ENVIRONMENTAL & ENGINEERING

REPORT

TRENTRA (PTY) LTD – VLAKLAAGTE 45-IS MP

GEOHYDROLOGICAL REPORT FOR THE INPUTS TO THE EIA/WULA

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- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing:
    - any decision to be taken with respect to the application by the competent authority; and
    - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Naude

Signature 18/11/2019 **Date**

Mrs. Elida Naude
MSc Geohydrology (UFS)
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EXECUTIVE SUMMARY

BACKGROUND

Eco Elementum Geohydrology (Pty) Ltd was contracted by Trentra (Pty) Ltd (to conduct a Geohydrological Investigation as part of the Environmental Impact Assessment and WULA to include the Mining Permit area of Vlaklaagte 45-IS.

The Trentra Vlaklaagte mining area is situated approximately 14 km north-east of Kriel and approximately 29 km south-east of eMalahleni the province of Mpumalanga. This report will investigate the contribution in term of quality and quantity impacts of the Trentra Vlaklaagte mining operations on the groundwater. The proposed project area is within the Witbank Coalfield and the site falls within the B11B quaternary catchment in the Olifants Water Management Area (WMA).

The following activities form / will form part of the Trentra mining operations:

- Opencast Pit,
- Overburden Stockpile,
- Topsoil Stockpile,
- ROM Stockpile (in-pit),
- Coal Stockpile,
- Mobile Washing & Screening Plant (In-pit),
- Pollution Control Dam (PCD),
- DMS Washplant
- Mobile fuel & storage,
- Workshop,
- Weighbridge,
- Mobile Offices, and
- Haul Road.

CONCLUSION / RECOMMENDATION

The geohydrological environment at the proposed Trentra Vlaklaagte mining area can be summarised as follows:

- The basis of the conceptual model can be summarised as follows:
- The proposed Trentra Vlaklaagte mining area is located in the Highveld region of Mpumalanga and in a summer rainfall region.
- The mean annual precipitation is ± 665 mm/annum, while the evaporation is estimated at 1 700 mm/annum.
- Drainage over the regional area is towards the north, while locally drainage is towards the north-east.
- The Trentra Vlaklaagte mining area is underlain by sedimentary rocks from the Karoo Super group's Vryheid Formation.

- Geological structures such as dykes and faults are known to exist in the region of the Trentra Vlaklaagte mining. These structures and the weathered zone are possible pathways of elevated groundwater flow and contamination migration.
- Two main aquifer systems are found in the Trentra Vlaklaagte mining region. Firstly, the shallow weathered aquifer and secondly, the deeper, secondary aquifer.
- Groundwater levels generally varied from less than 1 to 15 mbs in the boreholes recorded (GCS, 2017).
- With the short duration of opencast mining, the cone of depression due to dewatering is not expected to extent more than 60 m from the pit area.
- Groundwater Sources:
    - Recharge:
        - Natural recharge: in the region of the project the natural recharge is estimated between 1 and 3% of the MAP. Rivers and drainage systems can also be seen as potential recharge sources. Gaining or losing streams play a role here. Losing streams "lose" their water to the aquifer, making it a natural recharge source. The Olifants River to the south of the project is a gaining feature and may be connected to the groundwater regime.
        - Artificial recharge: Artificial recharge from sources including the PCD may occur in the mining operation should leakage from this feature occur. The backfilled opencast pit can act as an artificial recharge sources since the recharge through the spoils can recharge the underlying aquifer directly. Artificial recharge from surrounding mining operations may already be taking place/have taken place.
    - Contamination Sources: At the proposed mining operation the potential contamination sources include the opencast pit, especially post closure and any carbonaceous source which may include the PCD, ROM stockpiles or overburden stockpiles.
- Groundwater pathways:
    - Fault zones and dykes surrounding the proposed project area may be potential pathways for groundwater contamination migration. No site-specific geological structure information is available, but it is typical for Karoo geology to have these types of structures present.
- Groundwater receptors:
    - River Systems: any contamination from potential sources may be discharged in terms of baseflow into the receiving river systems in the area. The distance from the river systems minimise the impact, if any, on the surface water.
    - Potential groundwater users: No known groundwater users are expected or known within the potential impact zone of the proposed mining activity. The impact zone may increase should pathways such as geological structures be present.
    - Opencast pit: once dewatering of the pit commence, water will flow towards the pit and therefore act as a groundwater receptor, even though an artificial receptor.

The expected impacts as a result of the proposed mining operations (Lakeside Leeuwfontein) are summarised as:

- Construction phase:
    - Impacts in terms of groundwater levels are expected during this phase. The dewatering of the box-cut will cause a drawdown in the water levels within the immediate vicinity of the cut.
    - Fuel spillages from construction vehicles may occur during this phase.

- Operational phase:
  - Impacts in terms of groundwater levels are expected during this phase. The dewatering of the pit will cause a drawdown in the water levels within the immediate vicinity of the opencast activities.
  - The drawdown cone extent is not expected to exceed 60 m in the shallow weathered aquifer.
  - The maximum depth of drawdown at the pit is estimated at 18m,
  - Private users water levels within the cone of depression extent may be affected in terms of water levels.
  - No adverse impacts on the groundwater qualities surrounding the opencasts are expected during this phase.
- Post Closure:
  - The plume will migrate down gradient from the pit area.
  - The sulphate concentrations in the pit area increases as a result of acid generation.
  - The plume is not expected to reach any surface water features.

The contamination plume is not expected to extent more than 230 m from the source area.

The proposed mitigation measures for the proposed mining operation are summarised below:

- Operational phase:
  - Groundwater levels in the monitoring boreholes should be measured on at least a quarterly interval.
  - Should the water levels of surrounding users be influenced in terms of groundwater level or quality decline, the users should be compensated.
  - Monitor groundwater inflow rates on a monthly basis throughout the mining operation.
  - The groundwater quality in the monitoring boreholes should be analysed on a quarterly basis.
  - Annual reporting on the groundwater qualities and levels should be conducted and submitted to the DWA.
  - The numerical model should be updated once more time-series monitoring data (water levels and qualities) are available and on an annual basis.
  - Remove as much coal from the mining pit as possible to prevent continuous acid generation.

- Post-closure phase:
  - Carbonaceous material should be placed at the deeper base of the opencast pit to allow flooding with groundwater as soon as possible. This will reduce the redox reaction potential as oxygen is excluded from the system.
  - Rehabilitation should occur in such a manner that surface runoff is directed away from the rehabilitated pit and recharge to the pit minimized.
  - Flow paths which include fracture zones should be sealed to reduce inflow of fresh groundwater and outflow of contaminated groundwater.
  - Methods of handling the potential decant should be investigated and may include treatment of polluted water or a down gradient- intercepting trench.
  - The groundwater quality in the monitoring boreholes should continue to be analysed on a quarterly interval basis.
  - Monitoring of surface water features should eb conducted on a quarterly interval.

CONTENTS

List of Figures

List of Tables

List of Abbreviations

ABA-	Acid Base Accounting
ARD-	Acid Rock Drainage
EC-	Electrical Conductivity
EIA-	Environmental Impact Assessment
EMP-	Environmental Management Plan
GQM-	Groundwater Quality Management
Ha-	Hectares
Km^{2}-	Square Kilometre
L/s-	Litres per second
Meq/l –	Milliequivalent per litre
Mamsl-	Metres above mean sea level
MAP-	Mean Annual Precipitation
MAE-	Mean Annual Evaporation
Ml/d-	Mega litres per day
m/d-	meter per day
m-	meter
mbs-	meter below surface
mm-	Millimetre
mm/a-	Millimetres per annum
mS/m-	Millisiemens per metre
m^{3}-	Cubic metre
NGA-	National Groundwater Archive
PCD-	Pollution Control Dam

1. INTRODUCTION

Eco Elementum Geohydrology (Pty) Ltd was contracted by Trentra (Pty) Ltd (to conduct a Geohydrological Investigation as part of the Environmental Impact Assessment and WULA to include the Mining Permit area of Vlaklaagte 45-IS.

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Mining in the region of the Trentra Vlaklaagte mining area has been ongoing for several decades. The Trentra Vlaklaagte mining area is situated in an area with several mining and agricultural activities near its boundaries. These include:

- Exxaro New Clydesdale Colliery west of Trentra Vlaklaagte,
- Exxaro Dorstfontein less than 2km south of Trentra Vlaklaagte,
- Eyethu Kleinfontein Colliery 6km east of Trentra Vlaklaagte, and
- Agricultural activities at all of the Trentra Vlaklaagte boundaries.

The following activities form / will form part of the Trentra mining operations:

- Opencast Pit,
- Overburden Stockpile,
- Topsoil Stockpile,
- ROM Stockpile (in-pit),
- Coal Stockpile,
- Mobile Washing & Screening Plant (In-pit),
- Pollution Control Dam (PCD),
- DMS Washplant
- Mobile fuel & storage,
- Workshop,
- Weighbridge,
- Mobile Offices, and
- Haul Road.

The location of the Trentra Vlaklaagte mining area is indicated in **Figure 1.**

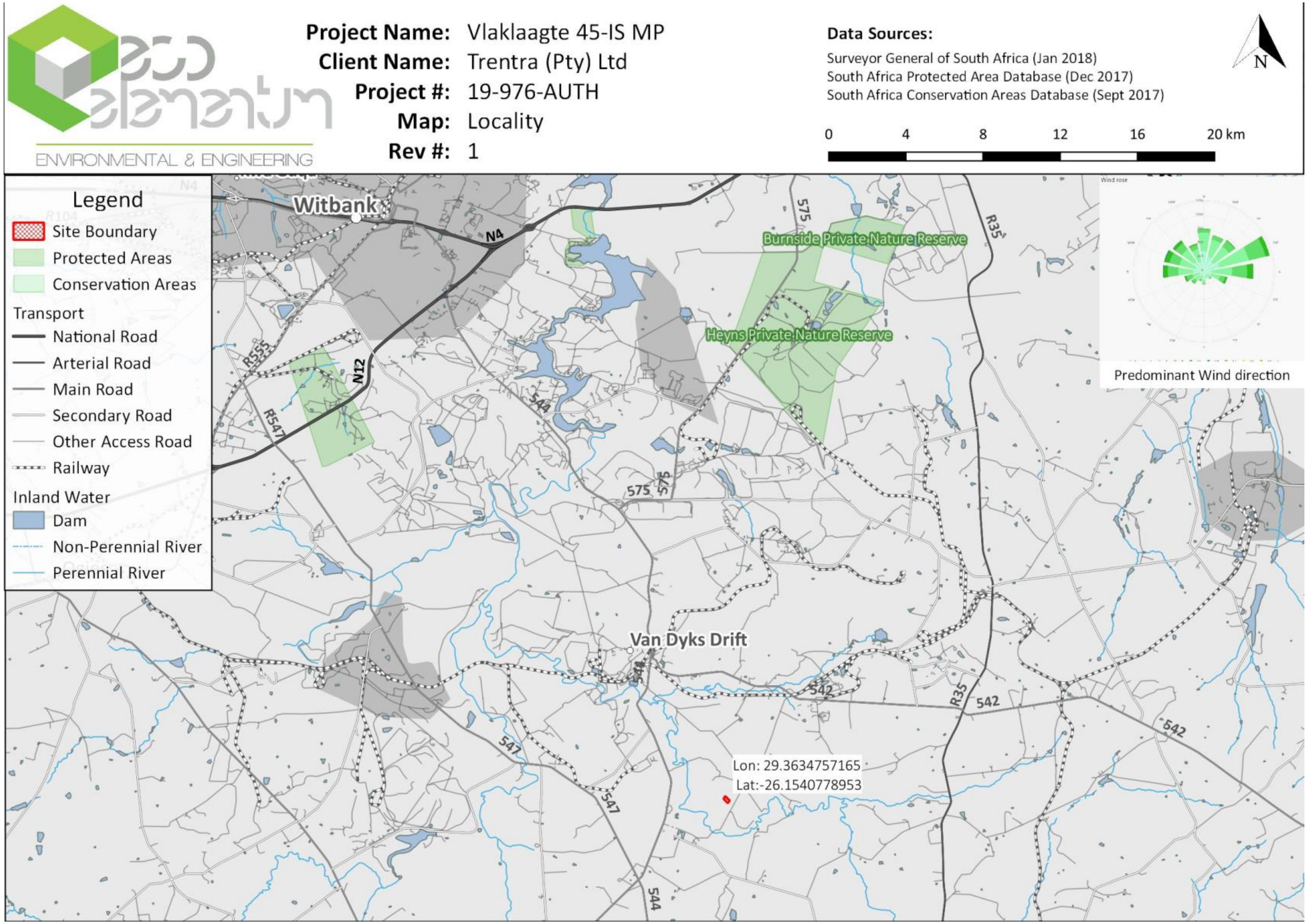

Figure 1: Trentra mining locality Map, Van Dyks Drift, Mpumalanga, South Africa

2. GEOGRAPHICAL SETTING

2.1 Topography and Drainage

The Trentra mining area is situated in the B11B quaternary catchment forming part of the upper Olifants River Catchment area. The Trentra mining area is situated approximately 1km from the Olifants River south- south-east and south-west of the site. Small tributaries of the river runs east and south-west of the mining area towards the Olifants rivier. The tributaries at the proposed mining site is of non-perennial nature which only flows for short periods of time after rainfall occurs, which is normally during the summer rainfall season. Drainage over the site is towards the south-west, while the Olifants River flows in towards the north further downgradient.

The area is located in the Eastern Highveld with gently rolling hills and shallow valleys. The natural topography of the area has generally been disturbed by several mining activities in the region which have been conducted over the past several decades. Typically, opencast mining and rehabilitation activities affects the natural topography. Wetlands have formed in the region of some of the flooded opencasts and vary from small scale vegetated depressions to large fixed features.

The topography within the Trentra mining area ranges between 1 540 metres above mean sea level (mamsl) south of the proposed mining area at the Olifants River to 1 600 m just north of the proposed mining area. The topography in the Trentra mining area generally dips towards the south-west at a gradient of 0.03.

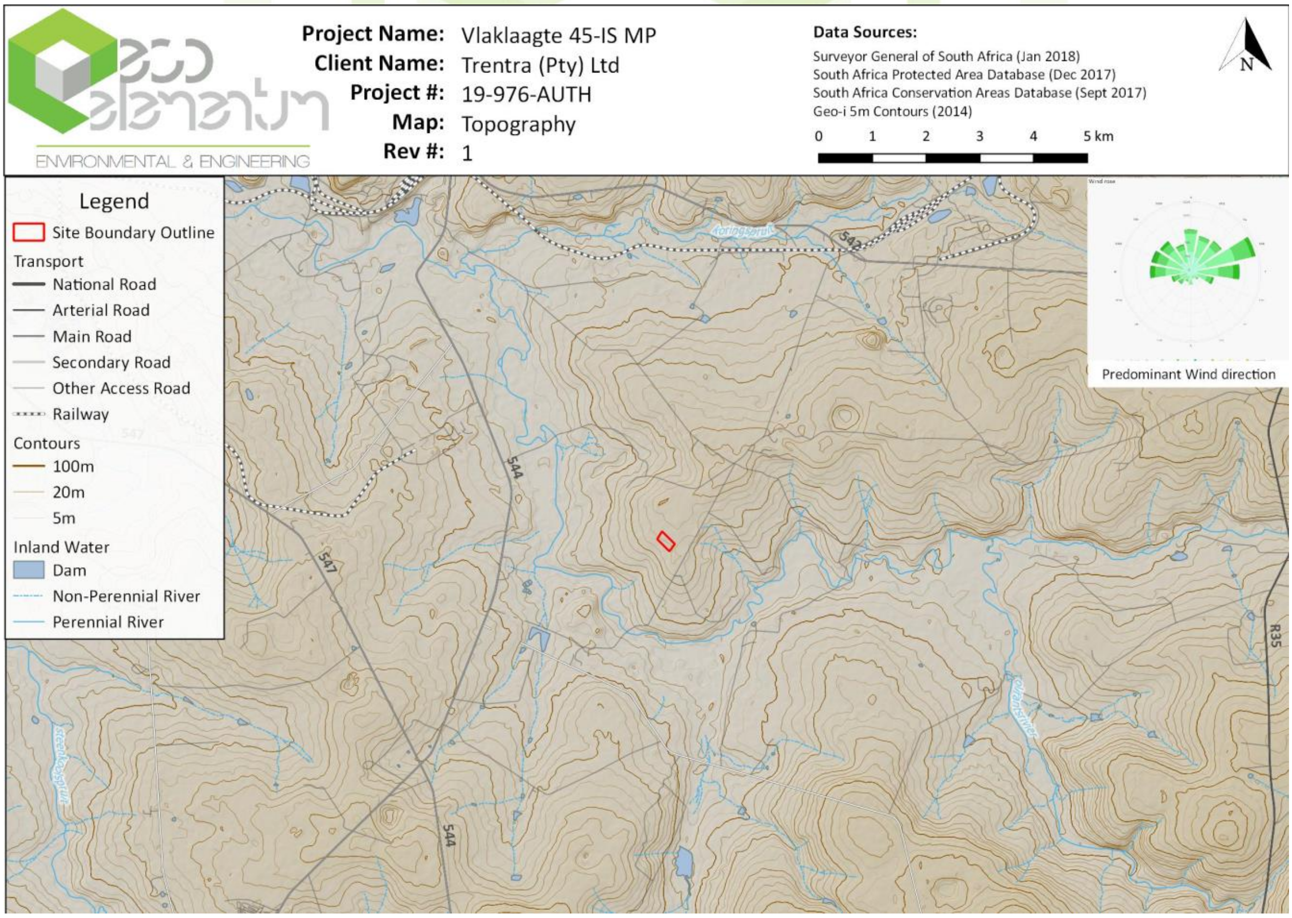

Figure 2: Topographical map for the proposed Trentra mining area.

2.2 Climate

The average daily maximum temperatures range from 17°C in June to 26°C in February, with nightly minimum ranging from 0.5°C in June to 13°C in January, February and December.

The average precipitation for the Trentra region is presented in **Figure 3** (WRC, 2015). The average precipitation for the region is approximately 665 mm/a with the majority of the rainfall over the summer months between October and March. Rainfall within the Highveld region is mainly contributed by thunderstorms where a large quantity of rainfall occurs within a short period of time.

Evaporation data is scarce and generally old. From available data the average annual precipitation for the Trentra area is ± 1 700 mma/a.

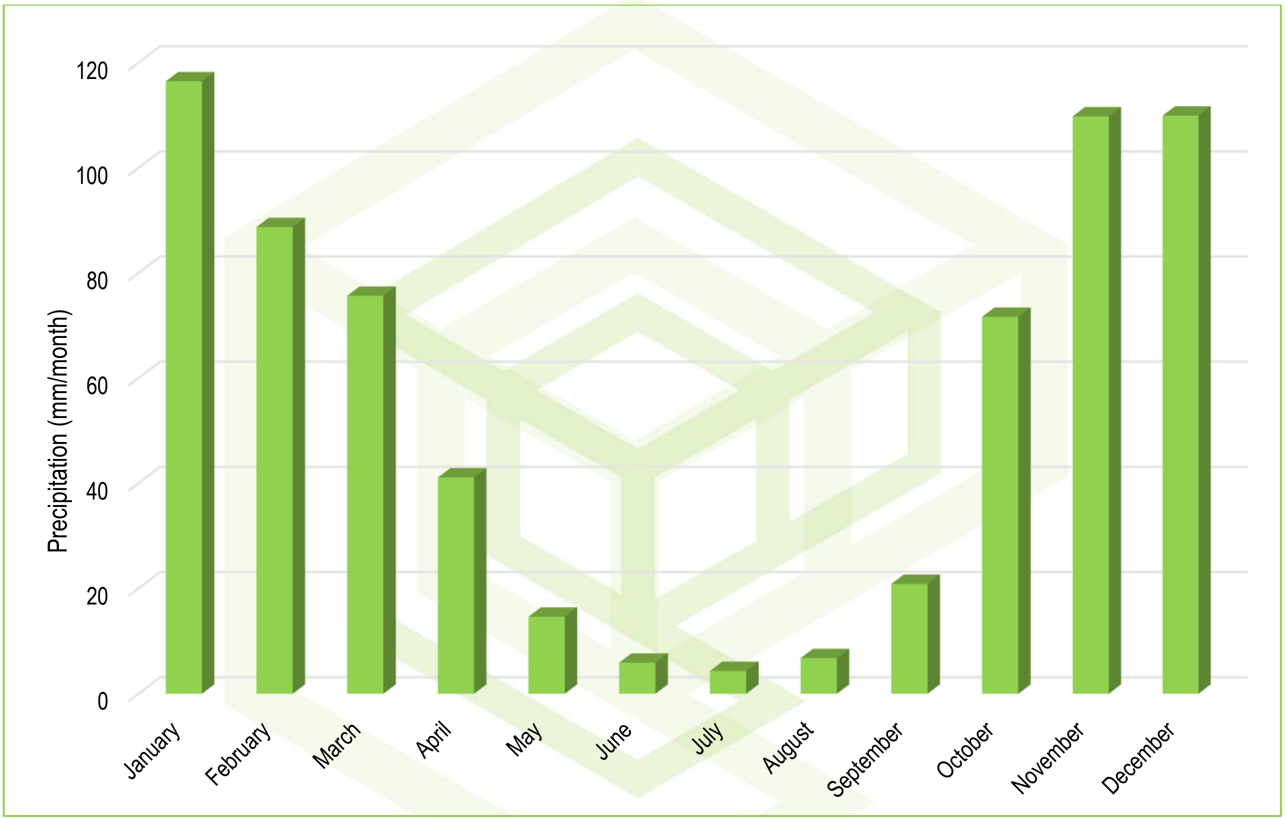

Figure 3: Monthly precipitation in the proposed Trentra Vlaklaagte mining area (WRC, 2015)

3. SCOPE OF WORK

The main aim of this report is to determine and discuss the main impacts of the proposed mining at Trentra Vlaklaagte. This report will include discussions on:

Asses the baseline conditions;

- Topography,
- Climate,
- Geology,
- Hydrogeology:
    - Unsaturated zone,
    - Saturated zone,
    - Groundwater recharge,
    - Hydraulic conductivity,
    - Groundwater levels,
    - Potential impacts on groundwater quality and quantity,
    - Aquifer characteristics.

