Geohydrological and geotechnical assessment for the proposed expansion of the Melkhoutsfontein Cemetery, Still Bay.

REPORT:	***PREPARED BY:***
GEOSS Report No: 2020/07-04	Charl Muller & Dale Barrow GEOSS South Africa (Pty) Ltd Unit 12, Technostell Building, 9 Quantum Street, Techno Park Stellenbosch 7600 Tel: (021) 880-1079 Email: info@geoss.co.za (www.geoss.co.za)
PREPARED FOR: John Sharples Sharples Environmental Services cc 102 Merriman Street George 6530 Tel: 044 873 4923 Email: john@sescc.net	

03 July 2020

GROUNDWATER AND EARTH SCIENCES
GEOSS
SOUTH AFRICA (Pty) Ltd

EXECUTIVE SUMMARY

GEOSS South Africa (Pty) Ltd was appointed by Sharples Environmental Services cc to complete a geotechnical and groundwater impact assessment for the expanding of the existing Melkhoutsfontein Cemetery near Still Bay. The aim of the hydrogeological assessment is to determine the impacts the proposed expansion may have on groundwater, whereas the geotechnical study is to determine and characterise the engineering properties of the site for road and foundation construction, including excavatability of the subsurface.

The site is directly underlain by the Wankoe Formation (calcarenite with aeolian cross-bedding and calcrete lenses). The Wankoe Formation is locally covered by light grey to pale-red sandy soil just south of the proposed cemetery site. The erosive action caused by the Goukou River and adjacent drainage channels towards the west and southwest of the site have exposed rocks of the De Hoopvlei Formation and Bokkeveld Group. The De Hoopvlei Formation is comprised of calcarenite with shells and conglomerate lenses. The Bokkeveld Group is comprised of shale and siltstone with occasional thin sandstone beds.

The underlying aquifer at the site is classified as an intergranular aquifer with an average yield potential of 5.0 L/s. Whereas, the regional groundwater quality, as indicated by electrical conductivity (EC), is in the range of 70 – 300 mS/m for the area. This is considered to be "good to moderate" quality for water, with respect to drinking water standards.

From the hydrocensus, it is clear that there are a number of groundwater users surrounding the cemetery. The groundwater is mainly used for irrigation and livestock watering; however, plans are in place for the water to be used for town supply. Groundwater was intersected in one of the trial pits (TP09) where the water level measured 2.9 mbgl after 1 hour. This site is dominated by fine sands of varying colour and is loose to very loose in consistency. With depth, the sands become medium dense and have a higher proportion of fines. A calcrete lens is present (intersected across the entire site). This lens ranges from 0.20 metres to at least 1.00 metres in thickness and in many places it is too hard for excavation with TLB.

The study site has been classified as having a groundwater vulnerability classification of "**high**" The contamination risk is considered to be "**Medium-High**". Given the relatively shallow-water table and presence of down-gradient drainage channel and spring, strict mitigation measures and groundwater monitoring plan should be implemented.

The consequence associated with contamination is considered to be very high as there are multiple municipal supply sources within 250 m of the cemetery expansion area. The aquifer developed for Melkhoutfontein is of strategic importance and requires strict protection.

The cemetery expansion should only be allowed in the case that no groundwater abstraction takes place within 250 m of the cemetery. This affects the developed municipal sources, which likely has significant implications. The following recommendations are made:

- The cemetery expansion can proceed if groundwater is not used for potable consumption within 250 m of the existing or expanded cemetery.
- Irrespective of whether the expansion takes place or not, groundwater monitoring should be initiated on site. Additionally, relevant mitigation measures and best practice procedures must be employed to minimize contamination of the subsurface takes place (**Table 11**, **12**, **13**, – Proposed Mitigation).
- Pz_2, BH4 and SPR01 should be considered as potential groundwater monitoring points.

TABLE OF CONTENTS

LIST OF MAPS AND FIGURES

LIST OF TABLES

ABBREVIATIONS

BH	Borehole
CGS	Council for Geoscience
DWA	Department of Water Affairs (used to be Department of Water Affairs and Forestry)
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water Affairs and Sanitation
EC	electrical conductivity
L/s	litres per second
m	metres
mbch	meters below collar height
mbgl	metres below ground level
mm	millimetre
mS/m	milli-Siemens per metre
NGA	National Groundwater Archive
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.

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.

Inferred: Where a geological contact or fault is believed to exist however is not confirmed.

DCP: Dynamic Cone Penetrometer

Suggested reference for this report: GEOSS (2020). Geohydrological and geotechnical assessment for the proposed expansion of the Melkhoutsfontein Cemetery, Still Bay. GEOSS Report Number: 2020/07-04. GEOSS South Africa (Pty) Ltd. Stellenbosch, South Africa.

Cover photo: Cover photo taken during site visit.

GEOSS project number: 2020_06-3971

Review by: Julian Conrad (3 July 2020).

CURRICULUM VITAE – Dale Barrow

GENERAL

Nationality:	South African
Profession:	Geohydrologist and Director
Specialization:	Groundwater exploration, development, management and monitoring including numerical modeling. Development of the groundwater component of catchment management strategies and other Resource Directed Measures (RDM) activities.
Position in firm:	Geohydrologist at GEOSS -Geohydrological and Spatial Solutions International (Pty) Ltd
Date commenced:	February 2008
Year of birth & ID #:	1985 – 851205 5227 082
Language skills:	English (mother tongue), Afrikaans (average)

KEY SKILLS

- Groundwater component of Catchment Management Strategies and other Groundwater Resource Directed Measures.
- Groundwater exploration - (aerial photo interpretation, resistivity, magnetic and EM34 geophysical surveys for borehole siting purposes)
- 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.
- Numerical modelling of groundwater flow and mass transport.
- Groundwater contamination assessments.
- GIS / WISH and GW Vistas and typical software skills.

EDUCATIONAL AND PROFESSIONAL STATUS

Qualifications

2017	MBA (Cum Laude)	University of Stellenbosch, South Africa
2010	M.Sc. (Geohydrology)	University of the Free State, South Africa
2007	B.Sc (Hons) Structural Geology	University of Stellenbosch, South Africa
2006	B.Sc Geology – Applied Earth Science	University of Stellenbosch, South Africa

Courses

2016	SPRING Software Modelling Course
2013	Aquifer Firm Yield; Wellfield Design; Wellfield costing
2010	Introduction to QGIS (GISSA)
2010	Presentation Skills (Elsabé Daneel productions cc)
2009	Introduction to Isotope Hydrology in Southern Africa (GSSA)
2009	Aquifer Mechanics (IGS-UOFS)
2009	Groundwater Chemistry (IGS-UOFS)
2009	Groundwater Geophysics (IGS-UOFS)
2009	Groundwater Modelling (IGS-UOFS)
2009	Groundwater Management (IGS-UOFS)

Memberships

- Groundwater Division of the Geological Society of South Africa
- South African Council for National Scientific Professions (SACNASP) Mem. No. 400289/13

EMPLOYMENT RECORD

1 February 2008 to present: GEOSS – Geohydrological and Spatial Solutions International (Pty) Ltd, Stellenbosch

23 July - November 2019 Design and part time lecturing of the Hydrogeology course for 3rd year students at Stellenbosch University.

CURRICULUM VITAE – Charl Muller

GENERAL

Nationality:	South African
Profession:	Geohydrologist
Specialization:	Groundwater exploration, regional development, monitoring and management, geohydrological impact assessment including GIS and Remote Sensing expertise.
Position in firm:	Geohydrologist at GEOSS South Africa (Pty) Ltd
Date commenced:	16th October 2017
Language skills:	English (good – speaking, reading and writing) Afrikaans (good - speaking, reading and writing).

KEY SKILLS

- Groundwater sampling, soil sampling, field measurements, borehole logging, data logging for groundwater monitoring, borehole depth and water level measurements, augering for piezometer installation, groundwater geophysics and conducting hydrocensus studies.

RELEVANT EXPERIENCE

- Numerous groundwater exploration - this includes aerial photo interpretation, resistivity, magnetic and electromagnetic geophysical surveys for borehole siting purposes, data analysis and interpretation and hydrogeological conceptualization, development, monitoring and management projects.
- Extensive satellite image data processing (including geo-referencing) for the Validation and Verification projects within the Breede-Overberg Catchment Management Agency.
- Smaller projects involving borehole siting's (aerial photo interpretation, geological mapping, geophysical profiling).
- Projects involving drilling supervision and pumping test supervision with associated data interpretation (FC Method) and writing of geohydrological reports.
- Groundwater and groundwater quality monitoring projects involving appropriate sampling, measurements, data analysis and reporting.

EDUCATIONAL AND PROFESSIONAL STATUS

Qualifications

2017	MEng (Geotechnical Engineering):	University of Stellenbosch, South Africa
2015	BSc Hon – Earth Science Degree:	University of Stellenbosch, South Africa
2014	BSc - Earth Science Degree:	University of Stellenbosch, South Africa

Memberships

- Groundwater Division of the Geological Society of South Africa – Member No. 6080/16

EMPLOYMENT RECORD

October 2017 to March 2019:	GEOSS – Geohydrological and Spatial Solutions International (Pty) Ltd, Stellenbosch
March 2019 to present	GEOSS SOUTH AFRICA (Pty) Ltd.

SPECIALIST DECLARATION

We, Charl Muller and Dale Barrow, as the appointed independent specialists hereby declare that we:

- act/ed as the independent specialist in this application;
- regard the information contained in this report as it relates to my 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
- am aware that a false declaration is an offence in terms of regulation 71 of GN No. R. 543.

Dale Barrow
GEOSS South Africa (Pty) Ltd.
SACNASP - 400289/13
03 July 2020

Charl Muller
GEOSS South Africa (Pty) Ltd.
SACNASP – 123456 (Candidate)
03 July 2020

1. INTRODUCTION

GEOSS South Africa (Pty) Ltd was appointed by Sharples Environmental Services cc to complete a geotechnical and groundwater impact assessment for the expanding of the existing Melkhoutsfontein Cemetery near Still Bay (**Map 1**). The aim of the hydrogeological assessment is to determine the impacts the proposed expansion may have on groundwater, whereas the geotechnical study is to determine and characterise the engineering properties of the site for road and foundation construction, including excavatability of the subsurface.

The study included a site visit, to assess National Groundwater Archive (NGA) borehole data, assess if there are proximal groundwater users such as neighbouring farms and small holdings and to conduct the geotechnical investigation. Twelve trial pits were excavated into the subsurface to determine soil characteristics, presence of groundwater, at what depth it occurs as well as the groundwater quality.

2. SCOPE OF WORKS

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

- Assessment of impact on geohydrological resources as a result of the expansion of the existing cemetery.
- Provide recommendations to minimize or mitigate impacts.
- Determine the engineering properties of the in-situ material for road and foundation construction, including excavatability of subsurface.

The results of the field investigation are presented in this report along with the data analysis and interpretation.

3. METHODOLOGY

The procedure adopted for this study involved a desktop study followed by the field work. The initial desktop study involved obtaining and reviewing all relevant data to the project. This included analysing data from the NGA, as well as groundwater yield, groundwater chemistry and geological maps of the area.

A site visit was then conducted to verify as much of this data as possible, as well as collect any additional data. This included a hydrocensus of groundwater users in the area, as well as noting any subsurface conditions where possible. Twelve trial pits were excavated in open land to measure water level depth, water quality and to characterise soil conditions.

All collected data was analysed and interpreted to assess the potential risks associated with the intended site development as they pertain to groundwater; together with classifying soil engineering properties for further expansion.

Map 1: Locality of the Melkhoutsfontein Cemetery, Still Bay, Western Cape.

4. SETTING

4.1 Topography

The study area (Melkhoutsfontein) is situated in the Western Cape on the outskirts of Still Bay with surrounding topography comprising of low relief, with an average elevation of 45 m above mean sea level (mamsl). The site is situated in the quaternary catchments, H90E, which has a General Authorisation abstraction volume of 275 m^3/ha/yr.

4.2 Climate

The Melkhoutsfontein area experiences a semi-arid climate with low rainfall occurring throughout the year. **Figure 1** shows the monthly average air temperature and rainfall distribution and **Figure** 2 shows the monthly median rainfall and evaporation distribution for the Melkhoutsfontein area (Schulze, 2009). Melkhoutsfontein receives a mean annual precipitation average of 433 mm/a. In terms of monthly averages, the rainfall does not exceed evaporation during the year.

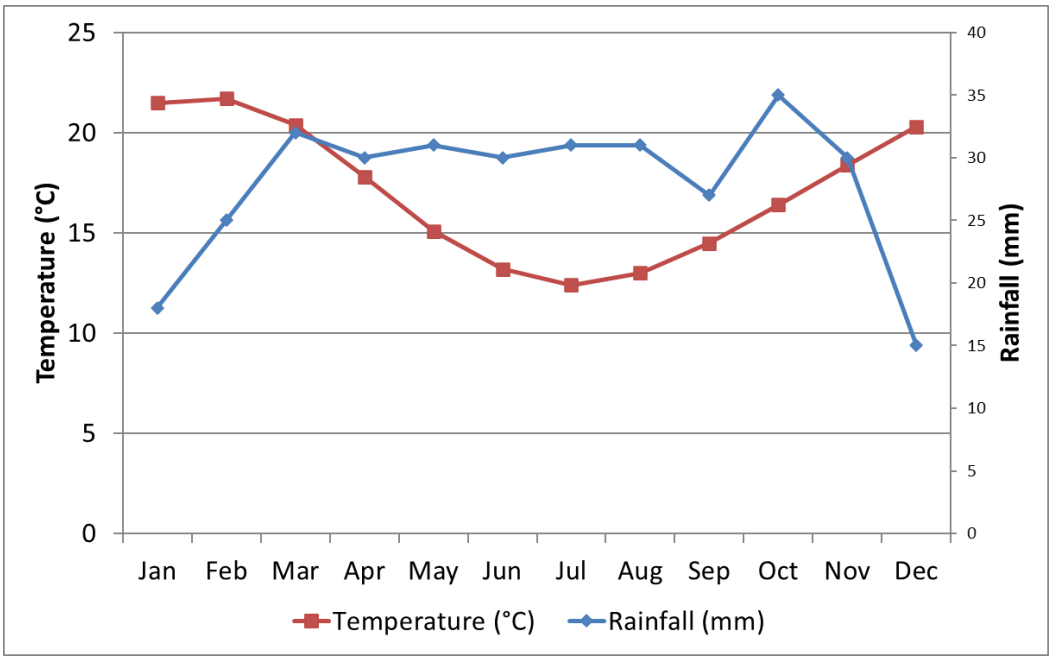


Figure 1: Monthly average air temperature and rainfall distribution for Melkhoutsfontein (Schulze, 2009).

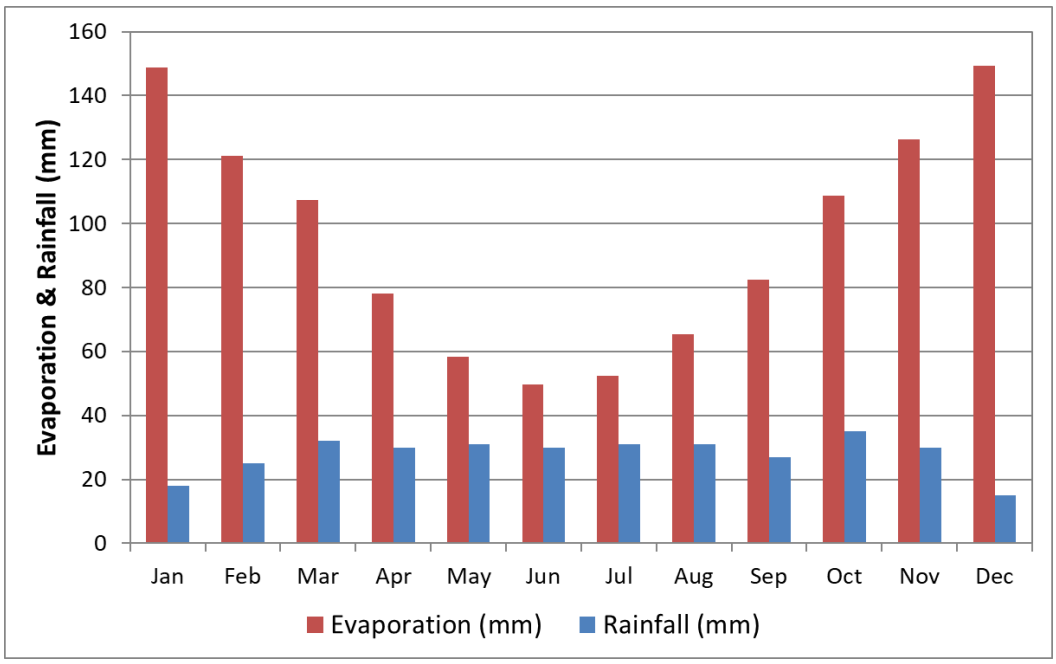


Figure 2: Monthly average rainfall and evaporation distribution for Melkhoutsfontein (Schulze, 2009).

