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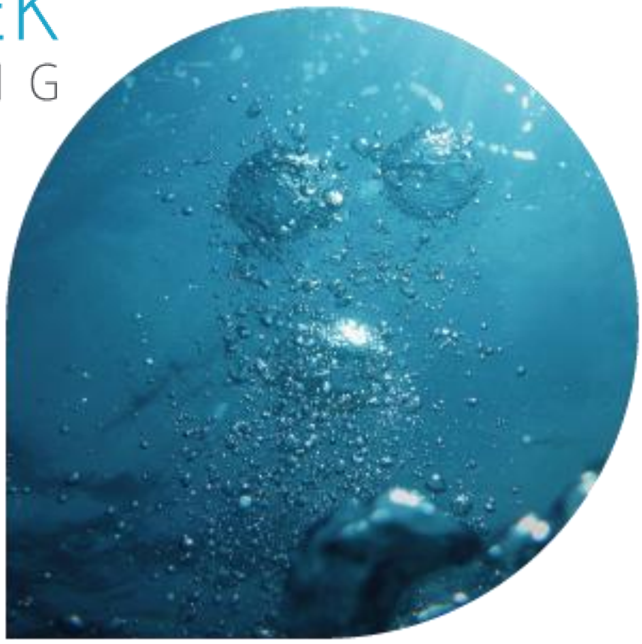

REPORT

EIMS
Hydrogeological Desktop Assessment for Sandgat Project Area

Submitted to:
EIMS

Prepared by:
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Distribution history

Name	Company
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Document history

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INDEMNITY AND SPECIALIST DECLARATION

The findings, results, observations, conclusions, and recommendations presented in this report are based on the author's best scientific and professional knowledge, as well as the available information. The assessment techniques employed are constrained by the information, time, and budgetary limitations relevant to the scope of the investigation. Hydrogeek Consulting (Pty) Ltd; (hereafter referred to as Hydrogeek) reserves the right to modify aspects of the report, including recommendations, should new information emerge from ongoing research, monitoring, or further work in the field.

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This report has been prepared in accordance with the latest requirements for specialist reports set forth by the Department of Environmental Affairs, as outlined in Government Gazette No. 40713 (24 March 2017) and Government Gazette No. 40772 (07 April 2017) under the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA).

I, NL van Zyl, hereby declare that:

- I act as the independent specialist for this application.
- I will conduct the work related to this application objectively, even if it leads to findings that are not favorable to the applicant.
- I have no circumstances that could compromise my objectivity in this work.
- I possess the necessary expertise relevant to this application, including knowledge of the Act, Regulations, and relevant guidelines.
- I will comply with all applicable legislation.
- I have not engaged, nor will I engage, in any conflicting interests related to this activity.
- I will disclose to the applicant and the competent authority any material information that could influence decisions regarding the application or the objectivity of any report or document prepared for submission.
- All information I have provided in this declaration is true and correct.

NL VAN ZYL

MSc. Hydrogeology, *Pr.Sci.Nat*.

LIST OF ABBREVIATIONS

DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
ET	Evapotranspiration
K	Hydraulic Conductivity
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
NGA	National Groundwater Archive
NWA	National Water Act (Act 36 of 1998)
S	Storativity
T	Transmissivity
WARMS	Water Use Authorisation and Registration Management System
WMA	Water Management Area

1 Introduction

EIMS has appointed Hydrogeek Consulting (Pty) Ltd (Hydrogeek) to undertake a groundwater desktop assessment for the delineated study area (Sandgat) associated with potential future prospecting activities. The objective of the assessment is to review and analyse available groundwater-related information to provide an initial understanding of the initial hydrogeological conditions underlying the site, as well as to comment on the groundwater potential and possible impacts underlying the study area.

This desktop assessment provides a preliminary evaluation of the groundwater regime based on existing data sources. The findings will inform the need for further, site-specific hydrogeological investigations and support early-stage decision-making, while ensuring alignment with the requirements of the National Water Act (Act 36 of 1998) and applicable environmental legislation.

2 Scope of Work

This report has been compiled in support of the application for a Prospecting Right and the associated Environmental Authorisation (EA). The purpose of the report is to provide a preliminary hydrogeological assessment of the study area and to evaluate the potential impacts associated with the proposed prospecting activities.

The applicant has indicated that prospecting will be limited to the drilling of approximately 16 boreholes distributed across the project area. No additional activities are currently proposed during the prospecting phase.

Accordingly, this assessment focuses on identifying and evaluating the potential hydrogeological and groundwater-related impacts arising from the drilling of these boreholes. The findings presented herein aim to inform the environmental assessment process, support regulatory decision-making, and ensure that any identified risks are appropriately understood and managed at an early stage.

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

1. Desktop assessment of available geological and hydrogeological data:
    - Review available geological, hydrogeological, climatic, and water use data.
    - Identify key aquifer characteristics and potential recharge zones.
    - Determine existing borehole locations and historical use in the surrounding area.
2. Groundwater potential and quality assessment
    - Evaluate the likelihood of successful groundwater development.
    - Provide an indication of expected yield ranges.
    - Provide insights into aquifer type and estimated sustainable abstraction rates.
    - Comment on expected water quality concerns based on regional data.
3. Preparation of a detailed geohydrological desktop report, signed by a qualified professional geohydrologist
    - Submit a geohydrological report, including methodology, findings, mapping, hydrogeological interpretation, and recommendations.

The assessment was undertaken in accordance with accepted hydrogeological practice and was limited to desktop-based review in line with the agreed scope of work.

3 Methodology

The hydrogeological assessment commenced with a comprehensive desktop study to compile and review relevant geological, hydrogeological, environmental, and land-use information for the study area and surrounding region. Information obtained through the desktop review was analysed and interpreted to inform the findings and conclusions presented in this report. This included an assessment of the underlying aquifer system in terms of groundwater occurrence, aquifer vulnerability, susceptibility to contamination, and overall groundwater resource significance.

In addition, the assessment considered the potential hydrogeological impacts associated with the proposed prospecting activities, including the drilling of approximately 16 prospecting boreholes across the application area. The impact assessment was undertaken in accordance with the Environmental Impact Management Services (Pty) Ltd (EIMS) / National Environmental Management Act, 1998 (Act No. 107 of 1998) and regulations (as amended) (NEMA) Environmental Impact Assessment methodology, which considers the nature, extent, duration, intensity, probability, and significance of identified impacts, as well as the effectiveness of proposed mitigation measures. The detailed impact assessment methodology is attached to and forms part of the broader Environmental Impact Assessment process.

4 Project description

No project details were provided at the time of writing this report for the Sandgat prospecting right project. Only the mineral deposit of the area was provided as shown below in Figure 1 below.

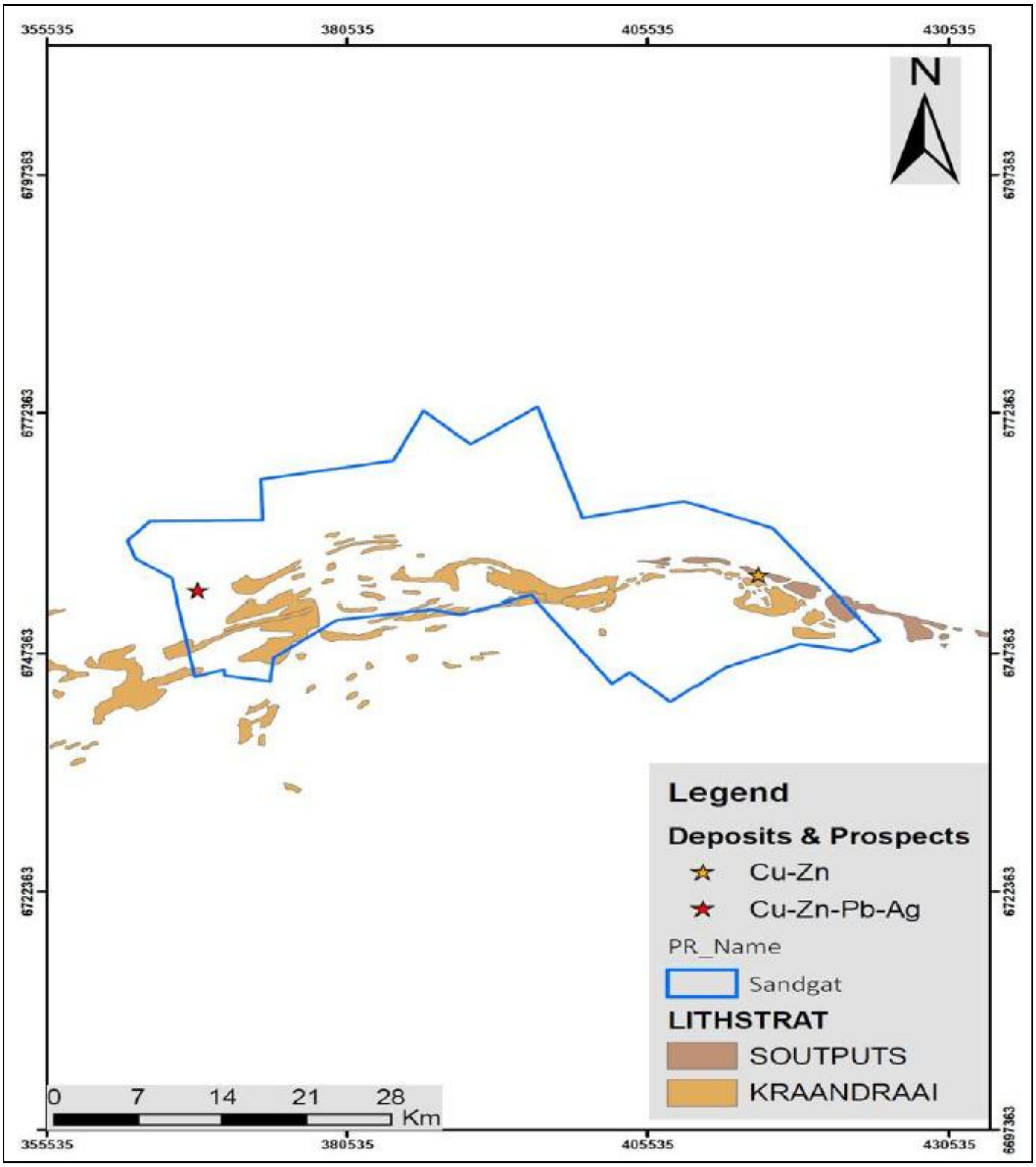

Figure 1: Proposed Project deposits and prospects

Sandgat prospecting right project description has been provided below which list similar activities expected for the project.

Black Mountain Mining (Pty) Ltd (BMM) (the Applicant) has submitted an application for a Prospecting Right in terms of Section 16 of the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002) (MPRDA) and an Application for Environmental Authorisation in terms of Chapter 4 of GNR 982 promulgated under the National Environmental Management Act (Act 107 of 1998) (NEMA) to prospect for ferrous & base metals (Copper Ore, Iron Ore, Lead, Ore, Zinc Ore, Manganese Ore, Nickel and Molybdenum) and associated metals and minerals , precious metals/Gemstones (Gold Ore, Silver Ore), and nuclear fuels/Ferrous and Base metals (Uranium ore) and all associated metals and minerals.

The proposed project will aim to ascertain if economically viable mineral deposits exist within the application area. In order to undertake prospecting activities, Black Mountain Mining will require a Prospecting Right in terms of the Mineral and Petroleum Resources Development Act (MPRDA, Act No.28 of 2002). The Applicant is also required to obtain an Environmental Authorisation (EA) in terms of the National Environmental Management Act (NEMA, Act No. 107 of 1998) which involves the submission of a Basic Assessment Report (BAR) and Environmental Management Programme (EMPr). Environmental Impact Management Services (Pty) Ltd (EIMS) have been appointed by Black Mountain Mining to compile the BAR and EMPr in support of the Prospecting Right application submitted by EIMS on behalf of Black Mountain Mining, which in turn will be submitted to the Department of Mineral and Petroleum Resources (DMPR) for adjudication.

The BAR has been designed to meet the requirements for a BAR and Environmental Management Programme (EMPr) as stipulated in the 2014 EIA Regulations (as amended) promulgated under the NEMA. The adjudicating authority for this Application will be the DMPR, and this report has been compiled in accordance with the applicable DMPR guidelines and reporting template.

This specialist assessment is compiled to support the BAR and EMPr to be submitted.

Details surrounding the project and the type of minerals to be prospected for can be seen in

Table 1: Details of the project and type of minerals

Item	Detail
Type of mineral(s)	Ferrous & base metals: Cu – Copper
Type of minerals continued	Ferrous & base metals: Fe- Iron
Type of minerals continued	Ferrous & base metals: Pb -Lead
Type of minerals continued	Ferrous & base metals: Zn - Zinc
Type of minerals continued	Ferrous & base metals: Mn - Manganese
Type of minerals continued	Ferrous & base metals : Ni - Nickel
Type of minerals continued	Ferrous & base metals: Mo – Molybdenum
Type of minerals continued	Precious Metals: Au - Gold
Type of minerals continued	Precious Metals: Ag - Silver
Type of minerals continued	Nuclear Fuels: U - Uranium
Geological formation	The target geological formation is the Bushmanland Group

The historic geological data obtained from previous prospecting work in the area and recent prospecting work conducted utilizing advanced geoscientific methods has helped to better refine the underlying geology of the area. This has led to the discovery of Gamsberg East Extension deposit west of this prospecting area and highlighted further potential for the discovery of additional economic zinc-copper-lead-silver mineralization.

This application employs a phased approach, where the work program is divided into several sequential sections. At the end of each section there will be a period of compiling, evaluating and reporting results. These results will not only determine whether the project proceeds, but also the way it will go forward. Essentially, the Applicant will only action the next phase once satisfied with the results obtained.

It is not possible to give details of the drilling program before the surveys and surface work phase 1 is completed. In the event that more information becomes available or that an ore body is located at an earlier stage, then an amended program will be put forward for the DMPR's approval.

No bulk sampling work is to be carried out during this prospecting program.

Initial prospecting will be carried out by the applicant itself, utilizing its own in-house geologists to conduct and oversee the work. Drilling will be outsourced to a local drilling company. The methods detailed below will be used to investigate the prospecting area.

Please note, the "invasive prospecting" phases, which will have an environmental impact, have been highlighted with red text.

