Environmental Management Assistance (PTY) LTD

Vlakfontein Coal Mine – Baseline Geohydrological Study

Project Number: Delh.2022.045-05

WATER SYSTEMS MODELLING

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EXECUTIVE SUMMARY

BCR Coal (Pty) Ltd (the applicant) is proposing an open pit mining operation, hereafter referred to as the BCR Coal Vlakfontein Mine, situated on Portion (Ptn.) 2, Ptn 11 and Ptn 21 of farm Vlakfontein 108 IT, Ptn 1, 7, 14, and 12 of farm Welgelegen 107 107 IT, Msukaligwa Municipality, Mpumalanga.

A desktop level hydrogeological assessment was conducted as a first phase assessment to determine the groundwater conditions at BCR Coal Vlakfontein Mine.

The proposed BCR Coal Vlakfontein mining activities, is located on approx. 10 km southeast from Breyten, 20 km southwest from Chrissiesmeer and 15 km northeast from Ermelo. The project area falls within the quaternary catchment C11A with the Upper Vaal Water Management Area.

The topography of the project area is characterised by mostly flat laying areas with some crests and valleys. The highest elevation at the mine site is approx. 1780 mamsl and the lowest elevation is approx. 1680 mamsl, sloping towards the river drainage in an eastern direction towards the Vaal River.

The prevailing geology is characterised by the Vryheid formation form the Karoo Supergroup, consisting of sedimentary rocks and coal deposit. Some dolerite intrusions are observed in the region as well. The dolerite intrusions typically occur as sills or dykes and are often responsible for the devolatization of the coal adjacent to these intrusions. The target coal deposit forms part of the Ermelo Coalfields, with the C-seam being the target.

The geology drives two main aquifer systems, a shallow weathered with alluvial aquifer system and a deeper fractured aquifer system. The shallow alluvial and weathered aquifer system is an intergranular water table aquifer with expected depths up to 20m with low to moderate permeability but high storativity. The deeper fractured aquifer system, semi-unconfined aquifer, consists of fractured rock with a low hydraulic conductivity, with water mostly stored in fractured and fissures.

Based on the borehole information retrieved on catchment scale the aquifer is characterised by groundwater levels ranging from surface to 65.9 m bgl (or deeper). Based on the data obtained site specific groundwater levels has an average depth of 9.9 mbgl. Typical water strikes are approx. 25m bgl with blow yields of approx. 1L/s.

The expected groundwater quality, derived from 3 boreholes on catchment scale, is to be within concentration values within drinking water standards. Mining exposes sulphide bearing minerals which may impact on the ambient groundwater quality.

Based on the vulnerability assessment the underlying aquifer is regarded as a low to medium vulnerability aquifer system requiring reasonable groundwater protection measures to ensure that no cumulative pollution affects the aquifer.

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1. INTRODUCTION

1.1. Background

Delta H (Delta-H Water System Modelling PTY Ltd) has been appointed by Environmental Management Assistance (EMA) (Pty) Ltd to conduct a baseline hydrogeological study in support of the required Scoping Report for the proposed mining activities by BCR Coal (Pty) Ltd.

BCR Coal (Pty) Ltd (the applicant) is proposing an open pit mining operation, hereafter referred to as the BCR Coal Vlakfontein Mine, situated on Portion (Ptn.) 2, Ptn 11 and Ptn 21 of farm Vlakfontein 108 IT, Ptn 1, 7, 14, and 12 of farm Welgelegen 107 107 IT, Msukaligwa Municipality, Mpumalanga.

The surface sub-outcrop of the coal seams is planned to be mined using an advancing open pit mining method which allows for concurrent filling of the pit. The pit will be used to develop portals which will allow the remainder of the ore to be exploited using underground mining methods.

1.2. Legislative Context

Part of the application for environmental authorisation, specialist studies (reports) are required, as stipulated in Chapter 4, Paragraph 19, subparagraph 8 and paragraph 23, subparagraph 5 of the Environmentally Impact Assessment Regulations, gazetted under GN R982 in GG 38282 of 4 December 2014 with ongoing amendments. The hydrogeological specialist report is therefore undertaken in accordance with the following legal and administrative documents:

- Scoping Phase as described in Appendix 2 of the EIA Regulation (gazetted in GN 326 of 7 April 2017) and follows regulations set out in Appendix 6 of EIA Regulations of 2014.
- The procedural requirements for Environmental Impact Assessments and according to the Government Notice R. 267 (Government Gazette No. 40713, 27/03/2017) pertaining to the National Water Act, 1998 (Act No. 36 of 1998).

1.3. Assumptions and Gaps in Knowledge

The information used in the hydrogeological assessment was conducted on desktop level. The following assumptions and limitation are noted:

- No intrusive investigation, i.e. site visit and hydrocensus, could be conducted during writing of this report.
- Borehole information (e.g. locations, logs, depth, current water levels, abstraction rates etc.) in and around the project area are required to obtain current groundwater levels, and quality. Further limitations based on the borehole information include:
    - The information used were based on readily available published information that represent the overall groundwater conditions, however, does not represent the current date of site-specific conditions, i.e. groundwater volumes abstracted and third party groundwater users needs to be identified to verify current on site conditions.
    - The groundwater quality was based on catchment scale and not site-specific conditions. This should be augmented by a hydrocensus.
- No available hydraulic test results, i.e. slug, pumping and/or packer tests, to determine the transmissivity values for the heterogeneous aquifer systems are available.
- No information is available on the potential mine residue deposits' water quality concentrations, i.e., geochemical assessment of potential contaminating sources providing potential seepage concertation into the groundwater needs to be verified.

