Groundwater Impact Assessment for the Proposed Expansion of the Klip Road Cemetery, Grassy Park, Cape Town

Prepared by

GEOSS

26 June 2024

GROUNDWATER AND EARTH SCIENCES
GEOSS
SOUTH AFRICA (Pty) Ltd

Executive Summary

GEOSS was appointed by Angela Botha of Zutari (Pty) Ltd to complete a groundwater impact assessment of the proposed extension of the existing Klip Road Cemetery in Grassy Park (Map 1 and Map 2). The proposed extension is to take place on Erf 75570 and Remainder Erf 75567, located along Klip Road, a portion of Remainder Erf 75569, located along Victoria Road, as well as on Erf 75571, located between Victoria Road, Klip Road and Prince George Drive in Grassy Park. Due to the shortage of suitable burial locations within the City of Cape Town Metropolitan Municipality, the City is seeking to develop additional burial grounds on the property.

The study included a desktop assessment of various groundwater databases, a review of hydrogeological and geological maps and reports for the study area, and a field visit to determine the potential impact on the existing groundwater resources and users. The field visit entailed a hydrocensus of existing groundwater users surrounding the study site and the installation of piezometers to understand the subsurface.

The site is directly underlain by Quaternary-age deposits of the Springfontyn Formation, primarily comprised of reddish to grey quartzose aeolian sand. Underlying the sediment cover are likely shale, siltstones, and greywackes of the Malmesbury Group, which forms the bedrock in this area. Based on published information, the depth to the bedrock varies between 17 and 25 mbgl at locations situated some 7 km to the north-east and south-east of the site, respectively.

The aquifer underlying the site is classified as an intergranular aquifer with good to marginal water quality that is highly susceptible to point-based contamination, with an average yield potential of 0.5 – 5.0 L/s. Based on the information collected during the present investigation, the EC on site ranges between 55.9 and 242 mS/m which is consistent with the published information.

Given the high vulnerability that is mapped for the underlying aquifer, the risk of contamination to the aquifer is considered. For a risk to exist there must be a source(s), pathway(s) and receptor(s). The proposed development represents a limited potential source of contamination. The underlying aquifer represents both a potential pathway and a receptor. Groundwater and surface water users and the surrounding environment, of particular interest to this study, is the drainage channel and Vlei located some 200 m from the western boundary of the site, which all represent receptors of potential contamination.

This assessment has generally confirmed the regional geological and hydrogeological conditions of published information. The site is underlain by mostly free-draining unconsolidated aeolian sands, which are interleaved with layers and lenses of lower-permeability clayey and organic horizons. The site is characterised by shallow groundwater conditions, with groundwater levels ranging between 2.80 and 1.64 mbgl. Based on the hydrogeological data available, the site that has been proposed for the expansion, should not proceed.

The nature of the proposed development poses a <u>high</u> risk of contamination to an aquifer that is considered to have a very high vulnerability to contamination based on published information. Based on the information collected on-site, this is consistent with the findings presented here. It is unlikely the risk of contamination to the aquifer, which is an important source of groundwater, can be practically and appropriately mitigated.

If possible, an alternative site should be investigated for the purpose of establishing a new cemetery due to the following factors:

- A typical mitigation measure would be that the burial of bodies should only take place where the depth to the water table exceeds 4 mbgl. In this case, it is unlikely that this mitigation measure can be met.
- Another standard mitigation measure to protect groundwater would be that boreholes should not be used for potable consumption within 350 m of the established cemetery. It must be noted that there are several boreholes within 350 m of the site, of particular significance in this instance are those situated south of the site (and the canal that feeds Princess Vlei).
- Establishment of a cemetery is not recommended within 200 m of a wetland. Princess Vlei is located 200 m away.

An alternative site with favourable geological and hydrogeological conditions (i.e. deep water levels in soils above a fractured aquifer) will be better suited. Should the development of the cemetery proceed, despite the current hydrogeological findings, the following recommendations are made:

- A comprehensive monitoring network will need to be established, including selected existing boreholes as well as the commissioning of three monitoring boreholes that are to be drilled on the site, and should be installed to depths of at least 10 mbgl using an appropriate design for these hydrogeological conditions.
- Relevant mitigation measures and best practice procedures must be employed to minimize contamination of the subsurface.
- Installation of impermeable liner beneath the cemetery to prevent the deterioration of groundwater quality.
- Once a grave is excavated, it should have a clay-rich material lining the bottom of the grave, upon which the coffin will rest. Once the coffin is emplaced, the backfill material should be clay-rich to at least within 1 m of the ground surface, and must cover the coffin. The material will reduce the permeability around the coffin and is also a good medium for natural attenuation. In this case, the bucket effect will need to be considered, an appropriate material for lining should be considered so as to improve the attenuation time, but not impede flow indefinitely.
- It must also be noted that the shallow water levels experienced on-site and the potential use of clay or liners to impede flow, may result in flooding/water ponding at the surface. It is recommended that a geotechnical specialist be enlisted to consult on appropriate mitigation measures.
- It is recommended that at least three monitoring wells are installed across the site, one up-gradient and two down-gradient, e.g. one on the northern most corner of Erf 75568, and one on the eastern- and southern-most corners of Erf 75571. The positions of the monitoring wells can be finalised once site plans have been finalised.
- Quarterly quality monitoring of the groundwater is recommended to monitor the change in quality. The data must be regularly assessed by a qualified hydrogeologist.

Based on the hydrogeological data available, the site that has been proposed for the expansion, should not proceed.

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Abbreviations

BH	Borehole
CoCT	City of Cape Town
CGS	Council for Geoscience
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water Affairs and Sanitation
EC	electrical conductivity
GA	General Authorisation
L/s	litres per second
m	metres
m^3/ha/a	cubic metres per hectare per annum
mamsl	metres above mean sea level
mbch	metres below collar height
mbgl	metres below ground level
mm	millimetre
mm/a	millimetres per annum
mS/m	milli-Siemens per metre
NGA	National Groundwater Archive
ORP	oxidation-reduction potential
SDP	site development plan
TDS	total dissolved solids
TOC	total organic carbon
WARMS	Water Authorisation and Registration Management System

Glossary of Terms

aquifer	a geological formation, which has structures or textures that hold water or permit appreciable water movement through them [from National Water Act (Act No. 36 of 1998)].
borehole	includes a well, excavation, or any other artificially constructed or improved groundwater cavity which can be used for the purpose of intercepting, collecting or storing water from an aquifer; observing or collecting data and information on water in an aquifer; or recharging an aquifer [from National Water Act (Act No. 36 of 1998)].
electrical conductivity	the ability of groundwater to conduct electrical current, due to the presence of charged ionic species in solution (Freeze and Cherry, 1979).
fractured aquifer	Fissured and fractured bedrock resulting from decompression and/or tectonic action. Groundwater occurs predominantly within fissures and fractures.
intergranular aquifer	An aquifer in which groundwater is stored in and flows through open pore spaces in the unconsolidated Quaternary deposits.
groundwater	Water found in the subsurface in the saturated zone below the water table or piezometric surface i.e., the water table marks the upper surface of groundwater systems.
vlei	a natural, shallow pool of water, mostly of a seasonal or intermittent nature; low-lying grassy or marshy wetland.

SPECIALIST EXPERTISE

CURRICULUM VITAE – Zita Harilall

GENERAL

Nationality:	South African
Profession:	Hydrogeologist
Specialization:	Groundwater impact and contamination assessments, groundwater management and monitoring including stable and radioisotope analysis.
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KEY SKILLS

- Groundwater impact and contamination – investigation and assessment of industrial activities on groundwater resources.
- Groundwater sampling and monitoring – development and implementation of groundwater monitoring and management programmes; analysis of groundwater level and quality (chemistry) data.
- Advanced chemistry monitoring and residence time determination – stable and radioisotope analysis.
- Writing of hydrogeological reports
- Conducting hydrocensus studies
- ArcMap / Geochemist's Workbench / WISH and typical software skills.

EDUCATIONAL AND PROFESSIONAL STATUS

Qualifications

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2017	B.Sc. (Hons) Earth Science	Stellenbosch University, South Africa
2016	B.Sc. Earth Science	Stellenbosch University, South Africa

Courses and symposiums

2016	Introduction to C++ (US)
2017	Introduction to Micromine (US)
2018	Introduction to R (AEON – NMU)
2018	ArcGIS and Spatial Statistics (AEON – NMU)
2019	International Symposium of Isotope Hydrology (IAEA) [poster]
2019	Groundwater Age Dating using Noble Gas Concentrations (US)
2020	International Association of Hydrogeologists (IAH)
2022	NICOLA: Resiliency, Nature and Climate Solutions: Striving for Sustainable Land Management
2023	International Association of Hydrogeologists (IAH) – 50th Annual Congress
2024	Water Governance in South Africa

Memberships/Organisations

- South African Council for National Scientific Professions (SACNASP) – Mem. No. 134005 (Pr.Sci. Nat)
- Groundwater Division (GWD) of the GSSA – Mem No. 2742/22
- Network for Industrially Contaminated Land in Africa (NICOLA) – Mem No. NM60b/2022
- Golden Key Honours Society

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January 2020 – December 2022:	GEOSS South Africa (Pty) Ltd, Stellenbosch *Project Hydrogeologist*
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CURRICULUM VITAE – Shane Teek

GENERAL

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Specialization:	Soil classification and characterization for determination of engineering properties. Geotechnical data analysis and interpretation; factual reporting. Groundwater exploration, development, sampling, and monitoring.
Position in firm:	Geotechnical Geologist & Hydrogeologist at GEOSS – South Africa (Pty) Ltd.
Date commenced:	17 July 2021.
Year of birth & ID #:	1994 – 9404135162084.
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KEY SKILLS

- Geotechnical investigations.
- Groundwater impact and contamination assessments.
- Compilation of factual and interpretative reports.
- Field mapping.
- Soil and rock profiling.
- Laboratory testing.
- Material classification and material use determination.
- Supervision of geotechnical contractors.
- Groundwater geophysics and conducting hydrocensus studies.
- Groundwater development - borehole drilling and test pumping supervision and analysis.
- Groundwater monitoring - development and analysis of groundwater level and quality data.
- Groundwater management - sustainable aquifer development and management.
- ArcGIS, QGIS, Python, FLAC/SLOPE, Midas GTS NX.

EDUCATIONAL AND PROFESSIONAL STATUS

Qualifications

2021	M.Eng. (Civil Engineering – Cum Laude)	University of the Stellenbosch, South Africa.
2016	B.Sc. Hons. (Earth Science)	University of the Stellenbosch, South Africa.
2015	B.Sc. (Geology: Earth Science)	University of the Stellenbosch, South Africa.

Courses and symposiums

2021	Geotechnical Workshop (GSSA; course presenters: various including Prof Peter Day).
2018	Advanced Foundation Design (Course presenter: Prof Peter Day, Dr Marius de Wet).
2018	Advanced Geotechnics (Course presenters: Prof Peter Day, Prof Nico de Koker, Dr Richard Walls).
2018	Advanced Soil Behaviour (Course presenter: Dr Marius de Wet).
2018	GEO254 (Course presenter: Dr Nanine Fouché).
2018	GEO354 (Course presenter: Dr Marius de Wet).

EMPLOYMENT RECORD

July 2021 to present	GEOSS South Africa (Pty) Ltd, South Africa.
Jan 2020 to June 2021	Geotechnics Africa Western Cape, South Africa.
Feb 2019 to July 2019	Polytechnique Montréal, Canada.
Jan 2019 to Dec 2021	Geocroukamp, South Africa.
Jan 2017 to Dec 2017	Remote Exploration Services, South Africa.

SPECIALIST DECLARATION

We, Zita Harilall and Shane Teek, as the appointed independent specialist(s) hereby declare that we:

- act/ed as the independent specialist in this application;
- regard the information contained in this report as it relates to our specialist input/study to be true and correct, and
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- have and will not have no vested interest in the proposed activity proceeding;
- have disclosed, to the applicant, EAP and competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the NEMA, the Environmental Impact Assessment Regulations, 2010 and any specific environmental management Act;
- are fully aware of and meet the responsibilities in terms of NEMA, the Environmental Impact Assessment Regulations, 2010 (specifically in terms of regulation 17 of GN No. R. 543) and any specific environmental management Act, and that failure to comply with these requirements may constitute and result in disqualification;
- have provided the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not; and
- are aware that a false declaration is an offence in terms of regulation 71 of GN No. R. 543.

Zita Harilall
GEOSS South Africa (Pty) Ltd
SACNASP – Pr.Sci.Nat
26 June 2024

Shane Teek
GEOSS South Africa (Pty) Ltd
SACNASP – Pr.Sci.Nat
26 June 2024

1 Introduction

GEOSS was appointed by Angela Botha of Zutari (Pty) Ltd to complete a groundwater impact assessment for the purpose of extending the existing Klip Road Cemetery in Grassy Park (**Map 1** and **Map 2**). The proposed extension is to take place on Erf 75570 and Remainder Erf 75567, located along Klip Road, a portion of Remainder Erf 75569, located along Victoria Road, and on Erf 75571, located between Victoria Road, Klip Road, and Prince George Drive in Grassy Park. Due to the shortage of suitable burial locations within the City of Cape Town Metropolitan Municipality, the City is seeking to develop additional burial grounds on the property.

The study included a desktop assessment of various groundwater databases and a review of hydrogeological and geological maps and reports for the study area. Thereafter, a field visit was conducted to determine the potential impact on the existing groundwater resources and their users. The field visit entailed installing piezometers to understand the subsurface.

2 Scope of Work

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

- Review of available literature and other specialist studies pertaining to the study site.
- Assess the presence and quality of groundwater in the study area.
- Assess the potential impact of the proposed development on hydrogeological resources.
- Provide recommendations and mitigation measures to minimize the risk and impacts from on-site operations.

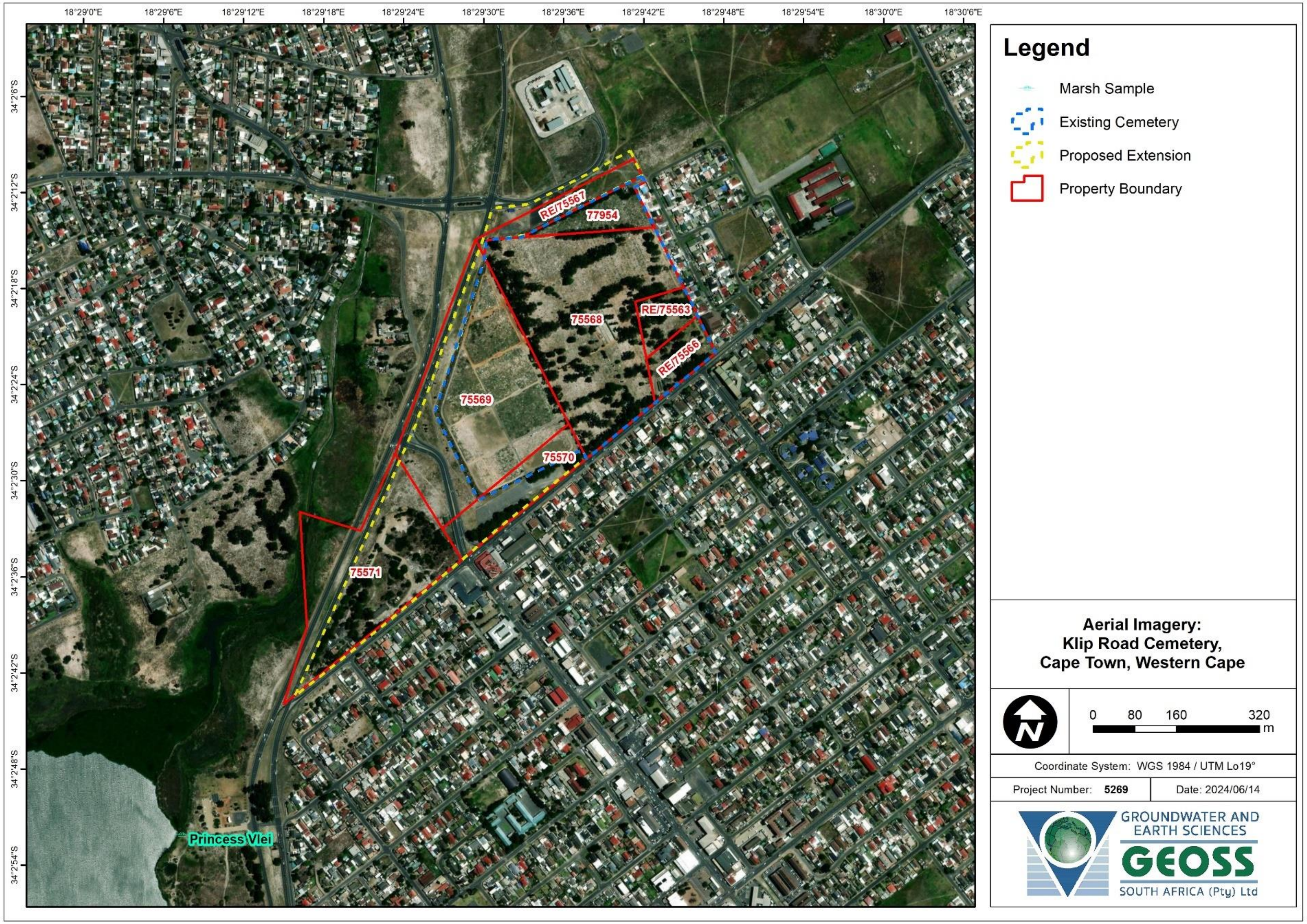
The assessment has been conducted in accordance with accepted best practice principles, particularly DEA&DP Guidelines for involving Hydrogeologists in the EIA Process (June 2005).

3 Methodology

The procedure adopted for this study involved a desktop study followed by field work. The initial desktop study involved obtaining and reviewing all relevant data for the project. This included reviewing relevant site plans, reports, and geological maps of the area and analysing data from multiple groundwater databases, which included information on groundwater yield and quality.

A site visit was then conducted to collect additional data and verify as much of the existing data as possible. This included the installation of piezometers, groundwater sampling and noting any subsurface conditions where possible. All collected data was analysed and interpreted to assess the potential risks associated with the intended site development as they pertain to groundwater.

Map 1: Locality of the existing and proposed extension of the Klip Road Cemetery, Grassy Park, Western Cape.



Map 2: Aerial imagery displaying the properties on which the existing Klip Road Cemetery is located and the proposed extension of the cemetery.