Table 2: Proposed duration of prospecting phases and associated activities

Phase	Activity (what are the activities that are planned to achieve optimal prospecting)	Skill(s) required. (refers to the competent personnel that will be employed to achieve the required results)	Timeframe (in months) for the activity)	Outcome (What is the expected deliverable, e.g., Geological report, analytical results, feasibility study, etc.)	Timeframe for outcome (deadline for the expected outcome to be delivered)	What technical expert will sign off on the outcome? (e.g., geologist, mining engineer, surveyor, economist, etc.)
1	Non-Invasive Prospecting Desktop Study: Literature Survey / Review	Geologist	Month 1-12	Initial geological targeting report supported by historical records and existing data	Month 12	**Geologist**
2	Non-Invasive Prospecting Geological Field Mapping	Geologist & field crew	Month 6-12	Detailed geological targeting report accompanied by maps & plans of ground truthing of initial geological targeting.	Month 12	**Geologist**
3	Non-Invasive Prospecting Semi-regional Ground Geophysical Survey	Geophysicist / Geologist / field crew	Month 12-24	Survey report detailing possible targets for further exploration, report supported by maps, plans & cross sections	Month 24	**Geophysicist**

Phase	Activity (what are the activities that are planned to achieve optimal prospecting)	Skill(s) required. (refers to the competent personnel that will be employed to achieve the required results)	Timeframe (in months) for the activity)	Outcome (What is the expected deliverable, e.g., Geological report, analytical results, feasibility study, etc.)	Timeframe for outcome (deadline for the expected outcome to be delivered)	What technical expert will sign off on the outcome? (e.g., geologist, mining engineer, surveyor, economist, etc.)
4	Invasive Prospecting Exploration Boreholes (16 RAB holes – 2400m; 4 DD holes – 2000m)	Geologist / drill rig team / field crew / laboratory technicians	Month 24-34	Borehole cored data & RAB data: lithological logs, geophysical down hole surveys, assay results for mineralized intercepts.	Month 34	**Geologist**
5	Non-Invasive Prospecting Compilation, interpretation, and modeling of data	Geologist / Geophysicist	Month 34-36	Modelling of data. Interpretation and 3D modeling of potential deposit. Generation & ranking of mineralized targets for further exploration work	Month 36	**Geologist**
6	Non-Invasive Prospecting Detailed Ground Geophysical Survey on individual positively mineralized targets to define extent	Geophysicist / Geologist / field crew	Month 36-42	Survey report detailing individual targets. Plans for drill hole intersections supported by cross sections	Month 42	**Geophysicist**
7	Invasive Prospecting Boreholes to confirm continuity of mineralization & potential deposit size (20 DD holes – 8000m)	Geologist / drill rig team / field crew / laboratory technicians	Month 42-48	Widely spaced borehole cored data: lithological logs, geophysical down hole surveys, assay results for mineralized intercepts, metallurgical test work	Month 48	**Geologist**

Phase	Activity (what are the activities that are planned to achieve optimal prospecting)	Skill(s) required. (refers to the competent personnel that will be employed to achieve the required results)	Timeframe (in months) for the activity)	Outcome (What is the expected deliverable, e.g., Geological report, analytical results, feasibility study, etc.)	Timeframe for outcome (deadline for the expected outcome to be delivered)	What technical expert will sign off on the outcome? (e.g., geologist, mining engineer, surveyor, economist, etc.)
				Risk assessment study to advance to next phase		
8	Invasive Prospecting Resource definition drilling (40 DD holes – 16000m)	Geologist / drill rig team / field crew / laboratory technicians	Month 48-60	Closely spaced borehole cored data: lithological logs, geophysical down hole surveys, assay results for mineralized intercepts, metallurgical test work Resource estimation work producing an Inferred Mineral Resource	Month 60	**Geologist**
9	Non-Invasive Prospecting Analytical Desktop Pre-Feasibility Study	Economic Geologist / Mining Geologist	Month 54-60	Geological & Pre-feasibility reports, maps & plans Risk assessment study to determine if full feasibility is warranted	Month 60	Mine Engineer / Economic Geologist (professionally qualified persons)

4.1 Description of Planned Invasive Activities

(These activities result in land disturbances e.g., sampling, drilling, bulk sampling, etc.)

4.1.1 Drilling

The targeting of all drilling activities will be dependent on the results obtained during the preceding phases of prospecting, namely the geological mapping and geophysical surveying and as such it is currently not possible to include a finalized surface plan showing the intended location, extent, and depth of boreholes to be completed.

Diamond drilling will be of the standard HQ or NQ size. Down hole surveys will be done every 50m in each hole. Core will be marked, logged, photographed, and sampled according to the standard of the applicant's logging and sampling procedures.

Down the hole geophysical surveying will take place upon completion of the exploratory boreholes along with Ground EM surveys to determine positions of conductors.

Rehabilitation of drill sites will be done according to an approved Environmental Management Plan.

Percussion Rotary Air Blast (RAB) or Reverse Circulation (RC) drilling may be carried out for pre-collaring of diamond drill boreholes or for obtaining samples if significant depth of cover is encountered over particular targets.

4.1.2 Assaying

Rock chip / soil samples will be sent to a laboratory of the applicant's choice to be crushed, split, pulverized, and assayed. Samples from core will be split using a core cutter before being sent to the laboratory for analysis.

4.1.3 Metallurgical Test Work

Metallurgical test work would start during phase 7 of the prospecting work programme. These tests will be done by and in consultation with a preferred and accredited Laboratory of the applicant's choice.

4.1.4 Boreholes

4.1.4.1 Phase 4: Boreholes

The initial planned invasive exploration activities will consist of diamond drill boreholes drilled to appropriate depths to target any anomalies identified during Phases 2 & 3 of the non-invasive portion of the prospecting work plan. The work will consist of:

- Access and drill site preparation.
- Diamond core drilling.
- Sampling and assaying.
- Quality assurance and quality control programs.
- Down hole geophysics.
- Rehabilitation of drill sites; and
- Recording & Integration of data.

4.1.4.2 Phase 7: Boreholes

This phase of boreholes would determine the continuity of mineralization & potential deposit size. The work will consist of:

- Access and drill site preparation.
- Widely spaced diamond drilling and analyses to confirm grade / tonnage potential.

- Sampling and assaying.
- Quality assurance and quality control programs.
- Metallurgical test work.
- Rehabilitation of drill sites; and
- Recording & Integration of data.

4.1.4.3 Phase 8: Boreholes

This phase of boreholes would provide enough information to be able to calculate an inferred resource. The work would consist of:

- Access and drill site preparation.
- Close spaced infill diamond drilling and analyses to determine actual grade / tonnage.
- Sampling and assaying.
- Quality assurance and quality control programs.
- Metallurgical test work.
- Geotechnical drilling program.
- Rehabilitation of drill sites; and
- Recording & Integration of data

5 Study area Location

The study area is located approximately 30 km south-east of the town of Pofadder, within the Northern Cape Province. The boundaries of the site extend across a regional-scale footprint of approximately 47 065 ha and encompasses multiple farm portions and cadastral properties.

The properties included within the study area extent are presented in **Table 3** below:

Table 3: Properties included within the Study area boundary

Farm Name	Portion	Farm Nr.	Area (ha)
Lovedale	Remainder	RE/201	8 460.99
Ougga Maag	Remainder	RE/200	7 660.54
Haartebeest-vlei	Full Portion	199	7 456.8
Vaalkop	Remainder	RE/225	8 220.93
Vaalkop	1	1/225	0.09
Farm 197	Remainder	RE/197	3 061.62
Farm 197	8	8/197	1 515.12
Farm 197	4	4/197	1 490.51
Farm 197	2	2/197	1 528.65
Farm 197	1	1/197	3 012.34
Farm 197	3	3/197	3 037.83
Farm 197	6	6/197	1 578.93

Regional and local maps of the study area location are included in **Figure 2** and **Figure 3.**

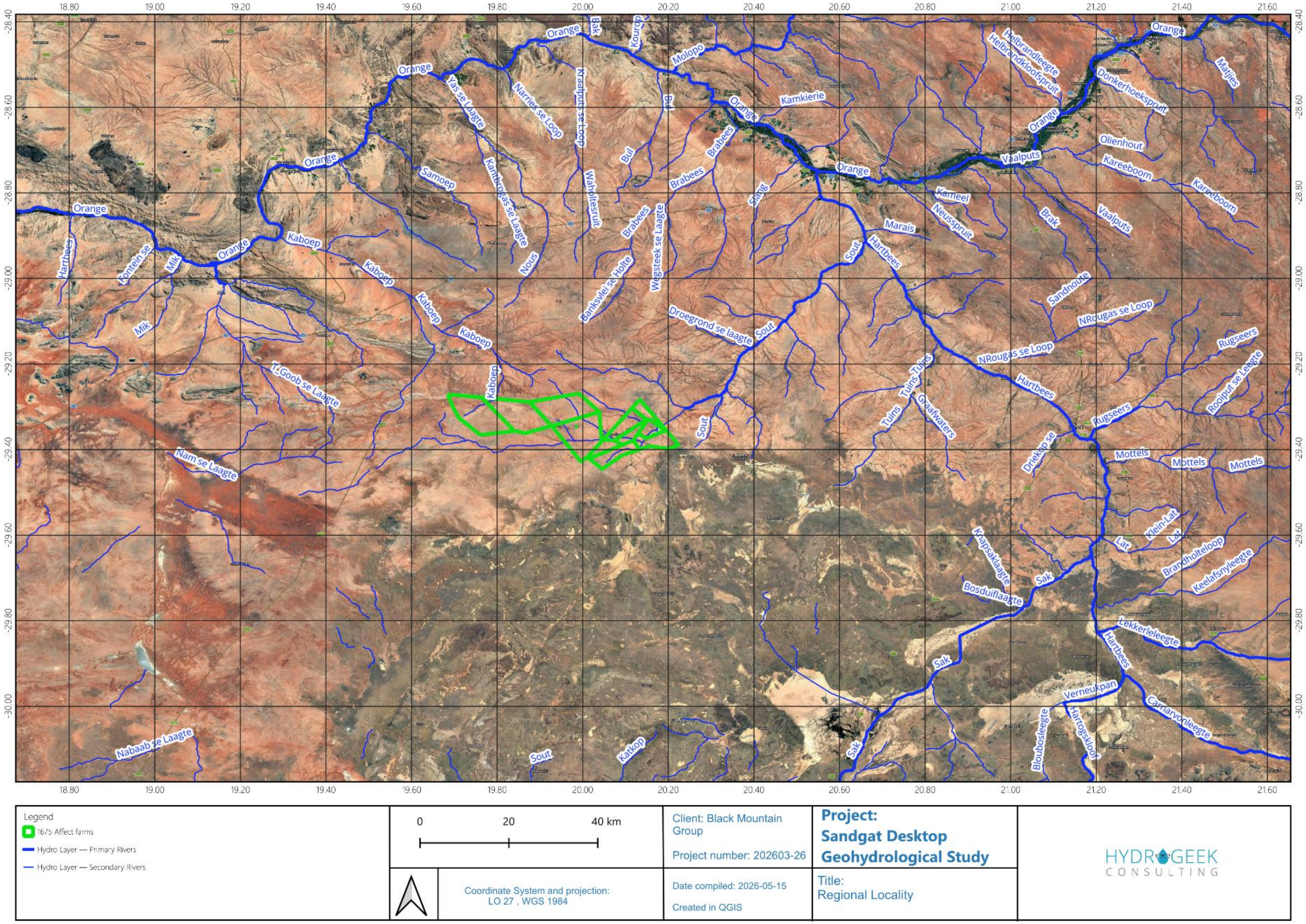

Figure 2: Regional Study area Location (study area), overlaid on satellite imagery.

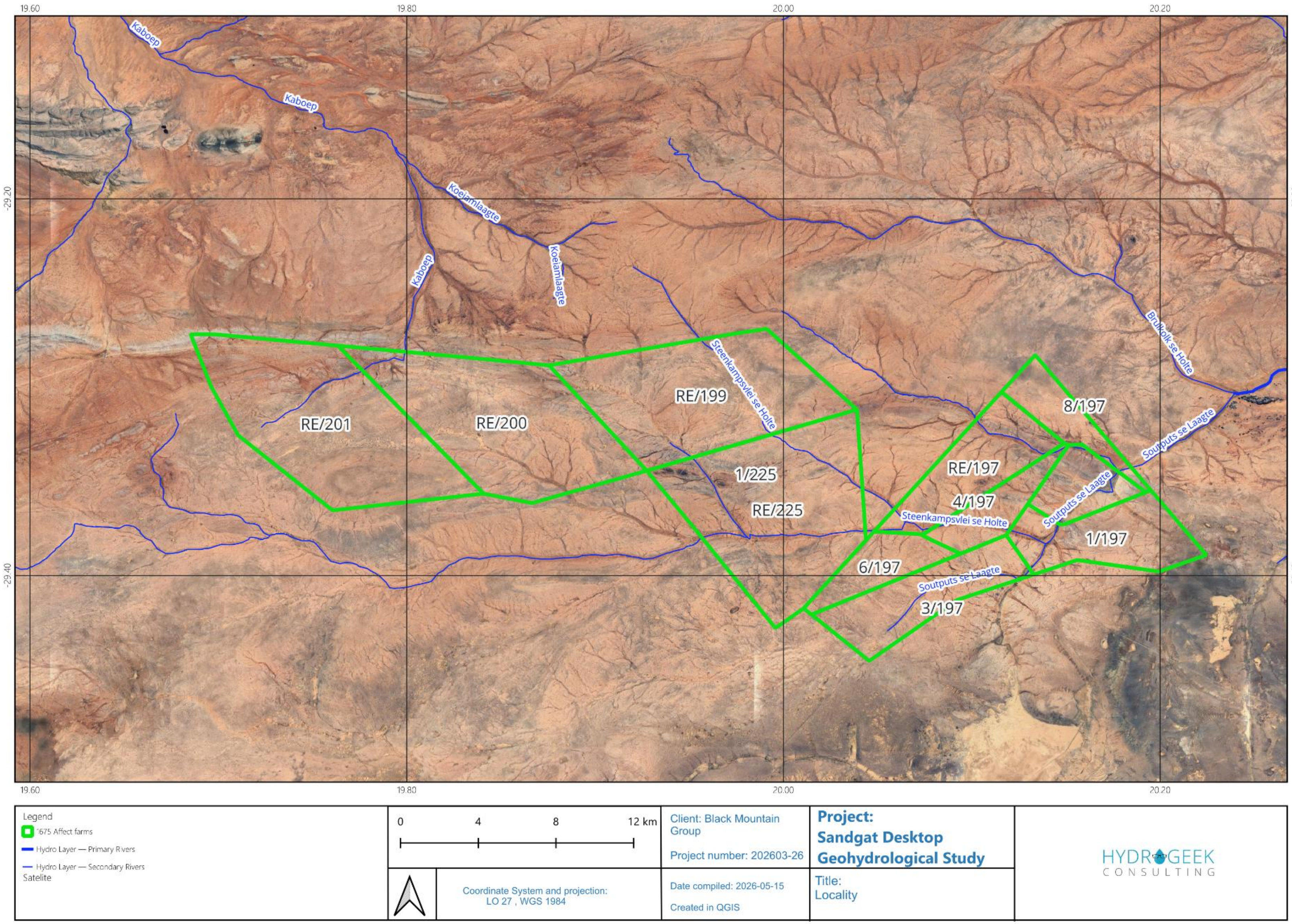

Figure 3: Local Study area Location (study area), overlaid on satellite imagery.

6 Regional Setting

6.1 Climate

The north-western region of the Northern Cape is characterised by a hot, arid to semi-arid climate. Climate data for the town of Pofadder, indicates that rainfall is strongly seasonal, with most precipitation occurring during the summer months (November to March), peaking in February and March. Rainfall events are generally convective in nature, occurring as short-duration, high-intensity storms. Winters (May to August), in contrast, are predominantly dry, with little to no rainfall recorded during this period.

Average rainfall data taken over a 10-year period (2016 to 2026) shows annual rainfall at 84 mm/a (World Weather, 2025). This data also confirms the strongly seasonal nature of precipitation in the area. Average monthly rainfall during the summer months ranges between approximately 9 mm and 24 mm, while winter rainfall is minimal, with averages recorded between 1.6 mm and 5 mm. Pofadder Rainfall data is included in **Figure 4.**

Temperature patterns over the same period show average minimum temperatures during winter dropping to around 6°C, and average maximum temperatures during summer reaching approximately 35°C (World Weather, 2025).

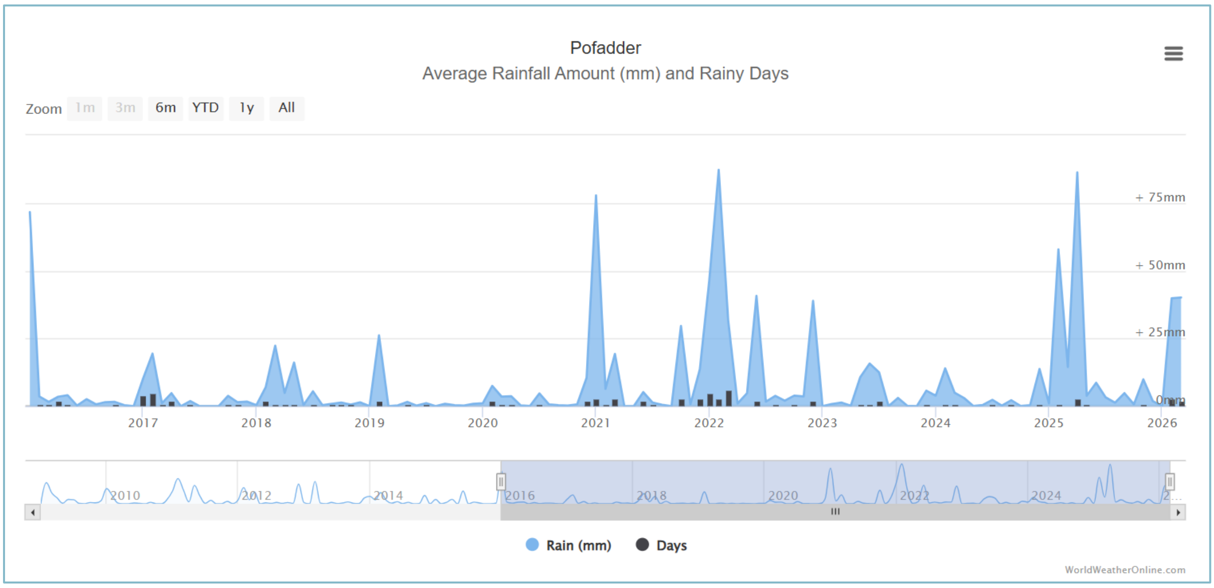

Figure 4: Pofadder Rainfall Data (2016-2026) (source: World Weather Online, 2025).

