PROGRESS REPORT 1: GROUNDWATER IMPACT ASSESSMENT REPORT AT PROPOSED TENBOSCH MINE

TECKLENBURG 548 JU, PORTION RE

MPUMALANGA PROVINCE

MAY 2023

PRJ_R_1/Rev0

Directors: C Monokofala | MS Masoga

Email: info@kimopax.com | Website: www.kimopax.com

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Conducted on behalf of:

TENBOSCH MINING COMPANY

Compiled by:

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Ntsako Maluleke (Cand.Sci. Nat,)

Reviewed by:

____

Collen Monokofala (Pr. Sci.Nat)

Project Team:

C. Monokofala (Principal Hydrogeologist)

K Lenkoe-Magagula (Senior Hydrogeologist)

N. Maluleke (Hydrogeologist)

C. Gulubela (GIS Specialist)

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Name	Institution
Phillip Mkhatshwa	Tenbosch Mine (Pty) Ltd
Kimopax Library	Kimopax (Pty) Ltd

List of Abbreviations

EIA	: Environmental Impact Assessment
EMP	: environmental Management Program
FC	: Flow Characteristics
GQM	: Groundwater Quality Management
GRUs	: Groundwater Resource Units
MAP	: Mean Annual Precipitation
PCD	: Pollution Control Dams
SABS	: South African Bureau of Standards
SANAS	: South African National Accreditation System
WULA	: Water Use Licence Application

List of Units

l/s	: Litres per second
km	: Kilometre
m	: meters
mbgl	: meter below ground level
mm	: millimetre
mm/a	: millimetre per annum
mS/m	: milli Siemens per meter

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1 INTRODUCTION

Tenbosch Mine (Pty) Ltd (herein referred to as Tenbosch) appointed Kimopax (Pty) Ltd (herein referred to as Kimopax) to conduct a geohydrological study and report on findings as specialist input to the Environmental Impact Assessment (EIA) and Environmental Management Program (EMP) for their proposed resource development and exploitation of the coal resource.

It is proposed that the mine will be underground (110 – 120 mbgl) with life of mine (LOM) of 30 years. The Groundwater Impact Assessment will form part of an Environmental Authorisation (EA) application process in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) for the proposed mining activities. This document outlines the general description of the proposed mining activities, the methodology, the baseline groundwater assessments and preliminary results for the groundwater impact assessment.

2 PROJECT OBJECTIVES

The focus of this investigation is centred around two (2) main objectives:

a) Determining a sound baseline picture of groundwater conditions on and around Tenbosch Mine project area;
b) Determining of the groundwater quality and quantity impacts related proposed Tenbosch coal ore mining activities.

3 SCOPE OF WORK

The scope of work is to provide groundwater specialist services, including the tasks outlined below:

a) Desktop study:
    - Collecting data relevant to the study, including:
        - Geology;
        - Water levels
        - Water quality data
        - Relevant site information from visual inspection and discussions;
a) Hydrocensus within 2km radius from the proposed mining activity
b) Aquifer and borehole hydraulic testing on existing boreholes:

  - Slug test to identify potential borehole yield
  - 4 x 60 minutes step test;
  - 24-hour constant discharge; and
  - Recovery measurements

a) Collection of water samples for existing boreholes during hydrocensus and aquifer testing
b) Data gap analysis, and
c) Recommendation of steps for phase 2 based on phase 1 assessment.

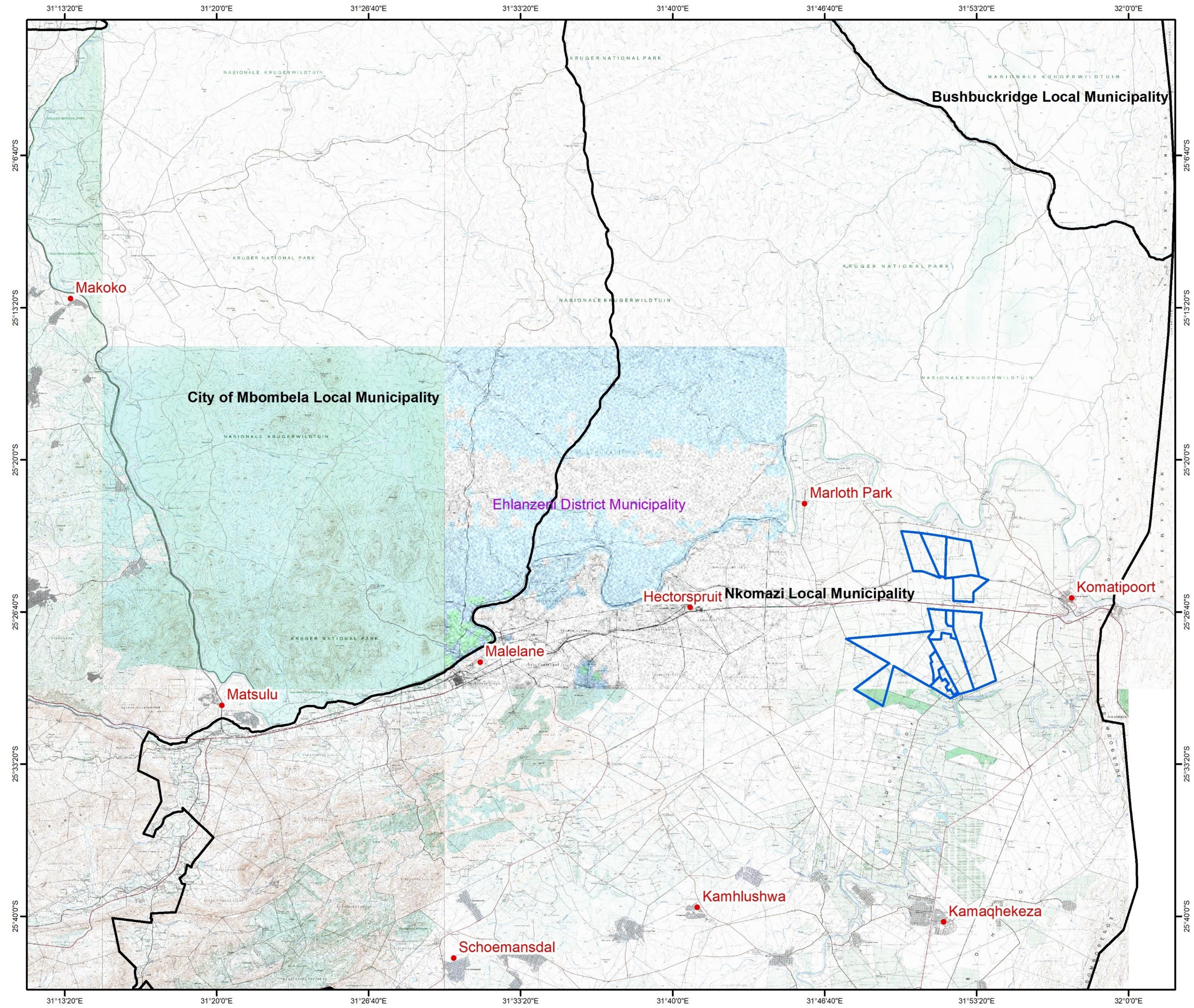
4 DESCRIPTION OF THE STUDY AREA

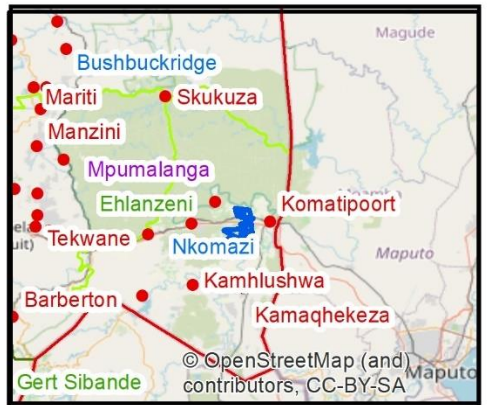
4.1 Locality

Tenbosch Mine is located approximately 12 km south of Kruger National Park,20km away from the Mozambique border. The proposed mine is situated under the Nkomazi Local Municipality, Ehlanzeni District of Mpumalanga Province, South Africa. The proposed site is located at the remainder of the portion of the Tecklenburg 548 JU. The site is bound by three main roads which are R582, which is south and on the east is Strydom Block Road. The N4 to Komatipoort borders on the north at approximately 4km from the site, see Figure 4-1.

4.2 Topography Drainage

The proposed area is characterised by gentle undulating slope dipping very low angle towards northeast of the study area (the topography is low towards Crocodile and Ngweti River in relation to the study area). According to the topographic plan the altitude range is approximately 160 - 220 mamsl, see Figure 4-1 The site is considered well drained with numerous perennials and non-perennials streams flowing into the Crocodile River and Ngweti River, see Figure 4-1. There are also numerous wetlands and swamps which are seemingly created as pond during farming. Groundwater flow generally mimics surface topography (in a homogeneous setting without flow boundaries and preferential flow path).





LEGEND

- Towns
- Local Municipalities
- Mining Right Area

0 1.5 3 6 9 12
Kilometers

N

REFERENCE: Transverse Mecartor (Gauss-Kruger)
WGS84 Ellipsoid
Hartebeesthoek 94 Datum
Central Meridian 23º

PROJECT:
TENBOSCH 162 JU

TITLE: TOPO-GEOLOGICAL MAP
OF
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4.3 Climate

Rainfall occurs partially throughout the year, but predominantly between October and March. Mean Annual Precipitation (MAP) is approximately 533 mm. The wettest month of the year is January, with an average total rainfall of 104 mm (Figure 4-2). The driest months are June, July and August with 3 mm average of rainfall in June and 2 mm average rainfall in July and August. It must be noted with an assumption that the aquifer is unconfined, isotropic and homogeneous that during the wettest periods, it is expected to have high groundwater recharge and water table fluctuation within this period (i.e. January). Groundwater monitoring (water level and groundwater quality) strategies need to be implemented within this period of high rainfall to have baseline understanding of quality and quantity of water within the aquifer in relation to the driest months within the proposed mining area.

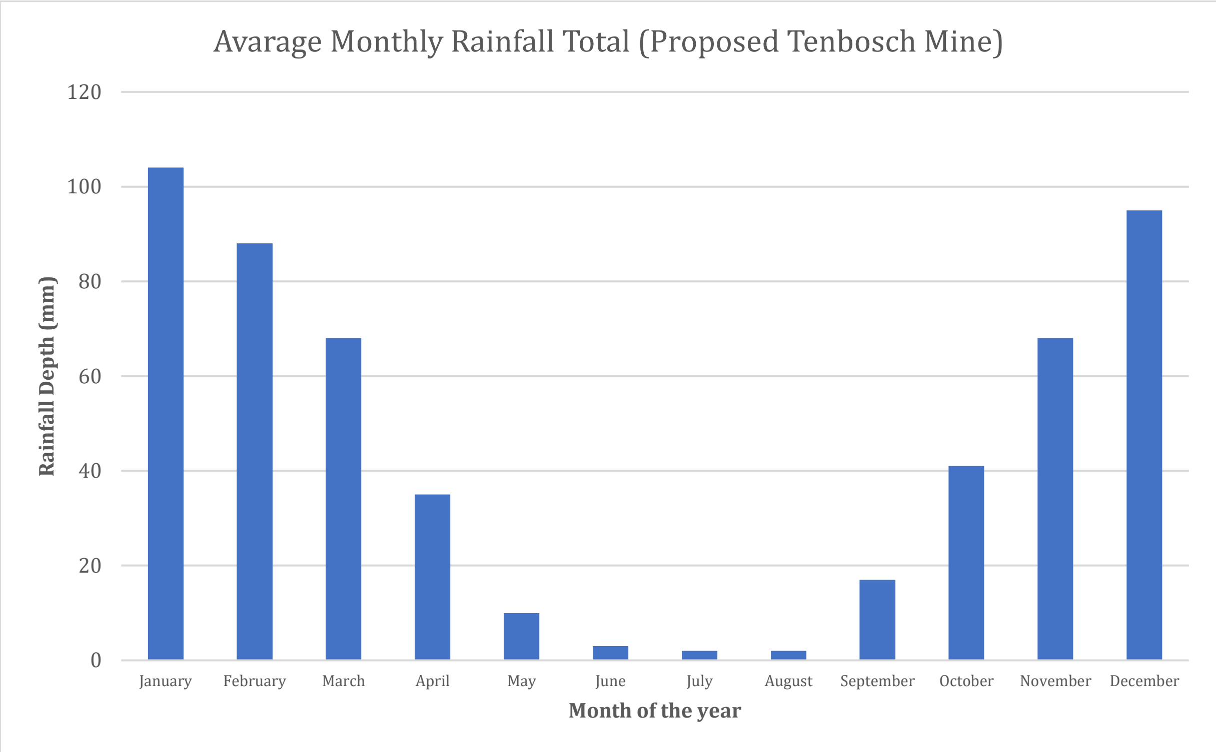


Figure 4-2: Mean Monthly Rainfall for Ward 3 and Ward 2 (CapeFarmMapper Ver 2.6.7)

4.4 Geological Setting

The distribution of geological formations of project area includes rocks from a wide variety of lithological units ranging in age from Swazian to Resent. Included in these are the biotite-trondhjemite gneiss and migmatite of the Swazian basement complex, rocks of the Barberton Sequence and intrusions of Timbavati Gabbro and Dolerite dykes.

4.4.1 Barberton sequence

The rock formations of this area are among the oldest on earth and are collectively grouped as the Barberton Sequence, and exceed a total thickness of 16 km. This group consists as a succession of volcanic layers, overlaid by sedimentary rocks. The oldest rocks of the Barberton Sequence are the ultra-basic to basic igneous rocks of the Onverwacht Group. This includes ultra-basic high-magnesium lavas, periodic komatite, intermediate to basaltic metamorphic rock, intermediate to acid volcanic rocks and a large variety of pyroclastic rocks (Figure 4-3).

A succession of rocks, mainly pelitic, follows on the Onverwacht Group and is collectively known as the Fig Tree Group. A striking layer of Chert and striped iron-containing Chert, the Ulundi layer, is found about halfway in the Fig Tree Group. The top formation in this group consists of pyroclastic rock, mainly tuff and agglomerate. The beginning of the Fig Tree Group is recognized by the exposure of shale interlayered with Chert, a hard, extremely compact, semivitreous cryptocristalline rock (2530 Barbeton Geological Sheet).

4.4.2 Granite and gneiss of the Swazian quaternary

The geology of the area is biotite-tonalite. Tonalite exhibits a wide range in texture varying from non-exfoliated to lightly exfoliated, medium grained granite to gneiss and migmatite. The rocks are light grey when fresh but weather to a light brown colour. In the veld a low relief and relatively high degree of weathering characterize the rocks. Abrupt changes between textural variants and the presence of pegmatite veins are characteristic of this formation. Biotite is the only mafic mineral in gneiss that otherwise consists of plagioclase, quartz and potassium (K) feldspars.

4.4.3 Tonalitic granite and gneiss

A section of tonalitic biotite-trondhjemite granite and gneiss is found on the area. This rock is elliptic and is found to terminate the layered effect of the surrounding rock formation rather abruptly. The granite gneiss formations are usually lower than the surrounding rock formations.

Many dykes traverse the granite gneiss formation and are found to protrude above this formation due to the difference in resistance to weathering. Although the tonalite exhibits a central massive structure, a strongly exfoliated edge is found parallel to the point of contact with the surrounding rock formations. Tonalites consist of plagioclase and quartz with subservient biotite and hornblende. Tonalites are characterized by a relative homogeneity and restricted variation in chemical composition.

4.4.4 Nelspruit suite

The Nelspruit Suite consists of granite, porphyritic and magmatic granite. The granite is a grey to white biotite granite characterized by its colour and grain size that varies from medium to coarse grained. Magmatic and gneiss-like variants of this granite are found along east to west dykes running through Marloth Park and Lionspruit Game Reserve. Characteristic of the Nelspruit Suite is the general presence of coarse-grained pegmatite. Pegmatite being an igneous rock, with interlocking crystals, resembles granite in composition. The granite forms a coarse topography in contrast to the biotite gneiss and migmatite. The Nelspruit Suite consists of granite containing potassium feldspars, plagioclase, quartz, biotite and other minerals. Although the central granite area is mafic with no exfoliation, it may be found where contact is made with the surrounding rock formations. This exfoliation is accentuated by the parallel orientation of feldspar crystals.