4 Regional Setting

4.1 Site Context

The study area is located in Grassy Park in the Cape Flats region of Cape Town, approximately 15 km southeast of Cape Town city centre. The proposed extension is to take place on Erf 75570 and Remainder Erf 75567, located along Klip Road, a portion of Remainder Erf 75569 located along Victoria Road as well as on Erf 75571 located between Victoria Road, Klip Road and Prince George Drive. The study area is bound by Klip Road to the southeast, Prince George Drive (M5) to the northwest and on the north-east by Erven 75569 and 75570 (**Map 2**). The site falls within the City of Cape Town Metropolitan Municipality and is located within quaternary catchment G22D, which has a General Authorisation (GA) of 400 m3/ha/a for groundwater use and forms part of the Berg-Olifants Management Area. The general relief of the area is gentle, sloping west and southwest towards Diep River and Princess Vlei. The elevation range of the entire property is small, ranging between 10 – 20 metres above mean sea level (mamsl).

Notable features in the vicinity include Princess Vlei, a naturally occurring wetland located approximately 200 metres southwest of the proposed expansion site. The canal that feeds Princess Vlei discharges drainage from various water sources including general urban run-off, stormwater drainage pipes, and potentially minor industrial run-off into Princess Vlei (Underhill, 2017). However, based on available satellite imagery at the time of report compilation, this canal appears to cease some 400 m from the boundary of Princess Vlei. This unlined portion of the drainage channel occurs along the mid-section of the site, near the portion of Erf 75571 that has been proposed for use as a cemetery (**Map 2**).

4.2 Site History

Klip Road Cemetery (also referred to as Klip Cemetery) was established in 1938 (CoCT, 2016) and serves as a burial ground for various religions. The property belongs to the City of Cape Town and is managed by the Recreation and Parks Department. The neighbouring property (Erf 75571), located across Victoria Road, has been demarcated for future expansion of the existing cemetery. This property is also owned by the City of Cape Town and has been leased to the Western Cape Scouts since 1954 as a campsite and training facility (Southern Mail, 2023). On 13 December 2023, a fire resulted in most of the buildings on the property being destroyed.

4.3 Climate

The study area experiences a Mediterranean climate with cool wet winters and warm dry summers. **Figure 1** illustrates the monthly average minimum and maximum air temperatures, and **Figure 2** illustrates the monthly mean rainfall and evaporation distribution for the study area (Schulze, 2009). The study area receives a mean annual precipitation of 767 mm/a. Rainfall volumes exceed evaporation rates during the rainfall season during the months of May to September. The peak groundwater recharge period is therefore during the winter.

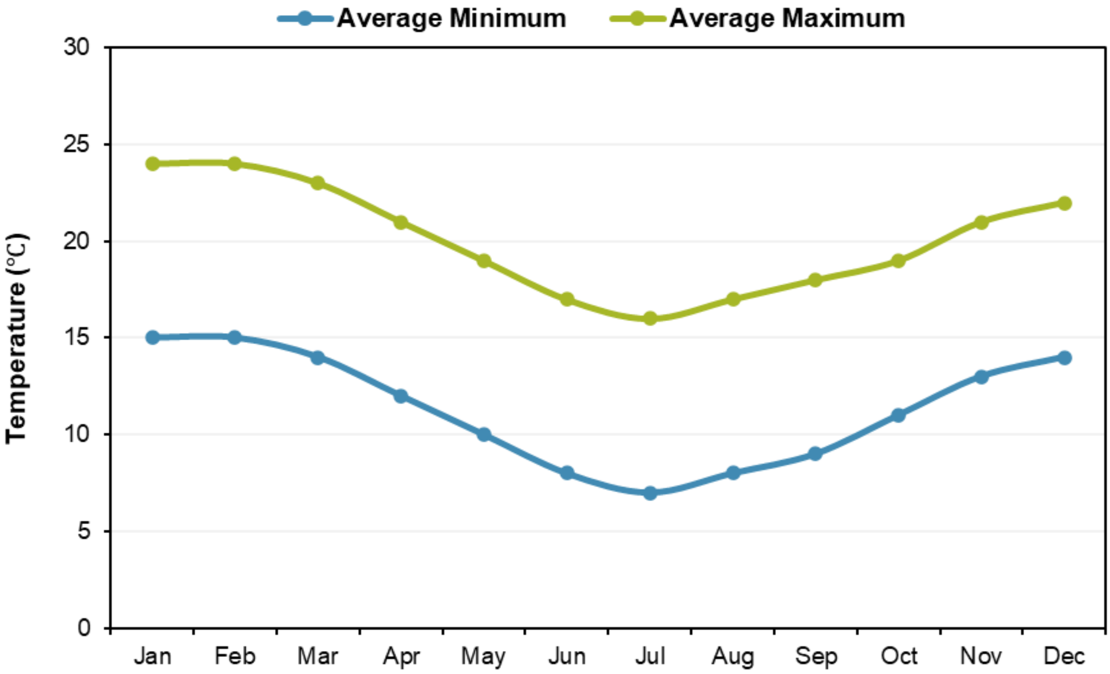


Figure 1: Monthly average minimum and maximum air temperatures for the study area (Schulze, 2009).

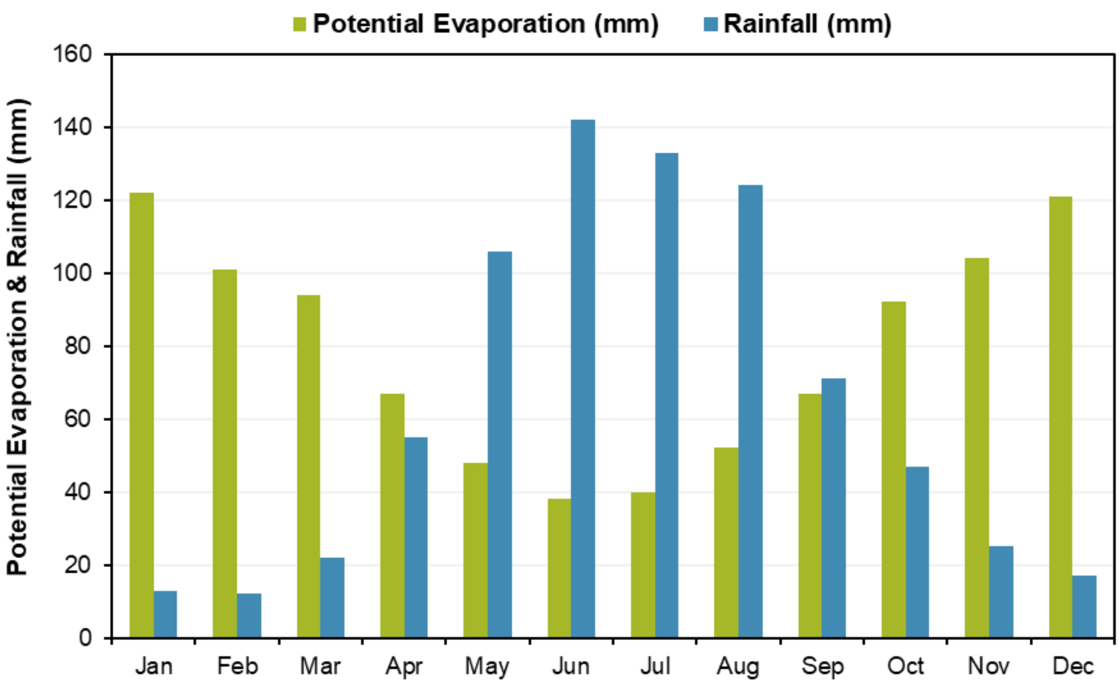


Figure 2: Monthly average rainfall and evaporation distribution for the study area (Schulze, 2009).

5 Regional Geology

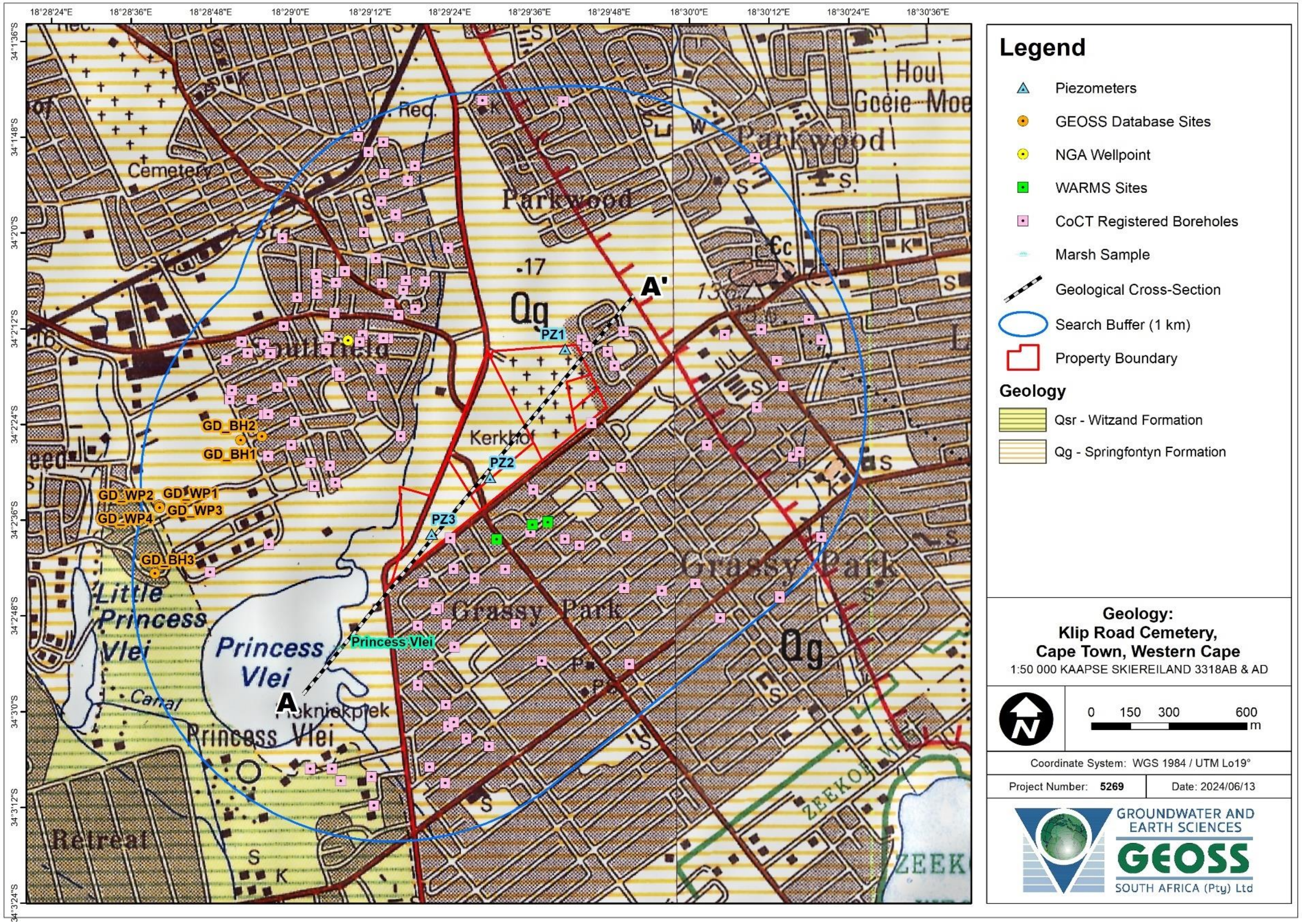
The Geological Survey of South Africa (now the Council for Geoscience (CGS)) has mapped the area at 1:50 000 scale (3318AB and 3318AD (CGS, 1984)). The geological setting is shown in **Map 3** and the main geology of the area is listed in **Table 1.**

Table 1: Geological formations within the study area

Code	Formation	Group	Lithology
Qsr	Witzand	Sandveld	White sand with finely crushed shell; pebbles and shells in places along the beach
Qg	Springfontyn		Light-grey to pale red sandy soil

The site is directly underlain by Quaternary-age sedimentary deposits of the Springfontyn Formation, primarily comprised of light-grey to pale red sandy soil. To the west and south of Princess Vlei, the geology of the Witzand Formation is encountered. The Witzand Formation is comprised of white sand with finely crushed shells. These two sedimentary formations form part of the Sandveld Group, which overlie the basement rocks of the Malmesbury Group, which have been intruded by batholiths of the Cape Granite Suite. The Sandveld Group sediments originate from two sources: the weathering of the quartzites and sandstones of the Malmesbury Group and the Table Mountain Group (TMG) which was deposited under marine conditions; as well as from the beaches in the areas, from where aeolian sand was deposited as dunes on the top of the marine sands (Adelana, Xu and Vbrka, 2010). The bedrock in the area is interpreted to be lithologies of the Tygerberg Formation of the Malmesbury Group, based on information derived from CGS (1984) indicating intersection of the Tygerberg Formation between 17 and 25 mbgl, approximately 7 km to the northeast and southeast of the site.

The sediments of the Springfontyn Formation has been indicated to be classified as SP (poorly graded sand), SP-SM (poorly graded, silty sands, sand-silt mixtures), or SC (clayey sands, sand-clay mixtures) in terms of the Unified Soil Classification System (USCS) (Fouche, 2021). Further, materials including clayey or silty sands, fine uniform sands and well-graded sands from the Cape Flats have recorded densities between 1 350 and 1 750 kg/m^3, peak friction angles of between 30° and 40°, and cohesion values of up to 13 kPa (Fouche, 2019). Test pit sidewalls excavated within Cape Flats sands typically collapse beneath 2 metres below ground level and this can often be ascribed to shallow groundwater conditions (Fouche, 2021). Finally, Springfontyn Formation sediments were found to have a permeability of 2.8 x 10^{-5} m/s by means of a constant head test undertaken at a density of 1 560 kg/m^3 (Fouche, 2021).



Map 3: Geological setting of the study site and the surrounding boreholes (1:50 000 scale 3318AB, 3418AD; Kaapse Skiereiland (CGS, 1984)).

6 Regional Hydrogeology

The aquifer that directly underlies the site is unconfined and is defined by unconsolidated Quaternary sands. The aquifer yield and aquifer quality classifications are based on regional datasets, and therefore, only provide an indication of conditions to be expected.

6.1 Aquifer Yield

According to the 1:500 000 scale groundwater map of Cape Town (3318), the study area hosts an **intergranular aquifer** of varying yield (**Map 4**) (DWAF, 2005). Directly beneath the study site and the existing cemetery, the average **borehole yield is in the range of 2.0 – 5.0 L/s**. To the north, the average borehole yield ranges between 0.5 - 2.0 L/s whereas further north, the yield decreases to a range of 0.1 - 0.5 L/s. The unconsolidated Quaternary deposits form the primary aquifer directly beneath the site. The intergranular aquifer is described as an aquifer in which groundwater is stored within, and flows through open pore spaces in the unconsolidated Quaternary deposits.

6.2 Aquifer Quality

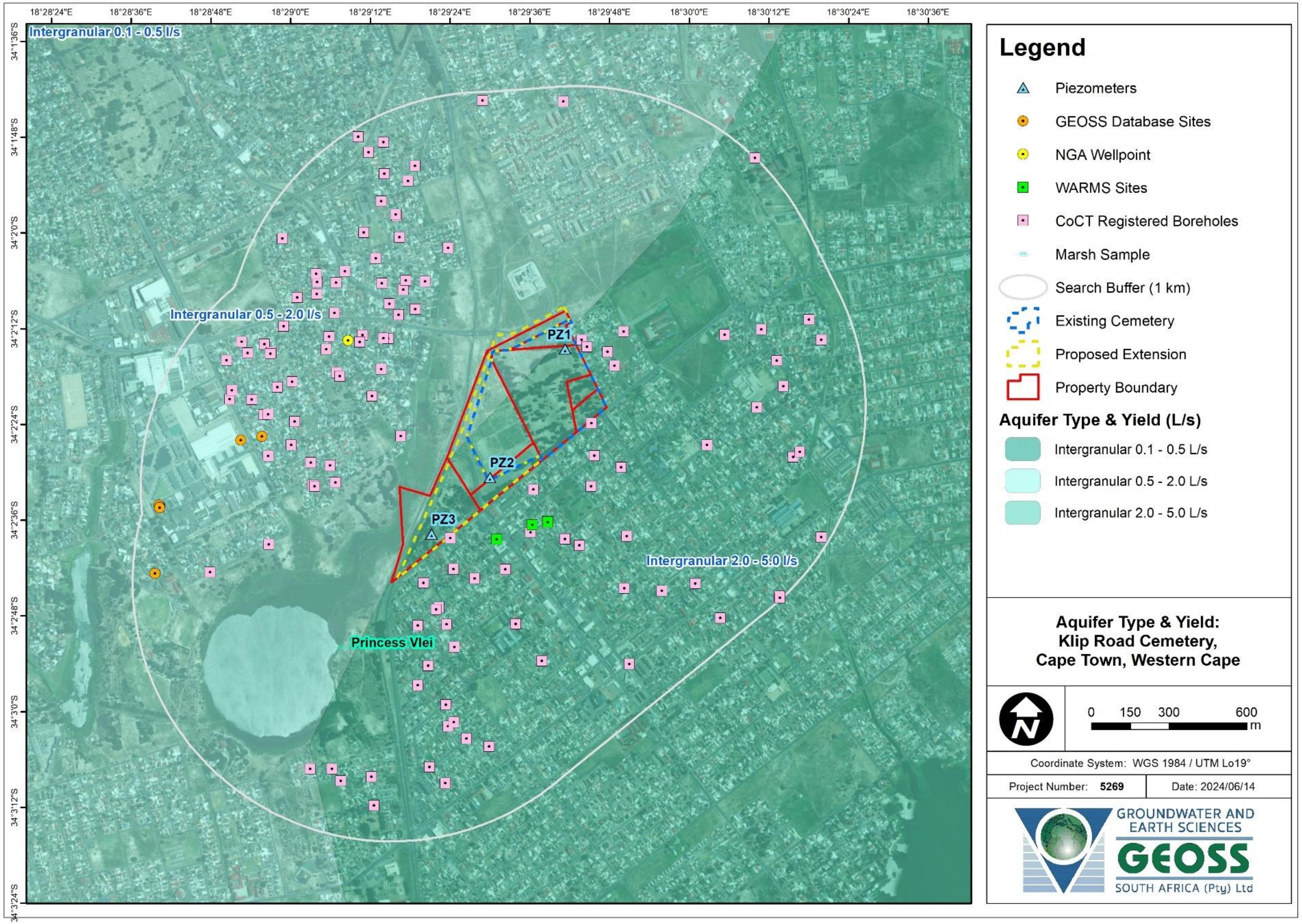
Electrical conductivity (EC) is a measure of the ability of the groundwater to conduct electricity. EC is directly related to the concentration of dissolved ions in the water and this parameter is used as an indication of groundwater quality. The groundwater map indicates that the aquifer has electrical conductivity values in the range of 70 – 300 mS/m (**Map 5**) (DWAF, 2005). In terms of domestic water standards (DWAF, 1998), water quality in the area ranges from **good** (Class I) (70 – 150 mS/m) to **marginal** (Class II) (150 – 370 mS/m).