Evaporation data for the quaternary catchments (D81F and D53G) are derived from the WR2005 dataset, which provides hydrological parameters at quaternary scale based on WRSM/Pitman modelling (WRC, 2012; Middleton and Bailey, 2011). The data indicates very high evaporation of approximately 2 000 mm/a, far exceeding mean annual rainfall. According to DWAF, (2004), only 1 to 10% of rainfall contributes to recharge during larger rainfall events, with most water lost to evaporation.

From a hydrogeological perspective, the area is therefore characterised by low recharge and high evaporative demand. Recharge is largely episodic and event-driven, while surface water systems remain predominantly ephemeral. Groundwater resources are therefore expected to be limited, with recharge largely episodic and long-term abstraction potential likely constrained.

6.2 Topography and Drainage

The Study area crosses over two (3) quaternary catchments, namely D81F, D81G and D53G which form part of the Lower Orange Water Management Area (WMA). This WMA is dominated by the Orange River, located approximately 55 km north-east of the Study area. The Orange River is the primary river system in the region, and flows westward, ultimately discharging into the Atlantic Ocean.

Table 4 Catchments affected

Catch-ment	Quaternary Catchment	Area (km²)	MAP (mm/a)	MAR (mm/a)	MAR (Mm³/a)	Hydrological Zone	Drainage System
D81F	D81F	1,839	91.34	0.5	0.92	L	Orange River
D81G	D81G	2,005	101.64	0.4	0.80	L	Orange River
D53G	D53G	4,745	98.56	0.5	2.37	L	Orange River

Notably, most tributaries within the WMA (including the Molopo, Kuruman, Sak, and Hartebeest Rivers) are ephemeral, with flow occurring only in response to rainfall events. Hydrological processes within the WMA are therefore largely driven by episodic rainfall, with smaller drainage features being non-perennial in nature (DWAF, 2004; DWS, 2013).

At a local scale, the Study area is traversed by a network of ephemeral drainage features, including the Kaboep River, Steenkampsvlei se Holte, and Soutputs se Laagte. These drainage features follow the natural topography and typically flow only during, and shortly after, rainfall events. As is typical of arid environments, these features are not expected to sustain meaningful baseflow contributions (DWAF, 2004; WRC, 2012).

Topographically, elevations across the study area range from approximately 705 to 1 129 metres above mean sea level (mamsl), with higher elevations located to the west and lower-lying areas to the north-west and south-east. The study area is situated along a local topographic divide, with surface runoff and near-surface runoff expected to move toward the northern and eastern portions of the study area, in line with the prevailing gradient.

Overall, the drainage network is characterised by low flow frequency and high variability, consistent with the arid climatic conditions of the region. Regional topography and drainage patterns are presented in **Figure 5.**

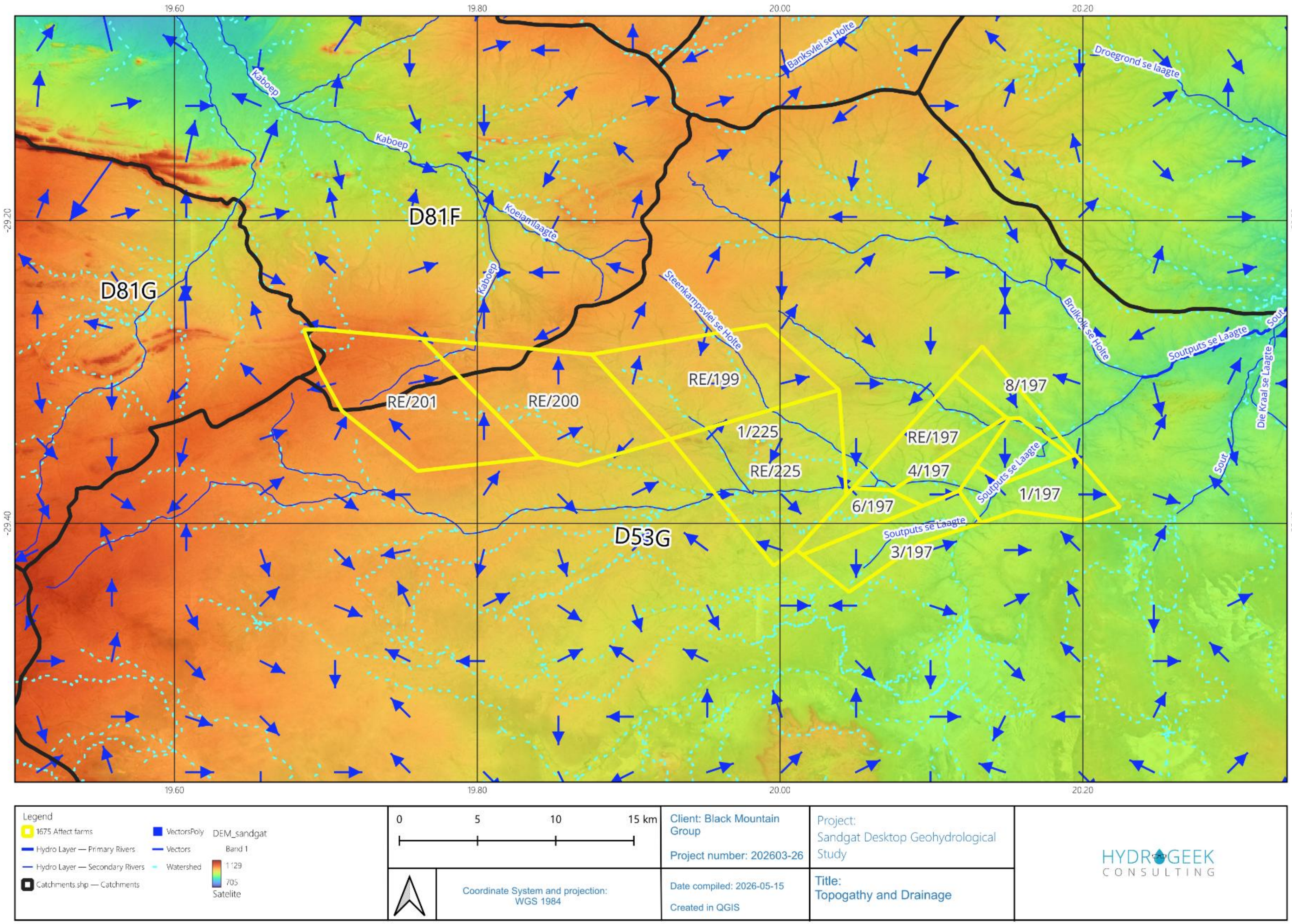

Figure 5: Regional topography and drainage patterns.

6.3 Geology

6.3.1 Regional Geology

According to the 1:250 000 geological map series 2919 Pofadder and 2920 Kenhardt (Council for Geoscience, 1992) (Agenbacht, 2007), the study area is situated within the Namaqualand Metamorphic Complex, which comprises a structurally complex assemblage of gneisses, schists and quartzites. These rocks have undergone multiple phases of deformation and form the regional crystalline basement (Maclaren, 1984; Agenbacht, 2007). The geological setting is strongly influenced by regional deformation and intrusive activity associated with the broader Pofadder Lineament.

The mapped geology includes a sequence of supracrustal meta-sedimentary units, represented by the Brulkolk Formation, Kraandraai Formation, Soutputs Formation and the Droëboom Group. These units consist predominantly of quartzites, schists and quartz-feldspar gneisses, with minor amphibolitic and pelitic lithologies (Maclaren, 1984; Agenbacht, 2007). The rocks are typically well indurated and exhibit negligible primary porosity.

The Kamiesberg Group comprises high-grade metamorphic rocks, including gneisses, amphibolites and schists, and forms part of the deeper crystalline basement. These units have been subjected to polyphase deformation, resulting in a complex structural fabric (Maclaren, 1984; Agenbacht, 2007; Viljoen et al., 2010).

The basement rocks are intruded by granitic to granitoid bodies, including units mapped as the T'oubep Suite, emplaced during regional tectonic events (Agenbacht, 2007). Earlier intrusive phases include mafic and intermediate rocks described by Maclaren (1984), such as the Nouzees Gabbroic Suite and associated granitoid intrusions. In places, the basement rocks are overlain by sediments of the Dwyka Group (Karoo Supergroup), comprising glacial diamictites (tillites) with minor interbedded sediments (Maclaren, 1984; Agenbacht, 2007).

The area is further affected by post-tectonic dolerite intrusions, occurring as dykes and sills, most likely associated with Karoo-age magmatism (Maclaren, 1984; Agenbacht, 2007). The emplacement of these intrusions appears to be structurally controlled and associated with pre-existing zones of weakness.

The study area is traversed by a prominent structural corridor, interpreted as a shear zone associated with the regional Pofadder Lineament (Maclaren, 1984; Agenbacht, 2007). This zone is discussed in detail in **Section 6.3.2**, and is characterised by folding, faulting and shearing, and represents a zone of mechanical weakness within the bedrock.

6.3.2 Structural

As briefly discussed, the study area is influenced by major shear zones, including the Nouzees shear zone, which play an important role in controlling both the emplacement of intrusive bodies and the distribution of secondary permeability. The study area is traversed by a prominent structural corridor, interpreted as a shear zone associated with the regional Pofadder Lineament. This zone is characterised by folding, faulting and shearing, and represents a zone of mechanical weakness within the bedrock.

Geology in the region has undergone multiple phases of deformation associated with the Namaqua Orogeny. Four principal deformation events (**F1-F4**) have been identified (Jackson, 1982).

The **F1** phase is characterised by tight, high-amplitude folding, most clearly developed in well-banded rocks. This was followed by the **F2** event, which represents the peak of regional metamorphism. During this phase, the rocks were further deformed under high temperature and pressure, resulting in a range of fold styles and the development of a strong, penetrative foliation (Jackson, 1982).

The **F3** phase is associated with flexural slip folding, where the rocks folded while also shearing along existing foliation planes. This resulted in the formation of broader, more open structures that generally trend east-west. The final phase, **F4**, is less prominent in the area, but where present, is characterised by north-west trending, gently curved (monoclinal) structures with steep eastern limbs (Jackson, 1982). Pegmatites are commonly linked to this phase and typically occur within folds or along associated fractures.

Later deformation led to the development of north-west trending fault zones, particularly to the north of Pofadder. Movement along these faults was predominantly horizontal movement, with the rocks shifting to the right, past one another. In places, this movement caused intense deformation, resulting in intensely sheared and deformed rock (Jackson, 1982).

Groundwater occurrence is largely controlled by these structural features, reflecting the limited primary porosity of the bedrock and resulting in generally low and variable yields.

The regional geology is depicted in **Figure 6.**

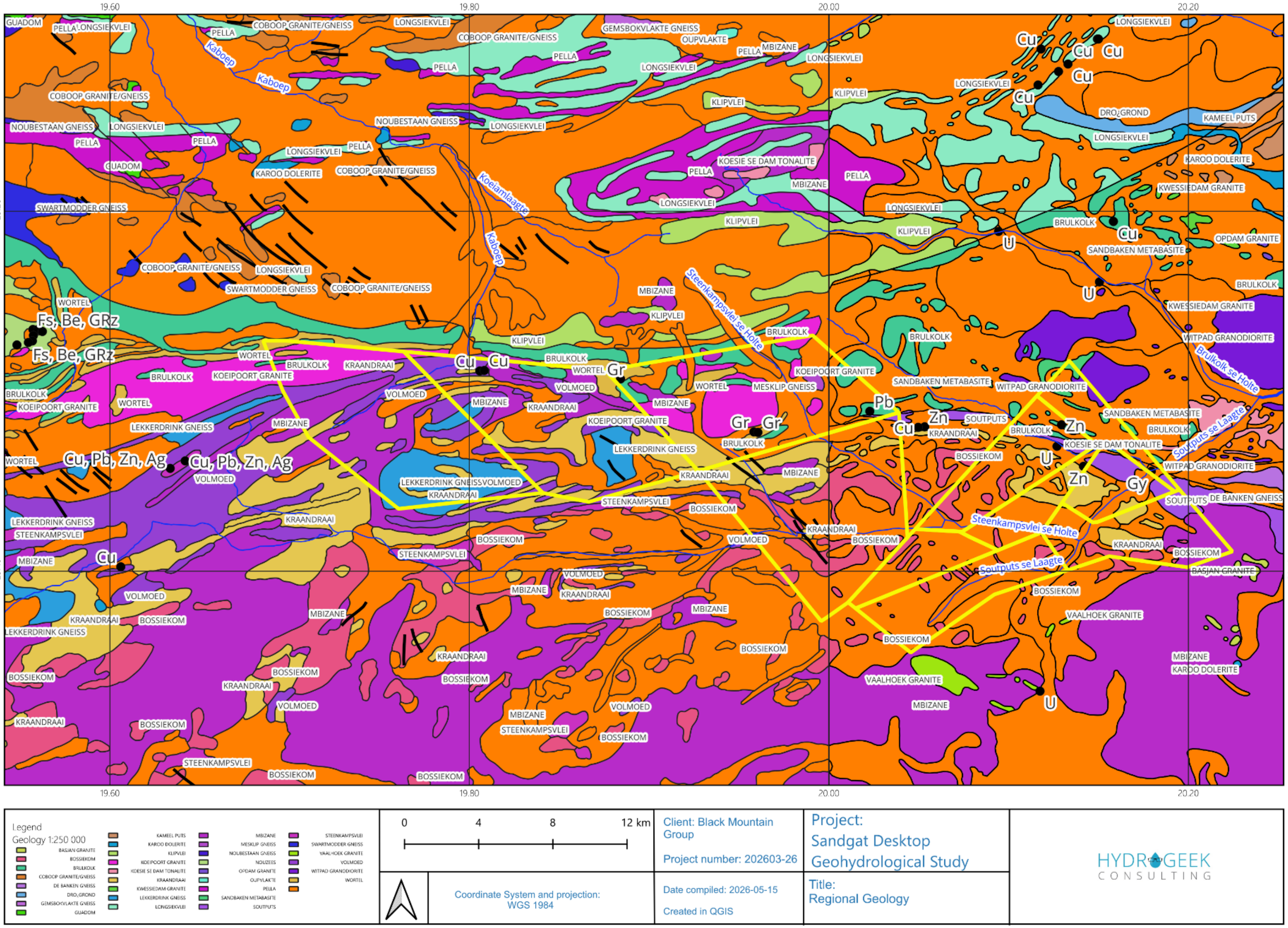

Figure 6: Regional Geology

7 Hydrogeology

From a hydrogeological perspective, the bedrock units within the study area are characterised by low primary porosity, with groundwater occurrence restricted to secondary features such as fractures, joints, foliation planes and shear zones (Viljoen et al., 2010). Groundwater movement is structurally controlled, with shear zones and well-developed fracture networks representing the most significant conduits due to their enhanced permeability and connectivity. In particular, groundwater is closely associated with fracturing and shearing within the metamorphic basement, as well as weathered zones within gneisses and schists.