2. GENERAL SETTING

2.1. Site Location

The proposed BCR Coal Vlakfontein mining activities, collectively referred to as project area, is located on approx. 10 km southeast from Breyten, 20 km southwest from Chrissiesmeer and 15 km northeast from Ermelo, illustrated in Figure 2.1.

2.2. Topography and Drainage

The topography of the project area is characterised by mostly flat laying areas with some crests and valleys. The highest elevation at the mine site is approx. 1780 mamsl and the lowest elevation is approx. 1680 mamsl, sloping towards the river drainage in an eastern direction (Figure 2.1). The project area falls within the quaternary catchment C11A with the Upper Vaal Water Management Area. A summary of readily available hydrological data for the catchment is provided in Table 2.1. The major river system is the Vaal River, flowing in a southeaster direction, located within the Welgelegen 107 IT Farm. Some unnamed tributaries of the Vaal River, hosting some dams, flow though the larger project area as well.

Table 2.1: Summary of information for the quaternary catchment (GRAII; DWAF 1996).

Quaternary catchment	Area (km^2)	Mean Annual Precipitation (mm/a)	Mean Annual Runoff (mm/a)	Mean Annual Baseflow (mm/a)	Mean Annual Recharge	
					mm/a	% of MAP
C11A	719.4	743	76	8	52.02	7

2.3. Climate

The study area falls within the summer rainfall region, with a Highveld climate of warm to hot summers and cold, dry winters. The Mean Annual Precipitation (MAP) is according to the GRA II by the Department of Water and Sanitation from 743 mm/a for quaternary catchment C11A (Table 2.1) and occurs mostly in the summer months.

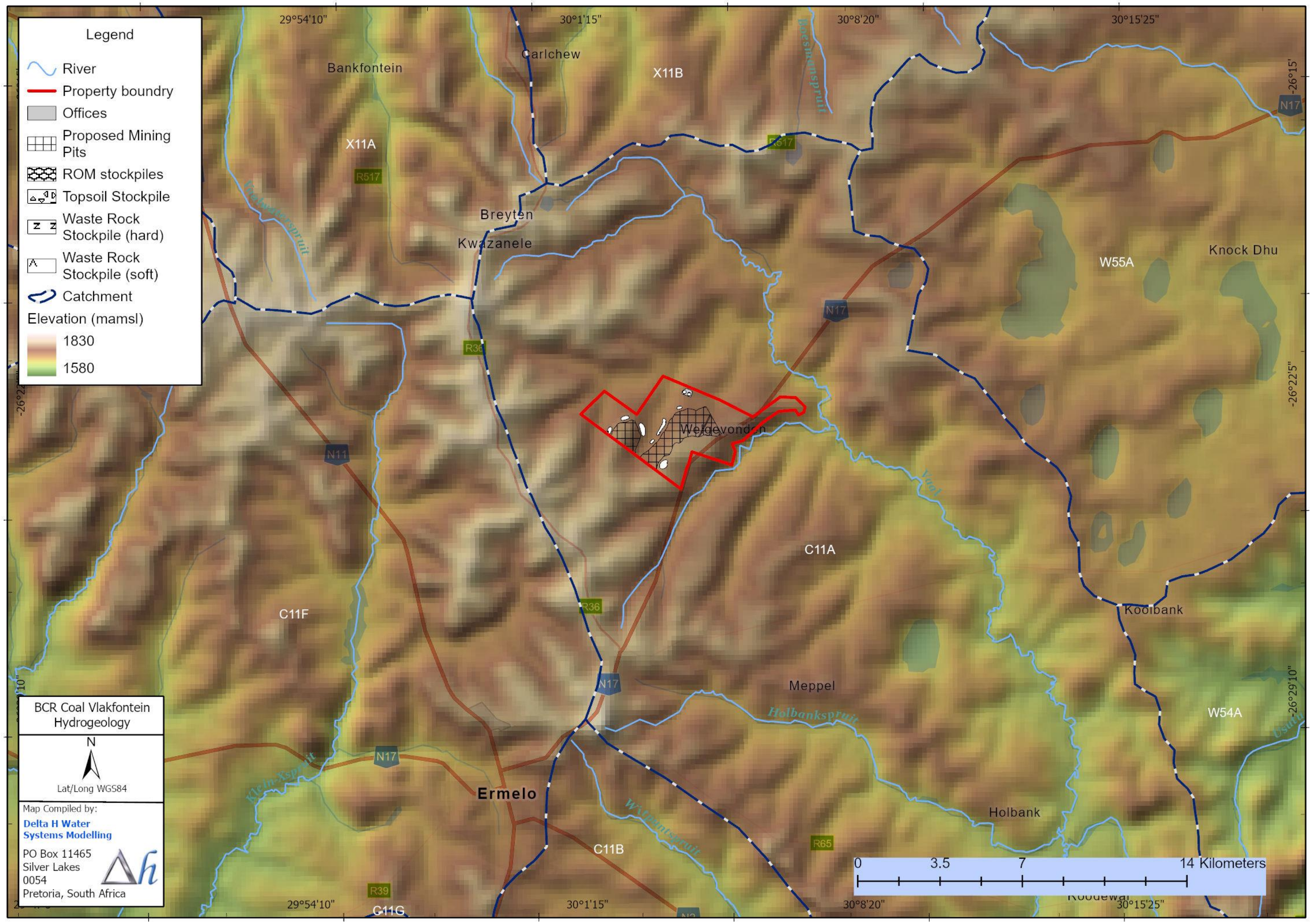

Figure 2.1: Locality with topography map of project area.