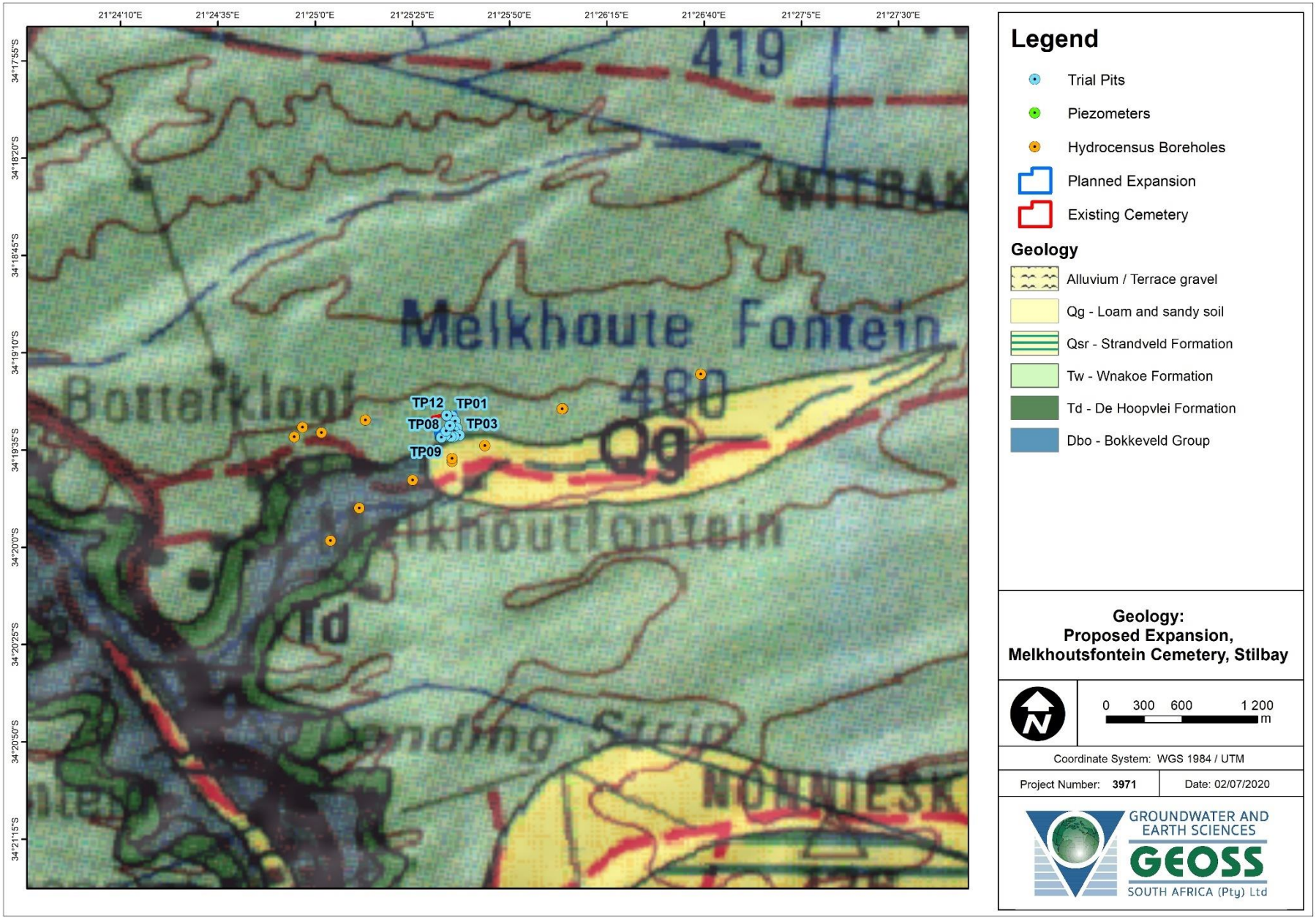
4.3 Geology

The Geological Survey of South Africa (now the Council for Geoscience (CGS)) has mapped the area at 1:250 000 scale (3420 Riversdale). The geological setting is shown in Error! Reference source not found. and the main geology of the area is listed in **Table 1**.

Table 1: Geological formations within the study area.

Code	Formation	Group	Lithology
	n/a – Quaternary Age		River-terrace gravel.
Qg			Light grey to pale-red sandy soil.
Qsr	Strandveld Formation	**Bredasdorp Group**	Predominantly white dune sand with calcrete lenses.
Tw	**Wankoe Formation**		**Calcarenite with aeolian cross-bedding and calcrete lenses**.
Td	De Hoopvlei Formation		Calcarenite with shells and conglomerate lenses.
Dbo	-	Bokkeveld Group	Shale and siltstone with occasional thin sandstone beds.

The site is directly underlain by the Wankoe Formation comprised of calcarenite (type of limestone) that show signs of aeolian type cross-bedding with the occasional presence of calcrete lenses. The Wankoe Formation is locally covered by light grey to pale-red sandy soil just south of the proposed cemetery site. The erosive action caused by the Goukou River and adjacent drainage channels towards the west and southwest of the site has exposed rocks of the De Hoopvlei Formation and Bokkeveld Group. The De Hoopvlei Formation is comprised of calcarenite with shells and conglomerate lenses. The Bokkeveld Group is comprised of shale and siltstone with occasional thin sandstone beds.



Map 2: Geological setting of the area (3420, Riversdale).

4.1 Hydrogeology

The underlying aquifer at the site is classified by the Department of Water Affairs and Forestry (DWAF, 2002) as an **intergranular aquifer** with an average **yield potential of 5.0 L/s** (**Map 3**). An intergranular aquifer refers to groundwater that is stored and flows through pore spaces between grains of sediment or weathered material. Based on the DWAF (2002) mapping of the regional **groundwater quality**, as indicated by electrical conductivity (EC), is in the range of 70 – 300 mS/m for the area. This is considered to be "**good to moderate**" quality for water (**Map 4**), with respect to drinking water standards. It is important to note that a small stream/drainage channel caused by the presence of a spring is located just south of the cemetery site. This flows towards the west into the Goukou River. Both the stream and river should be considered as a potential receptor for potential contamination.

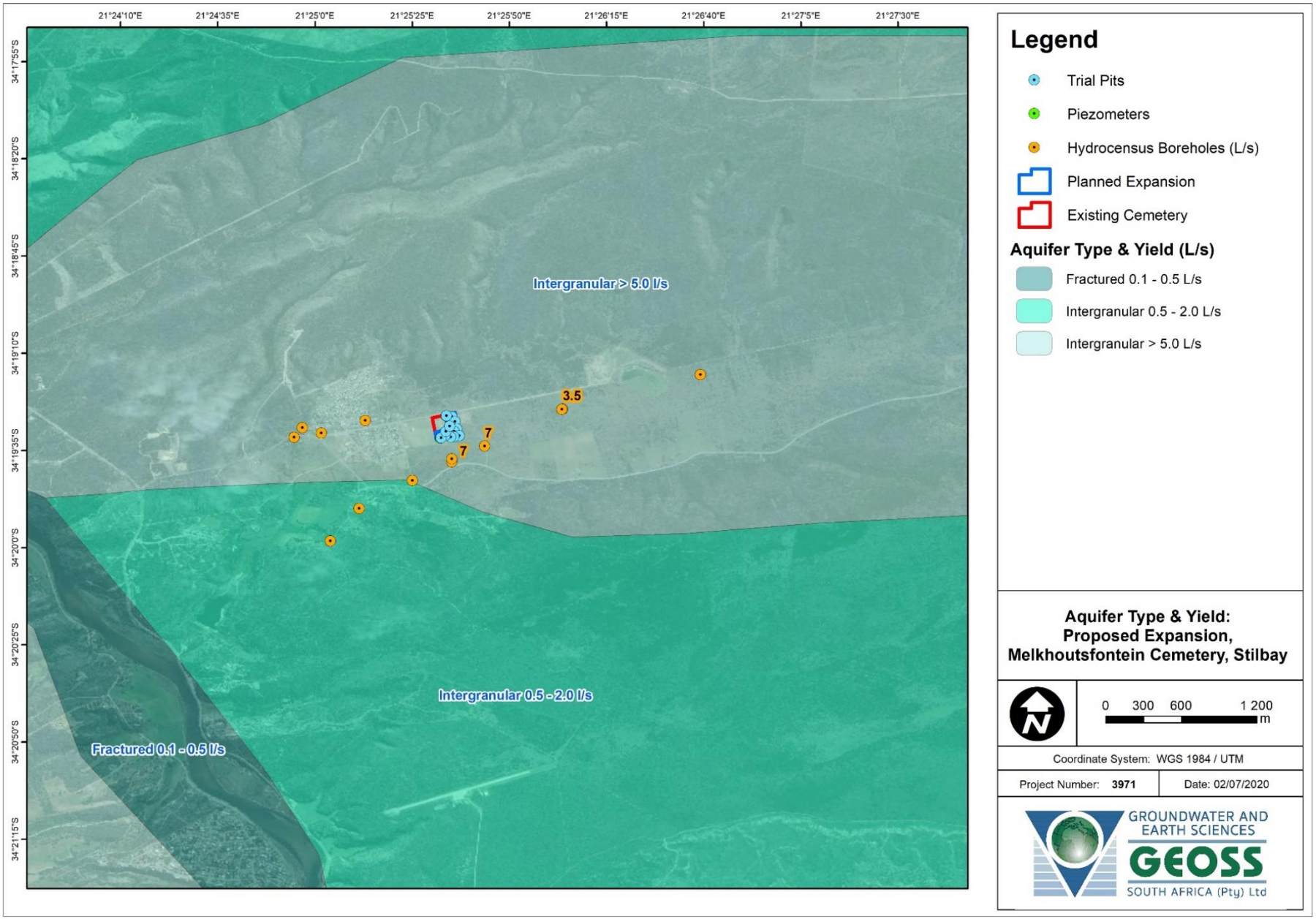
4.2 Aquifer vulnerability classification

The national scale groundwater vulnerability map, which was developed according to the DRASTIC methodology (DWAF, 2005), indicates that the site has a "**high**" **vulnerability** to surface-based contaminants (**Map 5**).

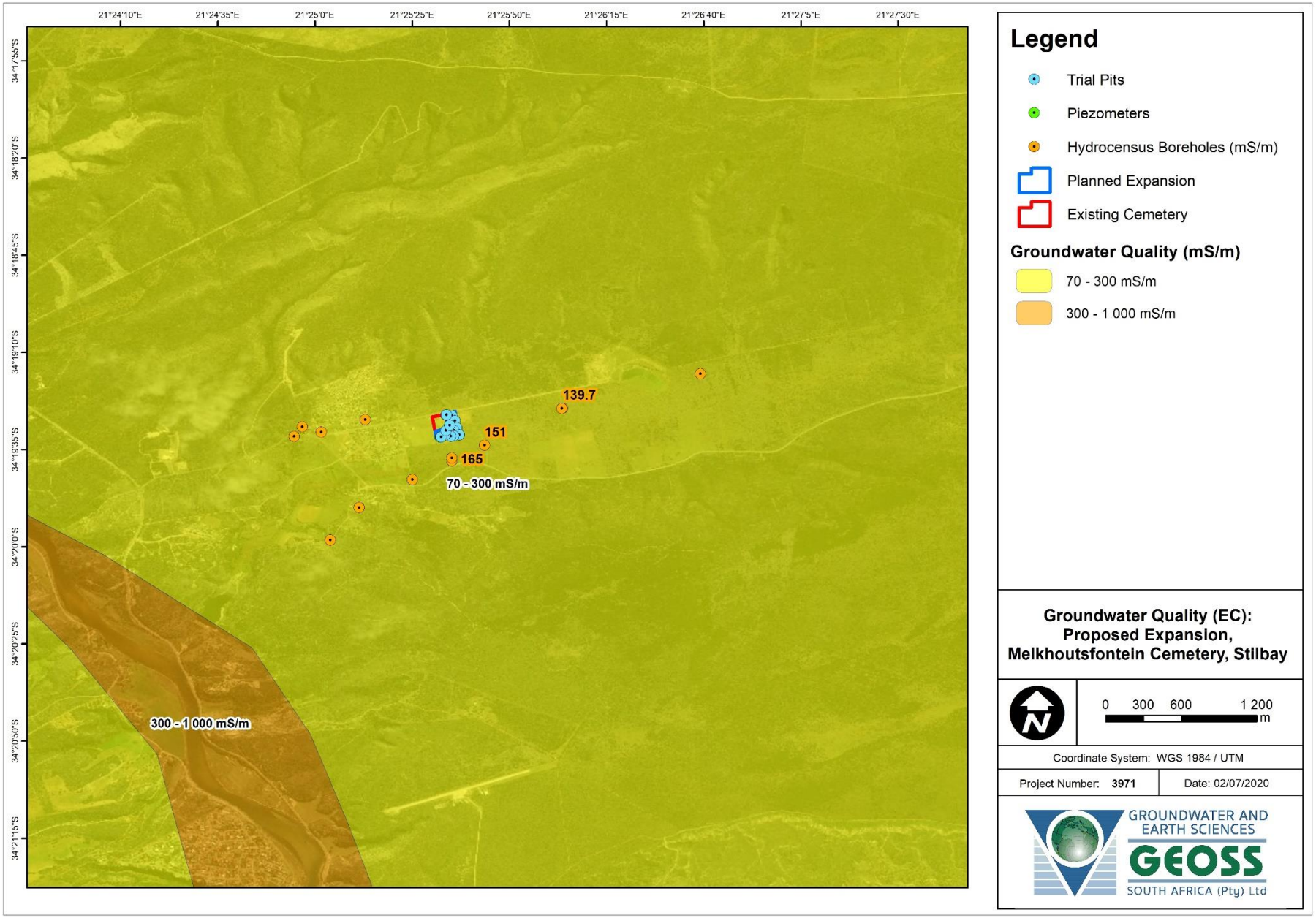
The DRASTIC method considers the following factors:
D = depth to groundwater (5); R = recharge (4); A = aquifer media (3); S = soil type (2); T = topography (1); I = impact of the vadose zone (5); C = conductivity (hydraulic) (3)

The number indicated in parenthesis at the end of each factor description is the weighting or relative importance of that factor. This "high" rating is associated with relatively shallow groundwater level (observed on and near the site, including the presence of a natural spring down-gradient of the site). The Wankoe Formation comprises largely unconsolidated sands and calcarenite (clastic or detrital sedimentary rock consisting largely of calcium carbonate grains). The aquifer is therefore classified as intergranular and therefore more susceptible to point and non-points sources of contamination. **Figure 3** shows a large piece of calcarenite observed on site.