4.4.5 Intrusive rock formations

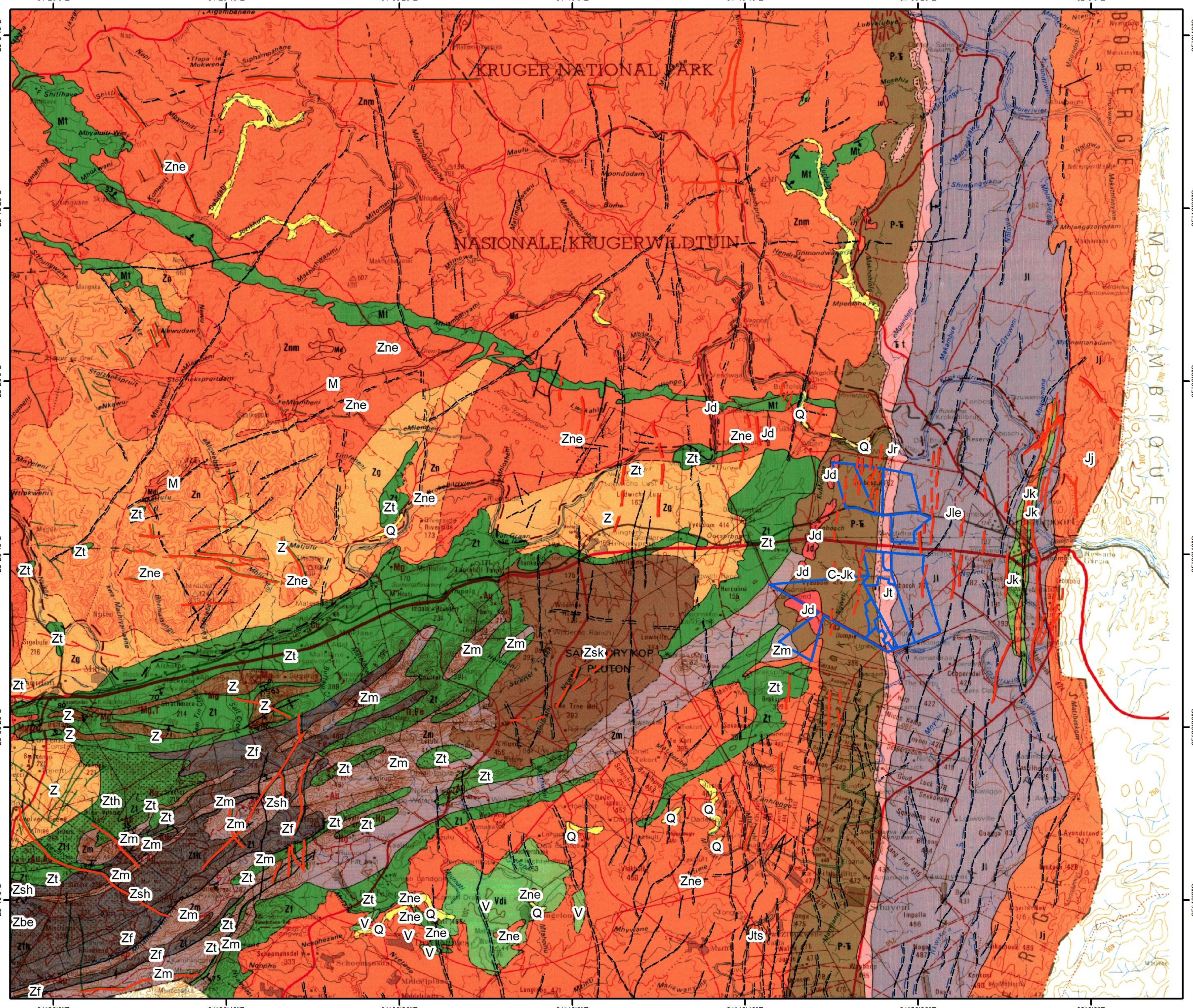
Many dykes and plate formations are found as intrusions in the Swazian granite and gneiss. This includes plate formations of diabase and peridotite forming characteristic topographical features. Red, clay soils and plateaus with round boulders are usually found on these formations. These plate formations and dykes of peridotite consisting of olivine, dioptic augite and other minerals intrude through olivine gabbro (plagioclase, olivine hypersthene and augite) to diabase (plagioclase, augite transposed to amphibole, biotite and chlorite). Porphyritic quartz, diorite and quartz-diorite dykes are also present.

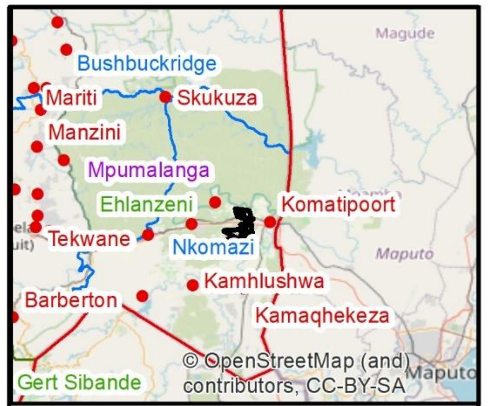
4.4.6 Timbavati gabbro

An area of Olivine Gabbro is found along the river bend and extends from east to west through Marloth Park. This area is included in the Timbavati Gabbro formation and is characterized by its concave shape with a slope of 20^{o} to 30^{o}. The Timbavati Gabbro consists of plagioclase (labradorite to bytownite), pyroxene (both hypersthene and augite) and olivine. Biotite and chlorite can displace the pyroxene and serpentinise the olivine. Other minerals are quartz, potassium feldspars, biotite and oxide minerals. Biotite gneiss in close proximity to gabbro may change its colour to red. Hybridisation of gabbro due to assimilation of granite material is also found.

4.4.7 Karoo dolerite

Basic dyke formation of the late Karoo magmatic period is found throughout the area. Due to their relatively high resistance to weathering and erosion the dolerite dykes appear more dominant in areas. The dolerite dykes are generally fine grained, dark grey to black in colour with massive structure. These dykes consist of plagioclase (labradorite to bytownite) with augite and other minerals. Intrusions of dolerite dykes are due to weaknesses in the older rock formations and a definite north to south orientation may be identified.





LEGEND

- Dykes
- Fault
- Mining Right Area

Geology

- C-Jk=Basal diamictite, overlain by mudrock and sandstone with minor conglomerate, coal and pyroclastic rocks, with basalt and rhyolite capping the succession
- Jd=Network of dolerite sills, sheets and dykes, mainly intrusive into the Karoo Supergroup
- Jj=Acid lavas (rhyolites with some dacites), minor tuffs
- Jk=Granophyre
- Jk=Granophyric gabbro, olivine gabbro and feldspathic gabbro
- Jle=Basic volcanic rocks (tholeiites, picrite basalts and nephelinites)
- Jr=Light red, fine-grained, argillaceous sandstone
- Jt=Relatively hard, fine-grained, white to cream sandstone
- Jts=Sill-like bodies and dykes of granophyre
- M=Granite, gneiss
- Q=Alluvium and scree
- V=Diabase
- Z=Biotite trondhjemite gneiss
- Z=Serpentinized dunite, harzburgite, orthopyroxenite and websterite, gabbro and anorthosite
- Zbe=Siltstone, shale, subordinate greywacke with banded ferruginous chart and a trachytic tuff
- Zf=Greywacke, mudrock, pyroclastic rocks, lava, chert
- Zm=Sandstone/quartzite, shale, conglomerate, minor jaspilite
- Zne=Homogeneous - to - slightly porphyritic granite; nebulitic in places.
- Zne=White to pale brown, medium- to coarse-grained porhyritic biotite granite, granodiorite.
- Zsh=Greywacke, shale
- Zsk=Medium- to coarse-grained, generally porphyritic (K-feldspar phenocrysts) granite/granodiorite
- Zt=Ultramafic and mafic lavas, tuffs
- Zth=Basic and subordinate ultrabasic lavas, felsic tuffs, schists, chert

0 1.25 2.5 5 7.5 10

Kilometers

N

REFERENCE: Transverse Mercator (Gauss-Kruger)
WGS84 Ellipsoid
Hartebeesthoek 94 Datum
Central Meridian 23°

PROJECT:

TENBOSCH 162 JU

TITLE:

GEOLOGICAL MAP
OF
TENBOSCH 162 JU

PROJECT No.		KIM-WAT-2023-009
SCALE	1:251 266	A3
GIS	OM	09/05/2023
CHECK	NM	09/05/2023
REVIEW		09/05/2023

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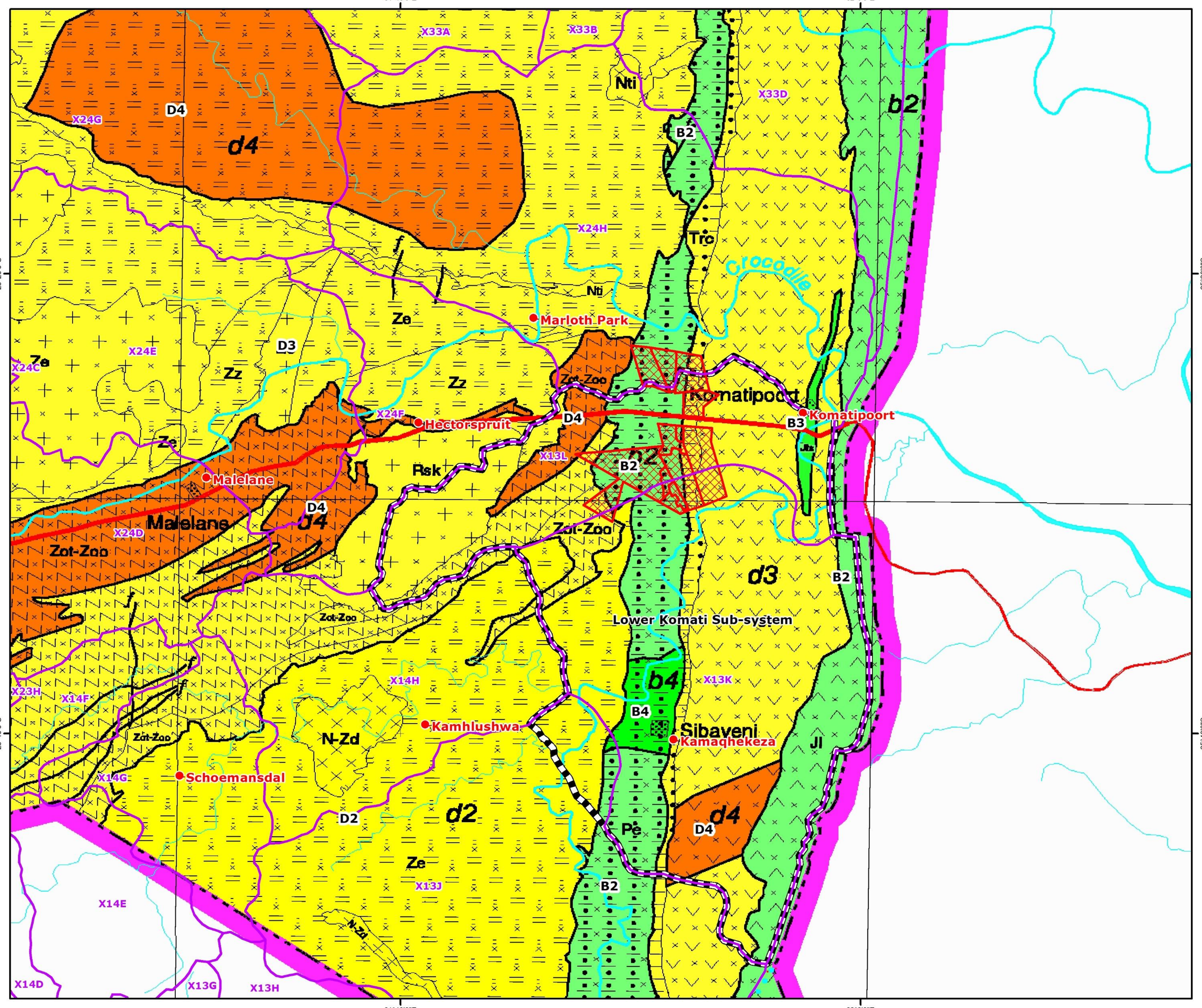
4.5 Hydrogeology

The aquifer underlying 80% of the proposed site area is classified as **fractured aquifer** with average **yield potential of 0.1 – 0.5 l/s**. 20% of the proposed site area is underlain by **intergranular and fractured aquifer** with average **yield potential of 0.5 – 2.0 l/s** (see Figure 4-4). Groundwater occurrences are generally associated with aquifers, confined to fractures, faults and contact zones with intrusive dykes, dolerites etc., and areas of deeper weathering. Typically, these aquifers are characterised by high yielding boreholes.

Intergranular and fracture aquifer is very common in South Africa. It is the type of groundwater aquifer in which the intergranular void spaces (rocks that has been weathered to an extent where its primary structure is that of loose or only partly consolidated material, also known as secondary aquifer) serves primarily as a storage and water is transmitted mainly through both fracture (type of groundwater aquifer which is associated with hard rock formation such as intrusive rocks in which fractures or joints occur and allow storage and supply of groundwater) and intergranular void spaces.

The study area falls within the b2 and d3 that indicates that the hydraulic conductivities are moderate to high which suggests that the aquifers are vulnerable to contamination and or pollutants especially along fractured zones caused by faults and dyke intrusions. This also suggests that should Tenbosch require groundwater sources for its mining operations, the potential is good.



LEGEND

- Towns
- Catchment Boundary
- Mining_Right_Area
- Lower Komati Sub-system

Hydrology

- B2 = Fractured 0.1 - 0.5 l/s
- B3 = Fractured 0.5 - 2.0 l/s
- B4 = Fractured 2.0 - 5.0 l/s
- D2 = Intergranular and fractured 0.1 - 0.5 l/s
- D3 = Intergranular and fractured 0.5 - 2.0 l/s
- D4 = Intergranular and fractured 2.0 - 5.0 l/s

0 2.5 5 10 15
Kilometers

REFERENCE: Transverse Mecartor (Gauss-Kruger) WGS84 Ellipsoid Hartebeesthoek 94 Datum Central Meridian 31°

PROJECT: TENBOSCH 162 JU

TITLE: HYDROLOGICAL MAP OF TENBOSCH 162 JU

PROJECT No.		KIM-WAT-2023-XXX
SCALE	1:280 000	A3
GIS	CSG	03/05/2023
CHECK	MM	03/05/2023
REVIEW		03/05/2023

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5 HYDROGEOLOGICAL INVESTIGATIONS

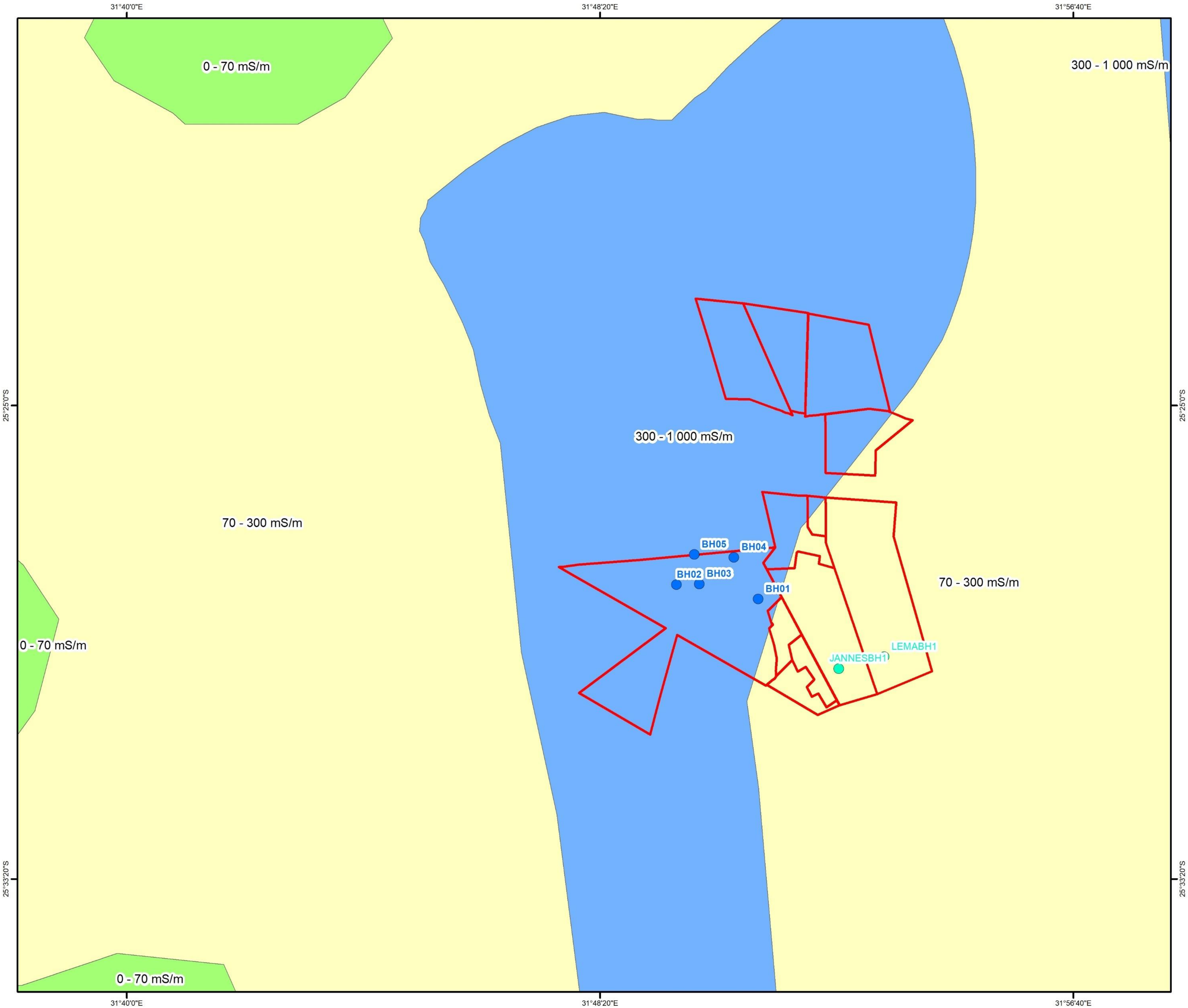
The hydrogeological activities undertaken to date includes desktop study, hydrocensus, groundwater flow direction, pump testing of boreholes and groundwater quality assessment.

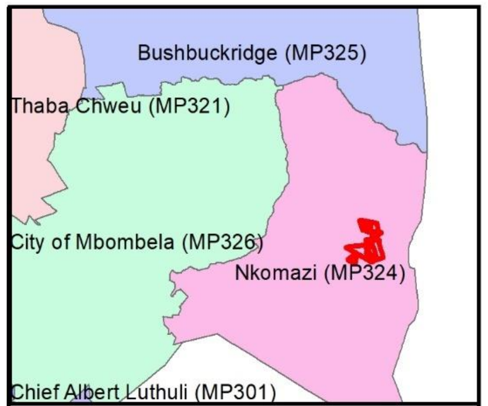
5.1 Desktop Assessment

A desktop study was carried out around the proposed mine to determine if there were any groundwater users in the area. The desk study involved a review of all available geological and hydrogeological literature, and previous study done by Kimopax. This included aerial photos, topographical sheets, geological and hydrogeological maps. Data was requested from the National Department of Water Affairs for existing boreholes and groundwater use of the area.

5.1.1 Regional Groundwater Quality

Based on the DWA (2002) mapping of the regional groundwater quality, classified by electrical conductivity (EC), the area is in range of 40 – 300 mS/m and 300-1000 mS/m as shown in Figure 5-1. Electrical conductivity is the measure of the ability of water to conduct an electric current, this means that an increase in concentration of ions makes groundwater to be highly conductivity. It is important to note that an increase in ions makes groundwater undesirable for domestic use, and for drinking purpose. It appears that the consumption of this water within the area does not appear to produce adverse health effect in the short term, but economic effects in such range of EC (40 – 300 mS/m) within proposed site appears to produce salty water and effects on plumbing and appliances such as corrosion and scaling may be expected. It is also noticed that the regional water quality range of 300 – 1000 mS/m may be expected within the proposed mining site. Short-term consumption of groundwater within this range may lead to disturbances of the body's salt balance. At high concentrations, noticeable short-term health effects can be expected (Volume 1: Domestic water use Second Edition, 1996).