3. METHODOLOGY

3.1. Desktop Study

The desk study entailed a review of the available groundwater related information at the project area. The information relied on the following:

- Geological information based on the 1:250 000 scale geology map.
- National hydrogeological map of South Africa, 1:500 000 scale hydrogeology map.
- Digital Elevation Model (DEM) based on a 30m x 30 m grid, Advanced Spaceborn Thermal Emission and Reflection Radiometer (ASTRA) data.
- National Groundwater Achieve (NGA) borehole database, upheld by the Department of Water and Sanitation (DWS).

3.2. Hydrocensus

At the time of finalising this report, access to the site associated with the proposed development could not be gained to conduct the required hydrocensus. The National Groundwater Achieve (NGA) database, upheld by the Department of Water and Sanitation (DWS), have been accessed to obtain regional borehole information to assist in the conceptualisation of the groundwater occurrence, such as groundwater flow, for quaternary catchment C11A.

3.3. Geophysical Survey and Results

No geophysical surveys were done as part of this study.

3.4. Drilling and Siting of Boreholes

No drilling was done as part of this study.

3.5. Aquifer Testing

No aquifer tests were done as part of this study.

3.6. Sampling and Chemical Analysis

At the time of finalising this report, access to the site associated with the proposed development could not be gained to conduct the required hydrocensus. The water quality was based on the NGA database for quaternary catchment C11A. Three (3) water samples for catchment C11A could be obtained.

3.7. Groundwater Recharge

The groundwater recharge rate at site is based on the GRAII data held by DWS. No independent measurements of recharge and seepage rates for the geology were taken.

3.8. Groundwater Modelling

No three dimensional (3D) numerical groundwater flow and transport modelling was conducted for this desktop study.

3.9. Groundwater Availability Assessment

No groundwater availability assessment was done as part of this study.

4. PREVAILING GROUNDWATER CONDITIONS

4.1. GEOLOGY

4.1.1. Regional Geology

The project area is predominantly underlain by litho-stratigraphic units from the Karoo Supergroup, illustrated in Figure 4.1, overlain along major river courses by quaternary, alluvial deposits. The Karoo Supergroup formed during the Late Carboniferous to Middle Jurassic eras from plant assemblages, thick glacial deposits and extensive flood basalts with their associated dolerite sills and dykes. Extensive coal deposits establish the economic importance of the Karoo Supergroup. The project area is characterised by the Main Karoo Basin, more specifically the Ermelo Sub-Basin, which is underlain by the stable Kaapvaal Craton floor. The Main Karoo Basin consists of a number of sub-groups, i.e. Dwyka, Ecca, Beaufo, Drakensburg and Lebombo Groups. These sub-groups are further divided into formations. One such formation, the Vryheid Formation, forms part of the Ecca Group, and characterise the geology and geomorphology of the project area. There are no exposures of Pre-Karoo rocks in the project area as outcrops are limited to Karoo dolerite and the Ecca Group. The Vryheid Formation is mainly from deltaic origin, consisting of upwards coarsening sedimentary material such as dark-grey, muddy siltstone, sandstone, dark siltstone and mudstone units, with interbedded coal units of variable thicknesses at depths.

The dolerite intrusions present within the project area are younger than the lithologies of the Ecca Group and intruded into and through these sedimentary lithological units. The dolerite intrusions typically occur as sills or dykes and are often responsible for the devolatization of the coal adjacent to these intrusions. Typically, dolerite sills crop out on surface, occur very close to the surface or have been entirely removed through erosion in places. These sills are usually fine crystalline, although it can occur in varying degrees of texture starting from fine crystalline and grading to a medium crystalline texture.

4.1.2. Local Geology

The coal seams in the Ermelo Coalfield are generally flat-lying to slightly undulating and are separated by fine- to coarse-grained sandstones, siltstones and mudstones. The A, D and E seams are usually too thin to be of economic interest and historically the C Seam group was the most important in the Carolina-Breyten area, and the B Seam group in the Ermelo area.

The C Seam group has been one of the main seam packages of economic importance throughout the Ermelo Coalfield. It is usually split by several partings which can lead to miscorrelation of the seams. In general, the C Seam is subdivided into the C Upper (CU) and C Lower (CL) seams. The CU Seam is well developed over the entire coalfield and is often split by partings of different lithologies, such as sandstone, siltstone, or mudstone, reaching a composite thickness of 0.7-4 m. The CL Seam is not developed throughout the entire coalfield, but where developed is between 0.5 and 2 m thick. It locally grades into carbonaceous siltstone and mudstone, which often form the roof of the seam, whereas the floor mostly consists of sandstone. It is the thickest of all the coal seams intersected here, reaching a thickness of more than 1.50 m over large parts of the project area. Locally seam floor rolls may negatively influence the thickness of the CL Seam in the Ermelo Coalfield. The B Seam group varies in thickness from 1-2.7 m and may be split into three units, B Lower (BL), B Upper (BU) and BX seams (BCR, 2022).

4.2. HYDROGEOLOGY

Based on the conceptual hydrogeological understanding of the site, the following hydro-stratigraphic zones are differentiated within the model area:

1. **Shallow alluvial and weathered Karoo aquifer**
2. **Fractured Karoo aquifer**

Weathered Karoo aquifer

The weathered zone of the Karoo sediments hosts the unconfined or semi-confined shallow weathered Karoo aquifer or hydro-stratigraphic zone. The weathered zone is typically around 2 m to 21 m thick and water levels within this aquifer are often shallow (few meters below ground level). Due to direct rainfall recharge and dynamic groundwater flow through the unconfined aquifer in weathered sediments, the water quality is generally good, but in the absence of an overlying confining layer also vulnerable to pollution. Localised perched aquifers may occur on clay layers or lenses but are due to their localised nature of no further interest in the context of the current study. Water intersections in the weathered aquifer are mostly above or at the interface to fresh bedrock (sandstone or sills), where less permeable layers of weathering products and capillary forces limit the vertical percolation of water and promote lateral water movement. Groundwater daylights as springs where the flow path is obstructed by less permeable dolerite sills (contact springs) or where the surface topography cuts into the groundwater level at e.g., drainage lines (free draining springs).