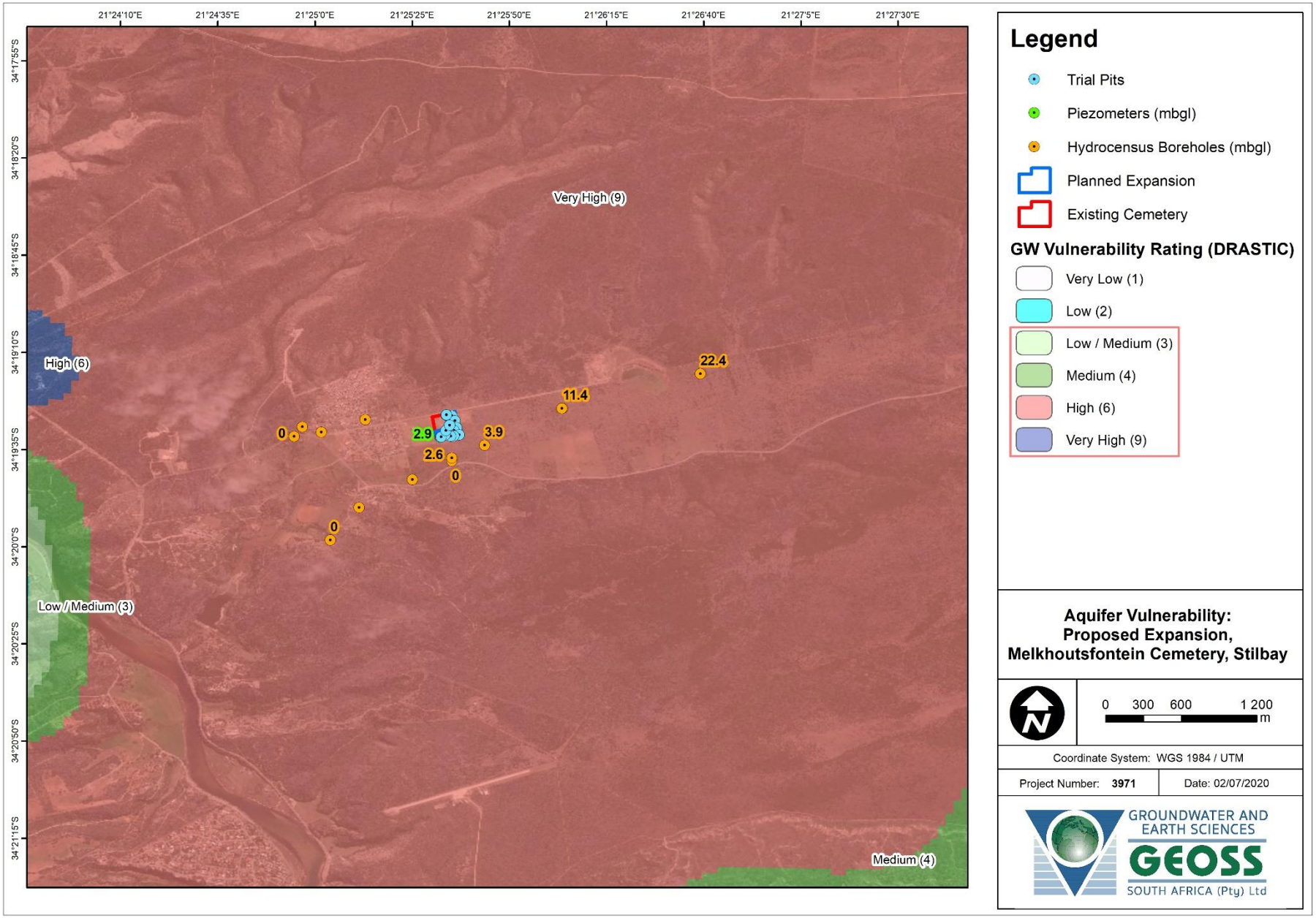
Figure 3: Calcarenite from the study area.



Map 3: Regional aquifer yield (DWAF, 2002) and borehole yields (L/s).



Map 4: Regional groundwater quality (mS/m) from DWAF (2002) and borehole groundwater quality (EC in mS/m).



Map 5: Vulnerability rating (DWAF, 2005) and groundwater depths (mbgl).

5. HYDROCENSUS

A desktop assessment was initially carried out around the property to determine if there were any groundwater users in the area. The National Groundwater Achieve (NGA) database which provides data on borehole positions, groundwater chemistry and yield is currently undergoing maintenance and no information could be retrieved from the database (last date visited 02 July 2020).

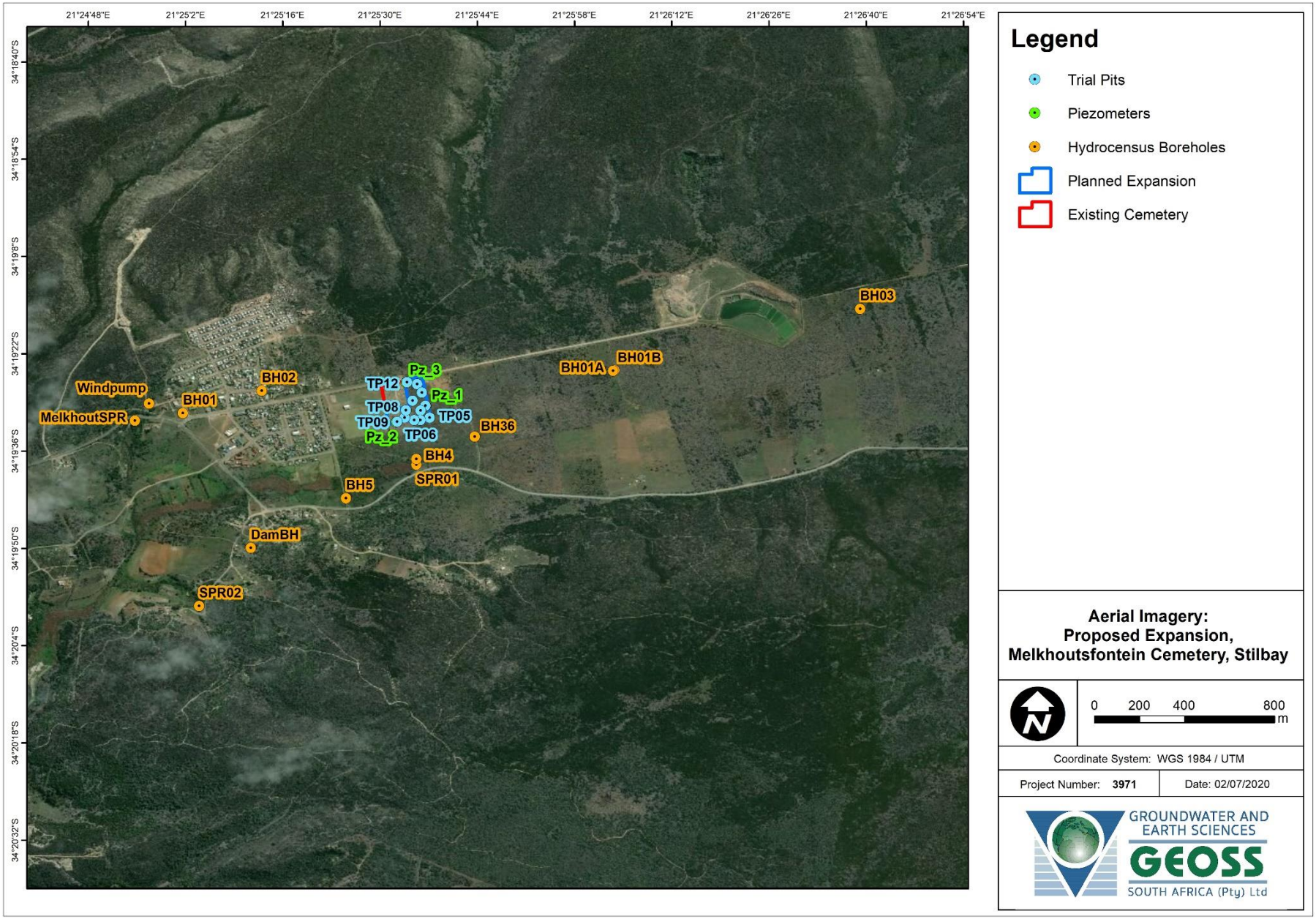
A site visit was conducted on 24 June 2020 to assess groundwater use within the study area (**Map** 6). The results of a field visit investigation are presented in **Table 2**. Based on the hydrocensus data it is evident that there are several groundwater users in the area surrounding the proposed site. The boreholes in the area surrounding the cemetery belong to the Hessequa Local Municipality. The municipality could not provide all the necessary information for most of the boreholes. However, the boreholes located during the site visit have not yet been equipped. These include the boreholes drilled by GHT in 2019.

Table 2: Hydrocensus Site Descriptions

Site Label	Latitude (DD, WGS84)	Longitude (DD, WGS84)	WL (mbgl)	Yield (L/s)	EC (mS/m)	Depth (m)	Comments	Photo
BH01	-34.325151	21.417129	-	-	-	-	Approximate location provided by municipality. No other information available. Could not be located in the field.	No photo.
BH02	-34.324259	21.420275	-	-	-	-	Approximate location provided by municipality. No other information available. Could not be located in the field.	No photo.
BH03	-34.320983	21.44422	22.4	-	-	-	Located in the field. Currently not equipped.	
BH01B	-34.323436	21.434382	11.4	3.5	139.7	24	Privately drilled borehole. Yield tested by GHT in 2019.	

Site Label	Latitude (DD, WGS84)	Longitude (DD, WGS84)	WL (mbgl)	Yield (L/s)	EC (mS/m)	Depth (m)	Comments	Photo
BH01A	-34.323459	21.434329	-	-	-	-	Exploration borehole.	
SPR01	-34.32721	21.426467	-	-	-	-	Not in use flows towards Olive Grove Dam.	No photo.
SPR02	-34.332863	21.417777	-	-	-	-	Approximate location provided by municipality. No other information available. Could not be located in the field.	No photo.
MelkhoutSPR	-34.325456	21.415202	-	-	-	-	Information supplied by the municipality. 3 Springs close proximity each other. Used for Municipal supply.	
DamBH	-34.330538	21.419848	-	-	-	-	Approximate location provided by municipality. No other information available. Could not be located in the field.	No photo.
Windpump	-34.324771	21.415775	-	-	-	-	Approximate location provided by municipality. No other information available.	No photo.

Site Label	Latitude (DD, WGS84)	Longitude (DD, WGS84)	WL (mbgl)	Yield (L/s)	EC (mS/m)	Depth (m)	Comments	Photo
BH4	-34.32699	21.42646	2.58	7	165	40	Drilled by GHT in 2019. Solution cavity within conglomerate well developed. Water strike at 10 and 13 mbgl.	
BH5	-34.32855	21.42365	Dry	-	-	18	Drilled by GHT in 2019. Bh drilled directly into shale and drilling was stopped. No water.	No photo.
BH36	-34.32609	21.4288	3.85	7	151	43	Drilled by GHT in 2019. Solution cavity within conglomerate well developed. Water strike at 13 mbgl.	



Map 6: Hydrocensus boreholes and trial pits.

6. GEOTECHNICAL INVESTIGATION

6.1 Trial Pits

The site visit involved the excavation of 12 trial pits coupled with DCP testing in an attempt to determine groundwater depth and quality, and soil properties respectively. The positions of the trial pits and DCP's were chosen to provide a good spatial coverage of the study area (vegetation permitting). The trial pits were excavated using a tractor loader backhoe (TLB) to a maximum depth of 3 m. Following the excavation, each trial pit was logged and photographed (**Appendix A**). A site walk-over sought to identify and confirm hydrological, hydrogeological and geotechnical features of interest. A total of 12 trial pits were excavated and details are summarised in **Table 3**. Only TP09 intersected water during excavation. The location of the trial pits is presented in **Map** 7.

Table 3: Summary of trial pits.

Label	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Elevation (mamsl)	TP EOH (mbgl)	Sample (S# mbgl)	DCP No.:	DCP EOH (mbgl)
TP01	-34.323987	21.426491	43	3.10	-	DCP01	0.99
TP02	-34.324327	21.426687	42	3.10	-	DCP02	1.02
TP03	-34.324854	21.426827	41	3.50	S1 (1.0) S2 (2.0)	DCP03	1.12
TP04	-34.325045	21.426635	40	1.20 R	-	DCP04	0.91
TP05	-34.325335	21.426994	40	1.10 R	S3 (0.8)	DCP05	1.03
TP06	-34.325428	21.426623	40	0.90 R	-	DCP06	0.84 R
TP07	-34.325435	21.426381	40	3.20	-	DCP07	0.67 R
TP08	-34.325337	21.425998	40	0.70 R	-	DCP08	0.79 R
TP09	-34.325494	21.425701	40	3.30	S4 (0.6) S5 (1.8)	DCP09	0.68 R
TP10	-34.325036	21.426047	40	1.3 R	-	DCP10	0.60 R
TP11	-34.32465398	21.42631198	41	3.00		DCP11	1.02
TP12	-34.32391897	21.42609296	43	3.10		DCP12	1.02

Following the completion of trial pits, DCP testing and a site walkover, a typical soil profile was developed, and is summarised in **Table 4**:

Table 4: Generalised soil profile (note these are disturbed samples).

Depth (mbgl)	Description
0.00 to ± 1.00	Dry, brown & orange brown, loose, intact, fine SAND. Transported sediment.
1.00 to ± 1.50	CALCRETE. Calcrete lens ranging in thickness from 0.20 to > 1.00 metres thick and present as soft to medium hard rock.
1.50 to ± 3.00	Dry, brown & white, medium dense, intact, silty fine SAND. Transported sediment.
> 3.00	Slightly moist, dark brown, medium dense, intact, clayey silty fine SAND. Transported sediment.

This site is dominated by fine SANDs of varying colour and is loose to very loose in consistency. With depth the sands become medium dense and have a higher proportion of fines. A CALCRETE lens is present across the entire site. This lens ranges from 0.20 metres to at least 1.00 metres in thickness and in many places it too hard for excavation with TLB. Groundwater was intersected at only one trial pit (TP09) and present at 2.90 mbgl after about 20 minutes.

Trial Pit logs and photographs are presented in **Appendix A**., and DCP testing logs are presented in **Appendix B.**

6.2 Laboratory Testing

One bulk disturbed soil sample was procured and has been stored should laboratory testing be required at a later stage.

Five bulk disturbed soil samples were procured and sent for laboratory analysis including; MOD, CBR and foundation indicators. These samples were procured to represent the sands above (S1, S3 and S4) and below (S2 and S5) the calcrete lens. Samples above the calcrete lens have little to no fines material while the sands procured below the lens have some fines material which dominated this site. **Table 5** summarises the laboratory results.

Table 5: Summary of laboratory results.

Sample Label	TP	Sample depth (mbgl)	Soil Type	CBR @					PI %	MDD kg/m^3	OMC %
				100%	98%	95%	93%	90%			
S1	TP03	1.0	Fine SAND	14	13	10	9	7	NP	1770	11.3
S2	TP03	2.0	Silty SAND	17	14	11	9	7	NP	1769	11.6
S3	TP05	0.8	Fine SAND	14	12	8	2	5	NP	1773	11.1
S4	TP09	0.6	Fine SAND	16	14	10	9	7	NP	1812	11.1
S5	TP09	1.8	Silty SAND	21	18	14	11	9	NP	2042	10.5

PI = Plasticity index
MDD = Maximum Dry density
OMC = Optimum moisture content
CBR = California bearing ratio.

6.3 Geotechnical Assessment

Despite all soil profiles showing loose to very loose soil consistency within the first one metre, these sands are not expected to be collapsible and this site is given a preliminary NHBRC classification of S1. This requires single storey masonry constructions to utilise; modified normal footings, compaction of in-situ soils below footings or deep strip foundations. The following procedure is recommended for foundation trenches:

- Foundation trenches to be excavated to 600 mm below surface
- Compaction of excavated surface
- Backfill trench to desired level and compact in 150 mm layers
- For single story buildings utilise conventional reinforced strip footings and design on allowable bearing capacity of 150 kPa

The excavation conditions are expected to be difficult from surface to a depth of 2.0 m below surface due to the presence of calcrete across this site. In discussion with the site manager, it was made known that graves are currently excavated by TLB only, despite some excavations taking a significantly long time. To mitigate this extended excavation time, it is suggested that a TLB fitted with a hydraulic hammer be made available to the site. In general, temporary excavation will not require shoring if conditions remain dry. Attaining minimum required depth of 1.4 m (as per Provincial Gazette no. 6898) will be possible across the proposed site utilising a TLB excavator (in combination with TLB hydraulic hammer).

6.4 Piezometer installation

The site visit involved the installation of temporary piezometers in an attempt to determine if groundwater is present and if so, at what depth it occurs. The holes were excavated using a TLB to a maximum depth of 3 m or until refusal (which ever comes fists). A total of 3 piezometers were installed and details are summarised in **Table 6**. Only TP_9 where Pz_2 was installed intersected water. The location of the installed piezometers is shown in **Map 7**.

Table 6: Summary of augered locations.