Legend

Existing Boreholes

Hydrocensus Boreholes

Mining_Right_Area

Groundwater Quality (mSm)

0 - 70 mS/m

300 - 1 000 mS/m

70 - 300 mS/m

0 600 1 200 2 400 3 600 4 800

Meters

N

REFERENCE: Transverse Mecartor (Gauss-Kruger) WGS84 Ellipsoid Hartebeesthoek 94 Datum Central Meridian 23°

PROJECT: TENBOSCH 162 JU

TITLE: GROUNDWATER QUALITY (mS/m): PROPOSED TENBOSCH MINE

PROJECT No.		KIM-WAT-2023-009
SCALE	1:112 871	A3
GIS	OM	04/05/2023
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REVIEW		04/05/2023

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5.1.2 Local Groundwater Quality

Kimopax conducted a study in 2021 within the Lower Komati Subsystem. Two (2) boreholes were identified within 5 km radius. The boreholes are labelled JANNESBH01 and LEMABH01 (Table 5-1). Groundwater quality data was sampled for these boreholes. Tracer elements were determined for these boreholes to delineate groundwater units within the sub-system. The following tracer elements were used to for delineation:

a) Chloride:

The geometric mean for Cl is 156.7 mg/l, borehole LEMABH01 has a concentration of 186 mg/l of which is much higher than the geometric mean, which makes it an outlier. The increased Chloride in the could be due to salt sprays used in farm close by close by, that have been transported on the surface or in the groundwater.

b) Fluoride

The geometric mean for F is 0.3 mS/m, all the boreholes have concentration values close to the geometric mean.

c) Nitrate

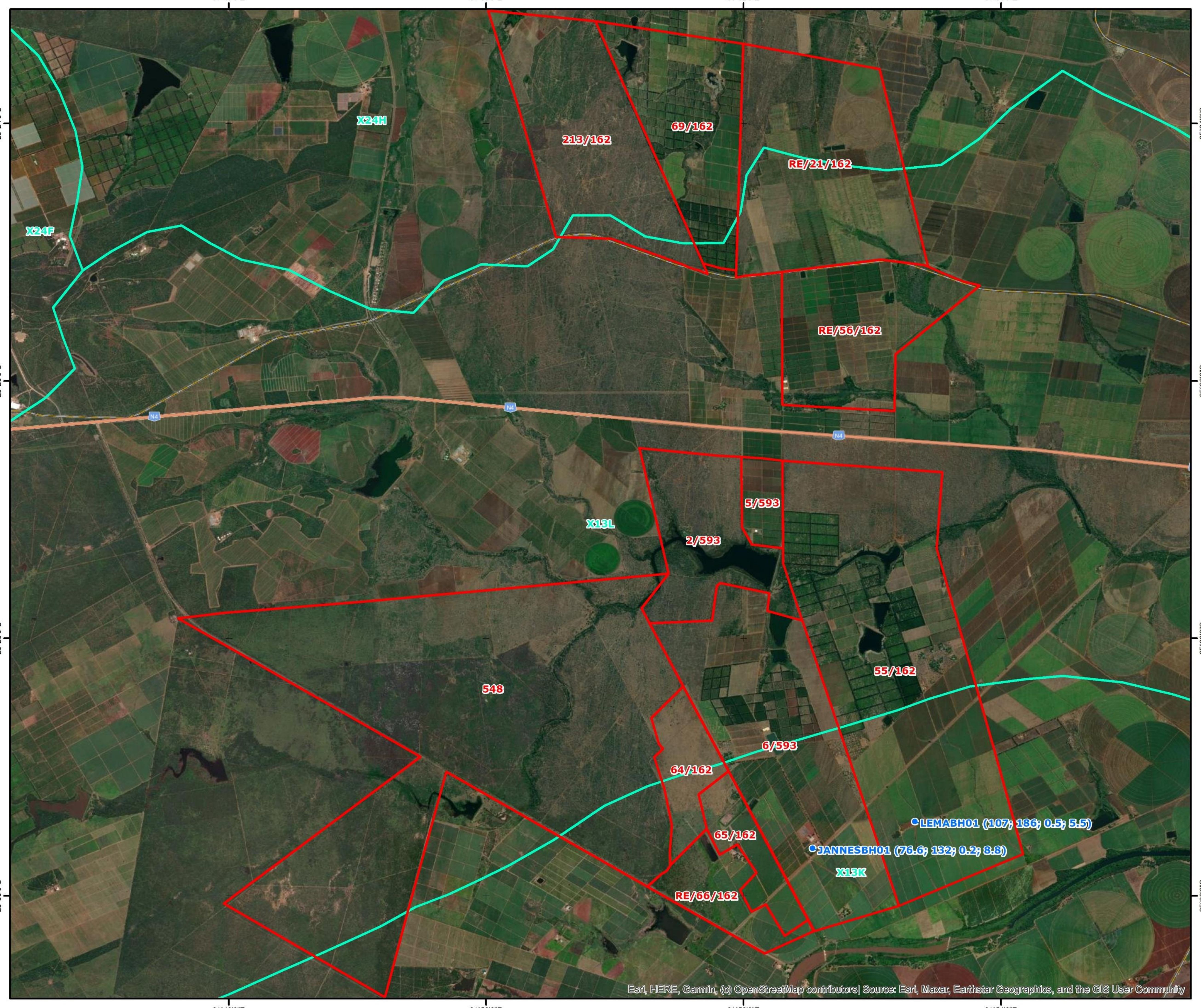
The geometric mean for N is 7.0 mS/m, all the boreholes have concentration values close to the geometric mean.

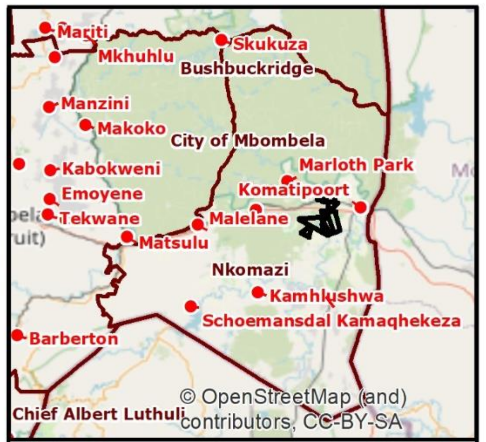
d) Electrical Conductivity

The geometric mean for EC is 90.5 mS/m, borehole LEMABH01 has a concentration of 107 mS/m of which is much higher than the geometric mean, which makes it an outlier (Table 5-2). The increased EC could be due to the groundwater and geology interactions, causing the groundwater to be high in salts, as well as the high chloride in groundwater could affect the EC. EC range for these boreholes correlate with regional groundwater quality as discussed in **Error! Reference source not found.**. This can be considered to be "**good to moderate"** quality for water with respect to drinking water standards.

Table 5-1: Existing boreholes (collected in 2021).

Borehole ID	Latitude	Longitude	Date Surveyed	Electrical Conductivity mS/m	Chloride as Cl mg/l	Fluoride as F mg/l	Nitrate as N mg/l	Possible contamination	Water type
JANNESBH01	-25.4939	31.87561	11/12/2021	76.6	132	0.2	8.8	BH located near a diesel tank	No dominant cations and Chloride water type
LEMABH01	-25.4904	31.88887	11/12/2021	107	186	0.5	5.5	Crop fertilizers	No dominant cations and No dominant Anions water type
GEOMEAN				**90,5**	**156,7**	**0,3**	**7,0**		





LEGEND

- Existing Boreholes_(Electrical conductivity; Chloridel; Fluoride; Nitrate)
- Mining_Right_Area
- Catchment Boundary

0 0.25 0.5 1 1.5 2 2.5 Kilometers

N

REFERENCE: Transverse Mecartor (Gauss-Kruger) WGS84 Ellipsoid Hartebeesthoek 94 Datum Central Meridian 31°

PROJECT: TENBOSCH 162 JU

TITLE: DESKTOP MAP OF TENBOSCH 162 JU

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GIS	CSG	18/05/2023
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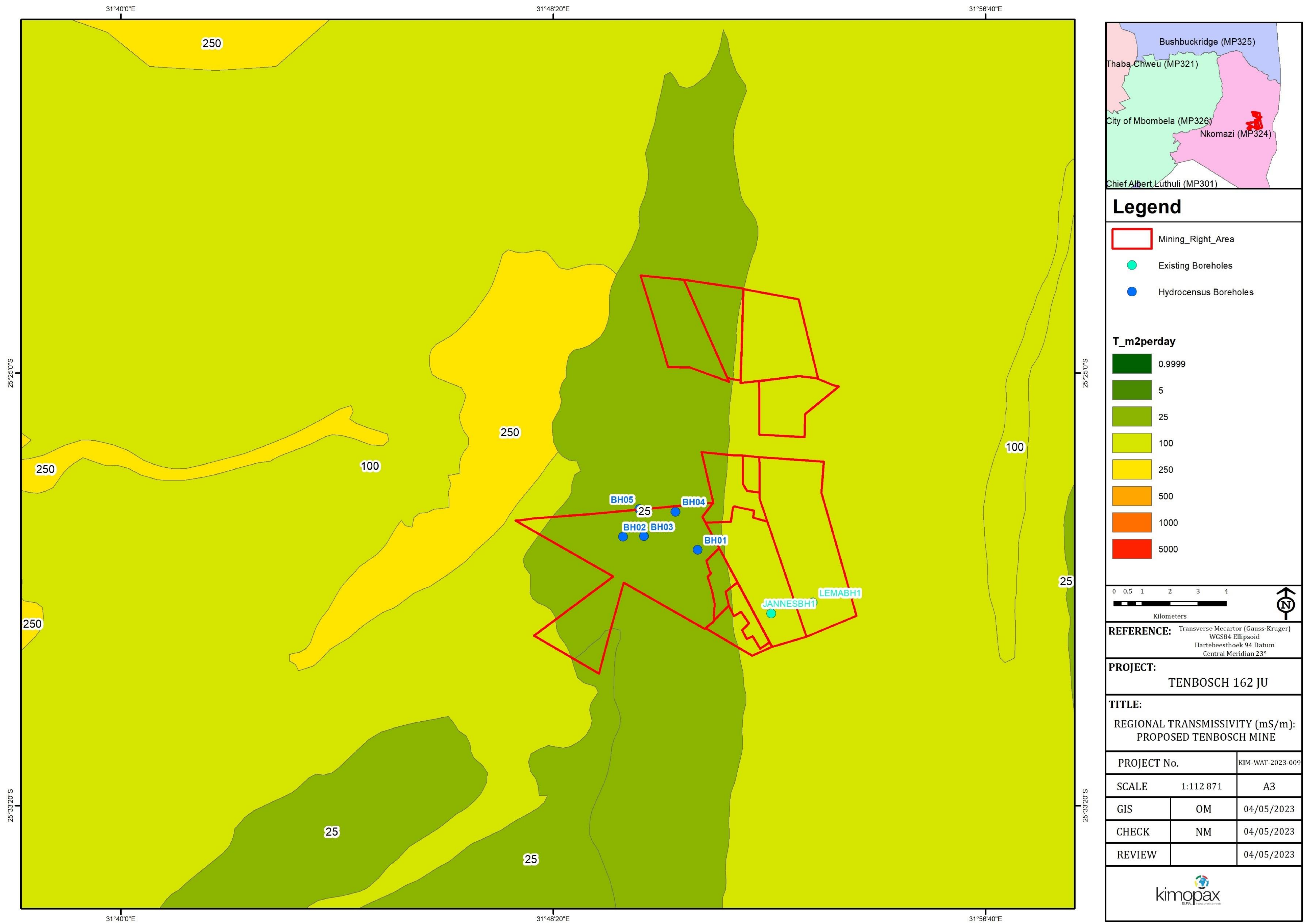
5.1.3 Expected Aquifer Parameters

Regional transmissivity (rate at which water is transmitted through unit width of aquifer) was abstained from WRC2012 Datasets. The aquifer transmissivity within the project area ranges from 25 to 100 m^2/ day. Transmissivity is important to understand, since it can give a conceptual idea on how contaminants will be transported within the groundwater aquifer with time, which can show the extent of contamination and mitigation strategies to be implemented. See, Figure 5-3. The rate of water transmitted through a unit width of aquifer is relatively slow and the extent of contamination to spread over large area will be reactively slow, although other parameter such as but not limited to variation of pore size and path length can affect the spreading and mixing of contaminants.

Transmissivity is also good for yield estimation of the boreholes within the area because it takes into consideration the whole thickness of the aquifer, unlike hydraulic conductivity.



31°40'0"E
31°48'20"E
31°56'40"E
25°25'0"S
25°33'20"S
250
100
25
BH05
BH04
BH02
BH03
BH01
JANNESBH1
LEMABH1
Bushbuckridge (MP325)
Thaba Chweu (MP321)
City of Mbombela (MP326)
Nkomazi (MP324)
Chief Albert Luthuli (MP301)
Legend
Mining_Right_Area
Existing Boreholes
Hydrocensus Boreholes
T_m2perday
0.9999
5
25
100
250
500
1000
5000
0 0.5 1 2 3 4
Kilometers
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REFERENCE: Transverse Mecartor (Gauss-Kruger)
WGS84 Ellipsoid
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Central Meridian 23º
PROJECT:
TENBOSCH 162 JU
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REGIONAL TRANSMISSIVITY (mS/m):
PROPOSED TENBOSCH MINE
PROJECT No. KIM-WAT-2023-009
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5.1.4 Groundwater Recharge

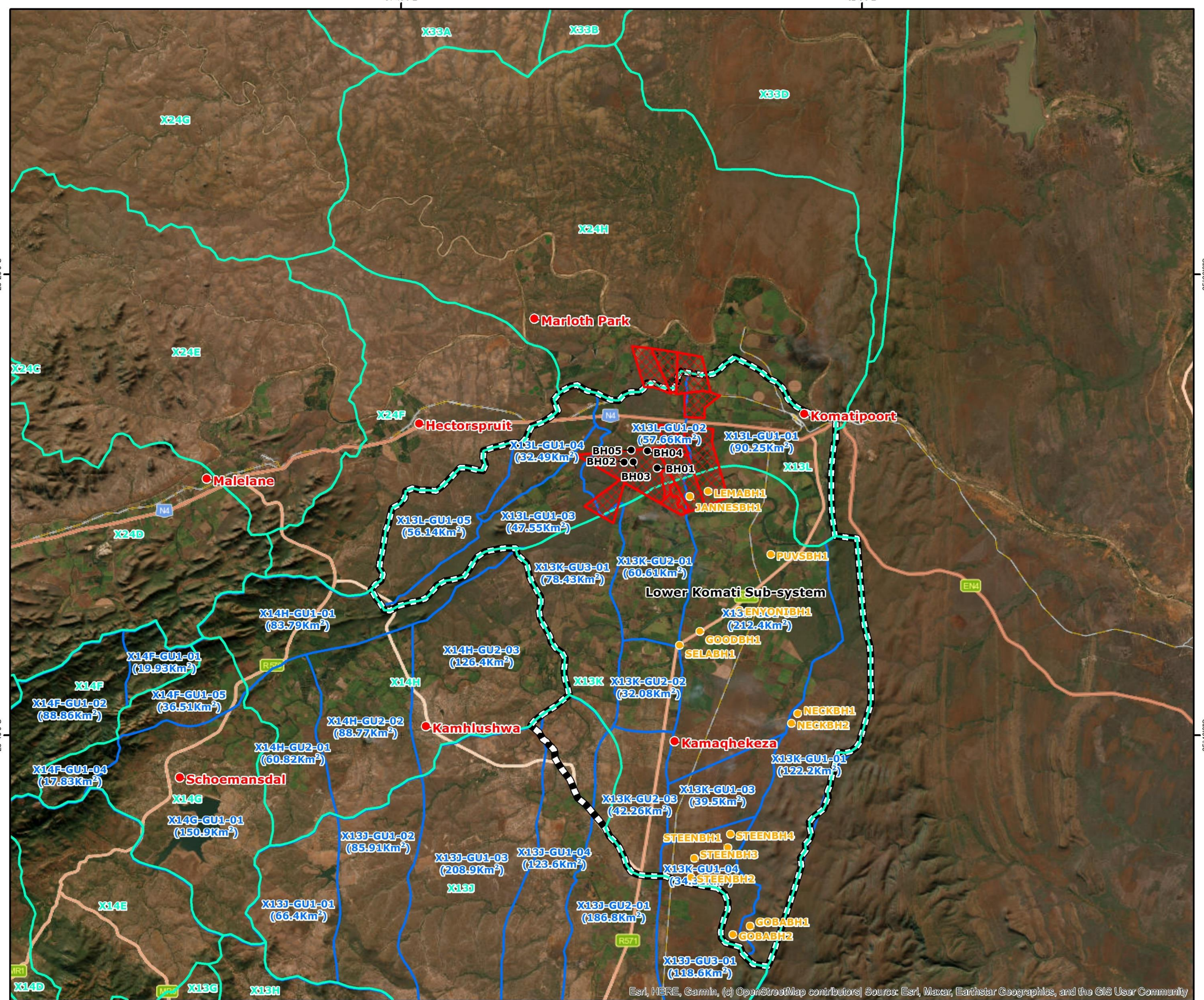
Previous study was done by Kimopax in 2021 to delineate Groundwater Resource Units (GRUs) within the Lower Komati subsystem. The study area (proposed mining area) is found within three delineated GRUs namely, X13K-GU2-01, X13L-GU1-01, and X13K-GU1-02 (Figure 5-4). Quantification of recharge was done within this area in 2021 to quantify portion of rainfall that reaches the saturated zone.

Four (4) different methods (CMB, Vegter Map, Harvest Potential and GRAll data) were used. Although Chloride Mass Balance was used to quantify recharge (i.e. X13K-GU1-02) as a base in view of recent available data, other regional recharge estimate methods were used to quantify recharge within this Groundwater Resource Unit (X13K-GU2-01 and X13L-GU1-01) due to unavailability of sufficient data to use Chloride Mass Balance as recharge estimate method.