The presence of major shear zones associated with the Pofadder Lineament is therefore considered to be the primary control on groundwater occurrence within the study area. These structurally weakened zones represent the most favourable targets for groundwater development, owing to increased fracturing and hydraulic connectivity. In contrast, the surrounding metamorphic and granitic units are expected to exhibit limited groundwater potential unless intersected by such structural features.

The overlying sediments of the Dwyka Group generally comprise low permeability diamictites and are not expected to constitute significant aquifers. Similarly, dolerite intrusions may locally influence groundwater flow, either acting as barriers to movement or, where sufficiently fractured, enhancing permeability.

Table 5 Hydrogeological units

Group / Suite	Subgroup / Formation	Lithology	Hydrogeological Characteristics	Aquifer Type	Groundwater Potential	Comments
Namaqua Metamorphic Complex	Gneissic Units	Banded gneiss, granitic gneiss	Very low primary porosity; groundwater limited to weathered and fractured zones	Fractured / weathered aquifer	Low to moderate	Regionally extensive basement; yields depend on degree of weathering and fracturing
Bushmanland Group (or equivalent supracrustal units)	Quartzite Units	Quartzite, metasandstone	Moderate to high secondary permeability due to fracturing	Fractured aquifer	Moderate to high	**Primary aquifer target**; best yields along fractures and contacts
Bushmanland Group (or equivalent)	Schist Units	Mica schist, foliated rocks	Anisotropic permeability along foliation planes	Fractured anisotropic aquifer	Low to moderate	Controls flow direction; may act as conduit or barrier depending on orientation
Younger Sedimentary Cover (if present)	Undifferentiated Sedimentary Units	Sandstone/Shale	Variable permeability; locally intergranular storage	Intergranular + fractured	Low to moderate	May act as semi-confined aquifer or aquitard depending on composition
Dwyka Group (Karoo Supergroup)	Tillite	Diamictite (glacial deposits)	Very low permeability	Aquitard	Very low	Acts as barrier; may create perched groundwater conditions
Karoo Igneous Suite	Dolerite Dykes/Sills	Dolerite	Low matrix permeability; enhanced flow along fractures and contacts	Fractured aquifer	Low to moderate (locally high)	Structurally important; contact zones may enhance yields

Table 6 Expected Aquifer Characteristics

Parameter	Expected Range / Behaviour
Aquifer Type	Fractured basement
Hydraulic Conductivity	Highly variable (10^{-6} – 10^{-3} m/s locally in fractures)
Yield	Low to moderate, highly variable
Storage	Low (unless weathered zone present)
Recharge	Low, episodic
Flow regime	Structurally controlled

7.1 Aquifer Yield

According to the 1:500 000 scale hydrogeological map (DWAF, 2000), the study area is predominantly underlain by meta-calcareous rocks (calc-silicate gneisses). These rocks typically occur as banded units, often interlayered with quartzite and schist. Groundwater occurrence is largely dependent on secondary permeability, associated with fractures and shear zones. **Figure 7** depicts the relative site position overlaid on the Springbok 2916- hydrogeological map.

The study area is therefore characterised predominantly by a fractured aquifer system, with localised occurrences of intergranular and fractured aquifers toward the western extent of the site. Based on the 1:500 000 scale hydrogeological map, both aquifer types are associated with regional average borehole yield indications of 0.1 to 0.5 L/s. **Figure 8** depicts the principal groundwater occurrence of the study area.

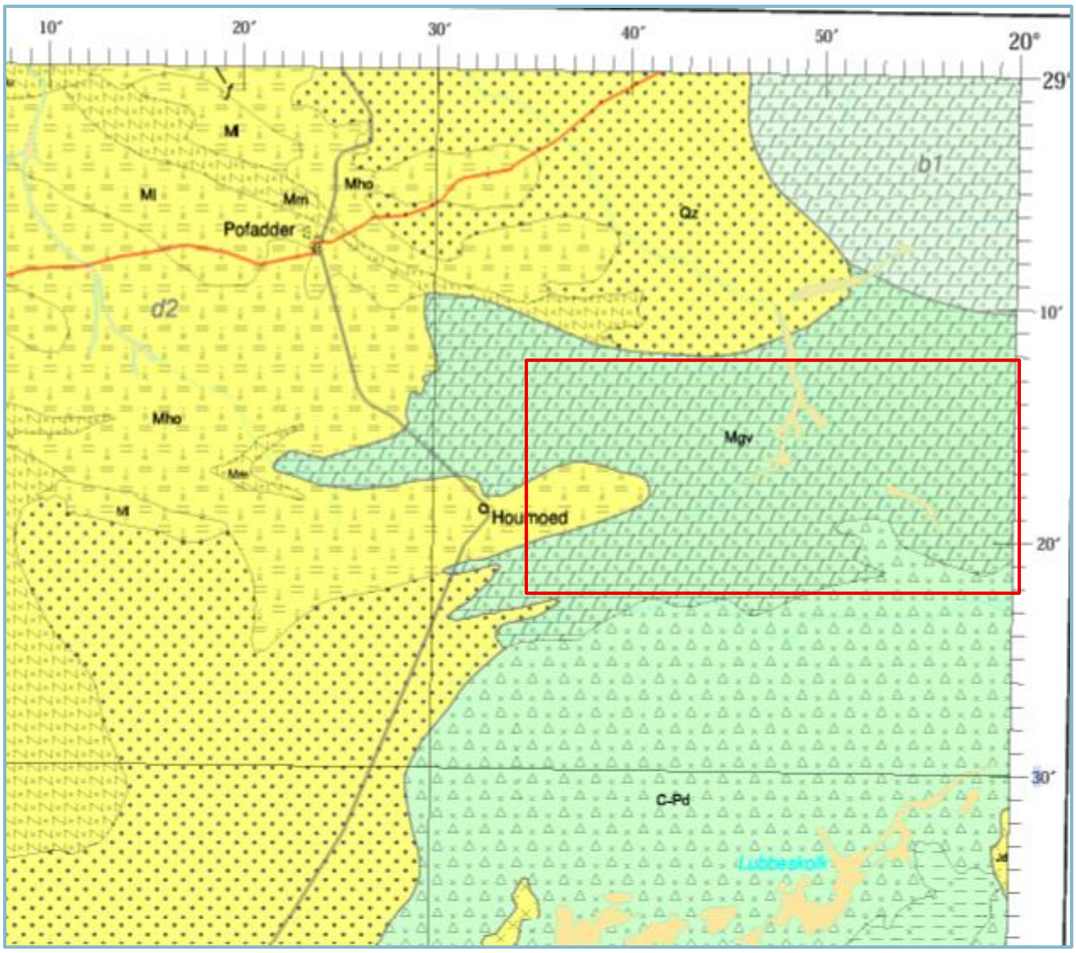

Figure 7: 1:500 000 scale hydrogeological map Springbok 2916 (DWAF, 2000)

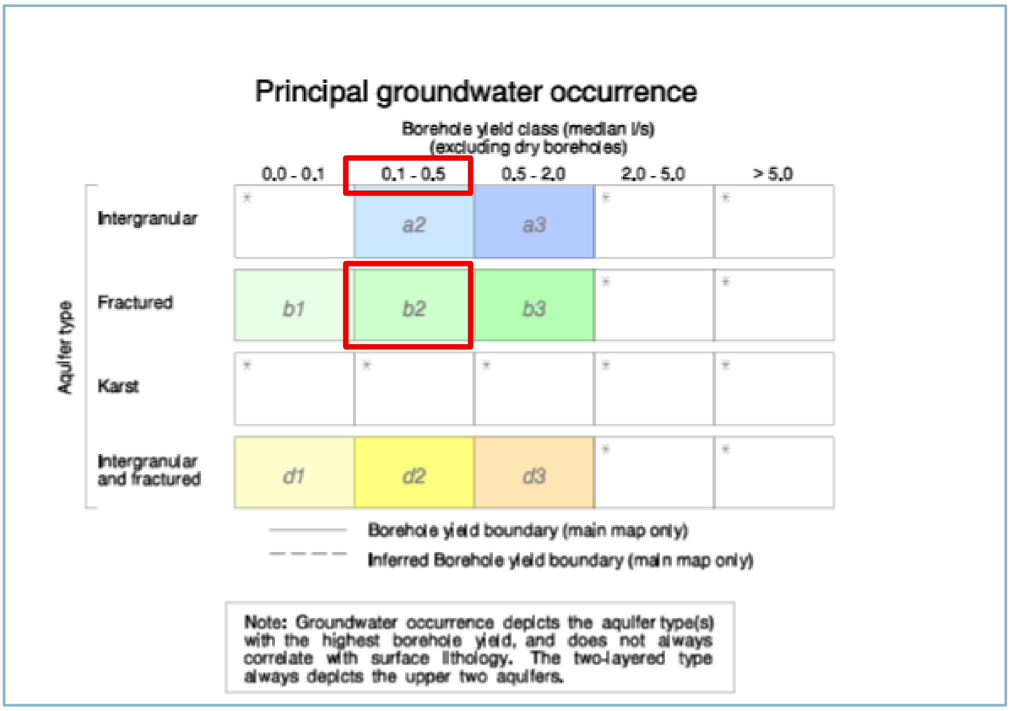

Figure 8: 1:500 000 scale hydrogeological map Springbok 2916, Principal Groundwater Occurrence (DWAF, 2000)

7.2 Aquifer Recharge

As part of the desk study, the Vegter Groundwater Recharge Map (Vegter, 1995) provides a regional context of natural groundwater recharge potential. This map, developed for South Africa, uses long-term climatic, geological, and hydrological data to estimate average annual recharge rates across the country. Recharge values are expressed in mm/yr of mean annual precipitation (MAP) and are influenced by factors such as rainfall intensity, evapotranspiration, soil type, vegetation cover, and underlying geology.

Recharge estimates by Vegter indicate values in the order of 0.1 to 3 mm/a for the study area. Groundwater recharge estimates derived from the Groundwater Resource Assessment Phase 2 (GRA2) similarly indicate extremely low recharge, with values approaching negligible levels (0 mm/yr) within the area (DWS, 2005). Taking this into account, the recharge is estimated to range between approximately 0% and 3.6% of the average mean annual precipitation (84 mm/yr). Such low recharge values are considered typical for arid environments. In addition, high evaporation rates characteristic of the region further reduces the proportion of rainfall contributing to groundwater recharge.

While the Vegter recharge map is useful for broad-scale assessments and comparative analysis between regions, it is intended as a regional-scale tool. Study area-specific recharge rates may differ significantly due to localised conditions such as land use changes, aquifer properties, and artificial recharge or abstraction impacts. Consequently, the map is best used as a screening-level indicator during the scoping phase, with study area-specific measurements and modelling recommended for accurate recharge estimation. **Figure 9** depicts the relative position of the study area relative to the estimated recharge.

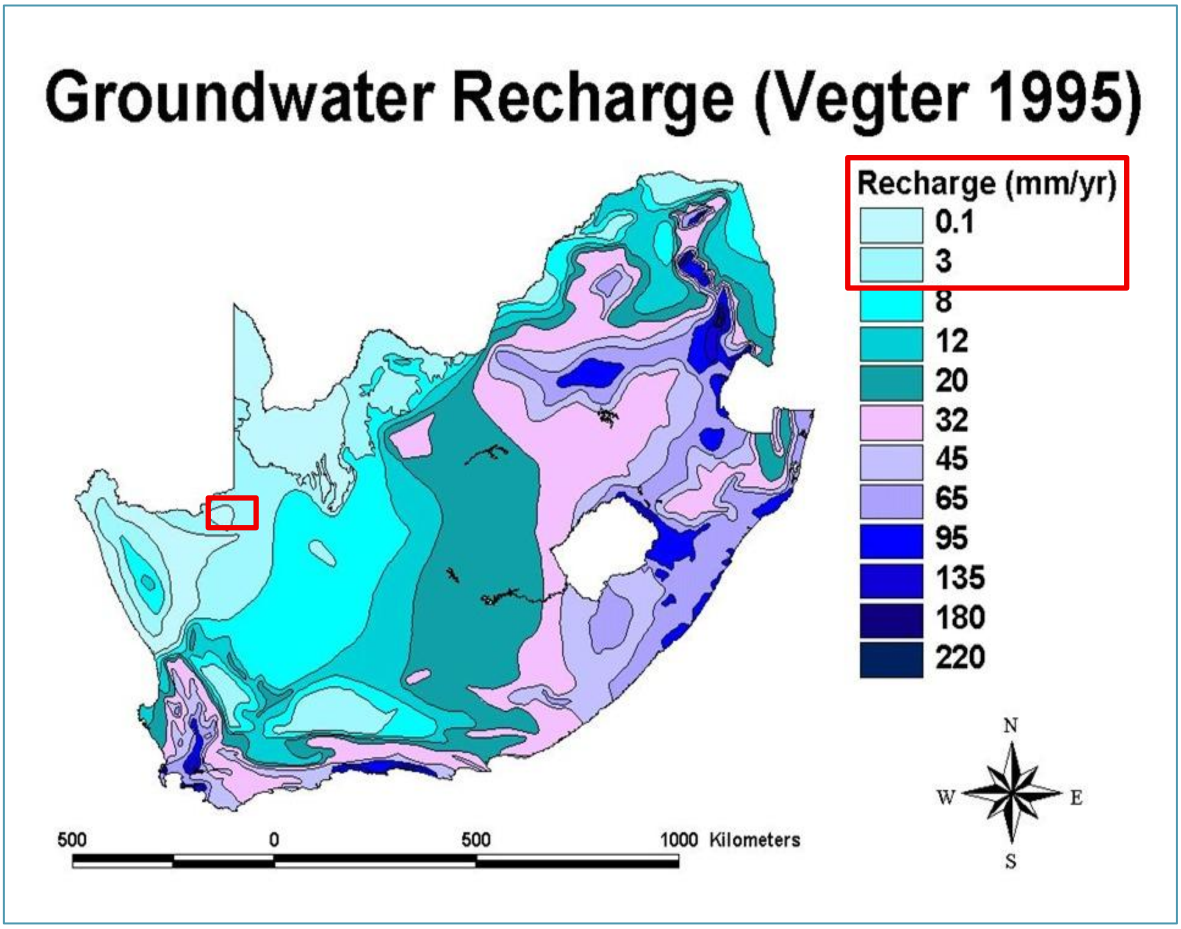

Figure 9 Vegter,1995, Recharge Map

7.3 Aquifer Quality

Electrical Conductivity (EC) reflects the groundwater's ability to conduct an electrical current and is directly proportional to the concentration of dissolved ions present in the water. It serves as a useful indicator of groundwater quality.

According to the 1:500 000 scale groundwater quality map (DWA, 2012), EC values range between 150 and 370 mS/m in the western extent of the study area, corresponding to 'acceptable' groundwater quality. These values increase to approximately 370 to 520 mS/m across the central and eastern portions, indicative of 'poor' (brackish) groundwater quality.

To more accurately characterise groundwater quality within the local area, groundwater samples should be collected from any available boreholes or water points within and around the Study area and submitted for laboratory analysis. If no boreholes are currently present, the installation of monitoring boreholes should be considered to enable representative sampling.

In addition, isotopic analysis may be considered to assess potential groundwater-surface water interactions, particularly in relation to the non-perennial drainage lines. Such analyses would assist in evaluating the degree of hydraulic connectivity and the potential impacts of activities such as dewatering on the local surface water system, and support any potential water use licensing process.

7.4 Groundwater flow directions

In natural, undeveloped settings, groundwater flow generally follows the hydraulic gradient from areas of higher groundwater head toward areas of lower head, which often broadly reflects surface topography. In fractured hard-rock environments, however, groundwater flow may also be significantly influenced by geological and structural controls such as fractures, faults, foliation planes, and shear zones. As a result, groundwater flow patterns do not necessarily mirror surface drainage or topographic gradients.

Within the study area, groundwater flow is therefore expected to be influenced by a combination of topography and structural features. Given the fractured nature of the underlying bedrock, structurally controlled flow along preferential pathways such as fractures and shear zones associated with the regional west-east Pofadder Lineament is deemed likely. Local drainage features may also act as zones of focused recharge or discharge during and after rainfall events, particularly where these intersect with structurally weakened zones.