Label	Latitude (DD, WGS84)	Longitude (DD, WGS84)	Elevation (mamsl)	EOH (mbgl)
Pz_1	-34.324862	21.426833	41	3.5
Pz_2	-34.323927	21.426064	38	3.3
Pz_3	-34.325508	21.425660	43	3.1

Piezometer installation involves installing a 50 mm PVC pipe as deep as possible below the groundwater level. The PVC pipe is slotted (i.e. screened) to allow groundwater to flow into the pipe. The general construction of such a screened piezometer can be seen in **Figure 4**.

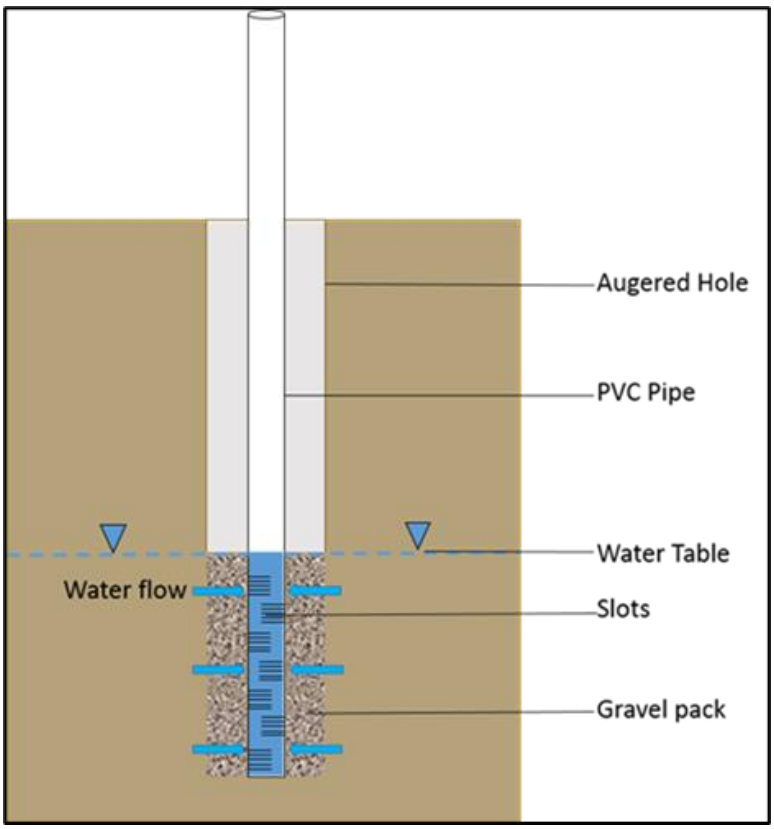
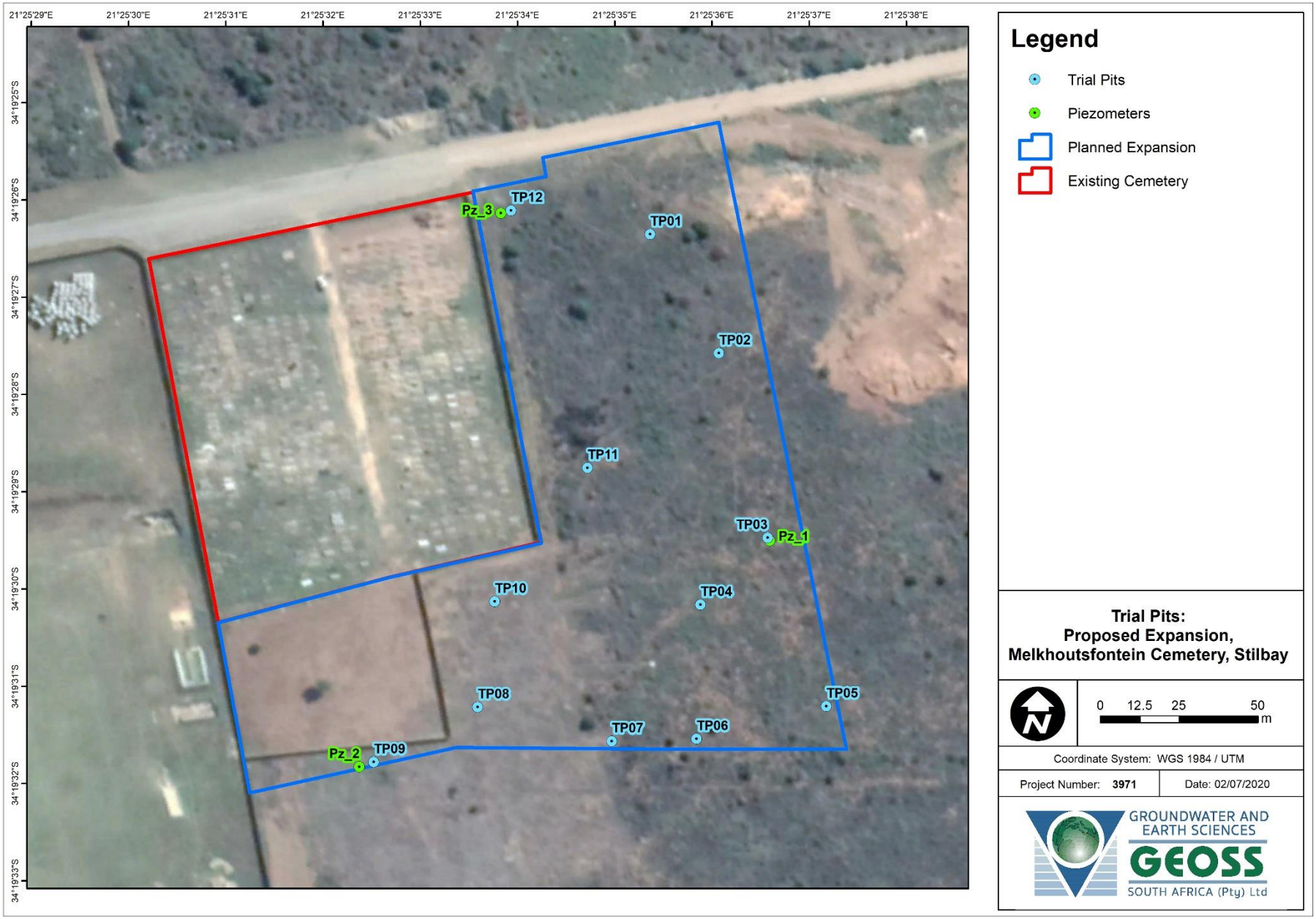


Figure 4: Typical piezometer installation.



Map 7: Aerial map showing trial pit and piezometer locations.

6.5 Groundwater flow direction

Groundwater level data was obtained from the field hydrocensus used to generate a groundwater level contour map to determine groundwater flow direction. Bayesian interpolation was used, making use of surface topography. **Map 8** shows the general flow direction across the study area. The groundwater locally flows towards the centre of the valley where it the flows in a south westerly direction towards the Goukou River.

In order to evaluate the relationship between groundwater levels and topography, and the applicability of the interpolation technique, the surface elevations and water table elevations are plotted relative to each other. The data is presented in **Figure 5**, and indicates a 76.9% correlation between surface topography and water level elevation. While not suitably high, Bayesian interpolation is considered an acceptable interpolation technique for indicative purposes only.

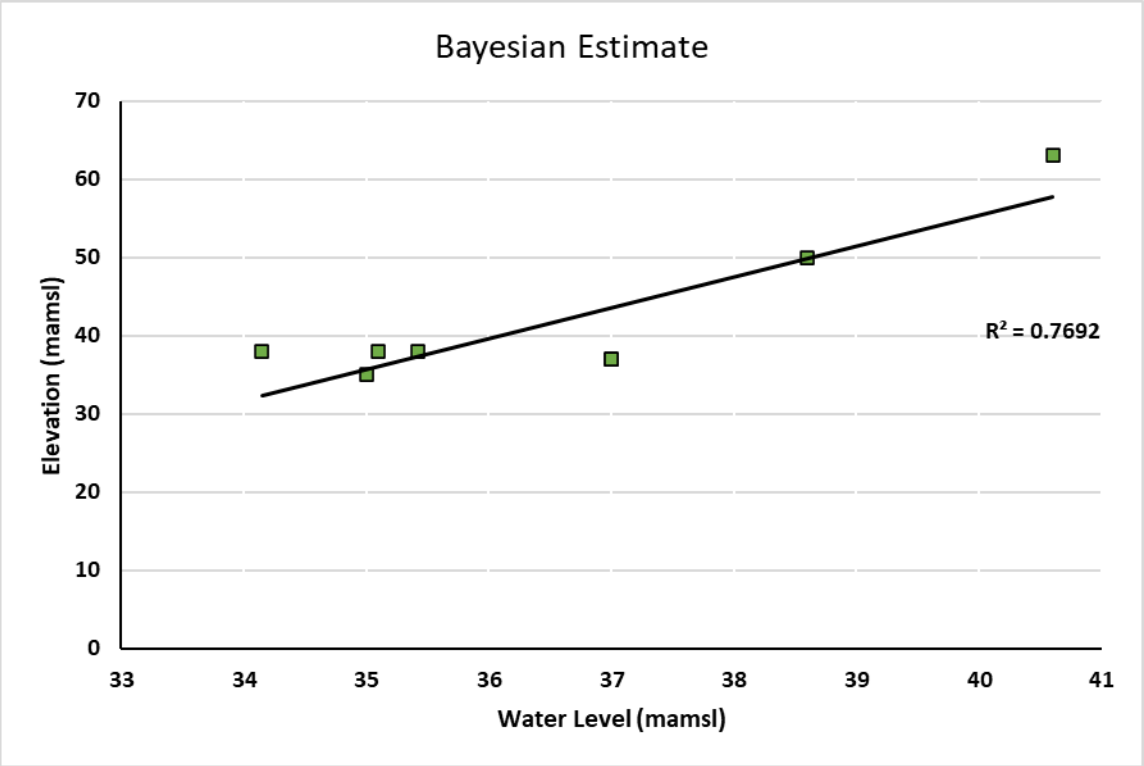
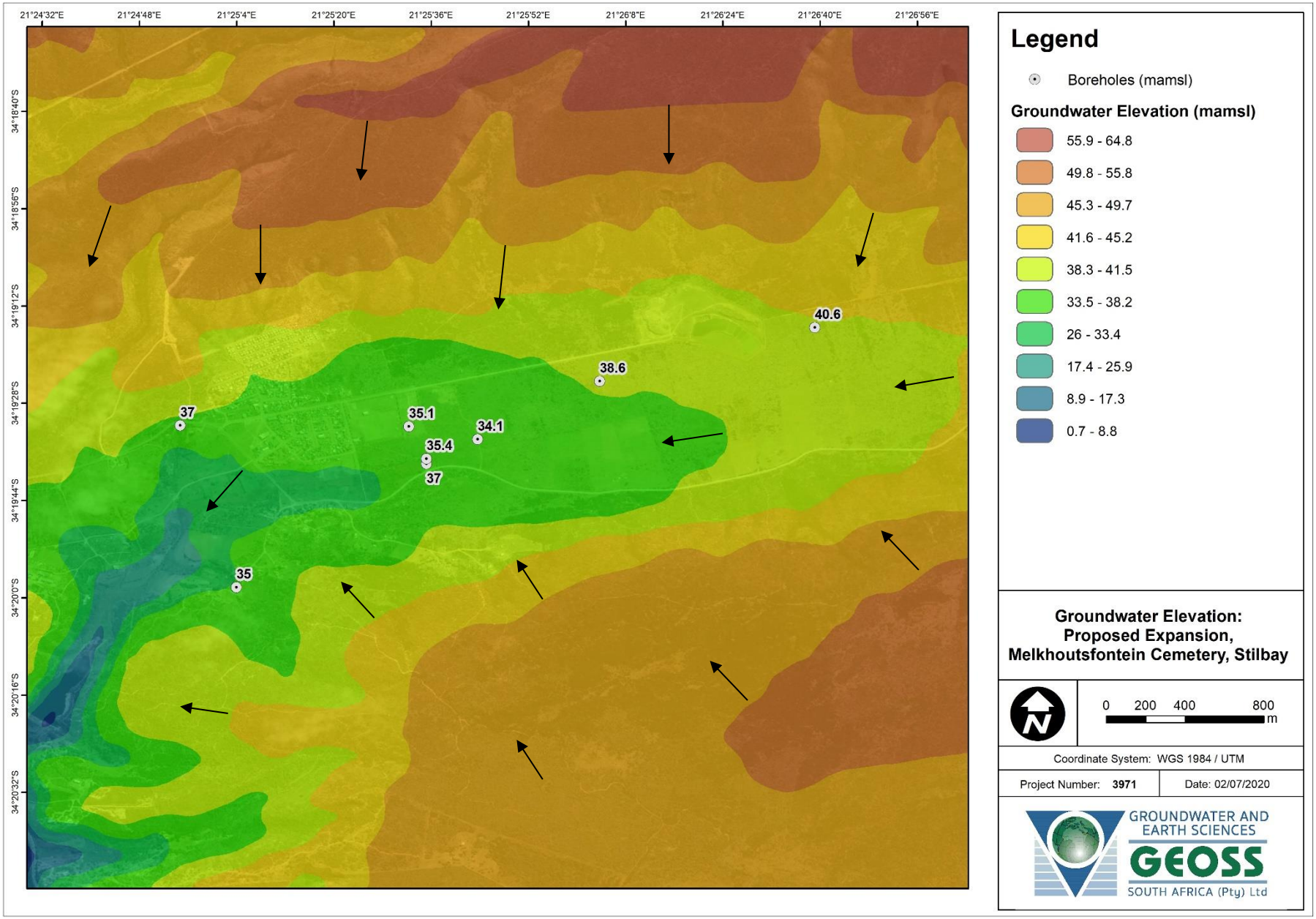


Figure 5: Correlation between surface topography and groundwater elevation for boreholes proximal to study site.



Map 8: Groundwater elevation (mamsl) map showing boreholes and flow directions.

6.6 Water Quality Analysis

Groundwater samples were collected from Pz_2 and BH01B and submitted for inorganic chemistry analysis to a SANAS accredited laboratory (Vinlab) in the Western Cape. These were selected as representative samples as BH01B is located upstream and Pz_2 located downstream to the cemetery. Additional groundwater exploration conducted by GHT yielded two successful boreholes of which the chemistry results are included in this report (GHT, 2019). The certificate of analysis for the samples is presented in **Appendix C**. The chemistry results obtained have been classified according to the SANS241-1: 2015 standards for domestic water (**Table 7**). **Table** 8 presents the water chemistry analysis results, colour coded according to the SANS241-1: 2015 drinking water assessment standards.

Table 7: Classification table for specific limits

Acute Health
Aesthetic
Chronic health
Operational
Acceptable

Table 8: Groundwater quality analysis results.