1. Conceptualize the project area,
2. Numerical Groundwater modelling,
    - Determine the impacts of the mining activities including:
        - Impacts on the water levels,
        - Impacts on the water quality,
        - Groundwater ingress to the mining areas.
3. Assess and determine the quantity and quality of decant post-closure.
4. The groundwater monitoring system,
5. Groundwater Environmental Management Programme,
6. Post-closure management plan.

The information sources for the Trentra Vlaklaagte mining geohydrological study include:

- Mine layouts and schedules obtained from the mine,
- Topographical and geological maps as well as satellite imagery for describing the physical site properties;
- Geohydrological and EIA reports compiled:
    - GCS, 2017. 2 Seam Pty Ltd Mine: Hydrogeological Assessment Report. Report Number: 15-0939.
    - GCS, 2019. Dorstfontein West – Hydrogeological Investigation Scoping Report.
    - SRK Consulting, 2017. Integrated Water and Wastewater Management Plan (IWWMP) for the Dorstfontein East Mine Extension of Pit 1 and Water Transportation Pipeline from Dorstfontein West to Dorstfontein East, eMalahleni Local Municipality, Mpumalanga.
- DWA series of maps that include:
    - Groundwater Quality of South Africa;
    - Aquifer Classification of South Africa;

- Aquifer Vulnerability of South Africa; and
- Aquifer Susceptibility of South Africa.

4. METHODOLOGY

4.1 Desk Study

This geohydrological investigation is based on a desk-top study with all the information gathered from the previous geohydrological investigation conducted in the area for mining projects in the vicinity of Trentra Vlaklaagte. This study and associated information have been assessed and used for the investigation as part of the EIA.

- GCS, 2017. 2 Seam Pty Ltd Mine: Hydrogeological Assessment Report. Report Number: 15-0939.
- GCS, 2019. Dorstfontein West – Hydrogeological Investigation Scoping Report.
- SRK Consulting, 2017. Integrated Water and Wastewater Management Plan (IWWMP) for the Dorstfontein East Mine Extension of Pit 1 and Water Transportation Pipeline from Dorstfontein West to Dorstfontein East, eMalahleni Local Municipality, Mpumalanga

4.2 Results Of Hydrocensus / User Survey

A hydrocensus survey is conducted to locate boreholes and springs within a specified area. The uses of the groundwater from the boreholes and springs are recorded together with abstraction rates, borehole depths and all possible properties of the boreholes are noted. Where possible water levels and water samples are taken for analysis.

GCS conducted a hydrocensus for the 2 Seam Vlaklaagte area in 2017. The results of the hydrocensus will be summarised in this section. A total of 20 boreholes were located during this hydrocensus. **Figure 4** indicates the uses of groundwater recorded during the census. The majority of the boreholes were not in use while 40% was used for domestic and stock watering purposes.

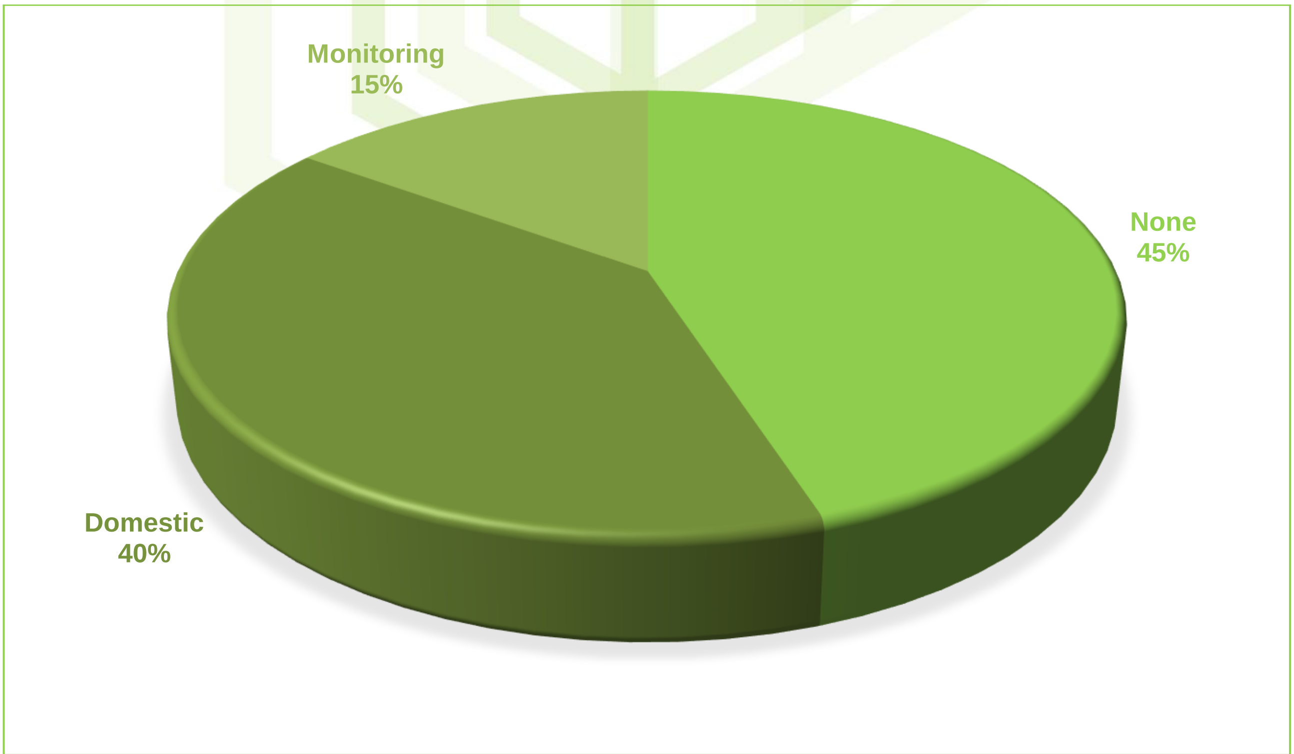

Figure 4: Groundwater use for 20 boreholes within the Trentra Vlaklaagte mining area.

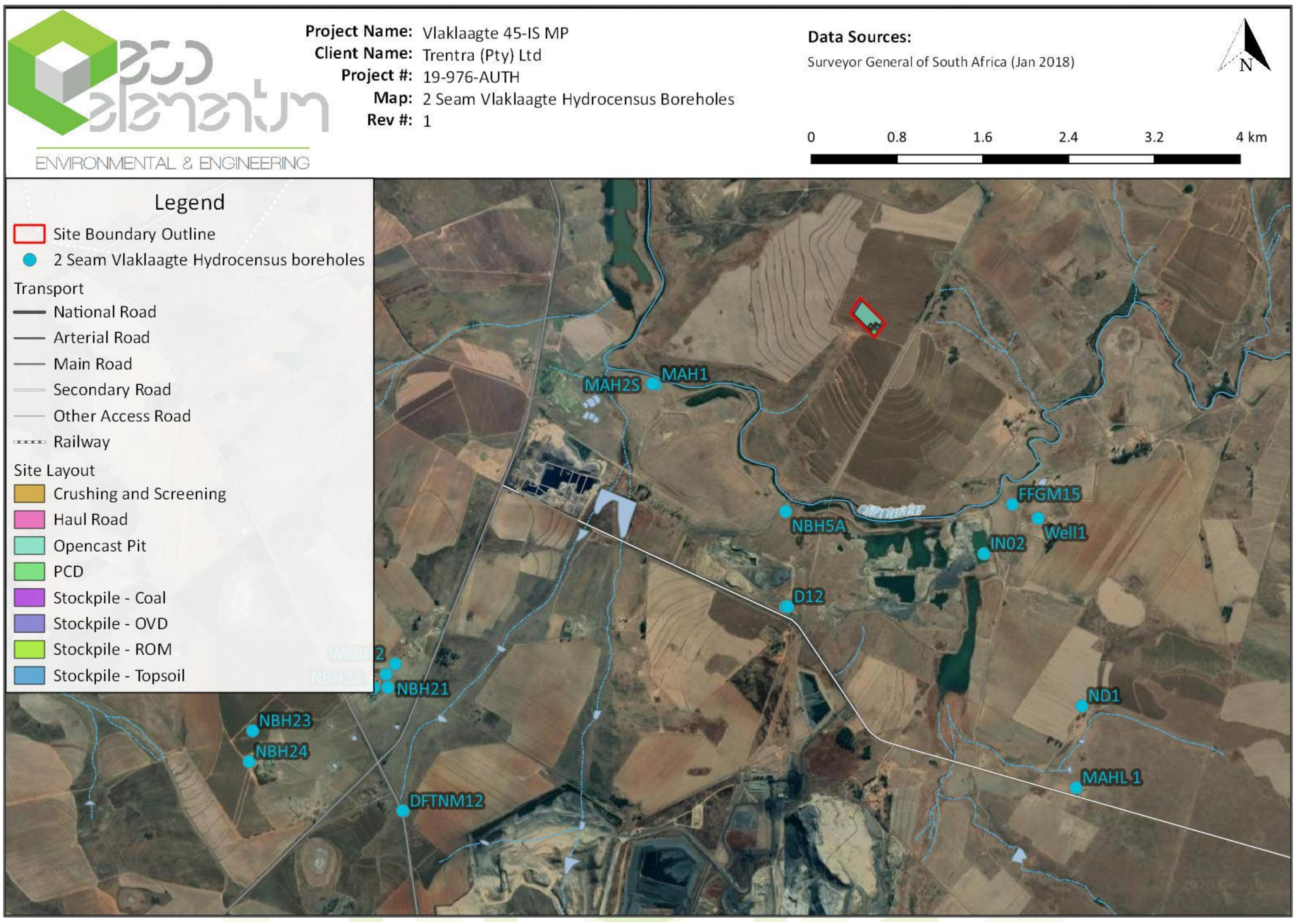

Figure 5: Positions of the 2 Seam Vlaklaagte hydrocensus boreholes.

Table 1: 2 Seam Vlaklaagte hydrocensus borehole information (GCS, 2017).

Borehole	X-coord	Y-coord	Elevation (mamsl)	Owner	Farm Name	Equipment	Abstraction Rate (l/s)	SWL (mbs)
IN02	37311	-2896147	1540	Unknown	Vlaklaagte	None	N/A	4,3
MAH1	34562	-2894567	1538	Unknown	Vlaklaagte	1532,1	N/A	5,9
MAH2S	34537	-2894561	1537	Unknown	Vlaklaagte	1531,8	N/A	5,2
MAH2M	34537	-2894561	1537	Unknown	Vlaklaagte	1531,8	N/A	5,2
MAH2D	34537	-2894561	1537	Unknown	Vlaklaagte	1530,8	N/A	6,2
ND1	38128	-2897564	1552	Unknown	Vlaklaagte	Windmill	N/A	2,0
MAHL 1	38076	-2898323	1563	S. Mahlangu	Vlaklaagte	Hand Pump	Unknown	-
DFTNM12	32442	-2898525	1600	Exxaro	Vlaklaagte	1589,8	N/A	10,3
Well1	37765	-2895820	1558	P.Chabagu	Vlaklaagte	1557,4	N/A	0,7
FFGM15	37550	-2895690	1552	Unknown	Vlaklaagte	1551,1	N/A	0,9
NBH5	35648	-2896634	1571	South 32	Vlaklaagte	N/A	N/A	8,6
NBH5A	35650	-2895750	1543	South 32	Vlaklaagte	N/A	N/A	11,7
DFTNM12	32434	-2898521	1595	Exxaro	Welstand	None	N/A	7,22
WSBH2	32375	-2897158	1599	Mr. Swart	Welstand	Submersible Pump	1,0	21,9
NBH21	32314	-2897377	1598	Mr. Swart	Welstand	Submersible Pump	1,0	15,2
NBH22	32194	-2897379	1599	Mr. Swart	Welstand	Windmill	N/A	20,6
NBH23	31179	-2897776	1612	IJG De Wet	Potion 2, Rietkuil	Submersible Pump	1,0	50,7
NBH24	31149	-2898062	1614	IJG De Wet	Potion 2, Rietkuil	Submersible Pump	1,0	13,2
BHU1	32298	-2897254	1604	South 32	Welstand	None	N/A	6,9
D12	35665	-2896635	1565	Unknown	Vlaklaagte	Windmill	N/A	3,1

4.3 Geophysical Survey And Results

A geophysical survey was not conducted for the Trentra Vlaklaagte mining area. Boreholes were sited up- and down-stream of the proposed mining areas by means of topographical data.

4.4 Drilling And Siting Of Boreholes

No new monitoring boreholes were drilled as part of this geohydrological investigation. Monitoring borehole positions were proposed and their locations are indicated in Error! Reference source not found.. It is suggested that geophysics be conducted to determine the best positions of the monitoring boreholes in the regions as indicated in Figure 22.

4.5 Aquifer Testing

Aquifer testing are conducted to determine the hydraulic aquifer characteristics which include the transmissivity or hydraulic conductivity. Aquifer testing is the abstraction of measured quantities of water over a period of time. Aquifer testing also involves the recovery of the water levels after the abstraction of groundwater has stopped. The results of the aquifer tests are important to form a conceptual model for the study area. This in turn form an integral part of the numerical groundwater modelling.

Transmissivity is the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It is expressed as the product of the average hydraulic conductivity and thickness of the saturated portion of an aquifer.

$$T = KhD$$

Where: T is the transmissivity,

Kh is the average horizontal conductivity (measured in length per unit time),

D is the aquifer thickness.

Aquifer tests were conducted by GCS in 2017 on the 5 monitoring boreholes for 2 Seam Vlaklaagte (Figure 6). Slug tests were conducted on all five boreholes, while constant discharge tests were performed on three of the boreholes. The results of the tests are summarised in **Table 2.** The Bouwer-Rice curve fitting method was used to estimate the hydraulic conductivity for the falling head tests, while the Cooper-Jacob curve fitting method was used to estimate the Transmissivity for the recovery testing.

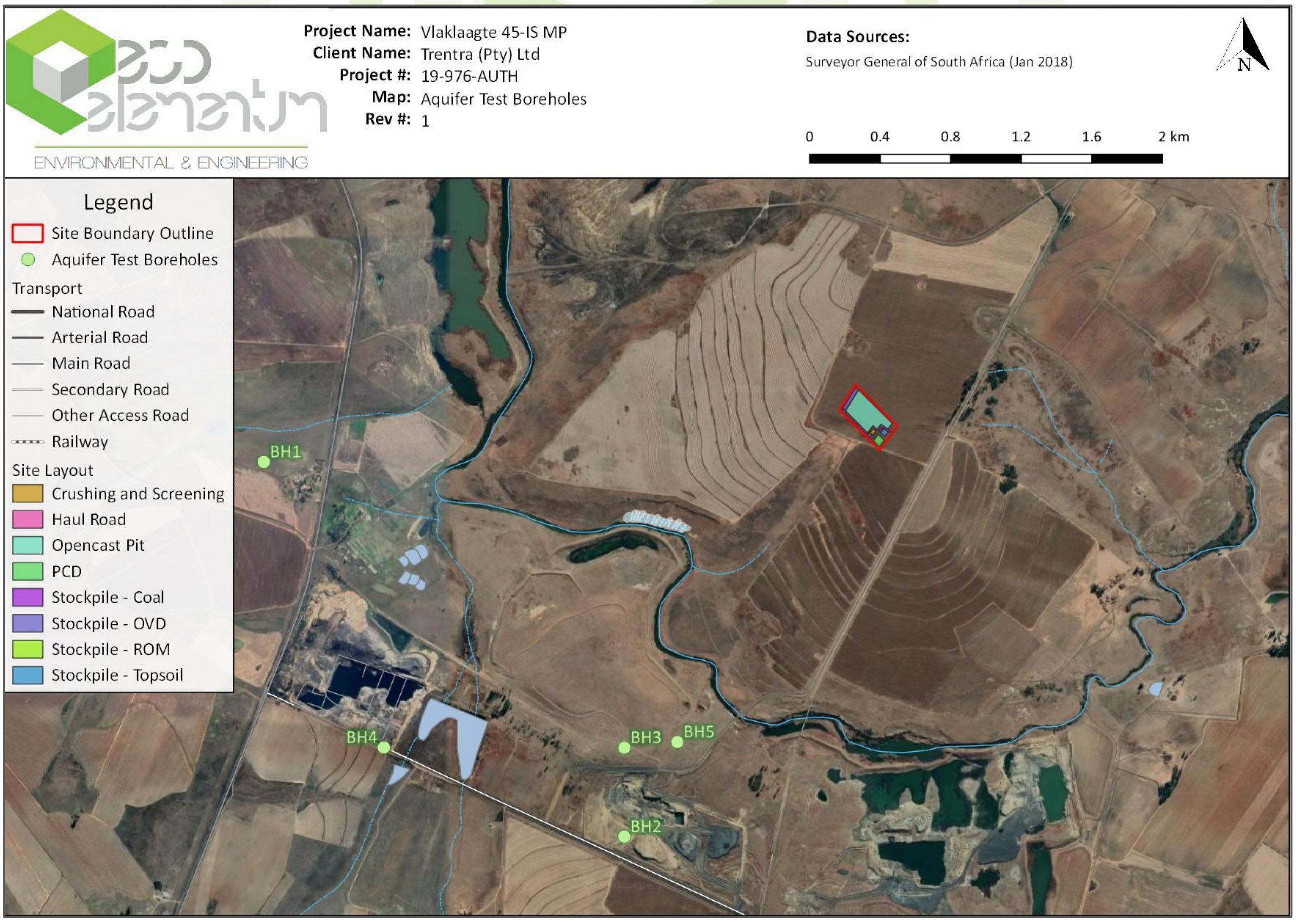

Figure 6: Aquifer test boreholes from the GCS 2017 study.

Table 2: 2 Seam Vlaklaagte Aquifer tests summary.

Borehole ID	SWL (mbs)	Slug Test Results			Recovery Test		
		Duration (min)	Maximum Displacement (m)	Hydraulic Conductivity (m/day)	Duration (min)	Maximum Displacement (m)	Transmissivity (m^2/day)
BH1	5,71	121	0,36	0,025	-	-	-
BH2	15,71	10	0,346	3,5	40/32	5,72	2,8
BH3	8,08	121	0,335	0,031	37/362	21,39	0,7
BH4	6,48	120	0,323	0,056	-	-	-
BH5	17,96	120	0,346	0,097	23/304	12,13	1,2

The results of these tests indicated the following:

- Transmissivity: 0.7 to 2.8 m^2/day,
- Hydraulic Conductivity: 0.031 to 3.5 m/day.

It could be that the higher transmissivity and hydraulic conductivity values measured in the on-site monitoring boreholes are influenced by the presence of the underground voids or previous blasting activities (GCS, 2016).

Aquifer tests were also discussed in the 2019 GCS report for Exxaro Dorstfontein West. The results yielded transmissivity values of between 0.01 and 22.5 m2/day with an average value of 3.3 m2/day. Hydraulic conductivities determined from aquifer tests correspond with expected hydraulic parameters for Karoo Aquifers. The values range from 10-2 to 10-4 m/d.

Table 3: Statistics of Transmissivity from the 2019, GCS report.

Transmissivity values (m^2/day)	
Number of observations	36
Minimum	0.01
Maximum	22.25
Average	3.32
Geomean	0.75
Harmonic mean	0.06

4.6 Sampling And Chemical Analysis

As this study is a desk-top investigation, no sampling for chemical analysis was conducted. Chemical information is available only from previous studies conducted in the region of the proposed mining area.

The following parameters should be analysed for in the monitoring program:

pH, Electrical Conductivity, Total Dissolved Solids, Calcium, Magnesium, Sodium, Potassium, Total Alkalinity, Chloride, Sulphate, Nitrate, Fluoride, Aluminium, Iron, Manganese, free and saline ammonia, Suspended Solids, Total Hardness, Turbidity, Dissolved Oxygen, Ortho Phosphate.

The quality analysis of these parameters should continue and be conducted by a SANAS approved laboratory.

4.7 Groundwater Recharge Calculations

Groundwater recharge is mainly identified as the percentage of mean annual precipitation (MAP) that seeps through the unsaturated zone and reaches the saturated zone. Therefore, the percentage that contributes to the aquifer water make after run-off and evaporation. Recharge to the region of the Trentra Vlaklaagte mining area has been estimated by the following methods (van Tonder & Xu, 2000):

- Soil cover,
- Geology,
- VegterAcru,
- Harvest Potential,
- Expert's Guesses.

These estimations represent the general region of the study site and the characters on site may differ by small percentages.