6.3 Aquifer Vulnerability Classification

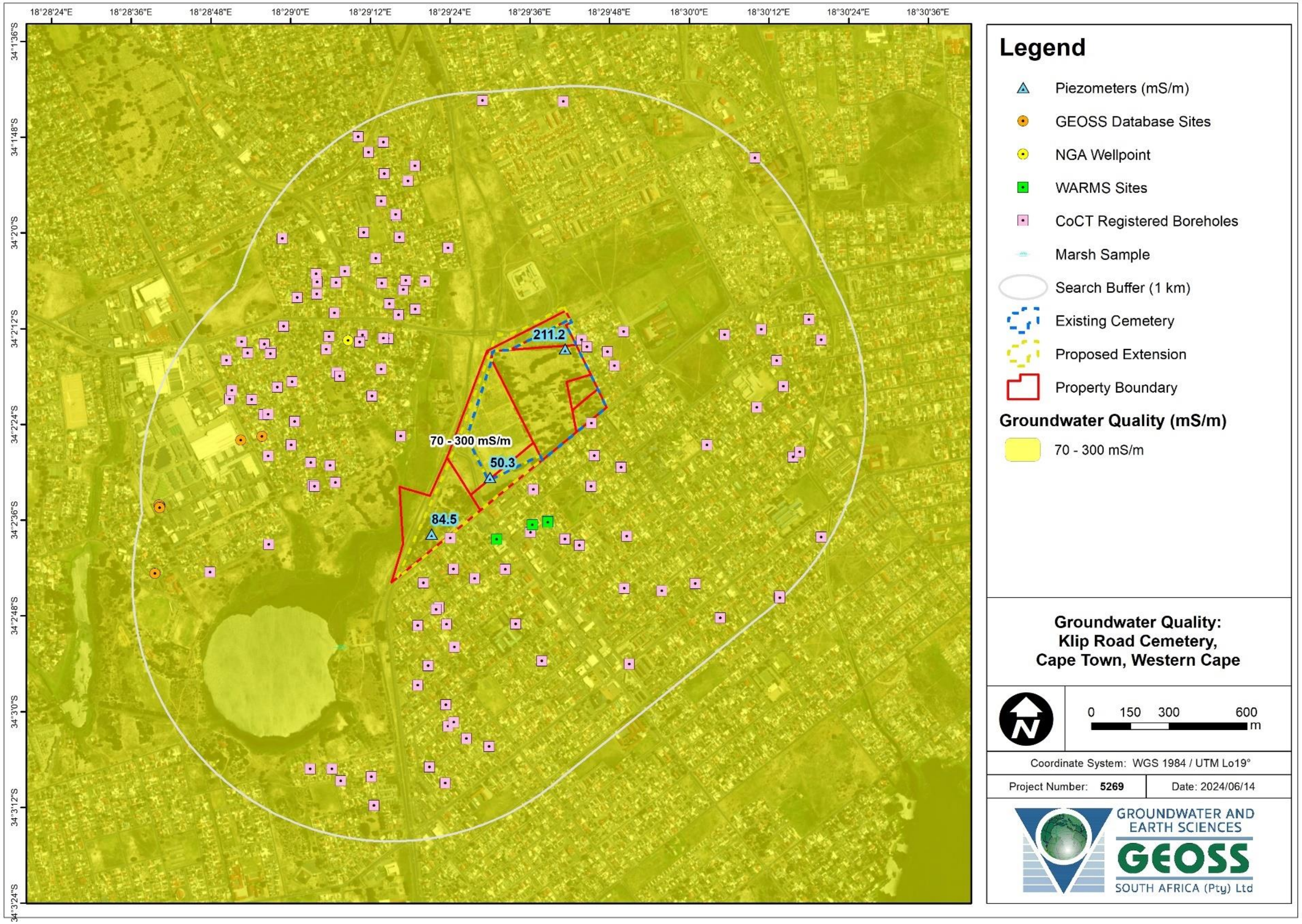
The national scale groundwater vulnerability map, which was developed according to the DRASTIC methodology (Conrad and Munch, 2007), indicates that the study site has a "**very high**" vulnerability to surface-based (**Map 6**). This vulnerability rating is linked to the host geology. High to very high vulnerability ratings are associated with the unconsolidated intergranular aquifer. The DRASTIC method considers the following factors:

D	=	depth to groundwater	(5)
R	=	recharge	(4)
A	=	aquifer media	(3)
S	=	soil type	(2)
T	=	topography	(1)
I	=	impact of the vadose zone	(5)
C	=	conductivity (hydraulic)	(3)

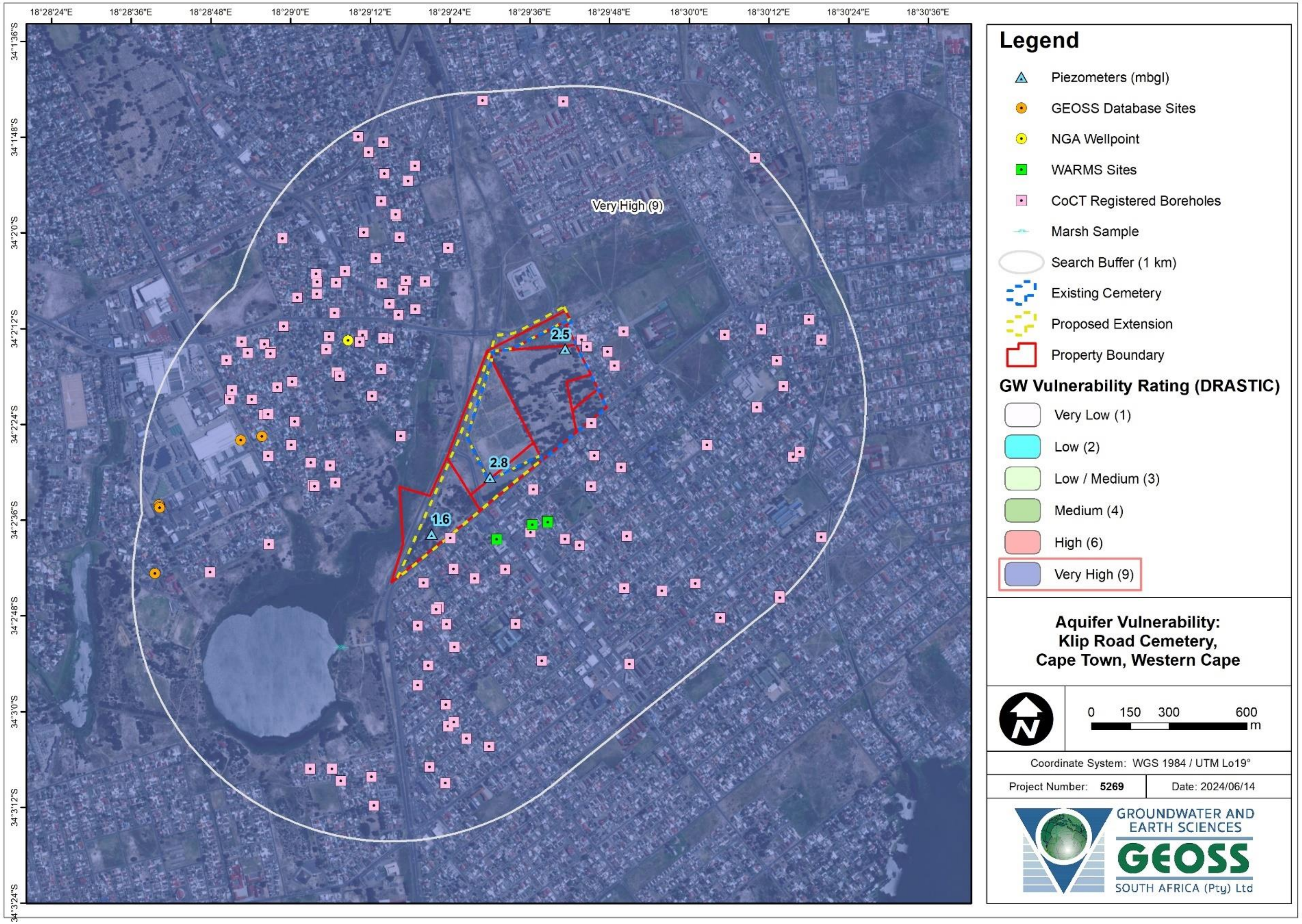
The number indicated in parenthesis after each factor description, is the weighting or relative importance of that factor. The intergranular aquifer hosted in the unconsolidated sands directly beneath the site is highly porous and permeable. Primary aquifers generally have less capacity for attenuating contaminated recharge entering at their surface (WRC, 1995). Therefore, the intergranular (primary) aquifer is susceptible to point and non-point sources of contamination.



Map 4: Regional aquifer yield (L/s) (DWAF, 2002).



Map 5: Regional groundwater quality (EC in mS/m) from DWAF (2005).



Map 6: Vulnerability rating (DWAF, 2005) and groundwater depths (mbgl).

7 Site Specific Information

7.1 Desktop Assessment (Existing Groundwater Information)

To determine whether there are any groundwater users in the area that may be affected by activities on site, a database search was conducted using a 1-km radius around the site. This portion of the study was completed by obtaining groundwater information from existing databases. A search was conducted on a number of databases, namely the National Groundwater Archive (NGA), the Water Use Authorisation and Registration Management System (WARMS), the City of Cape Town (CoCT) database as well as the internal GEOSS database. These resources provide data on borehole positions, groundwater chemistry and yield, when available. Based on the desktop assessment of the various databases, there are a large number of groundwater users in the area surrounding the existing and proposed cemeteries, particularly to the north west and south east.

7.1.1 National Groundwater Archive (NGA) Database

Assessment of the National Groundwater Archive (NGA) database, which provides data on borehole and wellpoint positions, groundwater level, chemistry and yield, indicated that there is only one (1) wellpoint located within a 1-km search area of the site. Unfortunately, there is no water level or yield data available for the NGA site. Since the groundwater abstraction site is noted to be a wellpoint, it can be assumed that the water level will be somewhat shallow (likely less than 10 mbgl) in the intergranular aquifer. The NGA site is indicated on **Map 7** and summarised in **Table 2.**

Table 2: Summary of NGA borehole/wellpoint details.

Site ID	Type	Latitude (DD, WGS84)	Longitude (DD, WGS84)	WL (mbgl)	Yield (L/s)
3418AB00007	Well Point	-34.037130	18.485680	-	-

7.1.2 City of Cape Town (CoCT) Database

Assessment of the City of Cape Town Database indicates that there are 136 boreholes located in the area surrounding the study site. Little information is known about these boreholes and there are no water level or quality measurements associated with these sites. The City of Cape Town maintains a separate database for wellpoints, but GEOSS was unable to obtain this information from the municipality. Consequently, it is highly likely that there are a greater number of groundwater users in the area than what has been reported. The borehole details are listed in Error! Reference source not found., and the sites are indicated on **Map 7.**

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

Assessment of the Water Use Authorisation and Registration Management System (WARMS) Database revealed that there are 35 registered boreholes within 1-km of the study site. All of these boreholes are registered for either agricultural or industrial use. No geological logs are available for these sites, so groundwater abstraction can be occurring from the intergranular Cape Flats Aquifer, or the underlying fractured aquifer. However, due to the mapped extensive sand cover in the area, the majority of the boreholes are suspected to be drilled into the intergranular aquifer. Boreholes and wellpoints are most Within this dataset are boreholes registered to the municipality to abstract water from the Cape Flats Aquifer. This data was extracted from the latest update of the WARMS database (2023). The borehole details are listed in **Table 3** and are presented in **Map 7.**

Table 3: Summary of WARMS borehole details.

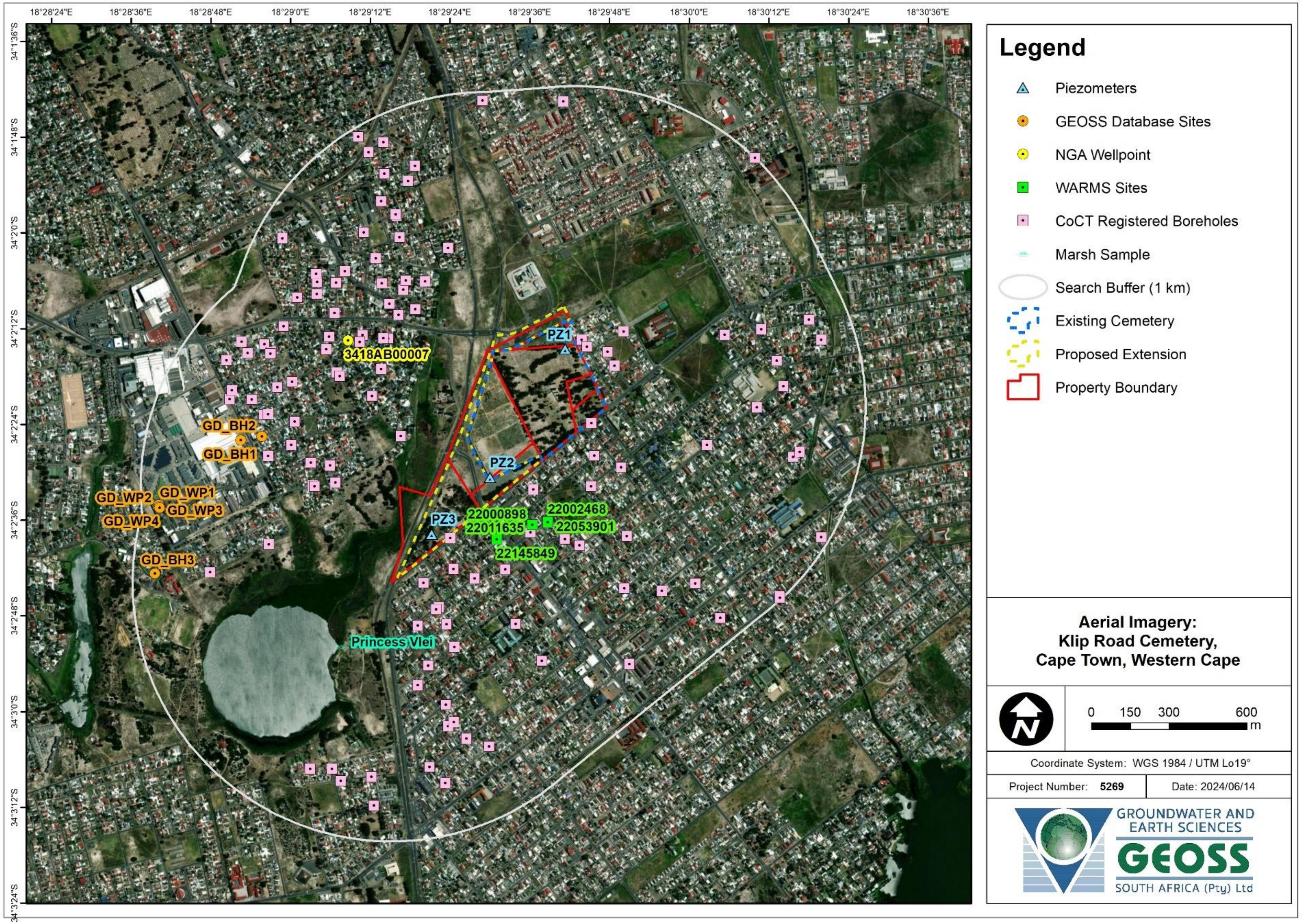
Site_ID	Registered Use	Resource Type	Latitude (DD, WGS84)	Longitude (DD, WGS84)
WARMS_BH1	Agriculture: Irrigation	Borehole	-34.043472	18.494000
WARMS_BH2	Agriculture: Irrigation	Borehole	-34.043500	18.494000
WARMS_BH3	Agriculture: Irrigation	Borehole	-34.043500	18.494000
WARMS_BH4	Agriculture: Irrigation	Borehole	-34.043500	18.494000
WARMS_BH5	Industry (Urban)	Borehole	-34.044083	18.491861
WARMS_BH6	Agriculture: Irrigation	Borehole	-34.043500	18.494000
WARMS_BH7	Agriculture: Irrigation	Borehole	-34.043500	18.494000
WARMS_BH8	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH9	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH10	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH11	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH12	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH13	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH14	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH15	Industry (Urban)	Borehole	-34.043586	18.493358
WARMS_BH16	Industry (Urban)	Borehole	-34.043586	18.493358
WARMS_BH17	Industry (Urban)	Borehole	-34.043586	18.493358
WARMS_BH18	Agriculture: Irrigation	Borehole	-34.043500	18.494000
WARMS_BH19	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH20	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH21	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH22	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH23	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH24	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH25	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH26	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH27	Agriculture: Irrigation	Borehole	-34.043586	18.493358
WARMS_BH28	Agriculture: Watering Livestock	Borehole	-34.043500	18.494000
WARMS_BH29	Industry (Urban)	Borehole	-34.043586	18.493358
WARMS_BH30	Agriculture: Irrigation	Borehole	-34.043500	18.494000
WARMS_BH31	Agriculture: Irrigation	Borehole	-34.043500	18.494000
WARMS_BH32	Industry (Urban)	Spring/Eye	-34.043586	18.493358
WARMS_BH33	Industry (Urban)	Spring/Eye	-34.043586	18.493358
WARMS_BH34	Industry (Urban)	Spring/Eye	-34.043586	18.493358
WARMS_BH35	Agriculture: Irrigation	Spring/Eye	-34.043500	18.494000

7.1.4 GEOSS Internal Database

A total of 8 groundwater sites (boreholes, wells, piezometers) were identified through the GEOSS Internal Database search and the locations of these sites are spatially represented on **Map 7** and summarised in **Table 4.** There is no information available for level, quality or yield for these sites.

Table 4: Summarised details for the GEOSS borehole details.

Site ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	EC (mS/m)	Yield (L/s)	Water Level (mbgl
GD_WP1	-34.042864	18.477771	-	-	-
GD_WP2	-34.042860	18.477763	-	-	-
GD_WP3	-34.042827	18.477734	-	-	-
GD_WP4	-34.042897	18.477742	-	-	-
GD_WP5	-34.042926	18.477765	-	-	-
GD_BH1	-34.040587	18.481168	-	-	-
GD_BH2	-34.040461	18.482053	-	-	-
GD_BH3	-34.045208	18.477546	-	-	-



Map 7: Piezometers as well as desktop and field hydrocensus groundwater locations.

8 Site Visit (Field Work)

8.1 Site Conditions

The site visit occurred on a single day on 5 June 2024. The weather was cool and overcast with light drizzle experienced during the course of the fieldwork. Once the fieldwork was completed, higher downpours were experienced. A few days prior to the site visit (since 30 May 2024), light rainfall was experienced in the area and marked the start of the wet season. During the site visit, ponding of water was noted on the surface in certain sections of the cemetery, particularly in the northern section on the untarred roads. The water level data collected during the GEOSS site visit is, therefore, more indicative of the end-summer water table.