Analyses	Pz_2	BH01B	BH4	BH36	SANS 241-1:2015
pH (at 25 °C)	7.5	7.5	7.5	7.6	≥5 - ≤9.7 Operational
Conductivity (mS/m) (at 25 °C)	234.0	139.7	165.0	151.0	≤170 Aesthetic
Total Dissolved Solids (mg/L)	1586.5	947.2	1469.0	885.0	≤1200 Aesthetic
Turbidity (NTU)	657.00	8.33	-	-	≤5 Aesthetic ≤1 Operational
Colour (mg/L as Pt)	<15	<15	-	-	≤15 Aesthetic
Sodium (mg/L as Na)	282.0	152.0	254.5	248.4	≤200 Aesthetic
Potassium (mg/L as K)	7.0	5.0	5.1	4.9	N/A
Magnesium (mg/L as Mg)	40.0	21.0	29.6	26.7	N/A
Calcium (mg/L as Ca)	176.0	84.0	97.8	94.3	N/A
Chloride (mg/L as Cl)	547.7	284.8	349.4	307.1	≤300 Aesthetic
Sulphate (mg/L as SO_4)	71.08	47.46	43.00	79.00	≤250 Aesthetic ≤500 Acute Health
Nitrate Nitrogen (mg/L as N)	3.19	3.08	3.23	2.64	≤11 Acute Health
Nitrite Nitrogen (mg/L as N)	<0.05	<0.05	0.00	0.00	≤0.9 Acute Health
Ammonia Nitrogen (mg/L as N)	<0.15	<0.15	0.28	0.28	≤1.5 Aesthetic
Total Alkalinity (mg/L as $CaCO_3$)	366.80	220.20	259.20	261.74	N/A
Total Hardness (mg/L as $CaCO_3$)	604.00	296.10	365.86	345.22	N/A
Fluoride (mg/L as F)	<0.15	0.5	0.3	0.3	≤1.5 Chronic Health
Aluminium (mg/L as Al)	2.0210	0.0840	0.0300	0.0300	≤0.3 Operational
Total Chromium (mg/L as Cr)	0.0300	0.0040	<0.004	<0.004	≤0.05 Chronic Health
Manganese (mg/L as Mn)	0.12	<0.000	0.01	0.00	≤0.1 Aesthetic ≤0.4 Chronic Health
Iron (mg/L as Fe)	15.28	0.10	0.24	0.39	≤0.3 Aesthetic ≤2 Chronic Health
Nickel (mg/L as Ni)	<0.008	<0.008	0.0087	0.0089	≤0.07 Chronic Health
Copper (mg/L as Cu)	0.0070	0.0070	0.0200	0.0200	≤2 Chronic Health
Zinc (mg/L as Zn)	<0.008	<0.008	0.03	0.08	≤5 Aesthetic
Arsenic (mg/L as As)	0.0239	<0.01	0.0050	0.0050	≤0.01 Chronic Health
Selenium (mg/L as Se)	<0.008	<0.008	0.0120	0.0120	≤0.04 Chronic Health
Cadmium (mg/L as Cd)	<0.003	<0.003	<0.003	<0.003	≤0.003 Chronic Health
Antimony (mg/L as Sb)	<0.013	<0.013	0.0068	0.0023	≤0.02 Chronic Health
Mercury (mg/L as Hg)	0.0014	<0.001	<0.001	<0.001	≤0.006 Chronic Health
Lead (mg/L as Pb)	0.0110	<0.008	0.0070	0.0070	≤0.01 Chronic Health
Uranium (mg/L as U)	<0.028	<0.028	0.0000	0.0000	≤0.03 Chronic Health
Cyanide (mg/L as CN^-)	<0.01	<0.01	0.0050	0.0060	≤0.2 Acute Health
Total Organic Carbon (mg/L as C)	5.00	1.70	7.90	8.30	N/A
E. coli (count per 100 ml)	nd	nd	nd	nd	Not Det. Acute Health-1
Total Coliform Bacteria (count per 100 ml)	55	2	5	167	Not Det.≤10 Operational
Heterotrophic Plate Count (count per ml)	70	10	3000	3000	≤1000 Operational

The chemistry results obtained have been classified according to the DWAF (1998) standards for domestic water. **Table 9** enables an evaluation of the water quality with regards to the various parameters measured (DWAF, 1998). **Table 10** presents the water chemistry analysis results colour coded according to the DWAF drinking water assessment standards.

Table 9: Classification table for the groundwater results (DWAF, 1998)

Blue	**(Class 0)**	**Ideal water quality** - suitable for lifetime use.
Green	**(Class I)**	**Good water quality** - suitable for use, rare instances of negative effects.
Yellow	**(Class II)**	**Marginal water quality** - conditionally acceptable. Negative effects may occur.
Red	**(Class III)**	**Poor water quality** - unsuitable for use without treatment. Chronic effects may occur.
Purple	**(Class IV)**	**Dangerous water quality** - totally unsuitable for use. Acute effects may occur.

Table 10: Classified production borehole results according to DWAF 1998.

Parameter	**Pz_2**	**BH01B**	**BH4**	**BH36**	**DWA (1998) Drinking Water Assessment Guide**				
					Class 0	**Class I**	**Class II**	**Class III**	**Class IV**
pH	7.5	7.5	7.5	7.6	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)	234.0	139.7	165.0	151.0	<70	70-150	150-370	370-520	>520
Turbidity (NTU)	657.00	8.33	-	-	<0.1	0.1-1	1.0-20	20-50	>50
	mg/L								
Total Dissolved Solids	1586.5	947.2	1469.0	885.0	<450	450-1000	1000-2400	2400-3400	>3400
Sodium (as Na)	282.0	152.0	254.5	248.4	<100	100-200	200-400	400-1000	>1000
Potassium (as K)	7.0	5.0	5.1	4.9	<25	25-50	50-100	100-500	>500
Magnesium (as Mg)	40.0	21.0	29.6	26.7	<70	70-100	100-200	200-400	>400
Calcium (as Ca)	176.0	84.0	97.8	94.3	<80	80-150	150-300	>300	
Chloride (as Cl)	547.7	284.8	349.4	307.1	<100	100-200	200-600	600-1200	>1200
Sulphate (as SO_4)	71.1	47.5	43.0	79.0	<200	200-400	400-600	600-1000	>1000
Nitrate& Nitrite (as N)	0.00	0.00	0.00	0.00	<6	6.0-10	10.0-20	20-40	>40
Fluoride (as F)	<0.15	0.5	0.3	0.3	<0.7	0.7-1.0	1.0-1.5	1.5-3.5	>3.5
Manganese (as Mn)	0.12	<0.000	0.01	0.00	<0.1	0.1-0.4	0.4-4	4.0-10.0	>10
Iron (as Fe)	15.3	0.1	0.2	0.4	<0.5	0.5-1.0	1.0-5.0	5.0-10.0	>10
Copper (as Cu)	0.01	0.01	0.02	0.02	<1	1-1.3	1.3-2	2.0-15	>15
Zinc (as Zn)	<0.008	<0.008	0.03	0.08	<20	>20			
Arsenic (as As)	0.0239	<0.01	0.0050	0.0050	<0.010	0.01-0.05	0.05-0.2	0.2-2.0	>2.0
Cadmium (as Cd)	<0.003	<0.003	<0.003	<0.003	<0.003	0.003-0.005	0.005-0.020	0.020-0.050	>0.050
	counts/100 mL								
Faecal coliforms	nd	nd	nd	nd	0	0-1	1.0-10	10-100	>100
Total coliforms	55	2	5	**167**	0	0-10	10-100	100-1000	>1000

From the chemical results presented in **Table 8** and **Table 10**, the groundwater from the three boreholes (BH01B, BH4 and BH36) is of marginal quality in terms of dissolved minerals and salts. Most chemical parameters are within the acceptable limits for drinking water, with the exception of slightly elevated sodium, chloride, iron., total coliforms and heterotrophic plate count. Pz_2 shows elevated aluminium, manganese, iron, arsenic and lead, as well the presence of coliforms. The anomalously elevated iron observed at this borehole is interpreted to relate to the high turbidity. Sampling was conducted following the excavation and installation of the piezometer, which is likely to have resulted in increased ion concentrations (particularly iron) at this site. Future sampling and monitoring at this piezometer should include analysis of both filtered and unfiltered samples to confirm this interpretation.

A number of chemical diagrams have been plotted for the groundwater samples and these are useful for chemical characterisation of the water. The chemistry of the samples has been plotted on a tri-linear diagram known as a Piper diagram. This diagram indicates the distribution of cations and anions in separate triangles and then a combination of the chemistry in the central diamond. From **Figure 6** (central diamond) the piezometer and borehole groundwater samples, Pz_1, BH01B, BH4 and BH36 is classified as having a mixed to sodium chloride hydrofacies.

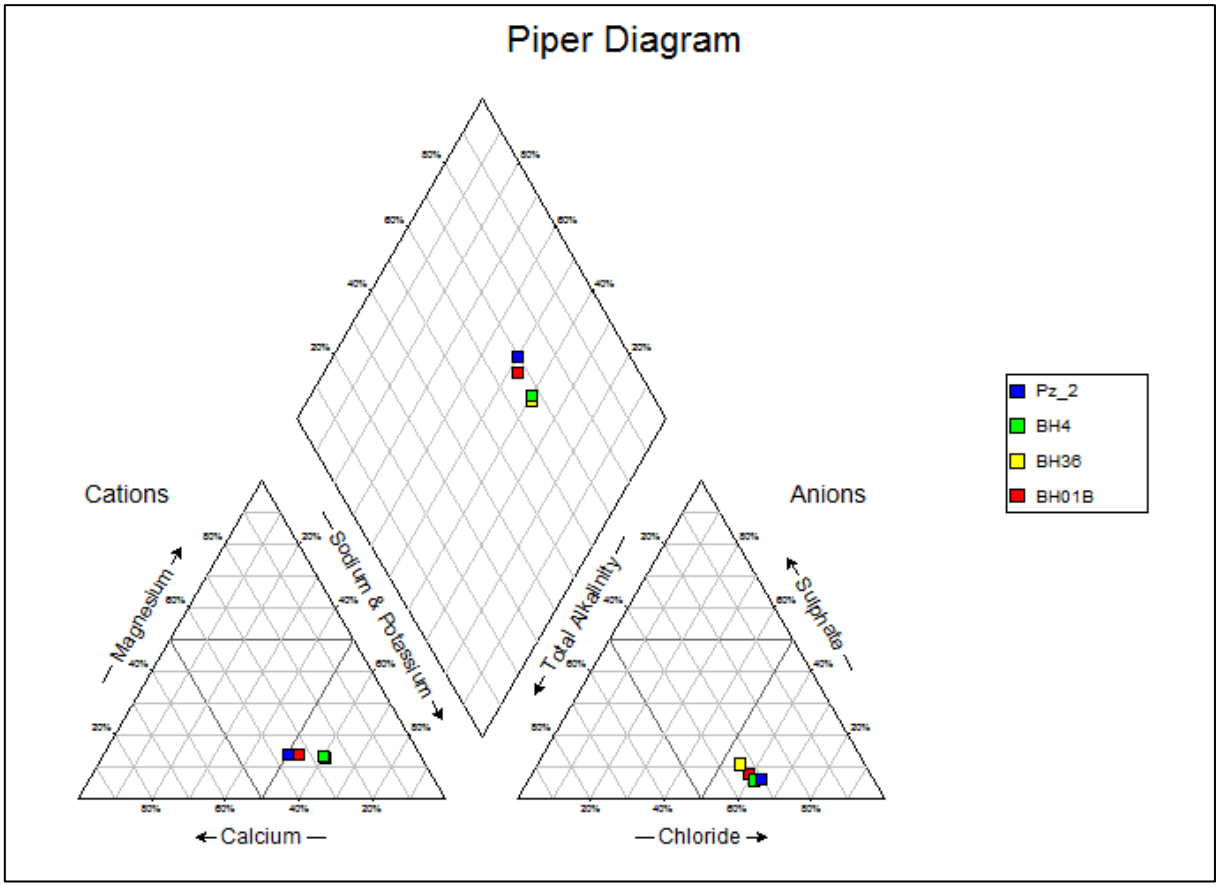


Figure 6: Piper diagram of the production borehole groundwater samples.

The Stiff Diagram is a graphical representation of the relative concentrations of the cations (positive ions) and anions (negative ions). This diagram shows concentrations of cations and anions

relative to each other and direct reference can be made to specific salts in the water. The Stiff Diagram for the samples from the boreholes and piezometer is shown in **Figure 7**. It is clear that the groundwater samples are dominated by Na+K and Cl - and that the groundwater has an overall high dissolved mineral concentration.

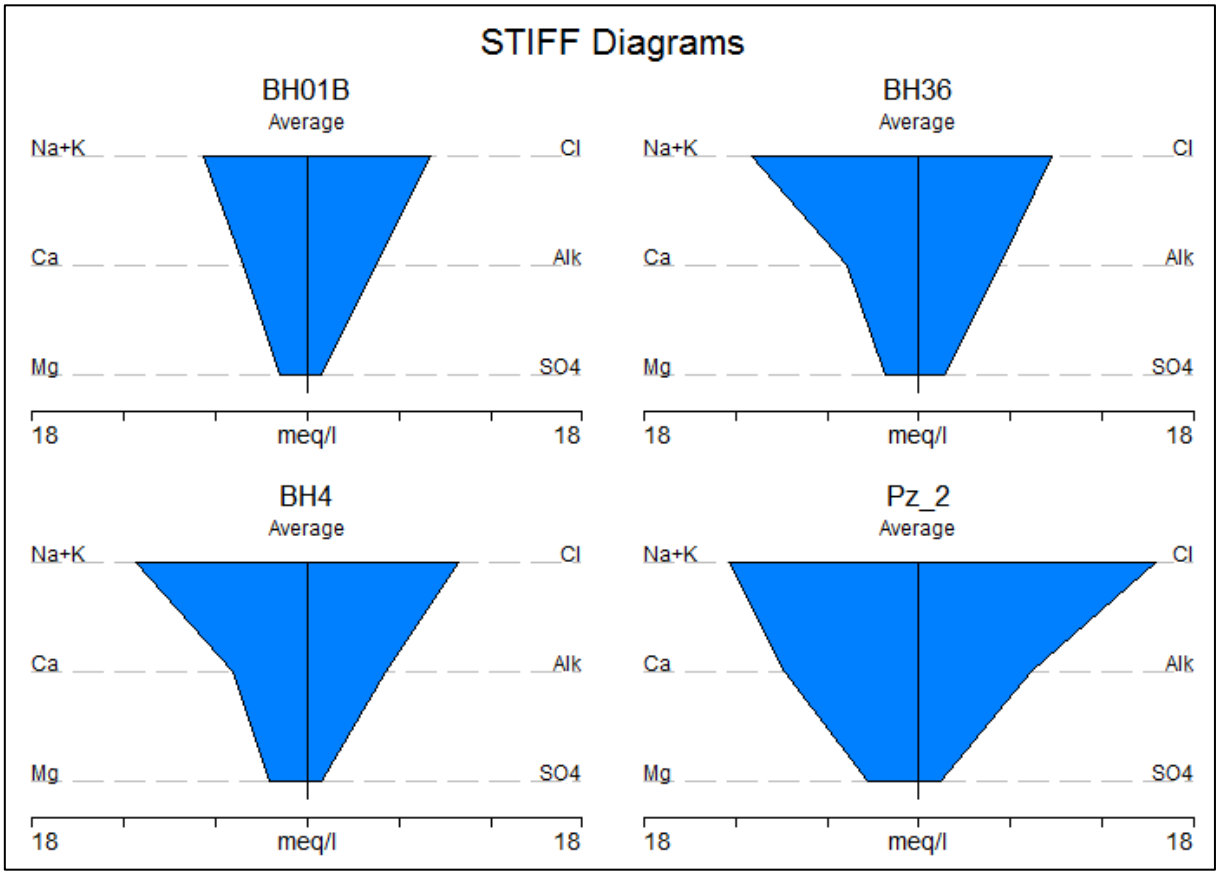


Figure 7: Stiff diagram of the borehole groundwater sample.

7. RISK ASSESSMENT

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 11 summaries possible impacts and proposed mitigation measures associated with the increased decomposition of human remains. **Table 12** presents a summary of possible impacts and proposed mitigation measures associated with the corrosion of metals used as ornaments, plastics, paints and varnishes. **Table 13** summarises the possible impacts and proposed mitigation measures associated with the formation of organics from the embalming process.

Table 11: Impact table for contamination of groundwater as a result of decomposition of human remains.

OPERATIONAL PHASE	
Potential impact and risk:	**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 and inorganic parameter concentrations in groundwater, and proximal drainage channel and Goukou River.
Probability of occurrence:	High probability.
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:	Low
Significance rating of impact prior to mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Low
Degree to which the impact can be managed or mitigated:	Low
Proposed mitigation:	Ensure burial occurs above water table depth to enable natural attenuation in the vadose zone. Harmful bacteria, viruses and pathogens tend to die off during final stages of decomposition and therefore tend not persist in the environment. Limit groundwater use immediately downgradient of the site. Monitoring boreholes are required (minimum of 1 down-gradient) in order to detect any potential contamination as quickly as possible. Potentially use BH4 as down-gradient monitoring point.
Cumulative impact post mitigation:	Low
Significance rating of impact after mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Low

Table 12: Impact table for contamination of groundwater as a result of metal corrosion, paints and varnishes.

OPERATIONAL PHASE	
Potential impact and risk:	**Addition of paints and varnishes to the environment and corrosion of metals.**
Nature of impact:	Negative
Extent and duration of impact:	Extent is local and duration is short term.
Consequence of impact or risk:	Contaminated groundwater, proximal drainage channel and Goukou River.
Probability of occurrence:	High probability.
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 wood or 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.
Cumulative impact post mitigation:	Medium
Significance rating of impact after mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Medium-High

Table 13: Impact table for contamination of groundwater as a result of compounds used during embalming.