At this stage, however, the available desktop information is insufficient to determine site-specific groundwater flow directions with confidence. No representative set of static groundwater level measurements is available across the study area to define groundwater heads or hydraulic gradients, and the current interpretation should therefore be regarded as conceptual only. To improve accuracy in the inferred groundwater flow direction, static groundwater levels should be measured across the study area and surrounding area during any future field-based hydrogeological assessment.

7.5 Aquifer Vulnerability Classification

7.5.1 Aquifer Classification

The underlying aquifer was classified in accordance with the South African Aquifer System Management Classification framework developed by Parsons (1995), which continues to serve as the national standard for assessing the significance of groundwater resources. This framework offers a strategic basis for the sustainable management and protection of aquifer systems by considering their hydrogeological properties, yield potential, and socio-economic value.

Based on the available data, the aquifer beneath the study area is classified as a Minor Aquifer. Such aquifers generally exhibit moderate yields sufficient for localised water supply but are not regarded as significant on a regional scale. Nevertheless, they warrant protection in cases of local dependency or heightened environmental sensitivity.

A summary of the aquifer system classification scheme and associated definitions is presented in Table 7.

Table 7: Aquifer System Management Classes (Parsons, 1995)

Sole source aquifer	An aquifer which is used to supply 50% or more of domestic water for a given area, and for which there are no reasonable available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.
Major aquifer system	Highly permeable formations, usually with a known 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, which do not have a high primary permeability, or other formations of variable permeability. Although these aquifers seldom produce large quantities of water, they are important both for local supplies and supplying base flow to 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 as unusable. However, groundwater flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.
Special aquifer system	An aquifer designated as such by the Minister of Water Affairs, after due process.

7.5.2 Aquifer vulnerability

Aquifer vulnerability refers to the intrinsic susceptibility of a groundwater system to contamination, specifically the likelihood that pollutants introduced at or near the land surface will reach a defined position within the aquifer. This concept considers the natural protective capacity of overlying geo-logical layers, recharge rates, and the hydraulic properties of the aquifer material.

According to the National Aquifer Vulnerability Map of South Africa (DWS, 2013), the aquifer system underlying the project area is classified as having Least Vulnerability. This rating indicates that the aquifer is only vulnerable to conservative pollutants in the long term when continuously discharged or leached.

7.5.3 Aquifer susceptibility

Aquifer susceptibility is a qualitative indicator of the relative ease with which a groundwater system may become contaminated as a result of human activities. It reflects the sensitivity of the aquifer to potential pollution based on factors such as depth to water table, recharge potential, lithology, and land use.

As per the National Aquifer Susceptibility Map of South Africa (DWS, 2013), the aquifer underlying the project area is assigned a Low Susceptibility rating. This suggests a low potential for contamination from surface or near-surface sources, highlighting the importance of implementing appropriate management and mitigation measures to safeguard groundwater quality.

7.6 Aquifer Protection

7.6.1 GQM Index

The Groundwater Quality Management (GQM) Index, developed by the Water Research Commission (WRC) and the former Department of Water Affairs and Forestry (DWAF) in 1995, forms part of South Africa's national framework for aquifer system management classification. Despite its name, the index does not assess water quality, but rather the management importance of groundwater resources based on aquifer characteristics, yield potential, and socio-economic reliance.

The GQM Index supports the strategic categorisation of aquifers and informs decisions related to groundwater protection, development, and monitoring priorities. It remains a key tool in implementing sustainable groundwater management under the National Water Act (Act 36 of 1998). Based on the GQM Index, the aquifer underlying the Study area requires Low Level Protection.

The Aquifer Vulnerability Classification is depicted in Table 8, with the GQM Index depicted in Table 9, below.

Table 8: Aquifer Vulnerability Classification (WRC & DWAF, 1995)

Aquifer system		Aquifer vulnerability	
Management qualification		**Classification**	
Class	**Points**	**Class**	**Points**
Sole Source Aquifer System	6	High	3
Major Aquifer System	4	Medium	2
Minor Aquifer System	**2**	**Low**	**1**
Non-Aquifer System	0		
Special Aquifer System	0-6		

Table 9: Groundwater Quality Management Index (WRC & DWAF, 1995)

GQM INDEX	Level of protection
<1	Limited Protection
1 to 3	**Low Level Protection**
3 to 6	Medium Level Protection
6 to 10	High Level Protection
>10	Strictly Non- Degradation

A study area-specific aquifer vulnerability assessment using the widely applied DRASTIC index (which considers factors such as water table depth, aquifer media, and recharge) can be incorporated in more detailed studies. However, this requires field-based data collection, including a hydrocensus, which was not conducted as part of the current investigation.

8 Site Specific Information

To determine whether there are any groundwater users in the area that may be affected by activities within the study area, a database search was conducted around the property boundary. This portion of the study was completed by studying and reviewing existing national databases that contain groundwater information. A search was conducted on a number of databases, namely the National Groundwater Archive (NGA) and the Water Use Authorisation and Registration Management System (WARMS). These resources provide data on borehole positions, groundwater chemistry and yield, when available.

8.1 National Groundwater Archive (NGA) Database

An assessment of the NGA database, incorporating information on borehole locations, groundwater quality, and yields, identified a total of 84 boreholes located within the study area boundary and a 1 km radius of the study area. A summary of data provided is in Appendix A.

A limited dataset of three (3) groundwater level measurements, recorded between 1990 and 1996, indicates water table depths ranging from 15.00 mbgl to 45.00 mbgl. The limited lithological descriptions captured in the NGA dataset suggest deeper water levels associated with quartzitic formations compared to more shallow granitic settings.

A discharge of approximately 2 L/s was recorded for borehole 2919BD00030, which is recorded as being drilled into quartzite. This value likely represents a reported pumping rate rather than a confirmed sustainable yield, as no supporting pumping test data are available. As such, it should be considered indicative only.

NGA data obtained for groundwater levels and discharge in and proximal to the study area is depicted in Table 10.

Table 10: NGA Data on Groundwater Levels and Discharge Rates

Identifier	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Water Level Measurement Date	Water Level (mBGL)	Discharge Rate Measurement Date	Discharge Rate	Depth Diameter Measurement Date	Depth to Bottom	Casing Depth to Bottom	Water Strike Depth to Top	Lithology Depth to Bottom	Lithology Name
2919BD00032	-29.336469	19.776430	1996/04/24	31	No data	No data	24/04/1996	6.00 72.00	6	31.00 56.00 31.00 56.00	72.00	Quartzite
2919BD00030	-29.296189	19.888100	1990/08/02	45	02/08/1990	2.000 l/s	02/08/1990	6.60 60.00	7	60.00	66.00	Quartzite
2920AC00013	-29.431190	20.000650	1990/11/06	15	No data	No data	06/11/1990	30.00	6		30.00	Granite

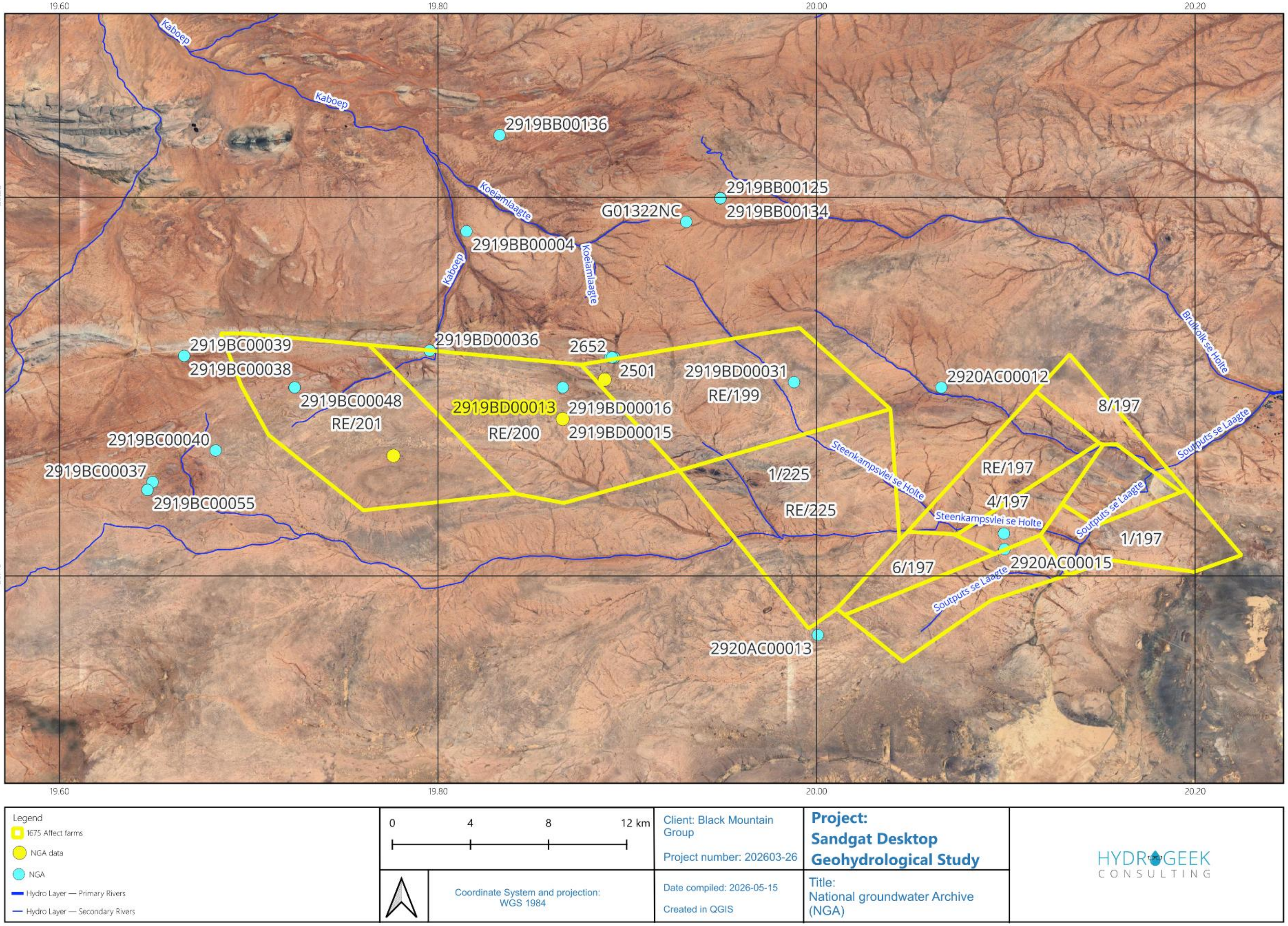

Figure 10 National Groundwater Archive (NGA) boreholes

8.2 Water Use Authorisation and Registration Management System (WARMS) Database

The WARMS is a national database managed by the Department of Water and Sanitation (DWS), used to record and monitor registered water uses across South Africa in accordance with the National Water Act (Act 36 of 1998). The system includes data on licensed and authorised water users, volumes abstracted, and types of water use. For this study, available WARMS data from 2025 was obtained from DWS and used to assess the status of registered water use within the surrounding area of the study area.

Assessment of the WARMS Database showed no active WARMS registrations in proximity to the study area. The nearest WARMS point (registered water user) is situated 5 km north of the study area boundary. Information on this point is included in Table 11 below.

Table 11: Summary of nearest WARMS registered water use point.*

Study area ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Registered Volume (m^3/a)	Use	Status
25023466	-29.1928	19.7679	66 000	Agriculture: Irrigation	Lawful

**It should be noted that the accuracy of information obtained from the database could not be independently verified and may contain errors.*

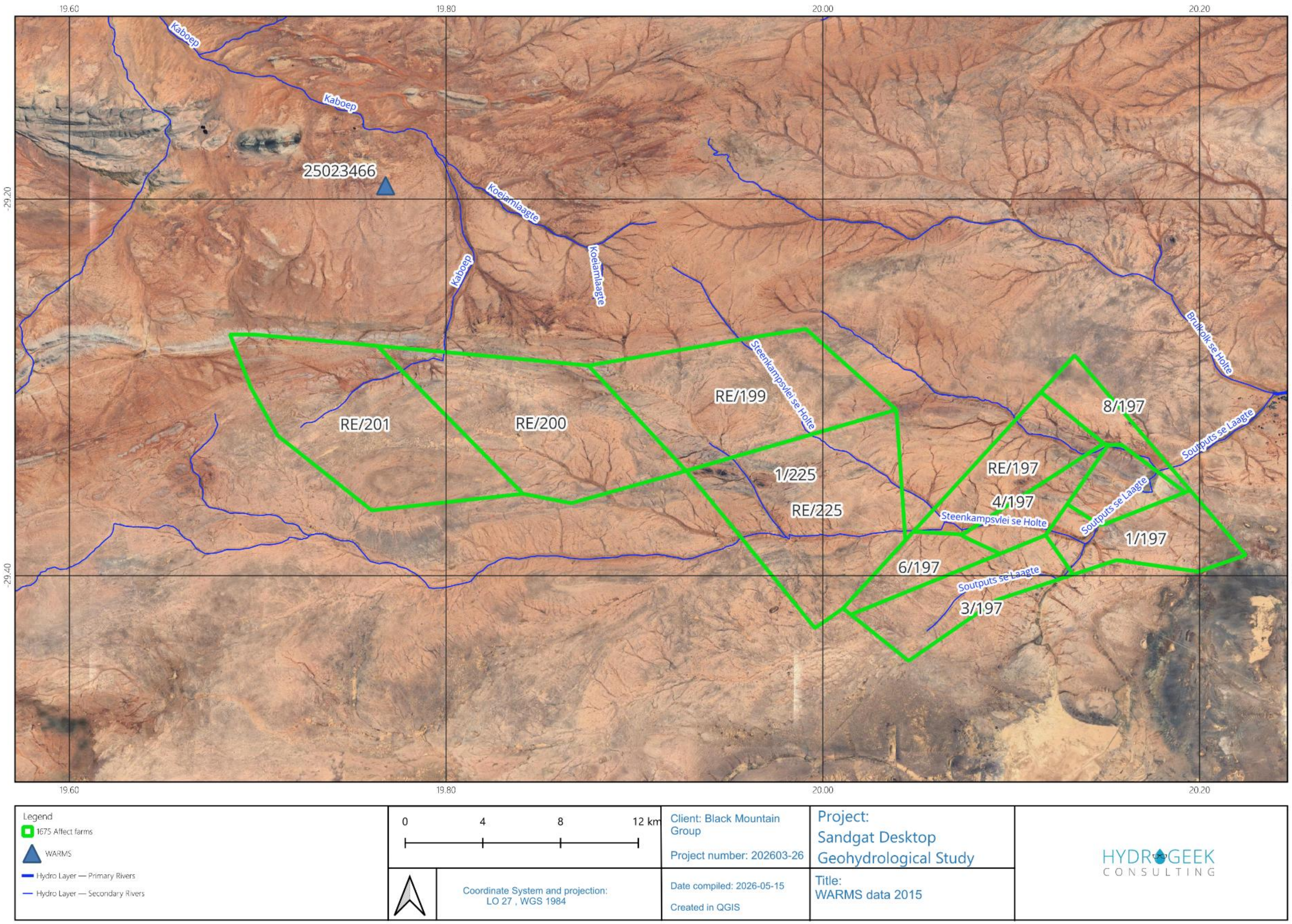

Figure 11 Water Use Authorisation and Registration Management System (WARMS) data

9 HYDROGEOLOGICAL RISK ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PROGRAMME

The study considered the potential cumulative impacts associated with the proposed prospecting programme, including the drilling of approximately 16 prospecting boreholes across the application area. The cumulative assessment evaluated the potential combined effects of drilling activities on groundwater resources, aquifer integrity, groundwater quality, and surrounding environmental receptors, considering existing activities within the broader area.

9.1 Desktop level

Statement on Impact Differentiation

The assessment included a desktop sensitivity assessment of the study area in relation to the proposed prospecting activities and associated infrastructure, specifically limited to the drilling of approximately 16 prospecting boreholes for sampling and exploration purposes during the construction/prospecting phase. The assessment considered the geological and hydrogeological setting, aquifer vulnerability, groundwater resource significance, surface water features, drainage characteristics, potential environmentally sensitive areas, and existing land-use activities within and surrounding the application area.