It was found that based on Mean Annual Precipitation (MAP) the recharge percentage within the study area is estimated to be about1.87% which is about 15.6 mm/annum for southwestern and eastern porting of study area within X13K-GU2-01 and X13L-GU1-01. Chloride Mass Balance was used to estimate recharge within the south-eastern part of the study area (X13K-GU1-02), where recharge was estimated to be 1,11% which is about 9,3 mm/annum rainfall recharge to groundwater aquifer, see Table 5-2.

Table 5-2: Lower Komati sub-system groundwater recharge estimate quantities (2021).

Sub-System	Surface	GRU	Sub-GRU	Area	Area	Chloride	Recharge	MAP	RE Mean	RE Mean	RE Mean
Name	Catchment	No	No	m2	km2	mg/l	%	mm	mm/a	m3/a	l/s
Lower Komati	X13K	X13K-GU1-02	2	212,400,000	212.4	126.05	1.11	833.66	9.3	1,966,719	62.4
Lower Komati	X13K	X13K-GU2-01	5	60,610,000	60.61		1.87	833.66	15.6	944,876	30.0
Lower Komati	X13L	X13L-GU1-01	8	90,250,000	90.25		1.87	833.66	15.6	1,406,947	44.6
Lower Komati	X13L	X13L-GU1-02	9	57,660,000	57,66		1.87	833.66	15.6	898,887	28,5



LEGEND

- Towns
- Existing Boreholes
- Hydrocensus Boreholes
- Mining_Right_Area
- Catchment Boundary
- Lower Komati Sub-system
- Groundwater_Units_by_Structural_Geology_202...

0 2.5 5 10 15 Kilometers

N

REFERENCE:	Transverse Mecartor (Gauss-Kruger) WGS84 Ellipsoid Hartebeesthoek 94 Datum Central Meridian 31°	
PROJECT:	TENBOSCH 162 JU	
TITLE:	GROUNDWATER UNITS MAP OF TENBOSCH 162 JU	
PROJECT No.		KIM-WAT-2023-XXX
SCALE	1:280 000	A3
GIS	CSG	03/05/2023
CHECK	MM	03/05/2023
REVIEW		03/05/2023

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5.2 Hydrocensus

A site visit was conducted on 19 April 2023 to assess groundwater use within the study area (Figure 5-5). The results of the field visit investigation are presented in Table 5-3. The summary of the collected data listed in Table 5-3 indicates that the area is assumed to be characterized with shallow water level with a recorded geometric mean value of 15,9 mbgl, although spatial data is needed to quantify regional water level within the study area. This indicates that some areas are more vulnerable to contamination from onsite activities such as pit-latrines, cattle kraal etc. Therefore, it is necessary to model groundwater vulnerability within the proposed area, also to clearly define the possible natural attenuation of non-point and point sources of contamination before reaching the groundwater, as supported by the DRASTIC methodology.

D- Depth to groundwater

R- Recharge rate

A- Aquifer

S-Soil

T-Topography

I-Vadose zone

C-Aquifer hydraulic conductivity

Table 5-3: Hydrocensus boreholes

Borehole ID	Latitude	Longitude	Elevation	Date Surveyed	Measured WL (mbgl)	Borehole depth	sampled	Comments
BH01	-25.47350	31.85195	169	19/04/2023	21,5	74,3	Yes	Borehole drilled for core drilling, but water was found and alternatively used for water supply (however submersible pump/pipes is removed)
BH02	-25.46930	31.82802	223	19/04/2023	51,7	84,6	Yes	Core drilling borehole (groundwater was intercepted)
BH03	-25.46910	31.83466	??	19/04/2023	14,8	58,9	Yes	Core drilling borehole (groundwater was intercepted)
BH04	-25.46126	31.84484	199	19/04/2023	6,6	45,54	Yes	Core drilling borehole (groundwater was intercepted)
BH05	-25.46045	31.83319	209	19/04/2023	9,5	67,8	Yes	Core drilling borehole (groundwater was intercepted)
GEOMEN					**15,9**	**64,8**		

LEGEND

- Hydrocensus Boreholes
- Existing Boreholes
- Mining_Right_Area
- Catchment Boundary

0 0.25 0.5 1 1.5 2 2.5 Kilometers

N

REFERENCE: Transverse Mecartor (Gauss-Kruger)
WGS84 Ellipsoid
Hartebeesthoek 94 Datum
Central Meridian 31°

PROJECT:
TENBOSCH 162 JU

TITLE:
HYDROCENSUS MAP
OF
TENBOSCH 162 JU

PROJECT No.		KIM-WAT-2023-XXX
SCALE	1:50 000	A3
GIS	CSG	26/04/2023
CHECK	MM	26/04/2023
REVIEW		26/04/2023

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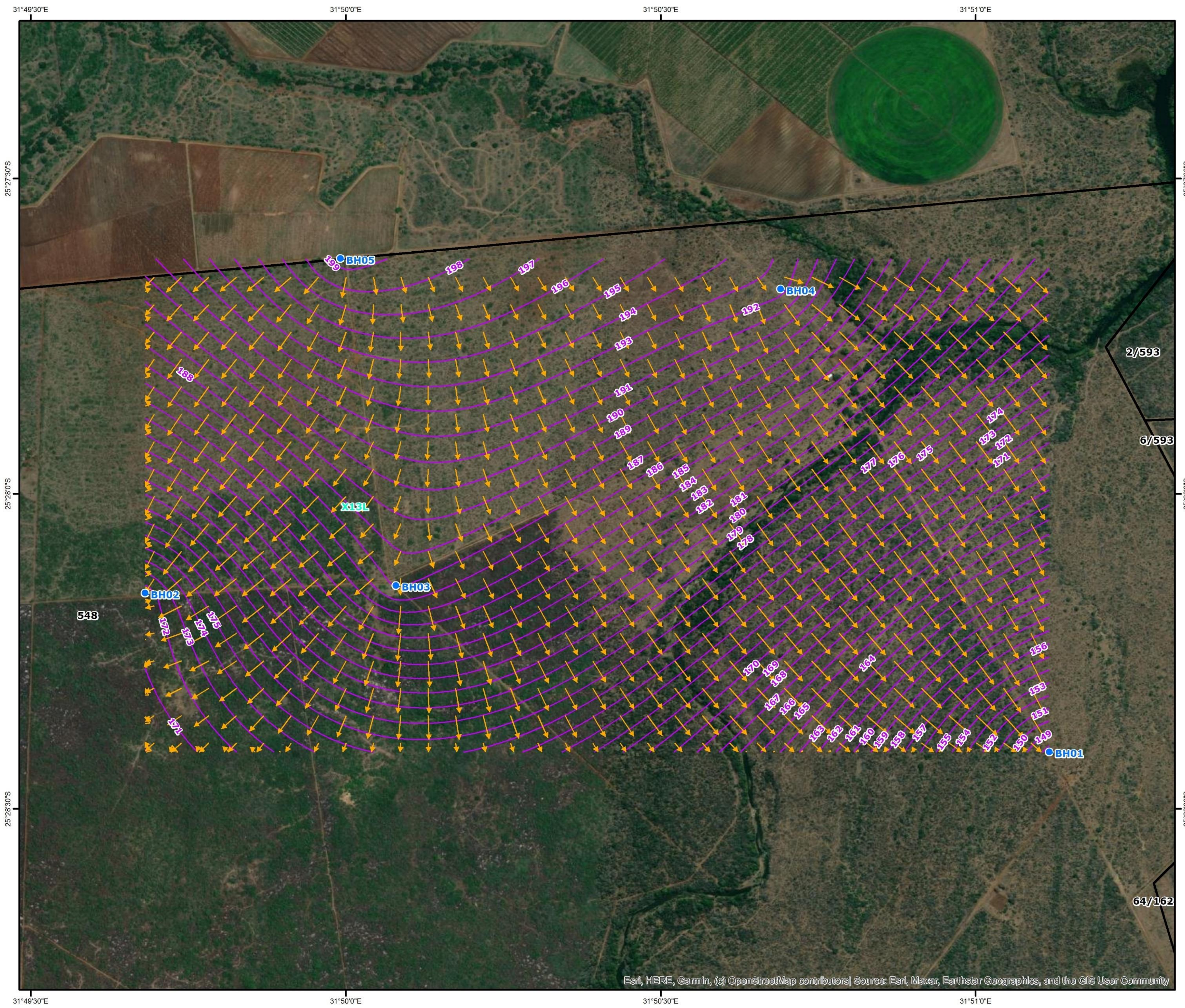
5.3 Groundwater flow direction

During site visits, five (5) groundwater levels could be obtained from the existing boreholes. Groundwater flow generally mimics surface topography (in a homogeneous setting without flow boundaries and preferential flow paths). The groundwater underneath the proposed site is interpreted to flow in a north to south-easterly direction toward the river (Figure 5-6). Groundwater flow direction is significant in positioning monitoring boreholes both up gradient and downgradient of the operation to provide adequate information on water quality between this site and potential downgradient receptors, as monitoring boreholes should take preferential groundwater flow paths into consideration.



LEGEND

- Hydrocensus Boreholes
- Groundwater flow
- Water Level
- Mining_Right_Area
- Catchment Boundary

0 50 100 200 300 400 500
Meters

REFERENCE: Transverse Mecartor (Gauss-Kruger)
WGS84 Ellipsoid
Hartebeesthoek 94 Datum
Central Meridian 31°

PROJECT:
TENBOSCH 162 JU

TITLE: GROUNWATER FLOW MAP OF TENBOSCH 162 JU

PROJECT No.		KIM-WAT-2023-XXX
SCALE	1:10 000	A3
GIS	CSG	26/04/2023
CHECK	MM	26/04/2023
REVIEW		26/04/2023

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5.4 Borehole and Aquifer Pumping Tests

5.4.1 Aquifer Hydraulic Conductivity

A total of 5 slug test were performed (Appendix A) in the boreholes drilled with the objective of estimating borehole yield and hydraulic parameters in each borehole. The Bouwer and Rice method (1976) was used to estimate aquifer hydraulic conductivity and transmissivity from the slug test field data. Borehole yield estimates were estimated from the log-log plot of borehole yield against recession time (Vivier *et al*. 1995). Slug test was conducted also with the objective to estimate potential yield of the boreholes. Solid body (slug) was submerged into the borehole, this displaces the water which rise to certain high (head). The head is recorded with time during the recession of the water level back to the static water level, from the time and head measurement, K of the aquifer was estimated using FC (Flow Characteristic).

5.4.1.1 Borehole yield and hydraulic parameters

Table 5-4 and Appendix B shows borehole yield and hydraulic parameters estimated from the slug recession time. High borehole yield estimate is, and hydraulic properties is expected for BH1 because the boreholes is drilled with the Karoo dolerite dyke. Low borehole yield and hydraulic parameters estimated for BH2, BH3, BH4, and BH5 are a reflection of low permeability properties of the aquifer system. It should however be mentioned the borehole construction techniques used on the site might have contributed to low hydraulic properties being measured from slug tests. From the results obtained during slug test, aquifer testing will be conducted at borehole BH1 to assess the contribution of the main hydraulic zones within the proposed mining area.

Table 5-4: Borehole yield and hydraulic conductivity estimates values determined from the slug test for the boreholes drilled within sandstone and mudrocks.

Borehole name	r_w(m)	Depth (m)	b (m)	Recession time (s)	Yield (l/s)	K (m/day)	T (m^2/day)
BH1	0,08	74,3	52,8	48	0,3	0,67	35,38
BH2	0,08	84,6	32,9	>180	<0,3	0,10	3,29
BH3	0,08	58,9	44,1	>180	<0,3	0,10	4,41
BH4	0,08	45,54	38,9	>180	<0,3	0,10	3,89
BH5	0,08	67,8	58,3	254	0,07	0,10	5,83
Min	**0,1**	**45,5**	**32,9**	**48,0**	**0,1**	**0,1**	**3,3**
Average	**0,1**	**66,2**	**45,4**	**151,0**	**0,2**	**0,2**	**10,6**
Max	**0,1**	**84,6**	**58,3**	**254,0**	**0,3**	**0,7**	**35,4**

5.5 Aquifer Pump Testing

Aquifer pump test were designed to assess the hydraulic and storage properties of the aquifer.

5.5.1 Aquifer parameter

BH1 was used as a single-borehole aquifer test due to its potential yield determine by slug testing to determine the aquifer transmissivity. Single-borehole aquifer tests provide good estimates of transmissivity. Accurate storativity was not determine due to lack of observation boreholes to both aquifer transmissivity and storativity. Copper-Jacob (1946) equation (Equation 1) was used to analyse the single-borehole aquifer tests due to its simplicity.

$$T = \frac{2.3Q}{4\pi\Delta s}$$

Equation 1: Cooper and Jacob (1946) aquifer transmissivity.

Figure 5-7 shows how the Cooper and Jacob equation (1946) is used to determine aquifer transmissivity from the pumping borehole.

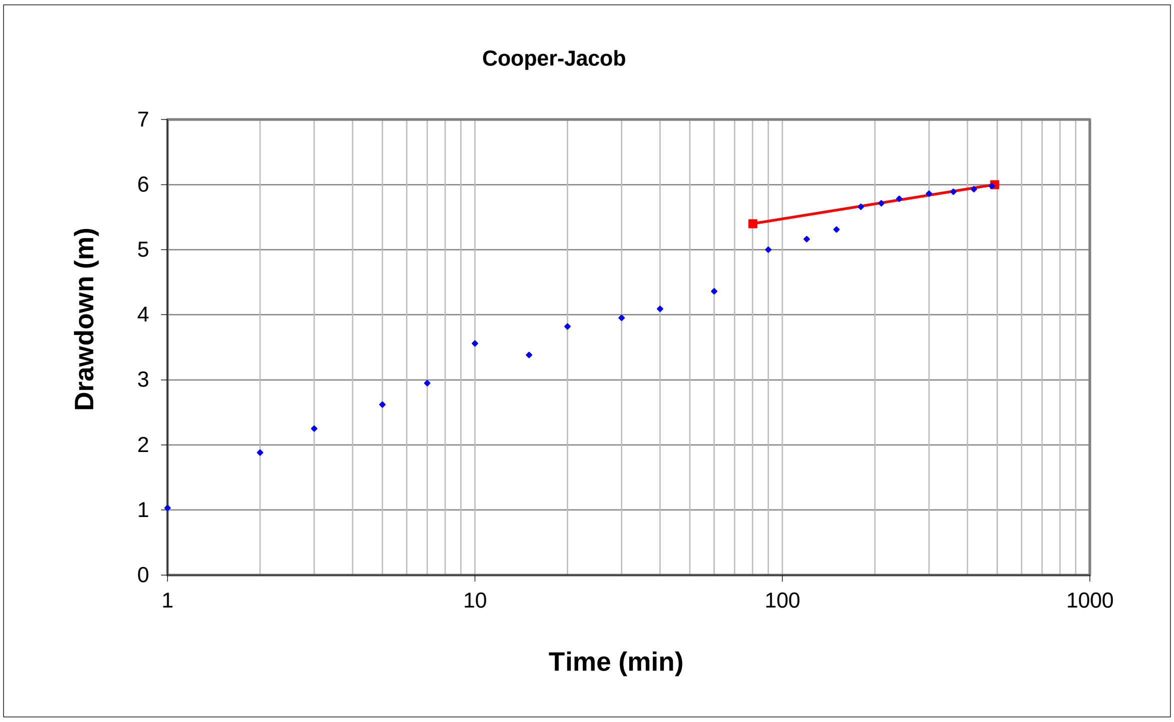


Figure 5-7: Semi-log plot of drawdown against time showing the application of Cooper and Jacob equation (1946) to get transmissivity from pumping borehole between the 100-1000 log cycle.

Table 5-5: Aquifer parameters determined from single-borehole test analysis.

Pumping borehole	T (m^2/day)
BH1	31,1

Based on the aquifer test results interpretation the area within BH1 shows high hydraulic conductivity. This means the aquifer in that area is more vulnerable to contamination than the area that is less permeable (BH2, BH3, BH4 and BH5). However more boreholes need to be drilled within the project area to be able to determine aquifer storativity which then help to understand the amount of groundwater stored and released from the porous medium, also if the aquifer within the proposed study is confined or unconfined.

5.6 Baseline Groundwater Quality

5.6.1 Comparison with the SANS

To have a better understanding of the groundwater qualities around the proposed project area, five (5) groundwater samples were collected during hydrocensus and analysed by Waterlab, a SANS accredited laboratory in Pretoria.

The water quality assessment is based on a once off analysis conducted by Kimopax during the hydrocensus task conducted on the 19 April 2023. The laboratory certificate of water quality is presented in Appendix C.

A summary of the results is presented in Table 5-6 referenced against the South African Bureau of Standards (SABS) (SANS 241:2015) guidelines for drinking water quality since the mine WUL it was not available during the task.

Based on the laboratory analysis, the following observations could be made regarding to the compliance with SANS 241:2015 drinking water quality standard:

a) A total of five (5) boreholes namely: BH1 and BH5 were found to be within recommended SANS 241: 2015 drinking guideline values. Based on the tested parameters, the water of only two boreholes is considered to be safe for human consumption. BH1 is drilled within the contact of dyke thus increase in aquifer dilution based on late transmissivity (Table 5-5), as a result the chemical composition within the borehole is found to be within standard of drinking water.

b) Groundwater samples from borehole BH2, BH3 and BH4 were found to be exceeding the acceptable aesthetic health level of Cl concentration when benchmarked against the SANS 241:2015. The increased level of chloride might be due to extensive evaporation water recharging the groundwater aquifer.

c) Concentration of Total dissolved Solids (TDS) and electric conductivity (EC) of the samples from borehole BH2 and BH3 were found to be exceeding the maximum allowed aesthetic limits sets by SANS 241:2015. The increased in concentration of TDS is as a result of presence of ions in water such as chloride which describes the degree of salinity of groundwater under the category of brackish water. Other presence of ions in water such as sodium, potassium, calcium, magnesium, nitrate and fluoride dissolved in water might increase the concentration of TDS within groundwater.

d) Concentration of fluoride of the sample BH3 is found to exceed the maximum allowed chronic limits as sets by SANS 241:2015. Slug test confirmed that BH3 has low transmissivity, as results deep aquifers with low groundwater movement can contribute to long residence time and increased the fluoride content.

Table 5-6:Water quality results compared to SANS 241-1:2015.