OPERATIONAL PHASE	
Potential impact and risk:	**Embalming process – formaldehyde.**
Nature of impact:	Negative
Extent and duration of impact:	Extent is local and duration is short term.
Consequence of impact or risk:	Contaminated groundwater and proximal drainage channel.
Probability of occurrence:	Low probability.
Degree to which the impact may cause irreplaceable loss of resources:	Minimal loss of resource.
Degree to which the impact can be reversed:	Reversible.
Cumulative impact prior to mitigation:	Low
Significance rating of impact prior to mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Low
Degree to which the impact can be managed or mitigated:	Typically mitigation is 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)
Cumulative impact post mitigation:	Low
Significance rating of impact after mitigation (e.g. Low, Medium, Medium-High, High, or Very-High)	Low

8. DISCUSSION

From the hydrocensus, it is clear that there are a number of groundwater users surrounding the cemetery. The groundwater is mainly used for irrigation and livestock watering; however, plans are in place for the water to be used for town supply. Groundwater was intersected in one of the trial pits (TP09) where the water level measured 2.9 mbgl after 1 hour. This site is dominated by fine sands of varying colour and is loose to very loose in consistency. With depth, the sands become medium dense and have a higher proportion of fines. A calcrete lens is present across the entire site. This lens ranges from 0.20 metres to at least 1.00 metres in thickness and in many places it too hard for excavation with TLB.

The groundwater quality of the area, based on four laboratory samples indicates that the groundwater quality is "moderate "(70 – 300 mS/m) according to the water quality classification. It is important to note that the groundwater sample for Pz_1 (TP09) did show elevated concentrations for aluminium, manganese, iron, arsenic and lead. The high aluminium concentration is most likely related to high clay content in the turbid sample (unfiltered). The elevated concentrations of manganese, iron, arsenic and lead are not commonly associated with cemeteries developed within the last 50 years and in this case is most likely related to a different source. It is believed that this cemetery was developed approximately 30 years ago.

The aquifer vulnerability to contamination is "high". This rating is associated with relatively shallow groundwater level (observed on and near the site, including the presence of a natural spring down-gradient of the site) as well as the primary (intergranular aquifer). The host formation consists of unconsolidated sand and calcarenite (which is a clastic or detrital sedimentary rock consisting largely of calcium carbonate grains). An intergranular aquifer is more susceptible to point and non-point source pollution. The groundwater levels measured in the boreholes were found to range between 2.58 and 22.4 mbgl. Considering the shallow depth of burials to be 1.4 mbgl, it is deemed that burial is unlikely to occur below the water table. This is generally favourable, enabling the dying off of bacteria and viruses in the unsaturated zone, and slowing the migration of potential contaminants introduced by the burial process.

Given the "high" vulnerability of the underlying aquifer, the risk of contamination is considered. For a risk to exist there must be a source (s), pathway(s) and receptor(s); these are presented in **Figure 8**. All three are present in this case (an SPR linkage exsits). The cemetery and proposed expansion represent potential sources of contamination. The underlying aquifer, proximal drainage channel and Goukou River represent both a potential pathway and receptor. Groundwater users represent an additional receptor of potential contamination.

Given the vulnerability of the aquifer, the **risk** assigned to potential impacts of contamination is considered to be **Medium-High**. It is important that no activities should be allowed that are likely to result in contamination of municipal supply. The main contaminant risks are not generally associated with the decomposition of the body, and pertain more to the burial process, entombing/encasing and ornaments. While these contaminant risks can strictly speaking be mitigated against, the practicalities of enforcing them are very challenging and unlikely to occur.

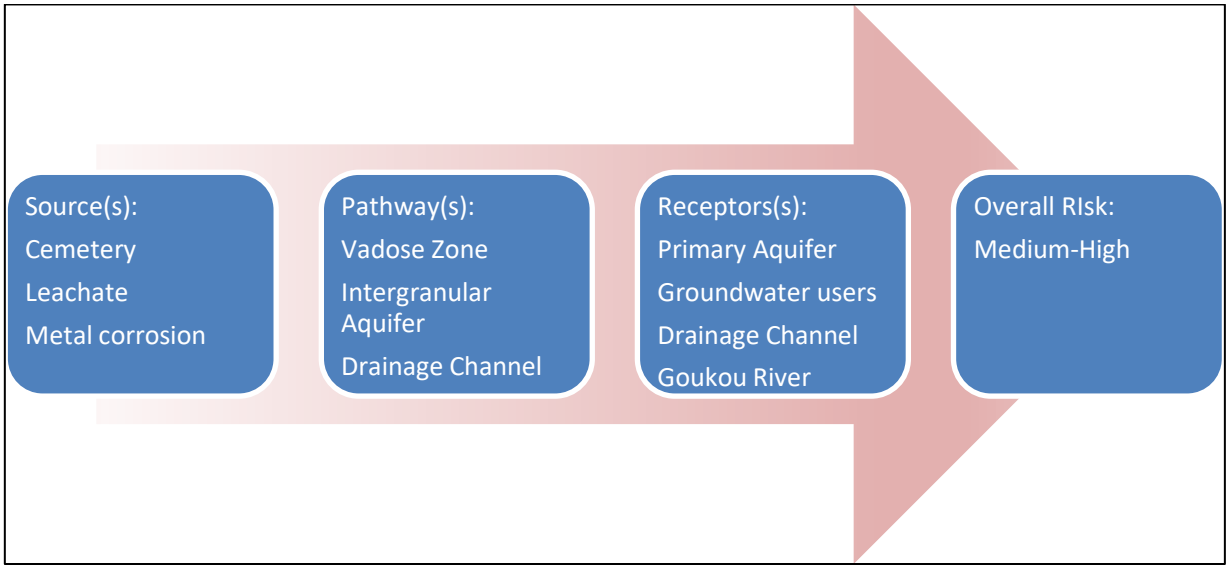


Figure 8: Source, Pathway and Receptor assessment.

It should also be noted that an existing cemetery exists at the site, and the proposed development is an expansion rather than a new development. The potential contamination is therefore not likely to represent a new contaminant source, but a potential increase in the existing contaminant source.

The most significant receptor of potential contamination is the municipal supply sources proximal to the site. While not currently in use, BH36 is about 175 m away and BH4 is 170 m away from the nearest boundary of the planned cemetery expansion (BH36 and BH4 are 275 m and 235 m from the existing cemetery boundary respectively). A review of international regulations and bylaws regarding cemetery setback distances indicates that they range from 250 m (WHO[§], UK Government[**], Scottish EPA[††]) to 100 m in Saskatchewan[‡‡] and 120 m in British Columbia[§§]. An anomaly is a recommendation of 30 m from the Ministry of Environment and Energy, Canada[***] (Miller & Wiens, 2017). These regulations on setback distances do not provide a rationale for the distance, and it is important that each cemetery should be evaluated independently.

§ Üçisik AS, Rushbrook P. The impact of cemeteries on the environment and public health: an introductory briefing. Copenhagen, Denmark: World Health Organization, Regional Office for Europe; 1998. Available from: http://apps.who.int/iris/bitstream/10665/108132/1/ EUR_ICP_EHNA_01_04_01(A).pdf.

** UK Environment Agency. The Environment Agency's approach to groundwater protection. Bristol, UK: Environment Agency; 2017. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/620438/LIT_7660.pdf.

†† Scottish Environment Protection Agency. Guidance on Assessing the Impacts of Cemeteries on Groundwater. Scotland: EPA; 2015. Available from: https://www.sepa.org.uk/media/143364/lups-gu32-guidance-on-assessing-the-impacts-of-cemetries-on-groundwater. pdf.

‡‡ Government of Saskatchewan. The Cemeteries Regulations 2001, Chapter C-4.01 Reg 1 as amended by Saskatchewan Regulations 15/2011 and 37/2015. Queen's Printer.(2001). Available from: http://www.qp.gov.sk.ca/documents/English/Regulations/Regulations/C4-01r1.pdf.

§§ Government of British Columbia. Public Health Act Health Hazards Regulation 216/2011. Available from: http://www.bclaws. ca/civix/document/id/complete/statreg/216_2011.

*** Soo Chan G, Scafe M, S E. Cemeteries and groundwater: an examination of the potential contamination of groundwater by preservatives containing formaldehyde. Toronto, ON: Ontario Ministry of the Environment, Branch WR;1992. Available from: https://archive.org/ details/cemeteriesground00chanuoft.

Given the high vulnerability of the aquifer and the medium-high contamination risk, it is recommended that a cautious approach be adopted. The fact that the proximal boreholes and spring are a municipal supply source means that a large number of people are placed at risk to contamination. The aquifer that has been developed for Melkhoutfontein is considered an aquifer of strategic importance, and will require protection. For this reason, even for the current cemetery, mitigation is necessary to prevent any potential contamination and regular groundwater monitoring is recommended to detect potential contamination proximal the cemetery.

9. RECOMMENDATIONS

The following recommendations are made:

- The cemetery expansion can proceed if groundwater is not used for potable consumption within 250 m of the existing or expanded cemetery.
- Irrespective of whether the expansion takes place or not, groundwater monitoring should be initiated on site. Additionally, relevant mitigation measures and best practice procedures must be employed to minimize contamination of the subsurface takes place (**Table 11**, **12**, **13**, – Proposed Mitigation).
- Pz_2, BH4 and SPR01 should be considered as potential groundwater monitoring points.

Note that these recommendations are based on GEOSS's opinion and the final decision on the necessary groundwater monitoring requirements resides with the regulatory authorities.

9.1 Proposed groundwater monitoring action plan:

It is recommended that the Pz_2 and two sources of groundwater (BH4 and SPR01) be utilised for regular monitoring. This will allow for monitoring of the groundwater quality and groundwater levels across the site. The water levels and the groundwater quality should be monitored quarterly, so as to determine seasonal fluctuation. The development of a groundwater monitoring programme will be important for assessing any impacts of the site on groundwater and the environment.

It is recommended that groundwater monitoring be undertaken at the proposed site in accordance with guidelines set out in the publication by DWAF (1998). The various aspects of the monitoring are presented in this section, along with relevant recommendations.

9.1.1 Groundwater levels

Groundwater level measurements are recommended for the monitoring borehole at the study site. A dip meter can be used to measure the water level below the top of the borehole collar/casing height (mbch). The height of the collar/casing height must then also be measured (m). The water level (metres below ground level (mbgl)) can then be calculated by subtracting the collar/casing height from the water level (mbch). The value must be recorded along with the date and time of measurement.

9.1.2 Sampling process

The monitoring borehole should be assessed to determine whether it is a low or high yielding borehole before sampling. Should the monitoring borehole be of low yield and unable to pump with a conventional pump (until field parameters stabilize and a sample collected), a bailer (grab) sample can be collected. It is preferable to use a low volume sampling pump in most monitoring boreholes (known as a bladder pump).

For a high yielding borehole, it is recommended that the pump be installed either half a meter above the bottom of the borehole or at the highest yielding fracture depth. The groundwater should be pumped into a flow-through cell, an EC and pH probe should be placed into the flow-through cell and be pumped until field chemistry parameters stabilise prior to sampling.

9.1.3 Sample Collection, Preservation and Submission

Sample bottles must be labelled with the borehole name, site name and date. At the time of sampling field, chemistry parameters must be measured and recorded. These include electrical conductivity (EC), oxidation reduction potential (ORP), pH, temperature and dissolved oxygen (DO). Samples must be taken in their correct sampling container and preserved in the correct manner prior to submission to an accredited laboratory for the analysis parameters. The sample method and preservation must be discussed with the laboratory prior to sampling.

9.1.4 Sampling frequency and parameter analysis

In order to best understand and monitor the site, it is recommended that quarterly water level measurements be taken (to determine seasonal fluctuation). It is however, considered adequate for boreholes to be sampled bi-annually. **Table 14** indicates the potential parameters for ongoing monitoring.

Table 14: Source-based selection of groundwater quality monitoring variables.

Source Activity	**Cemetery**
Category	**Parameter**
Inorganic	pH, EC, K, Cl, NO_3, NH_4, P, Na, Ca, HCO3
Metals	Fe, Mn, Ti, Cr, Cd, Pb, Ni
Organic (and indicator analysis	BOD, COD, total coliforms, E coli.

10. CONCLUSION

The study site has been classified as having a groundwater vulnerability classification of "**high**" (section 4.2). The contamination risk is considered to be "**Medium-High**". Given the relatively shallow-water table and presence of down-gradient drainage channel and spring, strict mitigation measures and groundwater monitoring plan should be implemented.

The consequence associated with contamination is considered to be very high as there are numerous municipal supply sources within 250 m of the cemetery expansion area. The aquifer developed for Melkhoutfontein is of strategic importance and requires strict protection.

The cemetery expansion should only be allowed in the case that no abstraction takes place within 250 m of the cemetery. This affects the developed municipal sources, which has significant implications.

Irrespective of whether the cemetery expansion occurs, the groundwater monitoring recommendations should be implemented for the current cemetery.

Should the cemetery expansion occur, the proposed expansion will need to conform to the standard industry mitigations measures for developing a cemetery in order to minimize contamination on site. GEOSS recommends the monitoring of the groundwater system on site, as specified in **Section 9.1**.

11. ASSUMPTIONS AND LIMITATIONS

A limitation experienced during this investigation was during the hydrocensus. Not all groundwater users could be located or visited due to a large number of the dwellings, plots and farms being gated. Additionally, not all groundwater users display the relevant signage to indicate groundwater use. It is therefore assumed that the number of groundwater users is in fact greater than are currently represented in this report.

Available data was sourced from relevant groundwater databases and sources. The Aquifer vulnerability, yield and quality data is predominantly accurate albeit mapped at a regional scale.

A further limitation was the temporal nature of the site visit. The field work was undertaken on a single day in June 2020, and does not account for the temporal variability of the water table. While this is not expected to impact the risk assessment for the site, the seasonal fluctuation of water levels will only be known once groundwater monitoring is initiated on the site.

12. REFERENCES

CGS (1993). The 1:250 000 geological map series. 3420 Riversdale.

Conrad J. and Munch Z., (2007). Groundwater recharge and vulnerability mapping – a national scale approach; GWD Conference Bloemfontein, 8 – 10 October 2007 pp 46 – 56.

Department of Water Affairs and Forestry, (1998). Minimum Requirements for Water Monitoring at Waste Management Facilities, Pretoria: Department of Water Affairs and Forestry.

Dippenaar, M. A., Olivier, J., Lorentz, S., Ubomba-Jaswa, E., Abia, A., and Diamond, R., (2018). Environmental Risk Assessment, Monitoring and Management of Cemeteries, Pretoria: Water Research Commission. WRCReport No. 244/1/18. ISBN: 978-1-4312-0978-1.

DWAF (1998). Waste Management Series. Minimum requirements for water monitoring at waste management facilities. Document 3 – monitoring of water at and around waste disposal facilities. Second Edition 1998. Department of Water Affairs and Forestry. Pretoria.

DWAF (2002). The hydrogeological map series of the republic of South Africa. Cape Town, 3318. Scale: 1:500 000.

DWAF (2005). Groundwater Resource Assessment Phase II (GRA II). Department of Water Affair and Forestry. Pretoria.

Freeze, R.A., and Cherry, J.A., (1979), Groundwater: Englewood Cliffs, NJ, Prentice-Hall.

GHT (2019) Exploration of Groundwater Resources for Stilbaai Western Cape Province. Report No: RVN801.11/1941.1. Geohydro Technologies OFS (Pty) Ltd. Bloemfontein, South Africa.

Miller A. & Wiens M., (2017). Cemetery setback distances to prevent surface water contamination. National Collaborating Centre for Environmental Health. October 2017.

National Water Act (1998). The National Water Act, No 36. Department of Water Affair and Forestry. Pretoria.

Schulze, R. E., (2009). SA Atlas of Climatology and Geohydrology; obtained from Western Cape Government Agriculture - http://gis.elsenburg.com/apps/cfm/: Long term median rainfall per month (1950-2000).

Western Cape Government, (2011). Cemeteries, Crematoria and Funeral Undertakers By-Law. Cape Town: Western Cape Government. Published in Province of Western Cape: Provincial Gazette no. 6898 on 12 August 2011.