Areas considered environmentally sensitive, including drainage features, wetlands, watercourses, steep slopes, and areas with elevated groundwater vulnerability, were identified as areas to be avoided where reasonably possible during the planning and positioning of prospecting boreholes and associated temporary access routes. The findings of the desktop assessment indicate that the proposed prospecting activities are localised, temporary in nature, and of relatively limited hydrogeological impact, provided that appropriate management and mitigation measures are implemented.

Potential impacts associated with the prospecting drilling activities during the construction/prospecting phase may include

- Localised disturbance of surface soils,
- Potential contamination of groundwater through poor drilling practices
- hydrocarbon spillages
- Improper handling of drilling fluids and cuttings
- Limited temporary disturbance to shallow groundwater flow conditions

No significant long-term impacts on regional groundwater resources are anticipated as part of the prospecting phase, as no abstraction, dewatering, or mining-related excavation forms part of the current application

9.1.1 Mitigation and management measures.

- Boreholes should be positioned outside of sensitive drainage features, wetlands, and watercourses where reasonably possible.
- All drilling activities should be undertaken using appropriate drilling and environmental management practices to prevent groundwater contamination.
- Hydrocarbon fuels, oils, and hazardous substances should be stored in designated bunded areas away from drainage lines and boreholes.
- Spill prevention and spill response measures should be implemented on site at all times.
- Drill sites should be kept clean, and all waste materials and drilling-related waste should be removed and disposed of at approved facilities.
- Disturbed areas should be rehabilitated following completion of drilling activities.
- Boreholes not required for future monitoring or exploration purposes should be appropriately sealed and decommissioned in accordance with recognised standards.
- No uncontrolled discharge of contaminated water or drilling fluids should be permitted to the surrounding environment.

9.2 Risk Assessment Criteria

9.2.1 Procedure

The impact significance rating methodology, as presented herein and utilised for all EIMS Impact Assessment Projects, is guided by the requirements of the NEMA EIA Regulations 2014 (as amended). The approach may be altered or substituted on a case by case basis if the specific aspect being assessed requires such-such instances require prior EIMS Project Manager approval. The broad approach to the significance rating methodology is to determine the significance (S) of an environmental risk or impact by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relating this to the probability/ likelihood (P) of the impact occurring. The S is determined for the pre- and post-mitigation scenario. In addition, other factors, including cumulative impacts and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the S to determine the overall final significance rating (FS). The impact assessment will be applied to all identified alternatives.

9.2.2 Determination of Significance

The final significance (FS) of an impact or risk is determined by applying a prioritisation factor (PF) to the post-mitigation environmental significance. The significance is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and Reversibility (R) applicable to the specific impact.

For the purpose of this methodology the consequence of the impact is represented by:

$$\boldsymbol{C} = \frac{(\boldsymbol{E} + \boldsymbol{D} + \boldsymbol{M} + \boldsymbol{R}) * \boldsymbol{N}}{\boldsymbol{4}}$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 12 below.

Table 12 Criteria for Determining Impact Consequence

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. Highly localised, limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property or site boundary, or the area within a few hundred meters of the site)
	3	Local (i.e. beyond the site boundary within the Local administrative boundary (e.g. Local Municipality) or within consistent local geographical features, or the area within 5 km of the site)
	4	Regional (i.e. Far beyond the site boundary, beyond the Local administrative boundaries within the Regional administrative boundaries (e.g. District Municipality), or extends into different distinct geographical features, or extends between 5 and 50 km from the site).
	5	Provincial / National / International (i.e. extends into numerous distinct geographical features, or extends beyond 50 km from the site).
Dura-tion	1	Immediate (<1 year, quickly reversible)
	2	Short term (1-5 years, less than project lifespan)
	3	Medium term (6-15 years)
	4	Long term (15-65 years, the impact will cease after the operational life span of the project)
	5	Permanent (>65 years, no mitigation measure of natural process will reduce the impact after construction/ operation/ decommissioning).
Magni-tude/ Inten-sity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected)
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected, or affected environmental components are already degraded)
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way; moderate improvement for +ve impacts; or where change affects area of potential conservation or other value, or use of resources).
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease; high improvement for +ve impacts; or where change affects high conservation value areas or species of conservation concern)
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease, substantial improvement for +ve impacts; or disturbance to pristine areas of critical conservation value or critically endangered species)

Revers-ibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring very high time and cost.
	5	Irreversible Impact.

Once the C has been determined, the significance is determined in accordance with the standard risk assessment relationship by multiplying the C and the P. Probability is rated/ scored as per Table 13.

It is noted that both environmental risks as well as environmental impacts should be identified and assessed. Environmental Risk can be regarded as the potential for something harmful to happen to the environment, and in many instances is not regarded as something that is expected to occur during normal operations or events (e.g. unplanned fuel or oil spills at a construction site). Probability and likelihood are key determinants or variables of environmental risk. Environmental Impact can be regarded as the actual effect or change that happens to the environment because of an activity and is typically an effect that is expected from normal operations or events (e.g. vegetation clearance from site development results in loss of species of concern). Typically the probability of an unmitigated environmental impact is regarded as highly likely or certain (management and mitigation measures would ideally aim to reduce this likelihood where possible). In summary, environmental risk is about what could happen, while environmental impact is about what does happen.

Table 13: Probability/ Likelihood Scoring

Probability	1	Improbable (Rare, the event may occur only in exceptional circumstances, the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <5% chance).
	2	Low probability (Unlikely, impact could occur but not realistically expected; >5% and <20% chance).
	3	Medium probability (Possible, the impact may occur; >20% and <50% chance).
	4	High probability (Likely, it is most probable that the impact will occur- > 50 and <90% chance).
	5	Definite (Almost certain, the impact is expected to, or will, occur, >90% chance).

The result is a qualitative representation of relative significance associated with the impact. Significance is therefore calculated as follows:

$$\boldsymbol{S = C\ x\ P}$$

Table 14 Determination of Significance

Consequence	5- Very High	5	10	15	20	25
	4- High	4	8	12	16	20
	3- Medium	3	6	9	12	15
	2- Low	2	4	6	8	10
	1- Very low	1	2	3	4	5
		1- Improbable	2- Low	3- Medium/ Possible	4- High/ Probable	5- Highly likely/ Definite
	Probability					

The outcome of the significance assessment will result in a range of scores, ranging from 1 through to 25. These significance scores are then grouped into respective classes as described in Table 15

Table 15 Significance Scores

S Score	Description
≤4.25	Low (i.e. where this impact is unlikely to be a significant environmental risk/ reward).
>4,25, ≤8.5	Low-Medium (i.e. where the impact could have a significant environmental risk/ reward).
>8.5, ≤13.75	High-Medium (i.e. where the impact could have a significant environmental risk/ reward).
>13.75	High (i.e. where the impact will have a significant environmental risk/ reward).

The impact significance will be determined for each impact without relevant management and mitigation measures (pre-mitigation significance), as well as post implementation of relevant management and mitigation measures (post-mitigation significance). This allows for a prediction in the degree to which the impact can be managed/mitigated.

9.2.3 Impact Prioritization

Further to the assessment criteria presented in the section above, it is necessary to consider each potentially significant impact in terms of:

- Cumulative impacts; and
- The degree to which the impact may cause irreplaceable loss of resources.

To ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impacts' post-mitigation significance (post-mitigation). This prioritisation factor does not aim to detract from the significance ratings but rather to focus the attention of the decision-making authority on the higher priority/significance issues and impacts. The PF will be applied to the post-mitigation significance based on the assumption that relevant suggested management/mitigation impacts are implemented.

Table 16: Criteria for Determining Prioritisation

Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/ definite that the impact will result in spatial and temporal cumulative change.
Irreplaceable Loss of Resources (LR)	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.
	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table 16. The impact priority is therefore determined as follows:

$$\boldsymbol{Priority = CI + LR}$$

The result is a priority score which ranges from 2 to 6 and a consequent PF ranging from 1 to 1.5 (Refer to Table 17).

Table 17: Determination of Prioritisation Factor

Priority	Prioritisation Factor
2	1
3	1.125
4	1.25

Priority	Prioritisation Factor
5	1.375
6	1.5

In order to determine the final impact significance (FS), the PF is multiplied by the post-mitigation significance scoring. The ultimate aim of the PF is an attempt to increase the post mitigation environmental risk rating by a factor of 0.5, if all the priority attributes are high (i.e. if an impact comes out with a high medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a higher significance).

Table 18: Final Environmental Significance Rating

Significance Rating	Description
<-25	Very High (Impacts in this class are extremely significant and pose a very high environmental risk. In certain instances these may represent a fatal flaw. They are likely to have a major influence on the decision and may be difficult or impossible to mitigate. Offset's may be necessary.
<-13.75 to -25	High negative (These impacts are significant and must be carefully considered in the decision-making process. They have a high environmental risk or impact and require extensive mitigation measures).
-8.5 to -13.75	Medium-High negative (i.e. Impacts in this class are more substantial and could have a significant environmental risk. They may influence the decision to develop in the area and require more robust mitigation measures).
<-4.25 to <-8.5	Medium- Low negative (i.e. These impacts are slightly more significant than low impacts but still do not pose a major environmental risk. They might require some mitigation measures but are generally manageable).
-1 to -4.25	Low negative (i.e. Impacts in this class are minor and unlikely to have a significant environmental risk. They do not influence the decision to develop in the area and are typically easily mitigated.
0	No impact
1 to 4.25	Low positive
>4.25 to <8.5	Medium-Low positive
8.5 to 13.75	Medium-High positive

Significance Rating	Description
>13.75	High positive

The significance ratings and additional considerations applied to each impact will be used to provide a quantitative comparative assessment of the alternatives being considered. In addition, professional expertise and opinion of the specialists and the environmental consultants will be applied to provide a qualitative comparison of the alternatives under consideration. This process will identify the best alternative for the proposed project.

9.2.4 Cumulative impact

The cumulative impacts associated with the drilling of sixteen prospecting boreholes are anticipated to be localised, temporary, and of low significance following the implementation of appropriate mitigation measures. Potential cumulative impacts include minor disturbance of surface soils and vegetation, temporary alteration of shallow groundwater flow conditions, and a low risk of groundwater contamination associated with drilling activities, hydrocarbon spillages, and improper handling of drilling fluids and cuttings. Due to the limited number, small footprint, and temporary nature of the proposed boreholes, significant cumulative impacts on groundwater resources or surrounding environmental features are not expected. With adherence to recognised drilling standards, spill prevention measures, and appropriate rehabilitation and sealing of boreholes after completion, the overall cumulative impact is of low negative significance.

9.3 EMPR inclusion

See attached Table 21

Table 19 Risk Assessment Rating Consequence

Impacts (Construction and Operation)	Phase	Extent	Duration	Magnitude	Reversibility	Nature	Consequence	Probability	Pre-mitigation Significance	Description	Mitigation measure
Localised disturbance of surface soils,	Desktop	2	1	2	2	-1	-1,75	2	-3,5	Low	Boreholes should be positioned outside of sensitive drainage features, wetlands, and watercourses where reasonably possible.
Potential contamination of groundwater through poor drilling practices	Desktop	2	1	2	2	-1	-1,75	2	-3,5	Low	All drilling activities should be undertaken using appropriate drilling and environmental management practices to prevent groundwater contamination.
Hydrocarbon spillages	Desktop	2	1	2	2	-1	-1,75	2	-3,5	Low	Hydrocarbon fuels, oils, and hazardous substances should be stored in designated bunded areas away from drainage lines and boreholes.
Improper handling of drilling fluids and cuttings	Desktop	2	1	2	2	-1	-1,75	2	-3,5	Low	Spill prevention and spill response measures should be implemented on site at all times.
Limited temporary disturbance to shallow groundwater flow conditions	Desktop	2	1	2	2	-1	-1,75	2	-3,5	Low	Disturbed areas should be rehabilitated following completion of drilling activities. Boreholes not required for future monitoring or exploration purposes should be appropriately sealed and decommissioned in accordance with recognised standards
Impacts with Mitigation (Decommissioning)	**Phase**	**Extent**	**Duration**	**Magnitude**	**Reversibility**	**Nature**	**Consequence**	**Probability**	**Significance**		
Localised disturbance of surface soils,	Desktop	2	1	1	1	-1	-1,25	2	-2,5	Low	Boreholes should be positioned outside of sensitive drainage features, wetlands, and watercourses where reasonably possible.
Potential contamination of groundwater through poor drilling practices	Desktop	2	1	1	1	-1	-1,25	2	-2,5	Low	All drilling activities should be undertaken using appropriate drilling and environmental management practices to prevent groundwater contamination.

Impacts (Construction and Operation)	Phase	Extent	Duration	Magnitude	Reversibility	Nature	Consequence	Probability	Pre-mitigation Significance	Description	Mitigation measure
Hydrocarbon spillages	Desktop	2	1	1	1	-1	-1,25	2	-2,5	Low	Hydrocarbon fuels, oils, and hazardous substances should be stored in designated bunded areas away from drainage lines and boreholes.
Improper handling of drilling fluids and cuttings	Desktop	2	1	1	1	-1	-1,25	2	-2,5	Low	Spill prevention and spill response measures should be implemented on site at all times.
Limited temporary disturbance to shallow groundwater flow conditions	Desktop	2	1	1	1	-1	-1,25	2	-2,5	Low	Disturbed areas should be rehabilitated following completion of drilling activities. Boreholes not required for future monitoring or exploration purposes should be appropriately sealed and decommissioned in accordance with recognised standards

Table 20 Risk Assessment Rating Final Environmental Significance

Impacts	Cumulative Impact (CI)	Loss of Resources (LR)	Priority (P)	Priority factor (PF)	Post mitigation Significance	Final Significance (FS)		Mitigation measure
Localised disturbance of surface soils,	1	1	2	1	-2,5	-2,5	Low negative	Boreholes should be positioned outside of sensitive drainage features, wetlands, and watercourses where reasonably possible.
Potential contamination of groundwater through poor drilling practices	1	1	2	1	-2,5	-2,5	Low negative	All drilling activities should be undertaken using appropriate drilling and environmental management practices to prevent groundwater contamination.
Hydrocarbon spillages	1	1	2	1	-2,5	-2,5	Low negative	Hydrocarbon fuels, oils, and hazardous substances should be stored in designated bunded areas away from drainage lines and boreholes.
Improper handling of drilling fluids and cuttings	1	1	2	1	-2,5	-2,5	Low negative	Spill prevention and spill response measures should be implemented on site at all times.
Limited temporary disturbance to shallow groundwater flow conditions	1	1	2	1	-2,5	-2,5	Low negative	Disturbed areas should be rehabilitated following completion of drilling activities.Boreholes not required for future monitoring or exploration purposes should be appropriately sealed and decommissioned in accordance with recognised standards

Table 21 EMPr Inclusion

Mitigation Measures	Phase	Timeframe	Responsible Party for Implementation	Monitoring Party (Frequency)	Target	Performance Indicators (Monitoring Tool)
Boreholes should be positioned outside of sensitive drainage features, wetlands, and watercourses where reasonably possible.	Desktop	Prior to construction	Applicant	One off	Ensure compliance with relevant legislation	No legal directives Legal compliance audit scores
All drilling activities should be undertaken using appropriate drilling and environmental management practices to prevent groundwater contamination.	Desktop	Prior to construction	Applicant	One off	Ensure compliance with relevant legislation	No legal directives Legal compliance audit scores
Hydrocarbon fuels, oils, and hazardous substances should be stored in designated bunded areas away from drainage lines and boreholes.	Desktop	Prior to construction	Applicant	One off	Ensure compliance with relevant legislation	No legal directives Legal compliance audit scores
Spill prevention and spill response measures should be implemented on site at all times.	Desktop	Prior to construction	Applicant	One off	Ensure compliance with relevant legislation	No legal directives Legal compliance audit scores

Disturbed areas should be rehabilitated following completion of drilling activities. Boreholes not required for future monitoring or exploration purposes should be appropriately sealed and decommissioned in accordance with recognised standards	Desktop	Prior to construction	Applicant	One off	Ensure compliance with relevant legislation	No legal directives Legal compliance audit scores

10 Conclusions

Based on the available desktop information, the study area is inferred to be underlain predominantly by fractured metamorphic and intrusive bedrock aquifers, in which groundwater occurrence is expected to be controlled mainly by secondary features such as fractures and shear zones. From a regional desktop perspective, the 1:500 000 scale hydrogeological map indicates that the study area is associated predominantly with fractured aquifer conditions, with localised occurrences of intergranular and fractured aquifers toward the western extent. In terms of this regional mapping, average borehole yields in the area are indicated to be in the order of 0.1 to 0.5 L/s; however, these values are map-derived regional yield indications and do not represent site-confirmed or tested borehole yields.