8.2 Site Observations

During the site visit, holes were augered into the subsurface and piezometers were installed to determine groundwater depth and groundwater quality on site. This exercise also indicates soil types across the study site. The positions targeted for the piezometers are chosen to provide good spatial coverage of the study area (vegetation permitting). Typically, the holes are hand dug using an auger kit to a maximum depth of 5 m or until water is reached, whichever comes first. The site visit occurred in early-June 2024, at the end of the dry season and beginning of the wet season. The water table is expected to still be relatively deep in comparison to post-winter season, typically September to October.

During the site visit, three piezometers were successfully installed. The piezometers were installed at depths ranging from 2.340 – 3.455 mbgl at elevations ranging between 8.0 – 10.9 mamsl. Water level depths ranged between 1.64 - 2.8 mbgl. Following the piezometer installation, each piezometer was surveyed and photographed, and data for each piezometer was logged. Piezometer logs for the sites are available in **Appendix B** and site photographs are available in **Appendix C.** In addition to the piezometers, data was collected for Princess Vlei, located down-gradient of the cemetery. The details for the sites are summarised in **Table 5** and **Table 6** and locations of the sites are illustrated **in Map 7.**

Table 5: Summary of field measurements (5 June 2024).

Site_ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Comments
PZ1	-34.03747339	18.49476935	This site is located less than 1 metre from burial land; burials are recent (Sep 2023). Site chosen as the most accessible up-gradient site in the existing cemetery.
PZ2	-34.04192672	18.49158819	This site is located down-gradient and south west of PZ1. This site is down-gradient of all burial land in the existing cemetery. Located approximately 4 - 5 m from burial land.
PZ3	-34.0438817	18.48913939	This site is located down-gradient and south west of PZ1 and PZ2. The land is undeveloped and located on the property demarcated for the proposed cemetery extension, west of Victora Road.
Princess Vlei	-34.04780994	18.48530946	The vlei is a surface water site located down-gradient and southwest of all the piezometers. It is anticipated that shallow groundwater in the area discharges into the vlei.

Table 6: Summary of field measurements (5 June 2024).

Site_ID	Surveyed Elevation (mamsl)	Depth (m)	CH (m)	WL (mbgl)	WL (mamsl)
PZ1	10.893	3.455	0.490	2.505	8.388
PZ2	9.870	3.245	0.075	2.800	7.070
PZ3	8.010	2.340	0.220	1.640	6.370
Princess Vlei	4.586	-	-	-	

Based on the data collected from the auger holes, the soil profile is generally dominated by fine—and medium-grained sands, with layers and lenses of clayey or gravelly horizons, and horizons characterised by a marked increase in their organic content.

A generalised soil profile is presented **in Table 7.** Typically, at the surface, dry, unconsolidated, pale-brown, fine- to medium-grained quartz-rich sand, and is typically up to 0.7 m thick. This is regarded as the topsoil layer and fine, shallow roots may be present in this layer. Generally, this is followed by a beige horizon that is about 1.0 m thick and comprised of well sorted fine- to medium-grained quartz-rich sand. This is regarded as a horizon of aeolian origins. Beneath which, a horizon with a height of approximately 1.5 - 2.0 m consisting of dry to moist, brown, fine- to medium-grained sand, which may contain discontinuous layers and lenses of gravelly material (for example as encountered in PZ2). Finally, the terminal unit for each auger hole was different, in PZ2 it was as described above; whereas for PZ1 and PZ3, the sand-dominated sediments were characterised by marked increases in their organic- and clay- contents, respectively.

Table 7: Generalised soil profile for the study area.

Unit	Depth (mbgl)	Description
Unit 1	0.00 to ± 0.50	Dry, unconsolidated, pale- to dark-brown, fine-to-medium grained SAND. Topsoil. Shallow roots present. Note: sub-horizon encountered at PZ1, as above but grey and includes 20 mm clasts.
Unit 2	0.50 to ± 1.50	Dry, often beige, sometimes consolidated, usually well-sorted, fine-to-medium, quartz-rich SAND. Aeolian.
Unit 3	1.50 to ± 2.00 - 3.00	Dry to wet, well-sorted, dark-brown, often medium-grained and well sorted quartz-rich SAND. Aeolian. Note: May anticipate intersection of shallow groundwater within this depth range.
Unit 4	2.00/3.00 to ± 2.50	As above: • At PZ1: Moist to wet, dark-brown to black organic-rich medium-and-fine grained SAND. • At PZ3: Wet, beige and brown clayey medium-and-fine grained SAND.

A site walk-over sought to identify and confirm hydrological and hydrogeological features of relevance. It must be noted that during the desktop assessment portion of the study, prior to the site visit, piezometer locations were planned along the suspected flow path, in undeveloped areas. During the site visit, however, not all of these sites were accessible as they have been used as burial spaces. This is particularly true for **PZ1. Field photographs are presented in Appendix C.**

8.3 Site Conceptual Model

A regional study undertaken by Adelana, Xu and Vbrka, (2010) sought to determine the hydrogeological conditions in the greater Cape Flats aquifer. Broadly, the conceptual geological and hydrogeological model of the present site is likely similar to those presented in **Figure 3.** The shallow groundwater intersected in the auger holes is generally encountered in Unit 3, potentially owing the presence at least in part to the terminal units of clayey and organic materials as encountered **in PZ1** and **PZ3** (**Table 7**). It is worth pointing out that the organic and clayey materials described in the present investigation, appear to be consistent with the data presented by Adelana, Xu and Vbrka, (2010; **Figure 3**). The reader's attention is drawn to the south-western end of the geological cross-section labelled G on the accompanying map within the figure.

Based on the field data, a northeast-southwest site conceptual model has been compiled for the study area. The soil horizons are not inferred beyond the piezometer sites and are based on the auger logs presented **in Appendix B.** The conceptual model is presented **in Figure 4** and based on the geological cross-section presented in **Map 3.**

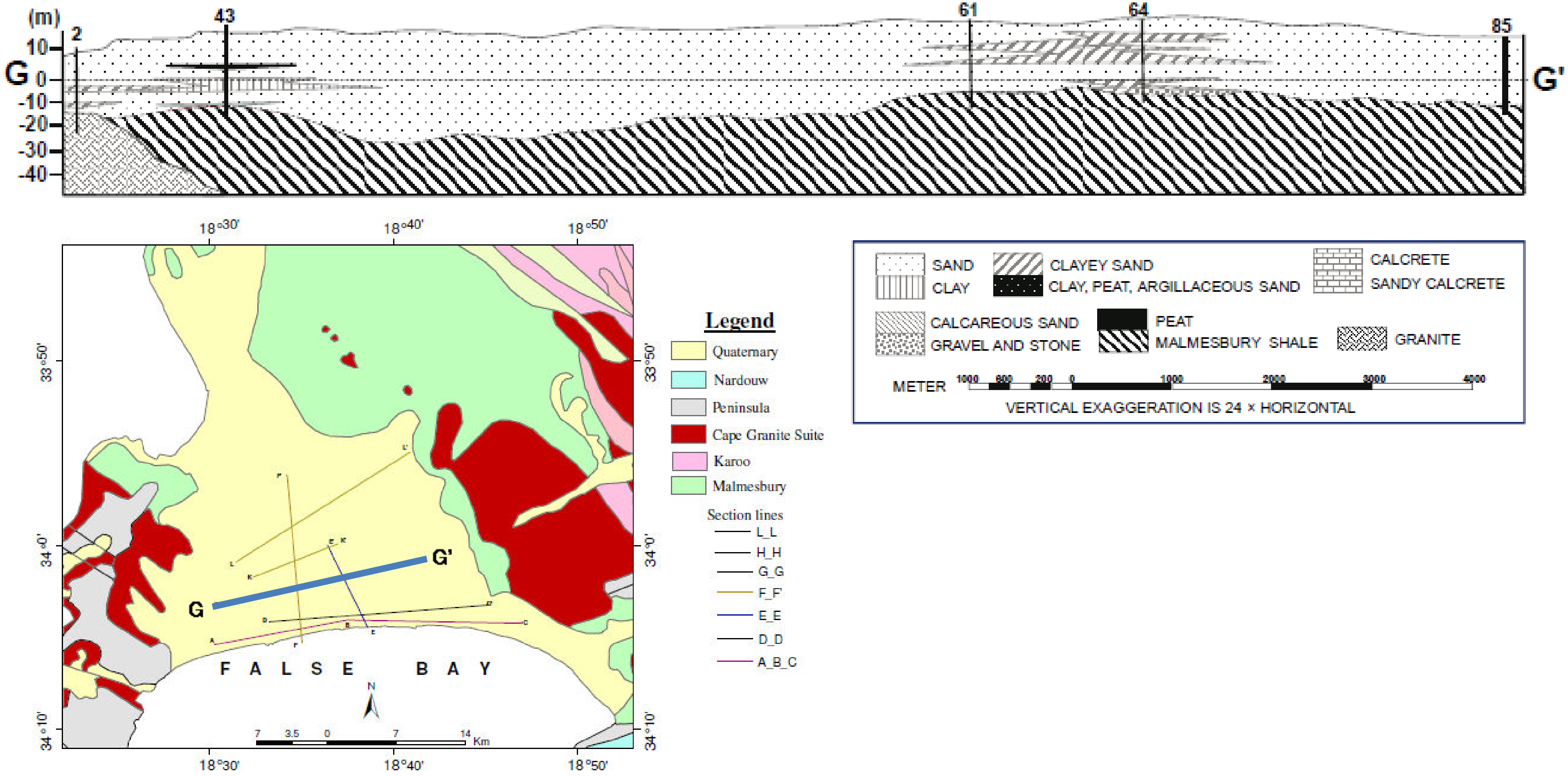


Figure 3: Conceptual diagram of the underlying geology (Adelana, Xu and Vbrka, 2010).

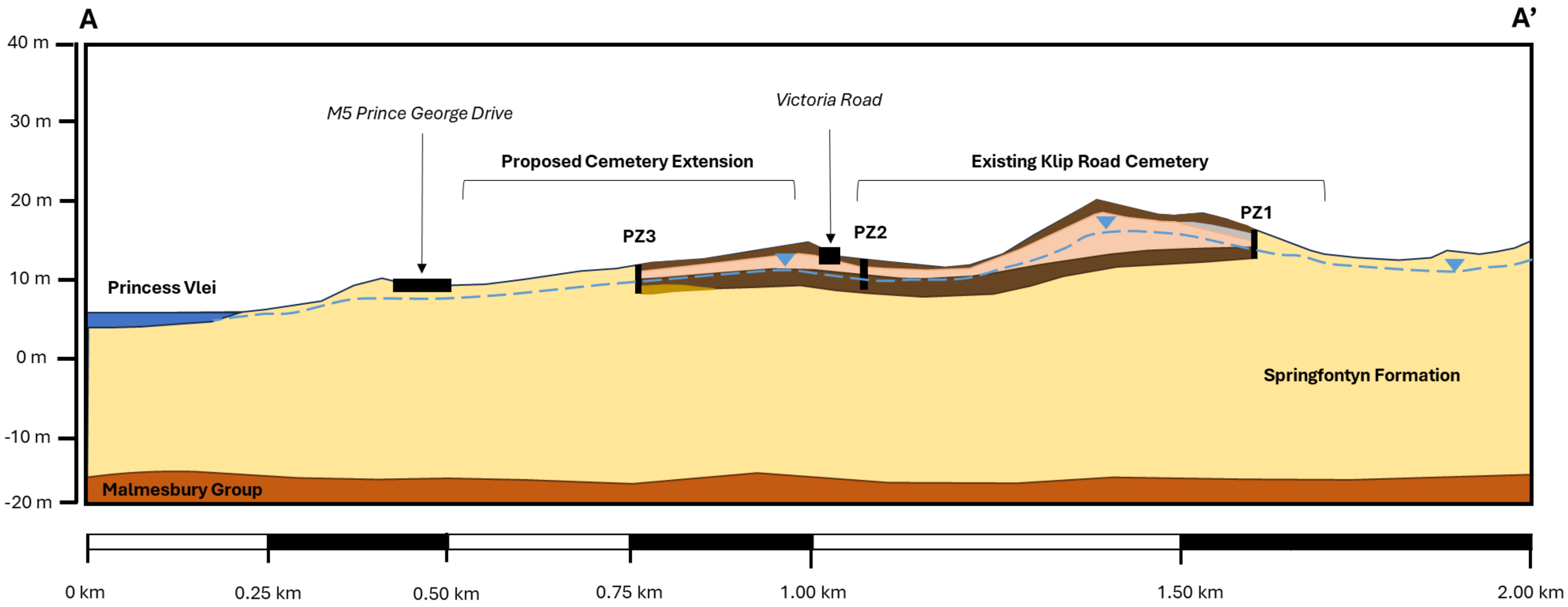


Figure 4: Conceptual diagram of the study area

8.4 Field Chemistry

During the site visit, field chemistry was recorded where possible. Groundwater pH, electrical conductivity (EC), total dissolved solids (TDS) content, salinity, oxidation-reduction potential (ORP) and temperature were recorded. Measurements were recorded from the piezometers installed during the site assessment as well as from the Princess Vlei. Measurements are available in **Table 8** below.

Table 8: Chemistry field measurements for the installed piezometers and the Vlei (5 June 2024).

Site_ID	pH	EC (mS/m)	TDS (mg/L)	Temp (°C)	SAL (ppt)	ORP (mV)
PZ1	5.48	242.8	1579.5	18.2	1.26	129.7
PZ2	6.50	55.9	364.0	19.7	0.27	103.3
PZ3	6.55	94.1	617.5	19.4	0.47	44.4
Princess Vlei	7.59	98.7	643.5	18.5	0.49	69.5

The field chemistry indicates that the water quality from the collected samples are variable. The water quality in PZ2 is classified as 'ideal' in terms of EC and TDS (DWAF, 1998), however, the shallow groundwater collected from PZ3 and the surface water sample collected from Princess Vlei is classified as 'good' (DWAF, 1998). It is important to note that the water collected from PZ1 has the worst quality and falls within the 'marginal' category in terms of EC and TDS. The water sampled from PZ2, PZ3 and Princess Vlei falls within 'operational' limits in terms of EC but quality observed at PZ1 exceeds limits (SANS, 2015).

The elevated EC values encountered in piezometer PZ1, has presumably been influenced by its close proximity to the existing cemetery site. However, these field chemistry results appear to be consistent with the regional datasets available for water quality, i.e. electrical conductivity (**Map 5; Table 8**). pH values appear to increase from acidic and neutral to basic, traversing the site from **PZ1** in the northeast end of the study area, to PZ2 and PZ3 and Princess Vlei in the southwestern region of the study area.

Again, this stresses the heterogenous, but porous nature of the primary aquifer in the area, resulting in high sensitivity to point-based contamination and can result in variable water quality results over short distances.

8.5 Groundwater Flow Direction

Groundwater flow generally follows surface topography, flowing from areas of high elevation to areas of lower elevation. In order to evaluate the relationship between groundwater levels and topography, the surface elevations and water table elevations are plotted relative to each other to assess the applicability of an interpolation technique. Where close correlation between surface elevations and water table elevations exist, interpolation techniques are an appropriate method to estimate values for areas with limited data.

Due to a lack of water level data available for the study area which actually has an abundance of groundwater abstraction points, groundwater level data was only obtained from the site assessment. By using the Bayesian Interpolation technique, the data was used to generate a groundwater level contour map to determine groundwater flow direction. The data is presented in **Figure 5** and on **Map 8**, and indicates a 90.55% correlation between surface topography and water level elevation. This correlation confirms that groundwater flow paths in the study area are from topographic highs to lows. There are topographical highs to the north and north west of the study site. As a result, water flows in a radial pattern from the study site towards the stream and Princess Vlei which it feeds, in the west and south west, but towards the south as well, towards Zeekoe Vlei.