World Health Organization. (2002). Formaldehyde: Concise International Chemical Assessment Document 40, Geneva: WHO.

Żychowski, J. & Bryndal, T. (2015). Impact of cemeteries on groundwater contamination by bacteria and viruses – a review. Journal of Water and Health. 13.2:285-301.

13. APPENDIX A: TRIAL PIT PHOTOS AND LOGS

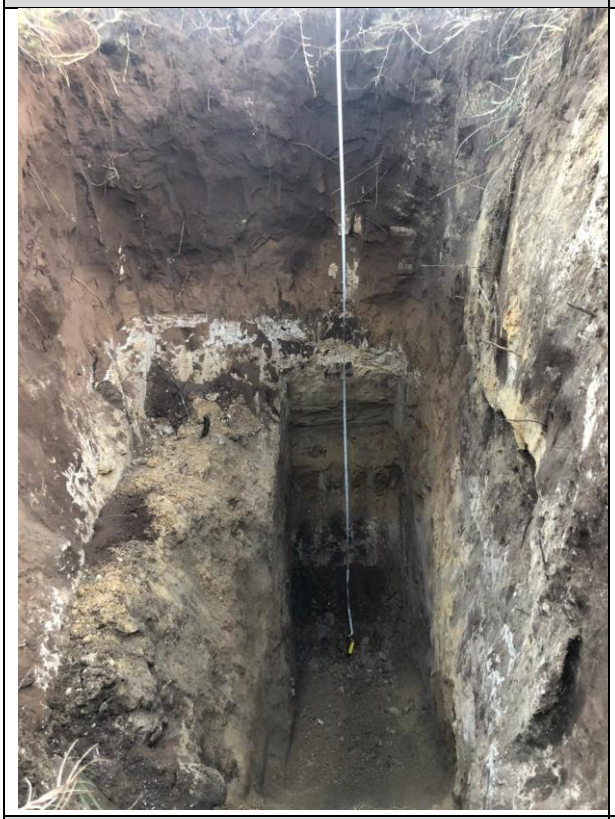
TP_01	*TP_02*
	
TP_03	*TP_04*
	

Figure 9: TP_01 to TP_04.

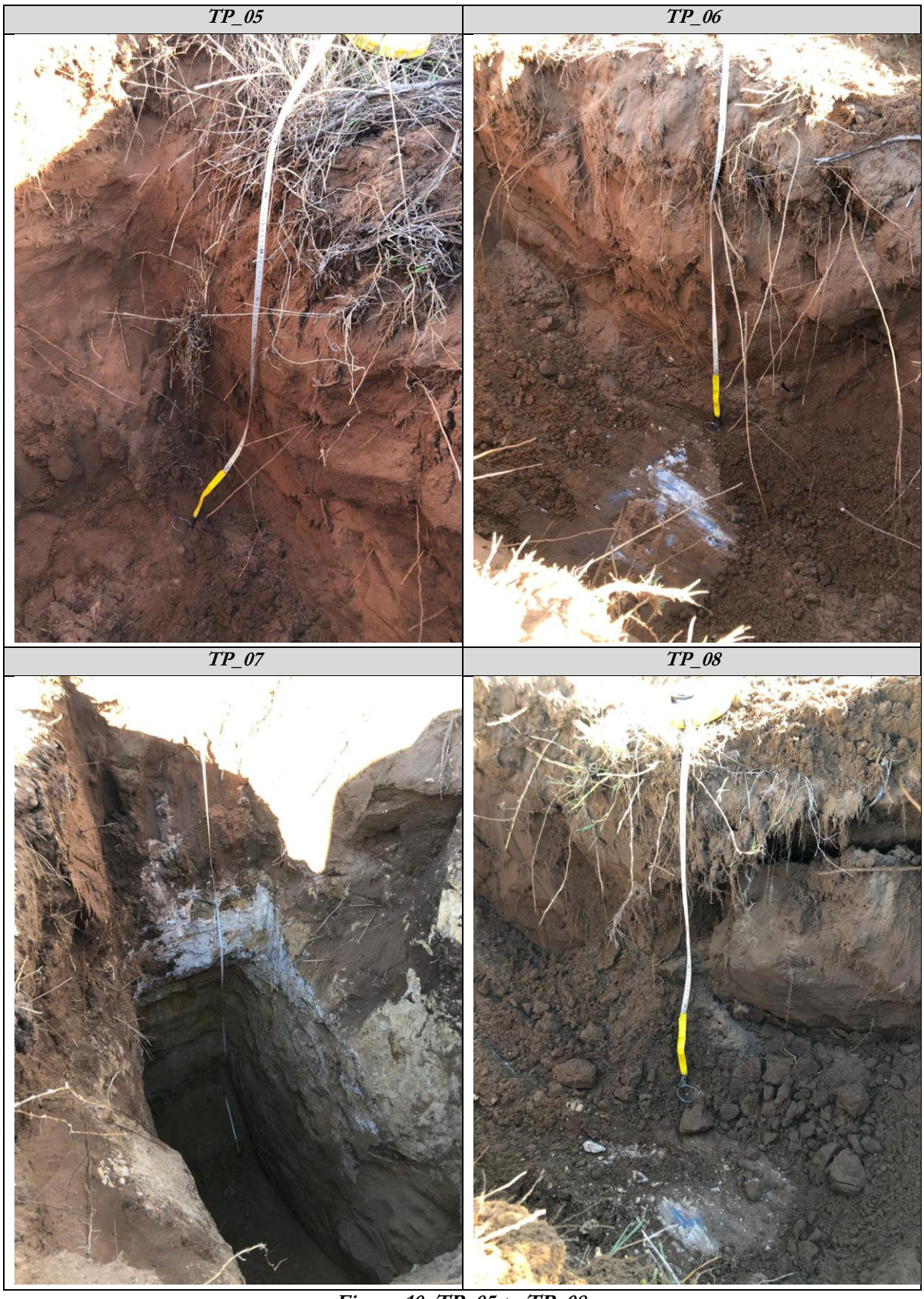


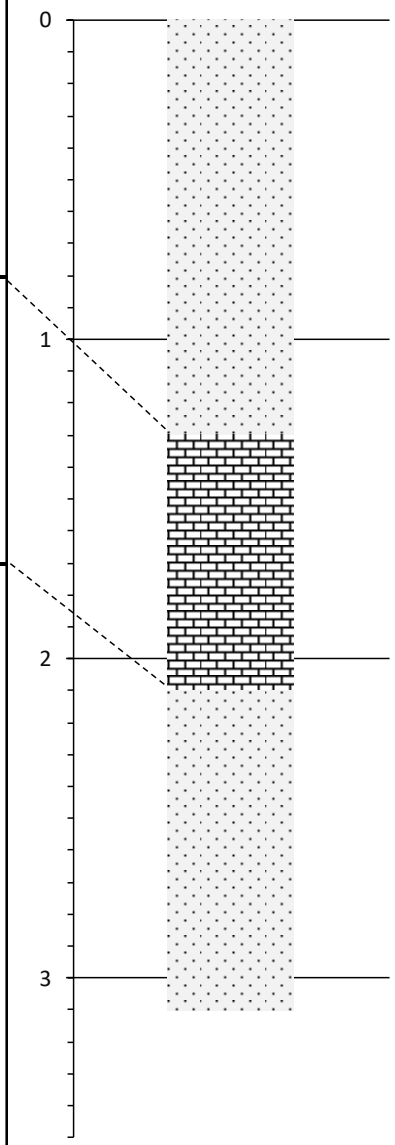
Figure 10: TP_05 to TP_08.

TP_09	*TP_10*
	
TP_11	*TP_12*
	

Figure 11: TP_09 to TP_12.

Log of Trial Pit No.: TP01

Location:	Melkhoutfontein Cemetery	**Latitude:**	-34.32398703
Date:	24-Jun-20	**Longitude:**	21.42649102
Client:	SES	**Ground Elevation:**	43

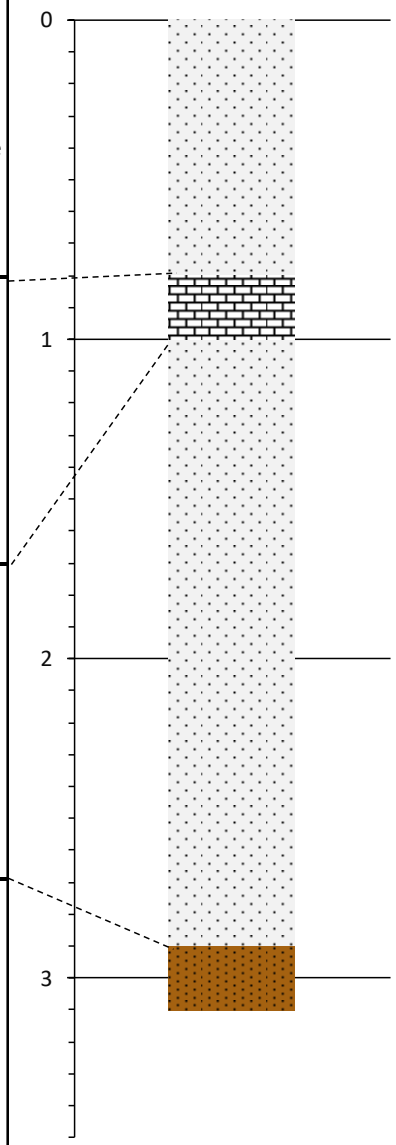
Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 1.30 Dry, brown & orange brown, loose, bedded, fine SAND. Transported sediments.			
Unit 2: 1.30 - 3.10 CALCRETE, soft rock			
Unit 3: 2.10 - 3.10 Dry, pale orange & white, medium dense, bedded, silty fine SAND. Transported sediments.			End of Hole = 3.10 mbgl

Excavated By:	GEOSS	**Remarks:**	
Drill Method:	TLB Excavator		No groundwater
Logged By:	CM/ MB		

GEOSS SOUTH AFRICA (Pty) Ltd

Log of Trial Pit No.: TP02

Location:	Melkhoutfontein Cemetery	**Latitude:**	-34.324327
Date:	24-Jun-20	**Longitude:**	21.42668699
Client:	SES	**Ground Elevation:**	42

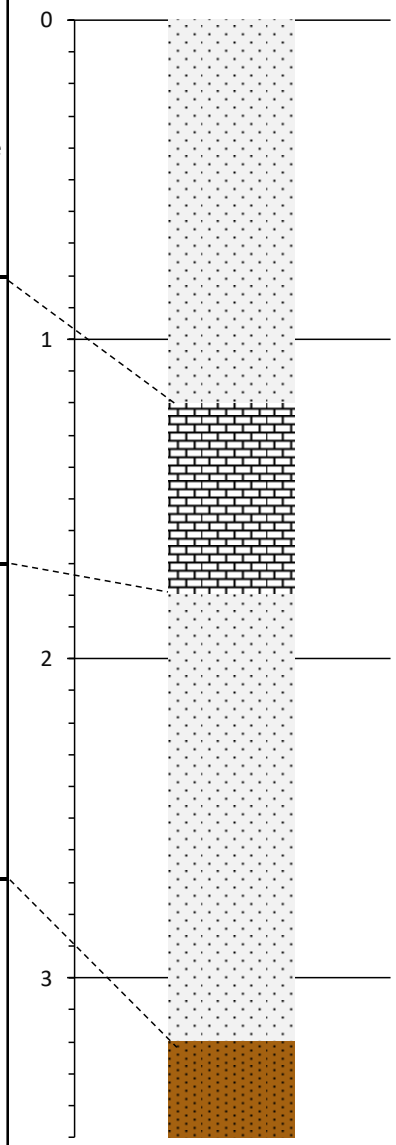
Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 0.80 Dry, brown & orange brown, loose, bedded, fine SAND. Transported sediments.			
Unit 2: 0.80 - 1.00 CALCRETE, soft rock			
Unit 3: 1.00 - 2.90 Dry, brown & white, medium dense, bedded, silty fine SAND. Transported sediments.			
Unit 4: 2.90 - 3.1 Slighty moist, dark brown, medium dense, intact, clayey silty Fine SAND. Transported sediment.			End of Hole = 3.10 mbgl

Excavated By:	GEOSS	**Remarks:**	
Drill Method:	TLB Excavator		No groundwater
Logged By:	CM/ MB		

GEOSS SOUTH AFRICA (Pty) Ltd

Log of Trial Pit No.: TP03

Location:	Melkhoutfontein Cemetery	**Latitude:**	-34.32485397
Date:	24-Jun-20	**Longitude:**	21.42682697
Client:	SES	**Ground Elevation:**	41

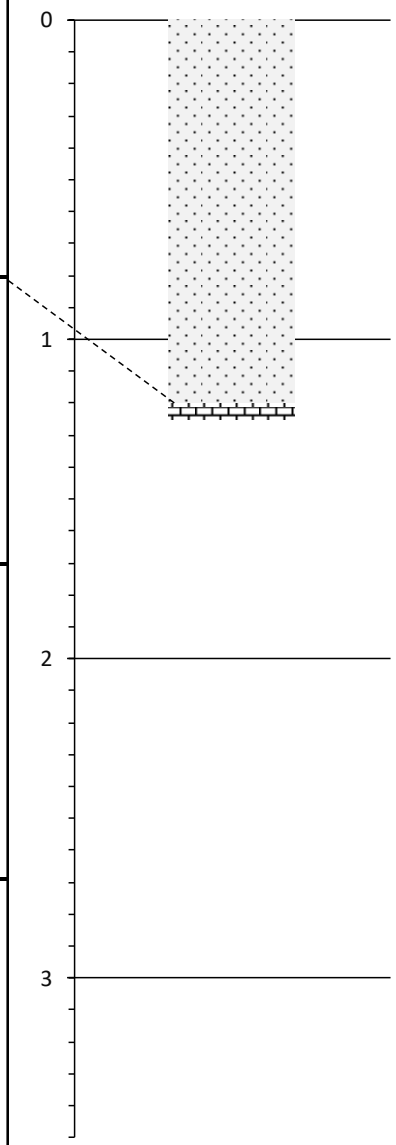
Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 1.20 Dry, brown & orange brown, loose, bedded, fine SAND. Transported sediments.			Piezometer Installed
Unit 2: 1.20 - 1.80 CALCRETE, soft rock			Sample S1 @ 1.0 mbgl
Unit 3: 1.80 - 3.20 Dry, pale brown & white, medium dense, bedded, silty fine SAND. Transported sediments.			Sample S2 @ 2.0 mbgl
Unit 4: 3.20 - 3.50 Slighty moist, dark brown, medium dense, intact, clayey silty Fine SAND. Transported sediment.			End of Hole = 3.50 mbgl

Excavated By:	GEOSS	**Remarks:**	
Drill Method:	TLB Excavator		No groundwater
Logged By:	CM/ MB		

GEOSS SOUTH AFRICA (Pty) Ltd

Log of Trial Pit No.: TP04

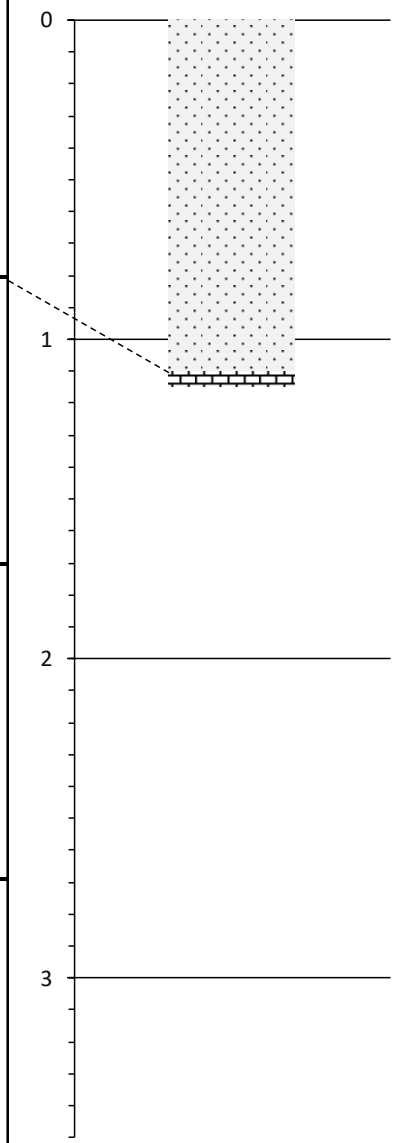
Location:	Melkhoutfontein Cemetery	**Latitude:**	-34.32504499
Date:	24-Jun-20	**Longitude:**	21.42663502
Client:	SES	**Ground Elevation:**	40