Recharge is likewise expected to be low. The Vegter Groundwater Recharge Map indicates recharge values in the order of 0.1 to 3 mm/a, while the GRA2 dataset indicates recharge approaching negligible values in parts of the area. These values suggest a low-recharge arid groundwater environment but should be regarded as regional screening-level estimates rather than site-specific quantified recharge.

Site-specific groundwater information remains limited. The NGA database identified 84 boreholes in and around the study area and within a 1 km radius thereof, with only three (3) groundwater level measurements and one (1) discharge value recorded. The available data indicates groundwater levels ranging from approximately 15 to 45 mbgl, recorded between 1990 and 1996. A single discharge value of approximately 2 L/s was recorded for borehole 2919BD00030.

The desktop groundwater assessment suggests that groundwater can potentially occur locally within structurally favourable zones, particularly where fracturing, shearing, or lithological contacts enhance secondary permeability. However, the current level of information is insufficient to confirm groundwater potential, sustainable yield, groundwater quality, or groundwater flow conditions on site. The present assessment should therefore be regarded as a scoping-level appraisal only, with further field-based hydrogeological investigation required to verify groundwater conditions and inform any future groundwater development or regulatory process.

Assumptions

- This assessment is based primarily on available desktop information, regional geological and hydrogeological datasets, and the proposed prospecting scope involving the drilling of approximately sixteen boreholes. No site-specific aquifer testing, groundwater quality sampling, or long-term groundwater monitoring data were available for the study area at the time of assessment. As such, several assumptions and uncertainties remain regarding the local hydrogeological conditions.

The assessment assumes that:

- The proposed activities are limited to prospecting-related drilling only and do not include mining, bulk abstraction, infrastructure development, or large-scale groundwater dewatering;
- Boreholes will be drilled using recognised industry-standard drilling methods and environmental management practices;

- Drilling fluids, fuels, and hydrocarbons will be appropriately managed onsite;
- All boreholes not required for future monitoring or exploration purposes will be sealed and rehabilitated in accordance with recognised standards.

Uncertainties remain regarding:

- The exact depth, extent, and hydraulic properties of local aquifer systems;
- Groundwater flow directions and seasonal groundwater level fluctuations;
- The potential presence of shallow perched groundwater zones or preferential flow pathways associated with geological structures;
- Existing baseline groundwater quality conditions in the immediate prospecting area.
- Due to the limited scale and temporary nature of the proposed prospecting activities, these uncertainties are not expected to materially alter the overall finding that impacts associated with the drilling programme are anticipated to be of low significance, provided mitigation measures are implemented.

Specialist Opinion:

No fatal flaws or showstoppers has been identified at the Desktop in terms of the Hydrogeological conditions at Sandgat project area.

11 Recommendations

Recommendations for Prospecting Activities

The following recommendations are specifically related to the proposed prospecting drilling activities and are intended to improve understanding of the local hydrogeological conditions while mitigating potential impacts associated with prospecting only:

- Boreholes should be positioned outside of wetlands, drainage features, and environmentally sensitive areas where reasonably possible;
- Appropriate spill prevention and containment measures must be implemented onsite during drilling activities;
- Hydrocarbons, drilling additives, and hazardous substances should be stored within designated bunded areas away from drainage features;
- Drilling fluids and cuttings should be managed and disposed of in an environmentally responsible manner;
- Disturbed areas should be rehabilitated as soon as reasonably possible following completion of drilling activities;
- Boreholes not required for future exploration or monitoring purposes should be sealed and decommissioned in accordance with recognised standards;
- Basic groundwater strike information encountered during drilling, including water levels and approximate yields, should be recorded to improve understanding of the local hydrogeological setting;
- Any visible groundwater seepages, inflows, or unexpected groundwater conditions encountered during drilling should be documented and assessed;

- If groundwater contamination, artesian conditions, or significant water strikes are encountered during drilling, additional hydrogeological assessment may be required; and
- Based on the limited scale, temporary duration, and nature of the proposed prospecting drilling programme, no significant long-term impacts on groundwater resources are anticipated.

12 References

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Signature Page

Hydrogeek Consulting (Pty) Ltd

Authorisation			
Name	**Designation**	**Signature**	**Date**
NL van Zyl	Project Hydrogeologist *Pr.Sci.Nat.*		May 2026

Reg.No. 2019/327216/07

Directors: NL van Zyl

Appendix 1

NGA Data within and proximal to the study are

Identifier	Latitude	Longitude	Water Level Status	WaterLevel Measurement Date And Time	Water Level	DischargeRate Measurement Date and Time	DischargeRate (L/s)	Depth Diameter Measurement Date	Depth Diameter Depth to Bot	Casing Depth to Bot	Water Strike mBGL	Lithology Depth to Top	Lithology Depth to Bot	Lithology
2919BC00053	-29.35453	19.64652						13/06/1989	30.00		74.00	0.00	30.00	Alluvium
												30.00	84.00	Granite
												0.00	30.00	Alluvium
												30.00	84.00	Granite
2919BC00055	-29.35454	19.64652						09/06/1989	78.00	4	42.00	0.00	30	Quartzite
												30.00	78	Granite
2919BC00054	-29.35453	19.64653						07/06/1989	114.00			0.00	114	Granite
2919BC00037	-29.35036	19.64921						27/01/1938	45.11		42.67	0.00	45.11	Quartzite
2919BC00038	-29.28369	19.66588						08/11/1977	54.00			0.00	5	Chalk
												5.00	12	Gneiss
												12.00	20	Schist
												20.00	54	Quartzite
2919BC00039	-29.28369	19.66589						10/11/1977	24.00		18	0.00	24	Quartzite
2919BC00040	-29.33369	19.68254						05/06/1937	40.23		32.91	0.00	40.23	Quartzite
2919BC00041	-29.30036	19.72421						27/10/1954	56.38	3	26.51	0.00	56.38	Granite
2919BC00043	-29.30037	19.72421						25/01/1960	53.34		48.76	0.00	53.34	Quartzite
2919BC00045	-29.30038	19.72421						21/05/1967	77.42	2	44.8	0.00	50.9	Quartzite
												50.90	77.42	Granite
2919BC00047	-29.30039	19.72421						28/03/1973	76.50		25	0.00	27.43	Quartzite
												27.43	76.5	Dolerite
2919BC00049	-29.3004	19.72421						31/08/1940	54.25		52.73	0.00	32	Quartzite
												32.00	36.88	Granite
												36.88	41.45	Dolomite
												41.45	54.25	Granite
2919BC00051	-29.30041	19.72421						18/05/1937	120.09			0.00	39.92	Granite
												39.92	71.01	Quartzite
												71.01	74.37	Granite
												74.37	120.09	Quartzite
2919BC00042	-29.30036	19.72422						05/01/1960	167.64		39.62	0.00	19.5	Quartzite
												19.50	29.87	Granite
												29.87	167.64	Quartzite
2919BC00044	-29.30036	19.72423						15/03/1960	50.29		42.67	0.00	14.02	Clay
												14.02	24.07	Quartzite
												24.07	35.66	Dolerite
												35.66	50.29	Granite
2919BC00046	-29.30036	19.72424						11/06/1969	61.26	18	32	0.00	17.06	Shale
												17.06	36.57	Quartzite
												36.57	61.26	Granite

Identifier	Latitude	Longitude	Water Level Status	WaterLevel Measurement Date And Time	Water Level	DischargeRate Measurement Date and Time	DischargeRate (L/s)	Depth Diameter Measurement Date	Depth Diameter Depth to Bot	Casing Depth to Bot	Water Strike mBGL	Lithology Depth to Top	Lithology Depth to Bot	Lithology
2919BC00048	-29.30036	19.72425						26/03/1973	94.18		81	0.00	6.09	Limestone
												6.09	94.18	Quartzite
2919BC00050	-29.30036	19.72426						06/07/1940	62.78		54.86	0.00	6.88	Quartzite
												6.88	62.78	Granite
2919BC00052	-29.30036	19.72427						01/01/1900	55.16			0.00	55.16	Granite
2919BD00032	-29.33647	19.77643	Static Water Level	1996/04/24 08:00:00.000	31			24/04/1996	6.00	6	31	0.00	72	Quartzite
											56			
									72.00		31			
											56			
2919BD00036	-29.28092	19.79559						16/06/1969	98.76		98.76	0	68.28	Quartzite
												68.28	98.76	Granite
2919BD00037	-29.28091	19.79559						04/06/1969	107.90		107.9	0	68.28	Quartzite
												68.28	87.78	Dolerite
												87.78	95.71	Quartzite
												95.71	107.9	Granite
2919BD00034	-29.28092	19.7956						25/06/1996	59.74		59.74	0	42.06	Quartzite
												42.06	59.74	Granite
2919BD00035	-29.28091	19.7956						11/06/1969	83.52		83.52	0	23.77	Quartzite
												23.77	83.52	Granite
2919BB00004	-29.21786	19.81504						18/09/1991	114.00			0	114	Granite
2919BB00136	-29.16703	19.83254						11/01/1979	84.00			0	3	SOIL
												3	84	Granite
2919BD00011	-29.31703	19.86588						26/12/1940	51.82		39.01	0	51.82	Quartzite
2919BD00013	-29.31704	19.86588						07/11/1940	67.06			0	0.3	Quartzite
												0.3	53.95	Granite
												53.95	67.06	Quartzite
2919BD00015	-29.31705	19.86588						10/07/1967	120.09		103.63	0	55.47	Granite
												55.47	112.78	Quartzite
												112.78	120.09	Granite
											106.68	0	55.47	Granite
												55.47	112.78	Quartzite
												112.78	120.09	Granite
2919BD00012	-29.31703	19.86589						04/02/1937	111.25		82.3	0	111.25	Quartzite
2919BD00016	-29.31703	19.86591						02/06/1960	92.66		88.39	0	92.66	Quartzite
2919BD00014	-29.317029999999999	19.865900000000000						28/07/1969	96.93		73.15	0	15.24	Shale
												15.24	96.93	Quartzite
											88.39	0	15.24	Shale

Identifier	Latitude	Longitude	Water Level Status	WaterLevel Measurement Date And Time	Water Level	DischargeRate Measurement Date and Time	DischargeRate (L/s)	Depth Diameter Measurement Date	Depth Diameter Depth to Bot	Casing Depth to Bot	Water Strike mBGL	Lithology Depth to Top	Lithology Depth to Bot	Lithology
												15.24	96.93	Quartzite
											94.49	0	15.24	Shale
												15.24	96.93	Quartzite
2919BD00023	-29.30036	19.86588						24/03/1938	123.93		61.26	0	25.91	Sandstone
												25.91	70.71	Shale
												70.71	103.33	Quartzite
												103.33	110.64	Granite
												110.64	116.74	Quartzite
												116.74	118.57	Shale
												118.57	123.93	Quartzite
2919BD00024	-29.30037	19.86588						09/05/1938	67.33		29.87	0	10.36	Quartzite
												10.36	27.74	Quartzite
												27.74	35.05	Quartzite
												35.05	36.88	Quartzite
												36.88	46.02	Gneiss
												46.02	47.24	Quartzite
									67.33		29.87	47.24	67.33	Gneiss
2919BD00026	-29.30038	19.86588						28/08/1946	107.59		45.72	0	3.05	Limestone
												3.05	9.14	Clay
												9.14	18.29	Shale
												18.29	37.49	Sandstone
												37.49	107.59	Granite
											51.82	0	3.05	Limestone
												3.05	9.14	Clay
												9.14	18.29	Shale
												18.29	37.49	Sandstone
												37.49	107.59	Granite
2919BD00028	-29.30039	19.86588						25/07/1966	122.22		38.71	0	6.1	Sandstone
												6.1	46.33	Quartzite
												46.33	74.37	Granite
												74.37	101.8	Quartzite
												101.8	122.22	Granite
2919BD00025	-29.30036	19.86589						05/12/1946	114.00			0	10.67	Quartzite

Identifier	Latitude	Longitude	Water Level Status	WaterLevel Measurement Date And Time	Water Level	DischargeRate Measurement Date and Time	DischargeRate (L/s)	Depth Diameter Measurement Date	Depth Diameter Depth to Bot	Casing Depth to Bot	Water Strike mBGL	Lithology Depth to Top	Lithology Depth to Bot	Lithology
												10.67	114	Granite
2919BD00027	-29.30036	19.8659						19/07/1966	107.59		38.4	0	4.57	Sandstone
												4.57	89.61	Quartzite
												89.61	107.59	Granite
2919BD00029	-29.30036	19.86591						29/07/1966	76.50		52.73	0	67.67	Quartzite
												67.67	76.5	Granite
											62.78	0	67.67	Quartzite
									76.50			67.67	76.5	Granite
2919BD00030	-29.29619	19.8881		1990/08/02 08:00:00.000	45	1990/08/02 00:00:00.000	2.000 l/s	02/08/1990	6.60	7	60	0	66	Quartzite
									60.00					
2919BD00061	-29.28452	19.89098						20/03/1958	165.81		165.81	0	165.81	Quartzite
2652	-29.2845	19.89195						13/07/1949	93.88		93.88	0	2.74	SOIL
												2.74	23.77	Granite
												23.77	93.88	Quartzite
2804	-29.28453	19.89195						25/05/1949	93.27		93.27	0	15.54	Quartzite
												15.54	93.27	Schist
2919BD00053	-29.28453	19.89196						08/09/1937	107.90	7	98.75	0	107.9	Quartzite
2919BD00047	-29.28455	19.89197						13/10/1958	86.26		86.26	0	49.38	Quartzite
												49.38	53.64	Granite
												53.64	57.3	Quartzite
												57.3	86.26	Granite
2919BD00049	-29.28453	19.89197						13/07/1961	136.55		125.58	0	132.89	Quartzite
												132.89	136.55	Granite
2919BD00051	-29.28453	19.89198						16/02/1959	151.49		151.49	0	58.22	Quartzite
												58.22	69.49	Granite
												69.49	76.5	Quartzite
												76.5	112.17	Granite
												112.17	129.24	Quartzite
								16/02/1959				129.24	151.49	Granite
2919BD00052	-29.28451	19.89198						15/01/1962	67.06		67.06	0	15.24	Quartzite
												15.24	67.06	Granite
2919BD00060	-29.28453	19.89198						22/08/1958	85.65		85.65	0	85.65	Quartzite
2919BD00038	-29.28453	19.89199						07/09/1954	154.23	5	113.39	0	4.88	Limestone
												4.88	32.31	Granite
												32.31	154.23	Quartzite
2919BD00045	-29.28452	19.89199						30/04/1967	156.06		156.06	0	4.57	Quartzite