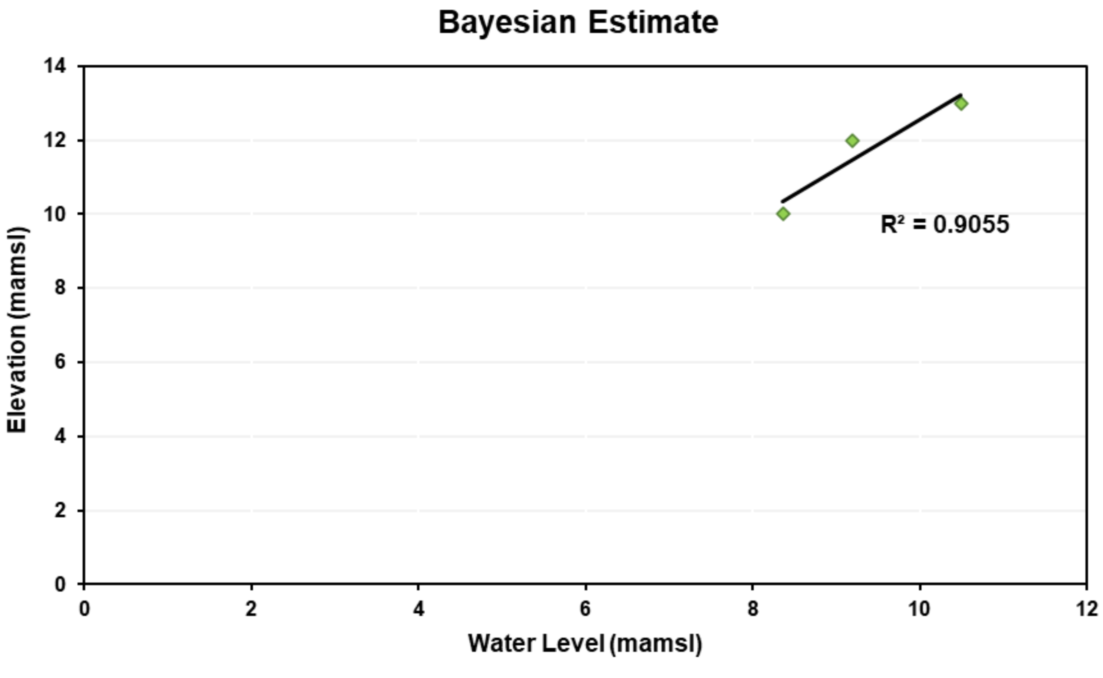
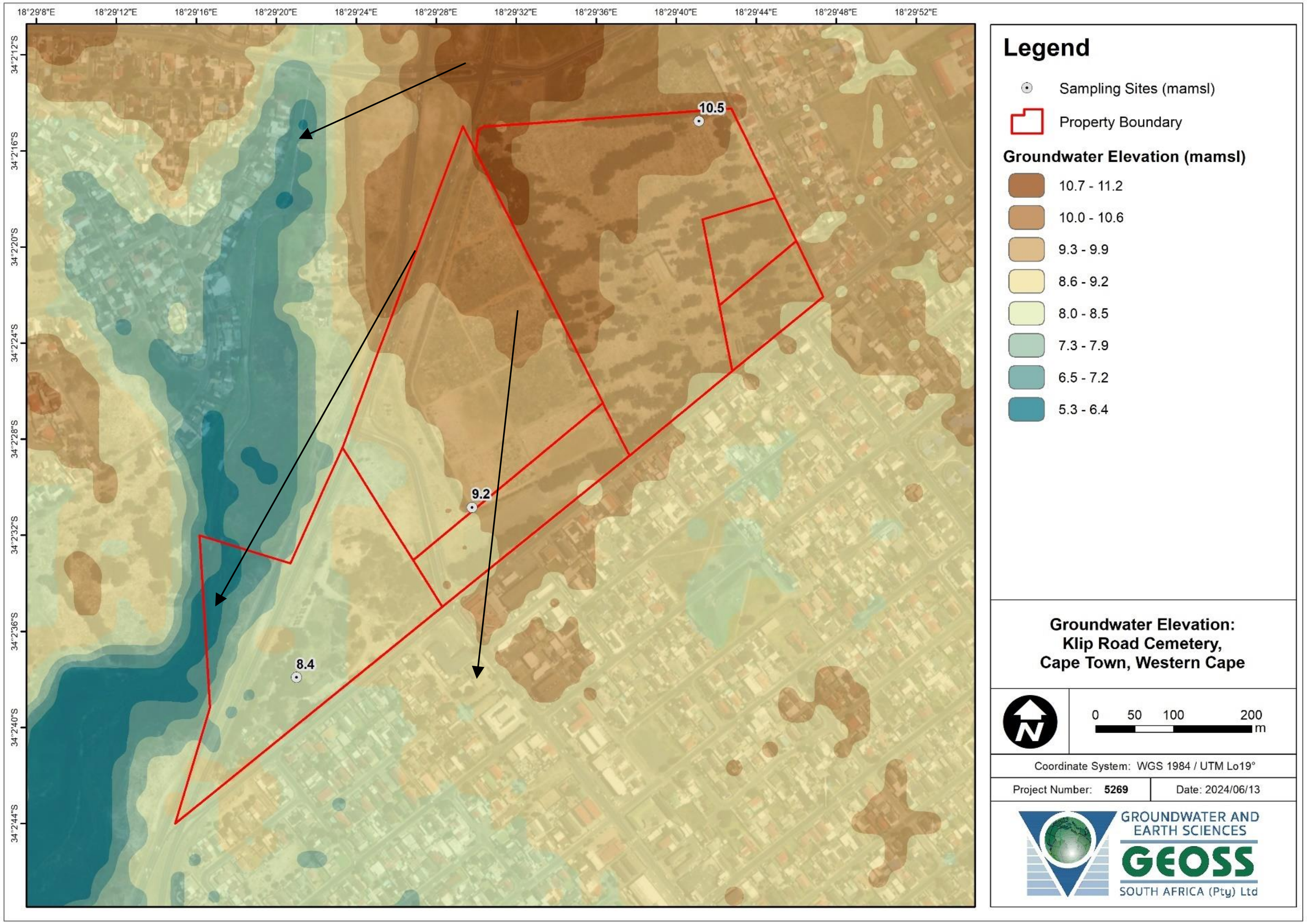


Figure 5: Correlation between surface topography and groundwater elevation for the piezometers proximal to the study site.



Map 8: Interpolated groundwater elevation map for the study area (Bayesian interpolation).

8.6 Water Quality Analysis

Four groundwater samples were collected during the field visit on 5 June 2024. The samples were collected from the three piezometers, PZ1, PZ2, PZ3 and Princess Vlei (P_Vlei). The chemistry data from the samples have been evaluated to give an indication of the groundwater quality that can be expected at the study site. The laboratory results are available in **Appendix D**. The chemistry results for these sites have been classified according to the SANS241-1: 2015 standards for drinking water (**Table 9**). **Table 11** presents the water chemistry analysis results, colour coded according to the SANS241-1: 2015 drinking water assessment standards.

Table 9: Classification table for the specific limits.

Acute Health	Aesthetic	Chronic Health	Operational	Acceptable

The chemistry results have also been classified according to the DWAF (1998) standards for domestic water. **Table 10** enables an evaluation of the water quality with regards to the various parameters measured (DWAF, 1998). **Table 12** presents the water chemistry analysis results colour coded according to the DWAF domestic water assessment standards.

Table 10: Classification table for the groundwater results (DWAF, 1998).

Class	Water quality	Description
Class 0	Ideal	Suitable for lifetime use.
Class I	Good	Suitable for use, rare instances of negative effects.
Class II	Marginal	Conditionally acceptable. Negative effects may occur.
Class III	Poor	Unsuitable for use without treatment. Chronic effects may occur.
Class IV	Dangerous	Totally unsuitable for use. Acute effects may occur.

It is essential to note that the groundwater sampled directly beneath the site or from the Vlei is not used for domestic or drinking water purposes. Therefore, these standards are used for reference purposes only as a widely used point of reference.

From the chemical results presented in **Table 11** and **Table 12**, the groundwater samples are observed to contain low concentrations of dissolved minerals and salts, however, certain metals are elevated in the water. Water pH is variable ranging from slightly acidic in PZ1, sub-neutral in PZ2 and PZ3, to basic in Princess Vlei. EC and TDS concentrations indicate variable water quality, with EC ranging from relatively low for PZ2, PZ3 and Princess Vlei (values less than 72 mS/m) to an elevated value of 298 mS/m for PZ1. Based on these results, the EC values for PZ2, PZ3 and Princess Vlei fall at the lower end of the mapped range of EC values (**Map 5**). However, the EC value measured at PZ1 falls in the upper end of the mapped range of EC values for the aquifer (**Map 5**).

All of the collected samples contained fine-grained suspended solids which has resulted in elevated turbidity and colour of the samples. During the augering process, soil layers were disturbed, some containing with high levels of organic matter, as well as clayey and silty materials, which have elevated the turbidity. The following observations are made based on the laboratory data for this site:

For each sample analysed, the parameters indicated below fall within the respective SANS (2015) categories:

- **PZ1:**
  - Aesthetic: EC, TDS, turbidity, colour, sodium (Na), chloride (Cl), and nitrogen (N) hosted within ammonia.
  - Operational: Aluminium (Al).
  - Chronic: Iron (Fe).
  - Acute: Sulphate (SO_4).
- **PZ2:**
  - Aesthetic: Turbidity.
  - Operational: Aluminium (Al) as well as the total coliform bacteria count.
  - Acute: Nitrogen (N) hosted within nitrates and nitrites combined, as well as nitrogen (N) hosted within nitrate alone.
- **PZ3:**
  - Turbidity, colour, and iron (Fe).
  - Operational: Aluminium (Al).
  - Chronic: Lead (Pb).
  - Acute: Nitrogen (N) hosted within nitrates and nitrites combined.
- **Princess Vlei:**
  - Turbidity, colour.
  - Operational: Total coliform bacteria count, and Heterotrophic Plate Count.
  - Acute: Nitrogen (N) hosted within nitrates and nitrites combined, as well as the E.coli count.

In addition to the parameters listed above, several metals were detected in addition to those that have been highlighted in terms of the SANS (2015) categories. For example, metals including chromium (Cr), zinc (Zn), cadmium (Cd) and mercury (Hg), as well as elevated total organic carbon content and cyanide (CN) were recorded in some or all of the samples analysed. The metals could cause health effects if the water were to be used for drinking purposes without treatment. Further, Dippenaar et al., (2018) indicated that some of these metals are used in coffin ornaments or jewellery, including aluminium, cadmium, chrome, iron, lead, mercury, zinc among others. Dippenaar et al., (2018) also indicated that nutrients and compounds associated with breakdown of the skeleton, and landscaping processes on and around the cemetery site could elevate sodium, magnesium, chloride, sulphate, nitrate and phosphate. Organics may be associated with embalming. Finally, pathogens present in the water could allude to breakdown of biological materials by microbes.

Table 11: Groundwater quality analysis classified results according to SANS 241-1:2015.

Analyses	PZ1	PZ2	PZ3	P_Vlei	SANS 241-1:2015
pH (at 25 °C)	5.6	6.7	6.7	7.9	≥5 - ≤9.7 Operational
Conductivity (mS/m) (at 25 °C)	298.0	60.7	59.8	71.3	≤170 Aesthetic
Total Dissolved Solids (mg/L)	2 020.44	411.55	405.44	483.41	≤1200 Aesthetic
Turbidity (NTU)	8 808.00	699.00	>10 000	18.30	≤5 Aesthetic ≤1 Operational
Colour (mg/L as Pt)	22.00	<15	26.00	22.00	≤15 Aesthetic
Sodium (mg/L as Na)	315	35	60	71	≤200 Aesthetic
Potassium (mg/L as K)	49	5	4	9	N/A
Magnesium (mg/L as Mg)	75	11	7	10	N/A
Calcium (mg/L as Ca)	152	58	47	49	N/A
Chloride (mg/L as Cl)	578.66	42.37	93.54	114.63	≤300 Aesthetic
Sulphate (mg/L as SO_4)	522.57	41.26	28.72	33.58	≤250 Aesthetic ≤500 Acute Health
Combined Nitrate & Nitrite (ratio)	0.79	1.91	0.068	0.068	≤1 Acute Health
Nitrate Nitrogen (mg/L as N)	8.30	19.38	<1.00	<1.00	≤11 Acute Health
Nitrite Nitrogen (mg/L as N)	<0.05	0.13	<0.05	<0.05	≤0.9 Acute Health
Ammonia Nitrogen (mg/L as N)	2.01	<0.15	<0.15	<0.15	≤1.5 Aesthetic
Total Alkalinity (mg/L as $CaCO_3$)	44.3	119.4	120.1	132.6	N/A
Total Hardness (mg/L as $CaCO_3$)	687.5	190.1	146.2	163.5	N/A
Fluoride (mg/L as F)	<0.15	<0.15	<0.15	<0.15	≤1.5 Chronic Health
Aluminium (mg/L as Al)	4.830	0.956	7.534	0.163	≤0.3 Operational
Total Chromium (mg/L as Cr)	0.007	0.005	0.006	<0.004	≤0.05 Chronic Health
Manganese (mg/L as Mn)	0.026	0.039	0.047	0.027	≤0.1 Aesthetic ≤0.4 Chronic Health
Iron (mg/L as Fe)	3.046	0.237	0.587	0.253	≤0.3 Aesthetic ≤2 Chronic Health
Nickel (mg/L as Ni)	<0.008	<0.008	<0.008	<0.008	≤0.07 Chronic Health
Copper (mg/L as Cu)	<0.002	<0.002	<0.002	<0.002	≤2 Chronic Health
Zinc (mg/L as Zn)	0.100	0.013	<0.008	<0.008	≤5 Aesthetic
Arsenic (mg/L as As)	<0.01	<0.01	<0.01	<0.01	≤0.01 Chronic Health
Selenium (mg/L as Se)	<0.008	<0.008	<0.008	<0.008	≤0.04 Chronic Health
Cadmium (mg/L as Cd)	0.001	0.001	<0.001	<0.001	≤0.003 Chronic Health
Antimony (mg/L as Sb)	<0.013	<0.013	<0.013	<0.013	≤0.02 Chronic Health
Mercury (mg/L as Hg)	0.003	<0.001	0.003	<0.001	≤0.006 Chronic Health
Lead (mg/L as Pb)	<0.008	<0.008	0.014	<0.008	≤0.01 Chronic Health
Uranium (mg/L as U)	<0.028	<0.028	<0.028	<0.028	≤0.03 Chronic Health
Cyanide (mg/L as CN^-)	0.036	0.011	0.015	0.011	≤0.2 Acute Health
Total Organic Carbon (mg/L as C)	65.70	9.04	19.20	15.80	N/A
E.coli (cfu/100 mL)	nd	nd	nd	2 000	Not Det. Acute Health-1
Total Coliform Bacteria (cfu/100 mL)	nd	100	nd	4 600	Not Det.≤10 Operational
Heterotrophic Plate Count (cfu/mL)	50	900	720	3 100	≤1000 Operational
Charge balance %	0.6	0.3	3.2	3.5	≥-5 - ≤5 Acceptable

Table 12: Classified groundwater sample results according to DWAF (1998).

Analyses:	**PZ1**	**PZ2**	**PZ3**	**P_Vlei**	**DWA (1998) Drinking Water Assessment Guide**				
					Class 0	**Class I**	**Class II**	**Class III**	**Class IV**
pH	5.6	6.7	6.7	7.9	5-9.5	4.5-5 & 9.5-10	4-4.5 & 10-10.5	3-4 & 10.5-11	< 3 & >11
Conductivity (mS/m)	298.0	60.7	59.8	71.3	<70	70-150	150-370	370-520	>520
Turbidity (NTU)	8 808.00	699.00	>10 000	18.30	<0.1	0.1-1	1.0-20	20-50	>50
	mg/L								
Total Dissolved Solids	2 020.44	411.55	405.44	483.41	<450	450-1 000	1 000-2 400	2 400-3 400	>3 400
Sodium (as Na)	315	35	60	71	<100	100-200	200-400	400-1 000	>1 000
Potassium (as K)	49	5	4	9	<25	25-50	50-100	100-500	>500
Magnesium (as Mg)	75	11	7	10	<70	70-100	100-200	200-400	>400
Calcium (as Ca)	152	58	47	49	<80	80-150	150-300	>300	
Chloride (as Cl)	578.66	42.37	93.54	114.63	<100	100-200	200-600	600-1 200	>1 200
Sulphate (as SO_4)	522.57	41.26	28.72	33.58	<200	200-400	400-600	600-1 000	>1 000
Nitrate (as N)	8.30	19.38	<1.00	<1.00	<6	6.0-10	10-20	20-40	>40
Fluoride (as F)	<0.15	<0.15	<0.15	<0.15	<0.7	0.7-1.0	1.0-1.5	1.5-3.5	>3.5
Manganese (as Mn)	0.026	0.039	0.047	0.027	<0.1	0.1-0.4	0.4-4	4-10	>10
Iron (as Fe)	3.046	0.237	0.587	0.253	<0.5	0.5-1.0	1.0-5.0	5-10	>10
Copper (as Cu)	<0.002	<0.002	<0.002	<0.002	<1	1-1.3	1.3-2	2.0-15	>15
Zinc (as Zn)	0.100	0.013	<0.008	<0.008	<20	>20			
Arsenic (as As)	<0.01	<0.01	<0.01	<0.01	<0.010	0.01-0.05	0.05-0.2	0.2-2.0	>2.0
Cadmium (as Cd)	0.001	0.001	<0.001	<0.001	<0.003	0.003-0.005	0.005-0.020	0.020-0.050	>0.050
Hardness (as $CaCO_3$)	687.50	190.10	146.20	163.50	<200	200-300	300-600	>600	
	counts/100 mL								
Faecal coliforms	nd	nd	nd	2 000	0	0-1	1.0-10	10-100	>100
Total coliforms	nd	100	nd	4 600	0	0-10	10-100	100-1 000	>1 000
Charge Balance %	0.6	0.3	3.2	3.5	≥-5 - ≤5 Acceptable				

8.7 Chemical Diagrams

The Piper diagram in **Figure 6** illustrates the cation and anion distribution relative to one another for the samples collected during the field visit. The Piper diagram indicates that the water quality results for the piezometers, are slightly variable. PZ1, PZ3 and Princess Vlei can all be classified as borderline sodium-chloride-type water. In fact, PZ3, the closest piezometer to Princess Vlei, has the same ionic distribution as that of the vlei. This provides indication that the shallow groundwater in the area, discharges into the vlei. PZ2 has a different hydrofacies type in comparison to the other sites. PZ2 is classified as calcium-bicarbonate-type water.

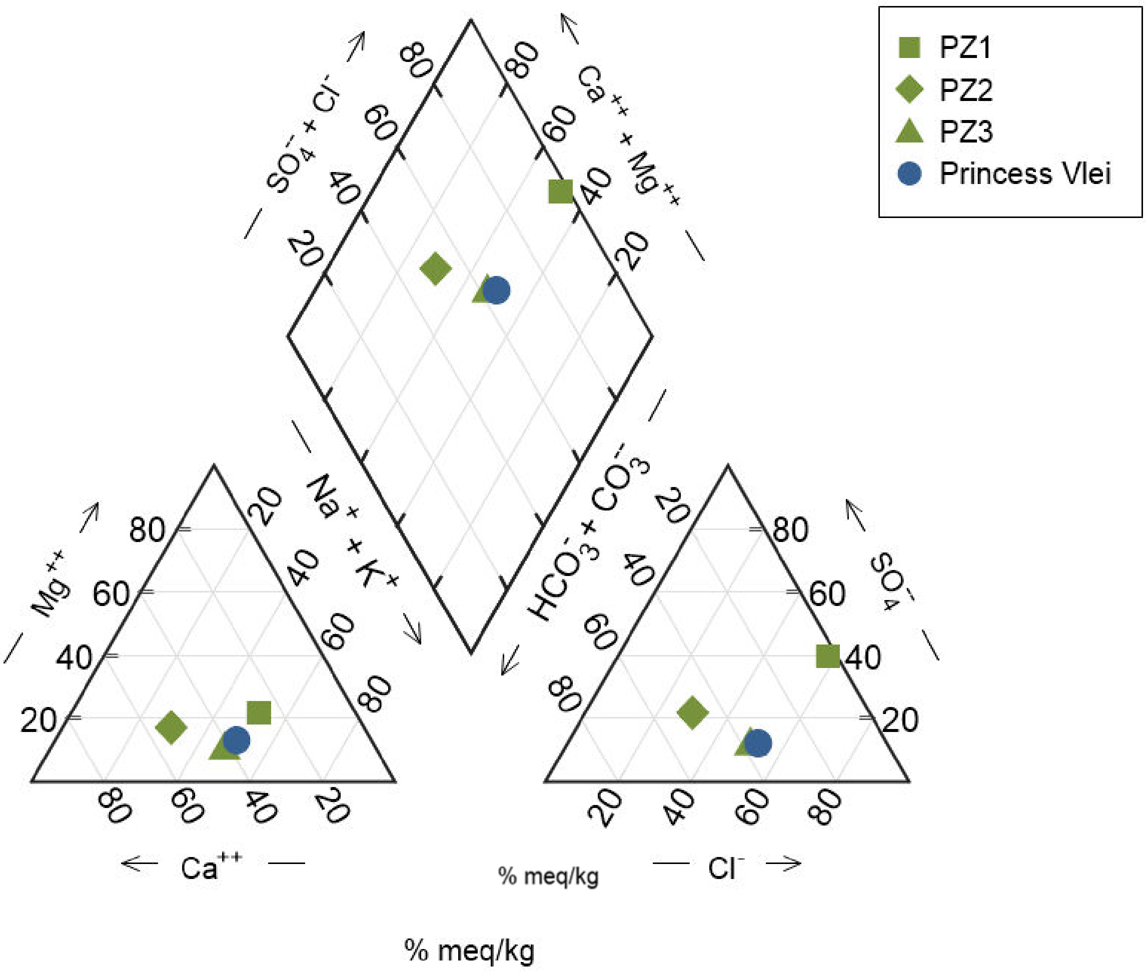


Figure 6: Piper diagram for the collected samples.

