench*.

	responsible for water leaving the system rapidly.		

The riparian habitat is well developed and easily visible on aerial imagery as a band of darker green vegetation. The riparian habitat includes the following species *Colophospermum mopane, Combretum appendiculatum, C. hereroense, Croton megalobotrys, Dalbergia melanoxylon, Dichrostachys cinerea, Flueggea virosa, Grewia flava, G. flavescens, Gymnosporia senegalensis, Schotia brachypetala, Sclerocarya birrea, Senegalia erubescens*. and *S. nigrescens*. Photographs of the Ga-Selati and associated riparian habitat are provided in Figure 7.4.10.1(b).

Figure 7.4.10.1(b): Photos of the Ga-Selati River and associated riparian habitat adjacent to the proposed development site.

The habitat associated with the smaller watercourses traversing the site covers 0.8 hectares of the project study area. All of these watercourses are considered ephemeral in nature and convey surface runoff only during periods of high rainfall. At the time of the site visit, none of these watercourses supported any surface water, despite a large rainfall event the evening before. These watercourses can be considered preferential flow paths for surface runoff generated in the landscape during large rainfall events (see Figure 7.4.10.1(c)).

With the exception of the watercourse in the extreme north-western corner of the site, the vegetation of these small watercourses is indistinguishable from the surrounding terrestrial vegetation and no riparian habitat is associated with these features.

The vegetation associated with the small watercourse in the extreme north-western corner of the site is described in the terrestrial ecology report by Zinn (2022) as follows:

> *For the most part, the flora composition along these drainage lines essentially mirrors that of adjacent areas of Colophospermum mopane – Combretum apiculatum Bushveld, with a few additional taxa recorded along the more defined drainage line in the north-west corner of the local study area. Additional woody species recorded include Manilkara mochisia, Pappea capensis, Phyllanthus reticulatus, Searsia leptodictya, Sesbania bispinosa* and Spirostachys africana, while additional herbaceous species recorded at this site include inter alia; Panicum deustum, Flaveria bidentis* and Xanthium strumarium*.*

The habitat associated with the watercourse in the north-western corner of the study site has thus been classed as a riparian zone. Photos of this habitat are provided in Figure 7.4.10.1(d).

This tributary exists as an ephemeral drainage line system that could be classed as a type "A" channel (refer to 7.4.10.1(a)) with some riparian habitat in evidence.

Figure 7.4.10.1(c): Photos of the small ephemeral watercourses on site.

Flowing parallel to the south eastern edge of the study area, a watercourse occurs along the base of the existing TSF. This watercourse has been extensively disturbed during construction and operation of the TSF, with most woody vegetation cleared from the watercourse and its banks.

A large Dirty Water Dam has also been constructed along this watercourse as part of the water management infrastructure associated with the existing TSF. Approximately half of the project study area falls within the catchment of this existing dirty water area.

Figure 7.4.10.1(d): Bottom right shows vegetation clearing under the powerline across the riparian habitat.

7.4.10.2. Present Ecological State (PES)

A Present Ecological State (PES) assessment was undertaken for all riparian habitat and watercourses within the proposed development footprint.

The riparian habitat within the site is characterised by natural vegetation, though a number of activities have impacted on the riparian habitat. Immediately upstream of the study area the riparian habitat is crossed by the eastern extension of Makhushani Drive, with culvert crossings concentrating flows. Makhushani Drive with associated road reserve and fences represents a 40m wide area of cleared and transformed habitat that fragments the riparian zone and limits its functionality as a movement corridor for wildlife. Immediately downstream of the project study area the riparian habitat is crossed by a large powerline, with the powerline servitude (40m wide) cleared of large woody vegetation, further impacting on the integrity of the riparian habitat. Consequently, the watercourse on site is considered to be in a PES C category, indicating a Moderately Modified riparian habitat (see Figure 7.4.10.2(a)).

The Ga-Selati River and associated riparian zone was assessed by Perlidae Aquatic Consulting (2021) at locations just upstream and downstream of the project study area and was found to vary from PES E (Seriously Modified) in the upstream reach to PES C/D (Moderately to Largely Modified) in the downstream reach. Within the reach adjacent to the project study area sand mining and associated disturbances such as erosion of disturbed banks, vegetation clearing and invasion by alien vegetation significantly degrade the Ga-Selati riparian zone.

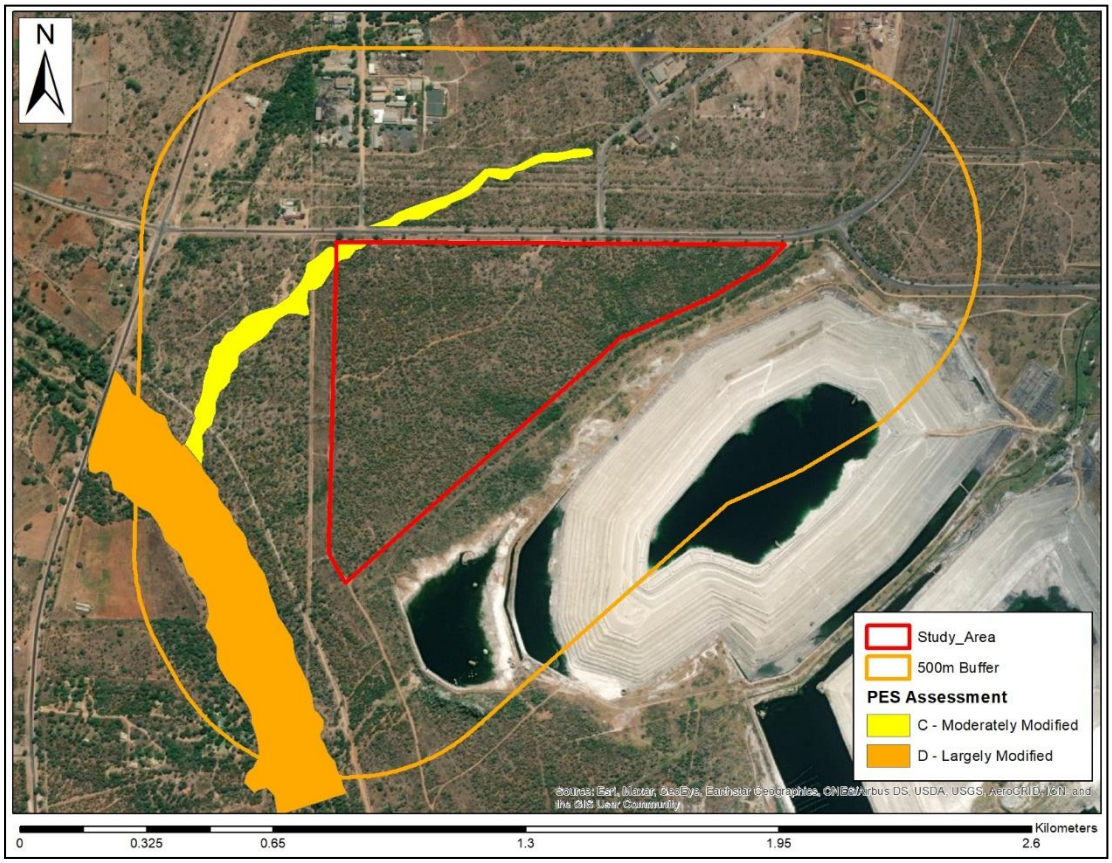


Figure 7.4.10.2(a): Map showing the results of the PES assessment.

7.4.11. Air Quality

Specialist consultants from EHRCON (Pty) Ltd were requested to conduct a detailed Air Quality specialist study in support of the proposed project.

The relevant Specialist Report is:

Air Quality Specialist Baseline Report commissioned by JMA Consulting on behalf of Bosveld Phosphates; May 2022

The information provided below represents a concise summary of the baseline description compiled for the study area.

7.4.11.1. Emission Inventory

Raw Materials - Phosphoric Acid Production

Major emissions from wet process acid production include gaseous fluorides, mostly silicon tetrafluoride (SiF_4) and hydrogen fluoride (HF). Phosphate rock from Foskor contains approximately 2.2% fluoride.

In general, part of the fluorine from the rock is precipitated out with the gypsum, another part is leached out with the phosphoric acid product, and the remaining portion is vaporized in the reactor or evaporator.

The reactor in which phosphate rock is reacted with sulfuric acid is the main source of emissions. Fluoride emission during cooling of the reactor slurry is limited using an enclosed vacuum flash cooling system.

Fluorine emissions from the reactor pass through a horizontal wet scrubber. The leachate portion of the fluorine is deposited on the gypsum stack. If the pond water becomes saturated with fluorides, fluorine gas may be emitted to the atmosphere.

Acid concentration by evaporation is another source of fluoride emissions. Approximately 20 to 40% of the fluorine originally present in the rock vaporizes in this operation.

Total particulate emissions from process equipment were measured for 1 reactor and for 1 filter. As much as 5.5 kilograms of particulate per megagram (kg/Mg) of P_2O_5 were produced by the reactor, and approximately 0.1 kg/Mg of P_2O_5 were released by the filter. Of this particulate, 3 to 6% were fluorides.

The production of wet process phosphoric acid generates a considerable quantity of acidic cooling water with high concentrations of phosphorus and fluoride. This excess water is collected in cooling ponds that are used to temporarily store excess precipitation for subsequent evaporation and to allow recirculation of the process water to the plant for re-use.

Raw Materials – Sulphuric Acid Production

Nearly all sulfur dioxide emissions from sulfuric acid plants are found in the exit stack gases. Extensive testing has shown that the mass of these SO_2 emissions is an inverse function of the sulfur conversion efficiency (SO_2 oxidized to SO_3). This conversion is always incomplete and is affected by the number of stages in the catalytic converter, the amount of catalyst used, temperature and pressure, and the concentrations of the reactants (sulfur dioxide and oxygen).

Dual absorption has generally been accepted as the best available control technology for meeting emission limits. There are no byproducts or waste scrubbing materials created, only additional sulfuric acid. Conversion efficiencies of 99.7% and higher are achievable, whereas most single absorption plants have SO_2 conversion efficiencies ranging only from 95 to 98%. Furthermore, dual absorption permits higher converter inlet sulfur dioxide concentrations than what are used in single absorption plants, because the final conversion stages effectively remove any residual sulfur dioxide from the interpass absorber.

In addition to exit gases, small quantities of sulfur oxides are emitted from storage tank vents and tank car and tank truck vents during loading operations, from sulfuric acid concentrators, and through leaks in process equipment. Few data are available on the quantity of emissions from these sources.

Figure 7.4.11.1(a) show the correlation between SO_2 levels in tail gases and the SO_2 conversion rates as well as the achieved SO_2 conversion rates and SO_2 emission levels. Figure 7.4.11.1(b) shows the correlation between the specific SO_2 loads in tail gases and the SO_2 conversion rates.

Nearly all the acid mist emitted from sulfuric acid manufacturing can be traced to the absorber exit gases. Acid mist is created when sulfur trioxide combines with water vapor at a temperature below the dew point of sulfur trioxide. Once formed within the process system, this mist is so stable that only a small quantity can be removed in the absorber. In general, the quantity and particle size distribution of acid mist are dependent on the type of sulfur feedstock used, the strength of acid produced, and the conditions in the absorber. Because it contains virtually no water vapor, bright elemental sulfur (used at Bosveld Phosphates) produces little acid mist when burned.

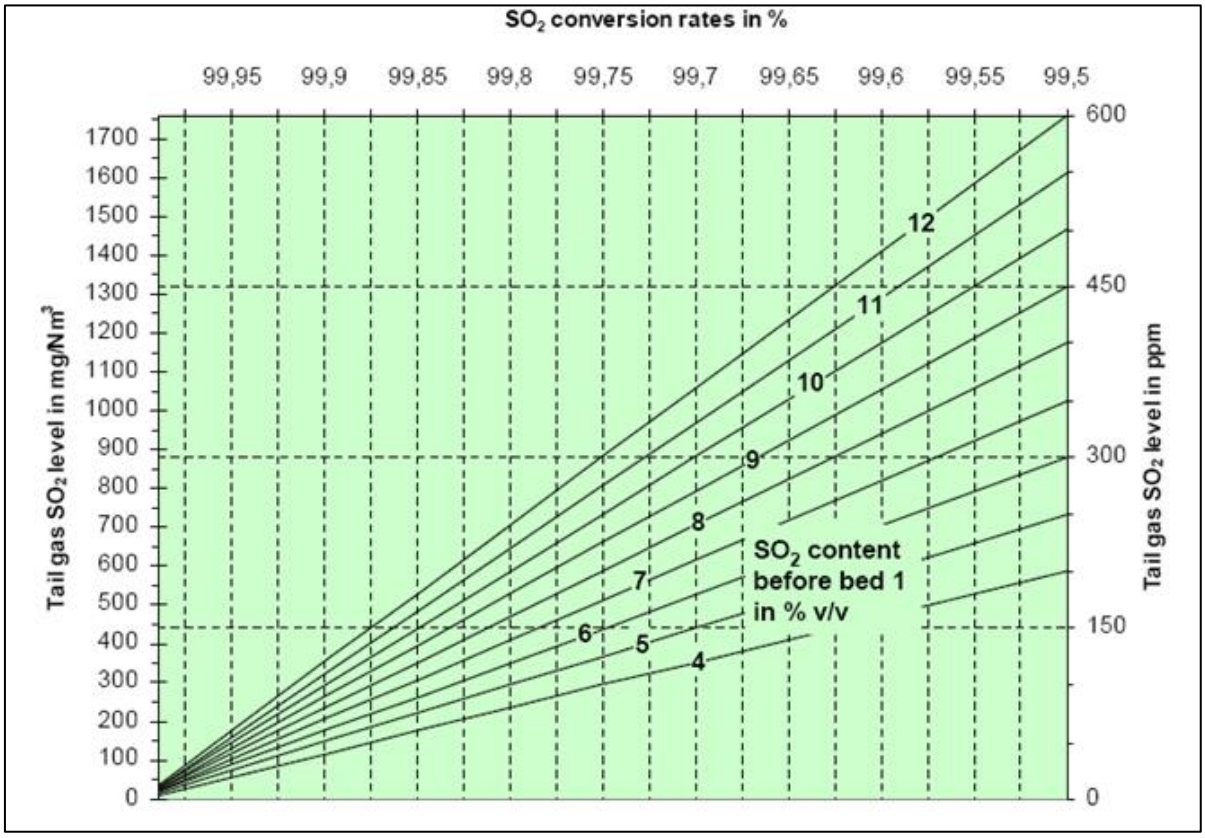


Figure 7.4.11.1(a): Conversion Rates of 99.5 to 99.9 % and Tail Gas SO_2 levels in Relation to the SO_2 content

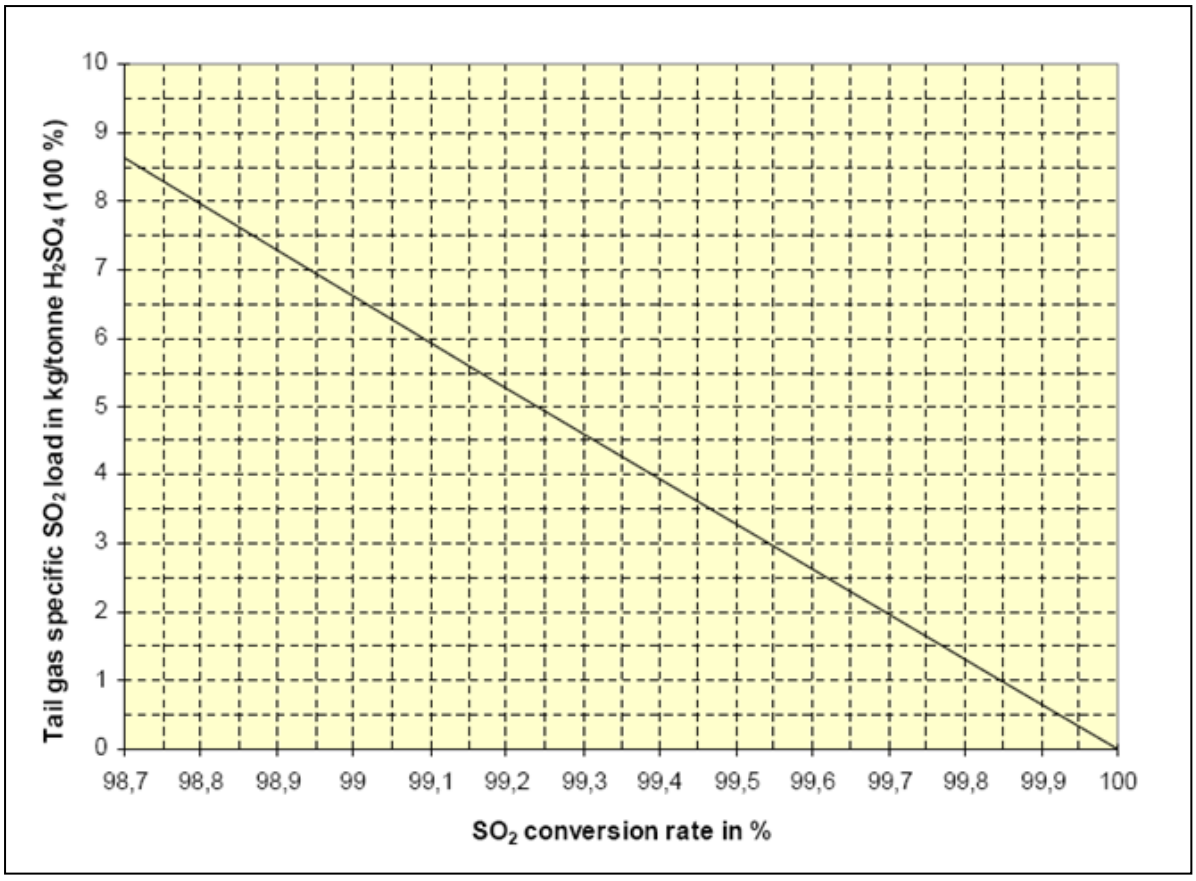


Figure 7.4.11.1(b): Correlation Between SO_2 Conversion Rates and Specific SO_2 Loads in Tail Gases

A mist eliminator has been added on the inter-absorption and final absorption towers to remove traces of sulphuric acid before the gas passes to the atmosphere via the exit gas stack.

Final Product – Mono Ammonium Phosphate (MAP)

Atmospheric emissions from the MAP process depends basically on the grade produced (amount of ammonia to be reacted, pH, temperature and slurry viscosity, drying rate) and the production process itself (again the amount of ammonia to be reacted, availability of acidic scrubbing liquors, etc.).

Sources of air emissions from the production of ammonium phosphate fertilisers include the pipe reactor (neutralisation process), the granulation drum (ammoniation), the dryer and coating drum, product sizing and material transfer. The reactor and granulation drum produce emissions of gaseous ammonia, gaseous fluorides such as hydrogen fluoride (HF) and silicon tetrafluoride (SiF_4), and particulate ammonium phosphates. These two exhaust streams are generally combined and passed through primary and secondary scrubbers.

Exhaust gases from the dryer and coating drum also contain ammonia, fluorides, and particulates and these streams are commonly combined and passed through cyclones and primary and secondary scrubbers. Particulate emissions and low levels of ammonia and fluorides from product crushing, sizing and material transfer operations are controlled the same way.

Exhaust streams from the reactor and granulation drum pass through a primary scrubber, in which phosphoric acid is used to recover ammonia and particulate.

Exhaust gases from the dryer, coating drum and screen first go to cyclones for particulate recovery, and then to primary scrubbers. Materials collected in the cyclone and primary scrubbers are returned to the process. The exhaust is sent to secondary scrubbers, where recycled gypsum pond water is used as a scrubbing liquid to control fluoride emissions. The scrubber effluent is returned to the gypsum pond.

Primary scrubbing equipment commonly includes venturi and cyclonic spray towers. Impingement scrubbers and spray-crossflow packed bed scrubbers are used as secondary controls. Primary scrubbers generally use phosphoric acid of 20 to 30% as scrubbing liquor, principally to recover ammonia. Secondary scrubbers generally use gypsum and pond water for fluoride control. Throughout the industry, however, there are many combinations and variations. Some plants use reactor-feed concentration phosphoric acid (40% phosphorous pentoxide [P_2O_5]) in both primary and secondary scrubbers, and some use phosphoric acid near the dilute end of the 20 to 30% P_2O_5 range in only a single scrubber. Plants are often equipped with ammonia recovery scrubbers on the reactor, granulation drum and dryer, and particulate controls on the dryer and coating drum. Additional scrubbers for fluoride removal exist, but they are not typical.

Emission control efficiencies for ammonium phosphate plant control equipment are reported as 94 to 99% for ammonium, 75 to 99.8% for particulates, and 74 to 94% for fluorides.

Final Product – Granular Super Phosphate (GSP) and Blending

Sources of emissions at a super phosphate plant include raw material unloading and feeding, mixing operations (in the reactor), storage (in the curing building), and fertiliser handling operations. Unloading, handling and feeding generate particulate emissions of phosphate rock dust. The mixer, den and curing building emit gases in the form of Sulphur dioxide, silicon tetrafluoride (SiF_4), hydrogen fluoride (HF) and particulates composed of fluoride and phosphate material. Fertiliser handling operations release fertiliser dust.

Emissions from the raw material and fertiliser handling operations are normally not controlled. Emissions from the mixer and broad field enclosure are controlled through a sodium hydroxide scrubber. The control efficiency of the system is unknown.

Sources of emissions during the granulation of normal superphosphate and during production of specialised fertiliser blends are limited to handling operations. Fertiliser unloading, grinding, screening, mixing and handling generate particulates composed of fluoride and phosphate material. Particulates and coal combustion gasses are also emitted during the drying process.

Magnetite Drying Plant

The rotary drum dryer is heated with two, 250k/h coal stokers and will be supplemented with a 200l/h HFO burner. See *Services – Steam Generation* below for emission from coal combustion.

Emissions from fuel oil combustion depend on the grade and composition of the fuel, the type and size of the boiler, the firing and loading practices used, and the level of equipment maintenance. Because the combustion characteristics of distillate and residual oils are different, their combustion can produce significantly different emissions.

Filterable particulate matter emissions depend predominantly on the grade of fuel fired. Combustion of lighter distillate oils results in significantly lower PM formation than does combustion of heavier residual oils. In general, filterable PM emissions depend on the completeness of combustion as well as on the oil ash content.

The PM emitted by distillate oil-fired boilers primarily comprises carbonaceous particles resulting from incomplete combustion of oil and is not correlated to the ash or sulphur content of the oil. However, PM emissions from residual oil burning are related to the oil sulphur content.

This is because low-sulphur, heavy residual oil, either from naturally low-sulphur crude oil or desulfurized by one of several processes, exhibits substantially lower viscosity and reduced asphaltene, ash, and sulphur contents, which results in better atomisation and more complete combustion.

Stoker load can also affect filterable particulate emissions in units firing heavy residual oil. At low load (50% of maximum rating) conditions, particulate emissions from utility boilers may be lowered by 30 to 40% and by as much as 60% from small industrial and commercial units.

Sulphur oxides (SOx) emissions are generated during oil combustion from the oxidation of sulphur contained in the fuel. The emissions of SOx from conventional combustion systems are predominantly in the form of SO_2.

Uncontrolled SOx emissions are almost entirely dependent on the sulphur content of the fuel and are not affected by boiler size, burner design, or grade of fuel being fired. On average, more than 95% of the fuel sulphur is converted to SO_2, about 1 to 5% is further oxidized to sulphur trioxide (SO_3), and 1 to 3% is emitted as sulphate particulate. SO_3 readily reacts with water vapor (both in the atmosphere and in flue gases) to form a sulfuric acid mist.

Oxides of nitrogen (NOx) formed in combustion processes are due either to thermal fixation of atmospheric nitrogen in the combustion air (thermal NOx), or to the conversion of chemically bound nitrogen in the fuel (fuel NOx). The term NOx refers to the composite of nitric oxide (NO) and nitrogen dioxide (NO_2). Test data have shown that for most external fossil fuel combustion systems, over 95% of the emitted NOx is in the form of nitric oxide (NO). Nitrous oxide (N_2O) is not included in NOx but has recently received increased interest because of atmospheric effects.

Experimental measurements of thermal NOx formation have shown that NOx concentration is exponentially dependent on temperature, and proportional to N_2 concentration in the flame, the square root of O_2 concentration in the flame, and the residence time. Thus, the formation of thermal NOx is affected by four factors:

- Peak temperature.
- Fuel nitrogen concentration.
- Oxygen concentration.
- Time of exposure at peak temperature.

The emission trends due to changes in these factors are generally consistent for all types of boilers: an increase in flame temperature, oxygen availability, and/or residence time at high temperatures leads to an increase in NOx production.

Fuel nitrogen conversion is the more important NOx-forming mechanism in residual oil boilers. It can account for 50% of the total NOx emissions from residual oil firing. The percent conversion of fuel nitrogen to NOx varies greatly, however; typically, from 20 to 90% of nitrogen in oil is converted to NOx. Except in certain large units having unusually high peak flame temperatures, or in units firing a low nitrogen content residual oil, fuel NOx generally accounts for over 50% of the total NOx generated. Thermal fixation, on the other hand, is the dominant NOx-forming mechanism in units firing distillate oils, primarily because of the negligible nitrogen content in these lighter oils.

Because distillate oil-fired boilers are usually smaller and have lower heat release rates, the quantity of thermal NOx formed in them is less than that of larger units which typically burn residual oil.

A number of variables influence how much NOx is formed by these two mechanisms. One important variable is firing configuration. NOx emissions from tangentially (corner) fired boilers are, on the average, less than those of horizontally opposed units. Also important are the firing practices employed during boiler operation. Low excess air (LEA) firing, flue gas recirculation (FGR), staged combustion (SC), reduced air preheat (RAP), low NOx burners (LNBs), burning oil/water emulsions (OWE), or some combination thereof may result in NOx reductions of 5 to 6%. Load reduction (LR) can likewise decrease NOx production. Nitrogen oxide emissions may be reduced from 0.5 to 1%for each percentage reduction in load from full load operation. It should be noted that most of these variables, with the exception of excess air, only influence the NOx emissions of large oil-fired boilers. Low excess air-firing is possible in many small boilers, but the resulting NOx reductions are less significant.

The rate of carbon monoxide (CO) emissions from combustion sources depends on the oxidation efficiency of the fuel. By controlling the combustion process carefully, CO emissions can be minimised. Thus, if a unit is operated improperly or not well maintained, the resulting concentrations of CO (as well as organic compounds) may increase by several orders of magnitude. Smaller boilers, heaters, and furnaces tend to emit more of these pollutants than larger combustors. This is because smaller units usually have a higher ratio of heat transfer surface area to flame volume than larger combustors have; this leads to reduced flame temperature and combustion intensity and, therefore, lower combustion efficiency.