Table 4: Recharge estimations for the proposed Trentra Vlaklaagte mining region.

Method	% of MAP	Certainty level (High = 5, Low = 1)
Soil	2,8	1
Geology	2,9	3
Vegter	4,8	1
Acru	3,0	3
Harvest Potential	3,0	3
Expert's Guesses	2,0	3
Average	3.1	**2.3**

The Vegter method estimates the recharge in the Trentra Vlaklaagte mining area to be a very high 4.8% of the MAP. Compared to the other methods this value is somewhat high at 4.8%. Recharge to the Trentra Vlaklaagte mining area is estimated to be as much as 3.1% if the Vegter method is included. If the Vegter method is disregarded from the estimation, the recharge is estimated to be 2.7%. Depending on the soil coverage, geology and other relevant factors the recharge may be higher and lower in some areas. Based on work by Kirchner et al. (1991) and Bredenkamp (1995) the recharge can range between 1% to 3% of the mean annual precipitation (MAP).

4.8 Groundwater Modelling

Groundwater modelling is an effective tool used for groundwater management and remediation. It is a simplified representation of reality used to replicate current groundwater conditions as well as predicting future potential impacts or conditions of the groundwater regime.

Once a conceptual model has been formed, the fundamentals are used as the basis of the numerical groundwater model. Known characteristics such as the aquifer parameters including transmissivity and conductivity as well as measured water levels, qualities, recharge etc. are used to calibrate the model.

Both flow and mass transport models were constructed for the proposed Trentra Vlaklaagte mining area. The software, model set-up and boundaries used are discussed in more detail in Section 7 of this report.

4.9 Groundwater Availability Assessment

No site-specific groundwater availability assessment was conducted. The following section is based on the quaternary catchment B11B and was extracted from: Department of Water and Sanitation (2017), Reserve Determination of Water Resources for the Catchments of the Olifants and Letaba in Terms of Section 16(1) and (2) of the National Water Act, 1998 (Act No. 36 Of 1998). Government Gazette, 22 September 2017, Vol. 627. No. 41132. Part 2 of 3.

"Resources Directed Measures (RDM) study results since 2005 for the study area. The sources of the datasets were: (i) Groundwater Resources Assessment Phase II (DWAF, 2005), (ii) Leshika Water Systems Management (2013 and 2014), ((iii) Exigo (2009) and SRK (2009).

Some variations in the groundwater recharge and baseflow were noted and where possible, a mean value was adopted. BHN values were calculated using a GIS algorithm around perennial river systems to differentiate between surface water and groundwater users – this application is not fully accurate as the differentiation of perennial and non-perennial river systems is vague in real time.

The prescribed GRDM algorithm was used and an "allocable groundwater" volume (MCM/a) was calculated. Two different Stress Indexes (SRK, 2009, Exigo, 2009 and WSM, 2014)) were adopted – although significant variations between the two sources were noted in a few cases.

A groundwater quantity ranking approach was applied, based on a ranking approach followed by SRK 2009, from an Unmodified System (A) to a Critically Modified System (F). This ranking approach was applied by considering the differences between the different data sources, but specifically applying a larger weight on the actual allocable groundwater (SRK-WSM) and physical assessments from the Exigo dataset.

The allocable groundwater value (MCM/a), as well as the dependence (%) of the Reserve depending on the groundwater recharge forms the basis of the ranking process. Several cases where the allocable groundwater value is ZERO, the quantity ranking was accordingly lowered (towards D, E or F) depending on the reserve dependence on recharge.

The potential impact of groundwater abstraction on the surface water component in the quaternary catchments is listed as well and use as a factor where the groundwater allocation was ZERO."

The allocable groundwater in the quaternary catchment of B11B were estimated to be 1.32 Mm^3/annum.

Table 5: Groundwater Resource Directed Measures (GRDM).

Catchment	B11B
Area (km^2)	435.3
Recharge to Aquifer (Mm^3/a)	5.66
Baseflow (Mm^3/a)	4.54
Ecological Water Requirement (Mm^3/a)	0.068
Basic Human Need Reserve (Mm^3/a)	0.12
Total Groundwater Reserve (Mm^3/a)	5.49
Total Groundwater Use (Mm^3/a)	0.20

Si = Groundwater Use / Aquifer Recharge (Mm^3/a)	0.39
Reserve (% of recharge)	80.3
Quantity (GRDM)	Unmodified
Surface Water Impact	Low
Allocable Groundwater (Mm^3/a)	1.32

5. PREVAILING GROUNDWATER CONDITIONS

5.1 GEOLOGY

5.1.1 Regional Geology

The following section on the regional geology have been extracted from the GCS, 2017 report.

All of the known coal deposits in South Africa are hosted in sedimentary rocks of the Karoo Basin, a large foreland basin which developed on the Kaapvaal Craton. The Karoo Supergroup is litho-stratigraphically subdivided into the Dwyka, Ecca and Beaufort groups. Sediments of the Dwyka Group and the coal-bearing Ecca Group developed on an undulating pre-Karoo erosion surface consisting of granite of the Lebowa suite, considered as the basement rock.

The undulating nature of this surface has had a large influence on the thickness and depth of the deposited coals seams.The coal seams are usually separated by course to fine-grained sandstone, siltstone and/or shale at the top. Glauconitic sandstones, indicative of transgressive marine periods, are present above the No.4 and No.5 Seams. The coal zone is overlain by another deltaic sequence, which consists of sandstone and sandy micaceous shale and siltstone with varying thickness (approximately 60 to 100 m thick).

Fractures are common in rocks such as sandstone, shale and coal as part of the Karoo sediments. Dolerite intrusions, in the form of sills or dykes cause in some locations various mining problems (i.e. devolatised coal, weakened roof strata and/or displaced coal seams), where near vertical dykes have very little displacement associated transgression through the seam.

Sill transgressions, on the other hand, generally results in displacement of the coal seams and strata. The magnitude of these displacement being dependent on a number of factors, including sill thickness and presence / orientation of pre-existing zones of weakness. These intrusions introduce local structural complexity by displacing seams relative to one another and isolating blocks of coal.

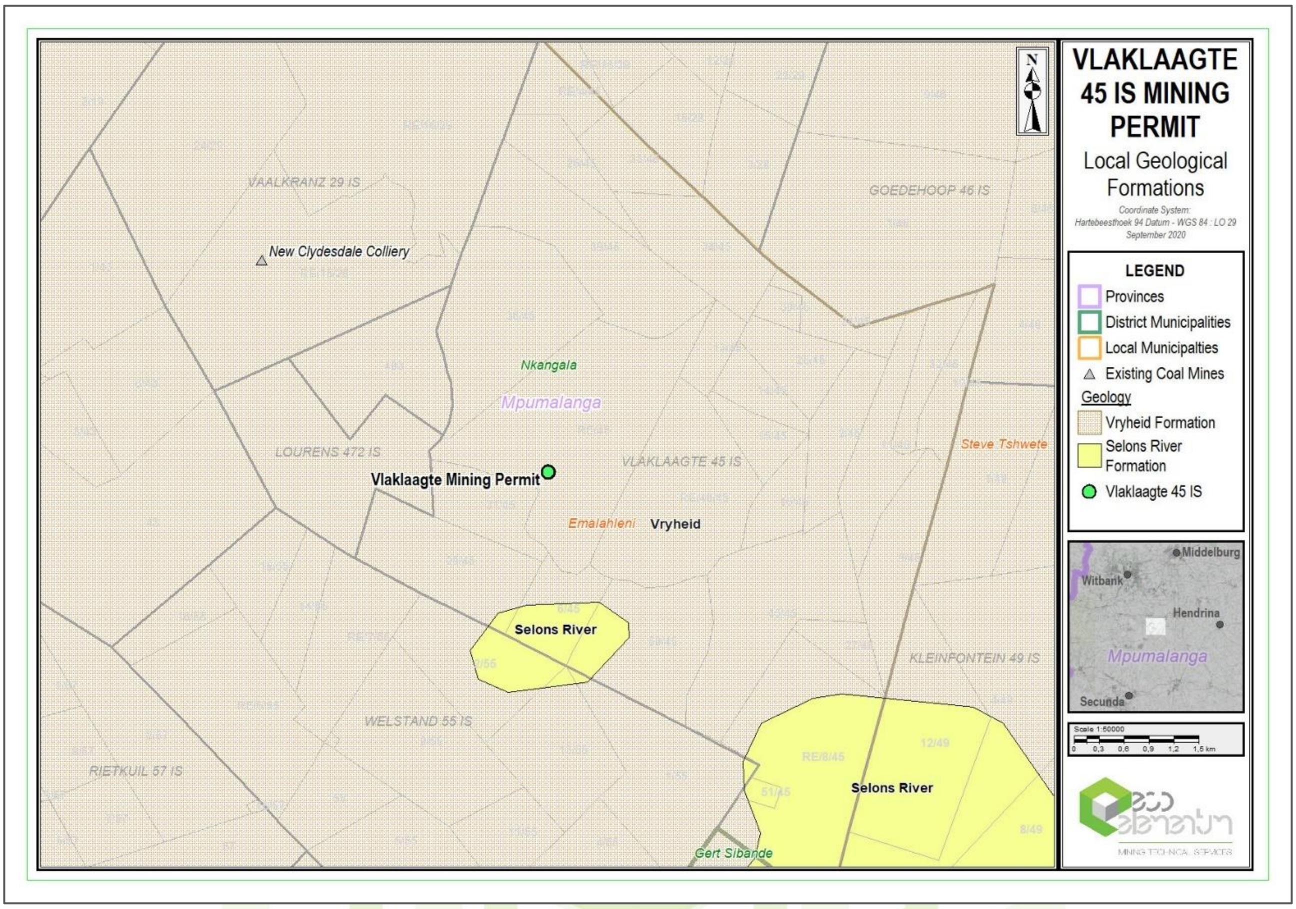

Figure 7: **Regional geology in the Trentra Vlaklaagte mining area.**

5.1.2 Local Geology

The following section on the regional geology have been extracted from the GCS, 2017 report. Similar geology can be expected at Trentra Vlaklaagte.

The coal reserves located at the project site form part of the Springs-Witbank Coalfield. The Karoo sediments at the project site comprise of the coal bearing Vryheid Formation (Ecca Group) and consists predominantly of fine grained sandstone, platy shale and coal (No. 4, No. 2 and No. 1 seams). Combinations of these rock types are often found in the form of interbedded shale, coal and sandstone.

The Ecca group at the project site is relatively thin and thicknesses range between 30 mbs to near surface. Based on the available data from previous studies and exploration boreholes at the site no evidence of large-scale intrusions of dykes or sills have been encountered at the site. The undulating nature of the pre-Karoo formations has resulted in sub-outcropping occurring in the south-south-eastern portion of the project site.

The coal seams (and strata) at the site are generally flat lying to gently undulating with a, regional dip to the south south-east. Due to the varied depositional environments (e.g. basement topography) and the present-day erosional surface not all of the seams are present at any one locality.

5.2 HYDROGEOLOGY

5.2.1 Unsaturated Zone

The unsaturated zone is the zone between the ground surface and the static water table. In the unsaturated zone the pores between the ground particles are filled with air and water- thus below saturation. Static water levels in the region of the 2 Seam Vlaklaagte mining areas obtained from the GCS (2017) report, generally range from less than 1 to15 mbs, therefore also the thickness of the unsaturated zone. These levels, under steady state conditions, can also be expected at the proposed Trentra Vlaklaagte mining area. The unsaturated zone may consist of soil, weathered bedrock and even solid bedrock from the sandstone and shale of the Ecca Group.

5.2.2 Saturated Zone

The saturated zone is that part of the aquifer below the regional static water level where all pores and fractures are filled with water at a pressure greater than atmospheric pressure. The depth of the saturated zone in the Trentra Vlaklaagte mining area, is therefore from ±1 to 15 mbs. From the GCS 2017 study and other studies in the region of the proposed Trentra Vlaklaagte mining area, the saturated zone mainly consists of two aquifer systems.

- Firstly, the weathered, unconfined aquifer that typically occurs on the transition between soil and weathered bedrock (typically sandstone and shale). The groundwater flow closely mimics the surface topography. Groundwater levels are usually shallow in the low lying topographical regions and may even daylight on surface which is referred to as springs. The weathered aquifer is more prominent in the wet season because it is located on top of solid bedrock or clayey layers. This aquifer normally has a low yield.
- The second aquifer is known as the deeper, confined aquifer. Flow in this aquifer mainly occurs along fractures, bedding planes and other groundwater flow paths. The presence of fractures generally decreases with depth in this aquifer. The secondary aquifer, due to its heterogeneous nature, may be higher yielding than the weathered aquifer. Due to longer residence time of the groundwater in this aquifer, the salt load may be higher than that of the weather aquifer.

A third aquifer at great depth may occur within the pre-Karoo geology (Transvaal Group), underlying the Dwyka-tillites. Very little information of this aquifer in the area is available since very few boreholes have been drilled to this great depth. The water quality and quantity in this aquifer may be inferior to that of the overlying Karoo aquifers.

5.2.3 Hydraulic Conductivity

Hydraulic conductivity refers to the ease with which water passes through a porous medium in a certain time under a hydraulic gradient (m/d). Hydraulic Conductivity (K) can be determined as:

$$K = \frac{\text{Transmissivity (T)}}{\text{Aquifer thickness (d)}}$$

Aquifer testing conducted during the 2017 study by GCS at 2 Seam Vlaklaagte identified the hydraulic conductivity of the aquifer. The hydraulic conductivity varied between 0.025 and 3.5 m/d. The high hydraulic conductivity in BH2 may be an indication of a connectivity with the old underground mine workings that has been flooded in all probability.

Of all the fresh sediments in the Ecca, the coal seams often have the highest hydraulic conductivity. Packer testing of the No. 2 seam (GCS, 2017) has the hydraulic conductivity distribution as indicated in **Table 6.** The results suggest that groundwater flow through the 2 seam is possible.

Table 6: 2 Seam Vlaklaagte: Statistics for results of packer tests (GCS, 2017).

Statistics	No. 2 Seam Hydraulic Conductivity (m/day)
Mean	0.102
Median	0.074
Standard deviation	0.13
Minimum	0.0007
Maximum	0.5

5.3 Groundwater Levels

Groundwater level information is available for the Vlaklaagte area as they were recorded during the GCS study in 2017. No water levels were available for the proposed Trentra Vlaklaagte mining area. Groundwater levels from the 2 Seam Vlaklaagte area generally varied from less than 1 to 15 mbs in the boreholes recorded during the hydrocensus and in the monitoring boreholes. Some deeper levels were observed but the majority of these levels were boreholes equipped with pump equipment which indicates that the levels may be affected by dewatering.

Table 7: Summary of 2 Seam Vlaklaagte water levels in the boreholes used as calibration points in the numerical model.

Borehole ID	X-coord	Y-coord	Surface Elevation (mamsl)	Static Water Level (mbs)	Water level Elevation (mamsl)
IN02	37311	-2896147	1540	4,3	1535,7
MAH1	34562	-2894567	1538	5,9	1532,1
MAH2S	34537	-2894561	1537	5,2	1531,8
MAH2M	34537	-2894561	1537	5,2	1531,8
MAH2D	34537	-2894561	1537	6,2	1530,8
ND1	38128	-2897564	1552	2,0	1550,0
DFTNM12	32442	-2898525	1600	10,3	1589,8
Well1	37765	-2895820	1558	0,7	1557,4
FFGM15	37550	-2895690	1552	0,9	1551,1
NBH5	35648	-2896634	1571	8,6	1562,4
NBH5A	35650	-2895750	1543	11,7	1531,3
WSBH2	32375	-2897158	1599	21,9	1577,1
NBH21	32314	-2897377	1598	15,2	1582,8
NBH22	32194	-2897379	1599	20,6	1578,4
NBH24	31149	-2898062	1614	13,2	1600,8
BHU1	32298	-2897254	1604	6,9	1557,2
D12	35665	-2896635	1565	3,1	1561,9
BH1	33264	-2894197	1552	5,71	1546,0
BH2	35094	-2896316	1557	15,71	1540,8

BH3	35096	-2895814	1536	8,08	1527,9
BH4	33871	-2895810	1544	6,48	1537,7
BH5	35366	-2895783	1544	17,96	1526,1

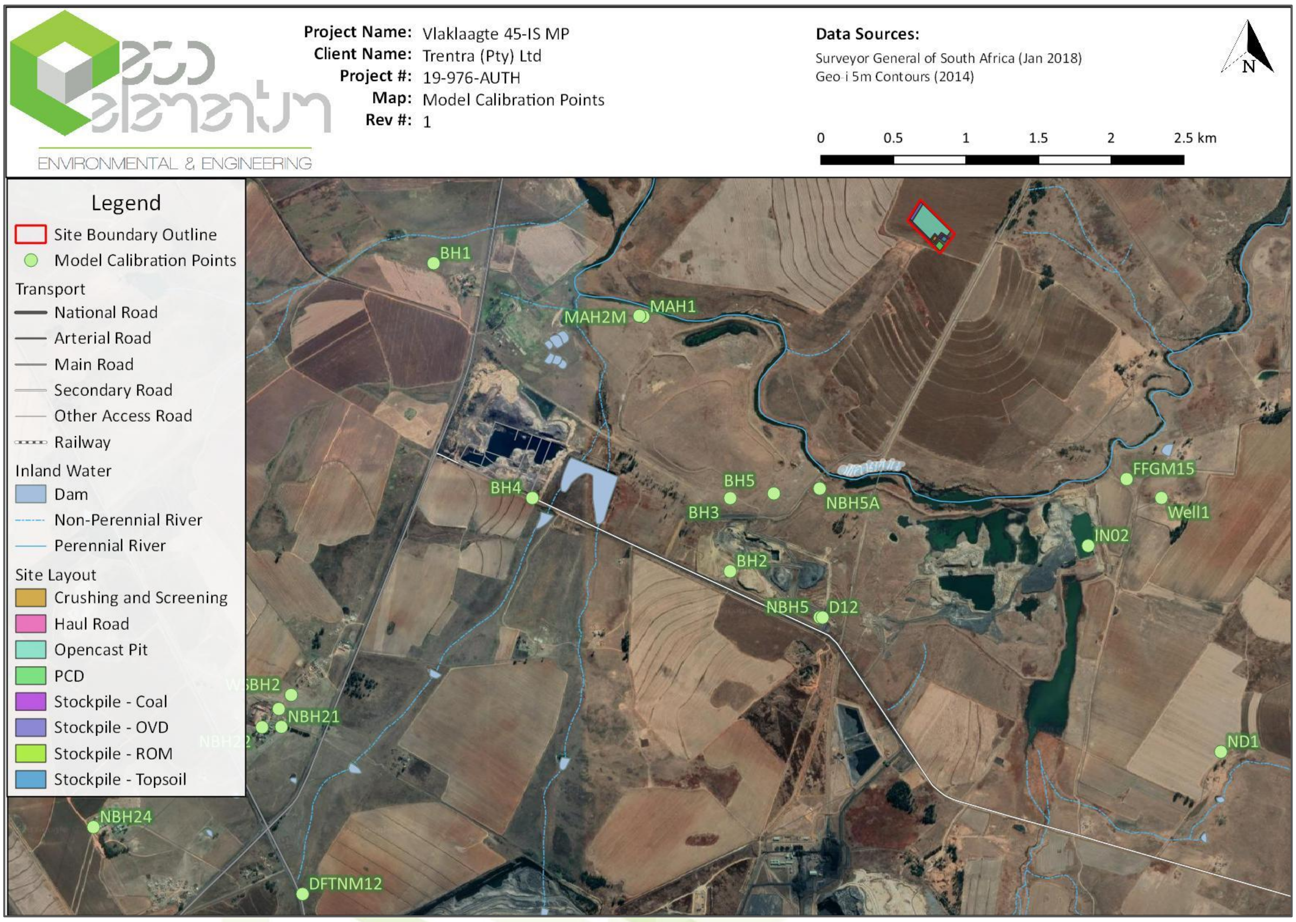

Figure 8: Model Calibration Points for the Trentra Vlaklaagte mining area.

The groundwater level elevations correlate very well with the topography – 95% **(Figure 9)**, which is typical of the Karoo aquifers. In regions where extensive mining in the proposed Trentra Vlaklaagte mining area have occurred, the water levels may have decreased in the near vicinity of the coal mining activities.