Constituent (mg/l)	Aesthetic	Operational	Chronic health	Acute health	BH1	BH2	BH3	BH4	BH5
pH - Value @ 25 ºC	No limit	5 to 9,7	No limit	No limit	6.7	7.2	7.1	7.1	7.3
Electrical Conductivity in mS/m @ 25°C	170	No limit	No limit	No limit	59.7	302	434	170	159
Total Dissolved Solids @ 180°C	1200	No limit	No limit	No limit	354	1650	2350	874	976
Chloride as Cl	300	No limit	No limit	No limit	98	806	1345	451	148
Sulphate as SO_4	250	No limit	No limit	500	38	2	<2	25	46
Fluoride as F	No limit	No limit	1.5	No limit	0.2	0.5	1.7	0.3	0.5
Nitrate as N	No limit	No limit	No limit	11	0.1	<0.1	<0.1	<0.1	0.3
Free and Saline Ammonia as N	1,5	No limit	No limit	No limit	0.4	3.3	1.0	0.3	1.0
Sodium as Na	200	No limit	No limit	No limit	89	460	753	176	284
Potassium as K	No limit	50	No limit	No limit	1.2	6.2	5.8	6.5	3.0
Calcium as Ca	150	No limit	No limit	No limit	13	100	41	54	41
Magnesium as Mg	70	No limit	No limit	No limit	10	19	6	59	25
Aluminum as Al	No limit	No limit	0,3	No limit	0,109	0,777	<0,100	<0,100	<0,100
Cadmium as Cd	No limit	No limit	0,3	No limit	<0.001	<0.001	<0.001	<0.001	<0.001
Iron as Fe	0,3	No limit	2	No limit	0.090	3.07	0.169	1.27	0.108
Lead as Pb	No limit	No limit	0,01	No limit	0.001	0.006	0.001	0.017	0.001
Manganese as Mn	0,1	No limit	0,4	No limit	<0.025	0.601	0.066	0.140	0.105

5.6.2 Diagnostic plots

A piper diagram (Figure 5-8) was created using the WISH program to characterise the groundwater in the area. A piper diagram is utilized to characterise water type in a graphical manner and to distinguish between specific water types in the area. The Piper diagram is quartered to simplify this process. The water samples can be grouped into the left, bottom, right and upper quarters. The position of the water sample on the plot is based on the ratio of the various constituents measured in equivalence and is not an indication of the absolute water quality or the suitability thereof for domestic consumption. The left quarter is characterised by freshly recharged water and is dominated by calcium-magnesium-bicarbonate. The right quarter is associated with stagnant or slow-moving groundwater and is dominated by sodium chloride. The bottom quarter is typical of dynamic groundwater flow and is dominated by sodium bicarbonate and the top quarter typically shows contamination by mining activities and is dominated by sulphate.

Groundwater results from borehole BH1, BH2, BH3 and BH4 plot at the right quarter which is an indication of slow-moving groundwater dominated by sodium chloride. Sample collected at the borehole BH5 plot at the bottom quarter indicating dynamic groundwater flow that is dominated by sodium bicarbonate.

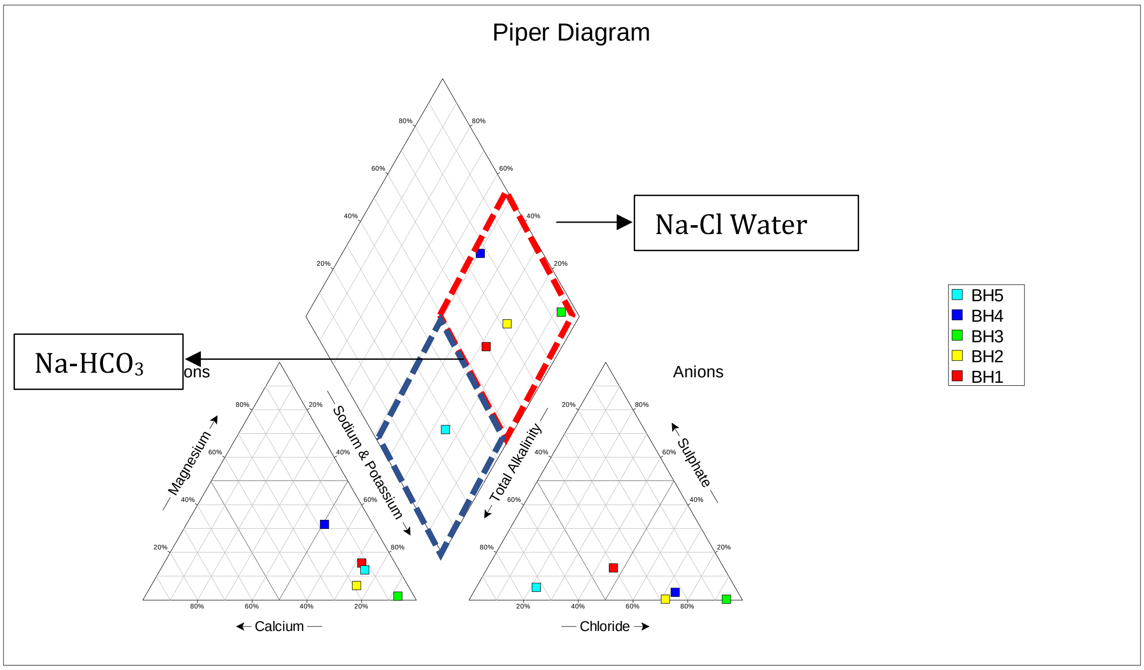


Figure 5-8: Piper diagram of the baseline water chemistry

6 AQUIFER CHARACTERISATION

6.1 Groundwater Vulnerability

The concept of aquifer vulnerability derives from the assumption that the physical environment may provide some degree of protection of groundwater against human impacts, especially with regard to pollutants entering the subsurface. Aquifer vulnerability thus combines the hydraulic inaccessibility of the saturated zone to the penetration of pollutants, with the attenuation capacity of the strata overlying the saturated zone (Foster, 1998).

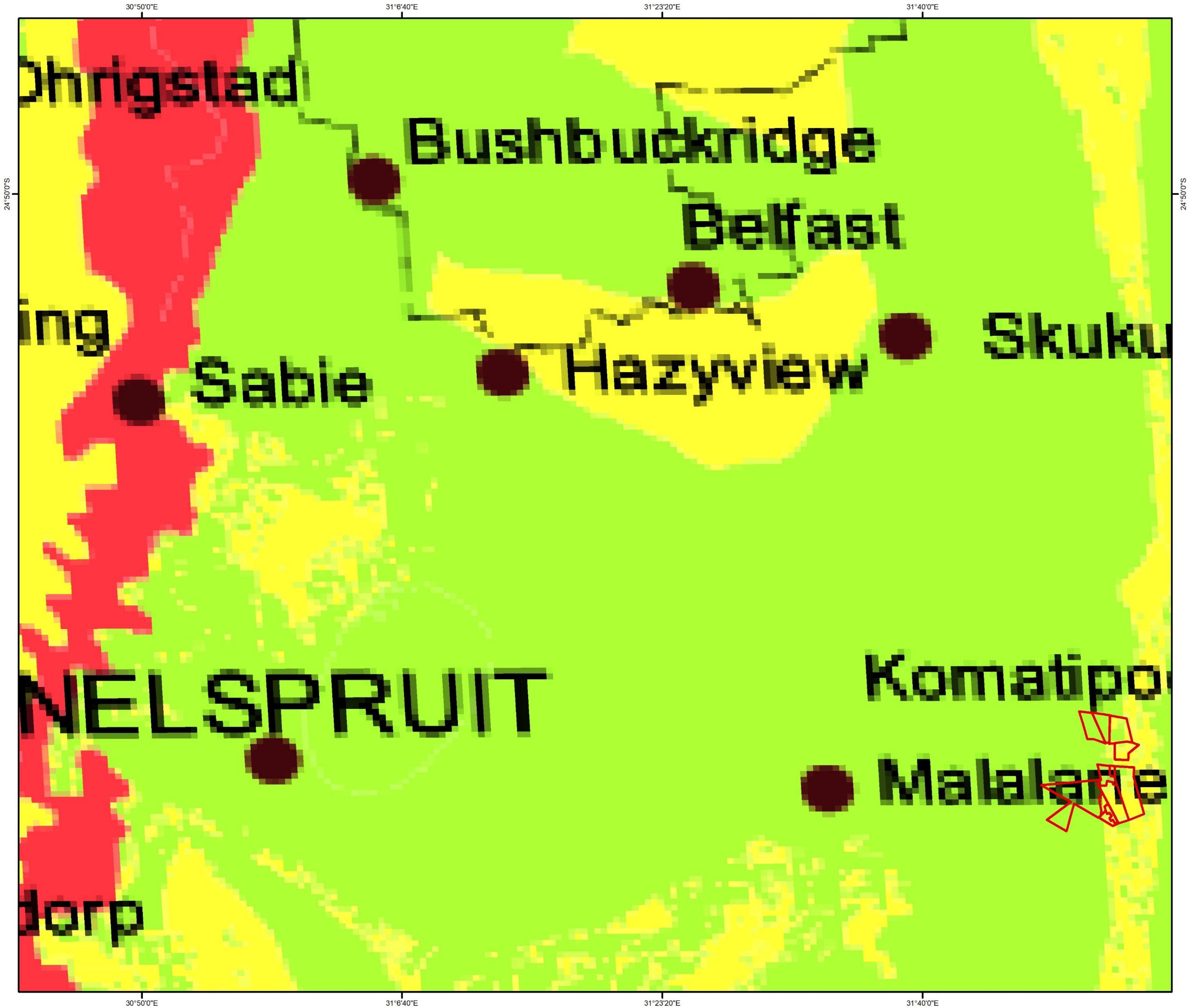
The vulnerability of the underground water source is related to the distance that the contaminant must flow to reach the water table, and the ease with which it can flow through the soil and rock layers above the water table.

Groundwater vulnerability to contaminants varies depending on the degree of protection provided by the physical environment. Groundwater vulnerability is defined as being an intrinsic property of groundwater system that depends on the sensitivity of that system to human and/or natural impacts (Zaporozec, 2004). The main factors used to access groundwater vulnerability are as follows:

a) Recharge;
b) Unsaturated zone characteristic; and
c) Groundwater flow system.

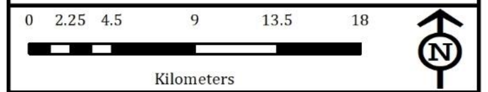
Other factors that are used to access groundwater vulnerability can include topography, surface-groundwater interaction and the nature of underlying aquifer. These parameters listed above can be used to evaluate vulnerability of groundwater contaminants in a specific area to a particular contaminants or group of contaminants (Zaporozec, 2004). These parameters are all considered during aquifer vulnerability assessment rating system. The following map outline that the area of study falls within **low to moderate degree of vulnerability**, which then shows moderate degree of aquifer protection to various contaminants (Figure 6-1)

The reason of moderate degree of vulnerability if because of the depth to groundwater (shallow water level) identified with the proposed site activity.



Legend

- Mining_Right_Area
- Least
- Moderate
- Most
- Tonws



REFERENCE: Transverse Mecartor (Gauss-Kruger)
WGS84 Ellipsoid
Hartebeesthoek 94 Datum
Central Meridian 23°

PROJECT:
TENBOSCH 162 JU

TITLE:
GW Vulnerability Rating (DRASTIC):
PROPOSED TENBOSCH MINE

PROJECT No.		KIM-WAT-2023-009
SCALE	1:410 579	A3
GIS	OM	04/05/2023
CHECK	NM	04/05/2023
REVIEW		04/05/2023

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6.2 *Aquifer Protection Classification*

Based on the information collected during desktop study and hydrocensus it can be deduced that the aquifer system within the project study area is classified as **Minor aquifer system** as shown in Figure 6-2 .The aquifer vulnerability or the tendency for contaminants to reach a specified position in ground water system is classified as "**Low to moderate"** (Figure 6-1).

In order to achieve the Groundwater Quality Management Index a point scoring system as presented in Table 6-1 was used.

Table 6-1: Rating for Groundwater Quality Management Classification System

Aquifer System Management Classification		
Class	**Point**	**Proposed Study area for mining**
Sole Source Aquifer System	6	-
Major Aquifer System	4	-
Minor Aquifer System	2	2
Non-Aquifer System	0	-
Special Aquifer System	0-6	-
Aquifer Vulnerability Classification		
Class	**Point**	**Proposed Study area for mining**
High	3	-
Medium	2	2
Low	1	-

The level groundwater protection based on the Groundwater Quality Management Classification:

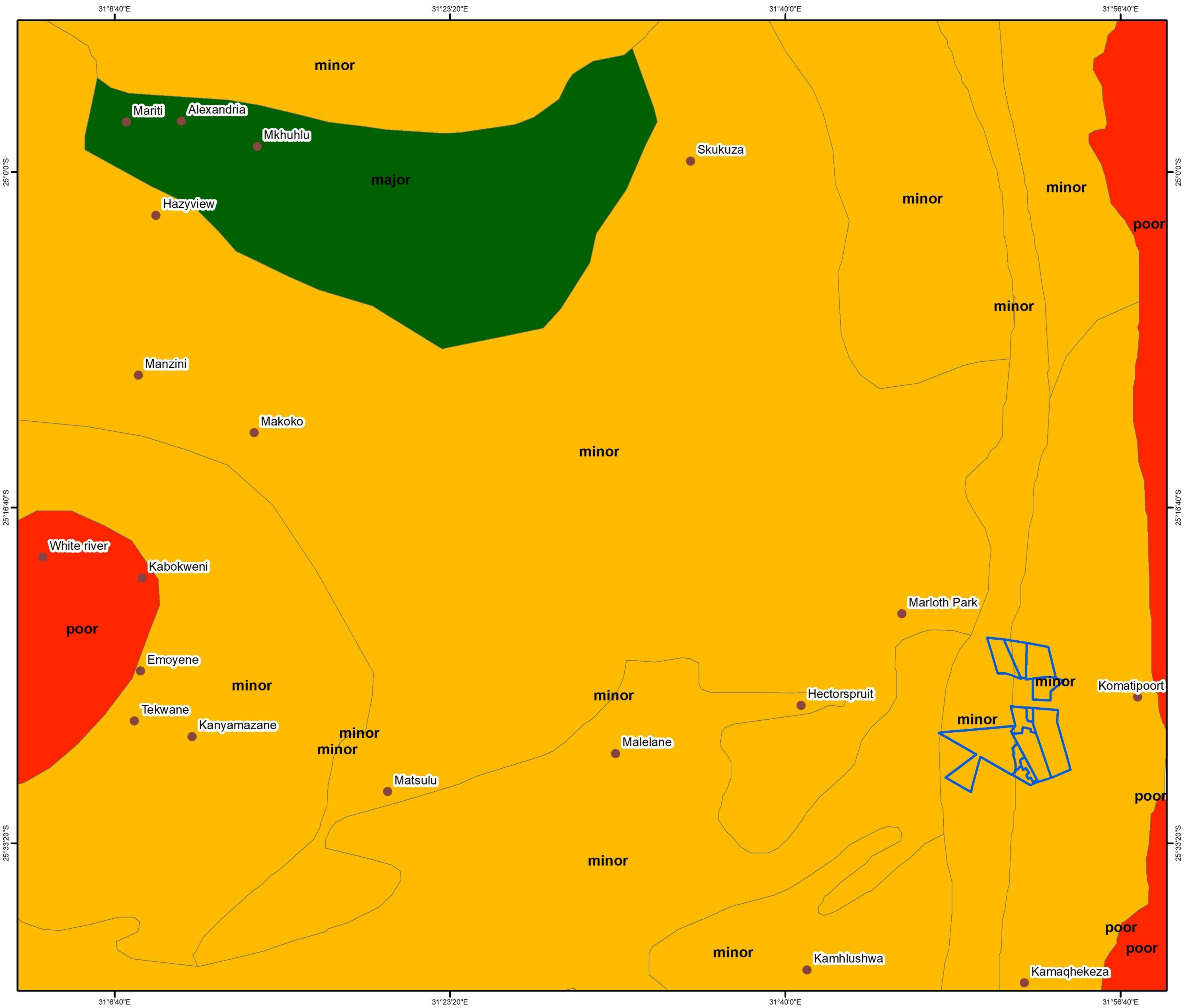
GQM (Groundwater Quality Management) index = Aquifer system Management x Aquifer Vulnerability

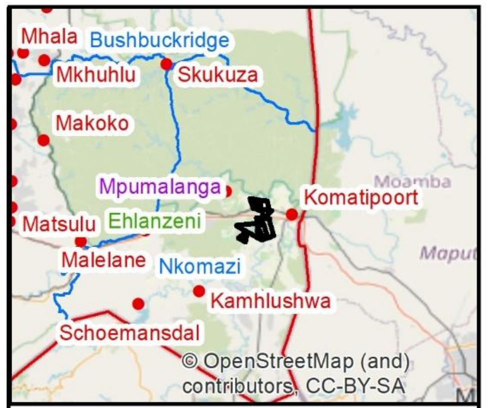
= 2 x 2

= 4 (Medium level of protection, refer to Table 6-2)

Table 6-2: GQM index for the proposed area.

GQM index	Level of protection	Proposed
<1	Limited	-
1-3	Low Level	-
3-6	Medium Level	4
6-10	High Level	-
>10	Strictly Non-Degradation	-





Legend

- Towns
- Mining_Right_Area

AQ_CLASS

- major
- minor
- poor

0 1.75 3.5 7 10.5 14
Kilometers

N

REFERENCE: Transverse Mecartor (Gauss-Kruger)
WGS84 Ellipsoid
Hartebeesthoek 94 Datum
Central Meridian 23°

PROJECT:
TENBOSCH 162 JU

TITLE:
Aquifer Classification Map
of
Tenbosch mine 162 JU

PROJECT No.		KIM-WAT-2023-009
SCALE	1:317 733	A3
GIS	OM	09/05/2023
CHECK	NM	09/05/2023
REVIEW		09/05/2023

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7 GROUNDWATER IMPACT ASSESSMENT

This impact assessment was undertaken based on the proposed extraction of coal within the proposed mining activity. The list of project activity that is relevant to the groundwater impact assessment is presented in Table 7-1.

Table 7-1: Description of activities to be assessed.