Stiff diagrams are a quick visual representation of the distribution of major anions and cations within a sample, and are presented **in Figure 7**. The Stiff Diagrams indicate that in terms of dissolved ionic content, the water quality observed at PZ1 is poorer than the quality observed at the other three sites. The dominant cation in sample PZ1 is $Na^+ + K^+$ and the dominant anion is Cl^- with notable proportions of SO_4^{2-}. The same major ions are evident in the samples collected from PZ3 and Princess Vlei, however, the dissolved ionic concentrations are much lower at this site in comparison to PZ1. Ca^{2+} is noted as the dominant cation in sample PZ2 wile $HCO_3^- + CO_3^{2-}$ are the dominant anions.

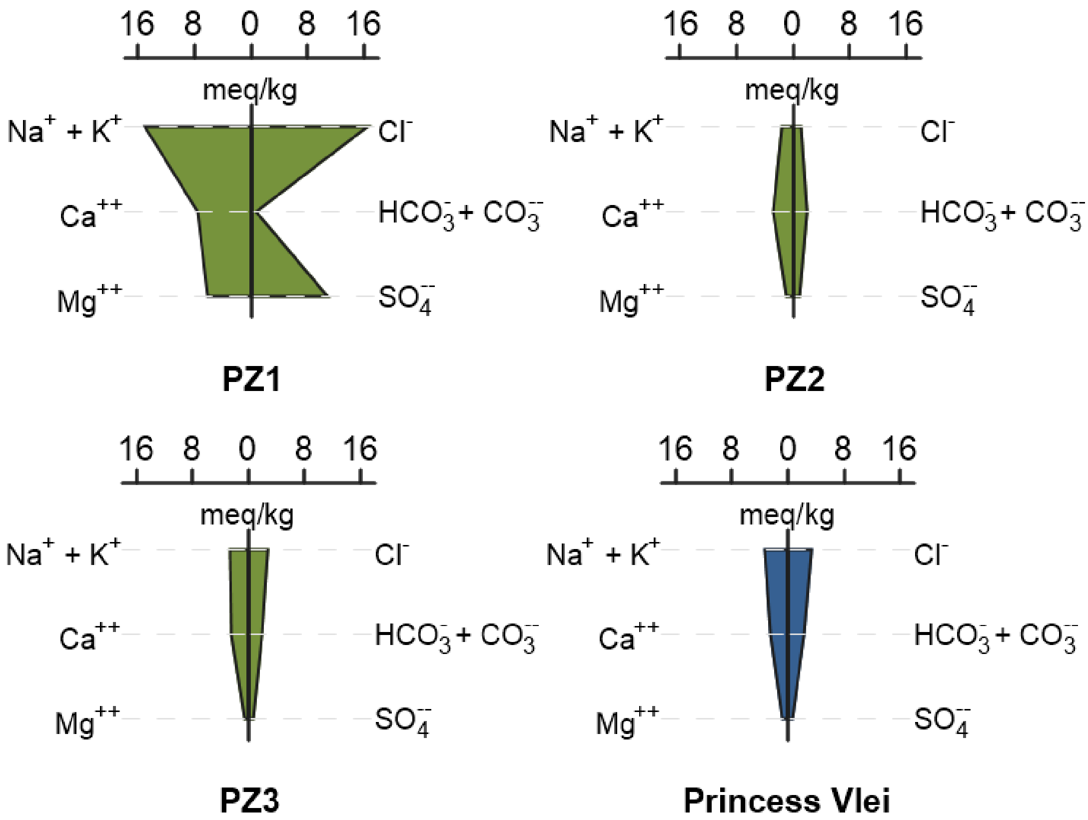


Figure 7: Stiff diagrams for the collected samples.

9 Risk Impact Assessment

Based on published information, the site is located on an intergranular aquifer which has a "very high" vulnerability classification indicating that the aquifer is highly susceptible to contamination from anthropogenic activities (Conrad and Munch, 2007). Data for the area also suggests that high levels of abstraction takes place from the primary aquifer in the area. As a result, the following impact assessment pertains to the primary unconsolidated aquifer.

There are risks associated with the cemetery site. These include (from Dippenaar et al., 2018):

- decomposition of the bodies producing leachate,
- chemicals used in the embalming process,
- metals from the ornamental hinges on coffins and/or jewellery, and
- other nutrient and pathogen sources from poor sanitary practices or landscaping.

The decomposition of human remains result in the formation of leachate which is comprised of 60% water, 30% salts (N, P, Cl, HCO_3, Ca, Na and compounds of metals such as Ti, Cr, Cd, Pb, Fe, Mn and Ni) and 10% organic substances (Żychowski and Bryndal, 2015).

Other contaminants associated with the decomposition of bodies include:

- Chemical substances derived from chemotherapy or the embalming process which could include arsenic, formaldehyde and methanol.
- Makeup such as cosmetics, pigments and other chemical compounds.
- Items such as cardiac pacemakers, paints, varnishes, metal hardware, chemicals batteries and dentures.

- Microorganisms such as bacteria, viruses, intestinal fungi, protozoa, and other pathogens.

Exposure to potential contaminants could be through contact with substances (contaminants or contaminated groundwater) via ingestion or dermal contact (with both groundwater and soil).

- **Table 13** summarises the possible impacts and proposed mitigation measures associated with the increased decomposition of human remains.
- **Table 14** presents a summary of the possible impacts and proposed mitigation measures associated with the corrosion of metals used as ornaments, plastics, paints and varnishes.
- **Table 15** summarises the possible impacts and proposed mitigation measures associated with the formation of organics from the embalming process.

The risk assessment includes the identification and rating of the potential risks associated with the proposed development options and any proposed mitigation measures where possible. Each risk is qualitatively assessed based on the existing information. The risk rating is measured according the criteria **in Appendix E.**

Table 13: Impact table for contamination of groundwater as a result of decomposition of human remains.

OPERATIONAL PHASE	
Potential impact and risk	**Contamination of Groundwater due to the Decomposition of Human Remains**
Nature of impact	Negative
Extent and duration of impact	Extent is local and duration is short term.
Consequence of impact or risk	Increased nutrient, pathogenic and inorganic parameter concentrations in groundwater. This may lead to adverse sanitary issues in the area and impact nearby ecological systems. Further, increased nutrient loadings may lead to eutrophic conditions.
Probability of occurrence	Highly probable
Degree to which the impact may cause irreplaceable loss of resources	Marginal loss of resource.
Degree to which the impact can be reversed	Reversible in shallow groundwater. This is challenging where infiltration into the deeper fractured aquifer takes place.
Cumulative impact prior to mitigation	High
Significance rating of impact prior to mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	High
Degree to which the impact can be managed or mitigated	Medium-Low
Proposed mitigation	• Where possible, ensure burial occurs sufficiently above water table depth to enable natural attenuation in the vadose zone (region between surface and water table). Harmful bacteria, viruses and pathogens tend to die off during final stages of decomposition and therefore tend to not persist in the environment. • Installation of impermeable liner beneath the cemetery to prevent the deterioration of groundwater quality. • Limit groundwater use of the shallow aquifer immediately downgradient /downstream of the site. • Install appropriate stormwater management systems to direct uncontaminated stormwater off-site. • Monitoring wells are required in order to detect any potential contamination as quickly as possible.
Cumulative impact post mitigation	Medium
Significance rating of impact after mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Medium

Table 14: Impact table for contamination of groundwater as a result of metal corrosion, paints and varnishes.

OPERATIONAL PHASE	
Potential impact and risk	**Groundwater contamination due to the addition of paints and varnishes to the environment and corrosion (and liberation of metals).**
Nature of impact	Negative
Extent and duration of impact	Extent is local and duration is short term.
Consequence of impact or risk	Contamination of the local groundwater.
Probability of occurrence	Highly probable
Degree to which the impact may cause irreplaceable loss of resources	Marginal loss of resource
Degree to which the impact can be reversed	Reversible
Cumulative impact prior to mitigation	Medium-high
Significance rating of impact prior to mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Medium-high
Degree to which the impact can be managed or mitigated	Medium
Proposed mitigation	• Standardise coffin size with ordinary dimensions. • **Coffin materials should primarily consist of untreated wood and/or other biodegradable materials.** • Refrain from using excessive ornamental metals, plastics, paints varnishes, etc. • Where possible, all jewellery, watches, batteries, excessive cosmetics, and other such materials should be removed prior to burial. It is harder to remove dentures and pace makers. • Installation of impermeable liner beneath the cemetery to prevent the deterioration of groundwater quality.
Cumulative impact post mitigation	Medium
Significance rating of impact after mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Medium

Table 15: Impact table for contamination of groundwater as a result of compounds used during embalming.

OPERATIONAL PHASE	
Potential impact and risk	**Potential leaching of chemicals used in the embalming process (e.g. formaldehyde and associated compounds) into the groundwater**
Nature of impact	Negative
Extent and duration of impact	Extent is local and duration is short term
Consequence of impact or risk	Contaminated groundwater
Probability of occurrence	Possible
Degree to which the impact may cause irreplaceable loss of resources	Minimal loss of resource
Degree to which the impact can be reversed	Reversible (but impractical)
Cumulative impact prior to mitigation	High
Significance rating of impact prior to mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	High
Degree to which the impact can be managed or mitigated	Mitigation is typically not required
Proposed mitigation	When formaldehyde comes into contact with water it tends to breakdown into methanol, amino acids and several other chemicals and therefore does not persist in the environment (World Health Organisation, 2002). However, these compounds can persist in saturated conditions (Dippenaar et al., 2018).
Cumulative impact post mitigation	Medium
Significance rating of impact after mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Medium

10 Discussion

From the desktop study and field work, it is evident that there are an extensive number of groundwater users surrounding the study area, and that groundwater can be considered a critical resource for the area (**Map 7**). Groundwater users are concentrated in the residential areas to the northwest, and southeast of the study area, many of which can be considered as down-gradient groundwater users. Although little information is available for the indicated boreholes in the area, it is likely that groundwater abstraction occurs from both the primary and the secondary aquifers. It is, however, unknown to what degree groundwater is used for domestic purposes within the 1-km buffer zone or whether the use identified in the residential area is primarily for garden irrigation. Due to safety concerns in the study area, an extensive hydrocensus was not conducted.

The site is covered by a blanket of dry, unconsolidated, pale-brown, fine- to medium-grained quartz-rich sand, which is typically up to 0.7 m thick. This is regarded as the topsoil layer and fine, shallow roots may be present in this layer. Generally, this is followed by a beige horizon that is about 1.0 m thick and comprised of well sorted fine- to medium-grained quartz-rich sand. This is regarded as a horizon with aeolian origins. Beneath which, a horizon with a height of approximately 1.5 - 2.0 m consisting of dry to moist, brown, fine- to medium-grained sand, which may contain discontinuous layers and lenses of gravelly material (for example as encountered in PZ2). Finally, the terminal unit for each auger hole was different, in PZ2 it was as described above; whereas for PZ1 and PZ3, the sand-dominated sediments were characterised by marked increases in their organic and clay contents, respectively.

Depths of the augered holes ranged from 2.34 mbgl and 3.45 mbgl and groundwater was intersected at all three of the piezometers that were installed within the study area. Water level measurements across the study area were observed to be shallow, and ranged between 1.64 – 2.8 mbgl. The site visit took place early-June 2024, at the end of the dry season and start of the wet season. Therefore, the collected water levels are likely indicative of the deepest levels in the area. Based on the analysis of 471 locations across the Cape Flats Aquifer (CFA), the average depth to groundwater is approximately 1.0 metre; however, this varies depending on topography (Fouché & Day, 2019). Considering a 1.0 metre seasonal variation in the groundwater table depth and assuming the presented data reflects the maximum depth, large portions (if not all) of this site would have groundwater depths shallower than 4.0 metres below ground level (mbgl) year-round.

In addition to Princess Vlei to the south west of the proposed cemetery, the larger Zeekoevlei is located approximately 1.8 km south of the study site. A study by Parsons and Harding (2002) found that groundwater accounts for about 15% of Zeekoevlei's annual inflow and is the sole source of inflow during summer, buffering against evapotranspiration. Since Zeekoevlei is situated in a similar hydrogeological context, the situation at Princess Vlei is considered to be similar, and therefore, a tangible risk of infiltration of persistent contaminants into Princess Vlei exists, arising from typical burials taking place at the proposed expansion site for the Klip Road Cemetery. Given the close proximity (200 m at south-west end) of the proposed site in relation to Princess Vlei the risk of contaminants entering the Vlei arising from the cemetery site is considered possible and likely.

The study site is located in a relatively high rainfall area, and considering the gentle relief of an intergranular aquifer with high primary permeability and porosity, the site is considered to be highly favourable for direct recharge from rainfall to groundwater. Consequently, the water levels beneath the study site are typically shallow (as reflected by the present investigation, typically < 3.0 mbgl). The depth of the water table has been recorded as shallow, despite this investigation having been undertaken toward the end of the summer period when the water table is anticipated to be nearing the deepest levels (i.e. water table is at deepest depth with respect to the surface). As an area close to the study site (Princess Vlei) has been deemed a conservation area that hosts a diverse range of flora and fauna, limiting the impact on groundwater recharge will be essential.

Although good to marginal quality groundwater (70 – 300 mS/m) is mapped for the area, information obtained during the site visit indicates that groundwater quality is often better than what was originally mapped and is within the range of 0 – 70 mS/m, apart from the water sampled at PZ1 which is located within the existing Klip Road Cemetery, and is affected by the recent burials. The primary aquifer is considered to be highly vulnerable to surface-based contaminants due to the intergranular nature of the sedimentary cover. This classification is due to the high permeability of the sands. Due to the nature of the development, it is highly unlikely that any potential groundwater contamination would affect the fractured rock (likely Malmesbury Formation) secondary aquifer, located beneath the primary intergranular aquifer. If contamination were to occur, it would most likely follow the groundwater flow direction. Based on the data available, the flow direction is interpreted to be generally from the north-east towards south to southwesterly and westerly directions.

Individual graves are typically dug to a depth of 2 metres and environmental compliance for burials dictate that the water table should be at least 2.5 metres deep (Department of Health, 2013) but further studies advise burial should occur in areas where the groundwater table exceeds 4.0 mbgl (Dippenaar, et. al., 2018; Hanbury and Hall 1990). Consequently, water levels within the current range measured beneath the surface pose a problem for the development of the cemetery. It is, however, stated in the 2013 Government Gazette that for areas with higher water tables, local government may determine a reasonable depth with additional walling recommendations to protect groundwater.

Given the very high vulnerability that is mapped for the underlying aquifer, the risk of contamination to the aquifer is considered. For a risk to exist there must be a source(s), pathway(s) and receptor(s). The proposed development presents potential source of contamination. The underlying aquifer represents both a potential pathway and receptor. Groundwater users and the surrounding environment represent receptors of potential contamination. The source-pathway-receptor linkages are considered to be complete. The source-pathway-receptor-model is illustrated in **Figure 8.**

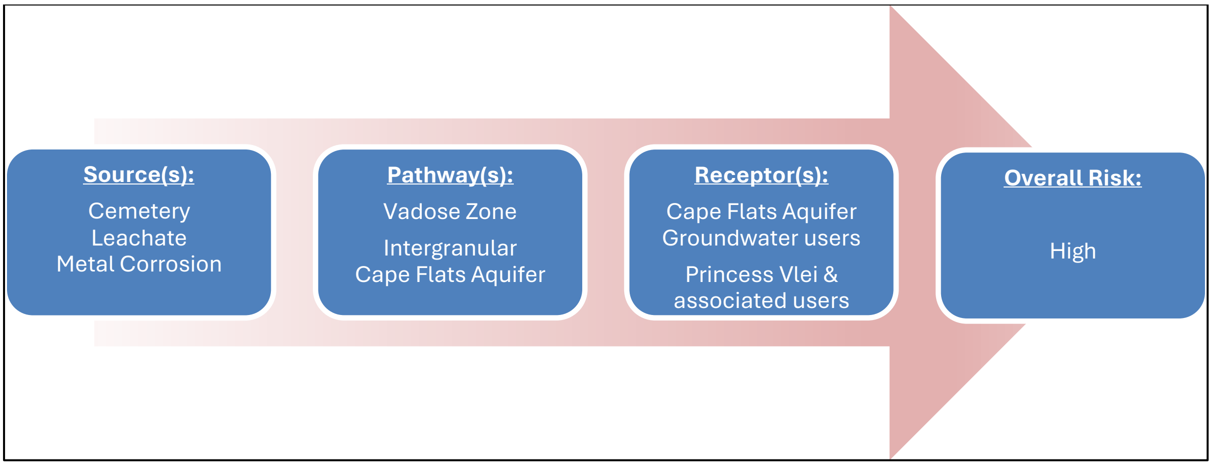


Figure 8: Source, Pathway and Receptor Assessment.

READ MORE: (a),(c) Fineza et al. 2014; Dent et al. 2004; EA [Environmental Agency] 2004; Rodriguez and Bass 1985;
ADAPTED FROM: Żychowski and Bryndal 2015 ; (b),(c) this document; Van Allemann 2017; Van Allemann et al. 2018

If groundwater contamination does occur, it would most likely follow the groundwater flow direction. Regionally, based on the data available, the groundwater flow is towards generally southward, in the direction of Princess Vlei, Zeekoevlei and groundwater abstraction points to the south and south west of the site that has been proposed for use as a cemetery. Here, the mobility and persistence of a given contaminant becomes applicable. Based on the literature, cemetery sites generate a range of contaminants including metals, nutrients, organics, and pathogens all of which have varying rates of mobilisation, persistence and toxicity (Dippernaar et al., 2018; Fineza, et al., 2014; Dent et al., 2004; Van Allemann et al., 2018; Żychowski & Bryndal, 2015). Despite sand-dominated materials typically being considered favourable as materials for burial sites (Dippenaar, 2018); the shallow groundwater system that is ubiquitous in this area, presents risk for rapid infiltration of leachates into. Furthermore, Dippenaar (2018) argues that under the National Water Act (Section 21(g)) cemeteries should not be located near water bodies (such as wetlands, pans, vleis, estuaries, and floodplains; or near fault zones, or ecologically sensitive areas, locations with shallow groundwater tables; or on sites overlying important water supply aquifers.

11 Conclusion and Recommendations

This assessment has generally confirmed the regional geological and hydrogeological conditions of published information. The site is underlain by mostly free draining unconsolidated aeolian sands, which are interleaved with layers and lenses of lower permeability clayey and organic horizons. The site is characterised by shallow groundwater conditions, with groundwater levels ranging between 2.80 and 1.64 mbgl. Based on the hydrogeological data available, the site that has been proposed for the expansion should not proceed.