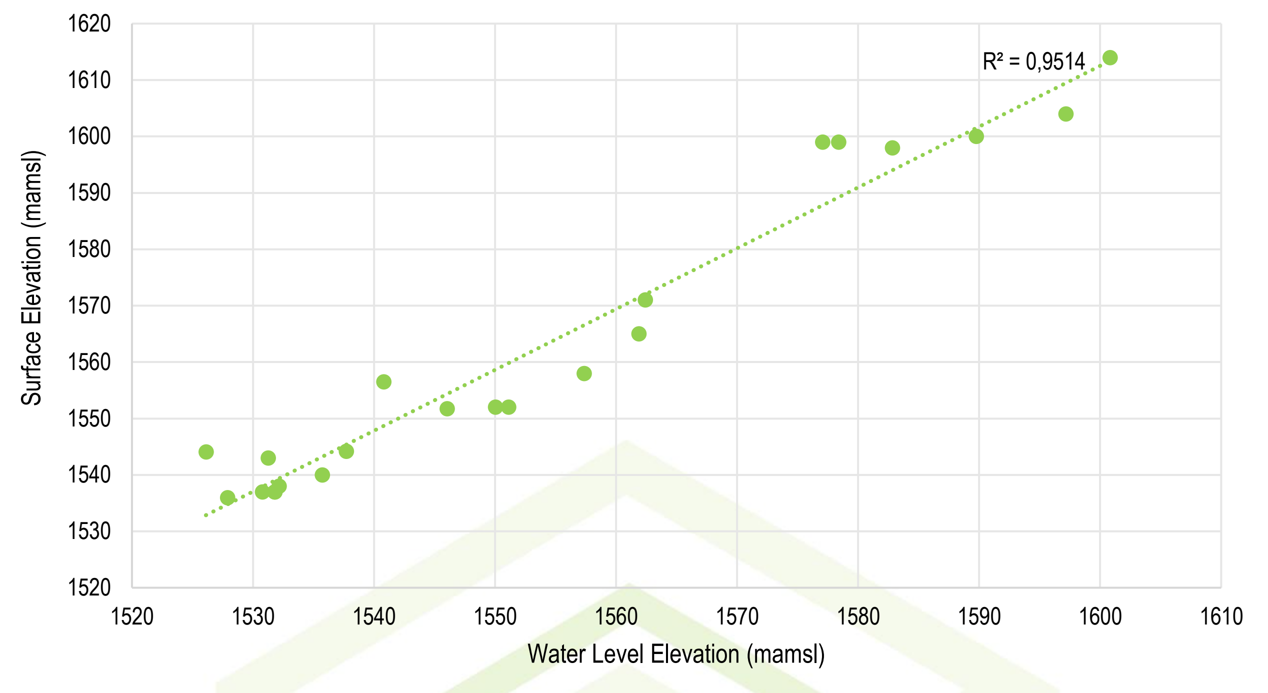

Figure 9: Correlation between groundwater level elevations and topography.

5.4 Groundwater Potential Contaminants

Acid generation is a common response to the coal mining environment. Coal and carbonaceous material contain a mineral known as pyrite, an iron-sulphide mineral, which is the main contributor to acid rock drainage (ARD). After being exposed to oxygen and water the sulphide minerals react to form an acid. Bacteria, which increases with the exposure to water and oxygen often accelerates the acidification process. The reaction can however also occur abiotically.

The general equation of pyrite oxidation is as follows:

$$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2Fe^{2+} + 4SO_4^{2-} + 4H^+$$

Ferrous iron is oxidised to ferric iron:

$$4Fe^{2+} + O_2 + 4H^+ \rightarrow 4Fe^{3+} + 2H_2O$$

As mentioned previously these two reactions can occur abiotically or with the catalisation by micro-organisms. These organisms arise from the oxidation reactions. The ferric cations reduce to ferrous ions:

$$FeS_2 + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H^+$$

The release of H+ lowers the ph. At the lower pH the solubility of the ferric ion continuous which increases the acid generation.

5.4.1 Acid Generation Capacity

ABA tests were conducted during the GCS (2017) study for 2 Seam Vlaklaagte. Similar results can be expected for the proposed Trentra Vlaklaagte mining operation. This section of the report will summarise the finding of the GCS, 2017 report. The ABA classification guidelines are described in **Table 9.** The results of the ABA tests are indicated in **Table 8**.

Table 8: ABA Classification Guidelines.

	Potentially Acid	Uncertain/Marginal	Non-acid Generating

	Generating		
Paste pH	<5.5	-	>5.5
NNP	<-20	-20 to 20	>20
NPR	<1	1 to 3	>3
S%	>0.3%	-	<0.3%
NAG	>0.1	-	<0.1
Rock Type	I	II	III

- ***Notes:***
    - *NNP: Net Neutralizing Potential,*
    - *NPR: Neutralisation Potential Ratio,*
    - *NAG: Net Acid Generation,*
    - *S%: Total Sulphur.*

Table 9: Results of the ABA tests (GCS, 2017).

Lithology	Paste pH	Total %C	Sulphide %S	AP CaCO3 kg/t	NP CaCO3 kg/t	NNP CaCO3 kg/t	NP:AP	Rock Type NNP	Rock Type %S	Rock Type NP:AP
Carbonaceous mudstone/shale	7,73	24,9	0,274	8,58	30,3	21,7	6,43	III	III	III
Coal	7,38	58,2	1,49	46,7	25,7	-21	0,78	I	I	I
Sandstone / Mudstone	7,65	10,4	0,317	9,92	17,54	7,62	2,47	Uncertain	I	III
Weathered sandstone and clay	6,41	9,92	0,12	3,73	5,2	1,47	1,39	Uncertain	III	III

The NAG test provides a direct assessment of the potential for a material to produce acid after a period of exposure (to a strong oxidant) and weathering. The test can be used to refine the results of the ABA predictions. In the Net-acid Generating (NAG) test hydrogen peroxide (H_2O_2) is used to oxidize sulphide minerals in order to predict the acid generation potential of the sample.

Table 10: NAG test screening method (GCS, 2017)

Rock Type	NAG pH	NAG Value (H_2SO_4 kg/t)	NNP ($CaCO_3$ kg/t)
Ia High Capacity Acid Forming	< 4.5	> 10	Negative
Ib Lower Capacity Acid Forming	< 4.5	≤ 10	-
Uncertain, Possibly Ib	< 4.5	> 10	Positive
Uncertain	≥ 4.5	0	Negative (Reassess mineralogy)*

IV Non-acid Forming	≥ 4.5	0	Positive

** if low acid forming sulphides is dominant then Rock Type IV*

Table 11: Net acid generation (NAG) test results

Sample	NAG pH: (H_2O_2)	NAG (kg H_2SO_4/t)	NNP ($CaCO_3$ kg/t)	Rock Type
Carbonaceous Shale 1	4.98	0	11.90	IV
Carbonaceous Shale 2	4.6	0	9.05	IV
Coal 1	5.01	0	-2.45	Uncertain
Sandstone/slightly carbonaceous mudstone	4.08	1.54	16.10	Ib
Coal 2	2.67	8.31	-17.40	Ib

The potential for the material sampled to generate acid mine drainage are summarized as follow (GCS, 2017):

- 33.3% of the carbonaceous mudstone/shale samples collected has a high potential to generate acidic drainage (and will generate a high salt load), 17% has a low potential to generate acidic drainage (and will generate a low to medium salt load), 17% has a very low potential to generate acidic drainage (and will generate a very low to medium salt load), 33.3%) of the carbonaceous mudstone/shale samples collected has no potential to generate acidic drainage (and will generate no salt load);
- 100% of the coal samples collected has a high potential to generate acidic drainage (and will generate a high salt load);
- 50% of the shale samples collected has a very high potential to generate acidic drainage (and will generate a very high salt load), 50% has a verylow potential to generate acidic drainage (and will generate a very low salt load);
- 25% of the sandstone/mudstone samples collected has a high potential to generate acidic drainage (and will generate a high salt load), 38% has a low to medium potential to generate acidic drainage (and will generate a medium to high salt load), 17% has a low potential to generate acidic drainage (and will generate a low to medium salt load), 17% has a very low potential to generate acidic drainage (and will generate a very low to medium salt load) 13, 13% of the sandstone/ mudstone samples collected has no potential to generate acidic drainage (and will generate no salt load); and
- 100% of the soil and clay samples collected has low potential to generate acidic drainage (and will generate a low to medium salt load);
- Overall it can be concluded that about 50% of the overburden/waste rock material (weathered sandstone, clay, sandstone, mudstones, carbonaceous mudstone and carbonaceous shales) have potential to generate acidic drainage if the material is oxidised and leaching occurs subsequently. The coal samples have a high potential to generate acidic drainage if subjected to oxidisation. Usually the coal is mined before significant oxidation occurs and only coal remaining in the mine will potentially be of concern over the long-term.

5.4.2 Waste Classification

A waste classification should be conducted in accordance with the National Environmental Management: Waste Act (NEM: WA) Regulations (2013). The assessment is undertaken by comparing the samples' leachate concentration (LC) to the leachable concentration threshold (LCT), and the total concentration (TC) to the total concentration thresholds (TCT). The results will indicate the type of waste and the type of liner, if any, required for the potential source.

A waste classification was not conducted for the proposed Trentra Vlaklaagte mining area. Generally, the results below are expected for the coal mining environment. Please note that these are only indicative and may differ from site to site.

- Coal material:
  - The coal samples are generally classed as Type 3 waste (hazardous) and according to the NEM: WA guidelines should be disposed of at a Class C landfill site or a site designed with the liner requirements as shown in Figure 10; and
  - The short-term storage of the coal material on stockpiles and good storm water management should ensure that environmental impacts are kept to a minimum and contained to the stockpile sites. Based on these management protocols the liner illustrated in **Figure 10** should be sufficient, however the decision lies with the Department of Environmental Affairs.
- Waste rock material:
  - Waste rock are generally also classed as Type 3 waste and should be disposed of at Class C landfill sites or sites designed with liner requirements illustrated in **Figure 10**.

Table 12: Waste Classification Criteria

Waste Type	Disposal
0	Not allowed
1	Class A or Hh:HH landfill
2	Class B or GLB+ landfill
3	Class C or GLB- landfill
4	Class D or GLB- landfill

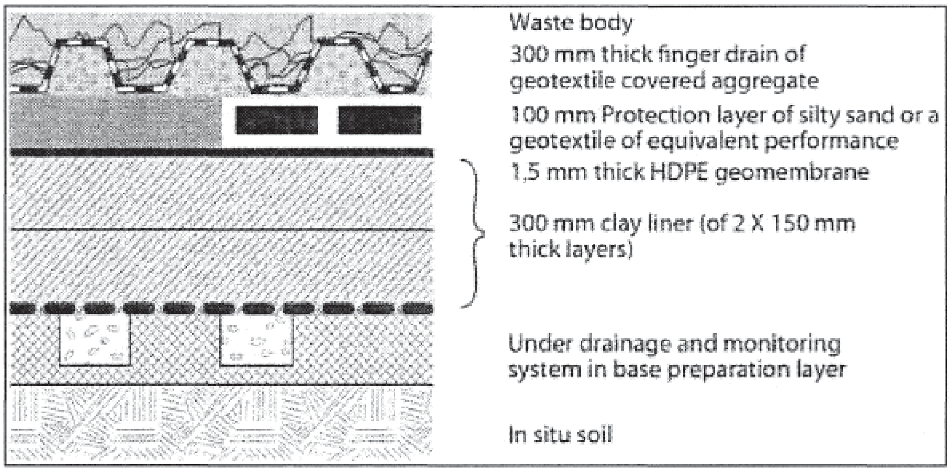

Figure 10: Class C landfill site liner requirements.

5.5 Groundwater Quality

Groundwater quality information is available from the mining areas in close proximity of the mining area. These include 2 Seam Colliery south of the proposed Trentra Vlaklaagte mining area (GCS, 2017) - Figure 5, as well as the Exxaro

Dorstfontein West mining area (GCS, 2019) - Figure 11. The Dorstfontein West hydrocensus borehole qualities are indicated in Table 13 while the 2 Seam Colliery hydrocensus and monitoring boreholes qualities are indicated in Table 14 (GCS, 2017).

The groundwater qualities in the majority of the hydrocensus boreholes were good. Some elevated nitrate concentrations were observed in the 2019 hydrocensus boreholes WSBH1 and NBH4 where the concentrations exceeded the permissible limits for drinking water. Manganese in NBH5A (Table 14) exceeded the permissible limits for drinking water in 2017.

Some of the mine monitoring boreholes from 2 Seam Colliery, south of the proposed Trentra Vlaklaagte mining area, indicated some impacts from mining activities with elevated sulphate concentrations in some of these boreholes (Table 14). The sulphate concentration in BH5 exceeded the maximum permissible limits for drinking water together with the EC and nitrate concentrations in this borehole.

The available water quality information was all south of the proposed Trentra Vlaklaagte mining area, south of the Olifants River. No quality information is available within 1km of the proposed mining area. It is also noted that no known mining activities is situated within 1km of the proposed mining operation and it is therefore not expected that the groundwater in the region of the proposed mining area will be impacted in terms of sulphate and mining related contamination. The proposed mining area is situated in an agricultural area. Agricultural activities may influence the groundwater qualities, but since no quality information for this site is available, no comments can be made in terms of agriculture.

Figure 11: Exxaro Dorstfontein West hydrocensus borehole positions.

Table 13: Groundwater qualities for the Exxaro Dorstfontein West hydrocensus boreholes (GCS, 2019).

	SANS 241-1:2015 Drinking Water Standard	NBH24	RK1	WSBH2	WSBH1	DFTNM12	NBH4	DFTNM4	DFTNM3	D4	D4a
pH Value @ 20°C	5-9.7 O	7,84	7,05	7,43	6,3	7,4	7,63	8,09	7,89	7,45	7,75
Conductivity mS/m @ 25°C	170	38,2	31,7	31,1	46,5	37,2	48,8	34,9	28,7	52,4	38,8
Total Dissolved Solids	1200	274	250	257	384	294	365	263	207	408	300
Calcium, Ca	NS	14,3	16,1	27,1	30,6	14,2	22,8	22,9	16,6	64,7	39,6
Magnesium, Mg	NS	6,84	9,4	11	20,5	10,6	37,6	9,6	11,6	24,6	13,2
Total Hardness as CaCO3	NS	64	79	113	161	79	212	97	89	263	153
Sodium, Na	200	62,6	22,1	27,6	39,7	57,5	7,69	41,7	40,1	27,2	38
Potassium, K	NS	5,78	9,8	5,84	9,76	5,47	3,24	3,16	2,02	2,57	3,27
Total Alkalinity as CaCO3	NS	174	85	69	12	180	110	173	177	234	194
Bicarbonate, HCO3	NS	173	85	69	12	180	109	171	175	233	193
Chloride, Cl	300	28,5	20,8	64,7	94,3	14,6	17,1	7,43	9,48	21,3	18
Sulphate, SO4	500	<0,141	1,57	34,7	22,4	21,7	75	16,5	<0,141	80,1	40,7
Nitrate as N	11	2,48	10,2	0,664	**24,7**	0,542	**12,2**	0,345	0,293	0,832	0,352
Nitrite as N	0.9	0,05	0,06	0,07	0,07	0,07	0,06	0,08	0,07	0,07	0,1
Ammonium, NH4	NS	0,09	0,06	0,02	0,02	0,03	0,07	0,23	0,19	0,03	0,48
Fluoride, F	1.5	0,51	<0,263	0,28	<0,263	0,4	<0,263	<0,263	1,05	<0,263	0,33

	SANS 241-1:2015 Drinking Water Standard	NBH24	RK1	WSBH2	WSBH1	DFTNM12	NBH4	DFTNM4	DFTNM3	D4	D4a
Iron, Fe	2	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004
Aluminium, Al	0.3	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002
Copper, Cu	2	0,098	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002
Chromium, Cr	NS	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003
Orthophosphate as PO4	NS	<0,005	0,05	<0,005	<0,005	<0,005	<0,005	0,013	<0,005	<0,005	<0,005
Lead, Pb	0.01	0,01	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004
Arsenic, As	0.01	<0,006	<0,006	<0,006	<0,006	<0,006	<0,006	<0,006	<0,006	<0,006	<0,006
Selenium, Se	0.04	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002
Mercury, Hg	0.006	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004
Barium, Ba	0.7	0,201	0,171	0,352	0,476	0,111	0,076	0,385	0,65	0,102	0,099
Antimony, Sb	0.02	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Nickel, Ni	0.07	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002
Manganese, Mn	0.4	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Cadmium, Cd	0.003	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002

Table 14: Groundwater qualities for the 2 Seam Colliery hydrocensus and monitoring boreholes (GCS, 2017).

	SANS 241-1:2015 Drinking Water Standard	D12	NBH5	NBH5A	NBH23	NBH24	BH1	BH2	BH3	BH4	BH5
pH Value @ 20°C	5-9.7	8	8,1	7,5	7,8	8	8,1	7,2	7,61	7,21	8,05
EC mS/m @ 25°C	170	42	19,8	75,1	40,2	33	24,4	27,6	117	14,7	297
Total Alkalinity as CaCO3	NS	233	110	208	186	85,6	115	98,8	303	59,3	357
Calcium, Ca	NS	34,7	14,5	61,2	15,2	18,4	17,3	28	93,1	9,59	284
Magnesium, Mg	NS	31,2	12,2	50,7	7	9,9	13,3	10,9	63	5,18	167
Sodium, Na	200	13,5	9,4	44,2	71,8	24,8	13,7	17,5	89,3	11,6	181
Potassium, K	NS	2	5,5	4,8	4,2	9,3	9,21	3,87	4,36	3,65	13,6
Chloride, Cl	300	4,3	4,8	7	29,9	20,3	11,2	8,02	18,2	5,49	97,6
Sulphate, SO4	500	11,2	3,8	244	2,9	4,3	11,4	52,4	410	1,79	1172
Nitrate as N	11	0,3	1,1	0,5	2,7	10,9	0,198	0,448	0,197	1,48	75,5
Iron, Fe	2	<0,004	0,11	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004
Manganese, Mn	0.4	<0,001	<0,001	0,83	<0,001	<0,001	0,13	0,15	0,1	0,054	0,352
Fluoride, F	1.5	0,275	<0,263	0,566	0,603	<0,263	0,398	0,269	0,586	0,385	0,603

6. AQUIFER CHARACTERISTICS

6.1 GROUNDWATER VULNERABILITY

Groundwater vulnerability refers to the likelihood for contamination to reach a certain area/receptor after it has been introduced to the surface. For the Trentra Vlaklaagte mining area the vulnerability was estimated from the Aquifer Vulnerability map of South Africa (DWA, 2013) and by the Groundwater Vulnerability Classification System. According to the Aquifer Vulnerability map the Trentra Vlaklaagte mining area is located in a least to moderate vulnerability rating area.

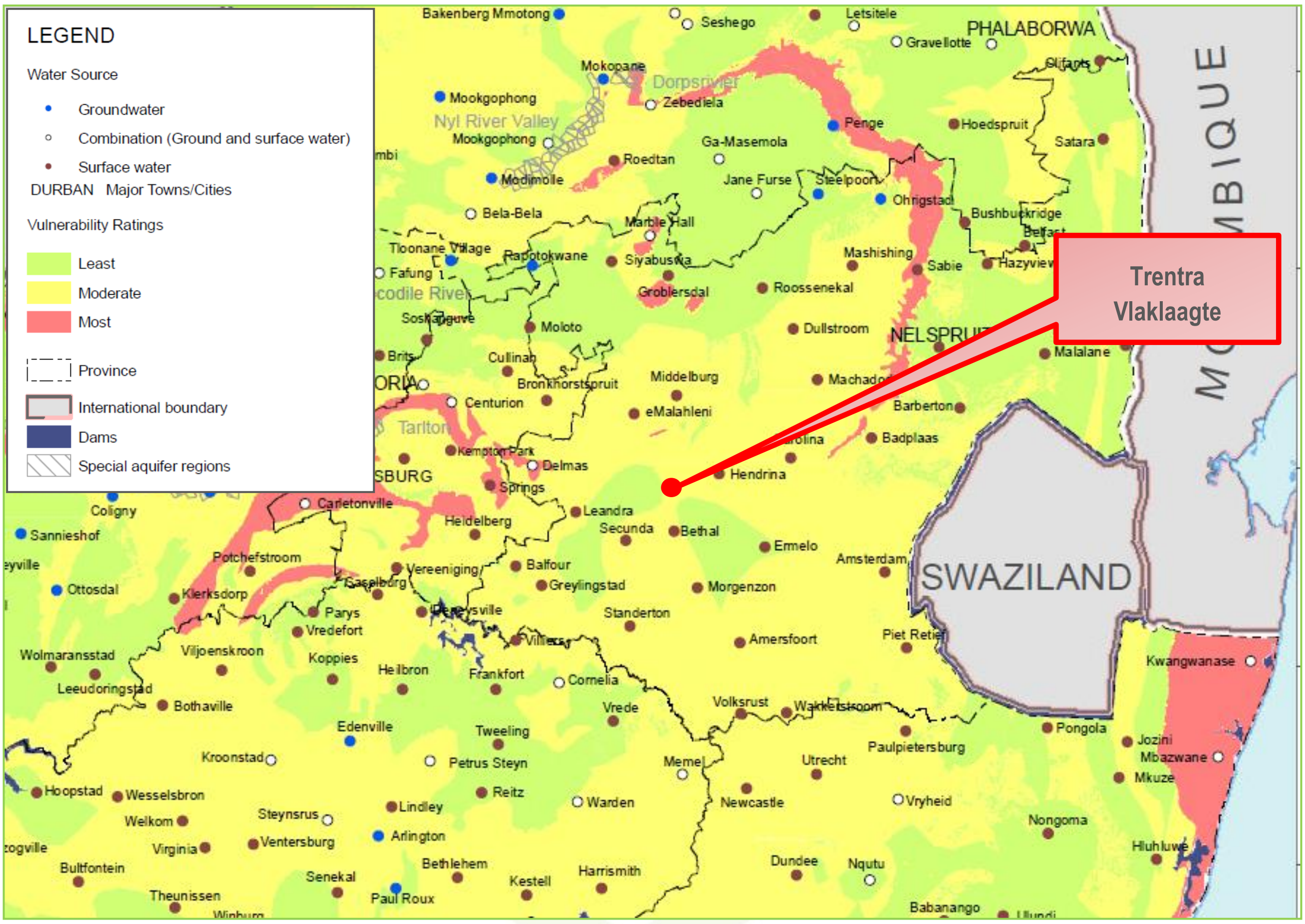

Figure 12: Aquifer vulnerability rating of the proposed Trentra Vlaklaagte mining area (DWA, 2013)

The Groundwater Vulnerability Classification System incorporates the Parsons Aquifer Classification System (Section 6.2) and the drinking water guidelines from the Department of Water Affairs and Forestry.