The presence of CO in the exhaust gases of combustion systems results principally from incomplete fuel combustion. Several conditions can lead to incomplete combustion, including insufficient oxygen (O_2) availability; poor fuel/air mixing; cold-wall flame quenching; reduced combustion temperature; decreased combustion gas residence time; and load reduction (i.e. reduced combustion intensity). Since various combustion modifications for NOx reduction can produce one or more of the above conditions, the possibility of increased CO emissions is a concern for environmental, energy efficiency, and operational reasons.

Small amounts of organic compounds are emitted from combustion. As with CO emissions, the rate at which organic compounds are emitted depends, to some extent, on the combustion efficiency of the boiler. Therefore, any combustion modification which reduces the combustion efficiency will most likely increase the concentrations of organic compounds in the flue gases.

Total organic compounds (TOCs) include VOCs, semi-volatile organic compounds, and condensable organic compounds. Emissions of VOCs are primarily characterised by the criteria pollutant class of unburned vapor phase hydrocarbons. Unburned hydrocarbon emissions can include essentially all vapor phase organic compounds emitted from a combustion source. These are primarily emissions of aliphatic, oxygenated, and low molecular weight aromatic compounds which exist in the vapor phase at flue gas temperatures. These emissions include all alkanes, alkenes, aldehydes, carboxylic acids, and substituted benzenes (e. g., benzene, toluene, xylene, and ethyl benzene).

The remaining organic emissions are composed largely of compounds emitted from combustion sources in a condensed phase. These compounds can almost exclusively be classed into a group known as polycyclic organic matter (POM), and a subset of compounds called polynuclear aromatic hydrocarbons (PAH or PNA). There are also PAH-nitrogen analogs. Information available in the literature on POM compounds generally pertains to these PAH groups.

Formaldehyde is formed and emitted during combustion of hydrocarbon-based fuels including coal and oil. Formaldehyde is present in the vapor phase of the flue gas. Formaldehyde is subject to oxidation and decomposition at the high temperatures encountered during combustion.

Thus, larger units with efficient combustion (resulting from closely regulated air-fuel ratios, uniformly high combustion chamber temperatures, and relatively long gas retention times) have lower formaldehyde emission rates than do smaller, less efficient combustion units.

Trace elements are also emitted from the combustion of oil. The quantity of trace elements entering the combustion device depends solely on the fuel composition. The quantity of trace metals emitted from the source depends on combustion temperature, fuel feed mechanism, and the composition of the fuel. The temperature determines the degree of volatilisation of specific compounds contained in the fuel. The fuel feed mechanism affects the separation of emissions into bottom ash and fly ash. In general, the quantity of any given metal emitted depends on the physical and chemical properties of the element itself; concentration of the metal in the fuel; the combustion conditions; and the type of particulate control device used, and its collection efficiency as a function of particle size.

Some trace metals concentrate in certain waste particle streams from a combustor (bottom ash, collector ash, flue gas particulate), while others do not. Various classification schemes have been developed to describe this partitioning behavior. These classification schemes generally distinguish between:

- **Class 1:** Elements that are approximately equally concentrated in the fly ash and bottom ash or show little or no small particle enrichment. Examples include manganese, beryllium, cobalt, and chromium.
- **Class 2**: Elements that are enriched in fly ash relative to bottom ash or show increasing enrichment with decreasing particle size. Examples include arsenic, cadmium, lead, and antimony.
- **Class 3:** Elements which are emitted in the gas phase (primarily mercury and, in some cases, selenium).

By understanding trace metal partitioning and concentration in fine particulate, it is possible to postulate the effects of combustion controls on incremental trace metal emissions. For example, several NOx controls for boilers reduce peak flame temperatures. If combustion temperatures are reduced, fewer Class 2 metals will initially volatilise, and fewer will be available for subsequent condensation and enrichment on fine PM. Therefore, for combustors with particulate controls, lower volatile metal emissions should result due to improved particulate removal. Flue gas emissions of Class 1 metals (the non-segregating trace metals) should remain relatively unchanged.

Lower local O_2 concentrations is also expected to affect segregating metal emissions from boilers with particle controls. Lower O_2 availability decreases the possibility of volatile metal oxidation to fewer volatile oxides. Under these conditions, Class 2 metals should remain in the vapor phase as they enter the cooler sections of the boiler. More redistribution to small particles should occur and emissions should increase. Again, Class 1 metal emissions should remain unchanged.

Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions are all produced during fuel oil combustion. Nearly all of the fuel carbon (99%) in fuel oil is converted to CO_2 during the combustion process. This conversion is relatively independent of firing configuration. Although the formation of CO acts to reduce CO_2 emissions, the amount of CO produced is insignificant compared to the amount of CO_2 produced. The majority of the fuel carbon not converted to CO_2 is due to incomplete combustion in the fuel stream.

Formation of N_2O during the combustion process is governed by a complex series of reactions and its formation is dependent upon many factors.

Formation of N_2O is minimised when combustion temperatures are kept high (above 1475°F) and excess air is kept to a minimum (less than 1%). Emissions can vary widely from unit to unit, or even from the same unit at different operating conditions.

Methane emissions vary with the type of fuel and firing configuration but are highest during periods of incomplete combustion or low-temperature combustion, such as the start-up or shut-down cycle for oil-fired boilers. Typically, conditions that favour formation of N_2O also favour emissions of CH_4.

Services – Steam Generation

Emissions from coal combustion depend on the rank and composition of the fuel, the type and size of the boiler, firing conditions, load, type of control technologies, and the level of equipment maintenance. The major pollutants of concern from bituminous coal combustion are particulate matter (PM), sulfur oxides (SOx), and nitrogen oxides (NOx). Some unburned combustibles, including carbon monoxide (CO) and numerous organic compounds, are generally emitted even under proper boiler operating conditions.

PM composition and emission levels are a complex function of boiler firing configuration, boiler operation, pollution control equipment, and coal properties. Uncontrolled PM emissions from coal-fired boilers include the ash from combustion of the fuel as well as unburned carbon resulting from incomplete combustion.

Coal ash may either settle out in the boiler (bottom ash) or entrained in the flue gas (fly ash). The distribution of ash between the bottom ash and fly ash fractions directly affects the PM emission rate and depends on the boiler firing method and furnace type (wet or dry bottom). Boiler load also affects the PM emissions as decreasing load tends to reduce PM emissions. The magnitude of the reduction varies considerably depending on boiler type, fuel, and boiler operation.

Soot blowing is also a source of intermittent PM emissions in coal-fired boilers. Steam soot and air soot blowing is periodically used to dislodge ash from heat transfer surfaces in the furnace, convective section, economizer, and air preheater.

Gaseous SOx from coal combustion are primarily sulfur dioxide (SO_2), with a much lower quantity of sulfur trioxide (SO_3) and gaseous sulfates. These compounds form as the organic and pyretic sulfur in the coal are oxidized during the combustion process. On average, about 95% of the sulfur present in bituminous coal will be emitted as gaseous SOx. The more alkaline nature of the ash in some subbituminous coals causes some of the sulfur to react in the furnace to form various sulfate salts that are retained in the boiler or in the fly ash.

NOx emissions from coal combustion are primarily nitric oxide (NO), with only a few volume percent as nitrogen dioxide (NO_2). Nitrous oxide (N_2O) is also emitted at a few parts per million. NOx formation results from thermal fixation of atmospheric nitrogen in the combustion flame and from oxidation of nitrogen bound in the coal. Experimental measurements of thermal NOx formation have shown that the NOx concentration is exponentially dependent on temperature and is proportional to nitrogen concentration in the flame, the square root of oxygen concentration in the flame, and the gas residence time.

Bituminous coals usually contain from 0.5 to 2 weight percent nitrogen, mainly present in aromatic ring structures. Fuel nitrogen can account for up to 80% of total NOx from coal combustion.

The rate of CO emissions from combustion sources depends on the fuel oxidation efficiency of the source. By controlling the combustion process carefully, CO emissions can be minimized. Thus, if a unit is operated improperly or is not well-maintained, the resulting concentrations of CO (as well as organic compounds) may increase by several orders of magnitude. Smaller boilers, heaters, and furnaces typically emit more CO and organics than larger combustors. This is because smaller units usually have less high-temperature residence time and, therefore, less time to achieve complete combustion than larger combustors. Combustion modification techniques and equipment used to reduce NOx can increase CO emissions if the modification techniques are improperly implemented or if the equipment is improperly designed.

As with CO emissions, the rate at which organic compounds are emitted depends on the combustion efficiency of the boiler. Therefore, combustion modifications that change combustion residence time, temperature, or turbulence may increase or decrease concentrations of organic compounds in the flue gas. Organic emissions include volatile, semi volatile, and condensable organic compounds either present in the coal or formed as a product of incomplete combustion (PIC). Organic emissions are primarily characterized by the criteria pollutant class of unburned vapor-phase hydrocarbons. These emissions include alkanes, alkenes, aldehydes, alcohols, and substituted benzenes (e.g., benzene, toluene, xylene, and ethyl benzene).

Emissions of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF) also result from the combustion of coal. Of primary interest environmentally are tetrachloro- through octachloro- dioxins and furans. Dioxin and furan emissions are influenced by the extent of destruction of organics during combustion and through reactions in the air pollution control equipment. The formation of PCDD/PCDF in air pollution control equipment is primarily dependent on flue gas temperature, with maximum potential for formation occurring at flue gas temperatures of 230°C to 340°C.

The remaining organic emissions are composed largely of compounds emitted from combustion sources in a condensed phase. These compounds can almost exclusively be classed into a group known as polycyclic organic matter (POM), and a subset of compounds called polynuclear aromatic hydrocarbons (PNA or PAH). Polycyclic organic matter is more prevalent in the emissions from coal combustion because of the more complex structure of coal.

Trace metals are also emitted during coal combustion. The quantity of any given metal emitted, in general, depends on the:

- Physical and chemical properties of the metal itself.
- Concentration of the metal in the coal.
- Combustion conditions.
- Type of particulate control device used, and its collection efficiency as a function of particle size.

Some trace metals become concentrated in certain particle streams from a combustor (e.g. bottom ash, collector ash, and flue gas particulate) while others do not. Various classification schemes have been developed to describe this partitioning behavior. These classification schemes generally distinguish between:

- **Class 1:** Elements that are approximately equally concentrated in the fly ash and bottom ash or show little or no small particle enrichment. Examples include manganese, beryllium, cobalt, and chromium.
- **Class 2**: Elements that are enriched in fly ash relative to bottom ash or show increasing enrichment with decreasing particle size. Examples include arsenic, cadmium, lead, and antimony.

- **Class 3:** Elements which are emitted in the gas phase (primarily mercury and, in some cases, selenium).

Control of Class 1 metals is directly related to control of total particulate matter emissions, while control of Class 2 metals depends on collection of fine particulates. Because of variability in particulate control device efficiencies, emission rates of these metals can vary substantially. Because of the volatility of Class 3 metals, particulate controls have only a limited impact on emissions of these metals.

In addition to SO_2 and NOx emissions, combustion of coal also results in emissions of chlorine and fluorine, primarily in the form of hydrogen chloride (HCl) and hydrogen fluoride (HF). Lesser amounts of chlorine gas and fluorine gas are also emitted. A portion of the chlorine and fluorine in the fuel may be absorbed onto fly ash or bottom ash. Both HCl and HF are water soluble and are readily controlled by acid gas scrubbing systems.

Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions are all produced during coal combustion. Nearly all the fuel carbon (99%) in coal is converted to CO_2 during the combustion process. This conversion is relatively independent of firing configuration. Although the formation of CO acts to reduce CO_2 emissions, the amount of CO produced is insignificant compared to the amount of CO_2 produced. Most of the fuel carbon not converted to CO_2 is entrained in bottom ash. CO_2 emissions for coal vary with carbon content, and carbon content varies between the classes of bituminous and subbituminous coals. Further, carbon content also varies within each class of coal based on the geographical location of the mine.

Formation of N_2O during the combustion process is governed by a complex series of reactions and its formation is dependent upon many factors. Formation of N_2O is minimized when combustion temperatures are kept high (above 1575°F) and excess air is kept to a minimum (less than 1%). N_2O emissions for coal combustion are not significant.

Methane emissions vary with the type of coal being fired and firing configuration, but are highest during periods of incomplete combustion, such as the start-up or shut-down cycle for coal-fired boilers. Typically, conditions that favor formation of N_2O also favor emissions of CH_4.

<u>Material Handling and Stockpiling</u>

Inherent in operations that use minerals in aggregate form is the maintenance of outdoor storage piles. Storage piles are usually left uncovered, partially because of the need for frequent material transfer into or out of storage. Dust emissions occur at several points in the storage cycle, such as material loading onto the pile, disturbances by strong wind currents, and load-out from the pile. The movement of trucks and loading equipment in the storage pile area is also a substantial source of dust.

The quantity of dust emissions from aggregate storage operations varies with the volume of aggregate passing through the storage cycle. Emissions also depend on three parameters related to the condition of the storage pile: age of the pile, moisture content, and proportion of aggregate fines.

When freshly processed aggregate is loaded onto a storage pile, the potential for dust emissions is at a maximum. Fines are easily disaggregated and released to the atmosphere upon exposure to air currents, either from aggregate transfer itself or from high winds. As the aggregate pile weathers, however, potential for dust emissions is greatly reduced. Moisture causes aggregation and cementation of fines to the surfaces of larger particles. Any significant rainfall soaks the interior of the pile resulting in a slow drying process.

Total dust emissions from aggregate storage piles result from several distinct source activities within the storage cycle:

- Loading of aggregate onto storage piles (batch or continuous drop operations).
- Equipment traffic in storage area.
- Wind erosion of pile surfaces and ground areas around piles.
- Load-out of aggregate for shipment or for return to the process stream (batch or continuous drop operations).

Either adding aggregate material to a storage pile or removing it usually involves dropping the material onto a receiving surface. Truck dumping on the pile or loading out from the pile to a truck with a front-end loader are examples of batch drop operations. Adding material to the pile by a conveyor stacker is an example of a continuous drop operation.

Fugitive Dust Sources

Significant atmospheric dust arises from the mechanical disturbance of granular material exposed to the air. Dust generated from these open sources is termed 'fugitive' because it is not discharged to the atmosphere in a confined flow stream. Common sources of fugitive dust include unpaved roads, agricultural tilling operations, aggregate storage piles, and heavy construction operations.

For the above sources of fugitive dust, the dust-generation process is caused by two basic physical phenomena:

- Pulverisation and abrasion of surface materials by application of mechanical force through implements (wheels, blades, etc.).
- Entrainment of dust particles by the action of turbulent air currents, such as wind erosion of an exposed surface by wind speeds over 19km/h (5.3m/s).

The impact of a fugitive dust source on air pollution depends on the quantity and drift potential of the dust particles injected into the atmosphere. In addition to large dust particles that settle out near the source (often creating a local nuisance problem), considerable amounts of fine particles also are emitted and dispersed over much greater distances from the source. The potential drift distance of particles is governed by the initial injection height of the particle, the terminal settling velocity of the particle, and the degree of atmospheric turbulence. Theoretical drift distance, as a function of particle diameter and mean wind speed, has been computed for fugitive dust emissions.

Results indicate that, for a typical mean wind speed of 16km/h (4.4m/s), particles larger than about 100µm are likely to settle out within 6 to 9m from the edge of the road or other point of emission. Particles that are 30 to 100µm in diameter are likely to undergo impeded settling.

These particles, depending upon the extent of atmospheric turbulence, are likely to settle within a few hundred feet from the source. Smaller particles, particularly TSP and PM_{10}, have much slower gravitational settling velocities and are much more likely to have their settling rate retarded by atmospheric turbulence.

Dust emissions may be generated by wind erosion of open aggregate storage piles and exposed areas within an industrial facility. These sources typically are characterised by non-homogeneous surfaces impregnated with non-erodible elements (particles larger than approximately 1cm in diameter).

Field testing of coal piles and other exposed materials using a portable wind tunnel has shown that:

- Threshold wind speeds exceed 5m/s at 15cm above the surface or 10m/s at 7m above the surface.
- Particulate emission rates tend to decay rapidly (half-life of a few minutes) during an erosion event.

In other words, these aggregate material surfaces are characterised by finite availability of erodible material (mass/area) referred to as the erosion potential. Any natural crusting of the surface binds the erodible material, thereby reducing the erosion potential.

Vehicle Entrained Emissions

When a vehicle travels an unpaved road, the force of the wheels on the road surface causes pulverisation of surface material. Particles are lifted and dropped from the rolling wheels, and 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 a given segment of unpaved road varies linearly with the volume of traffic. Field investigations also have shown that emissions depend on source parameters that characterise the condition of a road and the associated vehicle traffic.

Characterisation of these source parameters allow for 'correction' of emission estimates to specific road and traffic conditions present on public and industrial roadways. Dust emissions from unpaved roads have been found to vary directly with the fraction of silt (particles smaller than 75µm in diameter) in the road surface materials. Other variables are important in addition to the silt content of the road surface material. For example, at industrial sites, where haul trucks and other heavy equipment are common, emissions are highly correlated with vehicle weight.

7.4.11.2. Emission Factors

Process emission rates were obtained from emission factors which associate the quantity of a pollutant to the activity associated with its release. Due to the absence of locally generated emission factors, use was made of the comprehensive set of emission factors published by the United States Environmental Protection Agency (US-EPA) in its AP-42 document *Compilation of Pollution Emission Factors* and the reference document on *Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers Best* and *Available Techniques for the Management of Tailings and Waste Rock in Mining Activities* published by the European Integrated Pollution Prevention and Control Bureau.

Reference was made to routine emissions from the process. Table 7.4.11.2(a) to Table 7.4.11.2(c) summarises the emission factors for the current operations and the proposed Copper Flotation Plant and Magnetite Waste Site Disposal Facility of Bosveld Phosphates. Table 7.4.11.2(d) contains the most recent, emission rates for the current operations. Emission calculations were based on the parameters summarized in Table 7.4.11.2(e).

Table 7.4.11.2(a): Phosphoric Acid, Sulphuric Acid and Fertiliser Production – Emission Factors

Activity	Unit	Emission Factors											
		TSP	PM_{10}	$PM_{2.5}$	SO_2	SO_3	CO_2	CO	NO	NO_2	NH_3	H_2SO_4	F^-
A. Phosphoric Acid Production													
1. Reactor	kg/Mg	5.50E+00	4.40E+00	-	-	-	-	-	-	-	-	-	3.30E-01
2. Filtration	kg/Mg	1.00E-01	8.00E-02	-	-	-	-	-	-	-	-	-	6.00E-03
3. Concentration	kg/Mg	-	-	-	-	-	-	-	-	-	-	-	3.00E-03
4. Miscellaneous sources	kg/Mg	1.50E-02	1.20E-02	-	-	-	-	-	-	-	-	-	1.00E-03
B. Sulphuric Acid Production													
1. Production SA4	kg/Mg	-	-	-	1.03E+00	6.40E-02	-	4.05E+00	-	-	-	0.0640	-
2. Production SA5	kg/Mg	-	-	-	1.03E+00	6.40E-02	-	4.05E+00	-	-	-	0.0640	-
3. Miscellaneous sources SA4	kg/Mg	-	-	-	1.03E-01	6.00E-03	-	4.05E-01	-	-	-	0.0064	-
4. Miscellaneous sources SA5	kg/Mg	-	-	-	1.03E-01	6.00E-03	-	4.05E-01	-	-	-	0.0064	-
C. Fertiliser Production													
1. MAP reactor	kg/Mg	7.60E-01	6.10E-01	-	-	-	-	-	-	-	1.90E-01	-	2.00E-02
2. MAP granulation	kg/Mg	7.60E-01	6.10E-01	-	-	-	-	-	-	-	1.90E-01	-	2.00E-02
3. MAP drying and coating	kg/Mg	7.50E-01	6.00E-01	-	-	-	-	-	-	-	1.90E-01	-	2.00E-02
4. MAP product sizing & material transfer	kg/Mg	3.00E-02	2.00E-02	-	-	-	-	-	-	-	1.00E-02	-	1.00E-03
5. MAP miscellaneous sources	kg/Mg	3.40E-01	2.70E-01	-	-	-	-	-	-	-	7.00E-02	-	2.00E-02
6. SSP raw material handling	kg/Mg	1.10E-01	5.00E-02	-	-	-	-	-	-	-	-	-	-
7. SSP reaction process and	kg/Mg	2.60E-01	2.20E-01	-	-	-	-	-	-	-	-	-	1.00E-01
8. SSP curing and final product handling	kg/Mg	1.00E-01	8.00E-02	-	-	-	-	-	-	-	-	-	2.00E-02

Activity	Unit	Emission Factors											
		TSP	PM_{10}	$PM_{2.5}$	SO_2	SO_3	CO_2	CO	NO	NO_2	NH_3	H2SO4	F^-
9. GSP product sizing & material transfer	kg/Mg	3.00E-02	2.00E-02	-	-	-	-	-	-	-	-	-	0.001
10. GSP miscellaneous sources	kg/Mg	3.40E-01	2.70E-01	-	-	-	-	-	-	-	-	-	0.02
11. Blending plant miscellaneous sources	kg/Mg	3.40E-01	2.70E-01	-	-	-	-	-	-	-	-	-	0.02
D. Steam Generation													
1. Combustion	kg/Mg	3.30E+01	6.60E+00	6.60E+00	9.50E+00		3.09E+03	2.50E+00	-	2.75E-01	-	-	

Notes

kg/Mg : Kilogram per megagram.
Phosphoric acid production : US-EPA AP42, Volume 1, 5 Edition, Chapter 8.9 & EC LVIC-AAF.
Sulphuric acid production : US-EPA AP42, Volume 1, 5 Edition, Chapter 8.10 and EHRCON Process emission measurements.
Fertiliser production : US-EPA AP42, Volume 1, 5 Edition, Chapter 8.5, 8.9 & EC LVIC-AAF.
Steam generation : US-EPA AP42, Volume 1, 5 Edition, Chapter 1.1. Coal sulphur content of 0.5% and carbon content of 85%.

Table 7.4.11.2(b): Magnetite Beneficiation – Emission Factors

Activity	Unit	Emission Factors						
		TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO_2	CO
A. SAOB Plant (MGB)								
1. Feed handling (MGB-F)								
1. FEL operation	g/VKT	2.62E+03	7.45E+02	7.45E+01	-	-	-	-
2. Material handling (3 operations)	kg/Mg	5.00E-03	2.00E-03	2.00E-04	-	-	-	-
3. Fugitive emissions from storage	kg/ha/h	7.20E+00	2.20E+00	2.20E-01	-	-	-	-
2. Beneficiation operations (MGB-2)								
1. Screening	kg/Mg	1.25E-02	4.30E-03	4.30E-04	-	-	-	-
2. DMS Beneficiation (8 operations)	kg/Mg	5.00E-03	2.00E-03	2.00E-04	-	-	-	-
3. Product handling (MGB-P1/P2)								
1. FEL operation	g/VKT	2.62E+03	7.45E+02	7.45E+01	-	-	-	-
2. Material handling (3 operations)	kg/Mg	5.00E-03	2.00E-03	2.00E-04	-	-	-	-
3. Fugitive emissions from storage	kg/ha/h	7.20E+00	2.20E+00	2.20E-01	-	-	-	-
B. MP2 Plant (MGD)								
1. Feed handling (MGD-F)								
1. FEL operation	g/VKT	2.62E+03	7.45E+02	7.45E+01	-	-	-	-
2. Material handling (3 operations)	kg/Mg	5.00E-03	2.00E-03	2.00E-04	-	-	-	-
3. Fugitive emissions from storage	kg/ha/h	7.20E+00	2.20E+00	2.20E-01	-	-	-	-
2. Drying operations (MGD-2)								
1. Drying circuit	kg/Mg	9.97E+00	5.93E+00	5.93E-01	-	-	-	-
2. Combustion	kg/Mg	3.30E+01	6.60E+00	6.60E+00	9.50E+00	2.75E-01	3.09E+03	2.50E+00

Activity	Unit	Emission Factors						
		TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO_2	CO
3. Beneficiation operations (MGD-2)								
1. Magnetic separation (8 operations)	kg/Mg	6.00E-02	3.00E-02	3.00E-03	-	-	-	-
4. Product handling (MGB-P1/P2)								
1. FEL operation	g/VKT	2.62E+03	7.45E+02	7.45E+01	-	-	-	-
2. Material handling (3 operations)	kg/Mg	6.00E-02	3.00E-02	3.00E-03	-	-	-	-
3. Fugitive emissions from storage	kg/ha/h	7.20E+00	2.20E+00	2.20E-01	-	-	-	-
C. Magnetite Stockpiles								
1. Export stockpile 1 (Tengwa operations)(STN-1)								
1. FEL operation	g/VKT	2.62E+03	7.45E+02	7.45E+01	-	-	-	-
2. Material handling (3 operations)	kg/Mg	5.00E-03	2.00E-03	2.00E-04	-	-	-	-
3. Fugitive emissions from storage	kg/ha/h	7.20E+00	2.20E+00	2.20E-01	-	-	-	-
2. Export stockpile 2 (SAOB/MP2 operations)(STN-2)								
1. FEL operation	g/VKT	2.62E+03	7.45E+02	7.45E+01	-	-	-	-
2. Material handling (3 operations)	kg/Mg	5.00E-03	2.00E-03	2.00E-04	-	-	-	-
3. Fugitive emissions from storage	kg/ha/h	7.20E+00	2.20E+00	2.20E-01	-	-	-	-
3. Export stockpile 3 (SAOB/MP2 operations)(STN-3)								
1. FEL operation	g/VKT	2.62E+03	7.45E+02	7.45E+01	-	-	-	-
2. Material handling (3 operations)	kg/Mg	5.00E-03	2.00E-03	2.00E-04	-	-	-	-
3. Fugitive emissions from storage	kg/ha/h	7.20E+00	2.20E+00	2.20E-01	-	-	-	-

Activity	Unit	Emission Factors						
		TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO_2	CO
4. MP2 P2 stockpile (MGD-P2 East)								
1. FEL operation	g/VKT	2.62E+03	7.45E+02	7.45E+01	-	-	-	-
2. Material handling (3 operations)	kg/Mg	5.00E-03	2.00E-03	2.00E-04	-	-	-	-
3. Fugitive emissions from storage	kg/ha/h	7.20E+00	2.20E+00	2.20E-01	-	-	-	-
5. SAOB P2 stockpile (MGD-P2 West)								
1. FEL operation	g/VKT	2.62E+03	7.45E+02	7.45E+01	-	-	-	-
2. Material handling (3 operations)	kg/Mg	5.00E-03	2.00E-03	2.00E-04	-	-	-	-
3. Fugitive emissions from storage	kg/ha/h	7.20E+00	2.20E+00	2.20E-01	-	-	-	-
D. Haul Roads								
1. Mag Ore to SAOB (unpaved)	g/VKT	3.37E+03	9.60E+02	9.60E+01	-	-	-	-
2. Mag Ore to MP2 (unpaved)	g/VKT	3.37E+03	9.60E+02	9.60E+01	-	-	-	-
3. Mag Ore to Tengwa (unpaved)	g/VKT	3.37E+03	9.60E+02	9.60E+01	-	-	-	-
4. SAOB P1 to export STN-2 (unpaved)	g/VKT	3.18E+03	9.05E+02	9.05E+01	-	-	-	-
5. SAOB P2 to MGD-P2 West (paved)	g/VKT	9.31E+02	1.79E+02	4.33E+01	-	-	-	-
6. SAOB P2 to export STN-3 (unpaved)	g/VKT	3.18E+03	9.05E+02	9.05E+01	-	-	-	-
7. MP2 P1 to export STN-2 (unpaved)	g/VKT	3.18E+03	9.05E+02	9.05E+01	-	-	-	-
8. MP2 P2 to MGD-P2 East (paved)	g/VKT	9.31E+02	1.79E+02	4.33E+01	-	-	-	-
9. MP2 P2 to export STN-3 (unpaved)	g/VKT	3.18E+03	9.05E+02	9.05E+01	-	-	-	-
10. Gypsum GS2 to export (unpaved)	g/VKT	3.37E+03	9.60E+02	9.60E+01	-	-	-	-
11. Mag Ore to SAOB/MP2 (paved)	g/VKT	1.06E+03	2.04E+02	4.94E+01	-	-	-	-
12. Mag Ore to Tengwa (paved)	g/VKT	1.06E+03	2.04E+02	4.94E+01	-	-	-	-
13. Gypsum GS2 to export (paved)	g/VKT	1.06E+03	2.04E+02	4.94E+01	-	-	-	-

Activity	Unit	Emission Factors						
		TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO_2	CO
E. Tailings								
1. Gypsum A-Stack (GS1)								
1. Fugitive emissions from storage	$mg/m^2/day$	1.57E+02	4.80E+01	4.80E+00	-	-	-	-
2. Gypsum B-Stack (Bosveld operations)(GS2)								
1. FEL operation	g/VKT	2.62E+03	7.45E+02	7.45E+01	-	-	-	-
2. Material handling (3 operations)	kg/Mg	5.00E-03	2.00E-03	2.00E-04	-	-	-	-
3. Fugitive emissions from storage	$mg/m^2/day$	1.57E+02	4.80E+01	4.80E+00	-	-	-	-

Notes

g/VKT	:	Gram per vehicle kilometre travelled.
kg/Mg	:	Kilogram per megagram.
kg/ha/h	:	Kilogram per hectare per hour.
mg/m2/day	:	Milligram per square metre per day.
Mobile equipment operation	:	US EPA, AP42, Volume I, 5 Edition Chapter 13.2.
Material handling	:	US EPA, AP42, Volume I, 5 Edition Chapter 11.24. High moisture ore (>4%).
Fugitive emissions from magnetite storage	:	US EPA, AP42, Volume I, 5 Edition Chapter 11.9.
Screening	:	US EPA, AP42, Volume I, 5 Edition Chapter 11.19.
DMS beneficiation	:	US EPA, AP42, Volume I, 5 Edition Chapter 11.24. High moisture ore (>4%).
Magnetite drying	:	US EPA, AP42, Volume I, 5 Edition Chapter 11.19 and Chapter 11.24.
Coal combustion	:	US EPA, AP42, Volume I, 5 Edition Chapter 1.1. Coal sulphur content of 0.5% and carbon content of 85%.
Magnetic separation	:	US EPA, AP42, Volume I, 5 Edition Chapter 11.24. High moisture ore (<4%).
Fugitive emissions from gypsum storage	:	Bosveld ambient dust deposition monitoring for the period October 2019 to September 2021 .