Fractured Karoo aquifer

The fractured Karoo aquifer consists of the various lithologies of siltstone, shale, sandstone and the coal seams. Groundwater flow is governed by secondary porosities like faults, fractures, joints, bedding planes or other geological contacts (including coal seams), while the rock matrix itself is considered impermeable. Geological structures are generally better developed in competent rocks like sandstone, which subsequently show better water yields than the less competent silt- or mudstones and shales. Not all secondary structures are water bearing due to e.g. compressional forces by the neo-tectonic stress field overburden closing the apertures. The fractured Karoo aquifer is considered a semi-confined aquifer, depending on the prevailing sedimentary succession.

Fractured Karoo aquifers have typically a low hydraulic conductivity (<0.001 m/d) but are known to be highly heterogeneous with yields ranging from 0.5 to 2 L/s. Higher yields are typically associated with higher hydraulic conductivities along shallow coal seams and at contact zones with intrusive rocks. Depending on the residence time of the water in the aquifer, groundwater quality can be poor.

Dolerite intrusions

The Karoo rocks in the project area were intruded by dolerite sills or dykes, with their contact zones with the host rock providing preferential flow paths, while the dolerite itself is rather impermeable or semi-permeable (hydraulic conductivity of approximately 1E-8 m/s). This setting promotes groundwater ponding and flow along, but not across the sills and dykes.

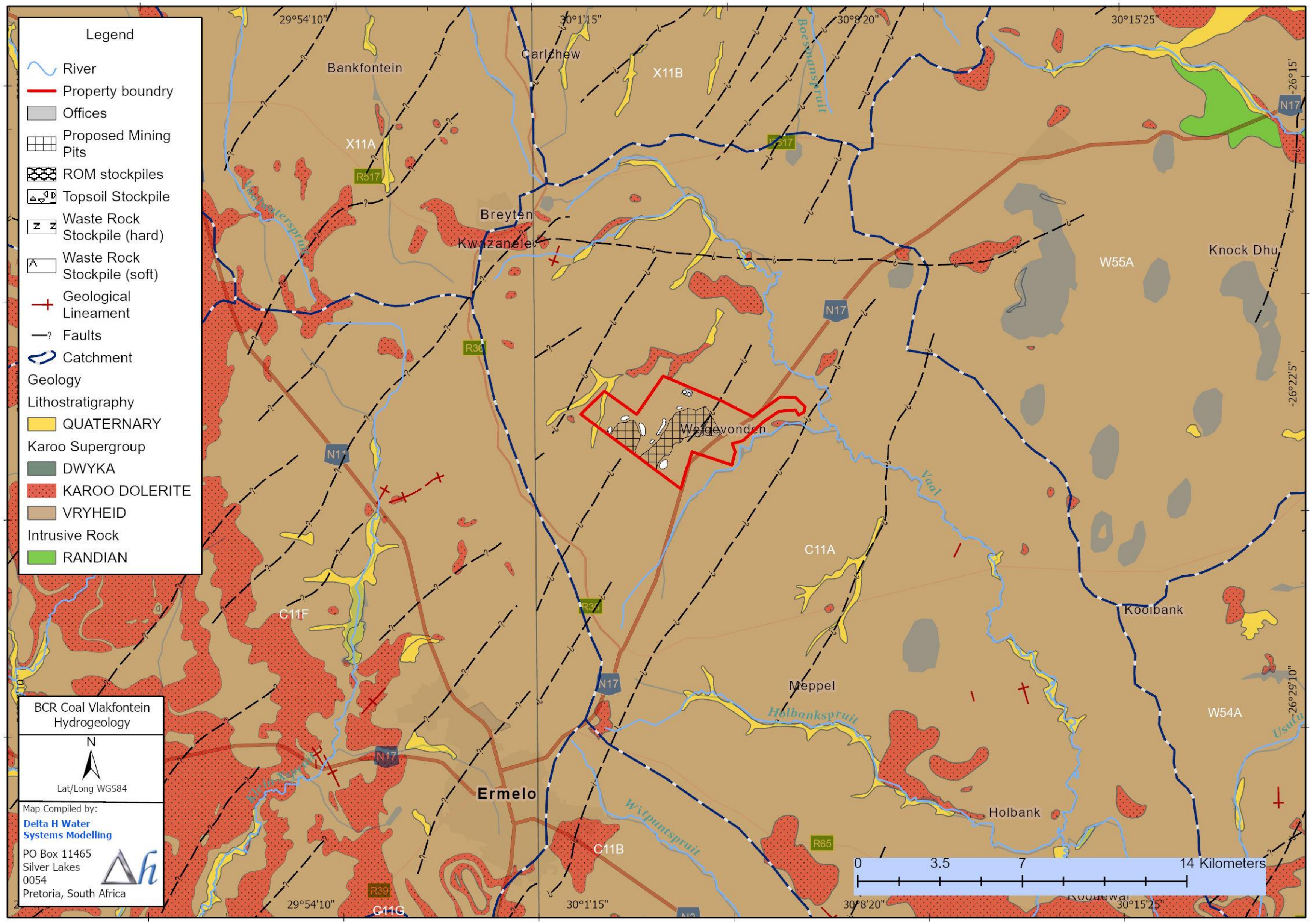

Figure 4.1: Geology map of the project area.