Table 15: Groundwater Vulnerability Classification System

Rating	Depth to Water Level	Groundwater Quality	Aquifer Type- Parsons
1	> 10 m	Poor (TDS > 2 400 mg/l)	Non-Aquifer System
2	6 – 10 m	Marginal (TDS > 1 000 < 2 400 mg/l)	Minor Aquifer System
3	3 – 6 m	Good (TDS > 450 < 1 000 mg/l)	Major Aquifer System
4	0 – 3 m	Excellent (TDS < 450 mg/l)	Sole Aquifer System

Table 16: Groundwater Vulnerability Rating

Rating	Vulnerability
≤ 4	Low
> 4 ≤ 8	Medium
≥ 9	High

Table 17: Groundwater Vulnerability for Trentra Vlaklaagte mining area.

Rating	
Depth to water level	2
Groundwater quality	3
Aquifer Type	2
Total Score	**7**

According to the Groundwater Vulnerability Classification System, the Trentra Vlaklaagte mining aquifer scored a rating of 7 which is indicative of medium vulnerability. Due to the groundwater qualities in terms of TDS concentrations being excellent in some areas, the aquifer may even be highly vulnerable.

6.2 Aquifer Classification

According to the Aquifer Classification map (DWA, 2012), the Trentra Vlaklaagte mining area is situated in a minor aquifer classification area. Aquifer classification is based on the Parsons System (1995) **- Table 18**. Qualities in these aquifers can vary and is typically moderately yielding aquifers.

Table 18: Aquifer System Management Classes.

Sole Aquifer System	An aquifer that is used to supply 50% 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 formation, 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).
Minor Aquifer System	These can be fractured or potentially fractured rocks that do not have a primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large volumes of water, they are important both for local suppliers and in supplying base flow for rivers.
Non-Aquifer System	These are formations with negligible permeability that are generally 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 impermeable, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.
Special Aquifer System	An aquifer designated as such by the Minister of Water Affairs, after due process.

Two main aquifer systems exist in the Trentra Vlaklaagte mining area. Firstly, is a swallow, weathered aquifer which is found in the transitional soil and weathered bedrock zone. Due to direct recharge and dynamic groundwater flow through the weathered sediments, the natural groundwater qualities are often good. The direct recharge and dynamic groundwater flow are also the reason why this aquifer is vulnerable to pollution. Water levels in this aquifer are often shallow (few meters below ground level) and follow the surface topography.

Secondly is a deeper semi-confined to confined fractured aquifer where groundwater flow is predominantly fracture flow. The fractured Karoo aquifer consists of sedimentary successions of siltstone, shale, sandstone and the coal seams. Groundwater flow is dominated by secondary porosities like faults, fractures, joints, bedding planes or other geological contacts. Yields can be higher in this aquifer along these geological structures. The rock matrix is characterised by a low permeability. Borehole yields in the in the Ecca aquifers are generally low and can be expected to be less than 2 l/s.

6.3 Aquifer Protection Classification

As part of policy and regulation development and implementation, the aquifer classification used in **Table 18** alone is not sufficient. To minimise misinterpretation, the decision support tool in **Table 19** also needs to be incorporated as part of aquifer classification (Parsons, 1995). The combination of the Aquifer System Management Classification and the Aquifer Vulnerability Classification rating is referred to as the Groundwater Quality Management (GQM) classification, which provide a level of aquifer protection.

GQM = Aquifer System Management x Aquifer Vulnerability

Table 19: GQM Classification for the proposed Trentra Vlaklaagte mining Area.

Aquifer System Management Classification		Aquifer Vulnerability Classification		GQM		GQM
Class	Points	Class	Points	Index	Level of protection	Trentra Vlaklaagte mining
Sole Source Aquifer System	6	High	3	<1	Limited	
Major Aquifer System	4			1 - 3	Low	
Minor Aquifer System	2	Medium	2	3 - 6	Medium	4
Non-aquifer System	0			6 - 10	High	
Special Aquifer System	0-6	Low	1	>10	Strictly non-degradation	

The level protection for the Trentra Vlaklaagte mining according to the GQM Index is 4. This indicates a medium level of protection. Based on the findings of the geohydrological study it is highly recommended that a proposed monitoring protocol should be in place for the proposed project area to detect any changes in groundwater quality and quantity that may affect the vulnerability of the aquifer.

The DWA has also compiled a susceptibility map for South Africa (2013) - **Figure 13**. This map indicates the qualitative measure of the relative ease with which an aquifer can potentially be contaminated. According to the aquifer susceptibility map, the Trentra Vlaklaagte mining area is also classified as low to medium susceptible to contamination.

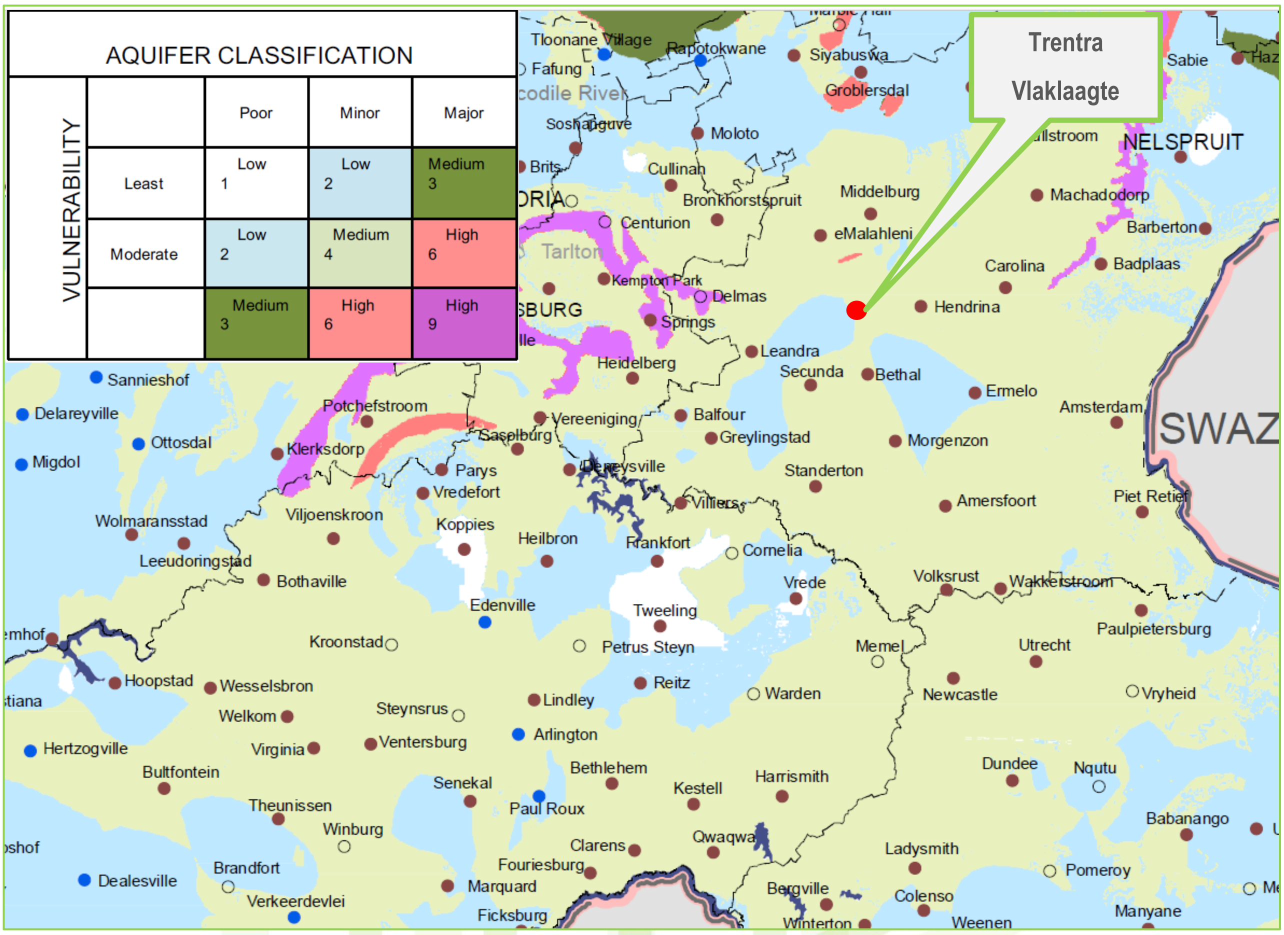

Figure 13: **Aquifer susceptibility map for the Trentra Vlaklaagte mining area.**

7. GROUNDWATER MODELLING

7.1 Software Model Choice

The Processing Modflow 8 (PMWIN) modelling package was used for the numerical flow and mass transport simulations. PMWIN is a finite difference modelling package where the domain is broken up into blocks or rectangular cells where the finite difference analogue of the partial differential equation for flow is applied to a node within a cell.

7.2 Model Set-up and Boundaries

After the conceptual model has been constructed, the numerical model is based on this model. The numerical model grid indicating the model boundaries are presented in **Figure 14**. The model dimensions used for the proposed Trentra Vlaklaagte numerical groundwater model is summarised in **Table 20**.

The following model boundaries have been used in the Trentra Vlaklaagte mining numerical model:

- River nodes were used in the northern and eastern region of the model and act as constant head boundaries. The river node will add or remove water from the aquifer as the water level increases or decreases. The water level at the river nodes therefore remain relatively constant.
- General Head boundaries: groundwater flow over these boundaries are possible. The rate at which groundwater flow over these boundaries depend on the specified hydraulic conductivity of the boundary and therefore the aquifer on the opposite side of the boundary.

Table 20: Model extent and aquifer parameters.

Model Grid Size	Easting = 18 870 Northing = 25 860
Rows	953
Columns	812
Cell Size	30 x 30 m and refined to 15 x 15 m within the mine boundary
Layer Thickness	Layer 1 = 20 m Layer 2 = 150 m
Layers	Layer 1 = Confined / Unconfined Layer 2 = Confined
Transmissivity	Shallow weathered aquifer = 1.4 m^2/day Deep, secondary aquifer = 0.5 m^2/day
Recharge	1.1%

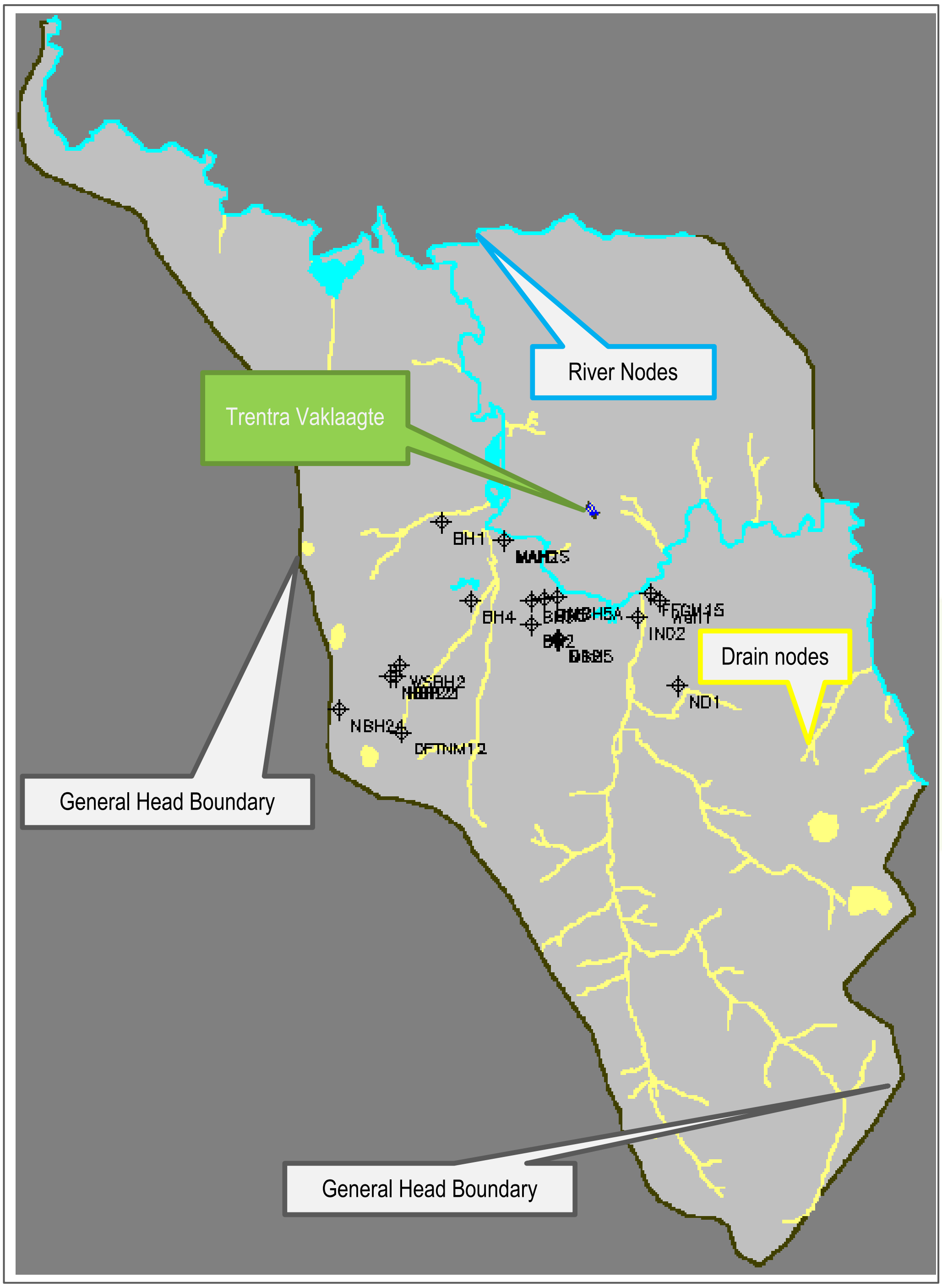

Figure 14: Trentra Vlaklaagte mining model domain and boundaries.

7.3 Groundwater Elevation And Gradient

Steady state flow model calibration involves the varying of aquifer parameters in the model until the observed water levels correlates well with the measured water levels. The measured water levels must represent the levels prior to any impacts from mining activities. Steady state water levels therefore represent "reality" prior to changes caused by mining activities.

Water level elevations used for steady state model calibration was obtained from geohydrological studies conducted in the area (

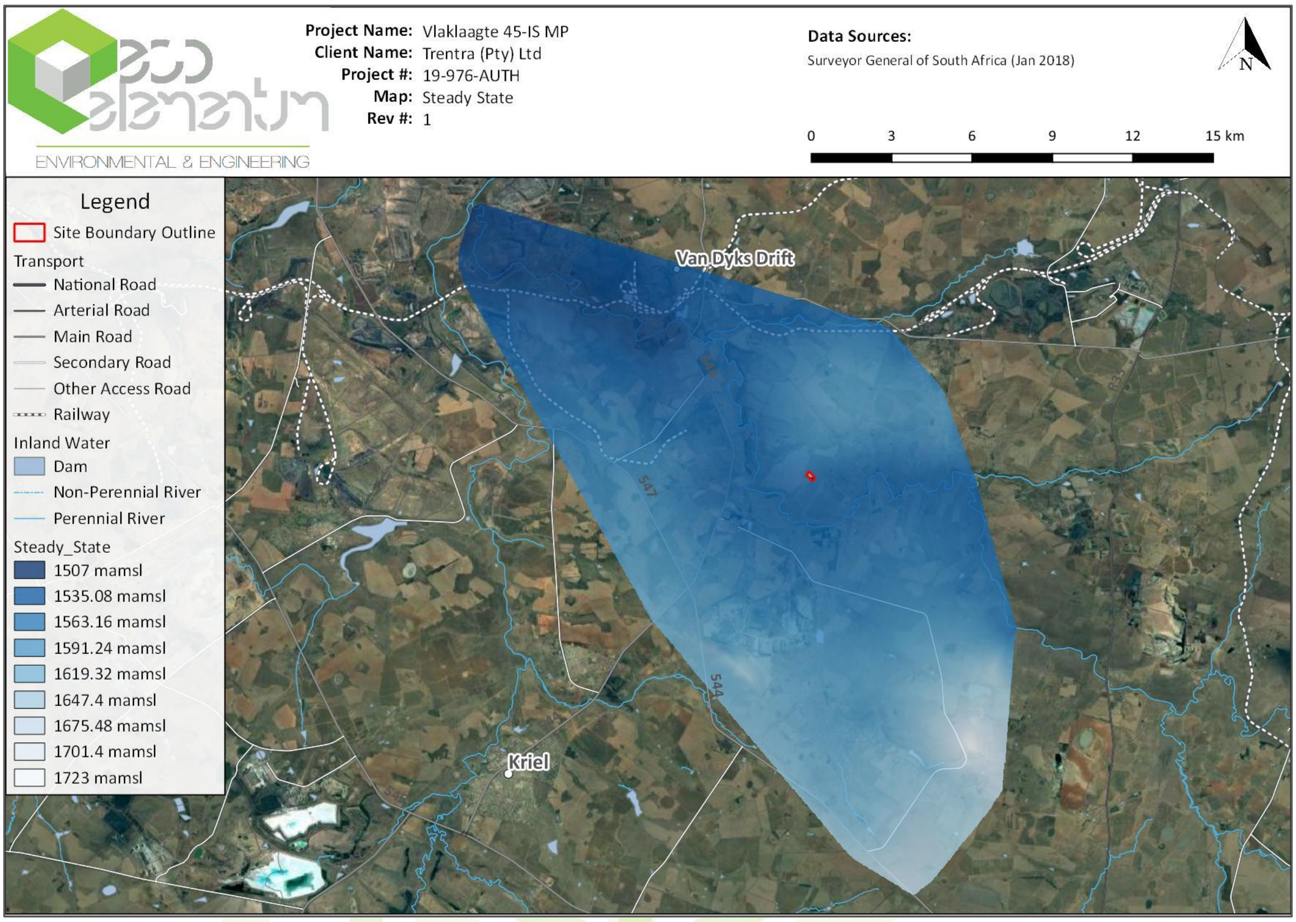

Figure 16).

By adjusting the aquifer parameters in the model to the values indicated in **Table 20**, a very good correlation of 95% were obtained (**Figure 15**). Due to the heterogeneous characteristics of the aquifer, over or under estimation of the water levels can be possible.

Groundwater within the Trentra Vlaklaagte mining model area decrease from approximately 1 720 mamsl (South-east of the Trentra Vlaklaagte mining area) to 1 507mamsl north-west of the mine area (

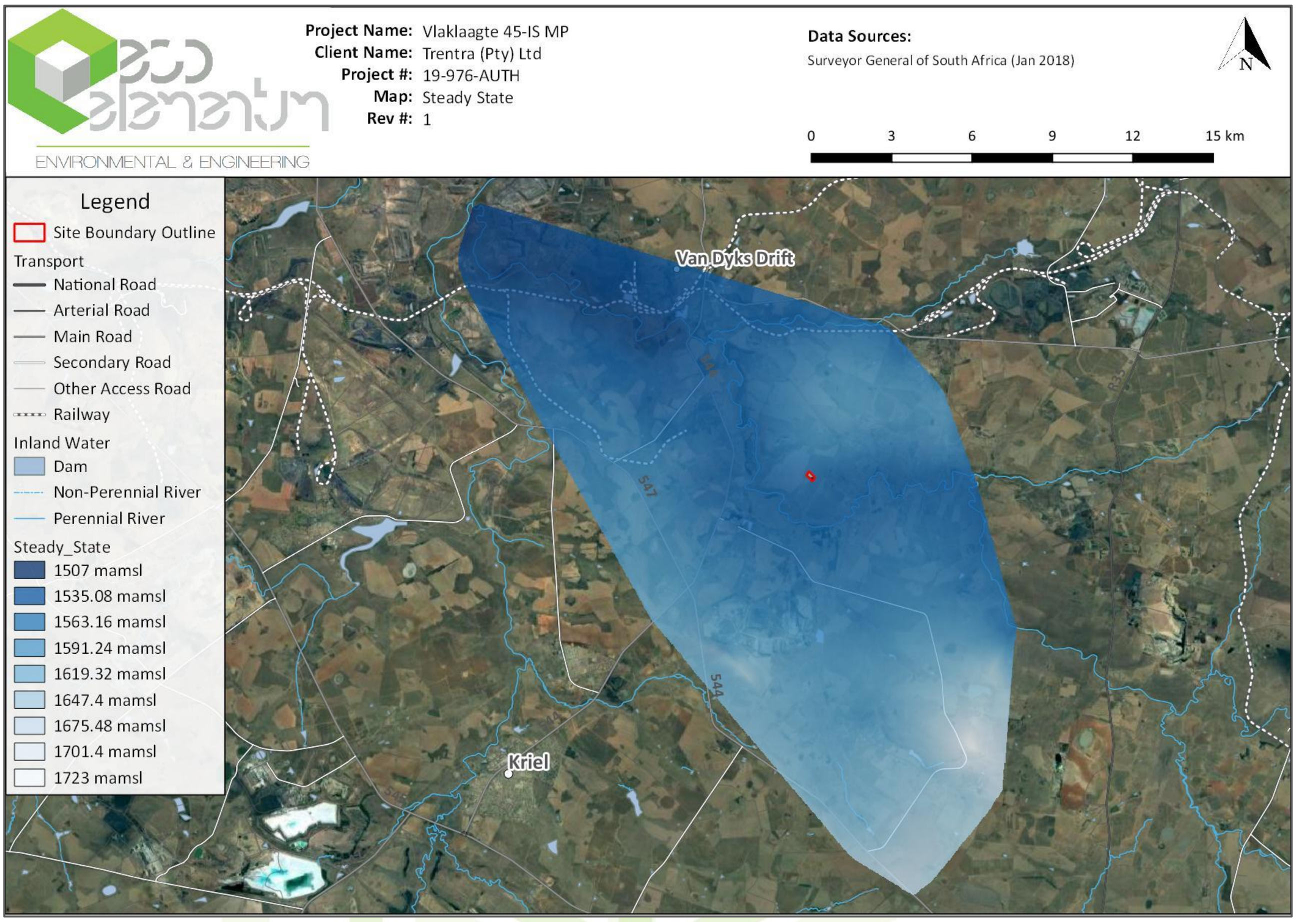

Figure 16). Groundwater gradients over the area is approximately 0.9%.