Table 7.4.11.2(c): Copper Flotation Plant, Waste Disposal Facility and Pollution Control Dam – Emission Factors

Activity	Unit	Emission Factors						
		TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO_2	CO
A. Copper Flotation Plant (CUF)								
1. Feed handling (CUF-F/CUF-1)								
1. FEL operation	g/VKT	2.62E+03	7.45E+02	7.45E+01	-	-	-	-
2. Material handling (3 operations)	kg/Mg	5.00E-03	2.00E-03	2.00E-04	-	-	-	-
3. Fugitive emissions from storage	kg/ha/h	7.20E+00	2.20E+00	2.20E-01	-	-	-	-
2. Beneficiation operations (CUF-2)								
1. Screening	kg/Mg	1.25E-02	4.30E-03	4.30E-04	-	-	-	-
2. DMS Beneficiation (8 operations)	kg/Mg	5.00E-03	2.00E-03	2.00E-04	-	-	-	-
3. Product handling (CUF-C)								
1. FEL operation	g/VKT	2.62E+03	7.45E+02	7.45E+01	-	-	-	-
2. Material handling (3 operations)	kg/Mg	5.00E-03	2.00E-03	2.00E-04	-	-	-	-
3. Fugitive emissions from storage	kg/ha/h	7.20E+00	2.20E+00	2.20E-01	-	-	-	-
B. Waste Disposal Facility (WDF) / Pollution Control Dam (PCD)								
1. Waste disposal facility (WDF)								
1. FEL operation	g/VKT	2.62E+03	7.45E+02	7.45E+01	-	-	-	-
2. Material handling (3 operations)	kg/Mg	5.00E-03	2.00E-03	2.00E-04	-	-	-	-
3. Fugitive emissions from storage	kg/ha/h	7.20E+00	2.20E+00	2.20E-01	-	-	-	-
C. Haul Roads								
1. CUF-C to export (unpaved)	g/VKT	3.18E+03	9.05E+02	9.05E+01	-	-	-	-
2. CUF-W to waste disposal facility (unpaved)	g/VKT	3.18E+03	9.05E+02	9.05E+01				

Notes

g/VKT	:	Gram per vehicle kilometre travelled.
kg/Mg	:	Kilogram per megagram.
kg/ha/h	:	Kilogram per hectare per hour.
Mobile equipment operation	:	US EPA, AP42, Volume I, 5 Edition Chapter 13.2.
Material handling	:	US EPA, AP42, Volume I, 5 Edition Chapter 11.24. High moisture ore (>4%).
Fugitive emissions from magnetite storage	:	US EPA, AP42, Volume I, 5 Edition Chapter 11.9.
Screening	:	US EPA, AP42, Volume I, 5 Edition Chapter 11.19.
DMS beneficiation	:	US EPA, AP42, Volume I, 5 Edition Chapter 11.24. High moisture ore (>4%).

Table 7.4.11.2(d): Magnetite Beneficiation – Emission Rates 2021 Reporting Period

Activity	Control Efficiency[b]	Emission Rate[a]							Totals	
		TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO_2	CO		
A. SAOB Plant (MGB)									**5.610**	**7.69%**
1. Feed handling (MGB-F)										
1. FEL operation	25%	0.409	0.116	0.012	-	-	-	-	0.536	0.74%
2. Material handling (3 operations)	0%	0.306	0.122	0.012	-	-	-	-	0.440	0.60%
3. Fugitive emissions from storage	0%	1.280	0.392	0.039	-	-	-	-	1.711	2.35%
2. Beneficiation operations (MGB-2)										
1. Screening	0%	0.255	0.088	0.009	-	-	-	-	0.351	0.48%
2. DMS Beneficiation (8 operations)	0%	0.815	0.326	0.033	-	-	-	-	1.174	1.61%
3. Product handling (MGB-P1/P2)										
1. FEL operation	25%	0.406	0.115	0.012	-	-	-	-	0.533	0.73%
2. Material handling (3 operations)	0%	0.304	0.121	0.012	-	-	-	-	0.437	0.60%
3. Fugitive emissions from storage	0%	0.320	0.098	0.010	-	-	-	-	0.428	0.59%
B. MP2 Plant (MGD)									**29.020**	**39.79%**
1. Feed handling (MGD-F)										
1. FEL operation	25%	0.403	0.115	0.011	-	-	-	-	0.529	0.73%
2. Material handling (3 operations)	0%	0.301	0.121	0.012	-	-	-	-	0.434	0.60%
3. Fugitive emissions from storage	0%	0.360	0.110	0.011	-	-	-	-	0.481	0.66%
2. Drying operations (MGD-2)										
1. Drying circuit	99%	2.004	1.192	0.119	-	-	-	-	3.315	4.55%
2. Combustion	50%	0.188	0.038	0.038	0.054	0.002	17.611	0.014	17.945	24.61%

Activity	Control Efficiency[b]	Emission Rate[a]							Totals	
		TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO_2	CO		
3. Beneficiation operations (MGD-2)										
1. Magnetic separation (8 operations)	50%	0.096	0.048	0.005	-	-	-	-	0.150	0.21%
4. Product handling (MGB-P1/P2)										
1. FEL operation	25%	0.150	0.043	0.004	-	-	-	-	0.197	0.27%
2. Material handling (3 operations)	0%	3.644	1.822	0.182	-	-	-	-	5.648	7.75%
3. Fugitive emissions from storage	0%	0.240	0.073	0.007	-	-	-	-	0.321	0.44%
C. Magnetite Stockpiles									**10.595**	**18.13%**
1. Export stockpile 1 (Tengwa operations)(STN-1)										
1. FEL operation	25%	0.992	0.282	0.028	-	-	-	-	1.303	1.79%
2. Material handling (3 operations)	0%	0.742	0.297	0.030	-	-	-	-	1.069	1.47%
3. Fugitive emissions from storage	0%	3.140	0.961	0.096	-	-	-	-	4.197	5.76%
2. Export stockpile 2 (SAOB/MP2 operations)(STN-2)										
1. FEL operation	25%	0.450	0.128	0.013	-	-	-	-	0.591	0.81%
2. Material handling (3 operations)	0%	0.337	0.135	0.013	-	-	-	-	0.485	0.66%
3. Fugitive emissions from storage	0%	1.780	0.545	0.054	-	-	-	-	2.379	3.26%
3. Export stockpile 3 (SAOB/MP2 operations)(STN-3)										
1. FEL operation	25%	0.106	0.030	0.003	-	-	-	-	0.139	0.19%
2. Material handling (3 operations)	0%	0.079	0.032	0.003	-	-	-	-	0.114	0.16%
3. Fugitive emissions from storage	0%	1.500	0.459	0.046	-	-	-	-	2.005	2.75%

Activity	Control Efficiency[b]	Emission Rate[a]							Totals	
		TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO_2	CO		
4. MP2 P2 stockpile (MGD-P2 East)										
1. FEL operation	25%	0.000	0.000	0.000	-	-	-	-	0.000	0.00%
2. Material handling (3 operations)	0%	0.000	0.000	0.000	-	-	-	-	0.000	0.00%
3. Fugitive emissions from storage	0%	0.000	0.000	0.000	-	-	-	-	0.000	0.00%
5. SAOB P2 stockpile (MGD-P2 West)										
1. FEL operation	25%	0.000	0.000	0.000	-	-	-	-	0.000	0.00%
2. Material handling (3 operations)	0%	0.000	0.000	0.000	-	-	-	-	0.000	0.00%
3. Fugitive emissions from storage	0%	0.000	0.000	0.000	-	-	-	-	0.000	0.00%
D. Haul Roads									**13.034**	**22.31%**
1. Mag Ore to SAOB (unpaved)	25%	1.038	0.295	0.030	-	-	-	-	1.363	1.87%
2. Mag Ore to MP2 (unpaved)	25%	5.120	1.456	0.146	-	-	-	-	6.721	9.22%
3. Mag Ore to Tengwa (unpaved)	25%	3.943	1.121	0.112	-	-	-	-	5.177	7.10%
4. SAOB P1 to export STN-2 (unpaved)	25%	1.927	0.548	0.055	-	-	-	-	2.529	3.47%
5. SAOB P2 to MGD-P2 West (paved)	25%	0.000	0.000	0.000	-	-	-	-	0.000	0.00%
6. SAOB P2 to export STN-3 (unpaved)	25%	0.730	0.207	0.021	-	-	-	-	0.958	1.31%
7. MP2 P1 to export STN-2 (unpaved)	25%	0.638	0.181	0.018	-	-	-	-	0.837	1.15%
8. MP2 P2 to MGD-P2 East (paved)	25%	0.000	0.000	0.000	-	-	-	-	0.000	0.00%
9. MP2 P2 to export STN-3 (unpaved)	25%	0.047	0.013	0.001	-	-	-	-	0.061	0.08%
10. Gypsum GS2 to export (unpaved)	25%	0.348	0.099	0.010	-	-	-	-	0.457	0.63%
11. Mag Ore to SAOB/MP2 (paved)	25%	1.864	0.180	0.044	-	-	-	-	2.087	2.86%
12. Mag Ore to Tengwa (paved)	25%	2.039	0.391	0.095	-	-	-	-	2.526	3.46%
13. Gypsum GS2 to export (paved)	25%	0.083	0.016	0.004	-	-	-	-	0.103	0.14%

Activity	Control Efficiency[b]	Emission Rate[a]							Totals	
		TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_2	CO_2	CO		
E. Tailings									**3.188**	**5.46%**
1. Gypsum A-Stack (GS1)										
1. Fugitive emissions from storage	0%	1.252	0.383	0.038	-	-	-	-	1.674	2.86%
2. Gypsum B-Stack (Bosveld operations)(GS2)										
1. FEL operation	25%	0.040	0.012	0.001	-	-	-	-	0.053	0.07%
2. Material handling (3 operations)	0%	0.030	0.012	0.001	-	-	-	-	0.044	0.06%
3. Fugitive emissions from storage	0%	1.067	0.326	0.033	-	-	-	-	1.426	1.95%
Totals		**40.773**	**13.050**	**1.422**	**0.054**	**0.002**	**17.611**	**0.014**	**72.926**	**100.00%**
		55.91%	**17.89%**	**1.95%**	**0.07%**	**0.00%**	**24.15%**	**0.02%**	**100.00%**	
Emissions Summary by Activity										
Mobile equipment operation		20.732	5.350	0.618	-	-	-	-	26.700	36.61%
Material handling		5.743	2.662	0.266	-	-	-	-	8.671	11.89%
Magnetite Beneficiation		3.358	1.691	0.203	0.054	0.002	17.611	0.014	22.934	31.45%
Fugitive emissions from magnetite storage		8.620	2.638	0.264	-	-	-	-	11.521	15.80%
Fugitive emissions from gypsum storage		2.319	0.710	0.071	-	-	-	-	3.099	4.25%

Notes

Emission rate : gram per second.

Control factor : Estimated control factors from various mining operations obtained from Holmes Air Sciences (1998).

Table 7.4.11.2(e): Magnetite Beneficiation – Emission Inventory Parameters

Parameter	Unit	Value
Annual production days	days/year	324.00
Monthly production days	days/month	27.00
Annual production hours	hours/year	7 776.00
Monthly production hours	hours/month	648.00
Daily production hours	hours/day	24.00
Coal used (Bosveld)(AEL)	tonnes/year	20 000.00
Coal used (MP2)(AEL)	tonnes/year	18 000.00
HFO used (MP2)(AEL)	litres/year	200 000.00
Mag Ore raw material (SAOB)(2021)	tonnes	642 600.21
Mag Ore raw material (MP2) (2021)	tonnes	633 793.25
Mag Ore raw material (Tengwa) (2021)	tonnes	1 560 629.11
Gypsum raw material (Bosveld) (2021)	tonnes	63 666.78
Mag Ore P1 produced (SAOB) (2021)	tonnes	521 401.53
Mag Ore P2 produced (SAOB) (2021)	tonnes	117 054.69
Mag Ore P1 produced (MP2) (2021)	tonnes	186 063.00
Mag Ore P2 produced (MP2) (2021)	tonnes	49 793.00
Mag Ore produced (Tengwa) (2021)	tonnes	1 560 629.11
TSP Particle Size Multiplier for Paved Road Equation	g/VKT	3.23
PM10 Particle Size Multiplier for Paved Road Equation	g/VKT	0.62
PM2.5 Particle Size Multiplier for Paved Road Equation	g/VKT	0.15
Paved surfaces silt loading	g/m^2	9.70
Unpaved surfaces silt content	%	8.30
Constant k TSP Particle Size for Unpaved Road Equation	lb/VMT	4.90
Constant k PM10 Particle Size for Unpaved Road Equation	lb/VMT	1.50
Constant k PM2.5 Particle Size for Unpaved Road Equation	lb/VMT	0.15
Constant a TSP Particle Size for Unpaved Road Equation	lb/VMT	0.70
Constant a PM10/2.5 Particle Size for Unpaved Road Equation	lb/VMT	0.90
Constant b TSP/PM10/PM2.5 Particle Size for Unpaved Road Equation	lb/VMT	0.45
Bell 467ZX FEL weight	tonnes	22.08
Bell 467ZX FEL bucket capacity	m3	3.50
Bell 467ZX FEL bucket capacity	tonnes	4.90
Bell B30E 4x4 ADT average weight of 33.99t (Gross weight 47.99t & Tare weight 19.99t)	tonnes	33.99
Road transport average vehicle weight of 38.75t (Gross weight 56t & Tare weight 21.5t)	tonnes	38.75
Bosveld Phosphates average annual wind speed for 2021	m/s	4.00
Paved Road - Mag Ore to SAOB/MP2	kilometres	1.96
Unpaved Road - Mag Ore to SAOB	kilometres	0.78
Unpaved Road - Mag Ore to MP2	kilometres	3.90
Paved Road - Mag Ore to Tengwa and Gypsum export	kilometres	2.00
Unpaved Road - Mag Ore to Tengwa	kilometres	1.22

Parameter	Unit	Value
Unpaved Road - SAOB P1 to STN2	kilometres	1.66
Paved Road - SAOB P2 to MGD-P2 West	kilometres	1.58
Unpaved Road - SAOB P2 to STN3	kilometres	2.80
Unpaved Road - MP2 P1 to STN2	kilometres	1.54
Paved Road - MP2 P2 to MGD-P2 East	kilometres	1.12
Unpaved Road - MP2 P2 to STN3	kilometres	0.42
Unpaved Road - Gypsum export	kilometres	2.64
Stockpile Operations	kilometres	0.05
Surface Area - SAOB feed handling	ha	0.64
Surface Area - SAOB plant	ha	0.49
Surface Area - SAOB product handling	ha	0.16
Surface Area - MP2 feed handling	ha	0.18
Surface Area - MP2 plant	ha	0.10
Surface Area - MP2 product handling	ha	0.12
Surface Area - STN 1	ha	1.57
Surface Area - STN 2	ha	0.89
Surface Area - STN 3	ha	0.75
Surface Area - MGD-P2 East	ha	0.96
Surface Area - MGD-P2 West	ha	0.91
Surface Area - Gypsum A-Stack	ha	68.92
Surface Area - Gypsum B-Stack	ha	58.70
Surface Area - Gypsum Remining	ha	34.96
Material handling emission control factor	unitless	1.00
Magnetite stockpile emission control factor	unitless	1.00
Gypsum stockpile emission control factor	unitless	1.00
Roads and marshalling areas emission control factor	unitless	0.75
MP2 plant particulate gas emission control factor	unitless	0.01
MP2 plant scrubber gas emission control factor	unitless	0.01

7.4.11.3. Pollution Sources

The outdoor sources of air pollution resulting from human activities comprise three broad categories.

- **Stationary sources** can be subdivided into; rural area sources, e.g. agriculture, mining and quarrying and industrial point and area sources, e.g. manufacturing of chemicals, non-metallic mineral products, basic metal industries and power generation.
- **Community sources** i.e., heating of homes and buildings, municipal waste and sewage sludge incinerators, fireplaces, cooking facilities, laundry services and cleaning plants.
- **Mobile sources** include sources such as combustion-engine vehicles, e.g. light duty petrol-powered cars, light and heavy-duty diesel-powered vehicles, motorcycles, aircraft and line sources such as fugitive emissions from vehicle traffic.

Air pollutants are traditionally classified into suspended particulate matter (dusts, fumes, mists and smokes), gaseous pollutants (gases and vapours) and odours.

As evident from Figure 7.4.11.3(a), the source groups per District Municipality for the Limpopo Province include industry, domestic fuel burning and mining, with differences in contribution by each source across the Districts. Other sources within the Province contributing to air pollution include domestic fuel burning, vehicle tailpipe emissions, and biomass burning.

The main sources of SO_2 and NOx within the Limpopo Province are the power generation sources within the Waterberg District Municipality. Small boilers, followed by mining operations (both coal and metallurgical), are the main contributing sources to total suspended particulate matter (TSP) with boilers (assuming all TSP to be PM_{10}) the main source of PM_{10}. Wood processing is the second most significant source of PM_{10}. The main contributor within the Province to fine particulate matter ($PM_{2.5}$) and CO is biomass burning. Vehicle tailpipe emissions are the main source of hydrocarbons specifically within the Districts of Waterberg, Capricorn and Vhembe. VOCs show to be primarily from wood treatment works and these are mainly restricted to Mopani District Municipality. Small boilers, where quantified, also indicated to be potential significant sources of CO_2.

Four 'hot-spot' areas were selected for dispersion modelling (see Table 7.4.11.3(a)) based on the current understanding of the air quality within the Province, the location of significant sources as well as available emissions data. These are:

- **Polokwane region**: a region with a high number of sources and no up-to-date ambient air quality data to determine the current state of air.
- **Lephalale region**: the only region within the Province with power stations and large-scale coal mining activities.
- **Phalaborwa region**: the only area with fertiliser manufacturing, a copper smelter and large opencast mining operations.
- **Steelpoort Valley**: an area with significant number of mining activities.

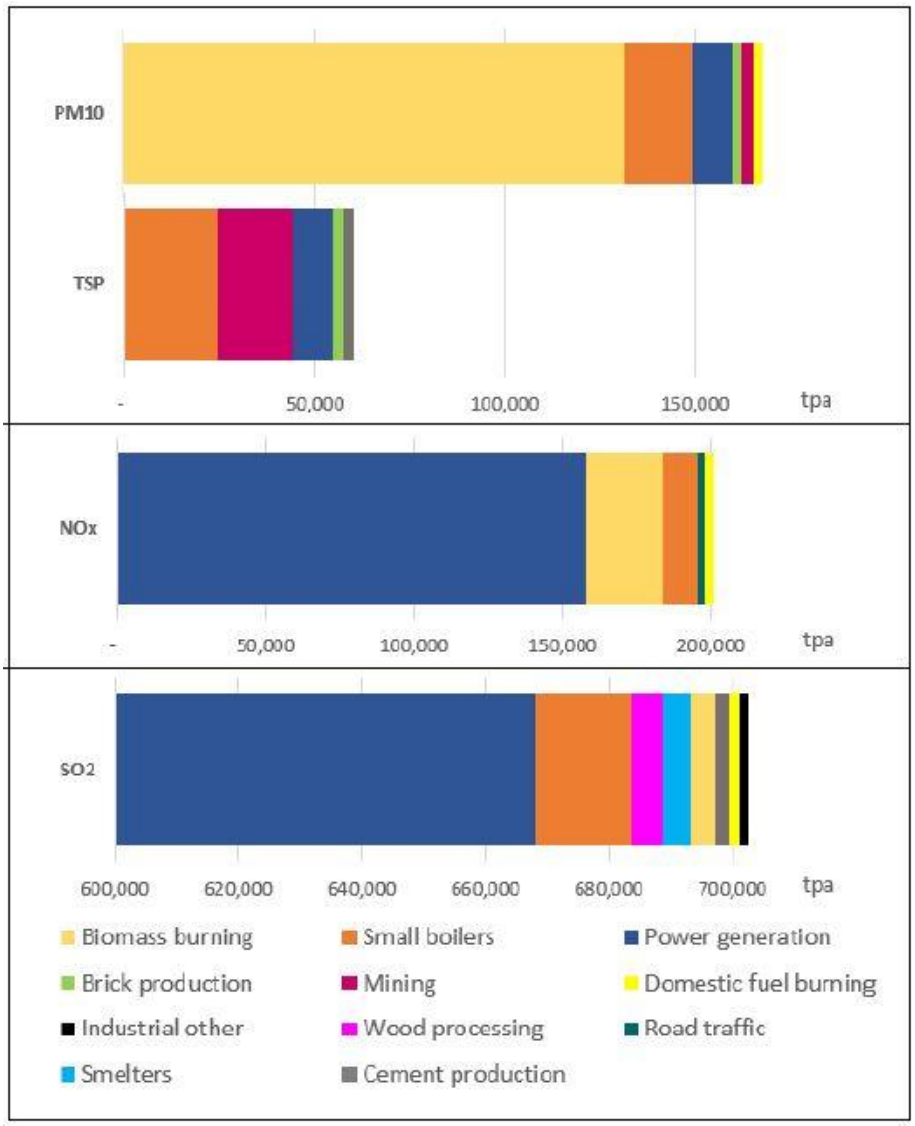


Figure 7.4.11.3(a): Limpopo Province Emission Per Source Group

Some of the concerns identified were:

- The predicted impacts within the Polokwane area are mainly localised.
- The area around Lephalale is of concern, due to the planned development rather than the current situation. Current Ground Level Concentrations (GLCs) PM_{10} are however a concern around the opencast mines in the area where it is predicted to exceed standards at nearby settlements.
- The main area of concern is around Phalaborwa due to very high SO_2 concentrations impacting on the town.
- The Steelpoort area due to the numerous mining operations within proximity to villages and homesteads resulting in high PM_{10} GLCs.

Table 7.4.11.3(a): Predicted Impact at the Four "Hot-spot" Areas Within the Limpopo Province

Identified Areas	Main Pollutant	Main Sources of Concern	Significance
Polokwane	PM_{10}	Brickworks and asphalt plants	Medium
	SO_2	Smelters	Medium
Lephalale	PM_{10}	Mining operations	High
	SO_2	Power plants	Medium
Phalaborwa	PM_{10}	Mining operations	Medium
	SO_2	Smelter and fertiliser production	High
Steelpoort	PM_{10}	Mining operations	High

All source groups were ranked in order of significance employing a typical Environmental Impact Assessment significance ranking methodology. The significance ranking for the areas of concern showed the following (see Table 7.4.11.3(b)):

- Wood processing, mainly based on the number of activities, was ranked first in Mopani and in Vhembe. There are, however, far more wood processing activities in Mopani than in Vhembe.
- The smelting and fertiliser operations at Phalaborwa, even though both ranked fourth, are significant impacting sources.
- Mining resulted in a significant source at Sekhukhune and Waterberg DMs. At Waterberg DM, the main concern is around the coal mining operations and at Sekhukhune it is around the numerous platinum mines within the Steelpoort Valley area.
- Brickworks and other industrial sources were flagged as significant contributing emission sources in the Capricorn DM.

Table 7.4.11.3(b): Ranked Significance of Source Groups in Each District Municipality

Source Group	Capricorn	Mopani	Sekhukhune	Vhembe	Waterberg
Brick production	1	3	-	3	2
Cement industry	3	-	-	-	5
Fertiliser	-	4	3	-	-
Fuel depot	-	7	5	-	-
Incinerators	-	-	-	-	-
Industrial stockpiles	7	-	-	-	-
Industrial other	1	6	4	4	3
Mining	3	2	1	2	1
Power generation	-	-	-	-	4
Small boilers	-	-	-	-	-
Smelter	5	4	2	-	-
Wood processing	6	1	-	1	-

Notes:
Ranking based on number of sources of each type and the total impact score.