The nature of the proposed development poses a <u>high</u> risk of contamination to an aquifer that is considered to have a very high vulnerability to contamination based on published information. Based on the information collected on site, this is consistent with the findings presented here. It is unlikely the risk of contamination to aquifer, which is an important source of groundwater, can be practically and appropriately mitigated.

If possible, an alternative site should be investigated for the purpose of establishing a new cemetery due to the following factors:

- A typical mitigation measure would be that the burial of bodies should only take place where the depth to the water table exceeds 4 mbgl. In this case, it is unlikely that this mitigation measure can be met.
- Another standard mitigation measure to protect groundwater would be that boreholes should not be used for potable consumption within 350 m of the established cemetery. It must be noted that there are several boreholes within 350 m of the site, of particular significance in this instance are those situated south of the site (and the canal that feeds Princess Vlei).
- Establishment of a cemetery is not recommended within 200 m of a wetland. Princess Vlei is located 200 m away.

An alternative site with favourable geological and hydrogeological conditions (i.e. deep water levels in soils above a fractured aquifer) will be better suited.
Should development of the cemetery proceed despite the current hydrogeological findings, the following recommendations are made:

- A comprehensive monitoring network will need to be established, including selected existing boreholes as well as the commissioning of three monitoring boreholes that are to be drilled on the site, and should be installed to depths of at least 10 mbgl using an appropriate design for these hydrogeological conditions.
- Relevant mitigation measures and best practice procedures must be employed to minimize contamination of the subsurface.
- Installation of impermeable liner beneath the cemetery to prevent the deterioration of groundwater quality.
- Once a grave is excavated, it should have a clay-rich material lining the bottom of the grave, upon which the coffin will rest. Once the coffin is emplaced, the backfill material should be clay-rich to at least within 1 m of the ground surface, and must cover the coffin. The material will reduce the permeability around the coffin and is also a good medium for natural attenuation. In this case, the bucket effect will need to be considered, an appropriate material for lining should be considered so as to improve the attenuation time, but not impede flow indefinitely.
- It must also be noted with the shallow water levels experienced on site and the potential use of clay or liners to impede flow; this may result in flooding/water ponding at the surface. It is recommended that a geotechnical specialist be enlisted to consult on appropriate mitigation measures.
- It is recommended that at least three monitoring wells are installed across the site, one upgradient and two down-gradient, e.g. one on the northern most corner of Erf 75568, and one on the eastern- and southern-most corners of Erf 75571. The positions of the monitoring wells can be finalised once site plans have been finalised.
- Quarterly quality monitoring of the groundwater is recommended to monitor the change in quality. The data must be regularly assessed by a qualified hydrogeologist.

12 Assumptions and Limitations

The following assumptions and limitations are noted for this study:

- Available data was sourced from the relevant groundwater databases and sources. The aquifer vulnerability, yield and quality data is predominantly accurate, albeit mapped at a regional scale.
- At the time of the report issue, no available site development plan was available and a general assessment was conducted of the demarcated properties to determine the potential impact on groundwater resources in the area.
- A further limitation was the temporal nature of the site visit. The field work was undertaken on a single day in June 2024, and does not account for the temporal variability of the water table, i.e. the shallow water table. Due to the nature of the geology and the topography (gentle relief and highly permeable, thick sand cover which promotes relatively high rates of infiltration), it is anticipated that the water table will become shallower during the wet season.
- It is possible that there are a greater number of groundwater users in the area than what has been reported in this study as not all groundwater use tends to be registered, particularly when small volumes are used for domestic purposes.

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14 Appendix A: CoCT Boreholes

Site ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)
CoCT_BH1	-34.03995096620	18.48342945140
CoCT_BH2	-34.04235025870	18.49340770360
CoCT_BH3	-34.03744241960	18.48476446320
CoCT_BH4	-34.03725625810	18.48218374400
CoCT_BH5	-34.04160500860	18.49707739610
CoCT_BH6	-34.04914958480	18.48852471610
CoCT_BH7	-34.04844760560	18.49737629610
CoCT_BH8	-34.04005725840	18.49584360980
CoCT_BH9	-34.04643714770	18.48942582410
CoCT_BH10	-34.03509386960	18.48440060190
CoCT_BH11	-34.03814445100	18.48705596910
CoCT_BH12	-34.03825054320	18.48519264170
CoCT_BH13	-34.04217578050	18.48417467120
CoCT_BH14	-34.03428124900	18.48685559760
CoCT_BH15	-34.04782810380	18.49006544780
CoCT_BH16	-34.03715363280	18.49545161470
CoCT_BH17	-34.03605299070	18.48850103690
CoCT_BH18	-34.04565889620	18.50016044280
CoCT_BH19	-34.04400212930	18.49730497340
CoCT_BH20	-34.05058967030	18.48978199680
CoCT_BH21	-34.03537039720	18.48800676610
CoCT_BH22	-34.03700071830	18.48489287400
CoCT_BH23	-34.03707248850	18.48735822450
CoCT_BH24	-34.04221122340	18.48424482150
CoCT_BH25	-34.03718733670	18.50547392510
CoCT_BH26	-34.03509393230	18.48892133600
CoCT_BH27	-34.03229361120	18.48709752790
CoCT_BH28	-34.03472131890	18.48556134470
CoCT_BH29	-34.05205069750	18.48492027660
CoCT_BH30	-34.05233444210	18.48657114360
CoCT_BH31	-34.03084686400	18.50273771010
CoCT_BH32	-34.03515445990	18.48710649300
CoCT_BH33	-34.03004150590	18.48614996580
CoCT_BH34	-34.03057979480	18.48657431880

Site ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)
CoCT_BH35	-34.03337924870	18.48635774370
CoCT_BH36	-34.03753174910	18.48247231820
CoCT_BH37	-34.03695454370	18.48628699640
CoCT_BH38	-34.03354839600	18.48786003040
CoCT_BH39	-34.03158855260	18.48821688290
CoCT_BH40	-34.03106130500	18.48851919370
CoCT_BH41	-34.03505057730	18.48810872270
CoCT_BH42	-34.04847071020	18.48896196020
CoCT_BH43	-34.04611772850	18.50366080360
CoCT_BH44	-34.04405981960	18.50544105940
CoCT_BH45	-34.03856100610	18.48333770720
CoCT_BH46	-34.05255998720	18.48965327590
CoCT_BH47	-34.04512733920	18.49221360530
CoCT_BH48	-34.04581392890	18.49718144280
CoCT_BH49	-34.02884599740	18.49473736490
CoCT_BH50	-34.04408984680	18.49471059510
CoCT_BH51	-34.04083578680	18.50067033640
CoCT_BH52	-34.04431059370	18.49532263890
CoCT_BH53	-34.04652005610	18.48930386790
CoCT_BH54	-34.03649072550	18.50496320980
CoCT_BH55	-34.05043764470	18.49003055510
CoCT_BH56	-34.03617056920	18.48511351140
CoCT_BH57	-34.04517397560	18.47986674170
CoCT_BH58	-34.04421796230	18.48231938200
CoCT_BH59	-34.03687330270	18.49721693910
CoCT_BH60	-34.04119012930	18.49596003090
CoCT_BH61	-34.04510817650	18.49004429460
CoCT_BH62	-34.05333522340	18.48666098630
CoCT_BH63	-34.05200267030	18.48899360620
CoCT_BH64	-34.04047198200	18.48786579570
CoCT_BH65	-34.03057979480	18.48657431880
CoCT_BH66	-34.04114805000	18.48230967440
CoCT_BH67	-34.03825054320	18.48519264170
CoCT_BH68	-34.03755982740	18.48148232040

Site ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)
CoCT_BH69	-34.04703440630	18.49263127010
CoCT_BH70	-34.03907734860	18.48667028670
CoCT_BH71	-34.03716402640	18.48123043560
CoCT_BH72	-34.03917688450	18.48164704430
CoCT_BH73	-34.03057979480	18.48657431880
CoCT_BH74	-34.03758625090	18.48243275840
CoCT_BH75	-34.03280368780	18.48774396670
CoCT_BH76	-34.04137727390	18.48409842110
CoCT_BH77	-34.03133653150	18.48722805630
CoCT_BH78	-34.03057979480	18.48657431880
CoCT_BH79	-34.03563303140	18.48357013460
CoCT_BH80	-34.04148460340	18.48490650920
CoCT_BH81	-34.03617056920	18.48511351140
CoCT_BH82	-34.04832896200	18.49372193620
CoCT_BH83	-34.04405981960	18.50544105940
CoCT_BH84	-34.04707171330	18.48853640740
CoCT_BH85	-34.03625579160	18.48780484960
CoCT_BH86	-34.03057979480	18.48657431880
CoCT_BH87	-34.03551686960	18.48438260190
CoCT_BH88	-34.04208342220	18.48511904910
CoCT_BH89	-34.03969896830	18.48214629280
CoCT_BH90	-34.03716402640	18.48123043560
CoCT_BH91	-34.03706348850	18.48716022450
CoCT_BH92	-34.03969102440	18.48232873270
CoCT_BH93	-34.03780013380	18.48059042300
CoCT_BH94	-34.03662443570	18.48298836710
CoCT_BH95	-34.03874594280	18.48271901870
CoCT_BH96	-34.04984240630	18.48969471900
CoCT_BH97	-34.03916212160	18.48071657410
CoCT_BH98	-34.03806179460	18.49682089310
CoCT_BH99	-34.03837106470	18.48533265210
CoCT_BH100	-34.03392659290	18.48988586750
CoCT_BH101	-34.03511845990	18.48519648190
CoCT_BH102	-34.02879803890	18.49136204240

Site ID	Latitude (DD, WGS84)	Longitude (DD, WGS84)
CoCT_BH103	-34.03756980180	18.49653932040
CoCT_BH104	-34.04558832970	18.48879250320
CoCT_BH105	-34.03884502660	18.48081518340
CoCT_BH106	-34.04686000000	18.50119000000
CoCT_BH107	-34.04590912520	18.49874961480
CoCT_BH108	-34.05246734720	18.48528001030
CoCT_BH109	-34.04703678680	18.48974336190
CoCT_BH110	-34.03790884600	18.50360637020
CoCT_BH111	-34.04076227590	18.48328728520
CoCT_BH112	-34.05204005360	18.48401056040
CoCT_BH113	-34.04686000000	18.50119000000
CoCT_BH114	-34.04403503830	18.48992205000
CoCT_BH115	-34.04385201280	18.49327280790
CoCT_BH116	-34.03586606660	18.48741911990
CoCT_BH117	-34.04544196170	18.49093225040
CoCT_BH118	-34.04225718760	18.49581433130
CoCT_BH119	-34.03880118760	18.50387480570
CoCT_BH120	-34.03480323980	18.48435639090
CoCT_BH121	-34.03739834170	18.49567338530
CoCT_BH122	-34.03718662670	18.48617395020
CoCT_BH123	-34.03953203110	18.50277315930
CoCT_BH124	-34.03682331450	18.50297018080
CoCT_BH125	-34.05129855370	18.49150274100
CoCT_BH126	-34.03023617650	18.48719527930
CoCT_BH127	-34.03275427950	18.48770108440
CoCT_BH128	-34.04126621320	18.50427530570
CoCT_BH129	-34.03700000000	18.50143500000
CoCT_BH130	-34.03700000000	18.50143500000
CoCT_BH131	-34.04108718760	18.50455430570
CoCT_BH132	-34.04617023870	18.50369366360
CoCT_BH133	-34.03356901330	18.48295862730
CoCT_BH134	-34.03700000000	18.50143500000
CoCT_BH135	-34.05101665190	18.49054452950
CoCT_BH136	-34.04703440630	18.49263127010

15 Appendix B: Piezometer Logs

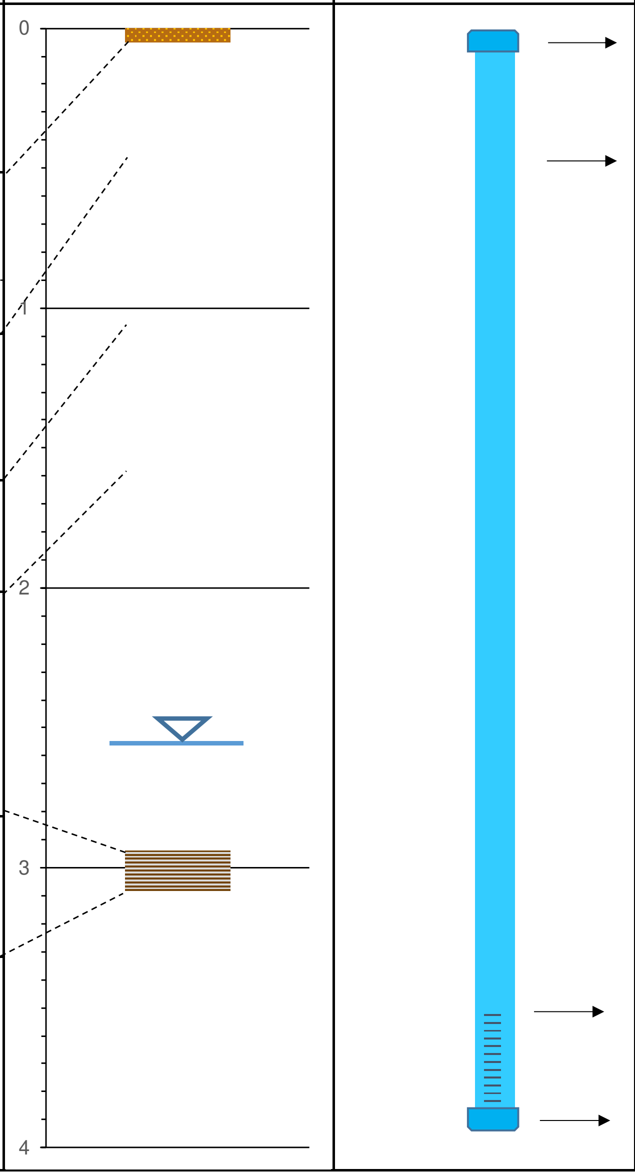
Log of Piezometer No.: PZ1

Location:	Grassy Park	**Latitude:**	-34.03747339
Date:	05-Jun-24	**Longitude:**	18.49476935
Client:	Zutari	**Ground Elevation:**	10.893 mamsl

Lithological Description

Unit	Depth (mbgl)	Description
Unit 1:	0.00 - 0.05	Dry, unconsolidated, pale brown fine-to-medium grained SAND, Top Soil. Roots present and discarded Material in this layer.
Unit 2:	0.05 - 0.46	Dry, medium brown, unconsolidated medium grained, clay-rich soil with 10-20 mm diameter angular grains.
Unit 3:	0.46 - 1.065	Dry, unconsolidated, pale-grey to brown, well-sorted medium grained angular quartz-rich SAND.
Unit 4:	1.065 - 1.58	Moist beige well sorted medium grained quartz-rich sand.
Unit 5:	1.58 - 2.94	Dry (becomes moist near base) brown, beige and yellow, unconsolidated fine-and-medium grained well-sorted quartz SAND. Increased consolidation and grain size, and colours intensify, with depth.
Unit 6:	2.94 - 3.08	As above, but organic-rich (visibly darker with depth and noticable olfactory prescence).
Unit 7:	3.08 - 3.445	Wet dark brown to black consolidated well sorted SAND organic content increases with depth. Clay rich?

Lithology (mbgl) / Construction



Comments

End Cap

50 mm solid PVC

(~0.50 meters of 50 mm slotted PVC)

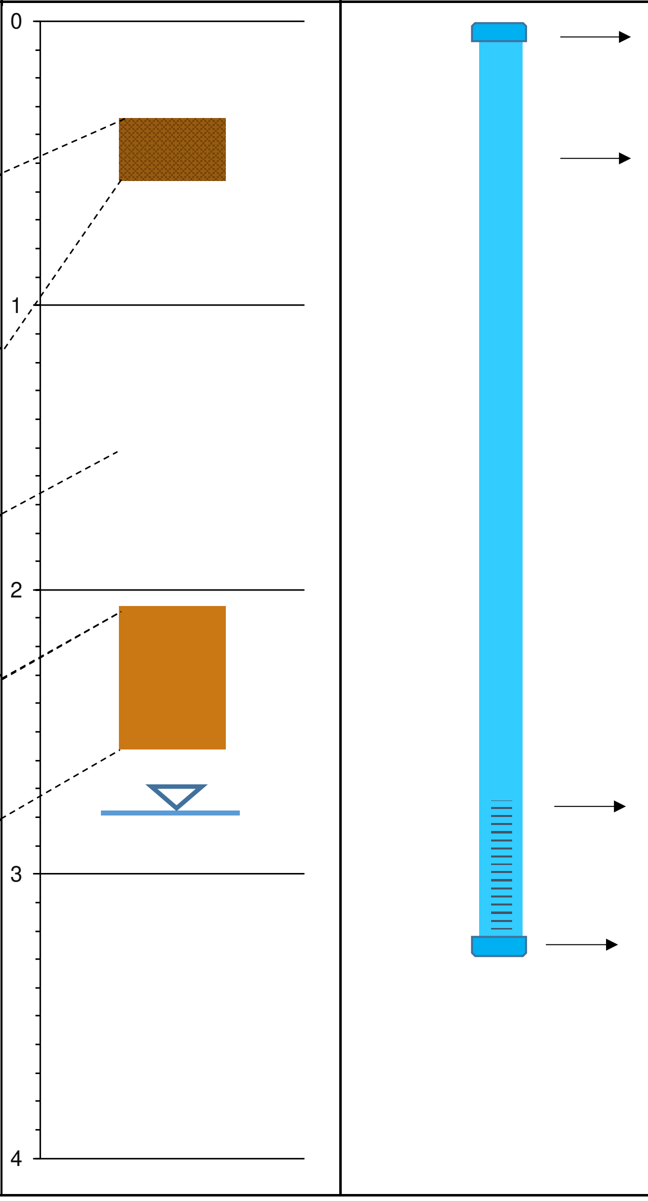
End Cap

Excavated By:	GEOSS	**Remarks:**	End of Hole = 3.455 mbgl. Water intersected at 2.505 mbgl.
Drill Method:	Hand Auger		
Logged By:	Zita Harilall		

Log of Piezometer No.:	**PZ2**		
Location:	Grassy Park	**Latitude:**	-34.001072
Date:	05-Jun-24	**Longitude:**	18.48028
Client:	Zutari	**Ground Elevation:**	9.87 mamsl

Lithological Description
Unit 1: 0.00 - 0.34 Dry, unconsolidated, pale brown, fine to medium grained SAND. Large angular transported material. Roots present.
Unit 2: 0.34 - 0.56 Dry, dark brown unconsolidated well-sorted medium grained SAND. Roots scattered throughout.
Unit 3: 0.56 - 1.515 Dry, pale brown to beige with depth, unconsolidated well-sorted quartz-rich medium-grained SAND.
Unit 4: 1.515 - 2.06 Dry, dark-rich brown gravelly (clasts up to 20 mm in diameter) poorly sorted SAND.
Unit 5: 2.06 - 2.56 Dry medium brown unconsolidated coarse-grained well sorted SAND.
Unit 6: 2.65 - 3.245 Moist orange-brown unconsolidated coarse-grained quartz-rich SAND. Increasing moisture with depth and deeper colours.