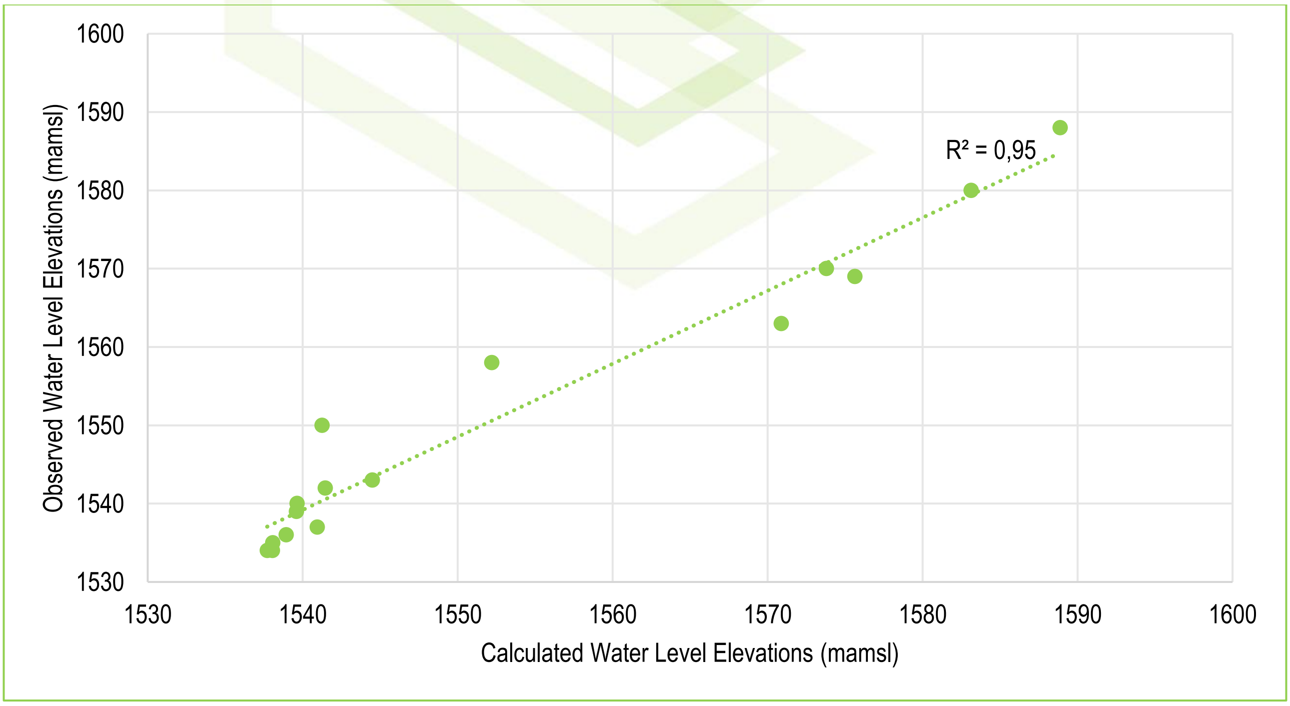

Figure 15: Model calculated water level elevations vs observed water level elevations correlation.

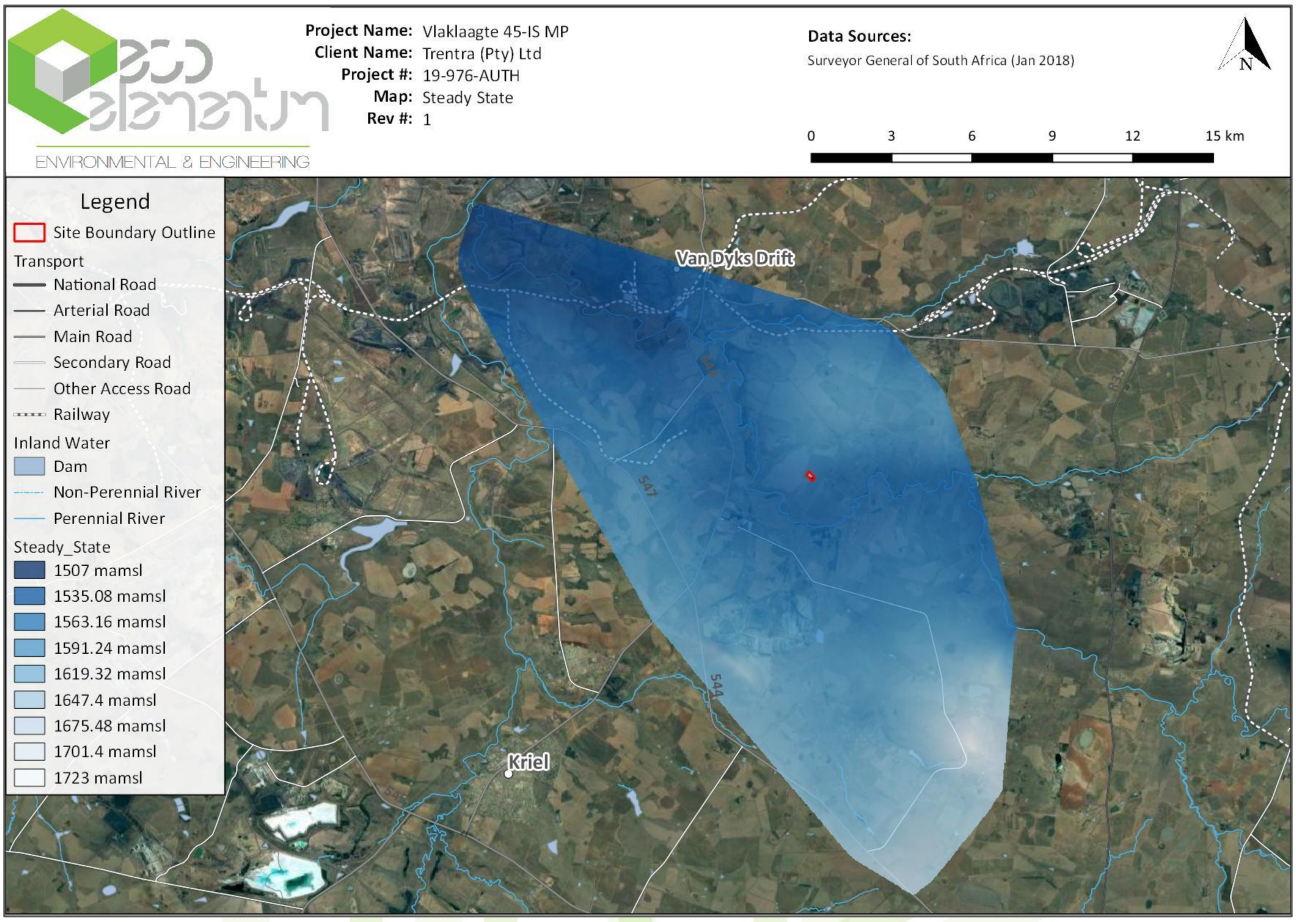

Figure 16: Steady state water level elevation contours.

7.4 Geometric Structure Of The Model

Table 20 in Section 7.2 summarises the geometric set-up of the model. The model grid simulates an area of just under 490 km^2 (25.9 km E and 18.9 km N). The grid cells are squares with a dimension of 30 x 30 m and refined at the mining site to 15 x 15m. The model grid consists off 773 836 cells.

Two layers were simulated in the model. Layer 1 represents the shallow, weather aquifer and was assigned a thickness of 20 m. The deep, secondary aquifer were simulated with Layer 2 with a thickness of 150 m.

7.5 Groundwater Sources And Sinks

Groundwater sources and sinks are features that either add (source) or remove (sink) water from the aquifer. During the steady state model calibration river nodes representing the streams can act as either a sink or a source. Drain nodes were used to represent less prominent streams, which is not perennial and therefore mostly act as a sink.

Recharge also act as a source since it contributes to the water make in the model. A recharge of 1.3% were used for the Trentra Vlaklaagte mining model area.

During the transient model simulations, the opencast mining operation will act as a groundwater sink, since groundwater flow will be towards the pit due to dewatering and therefore remove water from the model.

7.6 Conceptual Model

A conceptual model involves the construction of a simplified version of the real world. All the geohydrological information gathered by different means, including during the hydrocensus, aquifer tests, chemical analysis etc., are used to construct this simplified model. The conceptual model forms the basis of the numerical model and aids in understanding the geohydrological characteristics of the model area.

- The basis of the conceptual model can be summarised as follows:
- The proposed Trentra Vlaklaagte mining area is located in the Highveld region of Mpumalanga and in a summer rainfall region.
- The mean annual precipitation is ± 665 mm/annum, while the evaporation is estimated at 1 700 mm/annum.
- Drainage over the regional area is towards the north, while locally drainage is towards the north-east.
- The Trentra Vlaklaagte mining area is underlain by sedimentary rocks from the Karoo Super group's Vryheid Formation.
- Geological structures such as dykes and faults are known to exist in the region of the Trentra Vlaklaagte mining. These structures and the weathered zone are possible pathways of elevated groundwater flow and contamination migration.
- Two main aquifer systems are found in the Trentra Vlaklaagte mining region. Firstly, the shallow weathered aquifer and secondly, the deeper, secondary aquifer.
- Groundwater levels generally varied from less than 1 to 15 mbs in the boreholes recorded (GCS, 2017).
- With the short duration of opencast mining, the cone of depression due to dewatering is not expected to extent more than 60 m from the pit area.
- Groundwater Sources:
  - Recharge:
    - Natural recharge: in the region of the project the natural recharge is estimated between 1 and 3% of the MAP. Rivers and drainage systems can also be seen as potential recharge sources. Gaining or losing streams play a role here. Losing streams "lose" their water to the aquifer, making it a natural recharge source. The Olifants River to the south of the project is a gaining feature and may be connected to the groundwater regime.
    - Artificial recharge: Artificial recharge from sources including the PCD may occur in the mining operation should leakage from this feature occur. The backfilled opencast pit can act as an artificial recharge sources since the recharge through the spoils can recharge the underlying aquifer directly. Artificial recharge from surrounding mining operations may already be taking place/have taken place.
  - Contamination Sources: At the proposed mining operation the potential contamination sources include the opencast pit, especially post closure and any carbonaceous source which may include the PCD, ROM stockpiles or overburden stockpiles.
- Groundwater pathways:
  - Fault zones and dykes surrounding the proposed project area may be potential pathways for groundwater contamination migration. No site-specific geological structure information is available, but it is typical for Karoo geology to have these types of structures present.
- Groundwater receptors:

- River Systems: any contamination from potential sources may be discharged in terms of baseflow into the receiving river systems in the area. The distance from the river systems minimise the impact, if any, on the surface water.
- Potential groundwater users: No known groundwater users are expected or known within the potential impact zone of the proposed mining activity. The impact zone may increase should pathways such as geological structures be present.
- Opencast pit: once dewatering of the pit commence, water will flow towards the pit and therefore act as a groundwater receptor, even though an artificial receptor.

7.7 Numerical Model

The numerical groundwater model is used to represent both the flow and contamination/pollution migration of the groundwater regime. The numerical model consists of:

1. Groundwater Flow model,
2. Mass Transport Model.

7.7.1 Groundwater Flow Model

After the steady state calibration have been obtained (Section 7.4), the model is set-up for transient state simulations. The boundaries, mesh size, layer type, top and bottom of the layers and aquifer transmissivity of the model remain as defined in the steady state model. The transient state model consists of several stress periods which represents different time frames of the mining activities. The groundwater flow and mass transport conditions remain the same during a stress period. Sources and sinks can change between stress periods but not within a stress period. The groundwater flow model for Trentra Vlaklaagte mining consist of 3 stress periods of one month each **(Table 21).**

Table 21: Stress periods in the numerical model for Trentra Vlaklaagte.

Stress Period	Duration (Months)	Description
1	1	Simulates the box-cut and commencement of mining at Trentra Vlaklaagte.
2	1	Month 2 of mining.
3	1	Month 3 of mining.

7.7.2 Mass Transport Model

The mass transport model is used to simulate contamination migration in the aquifer. The main contaminant and a major concern in the coal mining environment is sulphate. Sulphate contamination was simulated for the Trentra Vlaklaagte mining mass transport model. A worst-case source concentration of 3 000 mg/l was used for the opencast area. A general representative source concentration for coal mining activities were applied to the source areas. The following parameters were used for the mass transport model:

Table 22: Parameters for the mass transport model.

Parameter	Value

Dispersion	5 m
Diffusion	0.00001
Sulphate Source Concentration	3 000 mg/l
Specific Yield	0.03
Storage Coefficient	0.001
Effective Porosity	8%

7.8 Results of the Model

7.8.1 Pre-facility

The pre-facility or steady state water level elevations were discussed in Section 7.3 of this document. These elevations represent the conditions prior to any impacts from the Trentra Vlaklaagte mining activities.

7.8.2 During Facility

The main purpose of this geohydrological investigation is to determine the impacts from the Trentra Vlaklaagte mining in terms of quality and quantity. Information in terms of the correct schedule and mine floor contours was based on assumptions from previous studies and information that was available for the study area. The model in terms of inflows, drawdowns and volumes should be updated once the correct and site-specific information for the area becomes available.

Mining at the Trentra Vlaklaagte pit was simulated over a period of 3 months.

The following activity is planned to take place at the Trentra Vlaklaagte mining area and was also simulated in the model:

- Opencast Pit,
- PCD,
- Coal, ROM, Overburden Stockpiles.
- DMS Wash Plant.

Table 23 represents the average estimated daily groundwater inflow at Trentra Vlaklaagte during mining. The average inflows are estimated to vary between ±260 and 290 m^3/day over the three month period.

Table 23: Average daily estimated groundwater inflows for each mining pit.

	Month 1	Month 2	Month 3
Average Daily Inflow (m^3/day)	290	280	260

7.8.2.1 Drawdown

The simulated drawdown cone as a result of the opencast mining area are presented in **Figure 17.** The maximum extent of the drawdown cone is not expected to exceed 60 m from the pit area. The maximum simulated drawdown was 18m, but as mentioned previously this value can change once more site-specific details becomes available. Private users within the cone of depression extent area may be influenced in terms of water level drawdown. No surface water features are expected to be impacted on in terms of base-flow decrease.

Table 24: Simulated maximum drawdown in the pit and drawdown cone extent from the pit boundaries.

Opencast Pit	Maximum simulated drawdown (m)	Maximum drawdown cone extent from pit boundary (m)
Tentra Vlaklaagte pit	18	60

Figure 17: Simulated drawdown in the Trentra Vlaklaagte mining pit.

7.8.2.2 Mass Transport during Facility

During the operational phase and for a period after, until the water level has reached equilibrium, a contamination plume will not migrate away from the mining operation. This is due to the fact that the opencast pits act as a groundwater sink. Contaminated groundwater, as a result of acid mine drainage will be contained within the pit areas. Where progressive backfilling has occurred at lower elevations, the water level may start to recover and cause a down gradient movement of a contamination plume. The mass transport simulations at the end of the proposed mining operations for Trentra Vlaklaagte are presented in **Figure 18**.

Figure 18: The simulated mass transport at the end of the operational phase at the Trentra Vlaklaagte mining area.

7.8.3 Post-Facility

For the post-facility model simulations, the model was run an additional 50 years for both the flow and mass transport models. The mass transport contours for Trentra Vlaklaagte are represented in **Figure 19**.

The most common effects of a coal mining operation post-facility are:

- Decanting of the open pit into the shallow aquifer and on surface.
- Acid generation and therefore decrease in groundwater qualities in the pit.
- Down gradient movement of a contamination plume.

The simulated groundwater contamination plumes at 50 years post-facility (**Figure 19)** indicates that the plume will start to migrate down gradient from the pit area. The sulphate concentrations in the pit areas increases as a result of acid generation **(**Error! Reference source not found.**)**. Overall the plume from the mine workings migrates towards the south-east with the groundwater flow directions. The contamination plume from the pits in **Figure 19** is not expected to extent more than 230 m over the period of 50 years post-mining.

Table 25: 50 years post-closure results of the potential sulphate pollution plume from the proposed pit at Trentra Vlaklaagte.

Opencast Pit	Maximum simulated Sulphate Concentration in pit (mg/l)	Maximum simulated plume extent from pit boundary (m)	Potential plume migration direction from the pit
Pit A	± 2 500	± 230	South-east

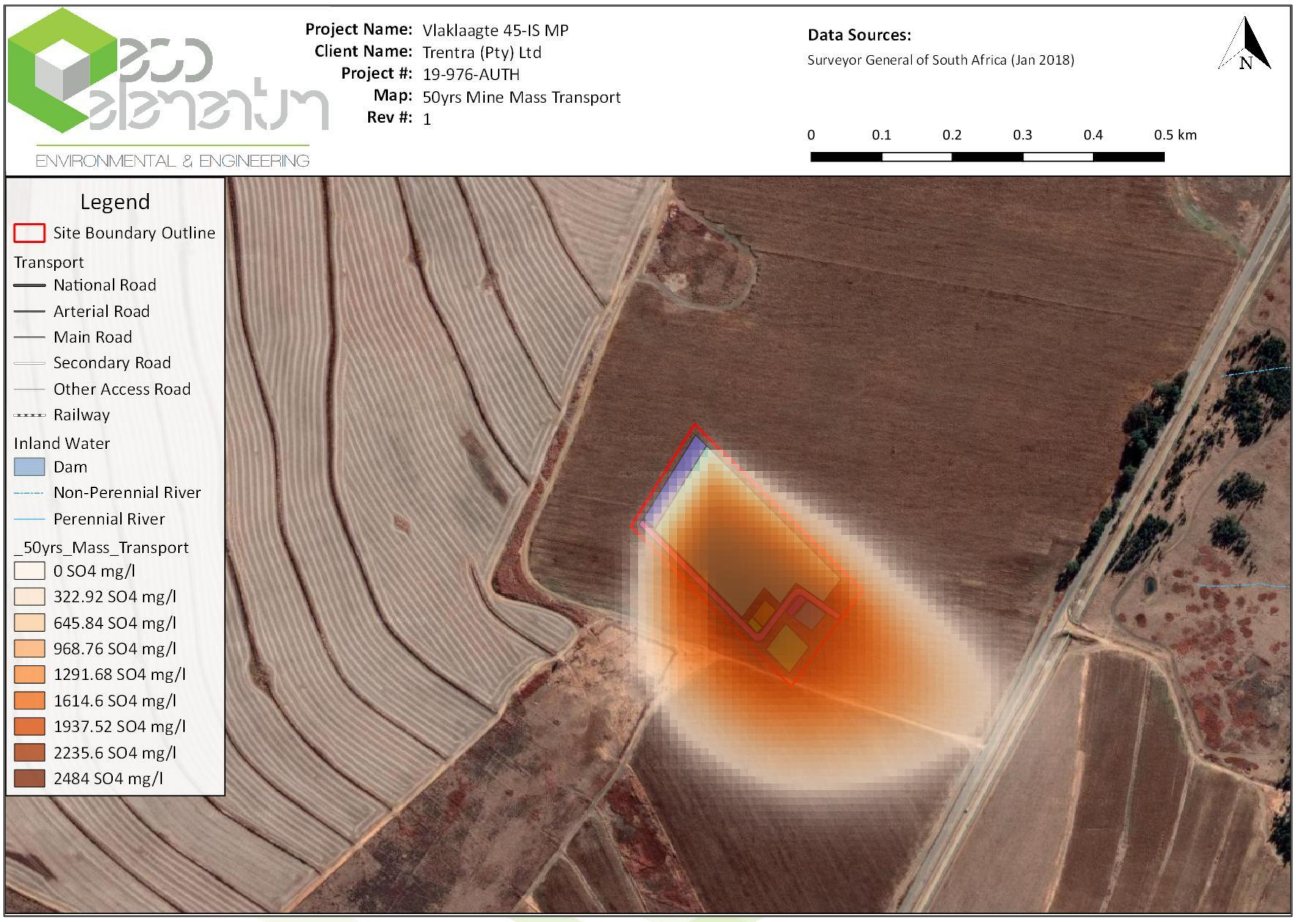

Figure 19: Model Simulated groundwater contamination plume 50 years post facility at Trentra Vlaklaagte.