The 2007 National Framework lists District and Metropolitan Municipalities where the ambient air is regarded as poor or potentially poor. For Limpopo Province, the ambient air in the Capricorn, Mopani and Waterberg District Municipalities are listed as 'potentially poor' with the definition as 'air quality poor at times or deteriorating'.

The National Framework describes, *inter alia*, the implementation of ambient air quality standards. In this discussion five zones of control are described, each summarised briefly below.

Green Zone: Class 1 Air Quality Area: The areas where ambient air quality remains within Target Levels and no substantive corrective air quality management interventions are required other than basic good air quality governance.

Target Levels – The ambient air quality targets for South Africa that provide an adequate 'development buffer' between air that is harmful and air that is not harmful to health and well-being. Target levels are likely to be set at 80% of the National ambient air quality standards.

Blue Zone: Class 2 Air Quality Area: The areas where ambient air quality remains within Alert Levels, but 'pre-emptive' air quality management interventions are required other than basic good air quality governance.

Alert Levels – will be the levels of ambient air quality where 'pre-emptive' governance interventions are triggered that provide an adequate 'intervention development buffer' between air that is harmful and air that is not harmful to health and well-being. Alert levels are likely to be set at 90% of the National ambient air quality standards.

Purple Zone: Class 3 Air Quality Area: The areas where ambient air quality remains within the standards, but sustained air quality management interventions are required to, at least, maintain or improve this situation.

The Ambient Air Quality Standards will be the levels of ambient air quality where immediate governance interventions are triggered with the aim of, at least, bringing the area into compliance with the standard. This standard is the boundary between air that is potentially harmful and air that is not harmful to health and well-being.

Orange Zone: Class 4 Air Quality Area: The areas where ambient air quality represents a possible threat to health and well-being and requires immediate and sustained air quality management interventions to, at least, bring the area into compliance with the standards within agreed time frames.

In order for Government to prioritise efficient and effective air quality interventions, although immediate interventions are required, Class 4 Air Quality Areas need not necessarily be declared as priority areas in terms of the AQA.

Red Zone: Class 5 Air Quality Area: The areas where ambient air quality represents a possible threat to health and well-being and requires immediate and sustained air quality management interventions to, at least, bring the area into compliance with the standards within agreed time frames. Class 5 Air Quality Areas must immediately be declared National or Provincial priority areas in terms of the AQA.

Dispersion modelling carried out as part of the baseline assessment indicated that ambient air quality standards of PM_{10} and SO_2 may be exceeded from time-to-time near Lephalale, Phalaborwa and in the Steelpoort Valley. This implies a potential of Zones 3 or 4 being approached, requiring action by Air Quality Officers.

However, as no substantive air quality measurements have been conducted in these areas, other than SO_2 by Palaborwa Copper, it is suggested that insufficient information exists to indicate which of the two air quality control zones is applicable. It was recommended, therefore, that current monitoring requirements are aimed at a Zone 3 (purple zone) level in those regions. Until better information becomes available, it was recommended that a Zone 2 classification be given to the other areas in the Province.

7.4.11.4. Bosveld Phosphates Air Quality

Ambient dust deposition monitoring commenced in October 2019 at Bosveld Phosphates. The program provided for 11 dust deposition monitoring stations indicated in Figure 7.4.11.4(a).

A summary of the dust deposition rates for the period October 2020 to September 2021 is presented in Table 7.4.11.4(a) and Figure 7.4.11.4(b) to Figure 7.4.11.4(m).

Figure 7.4.11.4(a): Bosveld Phosphates Dust Deposition Monitoring Matrix (Yellow markers – Non-residential receptor, Red marker – Source)

Table 7.4.11.4(a): Summary of Dust Deposition Rates – September 2020 to August 2021

Monitoring Station		Average Dust Deposition Rate (mg/m²/day)[1]	Comments[2]
Non-Residential Monitoring Stations			
BOS6	Loading Station #1 lat 23.975214° lon 31.100977°	**4 823.03**	- Dust deposition rate above the **1 200 mg/m²/day non-residential NEM: AQA** dust deposition standard. - Contraventions: **11** - Last three contraventions: **06/2021, 07/2021 & 08/2021** - Current Classification: **Excessive!**
BOS7	Northern Boundary lat 23.974907° lon 31.093576°	**924.63**	- Dust deposition rate above the **1 200 mg/m²/day non-residential NEM: AQA** dust deposition standard. - Contraventions: 3 - Last two contraventions: **10/2020, 11/2020 & 08/2021** - Current Classification: **Excessive!**
BOS8	North Western Boundary lat 23.973683° lon 31.079200°	**281.04**	- Dust deposition rate below the **1 200 mg/m²/day non-residential NEM: AQA** dust deposition standard. - Contraventions: **0** - Last contravention: **None** - Current Classification: **Acceptable**
BOS9	Eastern Boundary, Opposite Dry Magnetite Beneficiation Plant lat 23.979487° lon 31.104985°	**4 132.60**	- Dust deposition rate above the **1 200 mg/m²/day non-residential NEM: AQA** dust deposition standard. - Contraventions: **11** - Last three contraventions: **06/2021, 07/2021 & 08/2021** - Current Classification: **Excessive!**
BOS10	Eastern Boundary, Opposite Loading Station #2 lat 23.981442° lon 31.104088°	**3 509.32**	- Dust deposition rate above the **1 200 mg/m²/day non-residential NEM: AQA** dust deposition standard. - Contraventions: **10** - Last three contraventions: **06/2021, 07/2021 & 08/2021** - Current Classification: **Excessive!**
BOS11	Eastern Boundary, Opposite Loading Station #3 lat 23.984432° lon 31.102827°	**5 091.88**	- Dust deposition rate above the **1 200 mg/m²/day non-residential NEM: AQA** dust deposition standard. - Contraventions: **10** - Last three contraventions: **06/2021, 07/2021 & 08/2021** - Current Classification: **Excessive!**

Monitoring Station		Average Dust Deposition Rate (mg/m²/day)[1]	Comments[2]
Source Monitoring Stations			
BOS1	Dry Magnetite Beneficiation lat 23.978356° lon 31.103937°	**3 014.84**	- Standard for reference purposes only when evaluating source monitoring results within the plant boundary. - Source monitoring data is used to maintain the emissions inventory, for calibration of dispersion models, for prioritisation of management
BOS2	Loading Station #2 lat 23.980833° lon 31.102825°	**4 929.72**	
BOS3	Loading Station #3 lat 23.981953° lon 31.100642°	**4 014.73**	

Monitoring Station		Average Dust Deposition Rate (mg/m²/day)[1]	Comments[2]
BOS4	Wet Magnetite Beneficiation lat 23.977674° lon 31.099586°	**6 208.55**	actions and evaluation of the effectiveness of control measures.
BOS5	Gypsum Stack A lat 23.976481° lon 31.090588°	**272.31**	
BOS12	Fedex Plant Administration Building lat 23.979347° lon 31.101392°	**3 989.34**	

Notes:

mg/m²/day: milligram dust deposited on a horizontal area of one square meter in a period of 24-hours

1: Dust deposition for the monitoring period measured in accordance with ASTM D1739: 1998. Colours correspond to the coding used below, i.e. dust deposition rates indicated in blue indicate conformance to the national standard and red indicates that the national standard has been contravened.

2: Comments NEM: AQA dust deposition standard promulgated under the National Dust Control Regulations, National Environmental Management: Air Quality Act (Act No. 39 of 2004) Standard for reference purposes only when evaluating source monitoring results within the plant boundary.

Standard: Dust deposition rate below 1 200mg/m²/day in non-residential areas and below 600mg/m²/day in residential areas. These standards are aimed at avoiding, preventing, or reducing harmful effects on human health or the environment.

Contravention: Requires investigation and remediation if two sequential months exceed the standard or if the level is exceeded more than twice per annum.