Project phase	Project Activity	Project Structures
Construction	Site Clearance	Topsoil stockpiles
	Water abstraction and use	Water tanks and pipes
	Waste generation and disposal stockpiling (box-cut material)	Wate stockpile pollution control dam
Operations	Stockpiling	Overburden stockpile Slurry dam
	Plant and equipping operations	Workshop and diesel storage tanks
	Waste generation and storage	Waste water treatment plant Pollution control Waste stockpile
	Mine dewatering	Pump and pipes
Decommission and closure	Waste generation and disposal	Waste stockpile

7.1 Identification of potential impact

The proposed mine has the potential to impact the groundwater environment negatively through the depletion of groundwater resource and possible release of undesired contamination plumes. The groundwater quality at most of the coal mines in the country is characterised by sulphate concentrations in order of magnitude 2 500 mg/l. Similar impacts could also occur at the project site and management plans should be put in place to deal with these potential impacts.

Potential impacts are assessed in this section considering construction, operation, and closure phases. The list of project activities can be found in Table 7-1. Only project activities that are likely to results in groundwater impacts are assessed below.

7.1.1 Construction phase

7.1.1.1 Project activity assessed.

Mining activities during the construction phase that could results in groundwater impacts includes:

a) Site clearance and topsoil removal across the project area;
b) The construction of overburn stockpile areas; and
c) The construction of the PCD.

Table 7-2: Interactions and impact during the construction phase

Interaction	Impact
Site clearing	Lowering of the water table if the site clearing will take place below the water strike
PCD and stockpile construction	Lowering of the water table, if the construction activities are going to take place below the water table

7.1.1.2 Impact description

The water table at the proposed mine area is between 6,6 mbgl and 51,7 mbgl. Any site clearing or construction activities that would involve excavation below water table depth will have potential impact on groundwater quantity and quality. Site clearing will increase the exposure of the regolith, which might increase the probability of shallow aquifer contamination.

7.1.1.2.1 Management or mitigation measures

The following management objectives deigned for the construction phase:

a) Site clearance and construction activities should take place above water table, if applicable. No impact on the groundwater is expected if the activities take place above the water table;
b) Site clearance should be kept to a minimum area and short duration, if possible;
c) Dewatering of the aquifer to lower the water table locally can be considered to ensure that the construction takes place above groundwater level and water quality remains acceptable. The abstracted water can be utilised for dust suppression, vegetation of irrigation (existing nearby farms) or discharged to pollution control dams;
d) The PCD should not be placed on areas with the potential for increased infiltration to groundwater, such as dykes present within the study, see Figure 4-3; and
e) The PCD should be lined to pro-actively prevent infiltration of contaminated seepage water.

7.1.1.2.2 Management actions and Target

The following actions and target are required:

a) Restrict areas that must be cleared of vegetation for construction activities to those necessary;
b) Avoid constructing below water table as far as possible;
c) Apply liner underneath the PCD to minimise or avoid infiltration;
d) Implementation of adequate storm water management to contain all wastewater and/or volatile organic compounds for treatment and recycling; and
e) Install long term monitoring boreholes upgradient and downgradient, while targeting infrastructure which could be source of contamination.

7.1.2 Operational phase

Operational phase involves day to day activities, which may lead to domestic waste generation sewer water discharge, hydrocarbon spills and chemical spills. These activities may become a potential threat to groundwater if not handled with care or mitigated. The potential impact to groundwater during operation may include:

a) Lowering of groundwater level (dewatering);
b) PCD;
c) Overburden and topsoil stockpiling.

7.1.2.1 Impact description

Mine dewatering is crucial to keep the mine working dry for safe working conditions and geotechnically stability. Dewatering is recommended to start with the commencing of the excavations. This can potentially impact the groundwater environment negatively by lowering the water level and creating a cone of depression.

Groundwater inflow gives a baseline understanding of the current estimate of groundwater inflow; therefore boreholes need to be drilled around mining to quantify area within the mine expected to be impacted by mine dewatering and also to quantify the extent of radius of influence of cone of depression from the mining area to borehole around the mine.

A study of various coal mines shows that saline water with acidic or alkaline pH can be realised from the mine workings and stockpile once the coal and rocks are exposed to oxygen and moisture. It is therefore reasonable to assume that sulphate contamination could occur at the project area.

During operation any contaminants that will originate from the mine workings will be pumped our as part of the dewatering process.

7.1.2.2 Management actions and targets

The following actions and target are required:

a) Contain the contaminated water in the mine water systems;
b) Monitor the effects of dewatering;
c) Treat any water that is hazardous if planning to use in the environment; and
d) Minimise the impact associated with the lowering of water table. Always keep dewatering level close to the coal seam floor, not deeper if dewatering boreholes are used.

7.2 Impact Risk Rating

The impact risk rating is used in accordance with the National Environmental Management Act (Act 107 of 1998) (NEMA).

The maximum value of the environmental significant is 100. The following scale (Table 7-3) is applied to each identified potential impact (7.1 section above).

Table 7-3: Scales for potential impact rating

Extent-spatial scale (S)	**Duration (D)**
0-None	1-Immediate
1-Site only	2-Short term: 0 to 5 years
2-Local	3-Medium term
3-Regional	4-Long term: 50 to 15 years
4-National	5-permanent: operational lifetime
5-International	
Magnitude: Severity (M)	**Probability: Likelihood of occurring (P)**
2-Minor	0-None
4-Low	1-Improbable
6-Moderate	2-Low probable
8-High	3-Medium probable
10-Very high	4-High probable
	5-Definite

The environmental significance of each identified potential impact can be calculated using following formula: **Significant (R)** = (duration + extent + magnitude) x probability (Table 7-4)

The identified potential impact on groundwater will be assessed during construction phase and operational phase and needs to be assessed before and after proposed mitigation and management measures to understand the degree at which potential impact can be mitigated.

Table 7-4: Impact classification

Significance	**Environmental significance points**	**Colour code**
Neutral	0	
Low	<30	
Moderate	30 to 60	
High	>60	

Table 7-5: Potential impacts during the construction phase

Activity & interaction: Site clearing of the development of mine infrastructure (box-cut, stockpiles, PCD) through the removal of the topsoil and weathered rocks			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Lowering of the water table			
Pre-mitigation			
Duration (D)	Short term: (2)	Construction activities are expected to be short lived (i.e. during the construction phase)	Low (8)
Extent-spatial scale (S)	Limited (1)	Site clearing will only occur within and immediately around the project site	
Magnitude: Severity (M)	Minor (2)	Any dewatering will have minor environmental significance	
Probability (P)	Medium probable (3)	Dewatering during the construction phase (if any) is unlikely to cause environmental impact considering limited rock permeability, the duration and exaction depth	
Mitigation/Management actions			

a) Restrict areas that must be cleared of vegetation for construction activities to those absolutely necessary. b) Avoid or minimise construction activities to a depth of below the water table. c) Apply a liner underneath the PCD to minimise or avoid infiltration. d) Avoid placement of the pollution control dams on areas with the potential for increased infiltration to groundwater, such as over dykes. e) Pollution control dams should be lined to pro-actively prevent infiltration of contaminated seepage water. f) If that is not possible, dewatering of the aquifer to locally lower the water table can be considered to ensure that the construction takes place above the groundwater level and the water quality remains acceptable. The abstracted water can be utilised for dust suppression, vegetation or discharged to pollution control dams for evaporation. Since the groundwater is not expected to be polluted at this stage, the utilisation of the water for activities such as dust suppression or irrigation (if applicable) is not expected to cause environmental impacts. g) Adequate storm water management should be implemented to contain all wastewater and/or volatile organic compounds, for treatment and recycling. h) Install groundwater monitoring boreholes to assess the time series water level and quality impacts and trends.			
Post-Mitigation			
Duration (D)	Short term: (2)	Any lowering of the water table during the construction phase is expected to be shallow and recover relatively quickly	Low (8)
Extent-spatial scale (S)	Limited (1)	No impacts are expected however if they occur, they will be reduced to isolated parts of the mine where site clearing is going to take place	
Magnitude: Severity (M)	Minor (1)	Considering that the construction phase will be for a short period, the intensity will be minimal	

Probability (P)	Medium probable (3)	It is unlikely for groundwater impact to occur during the construction phase, especially with the implementation of the above proposed management plan	

Table 7-6: Potential impacts during the operation phase

Activity & interaction: Mine dewatering and creation of cone of dewatering			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Lowering of the water table			
Pre-mitigation			
Duration (D)	Permanent: (5)	The water level will remain below its natural level for some time after the life of a project	High (55)
Extent-spatial scale (S)	Local (2)	The cone of depression extends beyond the development area (the extend of cone of depression will be verified at phase 2)	
Magnitude: Severity (M)	Low (4)	Mine dewatering will result in lowering of the water table within the site, with a potential impact on the local and streams	
Probability (P)	Definite (5)	Definite: There are sound scientific reasons to expect that the impact will definitely occur with a >80% probability	
Mitigation/Management actions			

a) Store the dewatered water in pollution control dam and ensure that the dam will have sufficient storage volume and utilise this water in the process. If that is not possible, re-introduce treated water into the streams after ensuring that it meets the required river quality objectives. b) If impact is confirmed through monitoring, management solutions should be implemented acceptable to the authorities such as the purchase of impacted land or the provision of alternate sources of water. c) Groundwater monitoring should be conducted.			
Post-Mitigation			
Duration (D)	Permanent: (5)	The water level will remain below its natural level for some time after the life of a project.	Low (27)
Extent-spatial scale (S)	Local (2)	With the above stated mitigation methods, the extent is expected to be limited	
Magnitude: Severity (M)	Minor (2)	If the abstracted water is stored in the PCD or treated and re-introduced to the streams, the environmental significance is rated as minor	
Probability (P)	Medium probable (3)	With the application of the proposed mitigation plans, the probability of the impact will be unlikely	
Activity & interaction: Groundwater contamination as a result of mining			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Contamination plume in the groundwater			

Pre-mitigation			
Duration (D)	Permanent: (5)	Groundwater contamination due to mine disturbance will occur during the operational phase and is expected to persist even after closure	Moderate (36)
Extent-spatial scale (S)	Local (2)	The contaminated groundwater is unlikely to feed the river and will not contaminate an area larger than the mine footprint. This is due to the groundwater dewatering that will intercept the contamination plume during the operation phase. The net inflow will be toward underground mine	
Magnitude: Severity (M)	Minor (2)	The mine dewatering is expected to maintain the hydraulic head of the mine area to be below the regional groundwater level, thus containing the contamination plume to within the mine property	
Probability (P)	High probable (4)	The impact is likely to occur, although the plume is unlikely (due to the low transmissivity values obtained during slug test and no flow boundary conditions i.e., dykes) to migrate beyond the mine area during the operational phase	
Mitigation/Management actions			
a) Concurrent rehabilitation should be conducted to minimise water and oxygen inflow from the atmosphere. b) The voids should be enclosed with berms to contain surface water runoffs from entering. c) If impact is confirmed through monitoring, management solutions should be sought for upon agreement with the farmers or communities with impacted groundwater or mine purchase land. d) Contaminated water should be utilised by the mine, instead of using freshwater (if practical).			

Post-Mitigation			
Duration (D)	Permanent: (5)	Groundwater contamination due to mine disturbance will occur during the operational phase and is expected to persist even after closure	Low (27)
Extent-spatial scale (S)	Local (2)	With the implementation of the above stated mitigation methods, the impact extent can be minimised to the site only	
Magnitude: Severity (M)	Minor (2)	The dewatering of the underground mine will contain the pollution plume during the operational phase, with minor effects on the groundwater environment	
Probability (P)	Medium probable (3)	The impact is unlikely to be significant with the implementation of the above stated mitigation methods	

Activity & interaction: Groundwater contamination as a result of seepage from the waste stockpiles and slurry dam			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Contamination plume in the groundwater			
Pre-mitigation			
Duration (D)	Permanent: (5)	The stockpiles and slurry dam are likely to seep and contaminate the groundwater, even after mine closure	Moderate (45)
Extent-spatial scale (S)	Local (2)	The contaminated groundwater is unlikely to feed the rivers and will not contaminate an area larger than the mine footprint. This is due to the groundwater dewatering that will intercept the contamination plume during the operation phase	
Magnitude: Severity (M)	Minor (2)	The mine dewatering is expected to maintain the hydraulic head of the mine area to be below the regional groundwater level, thus containing the contamination plume to within the mine property	
Probability (P)	Definite (5)	Seepage from unlined dams will definitely impact the groundwater	
Mitigation/Management actions			

a) Slurry dam, overburden and topsoil stockpiles should be managed to minimise infiltration of contaminants to the groundwater. Mitigation methods that should be considered include the correct placement of the stockpile and covering them with soil to minimise rainfall infiltration and mobilisation of dissolved metals. The shape of the stockpile should be managed to control the ease with which water can run off from the facility. b) Implement the required prevention mechanisms at the discard and slurry stockpiles to prevent pollution migration. c) Discard being placed should be put on the coal seam floor or as low as possible and definitely below the water table in areas where there will be no oxygenation and water throughflow.			
Post-management			
Duration (D)	Permanent: (5)	Groundwater contamination due to mine disturbance will occur during the operational phase and is expected to persist even after closure	Low (27)
Extent-spatial scale (S)	Local (2)	With the implementation of the above stated mitigation methods, the impact extent can be minimised to the site only	
Magnitude: Severity (M)	Minor (2)	The dewatering of the underground mine will contain the pollution plume during the operational phase, with minor effects on the groundwater environment	
Probability (P)	Medium probable (3)	The impact is unlikely to be significant with the implementation of the above stated mitigation methods	

Activity & interaction: Dirty mine water storage in the PCD			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Contamination plume in the groundwater			
Pre-mitigation			
Duration (D)	Permanent: (5)	Seepage of contaminated water will occur during the operation of the dam	Moderate (45)
Extent-spatial scale (S)	Local (2)	The impact from the pollution control dam is expected to be local and limited to within 150 m of the PCD footprint area	
Magnitude: Severity (M)	Minor (2)	Once contamination starts, it takes time to rehabilitate naturally	
Probability (P)	Definite (5)	Seepage from unlined PCD will definitely impact the groundwater	
Mitigation/Management actions			
a) Apply a liner underneath the PCD to minimise or avoid infiltration; and b) Monitor the groundwater quality for impact detection.			
Post-management			

Activity & interaction: Dirty mine water storage in the PCD			
Dimension	**Rating**	**Motivation**	**Significance**
Impact Description: Contamination plume in the groundwater			
Duration (D)	Permanent: (5)	The seepage from the pollution control dam will take place throughout the project life	Low (24)
Extent-spatial scale (S)	Site only (1)	With the application of a liner, the plume will be very	
Magnitude: Severity (M)	Minor (2)	The intensity is minimal with the application of liners	
Probability (P)	Medium probable (3)	The impact is unlikely to occur	

8 CONCLUSION AND RECOMMEDANTIONS

The following conclusions are evident from the hydrogeological evaluation of the proposed Tenbosch Mine project area:

8.1 Conclusions

Based on the desktop study, site assessments and interpretation of collected data, the following conclusions are made:

a) Water levels are generally shallow ranging between 6,6 mbgl and 21.5 mbgl. The groundwater flow direction follows the surface topography. Therefore, groundwater will flow from highest to lowest elevation, in the direction of surface water drainage.
b) Groundwater generally flows towards the nearby Ngweti River.
c) Based on the regional aquifer types, all the boreholes identified during hydrocensus intersected fractured aquifer with average yield ranging between 0.1 – 0.5 l/s.
d) Existing boreholes (JANNESBH01 and LEMABH1) intersected intergranular and fractured aquifer with average yield ranges between 0.2 – 2.0 l/s.
e) Based on regional water quality, water quality is considered to be good to moderate; this is also confirmed by existing borehole (JANNESBH01 and LEMABH1) water quality with generally good to moderate water quality with the exception of LEMABH1 with elevated chloride.
f) According to slug test borehole BH1 has high borehole yield and hydraulic parameters as it is drilled within the fractured zone along a mapped dolerite dyke structure.
g) Data gaps identified are related to soil profiles, borehole logs, baseline water quality and hydraulic parameters of the underlain aquifer.
h) BH1 and BH5 were found to be within recommended SANS 241: 2015 drinking guideline values. Based on the tested parameters, the water of only these two boreholes is considered to be safe for human consumption.
i) BH1 shows high hydraulic conductivity. This means the aquifer in that area is more vulnerable to contamination than the area that is less permeable (BH2, BH3, BH4 and BH5),

8.2 Recommendations

a) Based on the conclusions made and gap analysis, the following recommendations are made: Geological logs of the five (5) exploration borehole drilled should be made available in order to understand the local geological conditions for the preparation of the numerical model layers;

b) Geophysical surveys should be conducted to delineate mapped structures and weathered zones as these acts as conduits for groundwater flow zones;
c) Exploration drilling of at least three boreholes should be conducted in phase 2 in the immediate area (southern portion) of the Tenbosh property;
d) Baseline groundwater quality and water level database should be conducted to collect seasonal fluctuations in data that can be used in the numerical transport model;
e) Monitoring boreholes area recommended to be drilled for multi-borehole aquifer tests to determine regional aquifer storativity and transmissivity, this will be used to quantify the rate of contamination plume movement within the porous media;
f) The groundwater impact assessment to be refined once Phase 2 of the project has been completed.