- Private users within the cone of depression extent area may be influenced in terms of quality decreases. No surface water features are expected to be impacted on in terms of poor-quality discharge to the features.

Estimated filling time of the opencast pit to decant elevation is presented in **Table 26**. The entire pit floor is below the potential decant point. The positions of the potential decant point is indicated in **Figure 20**. The estimations indicate that the time to decant is 120 years. Available information indicates that the pit depth will be as deep as 40m. The decant estimations should be updated once site-specific information becomes available.

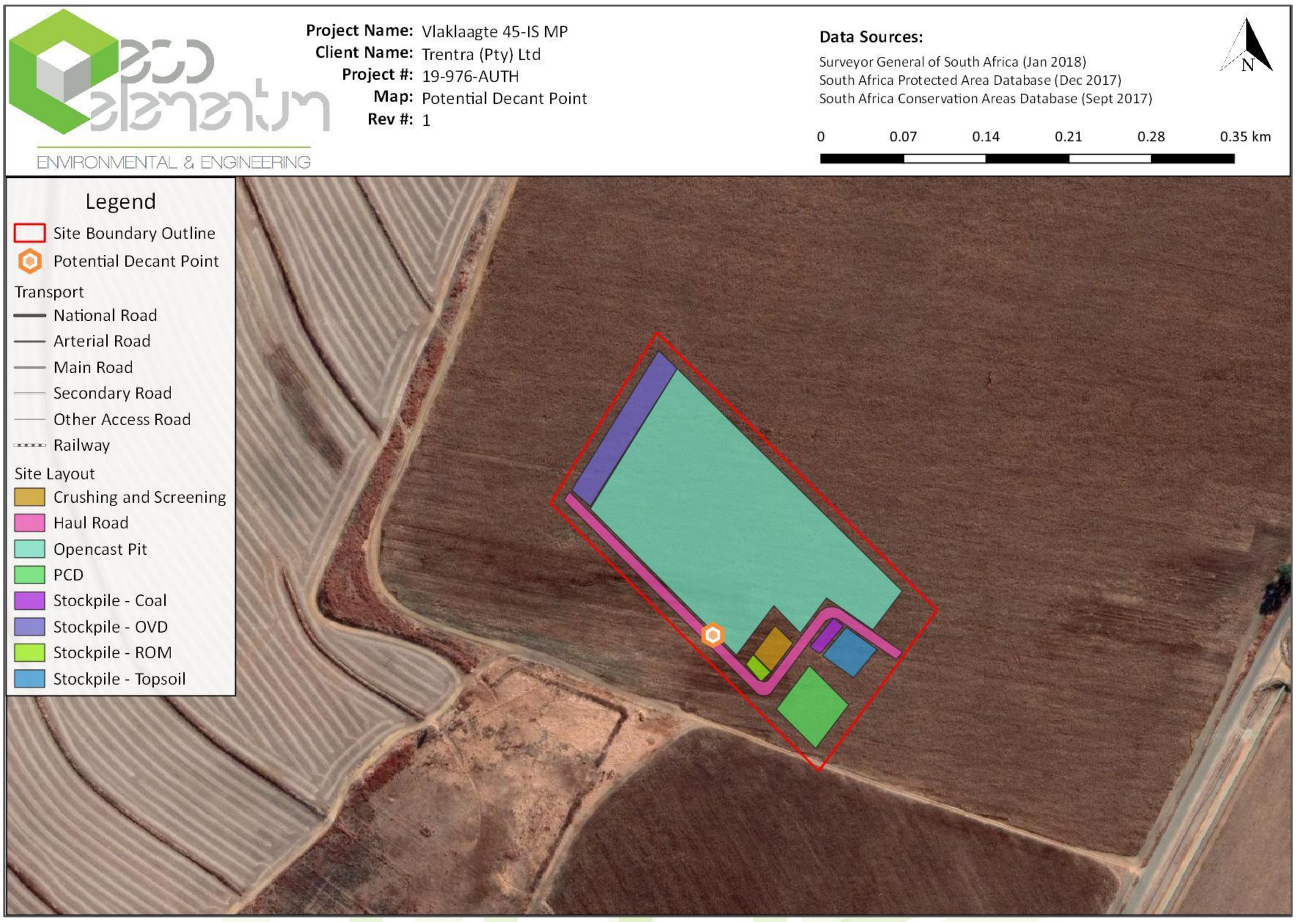

Figure 20: The potential decant point position.

Table 26: Estimated time to decant and fill time of the Trentra Vlaklaagte pit.

	Trentra Vlaklaagte
Annual Rainfall (m/a)	0,665
Decant Elevation (mamsl)	1576
Mined Area (m2)	27735
Mined Volume Below Decant Elevation (m3)	1109400
Annual Recharge to Rehab Pit area (m3/y):	
10%	1844
12,50%	2305
15%	2767
Voids (m3):	
20% porosity	221880
25% porosity	277350
30% porosity	332820
Average Time to Decant (years)	**120**
Average expected decant rate (m^3/d)	**6**

8. POTENTIAL GEOHYDROLOGICAL IMPACTS

The following methodology was used to rank these impacts. Clearly defined rating and rankings scales (**Table 27**) were used to assess the impacts associated with the proposed activities. The impacts identified by each specialist study and through public participation were combined into a single impact rating table for ease of assessment.

Each impact identified was rated according the expected magnitude, duration, scale and probability of the impact**.**

To ensure uniformity, the assessment of potential impacts will be addressed in a standard manner so that a wide range of impacts is comparable. For this reason, a clearly defined rating scale will be provided to the specialist to assess the impacts associated with their investigation.

Table 27: Potential Impacts rating and rankings scales

Intensity (Magnitude)		**ASSIGNED QUANTITATIVE SCORE**
The intensity of the impact is considered by examining whether the impact is destructive or benign, whether it has a significant, moderate or insignificant		
(L)OW	The impact alters the affected environment in such a way that the natural processes or functions are not affected.	**1**
(M)EDIUM	The affected environment is altered, but functions and processes continue, albeit in a modified way.	**3**
(H)IGH	Function or process of the affected environment is disturbed to the extent where it temporarily or permanently ceases.	**5**
Duration		
The lifetime of the impact, that is measure in relation to the lifetime of the proposed development.		
(S)HORT TERM	The impact will either disappear with mitigation or will be mitigated through a natural process in a period shorter than that of the construction phase.	**1**
(SM) SHORT - MEDIUM TERM	The impact will be relevant through to the end of a construction phase.	**2**
(M)MEDIUM	The impact will last up to the end of the development phases, where after it will be entirely negated.	**3**
(L)ONG TERM	The impact will continue or last for the entire operational lifetime (i.e. exceed 20years) of the development, but will be mitigated by direct human action or by natural processes thereafter.	**4**
(P)ERMANENT	This is the only class of impact, which will be non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact is transient.	**2**
Spatial Scale/Extent		
Classification of the physical and spatial aspect of the impact		
(F)OOTPRINT	The impacted area extends only as far as the activity, such as footprint occurring within the total site area.	**1**
(S)ITE	The impact could affect the whole, or a significant portion of the site.	**2**
(R)EGIONAL	The impact could affect the area including the neighbouring Farms, the transport routes and the adjoining towns.	**3**
(N)ATIONAL	The impact could have an effect that expands throughout the country (South Africa).	**4**
(I)NTERNATIONAL	Where the impact has international ramifications that extend beyond the boundaries of South Africa.	**5**
Probability		

This describes the likelihood of the impact actually occurring. The impact may occur for any length of time during the life cycle of the activity. The classes are rated as follows:		
(I)MPROBABLE	The possibility of the Impact occurring is none, due to the circumstances or design. The chance of this Impact occurring is zero (0%)	**1**
(P)OSSIBLE	The possibility of the Impact occurring is very low, due either to the circumstances or design. The chance of this Impact occurring is defined as 25% or less	**2**
(L)IKELY	There is a possibility that the impact will occur to the extent that provisions must therefore be made. The chances of Impact occurring is defined as 50%	**3**
(H)IGHLY LIKELY	It is most likely that the Impacts will occur at some stage of the development. Plans must be drawn up before carrying out the activity. The chances of this impact occurring is defined as 75 %.	**4**
(D)EFINITE	The impact will take place regardless of any prevention plans, and only mitigation actions or contingency plans to contain the effect can be relied on. The chance of this impact occurring is defined as 100 %.	**5**
Weighting Factor		
Subjective score assigned by Impact Assessor to give the relative importance of a particular environmental component based on project knowledge and previous experience. Simply, such a weighting factor is indicative of the importance of the impact in terms of the potential effect that it could have on the surrounding environment. Therefore, the aspects considered to have a relatively high value will score a relatively higher weighting than that which is of lower importance		
(L)OW		**1**
LOW- MEDIUM		**2**
MEDIUM (M)		**3**
MEDIUM-HIGH		4
HIGH (H)		5
Mitigation Measures and Mitigation Efficiency		
Determination of significance refers to the foreseeable significance of the impact after the successful implementation of the necessary mitigation measures		
Mitigation measures were recommended to enhance benefits and minimise negative impacts and address the following: Mitigation objectives: what level of mitigation must be aimed at: For each identified impact, the specialist must provide mitigation objectives (tolerance limits) which would result in measurable reduction in impact. Where limited knowledge or expertise exists on such tolerance limits, the specialist must make "educated guesses" based on professional experience; Recommended mitigation measures: For each impact the specialist must recommend practicable mitigation actions that can measurably affect the significance rating. The specialist must also identify management actions, which could enhance the condition of the environment. Where no mitigation is considered feasible, this must be stated and reasons provided; Effectiveness of mitigation measures: The specialist must provide quantifiable standards (performance criteria) for reviewing or tracking the effectiveness of the proposed mitigation actions, where possible; and Recommended monitoring and evaluation programme: The specialist is required to recommend an appropriate monitoring and review programme, which can track the efficacy of the mitigation objectives. Each environmental impact is to be assessed before and after mitigation measures have been implemented. The management objectives, design standards, etc., which, if achieved, can eliminate, minimise or enhance potential impacts or benefits. National standards or criteria are examples, which can be stated as mitigation objectives.		
HIGH	The impact is of major importance. Mitigation of the impact is not possible on a cost-effective basis. The impact is regarded as high importance and taken within the overall context of the project, is regarded as a fatal flaw. An impact regarded as high significance, after mitigation could render the entire development option or entire project proposal unacceptable.	**1,00**
MEDIUM-HIGH	The impact is of major importance but through the implementation of the correct mitigation measures, the negative impacts will be reduced to acceptable levels	**0,80**
MEDIUM	Notwithstanding the successful implementation of the mitigation measures, to reduce the negative impacts to acceptable levels, the negative impact will remain of significance. However, taken within the overall context of the project, the persistent impact does not constitute a fatal flaw	**0,60**
LOW -MEDIUM	The impact is of importance, however, through the implementation of the correct mitigation measures such potential impacts can be reduced to acceptable levels	**0,40**

LOW	The impact will be mitigated to the point where it is of limited importance	0,20

Extent	Duration	Intensity	Probability	Weighting Factor (WF)	Significance Rating (SR)	Mitigation Efficiency (ME)	Significance Following Mitigation (SFM)
Footprint 1	Short term 1	Low 1	Probable 1	Low 1	Low 0-19	High 0,2	Low 0-19
Site 2	Short to medium 2		Possible 2	Low to medium 2	Low to medium 20-39	Medium to high 0,4	Low to medium 20-39
Regional 3	Medium term 3	Medium 3	Likely 3	Medium 3	Medium 40-59	Medium 0,6	Medium 40-59
National 4	Long term 4		Highly Likely 4	Medium to high 4	Medium to high 60-79	Low to medium 0,8	Medium to high 60-79
International 5	Permanent 5	High 5	Definite 5	High 5	High 80-100	Low 1,0	High 80-100

The following activities form / will form part of the proposed Trentra Vlaklaagte mining operation:

- Opencast Pit,
- Overburden Stockpile,
- Topsoil Stockpile,
- ROM Stockpile (in-pit),
- Coal Stockpile,
- Mobile Washing & Screening Plant (In-pit),
- Pollution Control Dam (PCD),
- DMS Washplant
- Mobile fuel & storage,
- Workshop,
- Weighbridge,
- Mobile Offices, and
- Haul Road.

8.1 Construction Phase

8.1.1 Impacts on Groundwater Quantity

No significant impacts are expected during the construction phase in terms of groundwater quantity. The removal of vegetation in preparation of the mining area and PCD's construction may cause an increase in surface runoff and therefore a small decrease in aquifer recharge.

The box-cut may cause a decrease in the water level due to dewatering if the base of the box-cut is lower than the groundwater level at that position.

8.1.2 Impacts on Groundwater Quality

The proposed Trentra mining activities is not expected to impact on the groundwater quality during the construction phase. The only possible impacts may be from example fuel spillages from the construction vehicles.

8.1.3 Groundwater Management

Should fuel spillages occur during the construction phase immediate action is required to minimise the impact on the groundwater regime. No management can be incorporated to limit the impacts of dewatering should the box-cut floor be lower than the groundwater level.

8.2 Operational Phase

8.2.1 Impacts on Groundwater Quantity

The operational phase impacts on the groundwater quantity will mainly be as a result of the dewatering of the surrounding aquifer during the opencast mining. The groundwater level in close proximity of the pit is expected to decrease since groundwater seepage to the void will be abstracted.

As simulated with the numerical model the extent of the dewatering cone is not expected to extent more than 60 m from the pit area in the shallow aquifer. Any groundwater users within this dewatering cone extent may experience a decrease in water levels. The positions of potential groundwater users are unknown.

8.2.2 Impacts on Groundwater Quality

During the operational phase and for the period after mining when the groundwater level has not yet recovered, the mine voids will act as a groundwater sink area. Groundwater gradients and therefore groundwater flow will be towards the pit area. For this reason, groundwater contamination will not be able to flow down gradient from the pit area during the operational phase.

The acid-base accounting from GCS (2017) indicated a potential to generate acid. The dewatering of the pit will result in any contaminated water in the pit to be removed. For this reason, no impacts in terms of contamination is expected to influence any surrounding groundwater users during the operational phase. Due to the close proximity of the proposed surface infrastructure to the mining pits and being within the dewatering cone extent, a plume is also not expected to migrate downgradient from these areas.

8.2.3 Impacts on Surface Water

Based on **Figure 21**, NFEPA wetlands east, south-east, south, south-west and west of the proposed mining area. According to the model simulations neither the cone of depression, nor the 50 years post closure pollution plume is expected to reach the NFEPA wetland or the nearby streams.

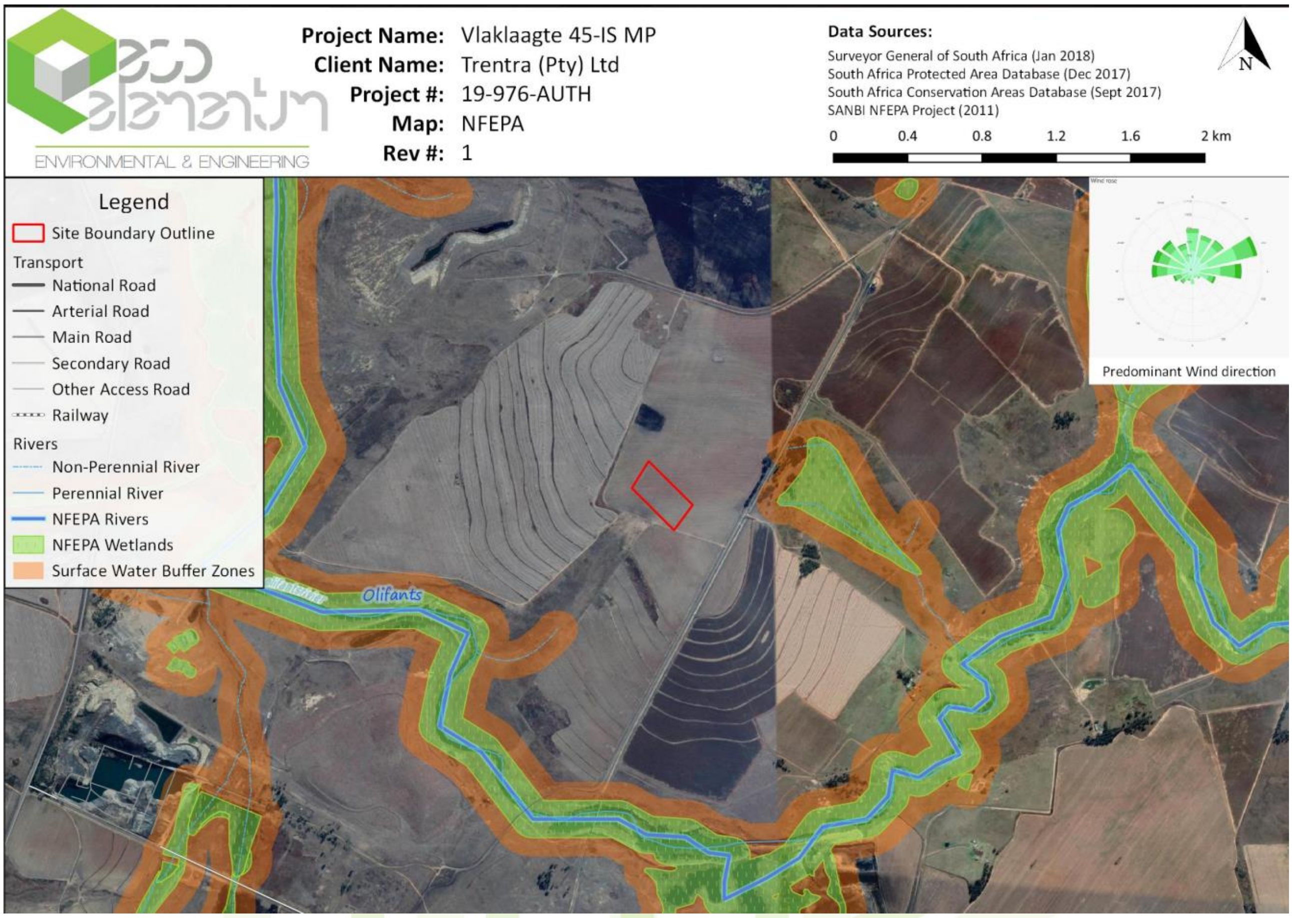

Figure 21: NFEPA Wetlands in the region of the Trentra mining area.

8.2.4 Groundwater Management

Dewatering of the mine pit is a necessity for safe mining. Dewatering as a result of the mining operations cannot be prevented. Some mitigation measures for the operational phase are indicated in the table below.

Table 28: Mitigation measures for the Operational Phase

Potential Impacts	Mitigation Measures
• Impacts in terms of groundwater levels are expected during this phase. The dewatering of the pit will cause a drawdown in the water levels within the immediate vicinity of the opencast activities. • No adverse impacts on the groundwater qualities surrounding the opencast are expected during this phase.	• Groundwater levels in the monitoring boreholes should be measured on at least a quarterly interval. • Should the water levels of surrounding users be influenced in terms of groundwater level or quality decline, the users should be compensated. • Monitor groundwater inflow rates on a monthly basis throughout the mining operation. • The groundwater quality in the monitoring boreholes should be analysed on a quarterly basis. • Annual reporting on the groundwater qualities and levels should be conducted and submitted to the DWA.

	• The numerical model should be updated once more time-series monitoring data (water levels and qualities) are available and on an annual basis. • Remove as much coal from the mining pit as possible to prevent continuous acid generation.

8.3 Decommissioning Phase

During the decommissioning phase all the potential surface contamination sources including the PCD's, ROM stockpiles and other infrastructure, will be removed. These include all carbonaceous or contaminated material. This will decrease the surface sources for further groundwater contamination.

The opencast pit area will be rehabilitated which will have a positive impact on the groundwater regime in some areas since the poor-quality seepage to the groundwater will decrease. Rehabilitation should occur in such a manner to divert as much as possible water away from the opencast areas.

8.4 Post Closure

8.4.1 Groundwater Quantity

Since dewatering has ceased at the end of the operational phase, the groundwater level will start to recover to a state of equilibrium. Decant from the lowest elevation on the pit boundaries may occur once the groundwater levels have recovered.

With sufficient and adequate rehabilitation, the recharge to the opencast pits will decrease to approximately 12,5%. Decant elevations and estimated rates were discussed in Section 7.8.3 of this report.

8.4.2 Groundwater Quality

Geochemical analysis conducted for the Trentra mining region during previous studies indicated a probability for acid generating. Therefore, the groundwater quality in the pit region will decrease as a result of the acidification. It is highly recommended that all carbonaceous material be placed on the pit floor and covered with overburden material. This will result in coverage of the carbonaceous material with water first, which will eliminate oxygen from the system to decrease the process of acid generation.

A groundwater pollution plume will start to migrate down gradient once the groundwater level has reached a point of equilibrium. Please refer to Section 7.8.3 of this document for more information in the expected groundwater quality conditions post closure.

8.4.3 Cumulative Impact

The Trentra Vlaklaagte mining area is situated in an area with several mining and agricultural activities at or near its boundaries. These include:

- Exxaro New Clydesdale Colliery west of Trentra Vlaklaagte,
- Exxaro Dorstfontein less than 2km south of Trentra Vlaklaagte,
- Eyethu Kleinfontein Colliery 6km east of Trentra Vlaklaagte, and
- Agricultural activities at all of the Trentra Vlaklaagte boundaries.