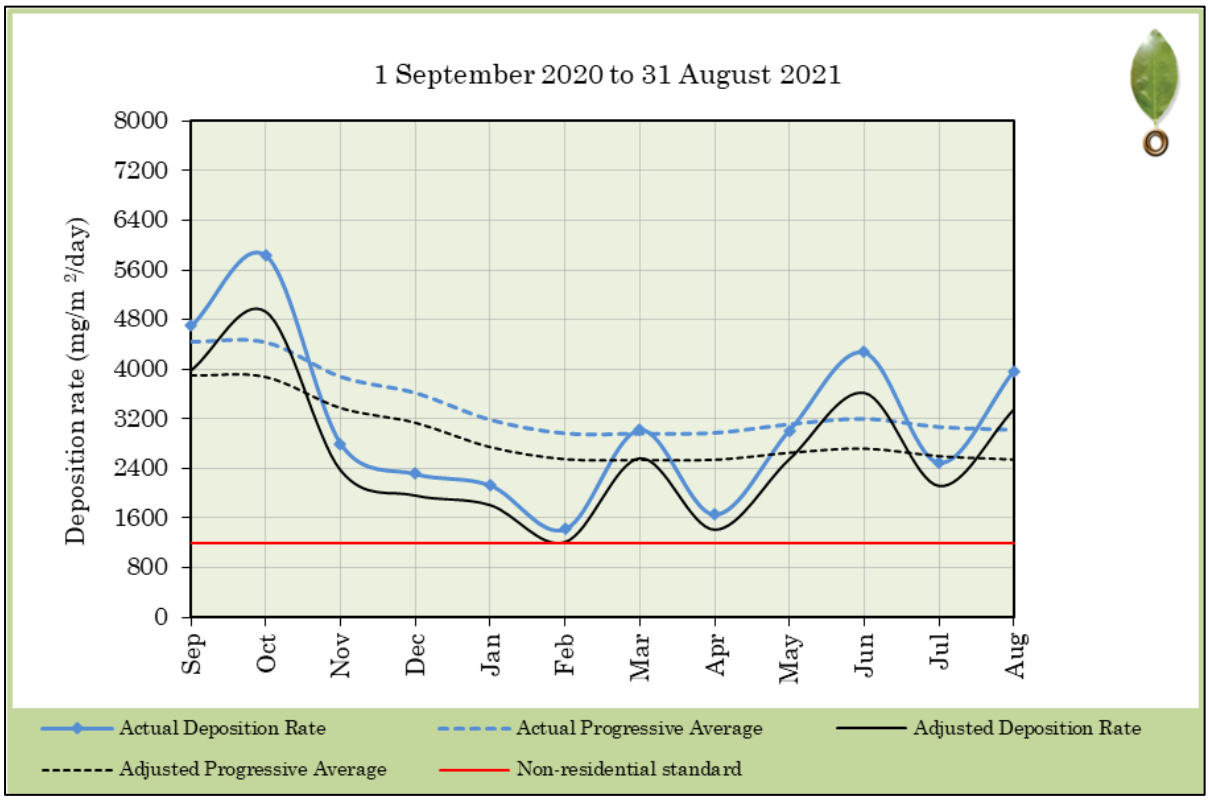


Figure 7.4.11.4(b): BOS#1 – Dry Magnetite Beneficiation

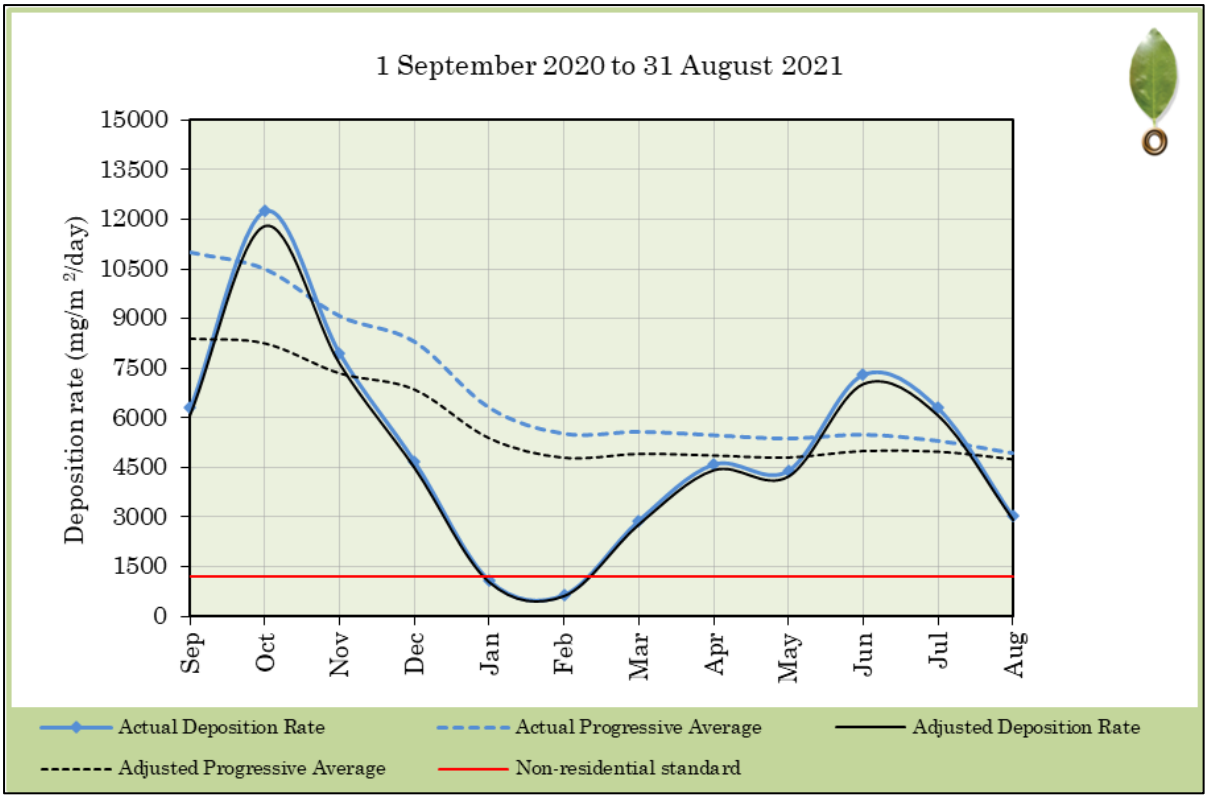


Figure 7.4.11.4(c): BOS#2 – Loading Station #2

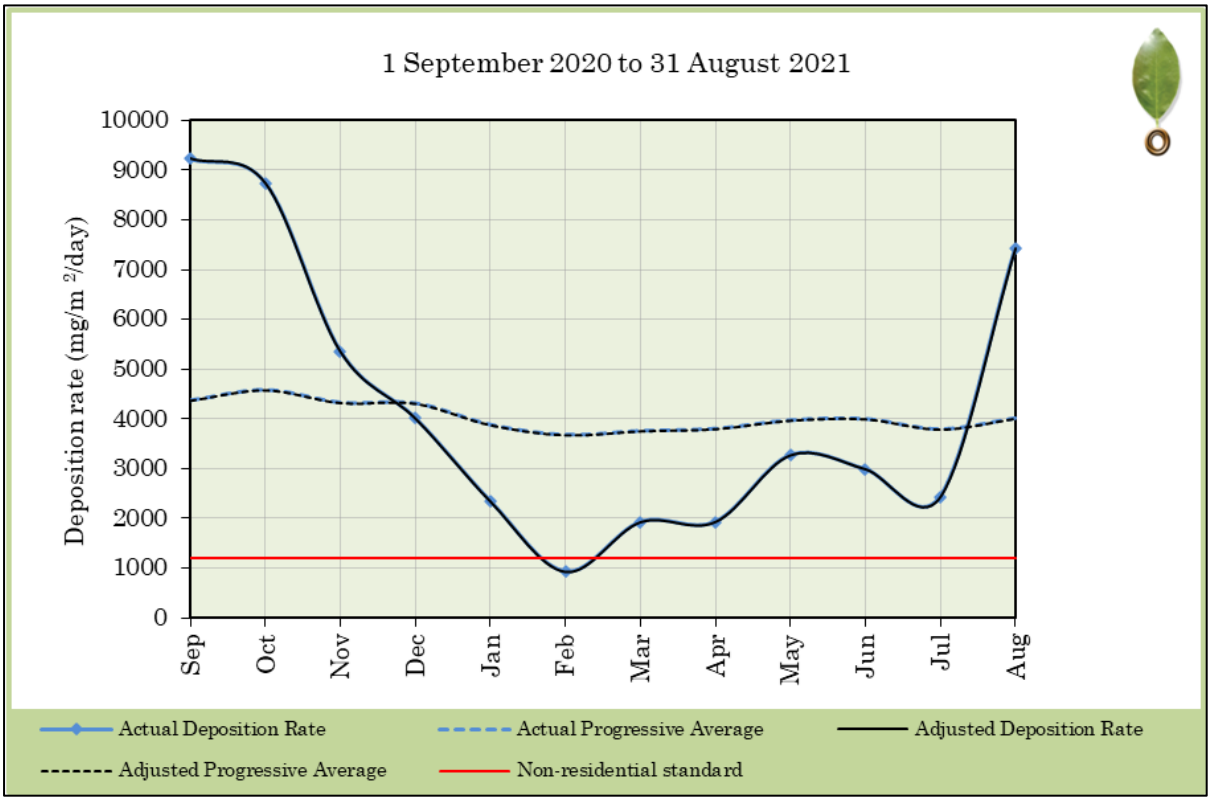


Figure 7.4.11.4(d): BOS #3 – Loading Station #3

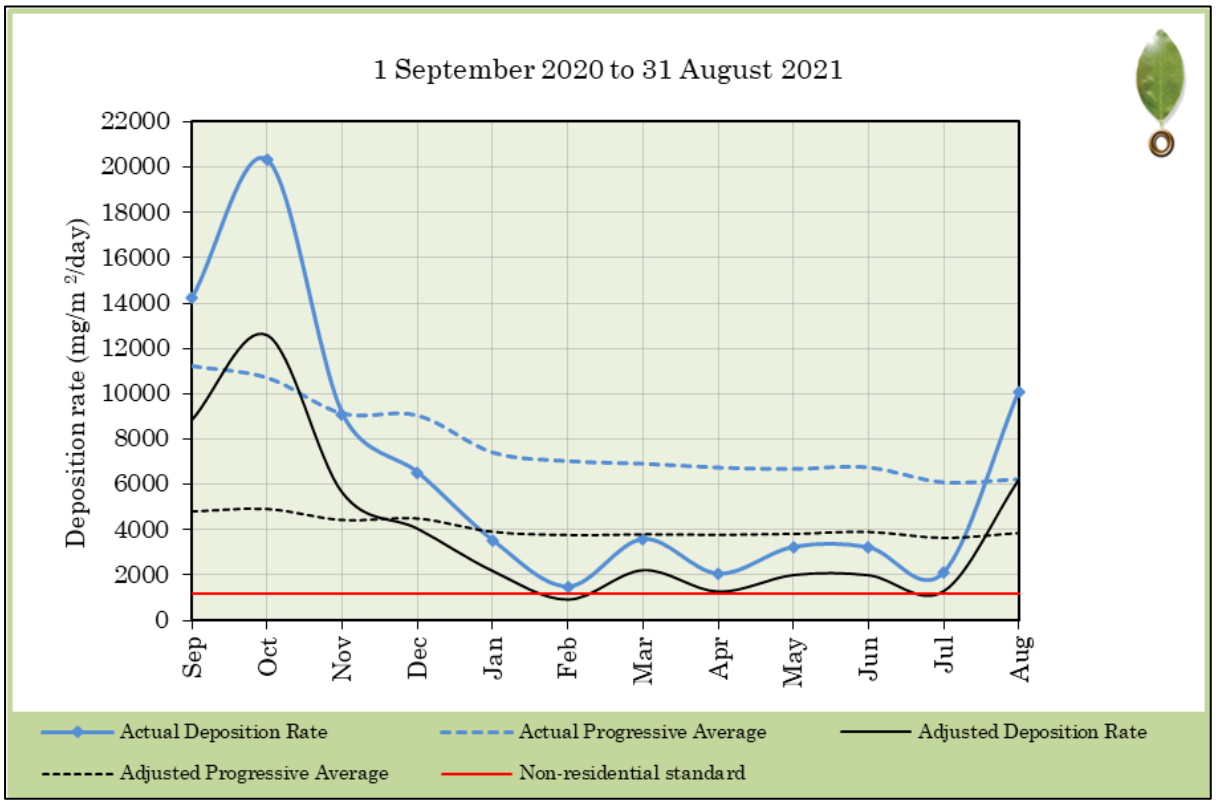


Figure 7.4.11.4(e): BOS #4 – Wet Magnetite Beneficiation

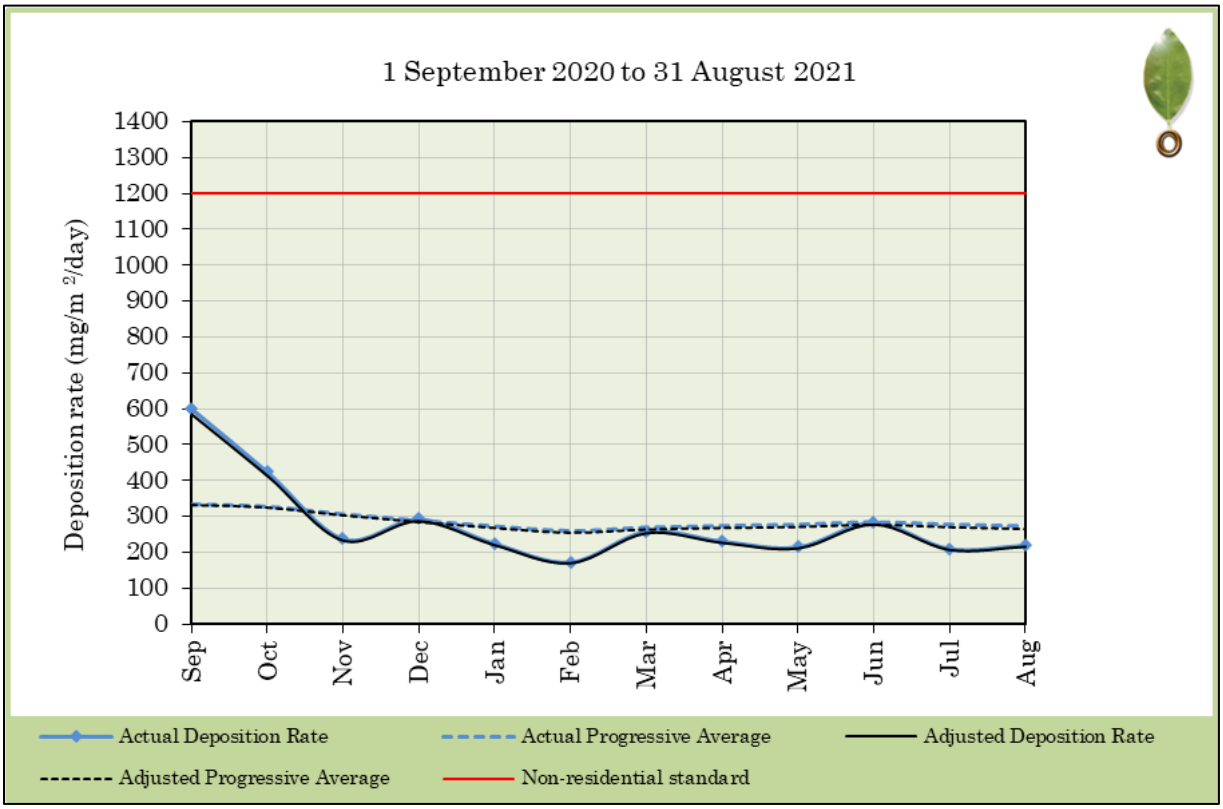


Figure 7.4.11.4(f): BOS #5 – Gypsum Stack A

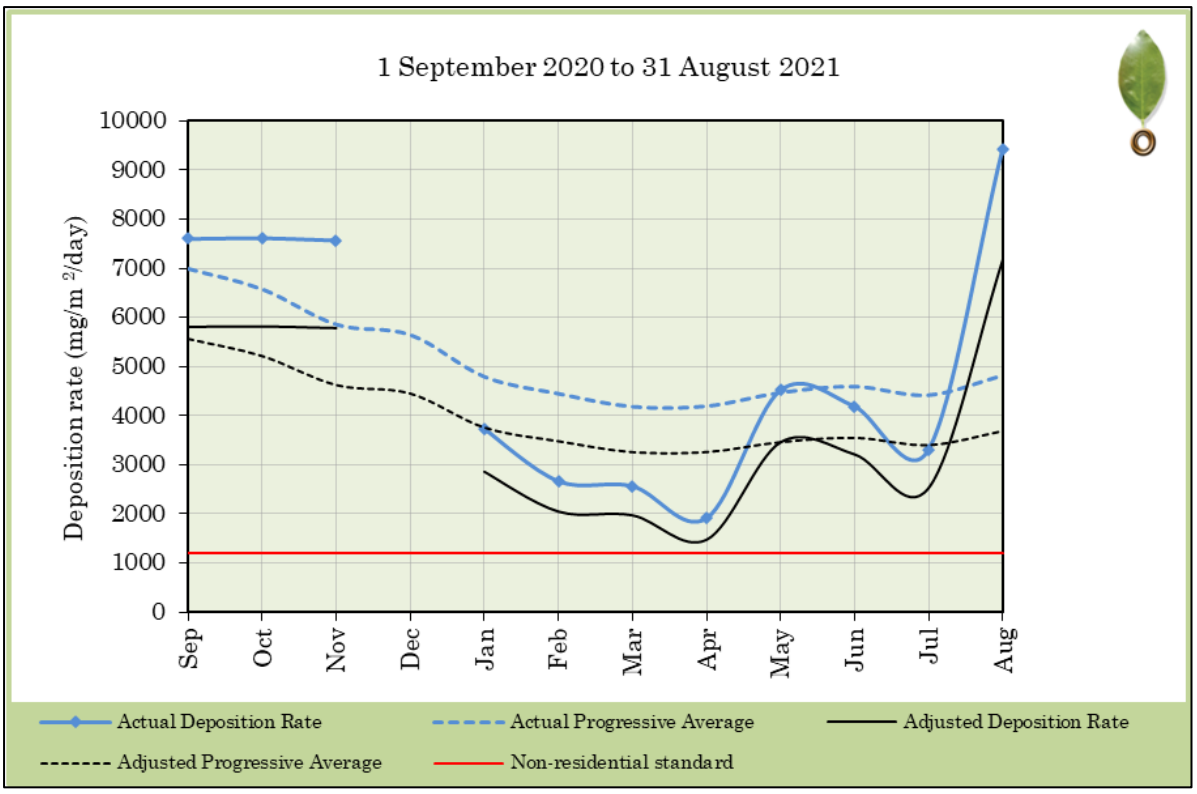


Figure 7.4.11.4(g): BOS #6 – Loading Station #1

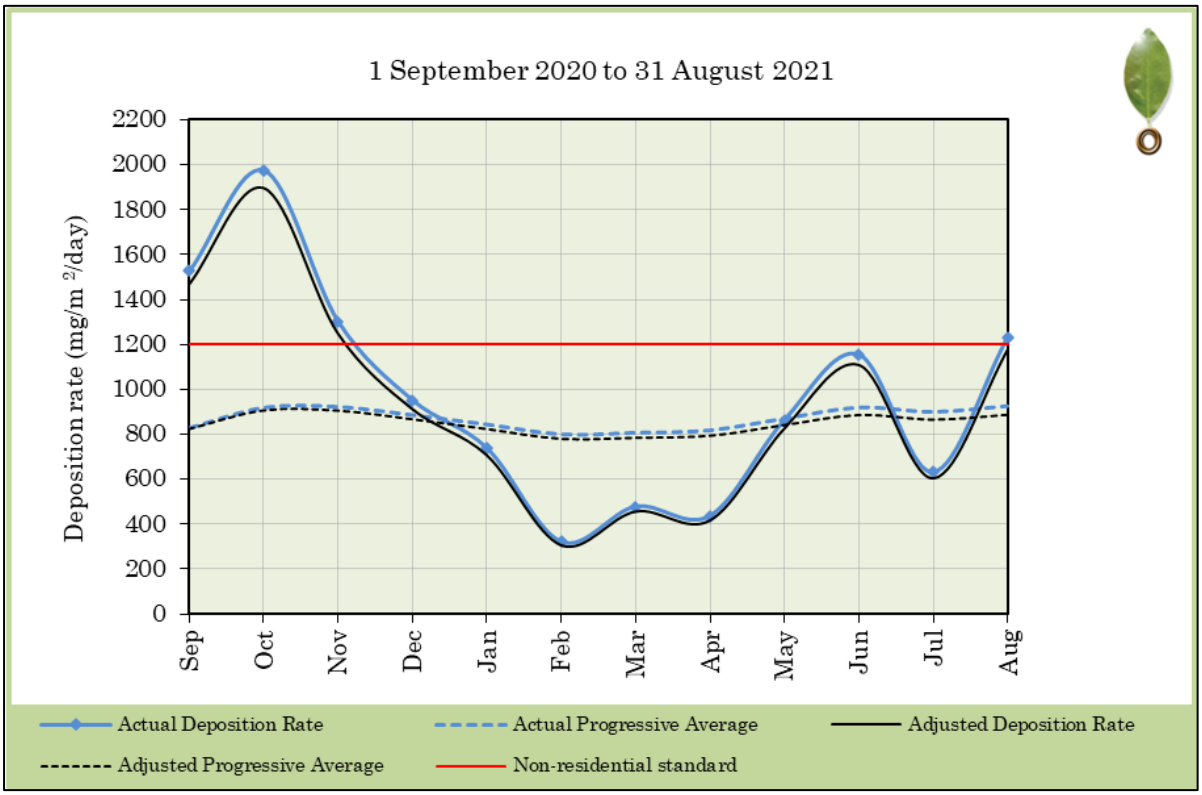


Figure 7.4.11.4(h): BOS #7 – Northern Boundary

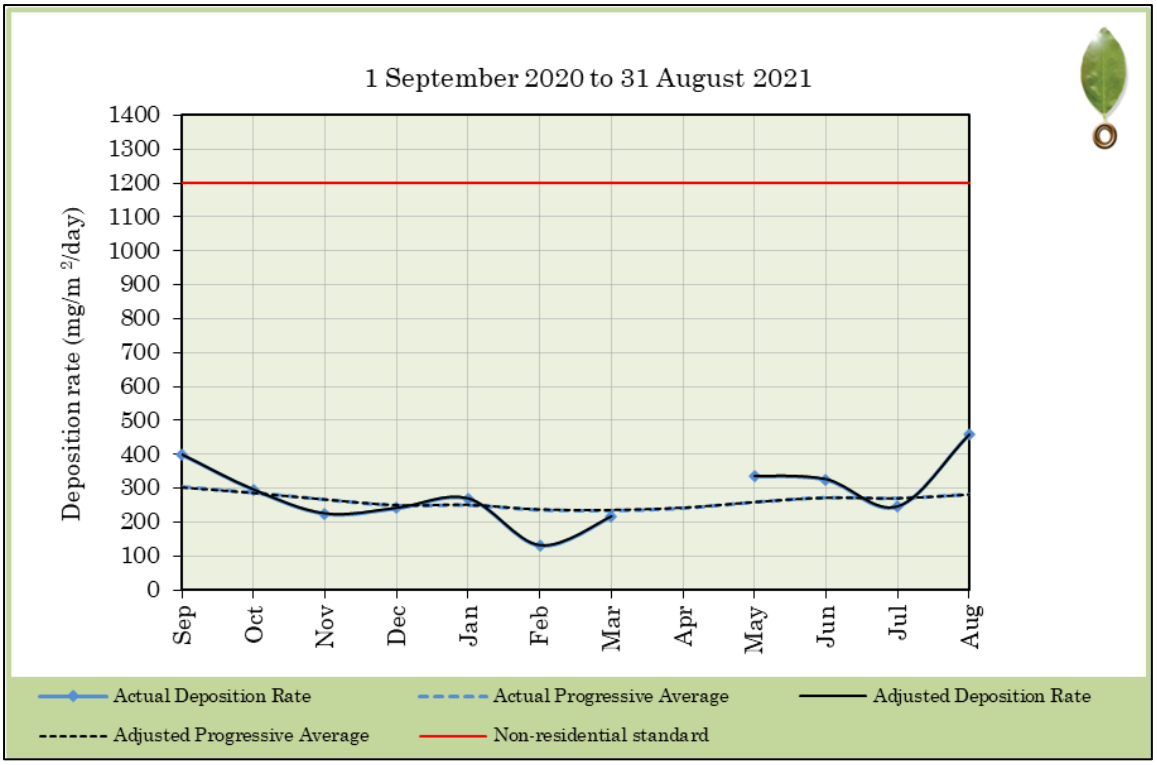


Figure 7.4.11.4(i): BOS #8 – North Western Boundary

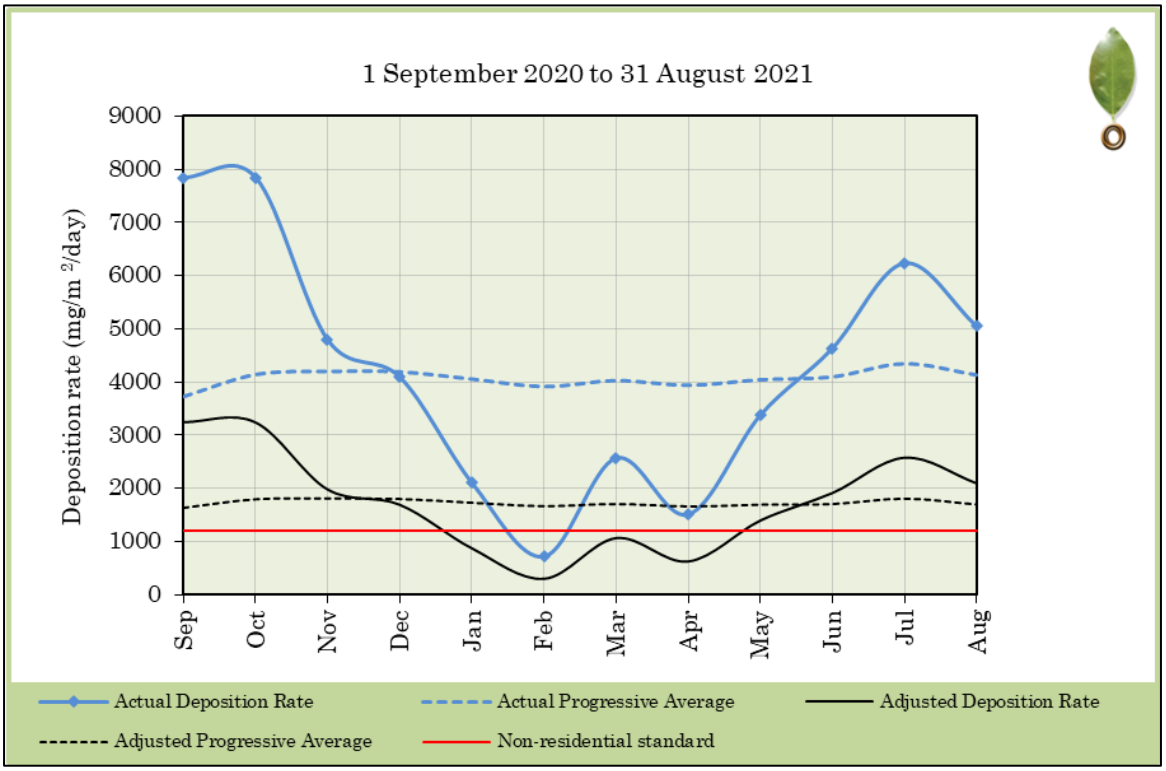


Figure 7.4.11.4(j): BOS #9 – Eastern Boundary Opposite Dry Magnetite Beneficiation

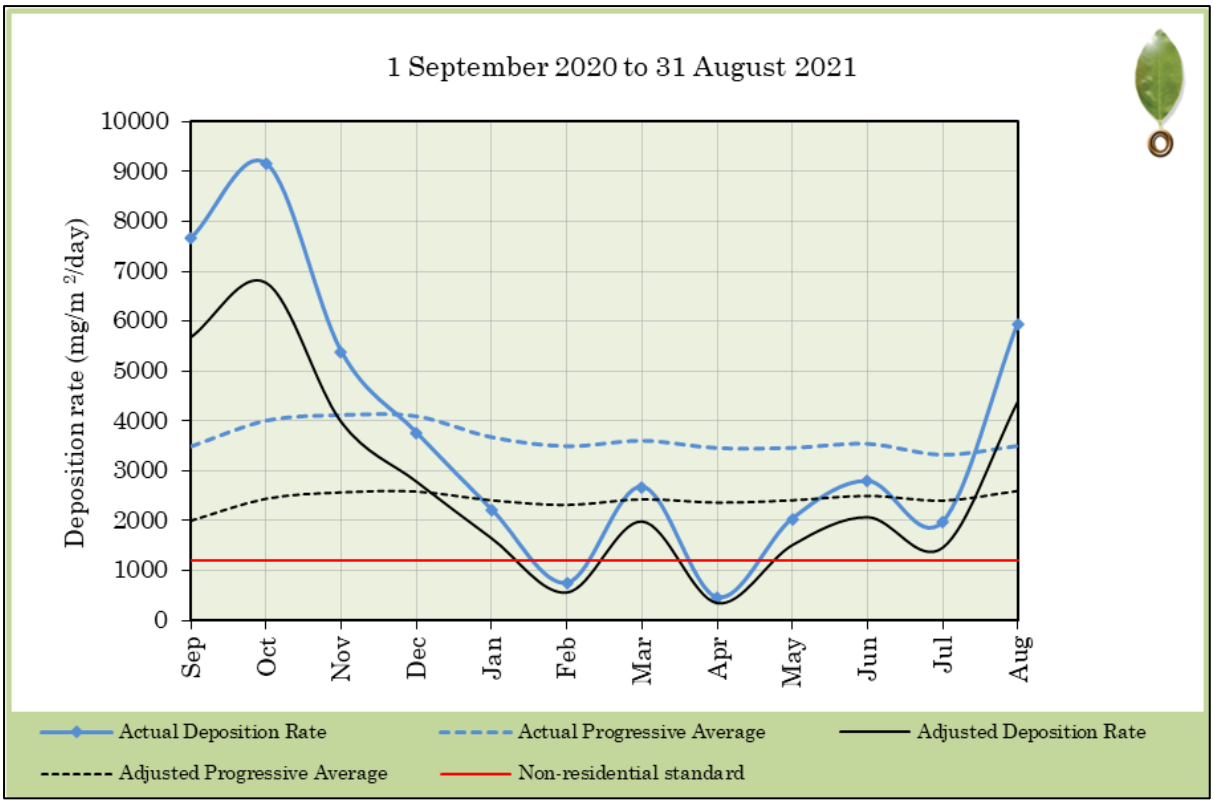


Figure 7.4.11.4(k): BOS #10 – Eastern Boundary Opposite Loading Station #1

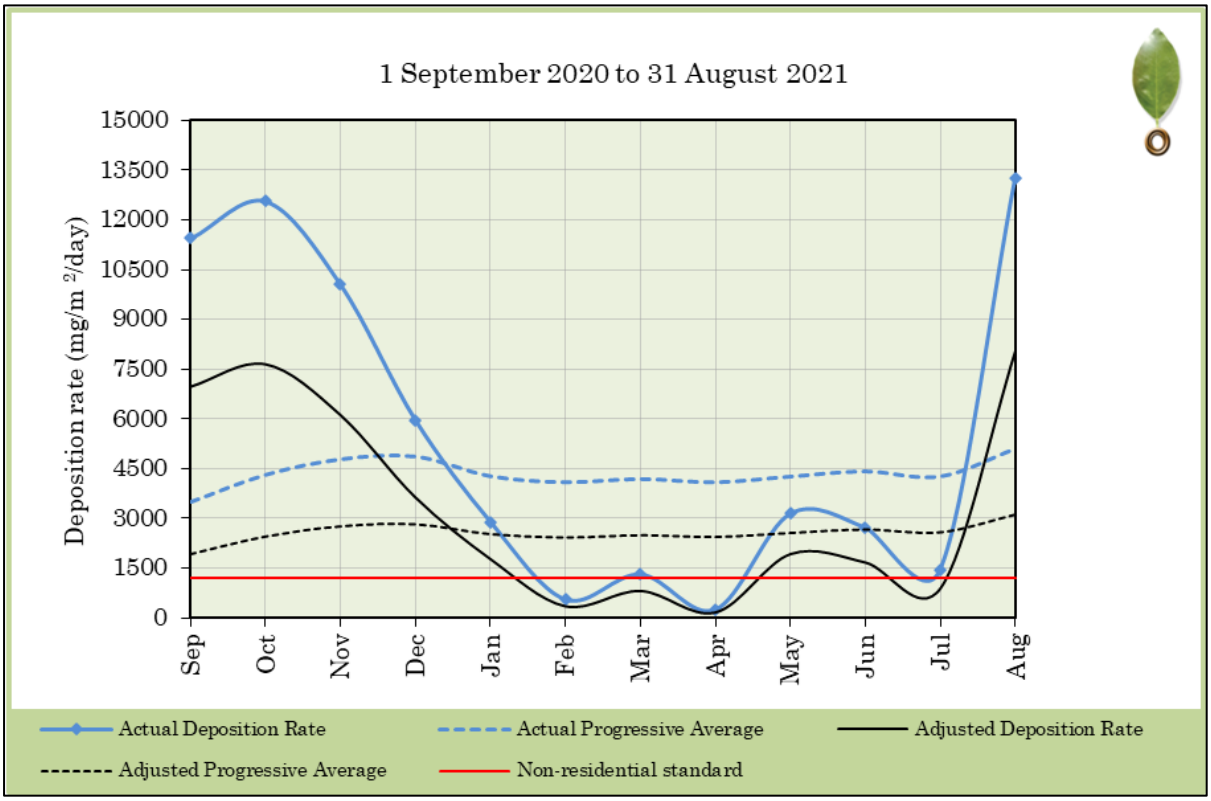


Figure 7.4.11.4(l): BOS #11 – Eastern Boundary Opposite Loading Station #3

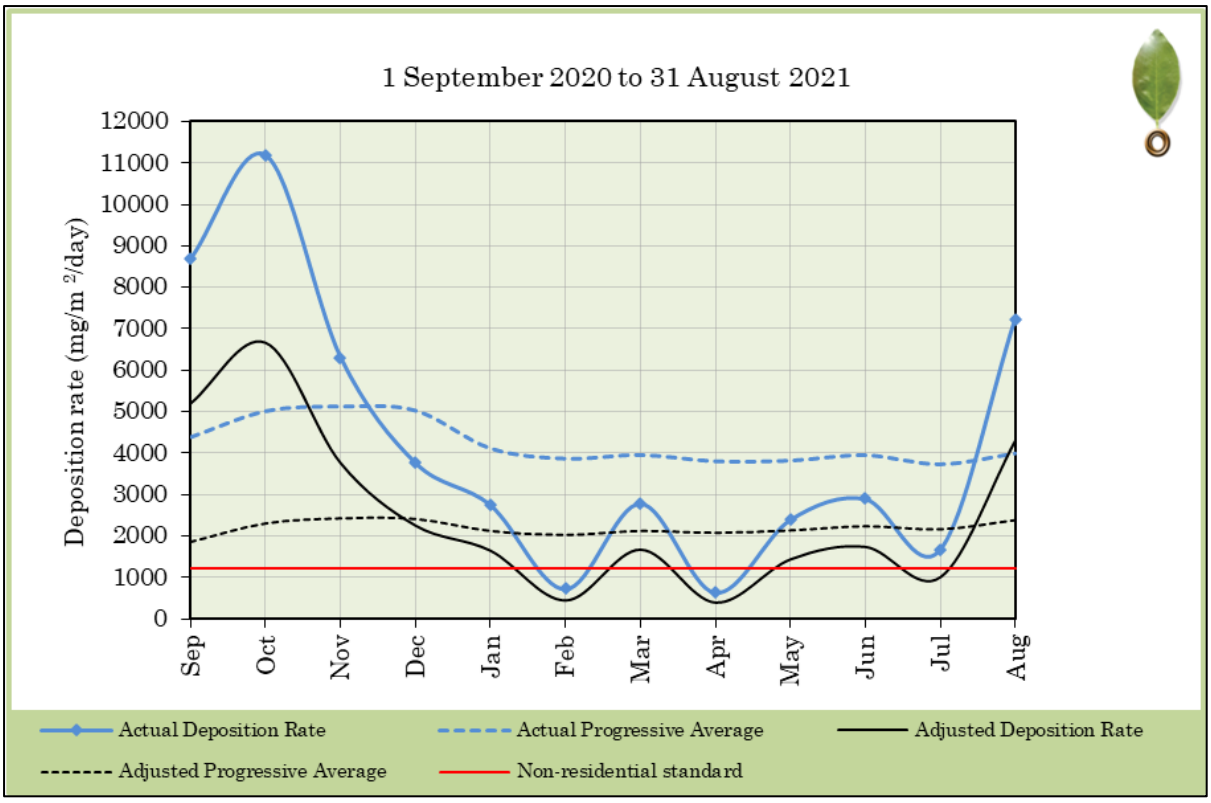


Figure 7.4.11.4(m): BOS #12 – Fedex Plant Administration Building

A number of exceedances were reported during the reporting period:

- BOS #6 – Loading Station #1 reported 11 consecutive exceedances of the non-residential standard.
- BOS #7 – Northern Boundary reported two consecutive exceedances in October and November 2020 and during August and September 2021 of the non-residential standard.
- BOS #9 – Eastern Boundary Opposite Dry Magnetite Beneficiation registered four consecutive exceedances from October 2020 to January 2021 and seven consecutive exceedances from March to September 2021.
- BOS #10 – Eastern Boundary Opposite Loading Station #1 registered four consecutive exceedances from October 2020 to January 2021 and five consecutive exceedances from May to September 2021.
- BOS #11 – Eastern Boundary Opposite Loading Station #3 reported four consecutive exceedances from October 2020 to January 2021 and five consecutive exceedances from May to September 2021.

<u>Process Emission Testing</u>

Process emission testing was performed on 19 August 2020. Key finding from emission testing include:

- The average of three particulate matter samples, collected was 2 390.77 mg/Nm^3. All samples contravened the minimum emission standard of 50mg/Nm^3 stipulated in the AEL.
- Sulphur dioxide (average 1.48 mg/Nm^3) concentrations remained below the minimum emission standard of 1000 mg/Nm^3, while nitrogen oxide (expressed as nitrogen dioxide) (average 45.95 mg/Nm^3) concentrations remained below the minimum emission standard of 500 mg/Nm^3.
- The average carbon monoxide concentration was 1590.70 mg/Nm^3, carbon dioxide concentration 1.52%v/v. and the average oxygen concentration 18.38 %v/v.

7.4.11.5. Mopani District Municipality

Criteria pollutants are pollutants commonly found from various sources and for which health-based criteria (science-based guidelines) have been established as the basis for setting permissible levels. Typical pollutants include particulates (including soot, fly ash and aerosols), sulphur oxides (SO_x), oxides of nitrogen (NO_x), carbon monoxide (CO), carbon dioxide (CO_2), volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), methane (CH_4), ammonia (NH_3), hydrogen chloride (HCl), hydrogen sulphide (H_2S), ozone (O_3) and other photochemical oxidants (as secondary pollutants) and various trace elements. Organic compounds released include formaldehyde, benzene, poly-aromatic hydrocarbons, PCBs and dioxins and furans.

Air pollution is a major environmental problem affecting most areas in the Mopani District. Vehicles, mines and industries, as well as burnings of refuse dumping sites and onsite incineration by households pollute the air by releasing harmful gasses, especially in urban areas. In the rural areas, air pollution is caused by the burning of wood and coal. Another source of air pollution is leakage of sewage and companies burning waste.

Based on an assessment of the Department of Environment Forestry and Fisheries, Mopani District Municipality was rated as having potentially poor air quality or deteriorating air quality. The major contributors to this rating are the mining activities in Ba-Phalaborwa municipality and wood-drying activities concentrated in Greater Tzaneen municipality.

Ambient air quality monitoring in the Limpopo Province, conducted by the Department of Economic Development, Environment and Tourism (LEDET) includes a station in Phalaborwa and two Eskom owned station at Marapong and Medupi. Waterberg District Municipality, as part of the monitoring of the Waterberg-Bojanala Priority Area (WBPA) has three monitoring stations. The stations are located in Thabazimbi, Lephalale and Mokopane. Ambient monitoring data from the Phalaborwa station has been included in the study.

<u>Particulate Matter</u>

Particulate matter (PM) is a broad term used to describe the fine particles found in the atmosphere, including soil dust, dirt, soot, smoke, pollen, ash, aerosols and liquid droplets. The most distinguishing characteristic of PM is the particle size and the chemical composition. Particle size has the greatest influence on the behaviour of PM in the atmosphere with smaller particles tending to have longer residence times than larger ones. PM is categorised, according to particle size, into TSP, PM_{10} and $PM_{2.5}$.

Figure 7.4.11.5(a) shows the 24-hour average PM_{10} concentrations for the Phalaborwa monitoring station.

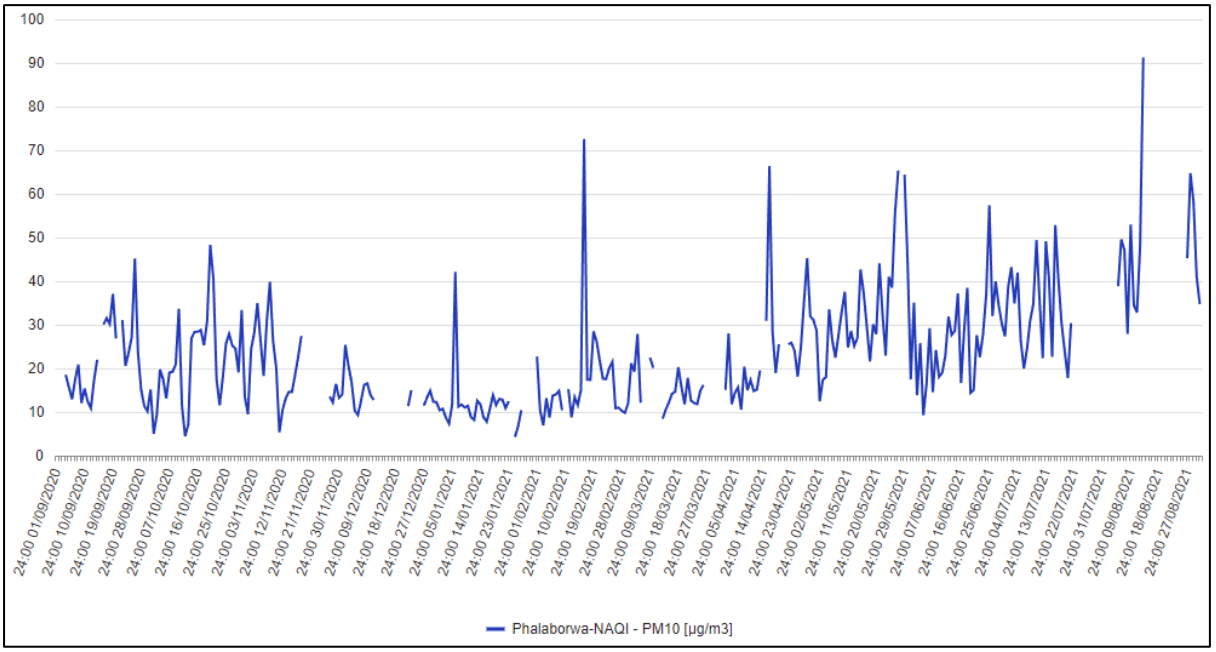


Figure 7.4.11.5(a): Phalaborwa Daily Average PM_{10} Concentration (SAAQIS, 2021)

Total suspended particulates (TSP) consist of all sizes of particles suspended within the air smaller than 100 micrometres (µm). TSP is useful for understanding nuisance effects of PM, e.g. settling on houses, deposition on and discoloration of buildings, and reduction in visibility.

PM_{10} describes all particulate matter in the atmosphere with a diameter equal to or less than 10µm. Sometimes referred to simply as coarse particles, they are generally emitted from motor vehicles (primarily those using diesel engines), factory and utility smokestacks, construction sites, tilled fields, unpaved roads, stone crushing, and burning of wood. Natural sources include sea spray, windblown dust and volcanoes.

Coarse particles tend to have relatively short residence times as they settle out rapidly and PM_{10} is generally found relatively close to the source except in strong winds.

$PM_{2.5}$ describes all particulate matter in the atmosphere with a diameter equal or less than 2.5µm. They are often called fine particles, and are mostly related to combustion (motor vehicles, smelting, incinerators), rather than mechanical processes as is the case with PM_{10}.

$PM_{2.5}$ may be suspended in the atmosphere for long periods and can be transported over large distances.

Fine particles can form in the atmosphere in three ways: when particles form from the gas phase, when gas molecules aggregate or cluster together without the aid of an existing surface to form a new particle, or from reactions of gases to form vapours that nucleate to form particles.

Particulate matter may contain both organic and inorganic pollutants. The extent to which particulates are considered harmful depends on their chemical composition and size, e.g. particulates emitted from diesel vehicle exhausts mainly contain unburned fuel oil and hydrocarbons that are known to be carcinogenic. Very fine particulates pose the greatest health risk as they can penetrate deep into the lung, as opposed to larger particles that may be filtered out through the airways' natural mechanisms.

Figure 7.4.11.5(b) shows the 24-hour average $PM_{2.5}$ concentrations for the Phalaborwa monitoring station.