9 REFERENCES

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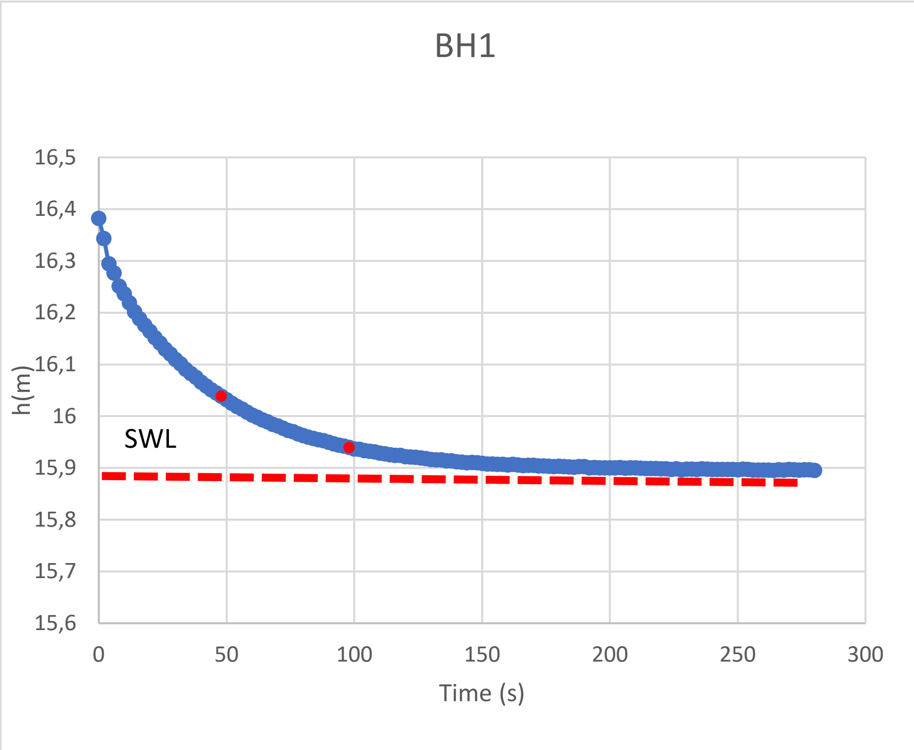
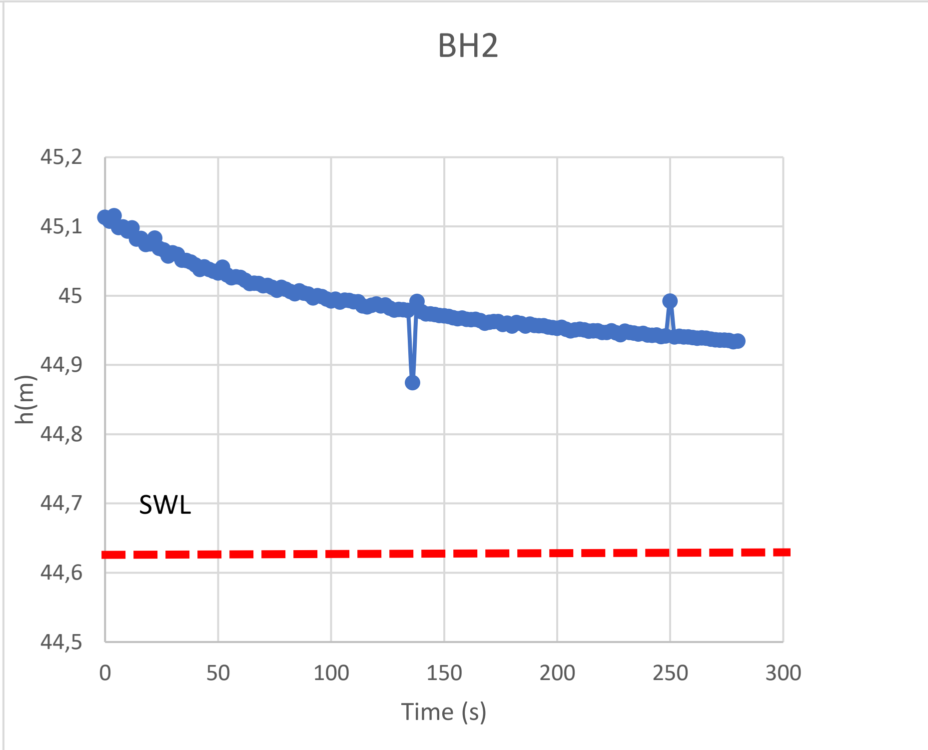
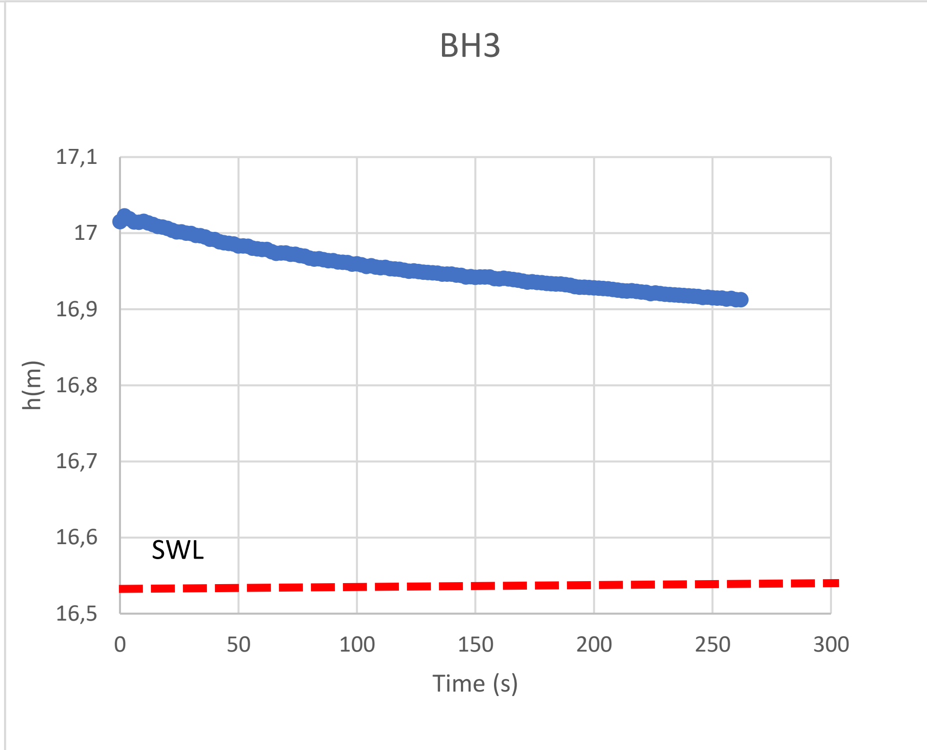
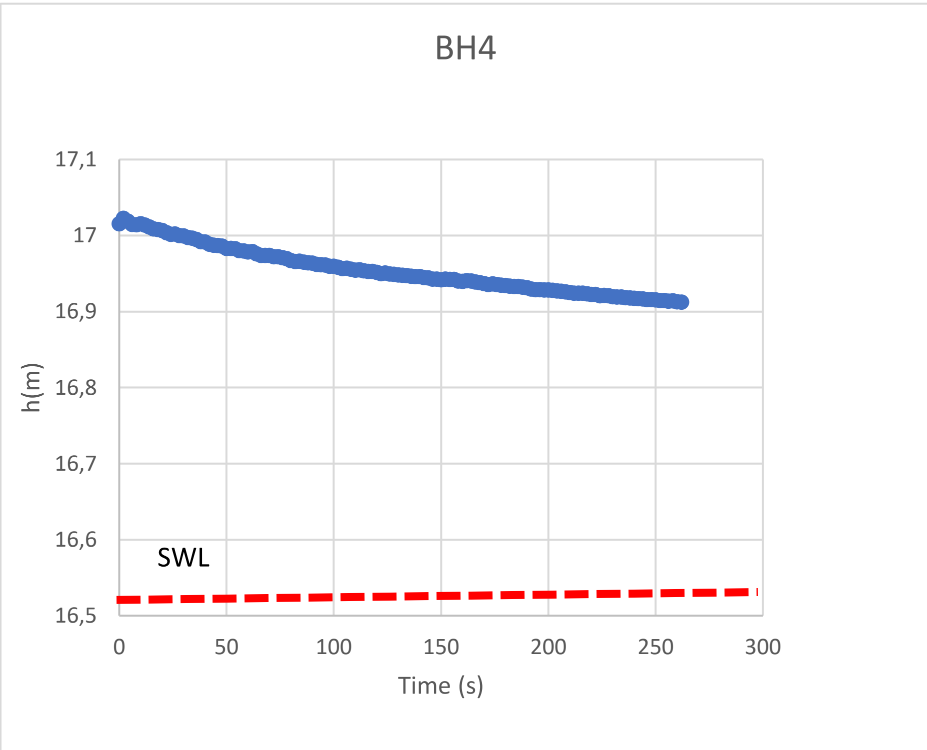
Appendix A:

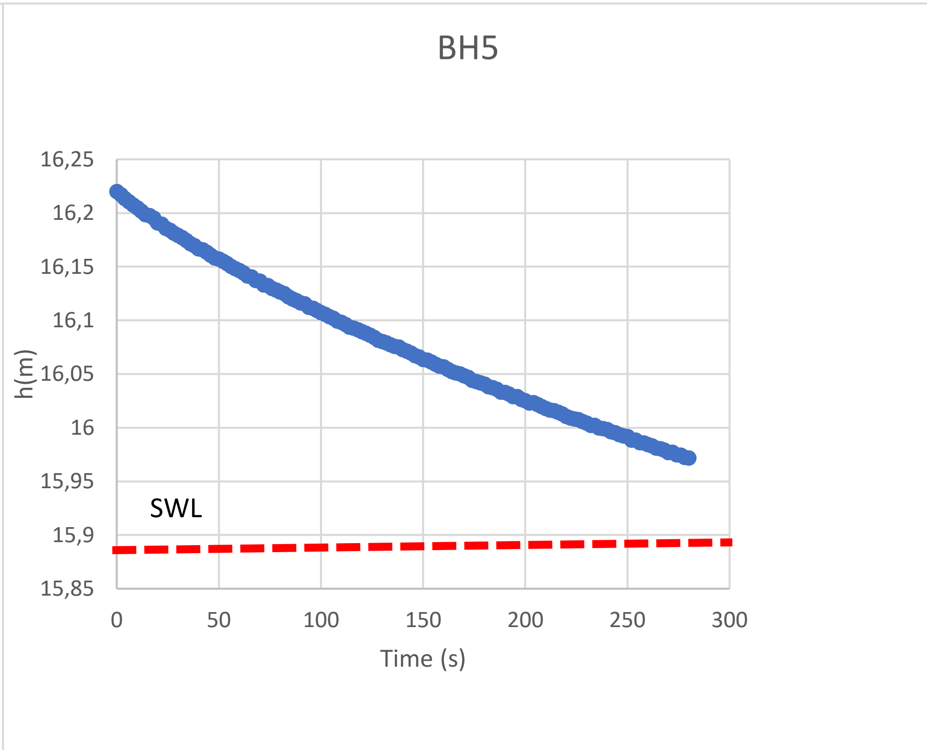
Borehole Slug Test


BH1
16,5
16,4
16,3
16,2
16,1
16
15,9
15,8
15,7
15,6
h(m)
SWL
0
50
100
150
200
250
300
Time (s)


BH2
45,2
45,1
45
44,9
44,8
44,7
44,6
44,5
h(m)
SWL
0
50
100
150
200
250
300
Time (s)

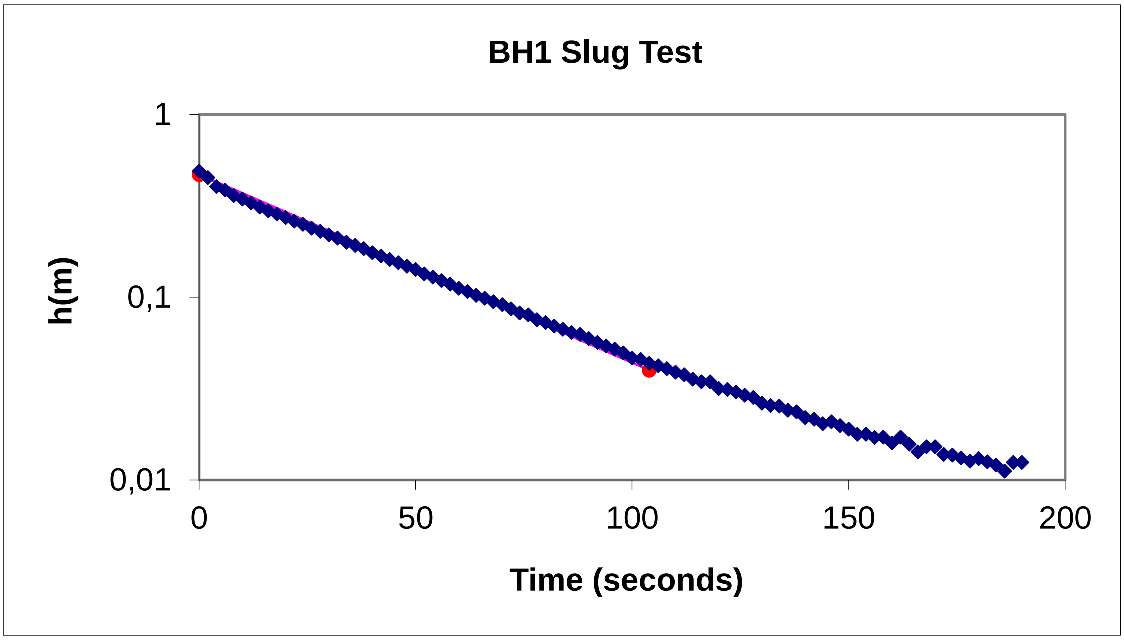

BH3
17,1
17
16,9
16,8
16,7
16,6
16,5
h(m)
SWL
0
50
100
150
200
250
300
Time (s)

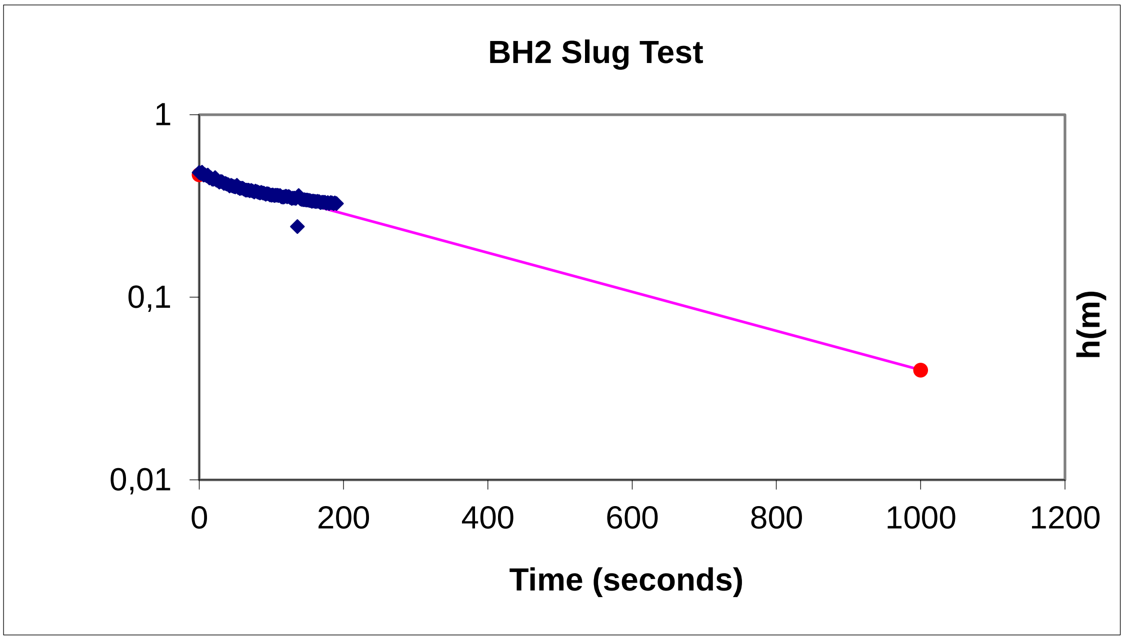

BH4
17,1
17
16,9
16,8
16,7
16,6
16,5
h(m)
SWL
0
50
100
150
200
250
300
Time (s)

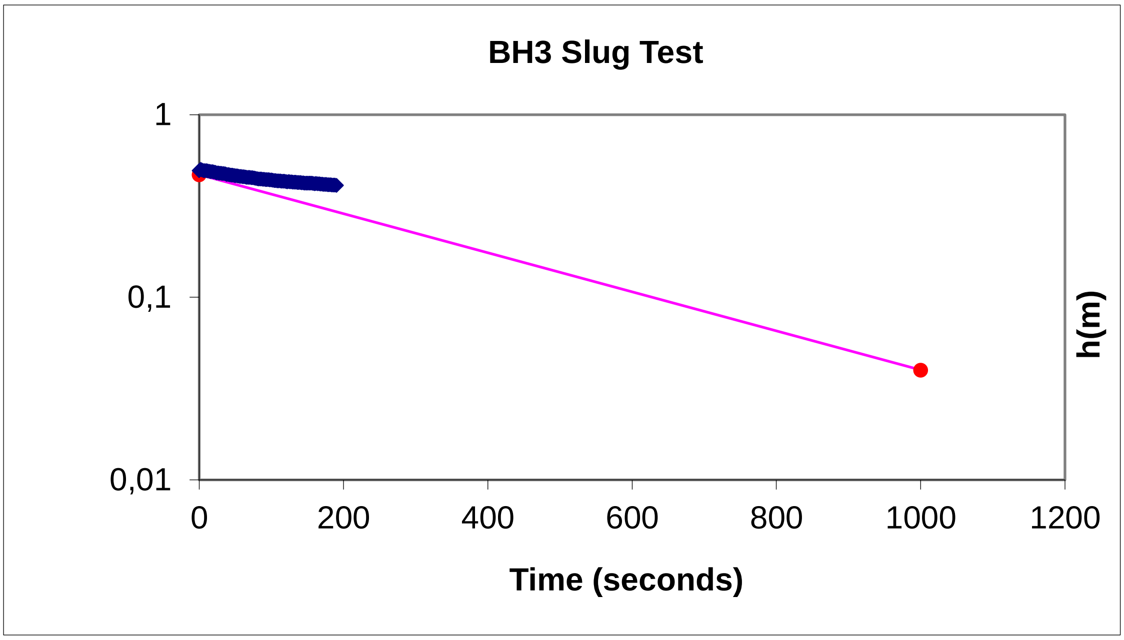

BH5
16,25
16,2
16,15
16,1
16,05
16
15,95
15,9
15,85
h(m)
SWL
0
50
100
150
200
250
300
Time (s)