4.3. Basic Aquifer Information

4.3.1. Borehole Database Information

Basic borehole information data was obtained from the NGA database upheld by DWS including borehole depth, water strike depth and yield as well as water levels. The data was obtained for catchment C11A. Additional water levels were obtained from previous studies conducted in the area for quaternary catchment C11A as well. The spatial spread of the borehole information is illustrated in Figure 4.2. The prevailing geology of quaternary catchment C11A is similar to the project area, mostly rocks form the Vryheid Fm and Dolerite intrusions, therefore the borehole information on catchment scale provides some indication of onsite aquifer conditions. A summary of the borehole information is provided in Table 4.1.

Although the spatial distribution of the borehole information obtained from the NGA database is limited to a plotting accuracy within a farm central point, the statistical analysis provides information of the aquifer characteristics. The borehole depth typically ranges from 10 m to 100 metres below ground level (m bgl) with the average depth is approx. 42 m bgl. Water strikes are typically located at 26 m bgl with an average blow yield of approx. 1 L/s. The groundwater levels range from 2.9 m bgl to 45.7 m bgl with average of 13.7 m bgl. A total of 49 water levels were obtained located within the project area, with groundwater levels ranging from 0.4 m bgl to 55.2 m bgl within an average of 9.9 m bgl. Shallower groundwater levels are expected closer to surface water drainage lines and depressions.

Table 4.1: Borehole information for catchment C11A based on the collated database.

Info	*Water Level [m bgl]*	*BH Depth [m bgl]*	*Water Strike [m bgl]*	*Blow Yield [L/s]*
Mean	13.3	41.6	25.7	1.0
Median	9.1	37.1	21.3	0.7
Standard Deviation	12.2	19.0	15.1	1.0
Minimum	0.4	9.3	2.4	0.1
Maximum	65.9	108.0	101.0	5.1
Count	189	96	126	105

4.3.2. Groundwater Quality

The DWS keeps a database record of basic water quality parameters that forms part of the NGA database. Three boreholes have been obtained from the database within quaternary catchment C11A. The closet water quality borehole is located approx. 5km southeast from the project area. A summary of the water quality data is shown in Table 4.2., while the spatial distribution is shown in Figure 4.2. The concentrations of selected constituents of groundwater samples were compared against the South African National Standards for Drinking Water (SANS, 241-1 2015) and South African Water Quality Guideline Volume 1 Domestic Use (DWAF, 1996). None of the observed chemical constituents were above any target concentrations values. The water quality should provide some indication of baseline / background water quality associated with rocks form the Vryheid formation, therefore similar to the project area.

Table 4.2: Groundwater quality data for catchment C11A based on the NGA database.

Site ID	Date	pH	EC (mS/m)	TDS	Total Alkalinity	Cl	SO_4	F	NO_3+ NO_2	PO_4-P	NH_4-N	Na	K	Ca	Mg
DWAF: Drinking Water			**70**	**450**	**NS**	**100**	**200**	**1**	**6**	**NS**	**NS**	**100**	**50**	**32**	**30**
SANS 241-1: 2015		**5-9.7**	**170**	**1200**	**NS**	**300**	**500**	**1.5**	**11**	**NS**	**NS**	**200**	**NS**	**NS**	**NS**
97132	1991/12/09	7.14	24.30	195.00	107.40	3.20	10.00	0.24	0.49	0.02	0.02	24.50	3.16	14.00	6.50
169110	1992/01/17	8.11	23.20	188.00	103.20	1.50	7.70	0.18	2.45	0.01	0.08	5.50	1.24	20.50	14.40
172687	1994/07/12	7.53	12.80	110.00	61.20	3.00	2.00	0.34	1.60	0.05	0.08	2.70	1.43	10.50	7.20