The mining operations as mentioned above will have a cumulative impact on the aquifers in the catchment in terms of quality and quantity. Acid mine drainage as well as the dewatering of the aquifers as a result of all these mining activities may decrease the groundwater qualities and have a nett loss on the water supply to the groundwater users and the springs in the area.

8.4.4 Groundwater Management

The potential impacts and mitigation measures post-closure are summaries in **Table 29** below.

Table 29: Mitigation measures for Groundwater Management

Potential Impacts	Mitigation Measures
• The water level post-closure will start to rise as the back-filled pit starts to fill. • Decant may occur once the water level in the back-filled opencast pit has recovered. • Once the water levels have recovered, decant can occur and a groundwater pollution plume will start to migrate down gradient away from the pit.	• Carbonaceous material should be placed at the deeper base of the opencast pit to allow flooding with groundwater as soon as possible. This will reduce the redox reaction potential as oxygen is excluded from the system. • Rehabilitation should occur in such a manner that surface runoff is directed away from the rehabilitated pit and recharge to the pit minimized. • Flow paths which include fracture zones should be sealed to reduce inflow of fresh groundwater and outflow of contaminated groundwater. • Methods of handling the potential decant should be investigated and may include treatment of polluted water or a down gradient- intercepting trench. • The groundwater quality in the monitoring boreholes should continue to be analysed on a quarterly interval basis. • Monitoring of surface water features should eb conducted on a quarterly interval.

Table 30: Potential impacts on groundwater regime rating summary for the Trentra Vlaklaagte mining operation.

Activity	Aspect	Impact	Phase	Significance without mitigation	Significance with mitigation	Mitigation measures	Action Plan
Surface clearing and preparation.	Removal of vegetation.	Increase in surface run-off and therefore decrease in aquifer recharge.	Construction	Low	Low	Re-vegetate.	Rehabilitation plan.
Box cut opening.	Dewatering.	Decrease in water level should the pit floor be lower than the water level.	Construction	Med-High	Med-High	No management can be incorporated to limit the impacts of dewatering should the box-cut floor be lower than the groundwater level.	Quarterly monitoring of monitoring boreholes.
Topsoil and overburden stockpiling.	Leaching from stockpiles.	Acid generation in the case of carbonaceous material placement.	Operation	Low-Med	Low	Should a contamination plume be detected, groundwater abstraction to contain plume.	Quarterly monitoring of monitoring boreholes.
ROM stockpiling.	Leaching from stockpiles.	Acid generation as a result of carbonaceous material.	Operation	Low-Med	Low	Should a contamination plume be detected, groundwater abstraction to contain plume.	Quarterly monitoring of monitoring boreholes.

Activity	Aspect	Impact	Phase	Significance without mitigation	Significance with mitigation	Mitigation measures	Action Plan
Pollution Control Dam	Seepage should lining fail or dam overflow	Contaminated water in the dams can seep to the aquifer.	Operation	Low-Med	Low	Should a contamination plume be detected, groundwater abstraction to contain plume.	Quarterly monitoring of monitoring boreholes.
Hydrocarbon spills.	Plume migration.	Spills from mining vehicles can infiltrate to the aquifer and cause a down gradient plume migration.	Operation	Low	Low	Clean any hydrocarbon spills in the appropriate manner.	Report any hydrocarbon spillage.
Pit dewatering	Dewatering	The water infiltrating the pit will be removed for safe mining, causing a decrease in the water level.	Operation	High	High	No management can be incorporated to limit the impacts of dewatering.	Quarterly Monitoring. Compensate users for losses. Monitor pit inflow rates, Annual Monitoring report, Update Numerical Model.
Topsoil and overburden removal.	Placement of topsoil and overburden into pit.	Carbonaceous material, if any in the overburden, will be placed at the bottom of the pit as to prevent or minimise the exposure to oxygen and potential acid generation.	Closure and decommissioning	Low	Low	Remove the top soil and overburden dumps during rehabilitation. Placement of carbonaceous material at bottom of pit.	Rehabilitation Plan- placement of topsoil and overburden in pit.

Activity	Aspect	Impact	Phase	Significance without mitigation	Significance with mitigation	Mitigation measures	Action Plan
Backfilling	Reshaping of area	Adequate backfilling and rehabilitation will decrease aquifer recharge. The period to decant will therefore be prolonged.	Decommissioning	Low-Med	Low	Carbonaceous material at deeper base of pit. Rehabilitation to direct surface runoff away from pit and recharge to pit minimized. Flow paths including fracture zones sealed.	Refer to rehabilitation plan.
Revegetation	Reshaping of area and revegetating the area.	Increase surface runoff over the rehabilitated opencast, therefore decreasing aquifer recharge.	Rehabilitation	Low	Low	Remove the ROM stockpile and PCD's. This will eliminate the ROM stockpile and PCD's as potential sources.	Rehabilitation Plan
Backfilling of pit	Backfilling of the pit and no more dewatering.	Recovery of the water level in the pit as dewatering ceases. In the case of acid generation, the plume will start to move away from the pit as the water level recovered. Decanting may occur once the water level has recovered to the decanting elevation.	Residual	High	High	Keep water level in pit lower than level in nearby streams. Maintain water level below decant level (e.g. abstraction). Investigate implementation of cut-off trench.	Abstracted/decant water to be treated or handled in appropriate manner and within legislation. Continue quarterly monitoring post-closure.

9. GROUNDWATER MONITORING SYSTEM

9.1 Groundwater Monitoring Network

9.1.1 Source, Plume, Impact and Background Monitoring

Source monitoring is the monitoring of specific and potential sources. These include the monitoring boreholes drilled strategically to detect any impact from sources as soon as possible. Once impacts in these boreholes, especially in terms of quality impacts are detected, additional boreholes down gradient of the source monitoring borehole can be included in the program and is referred to as plume monitoring.

In the Trentra mining area, only source monitoring boreholes will form part of the monitoring network. Three monitoring boreholes are proposed to form part of the monitoring network and their positions have been indicated in **Figure 22**. Quarterly monitoring is proposed for the monitoring program.

9.1.2 System Response Monitoring Network

The groundwater regime will mostly be impacted on in terms of dewatering (operational) and contamination (post-closure). A quarterly monitoring programme is critical to determine the response especially of groundwater levels during the operational phase and the qualities post-closure of the mining activities. Changes in the groundwater level will influence the flow directions and pollution migration rates. Frequent monitoring will aid in understanding the response of the system to the mining activities.

9.1.3 Monitoring Frequency

It suggested that monitoring boreholes be monitored on a quarterly basis. Samples and water levels should be collected by an independent groundwater consultant, using best practice guidelines.

9.2 Monitoring Parameters

Groundwater samples should be analysed by an SANAS accredited laboratory for parameters normally associated with coal mining activities. The following parameters should form part of the chemical analysis for the proposed Trentra mining monitoring program:

- pH, Electrical Conductivity, Total Dissolved Solids, Calcium, Magnesium, Sodium, Potassium, Total Alkalinity, Chloride, Sulphate, Nitrate, Fluoride, Aluminium, Iron, Manganese, free and saline ammonia, Suspended Solids, Total Hardness, Turbidity, Dissolved Oxygen, Ortho Phosphate.

9.3 Monitoring Boreholes

Positions of proposed monitoring boreholes are presented in **Figure 22.** It is recommended that three new monitoring boreholes be drilled and monitored on a quarterly interval for a complete record. The monitoring results will aid in future model updates and geohydrological annual reports.

Table 31: Coordinates of boreholes to include in the monitoring network.

Borehole ID	X-coordinate	Y-coordinate
TV-MON-01	36300	-2894027
TV-MON-02	36312	-2893807
TV-MON-03	36416	-2894150

Figure 22: Positions of the monitoring boreholes to form part of the monitoring program at Trentra Vlaklaagte mining.

10. GROUNDWATER ENVIRONMENTAL MONITORING PROGRAMME

10.1 CURRENT GROUNDWATER CONDITIONS

No site-specific groundwater information is available and all the current groundwater conditions have been obtained from groundwater studies conducted for mining operations in the vicinity of the proposed Trentra mining area.

The groundwater qualities in the majority of the hydrocensus boreholes from the 2017 GCS report were good. Some elevated nitrate concentrations were observed in some of the hydrocensus boreholes where the concentrations exceeded the permissible limits for drinking water. Manganese in one borehole exceeded the permissible limits for drinking water in 2017.

Some of the mine monitoring boreholes from 2 Seam Colliery, south of the proposed Trentra mining area, indicated some impacts from mining activities with elevated sulphate concentrations in some of these boreholes. The sulphate concentration in one borehole exceeded the maximum permissible limits for drinking water together with the EC and nitrate concentrations in the same borehole.

The available water quality information was all south of the proposed Trentra Vlaklaagte mining area, south of the Olifants River. No quality information is available within 1km of the proposed mining area. It is also noted that no known mining activities is situated within 1km of the proposed mining operation and it is therefore not expected that the groundwater in the region of the proposed mining area will be impacted in terms of sulphate and mining related contamination. The proposed mining area is situated in an agricultural area. Agricultural activities may influence the groundwater qualities, but since no quality information for this site is available, no comments can be made in terms of agriculture.

Groundwater level information is available for the Vlaklaagte area as they were recorded during the GCS study in 2017. No water levels were available for the proposed Trentra mining area. Groundwater levels from the 2 Seam Vlaklaagte area generally varied from less than 1 to 15 mbs in the boreholes recorded during the hydrocensus and in the monitoring boreholes. Some deeper levels were observed but the majority of these levels were boreholes equipped with pump equipment which indicates that the levels may be affected by dewatering.

10.2 PREDICTED IMPACTS OF FACILITY (MINING)

The expected impacts as a result of the Trentra mining operations are summarised as:

- Construction phase:
  - Impacts in terms of groundwater levels are expected during this phase. The dewatering of the box-cut will cause a drawdown in the water levels within the immediate vicinity of the cut.
  - Fuel spillages from construction vehicles may occur during this phase.
- Operational phase:
  - Impacts in terms of groundwater levels are expected during this phase. The dewatering of the pit will cause a drawdown in the water levels within the immediate vicinity of the opencast activities.
  - The drawdown cone extent is not expected to exceed 60 m in the shallow weathered aquifer.
  - The maximum depth of drawdown at the pit is estimated at 18m,
  - Private users water levels within the cone of depression extent may be affected in terms of water levels.
  - No adverse impacts on the groundwater qualities surrounding the opencasts are expected during this phase.
- Post Closure:

- The plume will migrate down gradient from the pit area.
- The sulphate concentrations in the pit area increases as a result of acid generation.
- The plume is not expected to reach any surface water features.
- The contamination plume is not expected to extent more than 230 m from the source area.
- Post closure simulated qualities in the opencast voids:

Pit	Sulphate concentration at 50 years post-closure (mg/l)
Trentra Vlaklaagte Pit	2 500

10.3 Mitigation Measures

Phase	Mitigation Measures
Construction Phase	• Should fuel spillages occur during the construction phase immediate action is required to minimise the impact on the groundwater regime. • No management can be incorporated to limit the impacts of dewatering should the box-cut floor be lower than the groundwater level.
Operational Phase	• Groundwater levels in the monitoring boreholes should be measured on at least a quarterly interval. • Should the water levels of surrounding users be influenced in terms of groundwater level or quality decline, the users should be compensated. • Monitor groundwater inflow rates on a monthly basis throughout the mining operation. • The groundwater quality in the monitoring boreholes should be analysed on a quarterly basis. • Annual reporting on the groundwater qualities and levels should be conducted and submitted to the DWA. • The numerical model should be updated once more time-series monitoring data (water levels and qualities) are available and on an annual basis. • Remove as much coal from the mining pit as possible to prevent continuous acid generation.
Post-Closure Phase	• Carbonaceous material should be placed at the deeper base of the opencast pit to allow flooding with groundwater as soon as possible. This will reduce the redox reaction potential as oxygen is excluded from the system. • Rehabilitation should occur in such a manner that surface runoff is directed away from the rehabilitated pit and recharge to the pit minimized. • Flow paths which include fracture zones should be sealed to reduce inflow of fresh groundwater and outflow of contaminated groundwater. • Methods of handling the potential decant should be investigated and may include treatment of polluted water or a down gradient- intercepting trench. • The groundwater quality in the monitoring boreholes should continue to be analysed on a quarterly interval basis. • Monitoring of surface water features should eb conducted on a quarterly interval.

11. POST-CLOSURE MANAGEMENT PLAN

The following suggestions are made for the post-closure management:

- Carbonaceous material should be placed at the base of the opencast pit to allow flooding with groundwater as soon as possible. This will reduce the redox reaction potential as oxygen is excluded from the system.
- Rehabilitation should occur in such a manner that surface runoff is directed away from the rehabilitated pit and recharge to the pit minimized.
- Flow paths which include fracture zones should be sealed to reduce inflow of fresh groundwater and outflow of contaminated groundwater.
- Methods of handling the potential decant should be investigated and may include treatment of polluted water.
    - Treatment options can either be passive or active.
    - For smaller rates of flow/decant passive treatment options are proposed. These volumes should be less than 500 to 1 000 m^3/day.
    - The estimated decant rate at the Trentra Vlaklaagte pit is estimated at 6 m^3/day.
    - Passive treatment options are therefore proposed for the proposed mining at Trentra Vlaklaagte.
    - Options include:
        - pH adjustment (anoxic limestone drains (ALD);
        - Bio neutralisation;
        - Successive alkalinity producing systems (SAPS);
        - Metals removal (ALD + oxidation pond; SAPS, sulphate reducing units, wetlands, oxidation cascades); and
        - Sulphate removal (sulphate reducing units + sulphide oxidising bioreactors).
- The groundwater quality in the monitoring boreholes should continue to be analysed on a quarterly interval basis post-closure.
- Down gradient water users should be notified should any impacts have an effect on their health or availability of groundwater.

12. CONCLUSIONS AND RECOMMENDATIONS

The geohydrological environment at the proposed Trentra Vlaklaagte mining area can be summarised as follows:

- The basis of the conceptual model can be summarised as follows:
- The proposed Trentra Vlaklaagte mining area is located in the Highveld region of Mpumalanga and in a summer rainfall region.
- The mean annual precipitation is ± 665 mm/annum, while the evaporation is estimated at 1 700 mm/annum.
- Drainage over the regional area is towards the north, while locally drainage is towards the north-east.
- The Trentra Vlaklaagte mining area is underlain by sedimentary rocks from the Karoo Super group's Vryheid Formation.
- Geological structures such as dykes and faults are known to exist in the region of the Trentra Vlaklaagte mining. These structures and the weathered zone are possible pathways of elevated groundwater flow and contamination migration.
- Two main aquifer systems are found in the Trentra Vlaklaagte mining region. Firstly, the shallow weathered aquifer and secondly, the deeper, secondary aquifer.
- Groundwater levels generally varied from less than 1 to 15 mbs in the boreholes recorded (GCS, 2017).
- With the short duration of opencast mining, the cone of depression due to dewatering is not expected to extent more than 60 m from the pit area.
- Groundwater Sources:
  - Recharge:
    - Natural recharge: in the region of the project the natural recharge is estimated between 1 and 3% of the MAP. Rivers and drainage systems can also be seen as potential recharge sources. Gaining or losing streams play a role here. Losing streams "lose" their water to the aquifer, making it a natural recharge source. The Olifants River to the south of the project is a gaining feature and may be connected to the groundwater regime.
    - Artificial recharge: Artificial recharge from sources including the PCD may occur in the mining operation should leakage from this feature occur. The backfilled opencast pit can act as an artificial recharge sources since the recharge through the spoils can recharge the underlying aquifer directly. Artificial recharge from surrounding mining operations may already be taking place/have taken place.
  - Contamination Sources: At the proposed mining operation the potential contamination sources include the opencast pit, especially post closure and any carbonaceous source which may include the PCD, ROM stockpiles or overburden stockpiles.
- Groundwater pathways:
  - Fault zones and dykes surrounding the proposed project area may be potential pathways for groundwater contamination migration. No site-specific geological structure information is available, but it is typical for Karoo geology to have these types of structures present.
- Groundwater receptors:

- River Systems: any contamination from potential sources may be discharged in terms of baseflow into the receiving river systems in the area. The distance from the river systems minimise the impact, if any, on the surface water.
- Potential groundwater users: No known groundwater users are expected or known within the potential impact zone of the proposed mining activity. The impact zone may increase should pathways such as geological structures be present.
- Opencast pit: once dewatering of the pit commence, water will flow towards the pit and therefore act as a groundwater receptor, even though an artificial receptor.

The expected impacts as a result of the proposed mining operations (Lakeside Leeuwfontein) are summarised as:

- Construction phase:
  - Impacts in terms of groundwater levels are expected during this phase. The dewatering of the box-cut will cause a drawdown in the water levels within the immediate vicinity of the cut.
  - Fuel spillages from construction vehicles may occur during this phase.
- Operational phase:
  - Impacts in terms of groundwater levels are expected during this phase. The dewatering of the pit will cause a drawdown in the water levels within the immediate vicinity of the opencast activities.
  - The drawdown cone extent is not expected to exceed 60 m in the shallow weathered aquifer.
  - The maximum depth of drawdown at the pit is estimated at 18m,
  - Private users water levels within the cone of depression extent may be affected in terms of water levels.
  - No adverse impacts on the groundwater qualities surrounding the opencasts are expected during this phase.
- Post Closure:
  - The plume will migrate down gradient from the pit area.
  - The sulphate concentrations in the pit area increases as a result of acid generation.
  - The plume is not expected to reach any surface water features.

The contamination plume is not expected to extent more than 230 m from the source area.

The proposed mitigation measures for the proposed mining operation are summarised below:

- Operational phase:
  - Groundwater levels in the monitoring boreholes should be measured on at least a quarterly interval.
  - Should the water levels of surrounding users be influenced in terms of groundwater level or quality decline, the users should be compensated.
  - Monitor groundwater inflow rates on a monthly basis throughout the mining operation.
  - The groundwater quality in the monitoring boreholes should be analysed on a quarterly basis.
  - Annual reporting on the groundwater qualities and levels should be conducted and submitted to the DWA.
  - The numerical model should be updated once more time-series monitoring data (water levels and qualities) are available and on an annual basis.
  - Remove as much coal from the mining pit as possible to prevent continuous acid generation.

- Post-closure phase:
  - Carbonaceous material should be placed at the deeper base of the opencast pit to allow flooding with groundwater as soon as possible. This will reduce the redox reaction potential as oxygen is excluded from the system.

- Rehabilitation should occur in such a manner that surface runoff is directed away from the rehabilitated pit and recharge to the pit minimized.
- Flow paths which include fracture zones should be sealed to reduce inflow of fresh groundwater and outflow of contaminated groundwater.
- Methods of handling the potential decant should be investigated and may include treatment of polluted water or a down gradient- intercepting trench.
- The groundwater quality in the monitoring boreholes should continue to be analysed on a quarterly interval basis.
- Monitoring of surface water features should eb conducted on a quarterly interval.

13. REASONED OPINION

A reasoned opinion-

* as to whether the proposed activity or portions thereof should be authorized and
* if the opinion is that the proposed activity of portion thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPR, and where applicable, the closure plan.

It is the opinion of the Geohydrologist that the proposed prospecting activities should be authorised.

- The environmental impacts associated with the mining activities are limited provided that the proposed mitigation is implemented.
- The impact zone in terms of water levels is not expected to extent more than 60 m from the mining pit boundaries during the operational phase.
- The impact zone in terms of groundwater qualities is not expected to extent more than 230 m from the mining pit boundaries at 50 years post-closure.
- These impact zones represent the impact of the mining activities without mitigation measures in place. Thus, worst-case scenario.
- Groundwater users in the area were not identified, but the proposed mining area is in the middle of an agricultural crop land and it is not expected that groundwater users will be found within the impact zone of the mining activities. Should any users occur in the impact zone or be impacted on by the mining activities, the users should be compensated for.
- Sufficient financial provision should be provided for the treatment of acid mine drainage (AMD) or decant of polluted water.
- No surface water features are within the estimated impact zone of the mining activities.

The impacts on the groundwater regime is inevitable, but with the proper proposed mitigation measures in place the impact can be limited.

14. KNOWLEDGE GAPS, LIMITATIONS, ASSUMPTIONS

The following knowledge gaps, limitations and assumptions apply to the Trentra Vlaklaagte study area in terms of the groundwater study:

- No information on the status of the neighbouring mining activities were available. The impacts and inter-mine interactions can therefore not be determined.
- No site-specific information regarding groundwater users, aquifer hydraulics, groundwater quality is available for the project site. The Trentra Vlaklaagte study was based on studies in the nearby vicinity of the proposed project of which the groundwater characteristics are expected to be similar.
- Information regarding the coal floor was extracted from previous investigations in the area and no site-specific core drilling results were available for the extraction of the coal floor contours. The calculations in terms of drawdown, pit inflows and time to decant should be updated once the coal floor information becomes available.
- No acid-base analysis were performed and the mining activities were regarded as acid generating.

15. REFERENCES

- ✓ Department of Water and Sanitation (2017), ***Reserve Determination of Water Resources for the Catchments of the Olifants and Letaba in Terms of Section 16(1) And (2) of the National Water Act, 1998 (Act No. 36 Of 1998). Government Gazette***, 22 September 2017, Vol. 627. No. 41132. Part 2 of 3.
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