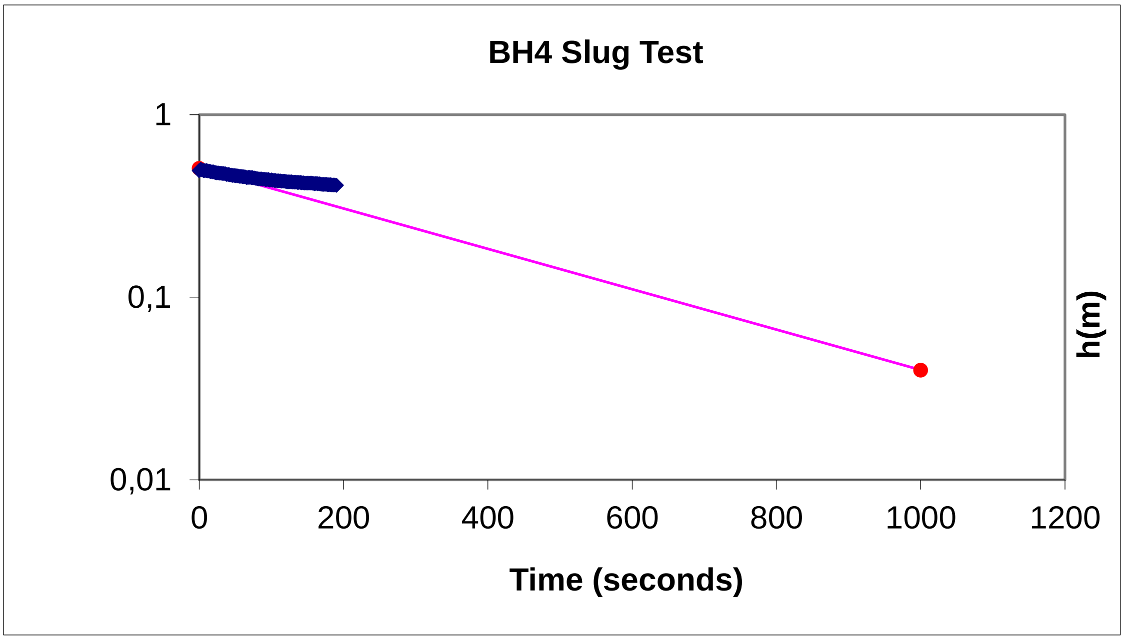
Appendix B:

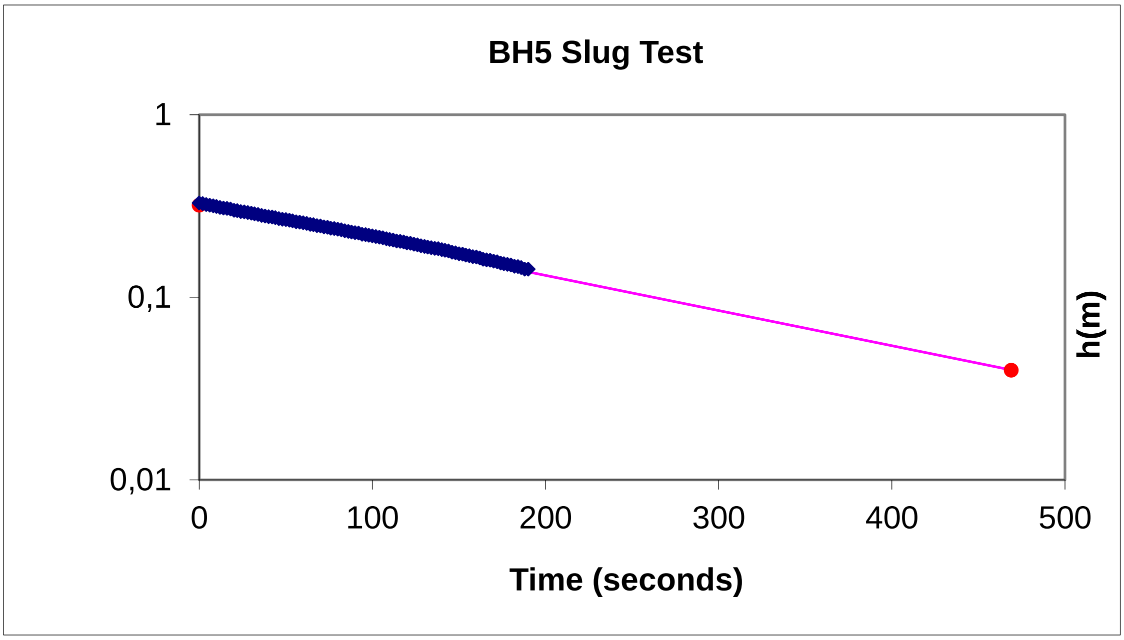
Aquifer test results


BH1 Slug Test
h(m)
1
0,1
0,01
0
50
100
150
200
Time (seconds)

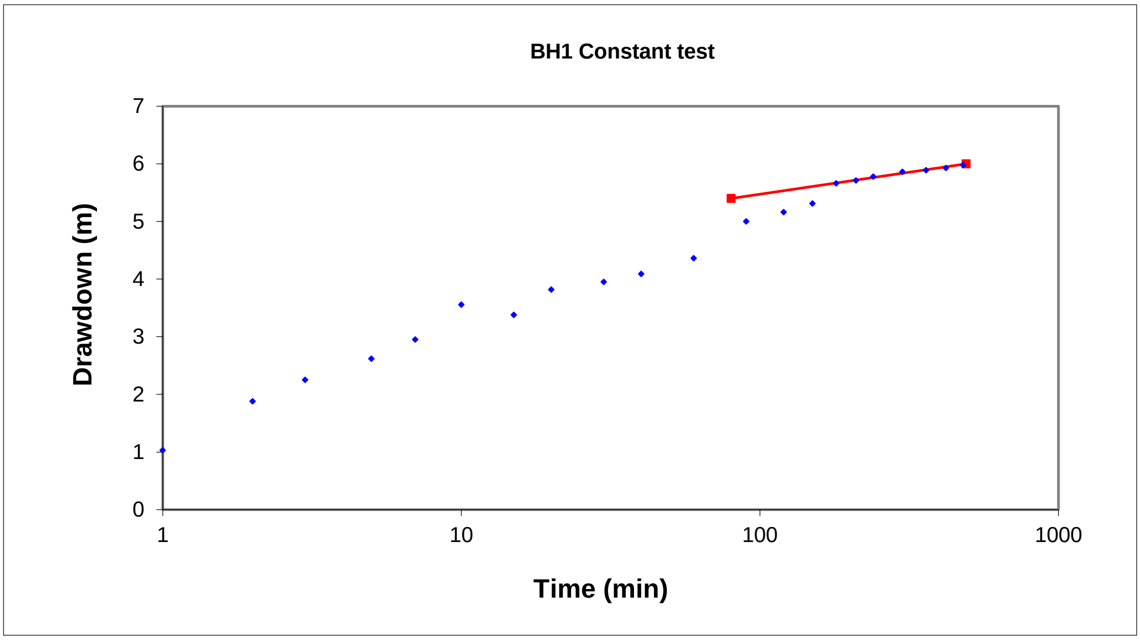

BH2 Slug Test
1
0,1
0,01
0
200
400
600
800
1000
1200
h(m)
Time (seconds)


BH3 Slug Test
1
0,1
0,01
0
200
400
600
800
1000
1200
Time (seconds)
h(m)


BH4 Slug Test
1
0,1
0,01
0
200
400
600
800
1000
1200
Time (seconds)
h(m)



Graphs for hydraulic head recovery following slug tests.



Drawdown data vs. time for the constant rate pumping test

Appendix C:

Lab results

WATERLAB (Pty) Ltd
Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891
23B De Havilland Crescent, Persequor Techno Park, Meiring Naudé Drive, Pretoria
P.O. Box 283, Persequor Park, 0020
Tel: +2712 - 349 - 1066
Fax: +2786 - 654 - 2570
e-mail: admin@waterlab.co.za

T0391

CERTIFICATE OF ANALYSES

GENERAL WATER QUALITY PARAMETERS

Date received: 2023-04-26 **Date completed:** 2023-05-12
Project number: 1000 **Report number:** 119914 **Order number:** KIM-WAT-2023-009

Client name: Kimopax (Pty) Ltd **Contact person:** Ntsako Maluleke
Address: P.O Box 4077, Halfway House, Johannesburg, Gauteng 1685 **e-mail:** ntsako@kimopax.com
Telephone: 011 312 9765 **Facsimile:** 011 312 9768 **Mobile:** 076 108 0872

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification: Tenbosch Mine			
			BH01	BH02	BH03	BH04
Sample Number			23-05117	23-05118	23-05119	23-05120
Date/Time Sampled			N/A	N/A	N/A	N/A
pH - Value @ 25 °C	A	WLAB065	6.7	7.2	7.1	7.1
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	59.7	302	434	170
Total Dissolved Solids @ 180°C	A	WLAB003	354	1650	2350	874
Suspended Solids at 105°C	A	WLAB004	6.7	159	18.7	22
Total Alkalinity as $CaCO_3$	A	WLAB007	120	440	112	196
Total Hardness as $CaCO_3$	A	WLAB051	75	327	130	375
Chloride as Cl	A	WLAB046	98	806	1345	451
Sulphate as SO_4	A	WLAB046	38	2	<2	25
Fluoride as F	N	WLAB014	0.2	0.5	1.7	0.3
Nitrate as N	A	WLAB046	0.1	<0.1	<0.1	<0.1
Nitrite as N	A	WLAB046	<0.05	<0.05	<0.05	<0.05
Total Phosphate as P	A	WLAB031	<0.2	0.8	<0.2	0.3
Ortho Phosphate as P	A	WLAB046	0.1	0.5	<0.1	<0.1
Free Cyanide as CN	N	WLAB056	<0.010	<0.010	<0.010	<0.010
Free and Saline Ammonia as N	A	WLAB046	0.4	3.3	1.0	0.3
Sodium as Na	A	WLAB015	89	460	753	176
Potassium as K	A	WLAB015	1.2	6.2	5.8	6.5
Calcium as Ca	A	WLAB015	13	100	41	54
Magnesium as Mg	A	WLAB015	10	19	6	59
Aluminium as Al	A	WLAB015	0.109	0.777	<0.100	<0.100
Arsenic as As	A	WLAB050	<0.001	<0.001	<0.001	<0.001
Boron as B	A	WLAB015	0.096	0.251	0.212	0.086
Cadmium as Cd	A	WLAB050	<0.001	<0.001	<0.001	<0.001
Total Chromium as Cr	A	WLAB015	<0.025	<0.025	<0.025	<0.025
Trivalent Chromium as Cr	N	WLAB015	<0.025	<0.025	<0.025	<0.025
Hexavalent Chromium as Cr	A	WLAB032	<0.010	<0.010	<0.010	<0.010
Cobalt as Co	A	WLAB015	<0.025	<0.025	<0.025	<0.025
Copper as Cu	A	WLAB015	<0.010	<0.010	<0.010	<0.010

A. van de Wetering - Chemical Technical Signatory

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Tests marked "Not SANAS Accredited" in this report are not included in the SANAS Scope of Accreditation for this Laboratory.
Results marked "Subcontracted Test" in this report are not included in the SANAS Scope of Accreditation for this Laboratory.

Sample condition acceptable unless specified on the report.
Microbiological standards dictate that zero cannot be reported in cases where no growth is observed. The requirement is to then report as <1cfu/g or ml. A result of <1 implies the absence of the specific test organism and is the lowest reportable result where no growth was detected.

The information contained in this report is relevant only to the sample/samples supplied to WATERLAB (Pty) Ltd. This report, or any parts of this report, shall not be reproduced by any means, except with the written approval of the Board of WATERLAB (Pty) Ltd. Details of sample conducted by Waterlab (PTY) Ltd according to WLAB/Sampling Plan and Procedures/SOP are available on request.

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WATERLAB (Pty) Ltd
Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891
23B De Havilland Crescent
Persequor Techno Park
Meiring Naudé Drive
Pretoria
P.O. Box 283, Persequor Park, 0020
Tel: +2712 - 349 - 1066
Fax: +2786 - 654 - 2570
e-mail: admin@waterlab.co.za

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Order number: KIM-WAT-2023-009

Client name: Kimopax (Pty) Ltd
Address: P.O Box 4077, Halfway House, Johannesburg, Gauteng 1685
Telephone: 011 312 9765
Facsimile: 011 312 9768
Contact person: Ntsako Maluleke
e-mail: ntsako@kimopax.com
Mobile: 076 108 0872

Analyses in mg/ℓ (Unless specified otherwise)		**Method Identification**	Sample Identification: Tenbosch Mine			
			BH01	BH02	BH03	BH04
Sample Number			23-05117	23-05118	23-05119	23-05120
Date/Time Sampled			N/A	N/A	N/A	N/A
Iron as Fe	A	WLAB015	0.090	3.07	0.169	1.27
Lead as Pb	A	WLAB050	0.001	0.006	0.001	0.017
Manganese as Mn	A	WLAB015	<0.025	0.601	0.066	0.140
Mercury as Hg	A	WLAB050	<0.001	<0.001	<0.001	<0.001
Nickel as Ni	A	WLAB015	<0.025	<0.025	<0.025	<0.025
Zinc as Zn	A	WLAB015	<0.025	<0.025	<0.025	<0.025
% Anion-Cation Balance	N	---	94.9	92.0	93.7	94.5

A. van de Wetering - Chemical Technical Signatory

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Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891
23B De Havilland Crescent
Persequor Techno Park
Meiring Naudé Drive
Pretoria
P.O. Box 283, Persequor Park, 0020
Tel: +2712 - 349 - 1066
Fax: +2786 - 654 - 2570
e-mail: admin@waterlab.co.za

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Order number: KIM-WAT-2023-009

Client name: Kimopax (Pty) Ltd
Address: P.O Box 4077, Halfway House, Johannesburg, Gauteng 1685
Telephone: 011 312 9765
Facsimile: 011 312 9768
Contact person: Ntsako Maluleke
e-mail: ntsako@kimopax.com
Mobile: 076 108 0872

Analyses in mg/ℓ (Unless specified otherwise)		Method Identification	Sample Identification: T BH05
Sample Number			23-05121
Date/Time Sampled			N/A
pH - Value @ 25 °C	A	WLAB065	7.3
Electrical Conductivity in mS/m @ 25°C	A	WLAB065	159
Total Dissolved Solids @ 180°C	A	WLAB003	976
Suspended Solids at 105°C	A	WLAB004	8.0
Total Alkalinity as $CaCO_3$	A	WLAB007	680
Total Hardness as $CaCO_3$	A	WLAB051	207
Chloride as Cl	A	WLAB046	148
Sulphate as SO_4	A	WLAB046	46
Fluoride as F	N	WLAB014	0.5
Nitrate as N	A	WLAB046	0.3
Nitrite as N	A	WLAB046	0.2
Total Phosphate as P	A	WLAB031	<0.2
Ortho Phosphate as P	A	WLAB046	<0.1
Free Cyanide as CN	N	WLAB056	<0.010
Free and Saline Ammonia as N	A	WLAB046	1.0
Sodium as Na	A	WLAB015	284
Potassium as K	A	WLAB015	3.0
Calcium as Ca	A	WLAB015	41
Magnesium as Mg	A	WLAB015	25
Aluminium as Al	A	WLAB015	<0.100
Arsenic as As	A	WLAB050	<0.001
Boron as B	A	WLAB015	0.357
Cadmium as Cd	A	WLAB050	<0.001
Total Chromium as Cr	A	WLAB015	<0.025
Trivalent Chromium as Cr	N	WLAB015	<0.025
Hexavalent Chromium as Cr	A	WLAB032	<0.010
Cobalt as Co	A	WLAB015	<0.025
Copper as Cu	A	WLAB015	<0.010

A. van de Wetering - Chemical Technical Signatory

A = Accredited N = Not Accredited S = Subcontracted
Tests marked "Not SANAS Accredited" in this report are not included in the SANAS Scope of Accreditation for this Laboratory.
Results marked "Subcontracted Test" in this report are not included in the SANAS Scope of Accreditation for this Laboratory.

Sample condition acceptable unless specified on the report.
Microbiological standards dictate that zero cannot be reported in cases where no growth is observed. The requirement is to then report as <1cfu/g or ml. A result of <1 implies the absence of the specific test organism and is the lowest reportable result where no growth was detected.

WATERLAB (Pty) Ltd
Reg. No.: 1983/009165/07 V.A.T. No.: 4130107891
23B De Havilland Crescent
Persequor Techno Park
Meiring Naudé Drive
Pretoria
P.O. Box 283, Persequor Park, 0020
Tel: +2712 - 349 - 1066
Fax: +2786 - 654 - 2570
e-mail: admin@waterlab.co.za

T0391

CERTIFICATE OF ANALYSES

GENERAL WATER QUALITY PARAMETERS

Date received: 2023-04-26
Project number: 1000
Report number: 119914
Date completed: 2023-05-12
Order number: KIM-WAT-2023-009

Client name: Kimopax (Pty) Ltd
Address: P.O Box 4077, Halfway House, Johannesburg, Gauteng 1685
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Facsimile: 011 312 9768
Contact person: Ntsako Maluleke
e-mail: ntsako@kimopax.com
Mobile: 076 108 0872

Analyses in mg/ℓ (Unless specified otherwise)		**Method Identification**	Sample Identification: T BH05
Sample Number			23-05121
Date/Time Sampled			N/A
Iron as Fe	A	WLAB015	0.108
Lead as Pb	A	WLAB050	0.001
Manganese as Mn	A	WLAB015	0.105
Mercury as Hg	A	WLAB050	<0.001
Nickel as Ni	A	WLAB015	<0.025
Zinc as Zn	A	WLAB015	<0.025
% Anion-Cation Balance	N	---	93.9

A. van de Wetering - Chemical Technical Signatory

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Page 4 of 4

Head Office: 546 16th Road, Constantia Park, Midrand, 1685

Tel: +27 11 312 9765 Fax: +27 11 312 9768/ +27 86 219 8717

East London: 62 Bonza Bay Road, Beacon Bay, East London, 5247

Tel: +27 43 721 0178 Fax: +27 86 558 7022

Gqeberha: 1st Floor, Habour View Building, Oakworth Road, Humewood, Gqeberha, 6001

Tel: +27 41 101 1112 Fax: +27 86 558 7022

Limpopo: 58-60 Landrose Mare Street,Thabakgolo Building, 3rd Floor Office 314, Polokwane, 0700

Tel: 015 101 0520 Fax: +27 86 219 8717

Western Cape: 50 Long Street Cape Town, 8000

Tel: 043 721 9765

Mpumalanga: Office 4, 5 Hans Strydom, Witbank,1034

Tel: 013 110 3653

Northern Cape: Thompsons View 29 A, Tsenin Road,

Kuruman, 8460

Tel: +27 65 927 1639 Fax: +27 86 219 8717

www.kimopax.com