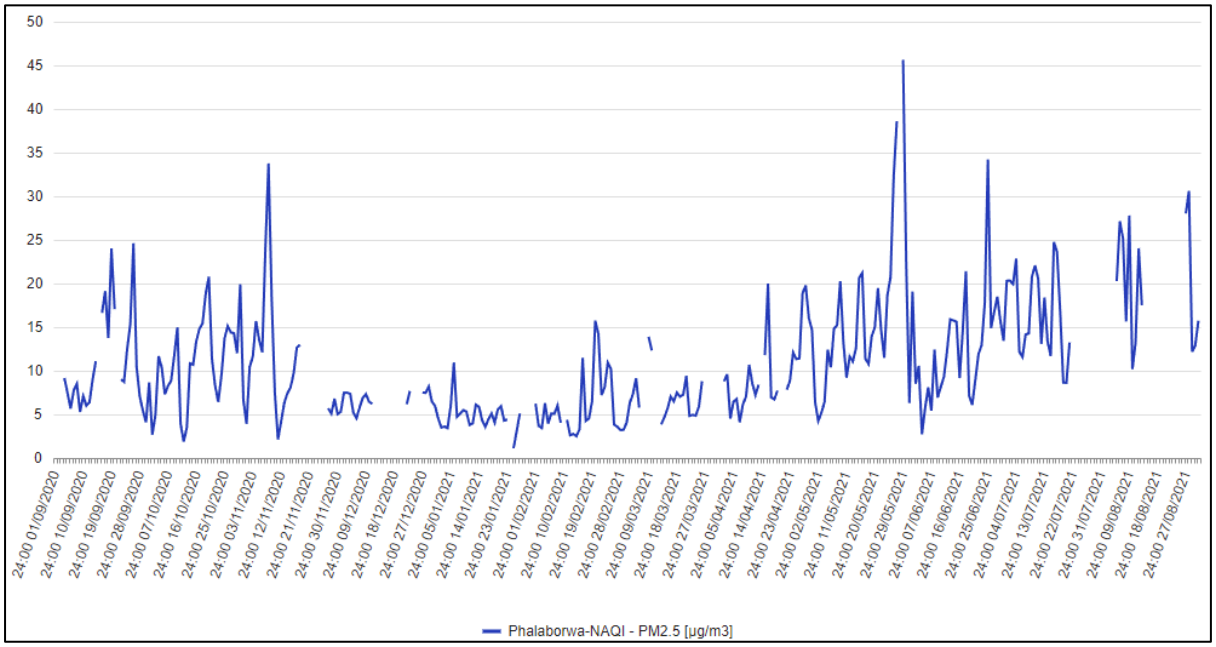


Figure 7.4.11.5(b): Phalaborwa Daily Average $PM_{2.5}$ Concentration (SAAQIS, 2021)

In normal nasal breathing, particles larger than 10µm are typically removed from the air stream as it passes through the nose and upper respiratory airways, and particles between 3µm and 10µm are deposited on the mucociliary escalator in the upper airways. Only particles in the range of 1µm to 2µm penetrate deeper where deposition in the alveoli of the lung can occur (WHO, 2003).

Coarse particles (PM_{10} to $PM_{2.5}$) can accumulate in the respiratory system and aggravate health problems such as asthma. $PM_{2.5}$ which can penetrate deeply into the lungs, are more likely to contribute to the health effects (e.g. premature mortality and hospital admissions) than coarse.

People with existing health conditions such as cardiovascular disease and asthmatics, as well as the elderly and children, are more at risk to the inhalation of particulates than normal healthy people.

Mortality outcomes calculated for South African urban areas estimate that outdoor air pollution caused 3.7% of total mortality from cardiopulmonary disease in adults aged 30 years and older, 5.1% of mortality attributable to cancers of the trachea, bronchus, and lung in adults, and 1.1% of mortality from acute respiratory infections in children under 5 years of age.

Sulphur Dioxide

SO_2 is a colourless pungent, irritating, water-soluble and reactive gas. The major source of SO_2 is the combustion fossil fuels such coal, oil and diesel which contain sulphur.

Figure 7.4.11.5(c) shows the 24-hour average SO_2 concentrations for the Phalaborwa monitoring station.

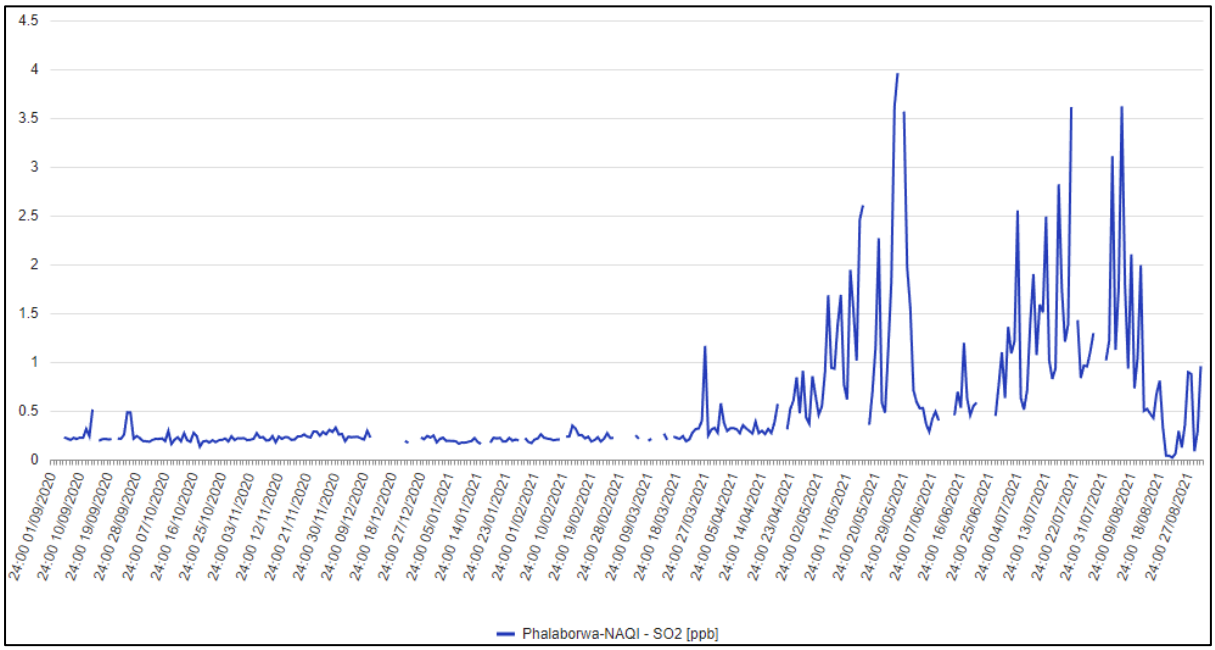


Figure 7.4.11.5(c): Phalaborwa Daily Average SO_2 Concentration (SAAQIS, 2021)

On inhalation, most SO_2 only penetrates as far as the nose and throat as it is readily soluble in the moist lining of the upper respiratory system, with minimal amounts reaching the lungs, unless the person is breathing heavily, breathing only through the mouth, or if the concentration of SO_2 is high. The acute response to SO_2 is rapid, within 10 minutes in people suffering from asthma (WHO, 2005). SO_2 reacts with cell moisture in the respiratory system to form sulphuric acid. This can lead to impaired cell function and effects such as coughing, broncho-constriction, exacerbation of asthma and reduced lung function.

Effects such as a reduction in lung function, an increase in airway resistance, wheezing and shortness of breath, are enhanced by exercise that increases the volume of air inspired, as it allows SO_2 to penetrate further into the respiratory tract (WHO, 1999).

Due to its reactivity, SO_2 has a highly non-uniform dose distribution along the conductive airways of the respiratory tract. For low to moderate tidal volumes and nasal breathing, the penetration into the lungs is negligible. For larger tidal volumes and oral inhalation, doses of interest may extend into the segmental bronchi. SO_2 can only reach the gas-exchange region of the lungs after adsorption onto particulate matter.

Another special consideration for SO_2 is that there is great variation in susceptibility to bronchoconstrictive responses. Persons having asthma or atopy can be about ten times more responsive than healthy subjects.

<u>Nitrogen Oxides</u>

Ambient concentrations of NO_2 in air are highly variable. Natural background concentrations can range from less than 0.4 µg/m³ to more than 9 µg/m³. In cities, ambient annual mean concentrations can range from 20 to 90 µg/m³ with hourly maximum concentrations from 75 to 1 000µg/m³. NO_2 is formed in combustion processes and other high temperature operations such as metallurgical furnaces, blast furnaces, and internal combustion engines.

In the atmosphere, NO_2 reacts with water vapour to produce nitric acid.

This acidic pollution can be transported over long distances by wind and deposited as acid rain, causing the acidification of soils, lakes, and streams, accelerated corrosion of buildings and monuments and damages paintwork. NO_2 is also a major source of secondary fine particulate pollution, which decreases visibility, and contributes to surface ozone formation through its reaction with VOCs in the presence of sunlight. Figure 7.4.11.5(d) shows the 24-hour average NO_2 concentrations for the Phalaborwa monitoring station.

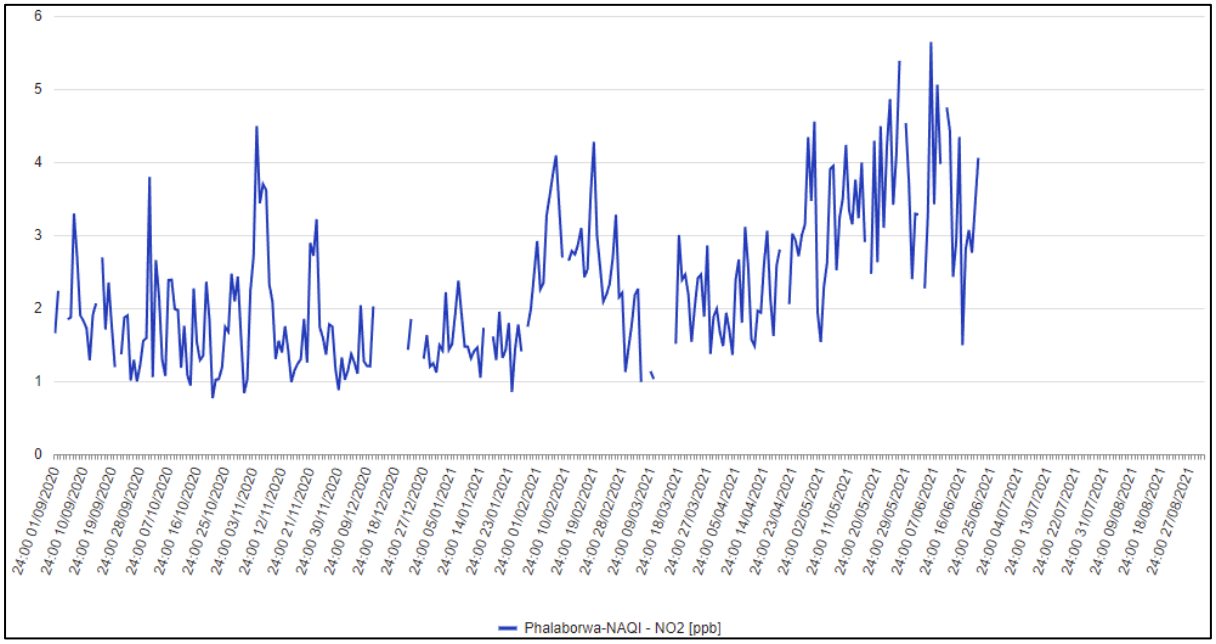


Figure 7.4.11.5(d): Phalaborwa Daily Average NO_2 Concentrations (SAAQIS, 2021)

The route of exposure to NO_2 is inhalation and the seriousness of the effects depends more on the concentration, than the length of exposure. The site of deposition for NO_2 is the distal lung as NO_2 does not readily dissolve in the moist upper respiratory system where it reacts with moisture in the fluids of the lower respiratory tract to form nitrous and nitric acids (WHO, 1997). About 80 to 90% of inhaled nitrogen dioxide is absorbed through the lungs (CCINFO, 1998). NO_2 present in the blood as the nitrite ion oxidises unsaturated membrane lipids and proteins, which result in the loss of cell permeability control. NO_2 causes decrements in lung function, particularly increased airway resistance. People with chronic respiratory problems and people who work, or exercise outside will be more at risk to NO_2 exposure.

Carbon Monoxide

CO is a product of incomplete combustion of fossil fuels. It is predominantly formed in internal combustion engines of motor vehicles, but the combustion of any carbon-based material can release CO. Chemical reactions in the atmosphere may also lead to the formation of CO by the oxidation of other carbon-based gases such as methane. Decomposition of organic material within soils can also result in the release of CO. When inhaled, CO enters the blood stream by crossing the alveolar, capillary and placental membranes. In the bloodstream approximately 80-90% of absorbed CO binds with heamoglobin to form carboxyhaemoglobin. The haemoglobin affinity for CO is approximately 200-250 times higher than that of oxygen. Carboxyhaemoglobin reduces the oxygen carrying capacity of the blood and reduces the release of oxygen from haemoglobin, which leads to tissue hypoxia. This may lead to neurological effects and sometimes delayed severe neurological effects that may include impaired coordination, vision problems, reduced vigilance and cognitive ability, reduced manual dexterity, and difficulty in performing complex tasks (WHO, 1999).

Ozone

Ozone is a colourless gas which carries a harsh odour. It occurs naturally in the lower stratosphere as the ozone layer. This layer protects the earth from shortwave ultraviolet radiation. Near the earth's surface, ozone is a secondary pollutant and a major constituent of photochemical smog. The formation of ozone is dependent on the availability of NOx, VOCs and sunlight. Thus, ozone may not be related directly to any source. Rather it may be associated with the sources of its precursor gases (NOx and VOCs). Ozone may also reach the lower troposphere from the stratosphere, mostly associated with deep frontal systems or with deep convective storms.

Background one-hour average concentrations of O_3 in remote and relatively unpolluted parts of the world are often in the range of 40 to 70 µg/m^3. In cities maximum mean hourly concentrations can be as high as 300 to 400µg/m^3. High O_3 concentrations can persist for 8 to 12 hours per day for several days, when atmospheric conditions favour O_3 formation and poor dispersion conditions exists. Figure 7.4.11.5(e) shows the 24-hour average O_3 concentrations for the Phalaborwa monitoring station.

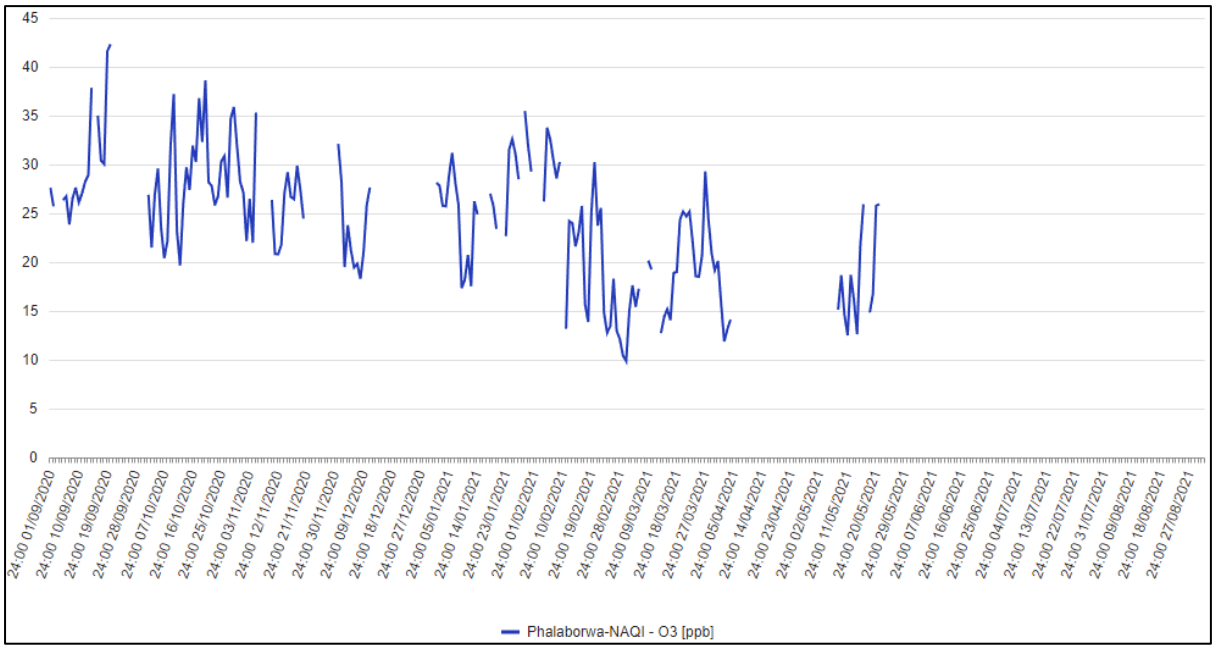


Figure 7.4.11.5(e): Phalaborwa Daily Average O_3 Concentrations (SAAQIS, 2021)

Ozone is a very reactive gas and a strong oxidant, associated with a number of health effects. Ozone toxicity occurs in a continuum in which higher concentrations, longer exposure duration and greater activity levels during exposure cause greater effects. These include respiratory system effects such as coughing, aggravation of asthma and reduced lung function.

Lead

Lead is a metal that occurs naturally in small amounts in the earth's crust. It is used in the production of some types of batteries, ammunition, metal products (such as solder and pipes) ceramic glazes and paint. Chemicals containing lead, such as tetraethyl lead and tetramethyl lead are used as gasoline additives. In the atmosphere, lead exists primarily in the particulate form and is removed from air by wet and dry deposition. Nearly all environmental exposure to lead is attributed to inorganic compounds.

Levels of lead found in air, food, water and soil/dust vary widely throughout the world and depend on the degree of industrial development, urbanisation and other lifestyle factors. In cities of developing countries traffic-related lead levels range between 0.3 and 1 µg/m^3 with extreme annual mean values between 1.5 and 2 µg/m^3.

Exposure to Pb may be through inhalation of contaminated air and ingestion of contaminated food, water and soil. Lead can accumulate in plants and animals. The half-life of lead in human blood (it affects haemoglobin synthesis in the blood) is 28 to 36 days, but lead accumulates in the bones and teeth where it can stay for decades and be released again. Children absorb more and excrete less of the absorbed lead than adults.

Volatile Organic Compounds

VOCs are compounds that have a high vapour pressure at ordinary, room-temperature conditions. It is noted that some organic compounds have little or no known direct human health effects, while others are extremely toxic and/or carcinogenic. The US-EPA has classified benzene as a Group A known human carcinogen. Increased incidence of leukaemia (cancer of the tissues that form white blood cells) has been observed in humans occupationally exposed to benzene. The US-EPA has derived a range of inhalation cancer unit risk estimates for benzene.

Chronic (long-term) inhalation exposure has caused various disorders in the blood, including reduced numbers of red blood cells and aplastic anaemia, in occupationally exposed humans. Reproductive effects have been reported in women exposed by inhalation to high levels of benzene, and adverse effects on the developing foetus have been observed in animal tests (US-EPA, 2001).

The US-EPA calculated a range of 2.2 x 10^{-5} to 7.8 x 10^{-6} as the increase in the lifetime cancer risk to an individual who is continuously exposed to 1 µg/m^3 of benzene in the air over his or her lifetime. EPA estimates that, if an individual were to continuously breathe air containing benzene at an average of 0.13 to 0.45 µg/m^3 over his or her entire lifetime, that person would have no more than a 1 in a million increased chance of developing cancer as a direct result (US-EPA, 2001).

Chronic inhalation of certain levels of benzene causes disorders in the blood of humans. Benzene specifically affects bone marrow (the tissues that produce blood cells). Aplastic anaemia, excessive bleeding, and damage to the immune system (by changes in blood levels of antibodies and loss of white blood cells) may develop. In animals, chronic inhalation and oral exposure to benzene produce the same effects as seen in humans. Reproductive effects have been reported for women exposed by inhalation to high levels, and adverse effects on the developing foetus have been observed in animal tests (US-EPA, 2001).

Magnetite

Magnetite is an iron-oxide mineral that occurs naturally on Earth. Because it is also an important component of many anthropogenic materials (i.e. coal fly ash) and synthetic products (i.e. black toner powders), magnetite can be released to the environment through human activities.

Magnetite belongs to the spinel group. It crystallises in the cubic crystal system and can be described by the general formula $Fe^{2+}Fe^{3+}{}_2O_4$. Magnetite is a common natural phase, occurring in various geological environments, ranging from igneous (i.e. layered ultra-basic rocks, basalts) to sedimentary (i.e. banded iron formations, beach sands) rocks and to high-grade meta-morphic rocks (i.e. schists, skarns), where it can be produced through a multitude of chemical reactions.

Due to its tendency to react with oxygen to form hematite (Fe_2O_3) and various iron oxyhydroxides (i.e. ferrihydrite, goethite), magnetite can be used as a powerful tool to explore oxygen concentrations in rocks during geological processes, changes in the oxygen content of the atmosphere and redox conditions in near surface environments (i.e. oxic-anoxic transition zone).

Because magnetite is ferrimagnetic, it represents a phase that is essential for paleomagnetic investigations, which help in reconstructing plate tectonics through Earth's history.

Biogenic, chemically pure magnetite crystals occur in the bodies of a wide range of organisms within the kingdoms of the Monera, Protista, and Animalia (i.e. magnetotactic microbes, insects, molluscs, fish, birds, mammals). In these organisms, magnetite forms the basis for one type of biophysical mechanism of magnetic field detection, which facilitates orientation and navigation. In the human brain, magnetite is also believed to precipitate biologically as part of the iron metabolism. Maher et al., 2016, suggest that it can originate from an external source.

Air pollution comprises not only gases (i.e. nitrogen oxides, ozone, sulphur dioxide) but also solid particles, which range in size from a few nanometres to several micrometres. These particles, known as particulate matter (PM), are generated through both natural processes and human activity and are emitted directly into, or formed within, the atmosphere. As a result of atmospheric circulation, the airborne particles in a given environment can be derived from both local and distant sources, such as dry lakes, deserts, fires, smokestacks, traffic, or mining operations. Magnetite is an abundant constituent of atmospheric PM pollution, especially in the urban environment, where it has been identified in diesel exhaust, as brake-abrasion particles, in the air of underground stations, along railway lines, at welding workplaces, and in the emissions from industrial combustion processes.

In addition to having major atmospheric, environmental, and ecological impacts, airborne PM may have adverse health effects, both acute and chronic, because with each breath, millions of solid particles, including magnetite, can enter our respiratory system. Once inhaled, coarse particles (>2.5 μm) may be deposited on the surfaces of the conducting airways of the upper respiratory system, whereas smaller particles (<2.5 μm) can migrate to the deepest parts of the lung where the gas exchange takes place. Ultrafine particles (<100 nm), or nanoparticles, may penetrate through the cell tissue that lines the respiratory tract and translocate into the blood circulation and into extrapulmonary organs, but also, via the olfactory nerve, into the central nervous system.

Maher et al., 2016 invoke this latter mechanism for the transfer of air pollution-derived magnetite nanoparticles to the brains of the studied individuals. These authors use the mostly spherical shapes of the magnetite as one of the main arguments for their hypothesis: Spherical shapes are typical of combustion-derived particles (i.e. in diesel exhaust) in contrast to abrasion-derived particles (e.g., brake-wear particles), which are typically irregularly shaped and angular, or to endogenous particles, which tend to be euhedral because they grew in situ (i.e. within the brain). Maher et al. (2) document that two types of magnetite, spherical and euhedral, are present in the studied brains, suggesting that they were derived from two different sources, one external (from air pollution) and one internal (i.e. biogenic). This conclusion is further supported by the presence of other transition-metal nanoparticles, which are common in air borne PM from polluted areas.

One of the questions that arises from the discovery of externally derived magnetite in brain tissue is whether or not the abundant additional magnetite adversely affects human health. It is well known from epidemiological and toxicological studies that exposure to $PM_{2.5}$ is linked to increases in mortality and hospital admissions due to respiratory and cardiovascular diseases. There is increasing evidence that coarser particles may also produce deleterious health effects.

In addition to being dependent on size, however, the interactions are influenced by other particle characteristics, including structure, chemical composition, shape, surface area and reactivity, absorptive properties and solubility. The adverse health effects include chronic bronchitis, exacerbation of asthma, fibrosis, and lung cancer. The mechanisms behind these diseases, as well as their dependence on particle properties, are still poorly known. The most likely mechanisms involve the excessive production of free radicals [i.e. reactive oxygen species (ROS)], which can lead to oxidative damage to cell membranes, proteins, and DNA, as well as to the release of chemical substances that trigger and perpetuate inflammation.

In regard to the human health effects of magnetite, published data exist for both the brain and the respiratory system. For example, the presence in the brain of magnetite may be linked to several neurodegenerative diseases, including Alzheimer's disease and oxidative stress appears to play a key role in the pathogenesis.

In vitro experiments with human lung cells, which were exposed for 24-hours to different magnetite size fractions (including nanoparticles) and doses, revealed that the studied particles, although being only slightly cytotoxic, led to increased ROS formation, mitochondrial damage, and genotoxic effects. The results allowed for the conclusion that ROS formation plays an important role in the genotoxicity of magnetite in lung cells. On the other hand, magnetite nanoparticles might be considerably less toxic when surface-modified (i.e. coated).

The presence of magnetite in humans, however, also has other potential implications, including possible biological disorders linked to the weak magnetic fields generated by cellular phones, electric power lines, and appliances, or high-field saturation effects from exposure to strong magnetic fields during MRI procedures. At the same time, nanoparticles of magnetite are of special interest in the biomedical sciences, because they can be used as carriers for targeted drug delivery. Moreover, magnetite nanoparticles can be exploited for hyperthermia-based cancer therapy, where the heat induced by application of an alternating magnetic field causes necrosis of cancer cells but does not damage the surrounding normal tissue. Various researchers have further proposed that endogenous magnetite might play a key role in perception, transduction, and long-term storage of information in the human brain and in other organisms.

The occurrence of magnetite in cell tissues therefore represents an intriguing dichotomy: On the one hand, the mineral can play a key role in magnetoreception and navigation, and thus survival, of various types of organisms, and on the other hand, it can impart deleterious effects in humans, especially when they are exposed to high PM concentrations in polluted urban environments.

Currently, the Occupational Safety and Health Administration (OSHA) has a permissible exposure limit of 10 mg/m^3 for fine iron oxide over the course of an 8-hour workday. The National Institute for Occupational Safety and Health (NIOSH) set a recommended exposure limit (REL) of 5 mg/m^3 for iron (in iron oxide) over a 10-hour workday, while the American Conference of Governmental Industrial Hygienists (ACGIH) recommended 5 mg/m^3 limit for the respirable fraction of iron oxide over an 8-hour workday. However, there is currently no separate REL for iron oxide nanoparticles (IONPs).