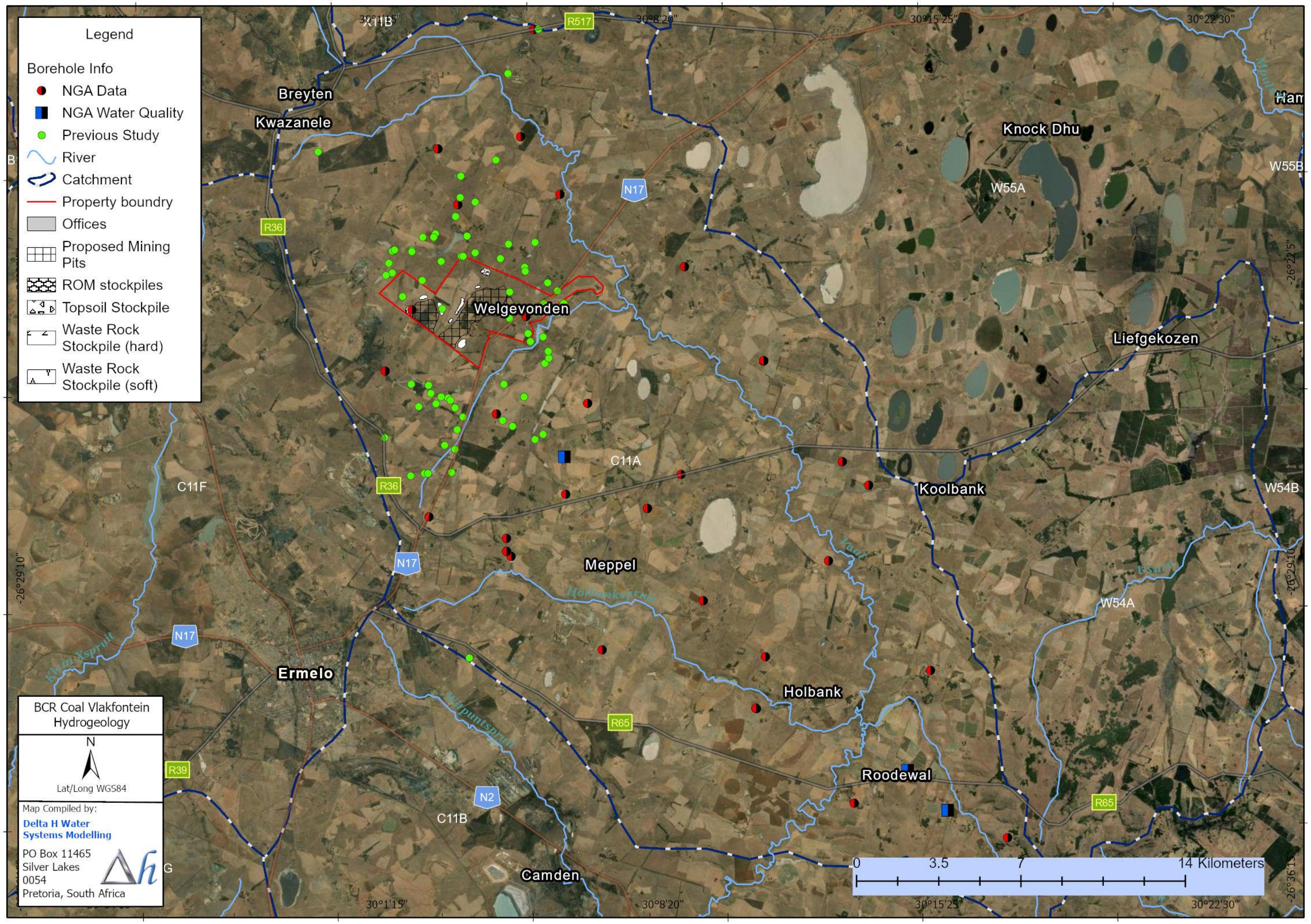

Figure 4.2: Spatial distribution of the borehole database for catchment C11A.

5. AQUIFER CHARACTERISATION

5.1. GROUNDWATER VULNERABILITY

Groundwater vulnerability gives an indication of how susceptible an aquifer is to contamination. Aquifer vulnerability is used to represent the intrinsic characteristics that determine the sensitivity of various parts of an aquifer to being adversely affected by a contaminant load imposed from surface. Figure 5.1 shows the national groundwater vulnerability ratings underlying the project area, indicating the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer. The method is based on the DRASTIC method which includes the following parameters: Depth to water table; Recharge (net); Aquifer media; Soil media; Topography; Impact of the vadose (unsaturated) zone; conductivity (hydraulic).

Based on the national results, the aquifer underlying the project area has a low to medium vulnerability rating.

5.2. AQUIFER CLASSIFICATION

According to the Hydrogeological Map (1:500 000) series, the regional hydrogeology is characterized as an 'intergranular and fractured aquifer' with a typical potential yield of 0.1 – 2.0 litres per second (L/s). A micro-fractured matrix in the fractured aquifers provides the storage capacity with limited groundwater movements, while secondary features such as fractures / faults and bedding planes enhance the groundwater flow. Based on the aquifer classification map (Parsons and Conrad, 1998), the aquifer system underlying the project area is regarded a "minor".

A summary of the classification scheme is provided in Table 5.1. In this classification system, it is important to note that the concepts of Minor and Poor Aquifers are relative and that yield is not quantified. Within any specific area, all classes of aquifers should therefore, in theory, be present.

Table 5.1: Aquifer classification scheme after Parsons and Conrad (1998).

Aquifer	Description
Sole source aquifer	An aquifer used to supply 50% or more of urban domestic water for a given area, for which there are no reasonably available alternative sources, should this aquifer be impacted upon or depleted.
Major aquifer region	High-yielding aquifer of acceptable quality water.
Minor aquifer region	Moderately yielding aquifer of acceptable quality or high yielding aquifer of poor-quality water.
Poor aquifer region	Insignificantly yielding aquifer of good quality or moderately yielding aquifer of poor quality, or aquifer that will never be utilised for water supply and that will not contaminate other aquifers.
Special aquifer region	An aquifer designated as such by the Minister of Water