Lithology (mbgl) | **Construction**



Comments

- End Cap
- 50 mm solid PVC
- (~0.50 metres of 50 mm slotted PVC)
- End Cap

Excavated By:	GEOSS	**Remarks:**	End of Hole = 3.245 mbgl. Water intersected at 2.800 mbgl.
Drill Method:	Hand Auger		
Logged By:	Zita Harilall		

Log of Piezometer No.: PZ3

Location:	Grassy Park	**Latitude:**	-34.04192672
Date:	05-Jun-24	**Longitude:**	18.49158819
Client:	Zutari	**Ground Elevation:**	8.010 mamsl

Lithological Description

Unit 1:
0.00 - 0.77
Dry, unconsolidated, pale-brown, fine-to-medium grained quartz-rich SAND.

Unit 2:
0.77 - 1.36
Dry, beige medium grained unconsolidated quartz-rich SAND. Contains scattered feldspar grains.

Unit 3:
1.36 - 1.51
Dry dark brown unconsolidated SAND. Contains clasts up to 20 mm in diameter.

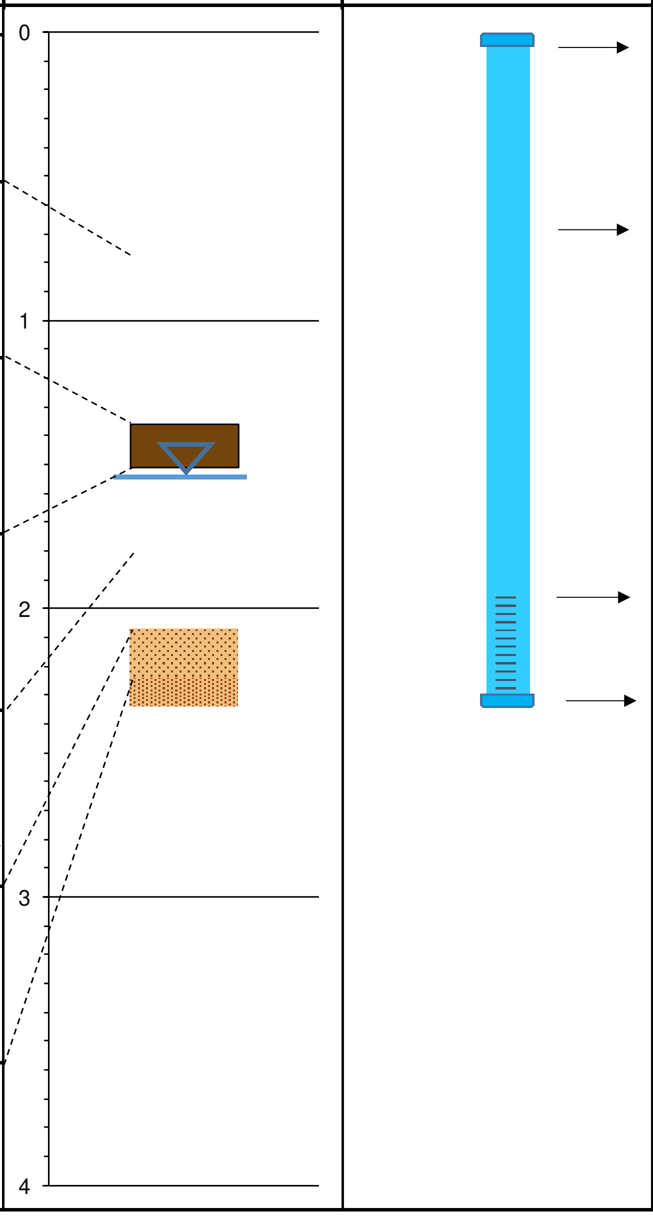
Unit 4:
1.51 - 1.79
Dry dark brown unconsolidated well sorted fine grained SAND. Increased organic content.

Unit 5:
1.79 - 2.07
Moist dark brown unconsolidated medium-grained SAND. Clasts of quartz and feldspar.

Unit 6:
2.07 - 2.24
Wet, medium brown to beige consolidated fine grained SAND. Increase in clay content with depth, clumping takes place.

Unit 7:
2.24 - 2.34
Wet begie fine grained quartz-rich SAND. Contains layers of clayey material.

Lithology (mbgl) | **Construction**



Comments

End Cap

50 mm solid PVC

(~1.50 metres of 50 mm slotted PVC)

End Cap

Excavated By:	GEOSS	**Remarks:**	End of Hole = 2.340 mbgl. Water intersected at 1.640 mbgl.
Drill Method:	Hand Auger		
Logged By:	Zita Harilall		

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16 Appendix C: Field Photos




Photo 1 - 10: Soil profiles encountered at PZ1

Photo 11: Piezometer 1 (PZ1)




Photo 12 - 17: Soil profiles encountered at PZ2

Photo 18 - 21: Soil profiles encountered at KRC_PZ3 and piezometer 3 (KRC_PZ3)

Photo 22: Piezometer 3 (PZ3)

Photo 23: West entrance to Klip Road Cemetery

Photo 24: Princess Vlei

17 Appendix D: Laboratory Results

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2024-06-11

TEST REPORT

Water

Geoss South Africa (Pty) Ltd

Attn: Alison McDuling

P.O.Box 12412
Die Boord, Stellenbosch
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Sample Details					
SampleID	W52426	W52427	W52428	W52429	
Water Type	Drinking Water	Drinking Water	Drinking Water	Drinking Water	
Water Source	Borehole				
Sample Temperature					
Description	PZ1	PZ2	PZ3	Princess Vlei	
Batch Number	PZ1	PZ2	PZ3	Princess Vlei	
PO Number	5269_A	5269_A	5269_A	5269_A	
Date Received	2024-06-06	2024-06-06	2024-06-06	2024-06-06	
Condition	Good	Good	Good	Good	

Water - Routine

	Unit	Method	Uncertainty	Limit	Results	Results	Results	Results	Results
pH@25C (Water)		VIN-05-MW01	^^^	>= 5 to <= 9.7	5.61	6.66	6.67	7.93	
Conductivity@25C (Water)	mS/m	VIN-05-MW02	^	<= 170	298	60.7	59.8	71.3	
Turbidity (Water)*	ntu			<= 5	8808.00	699.00	>10000	18.3	
Total dissolved solids (Water)*	mg/L			<= 1200	2020.44	411.55	405.44	483.41	
Free Chlorine (Water)*	mg/L			<= 5	<0.02	<0.02	0.16	<0.02	
Ammonia (NH_4) as N (Water)	mg/L	VIN-05-MW08	8.90%	<= 1.5	2.01	<0.15	<0.15	<0.15	
Nitrate as N (Water)	mg/L	VIN-05-MW08	11.00%	<= 11	8.30	19.38	<1.00	<1.00	
Nitrite as N (Water)	mg/L	VIN-05-MW08	4.50%	<= 0.9	<0.05	0.13	<0.05	<0.05	
Chloride (Cl^-) - Water	mg/L	VIN-05-MW08	10.12%	<= 300	578.66	42.37	93.54	114.63	
Sulphates (SO_4) - Water	mg/L	VIN-05-MW08	7.56%	<= 500	522.57	41.26	28.72	33.58	
Fluoride (F) - Water	mg/L	VIN-05-MW08	12.30%	<= 1.5	<0.15	<0.15	<0.15	<0.15	
Alkalinity as $CaCO_3$ (Water)*	mg/L				44.30	119.40	120.10	132.60	
Colour (Water)*	mg/L Pt-Co			<= 15	22	<15	26	22	
Total Organic Carbon (Water)*	mg/L			<=10	65.7	9.04	19.2	15.8	
Date Tested					2024-06-06	2024-06-06	2024-06-06	2024-06-06	

Water - Metals

	Unit	Method	Uncertainty	Limit	Results	Results	Results	Results	Results
Calcium (Ca) - Water	mg/L	VIN-05-MW43	14.60%		152	58	47	49	
Magnesium (Mg) - Water	mg/L	VIN-05-MW43	8.49%		75	11	7	10	
Sodium (Na) - Water	mg/L	VIN-05-MW43	11.45%	<= 200	315	35	60	71	
Potassium (K) - Water	mg/L	VIN-05-MW43	9.42%		49	5	4	9	

Please click here for SANS241-1:2015 drinking water limits

Test results relate only to the items tested as received. This Document shall not be reproduced without the written approval of Vinlab (Pty) Ltd.Opinions and interpretations expressed herein are outside the scope of SANAS accreditation. Results for methods VIN-05-MW12, 13 and 14, are based on Cq values, a positive result (detected) indicates a Cq value <35 and a negative result (non-detected) indicates a Cq value of >35.

*** Not SANAS Accredited. Results marked "Not SANAS Accredited" in this report are not included in the SANAS Scope of Accreditation for Vinlab.**

Vinlab is not liable to any client for any loss or damages suffered which could, directly or remotely, be linked to our services Alcohol results are obtained using the most appropriate or a combination of one of the following methods: Py= pycnometer; W=winescan; Al=alcolyzer. W = Winescan. Micro results: Enumeration of yeast: WL nutrient, 3 days unless otherwise specified, 30°C. Samples that have had prior microbiological spoilage or treatment for spoilage should always be sterile filtered at bottling. SO_2 additions less than 10 days may depress the growth of microbes in culture although they are viable/active in the wine. Some microbes, especially lactobacilli, may not grow in culture even where viable/potentially active in the wine.

^ - Conductivity <1000mS/m = ±1mS/m , >1000mS/m = ±9mS/m
^^ - COD, LR = ±16mg/L, MR = ±48mg/L, HR = ±477mg/L
^^^ - pH ± 0.1

Doc No V53421 | VIN 09-01 07-05-2024 | Page: 1 of 3 | Visit Vinlab H20

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Water

Geoss South Africa (Pty) Ltd

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Zinc (Zn) - Water	mg/L	VIN-05-MW43	19.40%	<= 5	0.100	0.013	<0.008	<0.008	
Antimony (Sb) - Water*	µg/L			<=20	<13.0	<13.0	<13.0	<13.0	
Arsenic (As) - Water*	µg/L			<= 10	<10.0	<10.0	<10.0	<10.0	
Boron (B) Water	µg/L	VIN-05-MW43	11.79%	<= 2400	119	25	41	62	
Cadmium (Cd) Water	µg/L	VIN-05-MW43	12.26%	<= 3	1	1	<1	<1	
Chromium (Cr) - Water	µg/L	VIN-05-MW43	13.03%	<= 50	7	5	6	<4	
Copper (Cu) - Water	µg/L	VIN-05-MW43	11.57%	<= 2000	<2	<2	<2	<2	
Iron (Fe) - Water	µg/L	VIN-05-MW43	12.49%	<= 2000	3046	237	587	253	
Lead (Pb) - Water	µg/L	VIN-05-MW43	16.32%	<= 10	<8	<8	14	<8	
Manganese (Mn) - Water	µg/L	VIN-05-MW43	12.44%	<= 400	26	39	47	27	
Nickel (Ni) - Water	µg/L	VIN-05-MW43	17.38%	<= 70	<8	<8	<8	<8	
Selenium (Se) - Water*	µg/L			<= 40	<10.0	<10.0	<10.0	<10.0	
Aluminium (Al) - Water	µg/L	VIN-05-MW43	13.49%	<= 300	4830	956	7534	163	
Cyanide (CN) - Water*	µg/L			<= 200	36.0	11.0	15.0	11.0	
Mercury (Hg) - Water*	µg/L			<= 6	3	<1.0	3	<1.0	
Barium (Ba) Water	µg/L	VIN-05-MW43	14.09%	<= 700	57	23	13	36	
Uranium (U) - Water*	µg/L			<= 30	<28	<28	<28	<28	
Date Tested					2024-06-06	2024-06-06	2024-06-06	2024-06-06	

Water - Micro

	Unit	Method	Uncertainty	Limits	Results	Results	Results	Results	Results
Total Coliforms (Water)	cfu/100mL	VIN-05-MW09		<= 10	nd	100	nd	4600	
E-Coli (Water)	cfu/100mL	VIN-05-MW09		not detected	nd	nd	nd	2000	
Heterotrophic plate count*	cfu/mL			<= 1000	50	900	720	4600	
Date Tested					2024-06-06	2024-06-06	2024-06-06	2024-06-06	

Comments

W52426
Two Samples received,

Sample centrifuged prior to the following analysis to remove suspended material:
-Gallery
-Cyanide
-TOC
-Metals (ICPMS + OES)
Ion balance = 0.6%

Please click here for SANS241-1:2015 drinking water limits

^ - Conductivity <1000mS/m = ±1mS/m , >1000mS/m = ±9mS/m
^^ - COD, LR = ±16mg/L, MR = ±48mg/L, HR = ±477mg/L
^^^ - pH ± 0.1

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Water

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W52427 Two Samples received, Sample centrifuged prior to the following analysis to remove suspended material: -Gallery -Cyanide -TOC -Metals (ICPMS + OES) Ion balance = 0.3%
W52428 Two Samples received, Sample centrifuged prior to the following analysis to remove suspended material: -Gallery -Cyanide -TOC -Metals (ICPMS + OES) Ion balance = 3.2%
W52429 Two Samples received, Ion balance = 3.5%

AEFourie

Adelize Fourie
Laboratory Manager (Waterlab)
VIN-05-
M01,M02,M03,M04,M05,MO8,M10,M28,
M43, MW01, MW02, MW03, MW04,
MW05, MW06, MW07, MW08/9/10,
MW12, MW13, MW14

Please click here for SANS241-1:2015 drinking water limits

^ - Conductivity <1000mS/m = ±1mS/m , >1000mS/m = ±9mS/m
^^ - COD, LR = ±16mg/L, MR = ±48mg/L, HR = ±477mg/L
^^^ - pH ± 0.1

18 Appendix E: Risk Rating Criteria

Nature of impact	Description
Positive	Impacts would benefit the receiving environment (including people).
Negative	Impacts would harm the receiving environment (including people).
Type of impact	**Description**
Direct	Impacts that result directly from the causal activity, usually at the same time and in the same space as that activity
Indirect	Secondary impacts may result from direct impacts, generally occurring later in time and may manifest elsewhere in space (e.g. downstream)
Induced	Impacts that may happen as a consequence of the Project (e.g., migration of people along newly created access routes)
Cumulative	Impacts that add to or magnify existing or reasonably foreseeable future impacts on the same receiving environment or specific resource
Extent Rating	**Description**
Site specific	Impact (and implications) limited to the project site.
Local	Impact extends only as far as the activity, limited to the site and its immediate surroundings, and local assets/ resources.
Regional	Impact extends to a regional scale, and affects provincial resources, e.g. District or Province; Western Cape
National	Impact extends to a national scale, and affects national resources; South Africa.
International	Impact extends across national borders, and affects global resources.
Duration Rating	**Description**
Short term	0 - 5 years
Medium term	5 - 15 years
Long term	Where the impact will cease after the operational life of the activity, either because of natural processes or by human intervention. Generally >15 years but <30 years
Permanent	Where the impact will, for all intents and purposes, endure in perpetuity. That is, it would be regarded as 'irreversible'
Intensity Rating	**Description**
Low	Where the impact affects the environment in such a way that a small or negligible proportion of resources and/or beneficiaries would be affected. Receptors in the receiving environment are not threatened or vulnerable, and affected communities have negligible or very low dependence on affected resources for livelihoods, health and safety.
Medium	Where a sizeable proportion of resources and/ or of beneficiaries would be affected, and natural, cultural and social functions and processes would continue, albeit in a modified way. Receptors in the receiving environment are moderately threatened or vulnerable, and/ or affected communities have some dependence on affected resources for livelihoods, health and safety, affected resources could be substituted.
High	Where most/ a major proportion of resources and/ or beneficiaries would be affected, and natural, cultural and social functions or processes are altered to the extent that they would temporarily or permanently cease. Receptors in the receiving environment are highly threatened or vulnerable (i.e. close to environmental or legal thresholds, standards or targets), and affected communities are highly dependent on affected resources for livelihoods, health and safety, and/ or resources are considered to be irreplaceable (if lost they could not be substituted, and/ or their loss would undermine achieving targets,

	standards).
Probability Rating	**Description**
Improbable	Where the possibility of the impact materializing is very low, but it could occur e.g. in unplanned / upset conditions
Possible	Where there is a possibility that the impact will occur during normal operations.
Probable	Where the impact is expected to occur during normal operations
Definite	Where the impact will undoubtedly occur.
Confidence Rating	**Description**
High	High confidence in predictions.
Medium	Some uncertainty in predictions e.g. due to information gaps, constraints on study
Low	Little confidence in predictions e.g. due to constraints on study, information gaps, inherent uncertainties
Significance Rating	**Description**
Negligible	Where the receiving environment (including people) would not be materially affected by the proposed activity(ies). *There would be no need for mitigation.*
Very Low	Where there would be minimal effect on the environment or human wellbeing, and impacts would be well within environmental quality standards or targets, or legal requirements. *There would be no need for mitigation.*
Low	Where there would be little material effect on the environment or human wellbeing, and impacts would be well within environmental quality standards or targets, or legal requirements. *Minor mitigation measures may be required.*
Moderate	Where the activity (ies) would have a material effect on the receiving environment (including people), legal requirements would still be met but thresholds of potential concern with regard to environmental quality may be crossed. *Mitigation measures – avoidance, minimization and rehabilitation/ restoration, and in some cases offsets/ compensation - would be needed to reduce the impact significance.*
High	Where there would be major effects on the receiving environment to the extent where environmental quality standards or targets may be jeopardized, legal requirements may not be met, and the health, safety, livelihoods and/or wellbeing of affected people could be jeopardized. *Mitigation measures – preferably avoidance/ impact prevention, minimization, rehabilitation/ restoration, and offsets/ compensation – are essential to reduce the impact significance substantially.*
Very High	Where there would be severe or substantial effects on the receiving environment to the extent where environmental quality standards or targets would be undermined/ exceeded, there would be non-compliance with legal requirements or commitments, and the health, safety, livelihoods and/or wellbeing of affected people would be jeopardized. *Mitigation measures – avoidance or prevention of impacts as a priority would be required, since impacts are unacceptable. Additional measures to minimize, rehabilitate/ restore, and offset/ compensate for residual impacts would be – are essential to reduce the impact significance substantially*

(last page)