Identifier	Latitude	Longitude	Water Level Status	WaterLevel Measure-ment Date And Time	Wa-ter Level	Dis-chargeRate Measure-ment Date and Time	Dis-chargeRate (L/s)	Depth Di-ameter Measure-ment Date	Depth Diam-eter Depth to Bot	Cas-ing Depth to Bot	Wa-ter Strike mBGL	Li-thol-ogy Depth to Top	Li-thol-ogy Depth to Bot	Lithol-ogy
												4.57	156.06	Granite
2919BD00048	-29.28455	19.89199						17/07/1958	80.47		80.47	0	2.44	Quartzite
												2.44	36.88	Granite
												36.88	48.16	Quartzite
												48.16	80.47	Granite
2919BD00050	-29.28451	19.89199						13/05/1954	34.44		34.44	0	34.44	Schist
2919BD00054	-29.2845	19.89199						15/06/1937	75.29		75.29	0	2.13	SOIL
												2.13	75.29	Quartzite
2919BD00057	-29.28449	19.89199						28/09/1949	89.31		89.31	0	0.3	SOIL
												0.3	1.52	Calcrete
												1.52	8.23	Sand-stone
												8.23	50.6	Granite
		19.89199										50.6	89.31	Quartzite
2919BD00059	-29.28454	19.89199						19/05/1958	15.85		15.85	0	15.85	Quartzite
2919BD00062	-29.28452	19.89199						01/01/1900	24.08			0	24.08	Quartzite
2919BD00063	-29.28453	19.89199						03/08/1961	28.96		28.96	0	28.96	Quartzite
2919BD00040	-29.28454	19.892						12/11/1957	29.87		29.87	0	29.87	Schist
2919BD00044	-29.28453	19.892						04/12/1961	155.14		155.14	0	38.1	Quartzite
												38.1	155.14	Granite
2919BD00046	-29.28452	19.892						02/10/1945	38.71		38.71	0	27.74	Quartzite
												27.74	38.71	Granite
2919BD00058	-29.28453	19.892						08/12/1949	89.61		89.61	0	89.61	Quartzite
2501	-29.28455	19.89301						22/02/1949	95.71		95.71	0	5.18	Lime-stone
												5.18	33.53	Quartzite
												33.53	95.71	Granite
2919BD00043	-29.28456	19.89302						23/06/1954	60.96		60.96	0	21.34	Schist
												21.34	30.48	Quartzite
												30.48	60.96	Granite
2919BD00042	-29.28457	19.89303						05/05/1958	169.16		169.16	0	13.72	Quartzite
												13.72	86.56	Schist
												86.56	166.12	Quartzite
												166.12	169.16	Granite
2919BD00041	-29.28458	19.89304						02/02/1946	111.25		93.27	0	1.52	Calcrete
												1.52	7.32	Quartzite
												7.32	42.37	Granite
												42.37	57.91	Quartzite

Identifier	Latitude	Longitude	Water Level Status	WaterLevel Measurement Date And Time	Water Level	DischargeRate Measurement Date and Time	DischargeRate (L/s)	Depth Diameter Measurement Date	Depth Diameter Depth to Bot	Casing Depth to Bot	Water Strike mBGL	Lithology Depth to Top	Lithology Depth to Bot	Lithology
												57.91	64.01	Granite
												64.01	67.67	Quartzite
												67.67	72.24	Granite
												72.24	111.25	Quartzite
G01322NC	-29.21283	19.93116												
2919BB00125	-29.20036	19.94921						13/10/1959	105.46		95.7	0	105.46	Quartzite
2919BB00127	-29.20037	19.94921						17/12/1953	148.13			0	51.81	Quartzite
												51.81	148.13	Granite
2919BB00129	-29.20038	19.94921						07/05/1934	116.43			0	9.14	Clay
												9.14	116.43	Quartzite
2919BB00131	-29.20039	19.94921						12/09/1934	120.70			0	120.7	Quartzite
2919BB00133	-29.2004	19.94921						17/01/1935	62.48			0	32	Vein-Quartz
												32	62.48	Granite
2919BB00135	-29.20041	19.94921						06/08/1912	60.35			0	60.35	Granite
2919BB00126	-29.20036	19.94922						31/03/1954	166.11		146.3	0	85.95	Quartzite
												85.95	166.11	Granite
2919BB00128	-29.20036	19.94923						15/10/1953	35.35			0	1.52	Limestone
												1.52	35.35	Quartzite
2919BB00130	-29.20036	19.94924						25/06/1934	99.36	15	69.8	0	36.57	Vein-Quartz
												36.57	99.36	Gravel
2919BB00132	-29.20036	19.94925						26/10/1934	68.27			0	68.27	Quartzite
2919BB00134	-29.20036	19.94926						04/08/1950	100.88		67.05	0	7.62	Limestone
												7.62	99.66	Quartzite
		19.94926										99.66	100.88	Granite
2919BD00031	-29.29758	19.9881						06/08/1990	6.00	6		0	6	Conglomerate
												6	90	Quartzite
									90.00			0	6	Conglomerate
												6	90	Quartzite
2920AC00013	-29.43119	20.00065		1990/11/06 08:00:00.000	15			06/11/1990	30.00	6		0	30	Granite
2920AC00011	-29.30035	20.06593						20/06/1985	18.00	6	10	0	18	Granite

Identifier	Latitude	Longitude	Water Level Status	WaterLevel Measurement Date And Time	Water Level	DischargeRate Measurement Date and Time	DischargeRate (L/s)	Depth Diameter Measurement Date	Depth Diameter Depth to Bot	Casing Depth to Bot	Water Strike mBGL	Lithology Depth to Top	Lithology Depth to Bot	Lithology
2920AC00012	-29.30036	20.06593						21/06/1985	30.00	6	24	0	30	Granite
2920AC00016	-29.37758	20.09898						17/04/1991	4.00	4		0	54	Quartzite
									54.00			0	54	Quartzite
2920AC00015	-29.3859	20.09926						16/04/1991	54.00	6		0	3	Chalk
												3	54	Quartzite
									6.00			0	3	Chalk
												3	54	Quartzite

Appendix 2 Curriculum Vita

HYDROGEEK CONSULTING

Curriculum vitae NICO VAN ZYL

Contact Details: nico@hydrogeekconsulting.com

+27718773744 (Mobile)

www.linkedin.com/in/nico-van-zyl-00b33a51 (LinkedIn)

hydrogeekconsulting.com (Company)

Education

M.Sc. Hydrogeology, University of the Free State, Bloemfontein, SA, 2011

Honours. Hydrogeology, University of the Free State, Bloemfontein, SA, 2009

B.Sc. Geology, University of the Free State, Bloemfontein, SA, 2009

Certifications

Collaboration for Success BHP Billiton - Bayside Aluminium, 5 December 2014

Languages

Afrikaans – Fluent

English – Fluent

Hydrogeek Consulting (Pty.) Ltd. – Johannesburg

Hydrogeologist/Groundwater Modeller

Nico is passionate about the field of Hydrogeology and have a special interest in Groundwater modelling (FEFLOW) as a tool to provide cost effective solutions to clients. We are moving more to decision support modelling , through uncertainty analysis using programs that PEST tools. There is so much uncertainty to groundwater modelling it is time we accept it and let allow the flow of information to reach the right places. We are committed to the Bayesian way of thinking, that we start with uncertainty and end with uncertainty. Information reduces uncertainty.

Our experience ranges from Interpretation of groundwater data to form Conceptual Hydrogeological Models and Numerical Groundwater Models for underground and open pit mines. In the past few years we have been busy in different regions around the world, developing Numerical Groundwater Models. Regions and countries include , USA, Australia (Pilbara region), Argentina, UAE, Germany, Peru, South Africa , African countries Zambia, DRC, Mozambique, Ghana and Guinea. The focus is on helping clients with planning and management decisions in terms of groundwater solutions (pore pressures, water supply, dewatering , cone of depressions and quality impacts from mining activities). Sectors we have worked in include mining (gold, platinum, coal and diamond) , manufacturing and government.

HG aim to solve complex issues by being well-informed on what the data is telling us. Our service will provide you with interpreted data to inform your Conceptual model and Uncertainty associated. HG consulting will always be based on cost effective solutions for your Groundwater models. HG believe in under promising and over delivering as we hold our client's long-term satisfaction in the highest regards.

Why us?
With good experience in FEFLOW a modelling software package, we are confident we can provide a service that yields trustworthy and professional results

Employment History

Hydrogeek Consulting (Pty) Ltd – Johannesburg

Director – (2019 to Present)

Golder Associates – Johannesburg

Hydrogeologist/Groundwater Modeller and Modelling team leader (2014 to 2019)

AGES – Potchefstroom

Hydrogeologist (2012 to 2014)

University of the Free State

Researcher (2011)

PROJECT EXPERIENCE – HYDROGEOLOGY

South32: Bayside Groundwater Management Plan Kwa-Zulu Natal, South Africa	This Groundwater Management Plan for Bayside was developed using a detailed Source-Pathway-Receptor (SPR) assessment and simulations to assess the effectiveness of the different scenarios that Bayside are considering.
Development of a post closure Water Management Plan -Phase 2 Decant Study Gauteng, South Africa	The decant study needed to investigate the potential for the South Deep underground workings to decant on surface based on conservative assumptions. In this report the available hydrogeological data is assessed in more detail as the results and findings are critical to the understanding of the post closure flow system at South Deep.
Western Hub Dewatering and Water Supply Project Pilbara, Australia	Groundwater Model developed in FEFLOW package. The simulations of dewatering boreholes together with water supply scenarios to meet the demand of the mine. The mine dewatering was done with dewatering boreholes. The project also involved the impact assessment and the recovery of pit water levels post closure.

Middelburg Ferrochrome – Groundwater Modelling as part of the Contaminated Land team, Middelburg, South Africa.

Mpumalanga, South Africa

This task involved numerical flow and solute transport modelling, developing a new groundwater model using, a highly sophisticated and powerful 3D finite element modelling package (FEFLOW). Data was interpreted and used to update the conceptual model of the site. Remediation scenarios was simulated from trenches to capture contamination downstream.

Amandelbult Groundwater Model for dewatering of the underground, Thabazimbi, South Africa.

Limpopo, South Africa

This task involved numerical flow and solute transport modelling, developing a new groundwater model using, a highly sophisticated and powerful 3D finite element modelling package (FEFLOW) designed to cope with complex hydrogeological situations was used. Dewatering of two underground mines was simulated and the post closure water management scenarios were also done as part of closure, different scenarios was simulated for the TSF's.

Platreef DFS Groundwater Model, Mokopane, Limpopo Province, South Africa.

Limpopo, South Africa

This task involved numerical flow and solute transport modelling, developing a new groundwater model using, a highly sophisticated and powerful 3D finite element modelling package (FEFLOW) for EIA purposes.

Jindal Groundwater Modelling Open Pit dewatering- KwaZulu-Natal, South Africa

Kwa-Zulu Natal, South Africa

This task involved numerical flow and solute transport modelling, developing a new groundwater model using, a highly sophisticated and powerful 3D finite element modelling package (FEFLOW) designed to cope with complex hydrogeological situations will be used.

KCC Hydrogeological Services

Kolwezi, DRC

This task involved numerical flow and solute transport modelling, developing a new groundwater model us-

	ing, a highly sophisticated and powerful 3D finite element modelling package (FEFLOW) designed to cope with complex hydrogeological situations in a Dolomitic karst environment.
Lonmin Marikana Groundwater Model Marikana, South Africa	Developing of a Groundwater Flow Model with Contaminant Transport.
UMK Mine Groundwater Model Hotazel, South Africa	Developing of a Groundwater Flow Model with Contaminant Transport. For closure purposes
Maamba Colliery HSESMP Hydrogeological Baseline and Groundwater Model Study Maamba, Zambia	This task involved numerical flow and solute transport modelling, developing a new groundwater model using, a highly sophisticated and powerful 3D finite element modelling package (FEFLOW) designed to cope with complex hydrogeological situations will be used.
WASSA Golden Star Dewatering Model underground and opencast mine WASSA, Ghana	The groundwater specialist study was completed to fulfil the objectives as required by the EIA, WUL and rehabilitation and closure strategy. Works included construction of a conceptual hydrogeological model and numerical groundwater model to assess the potential impacts on groundwater quantity and quality.
Klipspruit Colliery Mpumalanga, South Africa	This task involved numerical flow and solute transport modelling, developing a new groundwater model using, a highly sophisticated and powerful 3D finite element modelling package (FEFLOW) designed to cope with complex hydrogeological situations will be used.

Khutala Colliery

Mpumalanga, South Africa

This task involved numerical flow and solute transport modelling, developing a new groundwater model using, a highly sophisticated and powerful 3D finite element modelling package (FEFLOW) designed to cope with complex hydrogeological situations will be used.

Two Rivers Mine South Opencast Pit

Steelpoort, South Africa

Groundwater inputs to the overall EIA and EMPR, including, geophysical surveying, drilling, testing, groundwater quantity and quality impacts, modelling, reporting of the Two Rivers Mine South Opencast Pit.

Majuba Underground Coal Gasification

Amersfoort, South Africa

Project focussed on characterizing the hydrogeology and groundwater, including pore water pressure monitoring. The development of a conceptual hydrogeological model and numerical model to identify potential impacts on the groundwater system as result of UCG operations.

Townlands Underground Mine Project

North-West, South Africa

The groundwater specialist study was completed to fulfil the objectives as required by the water management strategy, EIA, WUL and rehabilitation and closure strategy. Works included construction of a conceptual hydrogeological model and numerical groundwater model to assess the potential impacts on groundwater quantity and quality.

Bayside Aluminium

Kwazulu-Natal, South Africa

The potential impacts from these identified sources on the groundwater system and migration of contaminant plumes from these sources were evaluated through the groundwater modelling.

KCM Nchanga SPR Model Study Groundwater Flow and Contaminat Transport Modelling

Developing of a Groundwater Flow Model with Contaminant Transport.

Nchanga, Zambia

Mopani Nkana Mine Dewatering Groundwater Model

Ndola, Zambia

Developing of a Groundwater Flow Model to determine dewatering rates and pore pressures.

Mopani Mufulira Mine Dewatering Groundwater Model

Mufulira, Zambia

Developing of a Groundwater Flow Model to determine dewatering rates and pore pressures.

Kinsevere Mine Dewatering and Post Closure Groundwater Model

Lubumbashi, DRC

Developing of a Groundwater Flow Model to determine dewatering rates and impact. Post closure study to determine Pit Lake conditions.

Reminex Mines TriK Dewatering Modelling Study, Guinea 2023

Details to follow

Waterval Smelter Numerical Model , Rustenburg, North Wes 2022

Details to follow

Talon Metals Hydrogeology and Modelling Review, Minnesota, US 2022

Details to follow

Bel Air Alufer Well field design DFS Groundwater Model, Bel Air, Guinea 2022

Numerical Modelling EÜ Magdeburg Concepts for dewatering of systems, Magdeburg, Germany

Details to follow

Modelo 3D Waste Dump Las Bambas, Peru , South America	Details to follow
Barberton Mines Geohydrological Study and Groundwater Model, Barberton, South Africa	Details to follow
Bunker Hill Mine Conceptual Understanding , Kellogg, IDAHO, USA	Details to follow
Groundwater flow and solute transport model, San Lorenzo, Argentina	Details to follow
Ardmore Graphite Open Pit Stage 3 Dewatering Model, Queensland, Australia	Details to follow
Casa Berardi Mine Principle Open Pit dewatering, Quebec, Canada	Details to follow
Sunnyside Diamonds Hydrogeological Conceptual Model, Northern Cape, South Africa	Details to follow
	Details to follow

Training

FEFLOW 7 Groundwater Modelling for Mine Sites

DHI WASY, 21-23 September 2016

FEFLOW Groundwater Modelling for Mine Sites

DHI WASY, 24 August - 26 August 2015

Advanced FEFLOW Groundwater modelling

DHI WASY, 30 October 2012- 2 November 2012

Symple School of Hydrogeological Modelling ,

Milan Italy (18 months)

SUPPLEMENTAL SKILLS

Leapfrog Hydro

Hydrogeological Modelling

Data interpretation

Surfer, GRAPHER

Maps

QGIS, Global Mapper

Groundwater Modelling

FEFLOW 8.0 and FEPEST

Python Coding

Past Statistics

PROFESSIONAL AFFILIATIONS Pr.Sci.Nat 400165/14

PUBLICATIONS

Conference Proceedings

Love*, David, Vanessa Aphane, Gerhard van der Linde and Nico van Zyl. 2015. *Innovative approaches to predicting, mitigating and remediating groundwater pollution in UCG*. SAUCGA Workshop, September. Muldersdrift, South Africa.