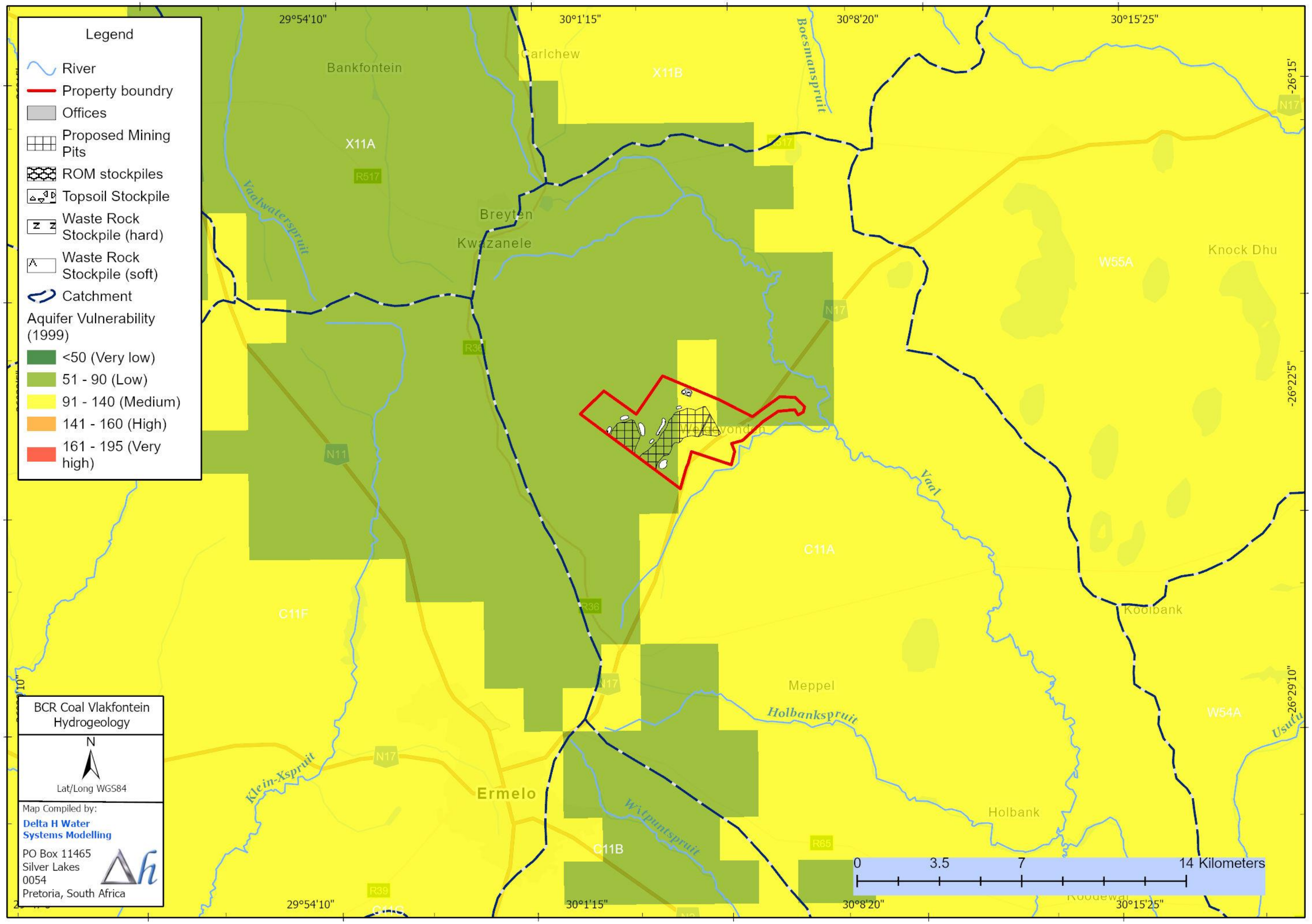

Figure 5.1: Groundwater vulnerability map of the project area.

5.3. AQUIFER PROTECTION CLASSIFICATION

As part of the aquifer classification, a Groundwater Quality Management (GQM) Index is used to define the level of groundwater protection required (Parsons 1995). The point scoring system and classification of the site-specific project area are presented in Table 5.2.

Table 5.2: Groundwater Quality Management (GQM) Classification System.

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

The recommended level of groundwater protection based on the Groundwater Quality Management Classification is calculated as follows: GQM Index = Aquifer System Management x Aquifer Vulnerability = 2 x 2 = 4

A Groundwater Quality Management Index of 4 was estimated for the project area from the ratings for the Aquifer System Management Classification (Table 5.3). According to this estimate, a low to medium level groundwater protection is required. Reasonable groundwater protection measures are recommended to ensure that no cumulative pollution affects the aquifer, even in the long term. DWS's water quality management objectives are to protect human health and the environment. Therefore, the significance of this aquifer classification is that if any potential risk exists, measures must be taken to limit the risk to the environment, which in this case is the protection of the underlying aquifer.

Table 5.3: GQM index for the project area.

Index	**Level of Protection**	**Project area**
<1 1 - 3 3 - 6 6 - 10 >10	Limited Low Level Medium Level High Level Strictly Non-Degradation	**4**

6. SUMMARY

The outcomes from the baseline groundwater assessment were based on a desk-top level assessment with no intrusive investigations, during writing of this report (first phase assessment). The key findings from the groundwater assessment are summarised below.

6.1. SUMMARY OF DESKTOP VERIFICATION OUTCOME

Aquifer Characteristics

The study area is underlain by sedimentary rocks from the Karoo supergroup consisting of sandstone, shales, siltstone, and coal from the Vryheid formation. Typical weathering depth is between 2 and 20 metres deep.

Two main aquifer systems are associated with the project area, i.e. a shallow and deeper fractured aquifer system. The shallow weathered aquifer (intergranular water table aquifer) that may be laterally connected to alluvial aquifers associated within the major river systems and/or non-perennial streams. The weathered aquifer unit (or weathered overburden) varies in thickness from 2 m to 20 m (or deeper) and is derived from the in-situ decomposition of the underlying rocks. The weathered overburden is considered to have low to moderate permeability but high storativity. The unweathered and fractured semi-confined bedrock aquifer consists of fractured rocks underlying the upper weathered aquifer. The intact bedrock matrix has a low matrix hydraulic conductivity, and its effective hydraulic conductivity is determined by the interconnectivity of the fractures. Water is generally stored and transmitted in fractures and fissures within a relatively impermeable matrix.

Groundwater level and flow

Site specific groundwater levels range from 0.4 m bgl to 55.2 m bgl with an average of 9.9 m bgl within the project area. Typical groundwater levels expected on catchment level is 13.3 m bgl. Such shallow groundwater levels potentially indicate a shallow driven aquifer system that could be acceptable to groundwater contamination from surface related impacts. In general, groundwater levels mimic the surface topography, indicting regional groundwater flow direction is generally towards the southeast. Lateral groundwater flow in the shallow weathered and fractured aquifer is driven by topographic gradients.

Groundwater quality

Background water quality is expected to be within the SANS and DWS drinking water guidelines. Mining exposes sulphide bearing minerals which may impact on the ambient groundwater quality.

Aquifer vulnerability

Based on the vulnerability assessment the underlying aquifer is regarded as a low to medium vulnerability aquifer system requiring reasonable groundwater protection measures to ensure that no cumulative pollution affects the aquifer.