7.5. POTENTIAL IMPACTS/RISKS ASSOCIATED WITH ALTERNATIVES

This section is not the main/comprehensive impact assessment for the project, but relates specifically to the impact and risk assessment conducted in support of the consideration of alternatives for the proposed Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure.

The potential impacts and risks identified informed and supported the alternatives selection process which determined the preferred alternative site (see Section 7.1).

The potential impacts listed in Table 7.5(a) below, therefore represent impacts that if not acceptable after mitigation, would require an alteration in:

- the proposed site locality
- the type of activity
- the design or layout
- the technology used
- any operational aspects
- invoking the no-go option

It should be noted that the impact assessment was conducted from the premise that all the design features aimed at environmental protection would be implemented during development. This would include aspects related to the minimisation of development footprints, the appropriate lining of facilities to protect the groundwater resources, a suitable design of required storage capacity to cater for rainfall storm events and operational aspects aimed at ensuring stability and the prevention of spillages, leakages or failures.

The environmental attributes selected and included in the impact assessment, were determined by the EAP and were based on the baseline descriptions provided in section 7.4 of this report.

With reference to the outcome of the impact assessment as reflected in Table 7.5(a), the following conclusions are relevant:

- All four site options for the proposed Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure had very similar Environmental Impact and Risk Assessment outcomes. The receiving environment and the ecological importance at all four sites options considered, are similar in nature.
- Two Late Iron Age and historical settlements (kopjes Serotwe and Mabadika) are located within close proximity of site options 3 and 4. No Heritage resources were identified for site option 1 (preferred alternative).
- Mitigation measures could however be proposed and implemented in terms of the potential risk associated with the heritage aspects at site options 3 and 4.
- The site selection for the proposed Magnetite Waste Site Disposal Facility (MWSDF) could therefore continue from the same Environmental Impact and Risk base and could be done subject to practical, engineering and operational considerations.

Table 7.5(a): Potential Impacts Identified and Assessed for Alternatives Considered (Design Mitigation taken into Consideration)

Development Activity	Environmental Aspect	Potential Impact	Magnitude	Duration	Spatial Scale	Consequence	Probability	Significance
Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure **Site 1 (Preferred Alternative)**	Heritage	**No potential impact.** None of the types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act within footprint area.	-	-	-	-	-	-
	Soils & Land Capability	Loss of wilderness and grazing (poor) potential at footprint.	**Moderate**	**Long term**	**Site**	**Medium**	**Definite**	**Medium**
	Groundwater	Seepage of leachate through the baseliner resulting in groundwater pollution.	**Moderate**	**Long Term**	**Local**	**Medium**	**Unlikely**	**Low**
	Surface Water	Spillage of process and storm water run-off resulting in surface water pollution.	**Moderate**	**Short Term**	**Regional**	**Medium**	**Unlikely**	**Low**
	Plant Life	Habitat loss and modification due to vegetation clearance.	**Moderate**	**Medium Term**	**Local**	**Medium**	**Definite**	**Medium**
	Animal Life	Disturbance and mortality of fauna species during construction activities.	**Major**	**Short Term**	**Site**	**Medium**	**Unlikely**	**Low**
	Aquatic Ecosystems	Spillage of process and storm water run-off resulting in surface water pollution.	**Moderate**	**Short Term**	**Regional**	**Medium**	**Unlikely**	**Low**
	Wetlands	**No potential impact.** No natural wetland habitat was identified within the project study area or the 500m buffer.	-	-	-	-	-	-
	Air Quality	Impact on air quality due to dust generation from MWSDF.	**Moderate**	**Medium Term**	**Local**	**Medium**	**Possible**	**Medium**
Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure **Site 2**	Heritage	Negative impact on heritage resources if present within footprint area.	**Major**	**Short Term**	**Site**	**Medium**	**Possible**	**Medium**
	Soils & Land Capability	Loss of land capability potential at footprint.	**Moderate**	**Long term**	**Site**	**Medium**	**Definite**	**Medium**
	Groundwater	Seepage of leachate through the baseliner resulting in groundwater pollution.	**Moderate**	**Long Term**	**Local**	**Medium**	**Unlikely**	**Low**
	Surface Water	Spillage of process and storm water run-off resulting in surface water pollution.	**Moderate**	**Short Term**	**Regional**	**Medium**	**Unlikely**	**Low**
	Plant Life	Habitat loss and modification due to vegetation clearance.	**Moderate**	**Medium Term**	**Local**	**Medium**	**Definite**	**Medium**
	Animal Life	Disturbance and mortality of fauna species during construction activities.	**Major**	**Short Term**	**Site**	**Medium**	**Unlikely**	**Low**
	Aquatic Ecosystems	Spillage of process and storm water run-off resulting in surface water pollution.	**Moderate**	**Short Term**	**Regional**	**Medium**	**Unlikely**	**Low**
	Wetlands	Negative impact on wetland resources if present within footprint area.	**Moderate**	**Long Term**	**Site**	**Medium**	**Possible**	**Medium**
	Air Quality	Impact on air quality due to dust generation from MWSDF.	**Moderate**	**Medium Term**	**Local**	**Medium**	**Possible**	**Medium**

Development Activity	Environmental Aspect	Potential Impact	Magnitude	Duration	Spatial Scale	Consequence	Probability	Significance
Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure **Site 3**	Heritage	Potential negative impact on two Late Iron Age and historical settlements (kopjes Serotwe and Mabadika).	**Major**	**Medium Term**	**Site**	**Medium**	**Possible**	**Medium**
	Soils & Land Capability	Loss of wilderness and grazing (poor) potential at footprint.	**Moderate**	**Long term**	**Site**	**Medium**	**Definite**	**Medium**
	Groundwater	Seepage of leachate through the baseliner resulting in groundwater pollution.	**Moderate**	**Long Term**	**Local**	**Medium**	**Unlikely**	**Low**
	Surface Water	Spillage of process and storm water run-off resulting in surface water pollution.	**Moderate**	**Short Term**	**Regional**	**Medium**	**Unlikely**	**Low**
	Plant Life	Habitat loss and modification due to vegetation clearance.	**Moderate**	**Medium Term**	**Local**	**Medium**	**Definite**	**Medium**
	Animal Life	Disturbance and mortality of fauna species during construction activities.	**Major**	**Short Term**	**Site**	**Medium**	**Unlikely**	**Low**
	Aquatic Ecosystems	Spillage of process and storm water run-off resulting in surface water pollution.	**Moderate**	**Short Term**	**Regional**	**Medium**	**Unlikely**	**Low**
	Wetlands	**No potential impact.** No natural wetland habitat was identified within the project study area.	-	-	-	-	-	-
	Air Quality	Impact on air quality due to dust generation from MWSDF.	**Moderate**	**Medium Term**	**Local**	**Medium**	**Possible**	**Medium**
Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure **Site 4**	Heritage	Negative impact on heritage resources if present within footprint area.	**Major**	**Short Term**	**Site**	**Medium**	**Possible**	**Medium**
	Groundwater	Seepage of leachate through the baseliner resulting in groundwater pollution	**Moderate**	**Long Term**	**Local**	**Medium**	**Unlikely**	**Low**
	Soils & Land Capability	Loss of land capability potential at footprint.	**Moderate**	**Long term**	**Site**	**Medium**	**Definite**	**Medium**
	Surface Water	Spillage of process and storm water run-off resulting in surface water pollution.	**Moderate**	**Short Term**	**Regional**	**Medium**	**Unlikely**	**Low**
	Plant Life	Habitat loss and modification due to vegetation clearance.	**Moderate**	**Medium Term**	**Local**	**Medium**	**Definite**	**Medium**
	Animal Life	Disturbance and mortality of fauna species during construction activities.	**Major**	**Short Term**	**Site**	**Medium**	**Unlikely**	**Low**
	Aquatic Ecosystems	Spillage of process and storm water run-off resulting in surface water pollution.	**Moderate**	**Short Term**	**Regional**	**Medium**	**Unlikely**	**Low**
	Wetlands	Negative impact on wetland resources if present within footprint area.	**Moderate**	**Long Term**	**Site**	**Medium**	**Possible**	**Medium**
	Air Quality	Impact on air quality due to dust generation from MWSDF.	**Moderate**	**Medium Term**	**Local**	**Medium**	**Possible**	**Medium**

7.6. ALTERNATIVES IMPACT ASSESSMENT METHODOLOGY

The impact and risk assessment methodology utilised for the alternative impact assessment (section 7.5) will be the same methodology employed during the EIA Phase of the project. This methodology/process comprise of the identification of the following:

- Project activity
- Aspect of activity that could potentially cause an impact
- Environmental component that could potentially be impacted upon
- Potential impact description
- Potential impact/risk evaluation

These steps are systematically described in the sections below. The activity is determined in order to identify the relevant aspects of the activity that could potentially cause an impact. Thereafter the environmental components that could potentially be impacted upon is identified. The potential environmental impact associated with this aspect is then defined/described and finally, evaluated with reference to the impact assessment methodology relayed in the section below.

7.6.1. Relevant Project Activity/ies

The development of the Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure (Access Road and Pollution Control Dam) and the Copper Flotation Plant were considered the project activities. The details pertaining to the development and operation of these activities is relayed in section 4.3 of this report.

7.6.2. Identification of Activity Aspects

The details pertaining to the development and operation of these activities is relayed in section 4.3 of this report and was perused to determine what particular aspect/action associated with the activity could potentially cause an impact.

7.6.3. Identification of Environmental Components

The relevant environmental components deemed to be impacted upon when conducting this activity and associated aspects/ actions were identified by the EAP subject to consideration of the environment encountered. These aspects are described in section 8.2 and 8.3 of this report.

7.6.4. Impact Description/Definition

The potential impact anticipated is described/defined for each environmental component assessed and considered.

7.6.5. Evaluation of Environmental Impacts

The potential impacts are ranked by means of the impact assessment methodology relayed in the section below.

7.6.6. Evaluation of Environmental Impacts

The basic elements used in the evaluation of impact significance are described in the table below (Table 7.6.6(a)) and the characteristics used to describe the consequence of an impact are outlined in Table 7.6.6(b). The impact significance rating system is presented in Table 7.6.6(c) and involves three parts:

- **Part A**: Define impact consequence using the three primary impact characteristics of magnitude, duration and spatial scale (extent);
- **Part B**: Use the matrix to determine a rating for impact consequence based on the definition identified in Part A;
- **Part C**: Use the matrix to determine the impact significance rating, which is a function of the impact consequence rating and the probability of occurrence;

Table 7.6.6(a): Key Elements in the evaluation of Impact Significance

Element	Description	Questions applied?
Consequence	An impact or effect can be described as the change in an environmental parameter, which results from a particular project activity or intervention. Here the term consequence refers to: • The sensitivity of the receiving environment, including its capacity to accommodate the kinds of changes the project may bring about • The type of change and the key characteristics of the change (these are magnitude, extent and duration) • The importance of the change (the level of public concern/ value attached to environment by the stakeholders and the change effected by the project) The following should be considered in the determination of impact consequence: • Standards and Guidelines (e.g. pollution and emissions thresholds) • Scientific evidence and professional judgement • Points of reference from comparable cases • Levels of stakeholder concern	Will there be a change in the biophysical environment? Is the change of consequence (of any importance)?
Probability	Likelihood/ Chances of an impact occurring	Is the change likely to occur?
Effectiveness of the Management Measures	Significance of the impact needs to be determined both without management measures and with management measures. The significance of the unmanaged impact needs to be determined so there is an appreciation of what could occur in the absence of management measures and of the effectiveness of the proposed management measures.	Will the management measures reduce impact to an acceptable level?

Table 7.6.6(b): Characteristics to be used in Impact Description

Characteristics used to describe Consequence	Sub-Components	Terms used to describe the Characteristics
Phase of Project		During the Pre-Construction (if applicable), Construction, Operational, Decommissioning/ Post Closure
Nature		Direct or Indirect or Cumulative
Magnitude	**Sensitivity of the Receiving environment/ receptors**	High, Medium or Low Sensitivity Low capacity to accommodate the change (impact)/ tolerant of the proposed change
	Severity/ Intensity (degree of change measured against thresholds and/ or professional judgment)	Gravity/ seriousness of the impact Intensity / Influence/ Power/ Strength
Spatial Extent The area affected by the impact.		Area/ Volume covered , Distribution, Population Site/ Local, Regional, National or International
Duration (and Reversibility) Length of time over which an impact occurs and potential for recovery of the endpoint from the impact		Short term. Long term Intermittent, Continuous Reversible, Irreversibility Temporary, Permanent

Table 7.6.6(c): Method for rating the Significance of Impacts

PART A: DEFINING CONSEQUENCES OF MAGNITUDE, DURATION AND SPATIAL SCALE (Use these definitions to define the consequence in Part B) + *denotes a positive impact*		
Impact Characteristics	**Definition**	**Criteria**
MAGNITUDE	**Major**	Substantial deterioration or harm to receptors; receiving environment has an inherent value to stakeholders; receptors of impact are of conservation importance; or identified threshold often exceeded
	Moderate	Moderate/ measurable deterioration of harm to receptors; receiving environment moderately sensitive; or identified threshold occasionally exceeded
	Minor	Minor deterioration (nuisance or minor deterioration) or harm to receptors; change to receiving environment not measurable; or identified threshold never exceeded
	Minor +	Minor improvement; change not measurable; or threshold never exceeded
	Moderate +	Moderate improvement; within or better than the threshold; or no observed reaction
	Major +	Substantial improvement; within or better than the threshold; or favourable publicity
DURATION	**Short term**	Quickly reversible. Less than two years
	Medium term	Reversible over time. Life of the project
	Long term	Permanent. Beyond closure
SPATIAL SCALE	**Site or Local**	Site specific or confined to the immediate project area
	Regional	May be defined in various ways e.g. cadastral, catchment, topographic
	National/ International	Nationally or beyond

PART B: DETERMINING CONSEQUENCE RATING (Rate consequence based on definition of magnitude, duration and spatial extent)					
			SPATIAL SCALE		
			Site or Local	**Regional**	**National/ International**
MAGNITUDE					
Minor	**DURATION**	**Long term**	**Medium**	**Medium**	**High**
		Medium term	**Low**	**Low**	**Medium**
		Short term	**Low**	**Low**	**Medium**
Moderate	**DURATION**	**Long term**	**Medium**	**High**	**High**
		Medium term	**Medium**	**Medium**	**High**
		Short term	**Low**	**Medium**	**Medium**
Major	**DURATION**	**Long term**	**High**	**High**	**High**
		Medium term	**Medium**	**Medium**	**High**
		Short term	**Medium**	**Medium**	**High**

PART C: DETERMINING SIGNIFICANCE RATING (Rate significance based on consequence and probability)				
		CONSEQUENCE		
		Low	**Medium**	**High**
PROBABILITY (of exposure to impacts)	**Definite**	**Medium**	**Medium**	**High**
	Possible	**Low**	**Medium**	**High**
	Unlikely	**Low**	**Low**	**Medium**

7.7. POSITIVE AND NEGATIVE IMPACTS

The impact and risk assessment conducted and discussed in section 7.5, indicate that the proposed development activities associated with this project, will have some degree of environmental impact and risk for all site options/alternatives considered. Table 7.7(a) below summarises potential positive and negative impacts anticipated with the different site options/ alternatives considered.

Table 7.7(a): Summary of Positive and Negative Impacts

Activity	Positive Impacts	Negative Impacts
Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure **Site 1 (Preferred Alternative)**	Tailings is removed from the adjacent Foskor site through the beneficiation process. The life of the operations will be extended thereby contributing to sustainable development and a positive socio-economic impact. The Phase I HIA study for the Bosveld Phosphates' proposed Magnetite Waste Site Disposal Facility footprint revealed none of the types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (Act No. 25 of 1999) for the Project Area. No natural wetland habitat was identified within the project study area or the 500m buffer.	The development of the MWSDF will lead to a loss of wilderness and grazing (poor) potential and habitat loss and modification due to vegetation clearance. Disturbance and mortality of fauna species can occur during construction activities. Seepage of leachate through the baseliner of the facility resulting in groundwater pollution is unlikely since the design and layout of the proposed MWSDF is governed by legal requirements as per the NEMWA and NWA Regulations. Spillage of process and storm water run-off resulting in surface water pollution is unlikely as the required storage capacity to cater for rainfall storm events and operational aspects aimed at ensuring stability and the prevention of spillages. Impact on air quality due to dust generation from MWSDF is possible if the impact is not mitigated. All potential impacts identified will not have unacceptable adverse effects as management measures can be proposed to mitigate adequately.
Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure **Site 2**	Tailings is removed from the adjacent Foskor site through the beneficiation process. The life of the operations will be extended thereby contributing to sustainable development and a positive socio-economic impact.	The development of the MWSDF will lead to a loss of land capability potential and habitat loss and modification due to vegetation clearance. Disturbance and mortality of fauna species can occur during construction activities. Negative impact on heritage resources if present within footprint area. Seepage of leachate through the baseliner of the facility resulting in groundwater pollution is unlikely since the design and layout of the proposed MWSDF is governed by legal requirements as per the NEMWA and NWA Regulations. Spillage of process and storm water run-off resulting in surface water pollution is unlikely as the required storage capacity to cater for rainfall storm events and operational aspects aimed at ensuring stability and the prevention of spillages. Impact on air quality due to dust generation from MWSDF is possible if the impact is not mitigated. All potential impacts identified will not have unacceptable adverse effects as management measures can be proposed to mitigate adequately.

Activity	Positive Impacts	Negative Impacts
Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure **Site 3**	Tailings is removed from the adjacent Foskor site through the beneficiation process. The life of the operations will be extended thereby contributing to sustainable development and a positive socio-economic impact. No natural wetland habitat was identified within the project study area.	The development of the MWSDF will lead to a loss of wilderness and grazing (low intensity) potential and habitat loss and modification due to vegetation clearance. Disturbance and mortality of fauna species can occur during construction activities. Potential negative impact on two Late Iron Age and historical settlements (kopjes Serotwe and Mabadika). Seepage of leachate through the baseliner of the facility resulting in groundwater pollution is unlikely since the design and layout of the proposed MWSDF is governed by legal requirements as per the NEMWA and NWA Regulations. Spillage of process and storm water run-off resulting in surface water pollution is unlikely as the required storage capacity to cater for rainfall storm events and operational aspects aimed at ensuring stability and the prevention of spillages. Impact on air quality due to dust generation from MWSDF is possible if the impact is not mitigated. All potential impacts identified will not have unacceptable adverse effects as management measures can be proposed to mitigate adequately.
Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure **Site 4**	Tailings is removed from the adjacent Foskor site through the beneficiation process. The life of the operations will be extended thereby contributing to sustainable development and a positive socio-economic impact.	The development of the MWSDF will lead to a loss of land capability potential and habitat loss and modification due to vegetation clearance. Disturbance and mortality of fauna species can occur during construction activities. Potential negative impact on two Late Iron Age and historical settlements (kopjes Serotwe and Mabadika). Seepage of leachate through the baseliner of the facility resulting in groundwater pollution is unlikely since the design and layout of the proposed MWSDF is governed by legal requirements as per the NEMWA and NWA Regulations. Spillage of process and storm water run-off resulting in surface water pollution is unlikely as the required storage capacity to cater for rainfall storm events and operational aspects aimed at ensuring stability and the prevention of spillages. Impact on air quality due to dust generation from MWSDF is possible if the impact is not mitigated. All potential impacts identified will not have unacceptable adverse effects as management measures can be proposed to mitigate adequately.

A comprehensive and detailed impact and risk assessment will be performed by a team of competent and qualified natural scientists for the preferred alternative site during the EIA Phase of this project.

Refer to section 8.8 of this report for a list of actions to be performed during the EIA Phase of this project.

Best practice, applicable management measures will also be proposed during this assessment in order to avoid, modify, remedy and/or control the negative impacts associated with the proposed activities.

7.8. POSSIBLE MITIGATION MEASURES

Possible mitigation measures available for all the site alternatives considered to manage the negative environmental impacts anticipated for the proposed project activities, can be summarised as follows:

- The footprint sites have been selected to not encroach on sensitive environmental features.
- The footprint sizes of all the new proposed facilities are minimized through detailed design according to site specific surface water run-off characteristics and precipitation event return intervals.
- All facilities conveying or containing "dirty water"/ waste are designed with appropriate liner systems to prevent seepage of contaminated water into the sub-surface.
- Furthermore the capacities of these facilities are designed to prevent spillages during storm rainfall events as specified by legislation.

Table 7.8(a) summarises the potential impacts identified for the preferred alternative site, the possible mitigation measures that could/should be implemented and the level of residual risk anticipated.

This section will be updated further if/when concerns are raised and inputs are provided by I&AP's or regulating authorities during the Public Participation process.

Table 7.8(a):Potential Impacts Identified, Possible Mitigation Measures and Level of Residual Risk

Development Element/Activity	Environmental Aspect	Potential Impact	Possible Mitigation Measures	Long Term Residual Risk Significance
Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure **Site 1 (Preferred Alternative)**	Soils & Land Capability	Loss of wilderness and grazing (poor) potential at footprint.	Minimise the development/ facility footprints. Optimise the post closure land capability to achieve the post closure land use objectives.	**Low**
	Groundwater	Seepage of leachate through the baseliner resulting in groundwater pollution.	Design and install an appropriate liner and under drain system in compliance with regulatory requirements and relevant guidelines.	**Low**
	Surface Water	Spillage of process and storm water run-off resulting in surface water pollution.	Design for adequate operational, storage and free board capacities in compliance with regulatory requirements and relevant guidelines.	**Low**
	Plant Life	Habitat loss and modification due to vegetation clearance.	Prior to any vegetation clearing, permits must be obtained from the relevant national and/or provincial authority to clear protected trees that occur within the development footprint. Vegetation clearing should be restricted to the proposed development footprints only, with no clearing permitted outside of these areas. The areas to be cleared should be clearly demarcated to prevent any unnecessary clearing outside of these areas.	**Low**
	Animal Life	Disturbance and mortality of fauna species.	Diligent monitoring during vegetation clearing to manage any wildlife-human interactions. Training and awareness raising (induction training and on-site signage) in terms of fauna species identification and snake handling. Appropriate barriers to prevent fauna gaining access to construction trenches and voids where they may become trapped. Enforce low-speed limit (recommended 20-40 km/h) to reduce wildlife-collisions. The handling, poisoning and killing of on-site fauna must be strictly prohibited. Consider noise abatement equipment fitment to machinery and vehicles. Regular dust suppression on roads and other sites where dust entrainment occurs.	**Low**
	Aquatic Ecosystems	Spillage of process and storm water run-off resulting in surface water pollution.	Design for adequate operational, storage and free board capacities in compliance with regulatory requirements and relevant guidelines to minimise any potential spills/seeping of waste material and other pollutants into on-site drainage lines and the surrounding aquatic ecosystems. Implement additional safety measures, such as stormwater infrastructure and silt/pollution traps, to further prevent any contamination/pollution entering the downstream environment.	**Low**
	Air Quality	Impact on air quality due to dust generation from MWSDF.	Effective operational procedures to manage the dry and wet sections on top of the MWSDF as well as regular on-site dust suppression.	**Low**

7.9. OUTCOME OF SITE SELECTION MATRIX

The nature of new development and expansion projects are such that their respective localities are more often than not dictated by topographical, logistical and operational aspects.

Alternative sites are identified to be considered if they are feasible in terms of the above-mentioned aspects. Further assessment of these alternative sites results in the identification of sensitive environmental features at each site.

A site selection matrix/ process aids in selecting a specific site, i.e. the preferred alternative site, which incorporates both the logistical and operational aspects but also the environmental attributes associated with these sites.

This section relays the site selection matrix compiled for all four alternative site options that were available for this specific development project from an environmental perspective.

Refer to Figure 7.1(a) which shows the four alternative sites located within the greater Bosveld Phosphates operational site. The four sites were subjected to an environmental impact and risk assessment (refer to section 7.5 of this report) in accordance to the same methodology as described in section 7.6. In order to support the site selection process, a site ranking was allocated to each site which was determined by allocating the following numerical values to the risk outcomes:

No Risk = 0;
Low Risk = 1;
Medium Risk = 2;
High Risk = 3

The sites were then ranked according to the total environmental risk score for each site. The outcome of the environmental risk ranking is presented in Table 7.9(a).

Table 7.9(a): Site Selection Matrix – Environmental Site Ranking

MWSDF & associated infrastructure	Total Environmental Risk Score	Site Ranking
Site Option 1	**10**	**1**
Site Option 2	14	4
Site Option 3	12	2
Site Option 4	13	3

The lower the score, the more preferred the site is from an environmental perspective. The p**referred alternative site** for the proposed Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure, from an **environmental perspective**, is **Site Option 1.**

7.10. NO ALTERNATIVE SITE MOTIVATION

Four site options/alternatives were considered and assessed for the development of the Magnetite Waste Site disposal Facility (MWSDF) and associated infrastructure. Refer to section 7.1 of this report for a comprehensive alternative assessment performed as per regulations. A potential impact/risk assessment considering a host of environmental components was furthermore performed for these four sites identified; refer to section 7.5 of this report. The outcome of the site selection matrix is discussed and provided in section 7.9 of this report.

Taken all of the above into account, no other site option/alternative is as feasible and favourable at this stage except the preferred alternative site, **site option 1**. Refer to Figure 7.1(a) where the locality of the preferred alternative site is provided in context of the greater Bosveld Phosphates site.

7.11. MOTIVATED PREFERRED ALTERNATIVE

The preferred alternative site for the development of the Magnetite Waste Site disposal Facility (MWSDF) and associated infrastructure is **site option 1.**

All four site options/alternatives for the proposed Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure had very similar Environmental Impact and Risk Assessment outcomes (section 7.5). The receiving environment and the ecological importance at all four sites options considered, are similar in nature.

Evident from Table 7.1(a) is that Bosveld Phosphates currently does not have surface rights to all this site options/alternatives available. Furthermore, as can also be seen on Figure 7.1(a), not all sites can ensure sustainable development as limited space is available for future operations and associated expansion considerations.

The site selection for the proposed Magnetite Waste Site Disposal Facility (MWSDF) could therefore continue from the same Environmental Impact and Risk base and could be done subject to legal and sustainable operational considerations.

Geotechnical and stability assessments were performed at the preferred alternative site (see **APPENDIX 7(G)**) as part of the civil design and engineering component of this project which informed the design specifications and parameters to ensure that development at this site does not pose a safety risk.

The proposed Site Layout Plan to be presented to I&AP's for consideration during the Scoping Phase of this project, is depicted in Figure 4.3(a). A large scale version of the proposed Site Layout Plan at the preferred alternative site is attached as **APPENDIX 7(A)** to this report.