6.2. REASONED "OPINION"

It is expected that long term groundwater related impacts are expected at BCR Coal Vlakfontein Mining activities, and potentially include:

- Lowering of the groundwater levels from dewatering resulting in a cone of depression (or dewatering) which may affect third party groundwater users.
- Interception of ambient (and a decrease in) groundwater flow, which would under natural conditions discharge into the surface drainages, provided baseflow to the rivers, or contributed to deeper regional groundwater flow.
- Exposure of sulphide bearing minerals (i.e., coal) during mining may negatively affect the ambient groundwater quality in the immediate vicinity of the Mine. Sources of pollution such may include stockpiles, discharges from mine workings and backfilled open pit (post-closure) (decant).
    - Opencast mining involves blasting and removal of the rocks overlying the coal layer, which is removed completely. The fragmented cover rock is then replaced (backfilled) and covered with soil and the

terrain is landscaped ('rehabilitated'). Rainwater penetrating through the soil into the backfill becomes acidified by pyrite in the backfill material and can potentially decant to the surface.
    - As for most coal mines (in the Mpumalanga Highveld) there's a risk for acid rock drainage and should be managed as such.
- Diffuse pollution of groundwater from backfilled and flooded voids.

Acid rock drainage is a process whereby contaminants (especially metals and sulphate) are released from solid to liquid phase under acidic pH conditions due to the oxidation of sulphide minerals in the presence of oxygen (or other oxidants like ferric iron or manganese) and water, potentially accelerated by bacteria. Heat may be generated in the process. The term acid rock drainage is also used to refer to saline and neutral mine drainage, which are characterised by neutral to alkaline pH conditions and more moderate metal and sulphate contents.

Best international practice as outlined in the Global Acid Rock Drainage (GARD) Guide (INAP, 2009) developed by the International Network for Acid Prevention (INAP) requires a geochemical characterization of a mining site for the prediction, prevention, and management of acid rock drainage. This includes the evaluation of potential Acid Rock Drainage (ARD) and Metal Leaching (ML) of mine residues and all formations foreseen to be disturbed or otherwise exposed by a mining project. Similarly, the International Finance Corporation Guideline for Mining (IFC 2007) recommends that mining operations undertake geochemical characterization of ores and mine wastes (e.g. tailings material and waste rock) in order to properly manage potentially acid generating materials and Acid Rock Drainage (ARD). Similarly, the Best Practice Guidelines for Water Resource Protection in the South African Mining Industry, published by the Department of Water Affairs, requires appropriate impact predictions (Department of Water Affairs and Forestry, 2008. Best Practice Guideline G4: Impact Prediction and mitigation of ARD).

6.3. Recommendations Plan of study for the EIA Phase

It is recommended to conduct a higher confidence level hydrogeological assessment to determine site-specific impacts related to the proposed mining activity.

Plan of study for the EIA Phase

Based on the limitation of the desktop level hydrogeological assessment, the following scope of work is recommended for the EIA phase:

- Establish the baseline hydrogeological conditions in and around the proposed mining area (i.e., hydrocensus and sampling)
- Assess alternative mining plans that could reduce the potential impacts on groundwater receptors.
- Pumping test to inform aquifer characterisation and parametrisation
- Geochemical assessment of the potential pollution sources (i.e., overburden, waste rock, stockpiles).
    - Representative samples can be retrieved from existing exploration holes.
    - Determine acid generation potential
- Development of a site-specific conceptual groundwater model.
    - The main objective of this task is to accurately conceptualise the aquifer, groundwater levels and flow regimes, groundwater qualities from the ongoing monitoring programme, potential pollution sources and concentrations of constituents of concern, which will form the basis for the numerical model development.
- Development of a numerical flow and transport model that will be used to:
    - Predict mine inundation, inflow rates and diffuse decant volumes.
    - Assess the spatial and extent of surface-groundwater interaction and to inform management decisions.
    - Establish cones of dewatering for the mine workings during life of mine.
    - Determine the potential migration of constituents of concern from mine residue deposits during life of mine and post closure for the open pits mining scenario.

7. REFERENCES

BCR (2022). Mining Work Programme. Submitted for a mining rights application. Internal Document to the Department of Mineral Resources.

Barnard, H.C. (2000) An Explanation of the 1:500 000 General Hydrogeological Map. Department of Water Affairs and Forestry, Pretoria.

Department of Water Affairs and Forestry (DWAF). (1996). Domestic water quality guidelines, volume 1, 1996. South African water quality guidelines (SAWQG).

Department of Water Affairs and Forestry (2004). Groundwater Resource Assessment II: Task 3aE Recharge. Version 2.0 Final Report 2006-06-20, Pretoria.

Department of Water Affairs and Forestry (2008). Best Practice Guideline G4: Impact Prediction.

International Finance Corporation (IFC) (2007) Environmental Health and Safety Guidelines: Mining. Price, W.A. (1997) Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Mine sites in British Columbia. BC Ministry of Employment and Investment.

The International Network for Acid Prevention (INAP) (2009). Global Acid Rock Drainage Guide (GARD Guide).http://www.gardguide.com'.

Parsons, R.P. (1995). A South African aquifer system management classification; WRC Report No. 77/95, Water Research Commission, Pretoria.

Parsons and Conrad, J.E. (1998). Explanatory notes for the aquifer classification map of South Africa; WRC Report No. 116/98, Water Research Commission, Pretoria.

SANS (241: 2015). South African National Standard (241) Drinking Water. South Africa, Pretoria.

Vegter, J.R. (1995). An explanation of a set of National Groundwater Maps. Water Research Commission. Report No TT 74/95.