8. PLAN OF STUDY

8.1. DESCRIPTION OF ALTERNATIVES TO BE CONSIDERED (INCLUDING NO-GO)

Four site options/alternatives were considered and assessed for the development of the Magnetite Waste Site Disposal Facility (MWSDF) and associated infrastructure. Refer to section 7.1 of this report for a comprehensive alternative assessment performed as per regulations. A potential impact/risk assessment considering a host of environmental components was furthermore performed for these four sites identified; refer to section 7.5 of this report. The outcome of the site selection matrix is discussed and provided in section 7.9 of this report.

Taken all of the above into account, no other site option/alternative is as feasible and favourable at this stage except the preferred alternative site, **site option 1**. Refer to Figure 7.1(a) where the locality of the preferred alternative site is provided in context of the greater Bosveld Phosphates site.

I&AP's will have a chance to review the alternatives considered during the Scoping Phase of this project al will have the opportunity to provide feedback and comments to the EAP in this regard.

8.2. ASPECTS FOR ENVIRONMENTAL IMPACT ASSESSMENT

The aspects to be assessed during the environmental impact assessment are listed in Table 8.2(a) below and are provisional. In preparation for the EIA Phase, workshops will be held with all the relevant specialists and they will finalise the aspects and impacts for each of the project activities listed in Table 8.2(a), after which they will conduct their individual impact assessments.

Column 1: Proposed **Activities** that could potentially have an environmental impact.
Column 2: **Aspects** associated with the Activity. Aspects were provisionally identified by the EAP and will be verified during the workshop with the relevant specialists. Aspects are defined as the mechanisms by which the project activities impact on receptors (e.g. people, economy, infrastructure, institutions and natural environment).
Column 3: **Environmental Components** provisionally identified by the EAP and to be verified during the workshop with the relevant specialists, that will be impacted on by the specific aspect during a specific project phase (Construction Phase, Operational Phase and Decommissioning Phase).

Proposed project activities will be assessed and management measures will be proposed by a team of specialists during the EIA Phase of the project. Table 8.2(b) provides further categorisation and an associated description of the different aspects and potential impacts related to a particular environmental component considered.

Table 8.2(a): Activity and Aspect Table for perusal during the EIA Phase

Activity	Aspect	Environmental Component
Magnetite Waste Site Disposal Facility and associated infrastructure	Construction of facility, disposal of material (operation of facility), decommissioning and closure of facility	Socio-Economic/Cultural, Topography & Land Use, Soils & Land Capability, Groundwater, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Wetlands, Air Quality.
Pollution Control Dam (PCD) and associated infrastructure	Construction of facility, reticulation of process and storm water (operation of facility), decommissioning and closure of facility	Socio-Economic/Cultural, Topography & Land Use, Soils & Land Capability, Groundwater, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Wetlands, Air Quality.
Access Road	Construction of road, vehicular traffic (transport of material), decommissioning and closure of road	Socio-Economic/Cultural, Topography & Land Use, Soils & Land Capability, Groundwater, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Wetlands, Air Quality.
Copper Flotation Plant	Construction of plant, extraction of copper mineral (operation of facility), decommissioning and closure of facility	Socio-Economic/Cultural, Topography & Land Use, Soils & Land Capability, Groundwater, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Wetlands, Air Quality.

Table 8.2(b): Generic Impact Categories and Potential Impact Descriptions

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue
Socio Cultural	Geographic Processes (land use patterns)	Changes in land use patterns; loss of wilderness and grazing potential.
	Demographic Processes (population composition e.g. age, gender, race)	Changes in population numbers and profile due to potential influx of migrant workers for construction, operation and decommissioning.
	Institutional & Legal Processes (municipal services, public infrastructure, housing)	Changes in the demand for municipal services, transport and housing due to the increase in population.
	Cultural Processes (social, cultural and traditional practices)	Changes in the cultural dynamics of the area due to influx of people with different cultural and social backgrounds.
Heritage Resources	Historical and Cultural (places, buildings, structures, burial grounds, graves)	Damage to, or destruction of, graveyards, graves and/or other heritage resources due to construction, mining and decommissioning activities.
Socio Economic	Economic Efficiency (labour, employment, output and growth)	Positive changes in economic output and regional exports due to the beneficiation processes.
	Economic Equity (poverty, income)	Positive changes in employment, tax income, increased social spending and increased incomes due to employment offered.
	Economic Stability (diversity, resource use)	Positive changes in economic stability through diversification due to the beneficiation processes.
Land Use	Beneficial Land Use (derelict, vacant, residential, industrial, mining, agricultural, recreational, wilderness, conservation)	Changes in land use patterns; loss of wilderness and grazing potential.

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue
Topography	Morphology	Creation of dangerous/unstable excavations as well as dangerous/ unstable mounds/ piles/ dumps due to stockpiling of soil, materials and product and due to disposal of waste onto land.
Soils	Soil Horizon	Loss of soil horizon due to site clearance for construction of project activities.
	Soil Fertility	Loss of soil fertility due to incorrect stockpiling of soils required for rehabilitation purposes.
	Soil Contamination	Contamination of soil due to spillages of raw material, ore and product during transport or due to spillages/seepages/leakages of contaminated water from pipes, canals, sumps and dams.
Land Capability	Land Capability (wetland, arable (dryland), arable (irrigation), grazing, wilderness, rehabilitated)	Changes in land use patterns; loss of wilderness and grazing potential.
Groundwater	Quantity (presence, flow, availability) of Groundwater	Depletion in the quantity of groundwater available in the area due to the formation of cones of groundwater level depression around boreholes from which groundwater is abstracted.
	Quality of Groundwater	Contamination of the groundwater resource due to spillages of contaminated water from tanks, sumps, pipes and dams and/or the infiltration of soluble contaminants into the subsurface through the basins of stockpiles, dumps, sumps and dams.
Surface Water	Quantity (presence, flow, availability) of Surface Water	Depletion in the quantity of surface water due to the capture of direct rainfall in dams, as well as the capture of contaminated storm water run-off in Pollution Control Dams.
	Quality of Surface Water	Contamination of the surface water resource due to contaminated run-off from "dirty areas" directly into the surface water resources and/or spillages of contaminated water from tanks, sumps, pipes and dams.
Plant Life	Habitat	Impact on or destruction of habitat due to site clearance for construction of activities and associated infrastructure.
	Bio-Diversity	Impact on or destruction of Bio-Diversity due to a loss in habitat or as a result of contamination of soils or water.
	Species of Conservation Concern	Threat to species of conservation concern due to site clearance.
Animal Life	Habitat	Impact on or destruction of habitat due to vegetation habitat disturbance as well the construction and presences of fences.
	Bio-Diversity	Impact on or destruction of Bio-Diversity due to habitat disturbance or as a result of water pollution, air pollution, noise and traffic.
	Species of Conservation Concern	Threat to species of conservation concern due to development activities.

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue
Wetlands	Habitat	Impact on or destruction of habitat due to site clearance for construction of activities and associated infrastructure.
	Present Ecological State (PES)	Deterioration in PES due to impacts on habitat as well as wetland functions and services attributes.
Aquatic Ecosystems	Habitat (IHAS)	Impact on or destruction of habitat due to impacts on habitat attributes such as water flow and water quality.
	Bio-Diversity (SASS5, FAII, Toxicity)	Impact on or destruction of bio-diversity due to impacts on habitat.
Air Quality	Gaseous Emissions	Deterioration in ambient air quality due to gaseous emissions from the beneficiation plants.
	Particulate Matter	Deterioration in ambient air quality due to particulate matter emissions from the beneficiation plants.
	Dust Fallout	Deterioration in ambient air quality due to dust generated by road transport, conveyor transport, crushing, handling, stockpiling and wind entrainment of raw materials, wastes and product as well as during construction and decommissioning activities.

8.3. ASPECTS TO BE ASSESSED BY SPECIALISTS

The following environmental aspects will be assessed by a team of specialists during the EIA Phase of the project. Refer to section 8.2 of this report for the details pertaining to this assessment.

- Socio-Cultural/ Socio-Economic Aspects
- Archaeological and Heritage Aspects
- Palaeontological Aspects
- Topographical Aspects
- Land Use Aspects
- Soils and Land Capability Aspects
- Geological Aspects
- Groundwater Aspects
- Surface Water Aspects
- Plant Life Aspects
- Animal Life Aspects
- Aquatic Ecosystems Aspects
- Wetland Aspects
- Air Quality Aspects

The outcomes of these assessments will be combined by the EAP and compiled into the EIA Report.

Separate Specialist Reports will be compiled for the following:

- Socio-Cultural/ Socio-Economic Aspects
- Archaeological and Heritage Aspects
- Palaeontology Aspects
- Geology and Groundwater Aspects
- Surface Water Aspects
- Terrestrial Ecology (Plant Life and Animal Life) Aspects
- Aquatic Ecosystems Aspects
- Wetland Aspects
- Air Quality Aspects

8.4. IMPACT ASSESSMENT METHODOLOGY

The impact and risk assessment methodology that will be utilised during the EIA Phase of the project for the comprehensive impact assessment will be the same methodology employed as during the alternative impact assessment; refer to Section 7.5 of this report.

This methodology/process comprise of the identification of the following:

- Project activity
- Aspect of activity that could potentially cause an impact
- Environmental component that could potentially be impacted upon
- Potential impact description
- Potential impact/risk evaluation

8.5. METHOD FOR ASSESSING DURATION AND SIGNIFICANCE

The proposed methods for assessing the duration and significance of an impact are listed in Tables 8.5(a) and 8.5(b) below.

Table 8.5(a): Method for Assessing Duration

PART A: DEFINING CONSEQUENCES OF MAGNITUDE, DURATION AND SPATIAL SCALE (Use these definitions to define the consequence in Part B) + *denotes a positive impact*		
Impact Characteristics	**Definition**	**Criteria**
DURATION	Short term	Quickly reversible. Less than two years
	Medium term	Reversible over time. Life of the project
	Long term	Permanent. Beyond closure

Table 8.5(a): Method for Assessing Significance

PART C: DETERMINING SIGNIFICANCE RATING (Rate significance based on consequence and probability)				
		CONSEQUENCE		
		Low	**Medium**	**High**
PROBABILITY (of exposure to impacts)	**Definite**	**Medium**	**Medium**	**High**
	Possible	**Low**	**Medium**	**High**
	Unlikely	**Low**	**Low**	**Medium**

8.6. CONSULTATION TIMELINE WITH COMPETENT AUTHORITIES

The Consultation and Interaction Timelines for the Competent Authorities are detailed in the two Tables below:

Table 8.6(a): Consultation Timeline with the LEDET

Pre-Application Meeting with DFFE	**6 July 2022**
Submission of the Environmental Authorisation (EA) application in terms of NEMA and the Waste Management Licence (WML) application in terms of NEMWA to the LEDET (CA)	**20 July 2022**
Scoping Phase Public Meeting for I&AP's	**21 July 2022**
Draft Scoping Report submitted to CA	**20/21 July 2022**
Draft Scoping Report available to I&AP's	**20/21 July 2022**
CA and I&AP Review Process (30 days) concludes	**22 August 2022**
Submit Final Scoping Report (which has been subjected to Public Participation) to CA 44 days after Application was received by CA	**5 September 2022**
CA to Review/Accept Scoping Report (43 days)	**19 October 2022**
Impact Phase Public Meeting for I&AP's	**7/8/9 December 2022**
Draft EIA and EMP Report submitted to CA	**8/9 December 2022**
Draft EIA and EMP Report available to I&AP's	**8/9 December 2022**
CA and I&AP Review Process (30 days) concludes	**30 January 2023**
Submit Final EIA and EMP Report (which has been subjected to Public Participation) to the CA 106 days after Acceptance of Scoping Report by CA	**16 February 2023**
Approval by CA 107 days after receipt of the Final EIA and EMP Reports	**8 June 2023**

8.7. EIA STAGE PUBLIC PARTICIPATION PROGRAMME PARTICULARS

8.7.1. Notification of Interested and Affected Parties

An extensive list/register of I&AP's and authorities will have been compiled by this phase and the same database will be used for communication with I&AP's during the EIA Phase.

However, should any person be identified, or should any person request to be registered as an I&AP to the project, at any stage of the project, he/she will be given the opportunity to do so and be notified of the project accordingly.

Notification of I&AP's and authorities on the progress of the project will be done according to the regulations as set out in GNR 982 (as amended) which includes notification letters, newspaper advertisements, and site notices. These notices and advertisements will inform the I&AP's on details of the Public Meeting during the EIA Phase.

8.7.2. Details of Engagement Process

Meetings with authorities during the EIA Phase will be arranged on request. I&AP's will be invited to attend a Public Meeting during which the results of the environmental impact assessment and proposed management and mitigation measures will be communicated to them. Should some of the I&AP's wish to be consulted in a Focus Group format, such meetings will be scheduled and conducted.

All I&AP's will receive the opportunity to comment on any of the information generated during the EIA/EMP Phase of the project, during the review period (30 days) of the draft reports.

All comments that are raised by I&AP's and provided to the EAP will be incorporated into an I&AP Issues and Concerns Register. The EAP and/or Applicant will address each issue or comment raised. Once this is completed the I&AP's will be notified of how their issue or comment have been addressed and the finalised reports will be submitted to the relevant authorities for approval.

8.7.3. Information to be provided to Interested and Affected Parties

Throughout the Public Participation Process, I&AP's will have access to draft reports at public venues. They will also be able to access all draft reports on the JMA Consulting website (www.jmaconsult.co.za).

A detailed Public Participation Report, containing information of all the actions that were undertaken with regard to the Public Participation Process (for both phases, Scoping and EIA), will be compiled for this project and will be submitted along with the final reports to the relevant competent authority.

8.8. TASKS TO BE UNDERTAKEN DURING ENVIRONMENTAL IMPACT ASSESSMENT

The following tasks will be conducted during the EIA Phase:

8.8.1. EIA Stage 3: Environmental Impact Assessment

- Commence to Implement Plan of Study
- Continue Public Participation Process
- Conduct Specialist Studies including Feasibility Studies and Engineering Designs
- Prepare EIA Report (EIAR comprising EIA, EMPr as per Regulations and Guidelines)
- EIA/EMP Public Meeting
- Make EIAR and EMPr available for Review
- Capture and Consider Comments from I&AP's and Relevant Authorities
- Finalize and Submit EIAR and EMPr to the Competent Authority for approval

8.8.2. EIA Stage 4: Consideration and Decision

- Authority Review and Decision
- Granting/ Refusal of Environmental Authorisation
- Notification of Decision by Competent Authority
- Inform I&AP's of Decision/Approval and of Opportunity to Appeal

8.8.3. EIA Stage 5: Appeal

- Appellant to give notice of intention to Appeal to Authority, Applicant and all I&AP's
- Submission of Appeal to Authority
- Submission of Responding Statement from Respondent/Applicant to Authority and Appellant
- Processing of Appeal
- Decision on Appeal
- Notification of Decision on Appeal to Appellant and Respondents by Authority

8.9. MANAGEMENT MEASURES TO AVOID, MANAGE OR MITIGATE IMPACTS

The details of the management measures to be implemented at Bosveld Phosphates will be developed during the EIA Phase of the project.

However, the EAP has developed a Mitigation/Management Measure Table (Table 8.9(a)) which indicates potential options available for the mitigation/management of specific environmental impacts and risks.

The table was compiled specifically for this project and considered all typical activities associated with this type of operation and identifies and describes the impacts and possible mitigation/management measures per environmental component.

The last column in the table indicates if a potential Residual Risk would be present after decommissioning and closure.

Table 8.9(a): List of Suitable Measures to Avoid, Reverse, Mitigate or Manage Identified Impacts

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue	Possible Mitigation/Management Measure	Potential for Residual Risk	
				Yes	No
Socio Cultural	Geographic Processes (land use patterns)	Changes in land use patterns; loss of wilderness and grazing potential.	Optimise the post closure land use to support the post closure land use objectives.	X	
	Demographic Processes (population composition e.g. age, gender, race)	Changes in population numbers and profile due to potential influx of migrant workers for construction, operation and decommissioning.	Implement an employment policy of local first as far as possible.	X	
	Institutional & Legal Processes (municipal services, public infrastructure, housing)	Changes in the demand for municipal services, transport and housing profile due to potential influx of migrant workers for construction, operation and decommissioning.	Consult with local authorities to ensure the availability and maintenance of services as a result of increased demand.	X	
	Cultural Processes (social, cultural and traditional practices)	Changes in the cultural dynamics of the area due to influx of people with different cultural and social backgrounds.	Implement an employment policy of local first as far as possible.	X	
Heritage Resources	Historical and Cultural (places, buildings, structures, burial grounds, graves)	Damage to, or destruction of, graveyards and graves due to construction, operational and decommissioning activities.	Avoid the encroachment upon and destruction of Heritage Resources.		X
Socio Economic	Economic Efficiency (labour, employment, output and growth)	Positive changes in economic output and regional exports due to the beneficiation processes.	Maximise local recruitment.		X
	Economic Equity (poverty, income)	Positive changes in employment, tax income, increased social spending and increased incomes due to employment offered.	Maximise local procurement. Minimise risks of external costs.		X
	Economic Stability (diversity, resource use)	Positive changes in economic stability through diversification due to the beneficiation processes.	Maximise impact of tax and social funds.		X
Land Use	Beneficial Land Use (derelict, vacant, residential, industrial, mining, agricultural, recreational, wilderness, conservation)	Changes in land use patterns; loss of wilderness and grazing potential.	Minimise the development footprints. Optimise the post closure land use to achieve the post closure land use objectives.	X	
Topography	Morphology & Stability	Creation of dangerous/unstable excavations as well as dangerous/ unstable mounds/ piles/ dumps due to stockpiling of soil, materials and product and due to disposal of waste onto land.	Ensure that relevant facilities (stockpiles, dumps, excavations) are operated in strict accordance with the design principles and ensure final decommissioning and closure are in compliance with closure designs.	X	

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue	Possible Mitigation/Management Measure	Potential for Residual Risk	
				Yes	No
Soils	Soil Horizon	Loss of soil horizon due to site clearance for construction of activities and associated infrastructure.	Minimise development footprints.	X	
	Soil Fertility	Loss of soil fertility due to incorrect stockpiling of soils required for rehabilitation purposes.	Handle and stockpile soil in compliance with the EMPr/ guidelines provided.		X
	Soil Contamination	Contamination of soil due to spillages of materials during transport or due to spillages/seepages/leakages of contaminated water from pipes, canals, sumps and dams.	Minimise spillages and leakages. Remediate spillages as soon as possible.	X	
Land Capability	Land Capability (wetland, arable (dry land), arable (irrigation), grazing, wilderness, rehabilitated)	Changes in land capability due to the transformation of the agricultural land use.	Minimise the development footprints. Optimise the post closure land use to achieve the post closure land use objectives.	X	
Groundwater	Quantity (presence, flow, availability) of Groundwater	Depletion in the quantity of groundwater available in the area due to the formation of cones of groundwater level depression around boreholes from which groundwater is abstracted.	Manage abstraction from production boreholes to optimise the sustainability of the groundwater resource.		X
	Quality of Groundwater	Contamination of the groundwater resource due to spillages of contaminated water from tanks, sumps, pipes and dams and/or the infiltration of soluble contaminants into the subsurface through the basins of stockpiles, dumps, sumps and dams.	Operate PCD's, Process Water Dams and Tailing Storage Facilities to prevent spillages. Maintain liner integrity to prevent seepage for these facilities.	X	
Surface Water	Quantity (presence, flow, availability) of Surface Water	Depletion in the quantity of surface water due to the capture of direct rainfall in dams, as well as the capture of contaminated storm water run-off in Pollution Control Dams.	Minimise dirty water areas at the site.		X
	Quality of Surface Water	Contamination of the surface water resource due to contaminated run-off from "dirty areas" directly into the surface water resources and/or spillages of contaminated water from tanks, sumps, pipes and dams.	Operate PCD's, Process Water Dams and Tailings Storage Facilities to prevent spillages. Optimise the Storm Water Management Plan to capture run-off from dirty water areas.		X
Plant Life	Habitat	Impact on or destruction of habitat due to site clearance for construction of activities and associated infrastructure.	Minimise the development footprints. Optimise the post closure land capability to achieve the post closure land use objectives.	X	
	Bio-Diversity	Impact on or destruction of Bio-Diversity due to a loss in habitat or as a result of contamination of soils or water.	Minimise the development footprints. Minimise spillages of contaminants.	X	

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue	Possible Mitigation/Management Measure	Potential for Residual Risk	
				Yes	No
			Optimise the post closure land capability to achieve the post closure land use objectives.		
	Species of Conservation Concern	Threat to species of conservation concern due to site clearance.	Permits must be obtained from the relevant national and/or provincial authority to clear protected trees that occur within the development footprint. Vegetation clearing should be restricted to the proposed development footprints. Areas to be cleared should be clearly demarcated to prevent any unnecessary clearing outside of these areas.	X	
Animal Life	Habitat	Impact on or destruction of habitat due to vegetation habitat disturbance as well the construction and presences of fences.	Minimise the development footprints. Optimise the post closure land capability to achieve the post closure land use objectives.	X	
	Bio-Diversity	Impact on or destruction of Bio-Diversity due to habitat disturbance or as a result of water pollution, air pollution, noise and traffic.	Minimise the development footprints. Minimise spillages of contaminants. Optimize the post closure land capability to achieve the post closure land use objectives.	X	
	Species of Conservation Concern	Threat to species of conservation concern due to development activities.	Diligent monitoring during vegetation clearing to manage any wildlife-human interactions. Training and awareness raising (induction training and on-site signage). Appropriate barriers to prevent fauna gaining access to construction trenches/ voids where they may become trapped. Enforce low-speed limit (recommended 20-40 km/h) to reduce wildlife-collisions. The handling, poisoning and killing of on-site fauna must be strictly prohibited. Consider noise abatement equipment fitment to machinery and vehicles. Regular dust suppression on roads and other sites where dust entrainment occurs.	X	

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue	Possible Mitigation/Management Measure	Potential for Residual Risk	
				Yes	No
Wetlands	Habitat	Impact on or destruction of habitat due to site clearance for construction of activities and associated infrastructure.	Avoid development within wetlands.		X
	Present Ecological State (PES)	Deterioration in PES due to impacts on habitat as well as wetland functions and services attributes.	Avoid development within wetlands.		X
Aquatic Ecosystems	Habitat (IHAS)	Impact on or destruction of habitat due to impacts on habitat attributes such as water flow and water quality.	Prevent surface water impacts into wetlands and streams through effective storm water management.		X
	Bio-Diversity (SASS5, FAII, Toxicity)	Impact on or destruction of bio-diversity due to impacts on habitat.	Prevent surface water impacts into wetlands and streams through effective storm water management.		X
Air Quality	Gaseous Emissions	Deterioration in ambient air quality due to gaseous emissions from the beneficiation plants.	Minimise gaseous emissions through the implementation and operation of effective air quality abatement equipment.		X
	Particulate Matter	Deterioration in ambient air quality due to particulate matter emissions from the beneficiation plants.	Minimise particulate matter emissions through the implementation and operation of effective air quality abatement equipment.		X
	Dust Fallout	Deterioration in ambient air quality due to dust generated by road transport, conveyor transport, crushing, handling, stockpiling and wind entrainment of raw materials, wastes and product as well as during construction and decommissioning activities.	Minimise dust fallout through the implementation and operation of effective dust suppression programmes.		X

9. UNDERTAKING - CORRECTNESS OF INFORMATION

I, **René van Greunen** herewith undertake that the information provided in the foregoing report is correct, and that the comments and inputs from Stakeholders and Interested and Affected Parties have been correctly recorded in the report.

Will be completed after the Public Review Period

Signature of the EAP: _____

René van Greunen (Pr. Sci. Nat.)

Date: _____

10. UNDERTAKING - PLAN OF STUDY LEVEL OF AGREEMENT

I, **René van Greunen**, herewith undertake that the information provided in the foregoing report is correct, and that the level of agreement with Interested and Affected Parties and Stakeholders, has been correctly recorded and reported herein.

Will be completed after the Public Review Period

Signature of the EAP: _____

René van Greunen (Pr. Sci. Nat.)

Date: _____

11. INFORMATION REQUIRED BY THE COMPETENT AUTHORITY

11.1. IMPACT ON SOCIO-ECONOMIC CONDITIONS OF DIRECTLY AFFECTED PERSONS

Required for the EIA Report.

A Socio-economic Specialist has been appointed and will compile a Specialist Study Report in this regard.

11.2. IMPACT ON THE NATIONAL ESTATE (SECTION 3(2) OF THE NHRA)

Required for the EIA Report.

A Heritage Specialist has been appointed and will compile a Specialist Study Report in this regard.

12. REQUIREMENTS IN TERMS OF SECTION 24(4)(A) AND (B) OF THE ACT

Refer to the Table provided below which provides the sections in this report which relays the information as requested in terms of Section 24(4)(a) and (b) of the Act.

24 (4) Procedures for the investigation, assessment and communication of the potential consequences or impacts of activities on the environment-		
(a)	**must ensure, with respect to every application for an environmental authorisation-**	**Section**
(i)	coordination and cooperation between organs of state in the consideration of assessments where an activity falls under the jurisdiction of more than one organ of state;	EA Application
(ii)	that the findings and recommendations flowing from an investigation, the general objectives of integrated environmental management laid down in this Act and the principles of environmental management set out in section 2 are taken into account in any decision made by an organ of state in relation to any proposed policy, programme, process, plan or project;	CA Responsibility
(iii)	that a description of the environment likely to be significantly affected by the proposed activity is contained in such application;	EA Application and Section 7
(iv)	investigation of the potential consequences for or impacts on the environment of the activity and assessment of the significance of those potential consequences or impacts; and	Section 7 & 8
(v)	public information and participation procedures which provide all interested and affected parties, including all organs of state in all spheres of government that may have jurisdiction over any aspect of the activity, with a reasonable opportunity to participate in those information and participation procedures; and	Section 8
(b)	**must include, with respect to every application for an environmental authorisation and where applicable-**	**Section**
(i)	investigation of the potential consequences or impacts of the alternatives to the activity on the environment and assessment of the significance of those potential consequences or impacts, including the option of not implementing the activity;	Section 7 & 8
(ii)	investigation of mitigation measures to keep adverse consequences or impacts to a minimum;	Section 7 & 8
(iii)	investigation, assessment and evaluation of the impact of any proposed listed or specified activity on any national estate referred to in section 3(2) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999), excluding the national estate contemplated in section 3(2)(i)(vi) and (vii) of that Act;	Section 11 & EIA Report to follow
(iv)	reporting on gaps in knowledge, the adequacy of predictive methods and underlying assumptions, and uncertainties encountered in compiling the required information;	Section 8 & EIA Report to follow
(v)	investigation and formulation of arrangements for the monitoring and management of consequences for or impacts on the environment, and the assessment of the effectiveness of such arrangements after their implementation;	Section 8 & EIA Report to follow
(vi)	consideration of environmental attributes identified in the compilation of information and maps contemplated in subsection (3); and	Section 7
(vii)	provision for the adherence to requirements that are pre scribed in a specific environmental management Act relevant to the listed or specified activity in question	Section 5

-END OF SCOPING REPORT-