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 1.20 Dry, brown, loose, intact, fine SAND. Transported sediments.			TLB Refusal on Calcrete
Unit 2: 1.20 CALCRETE, medium hard rock			
			End of Hole = 1.20 mbgl

Excavated By:	GEOSS	**Remarks:**	
Drill Method:	TLB Excavator		No groundwater
Logged By:	CM/ MB		

Log of Trial Pit No.: TP05

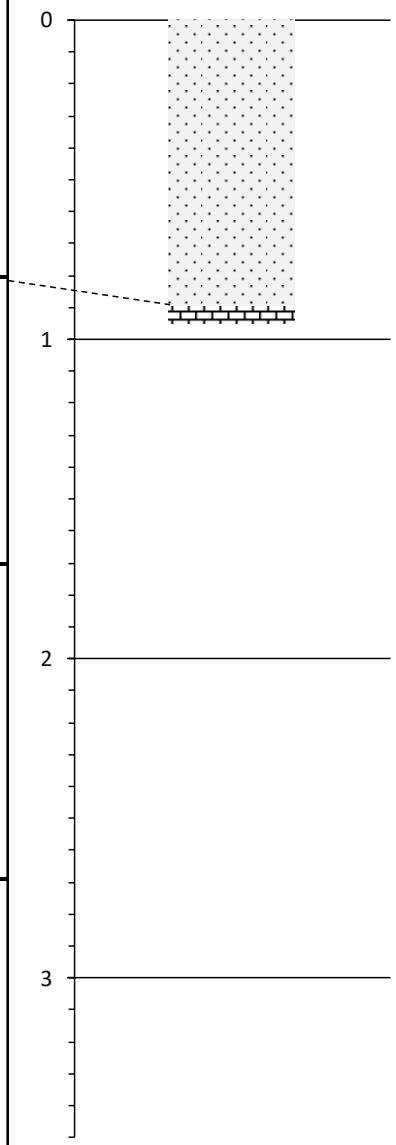
Location:	Melkhoutfontein Cemetery	**Latitude:**	-34.32533501
Date:	24-Jun-20	**Longitude:**	21.42699402
Client:	SES	**Ground Elevation:**	40

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 1.10 Dry, brown, loose, intact, fine SAND. Transported sediments.			TLB Refusal on Calcrete Sample S3 @ 0.8 mbgl
Unit 2: 1.10 CALCRETE, medium hard rock			
			End of Hole = 1.10 mbgl

Excavated By:	GEOSS	**Remarks:**	
Drill Method:	TLB Excavator		No groundwater
Logged By:	CM/ MB		

Log of Trial Pit No.: TP06

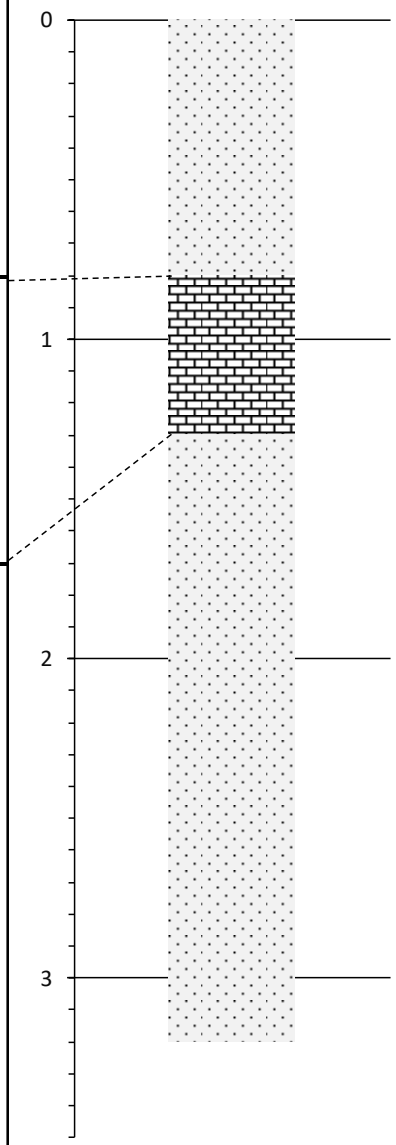
Location:	Melkhoutfontein Cemetery	**Latitude:**	-34.32542796
Date:	24-Jun-20	**Longitude:**	21.42662304
Client:	SES	**Ground Elevation:**	40

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 0.90 Dry, brown, loose, intact, fine SAND. Transported sediments.			TLB Refusal on Calcrete
Unit 2: 0.90 CALCRETE, medium hard rock			
			End of Hole = 0.90 mbgl

Excavated By:	GEOSS	**Remarks:**	
Drill Method:	TLB Excavator		No groundwater
Logged By:	CM/ MB		

Log of Trial Pit No.: TP07

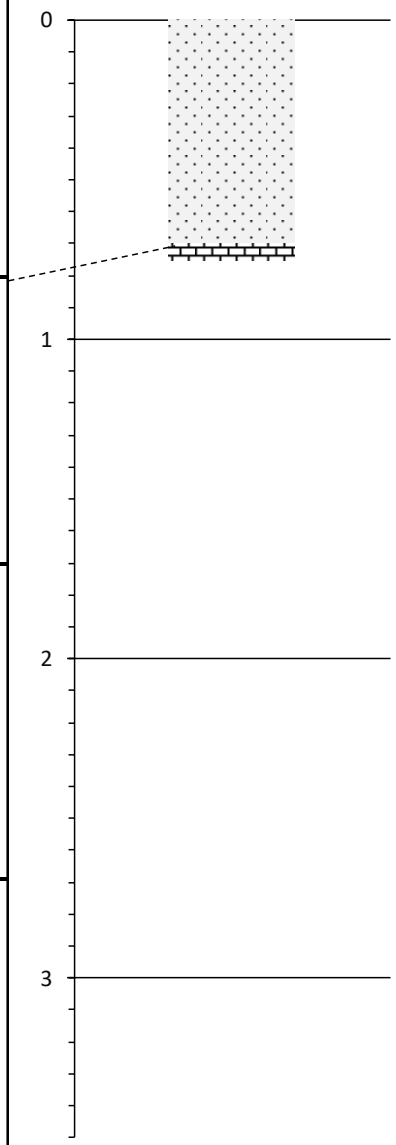
Location:	Melkhoutfontein Cemetery	**Latitude:**	-34.325435
Date:	24-Jun-20	**Longitude:**	21.42638097
Client:	SES	**Ground Elevation:**	40

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 0.80 Dry, brown, loose, intact, fine SAND. Transported sediments.			
Unit 2: 0.80 - 1.30 CALCRETE, soft rock			
Unit 3: 1.30 - 3.20 Dry, pale orange & brown medium dense, bedded, silty fine SAND. Transported sediments.			End of Hole = 3.20 mbgl

Excavated By:	GEOSS	**Remarks:**	
Drill Method:	TLB Excavator		No groundwater
Logged By:	CM/ MB		

Log of Trial Pit No.: TP08

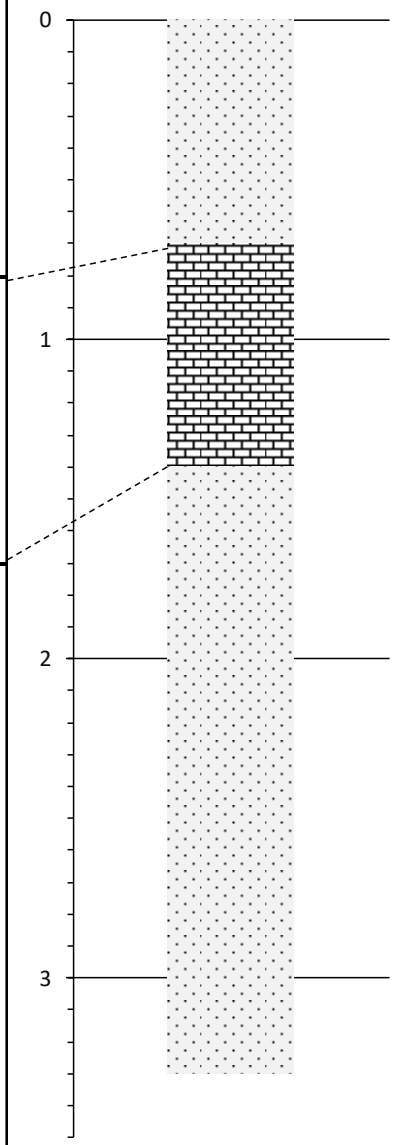
Location:	Melkhoutfontein Cemetery	**Latitude:**	-34.32533702
Date:	24-Jun-20	**Longitude:**	21.425998
Client:	SES	**Ground Elevation:**	40

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 0.70 Dry, brown, loose, intact, fine SAND. Transported sediments.			TLB Refusal on Calcrete
Unit 2: 0.70 CALCRETE, medium hard rock			
			End of Hole = 0.70 mbgl

Excavated By:	GEOSS	**Remarks:**	
Drill Method:	TLB Excavator		No groundwater
Logged By:	CM/ MB		

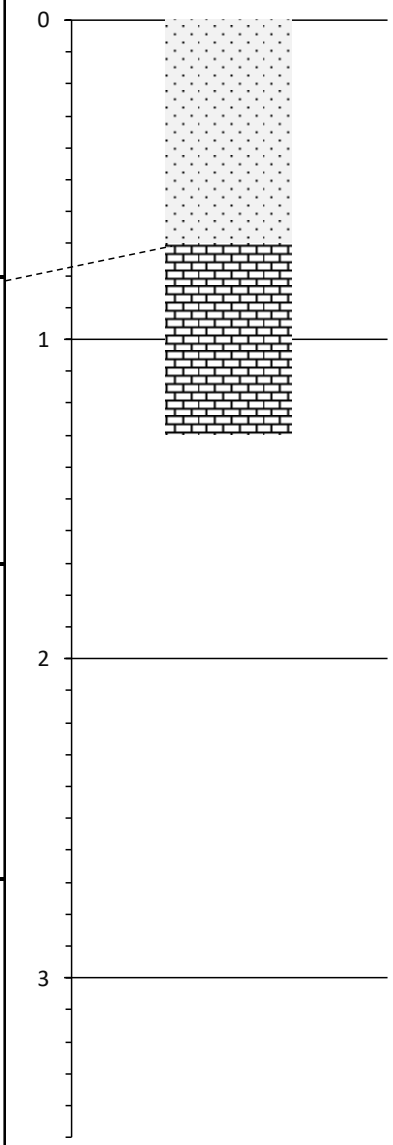
Log of Trial Pit No.: TP09

Location:	Melkhoutfontein Cemetery	**Latitude:**	-34.32549401
Date:	24-Jun-20	**Longitude:**	21.42570103
Client:	SES	**Ground Elevation:**	40

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 0.70 Dry, brown, loose, intact, fine SAND. Transported sediments.			Piezometer Installed Sample S4 @ 0.6 mbgl
Unit 2: 0.70 - 1.40 CALCRETE, soft rock			
Unit 3: 1.40 - 3.30 Dry, pale orange & brown medium dense, bedded, silty fine SAND. Transported sediments.			Sample S5 @ 1.8 mbgl Water Level @ 2.90 mbgl End of Hole = 3.30 mbgl

Excavated By:	GEOSS	**Remarks:**	
Drill Method:	TLB Excavator		WL = 2.90 mbgl
Logged By:	CM/ MB		

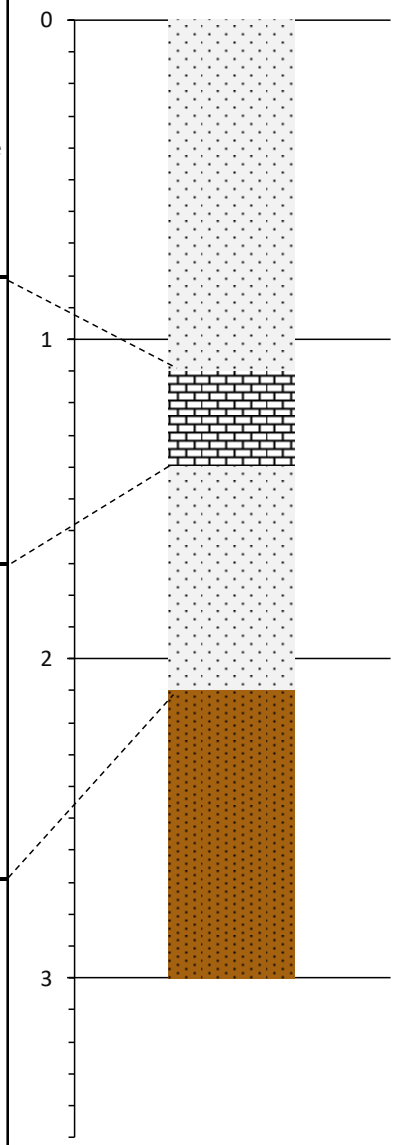
Log of Trial Pit No.:		TP10	
Location:	Melkhoutfontein Cemetery	**Latitude:**	-34.32503602
Date:	24-Jun-20	**Longitude:**	21.42604703
Client:	SES	**Ground Elevation:**	40

Lithological Description	**Lithology (mbgl)**	**Construction**	**Comments**
Unit 1: 0.00 - 0.70 Dry, dark grey, loose, intact, fine SAND. Transported sediments.			TLB Refusal in Calcrete
Unit 2: 0.70 - 1.30 CALCRETE, soft becoming medium hard rock			
			End of Hole = 1.30 mbgl

Excavated By:	GEOSS	**Remarks:**	
Drill Method:	TLB Excavator		No groundwater
Logged By:	CM/ MB		

Log of Trial Pit No.: TP11

Location:	Melkhoutfontein Cemetery	**Latitude:**	-34.32465398
Date:	24-Jun-20	**Longitude:**	21.42631198
Client:	SES	**Ground Elevation:**	41

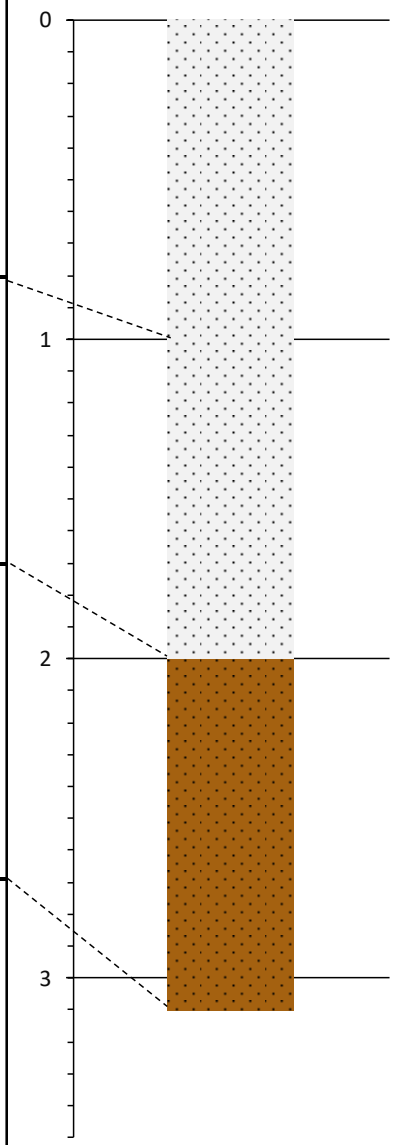
Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 0.80 Dry, brown & orange brown, loose, bedded, fine SAND. Transported sediments.			
Unit 2: 0.80 - 1.00 CALCRETE, soft rock			
Unit 3: 1.00 - 2.90 Dry, pale orange and brown, medium dense, bedded, silty fine SAND. Transported sediments.			
Unit 4: 2.90 - 3.1 Slighty moist, dark brown, medium dense, intact, clayey silty Fine SAND. Transported sediment.			End of Hole = 3.00 mbgl

Excavated By:	GEOSS	**Remarks:**	
Drill Method:	TLB Excavator		No groundwater
Logged By:	CM/ MB		

GEOSS SOUTH AFRICA (Pty) Ltd

Log of Trial Pit No.: TP12

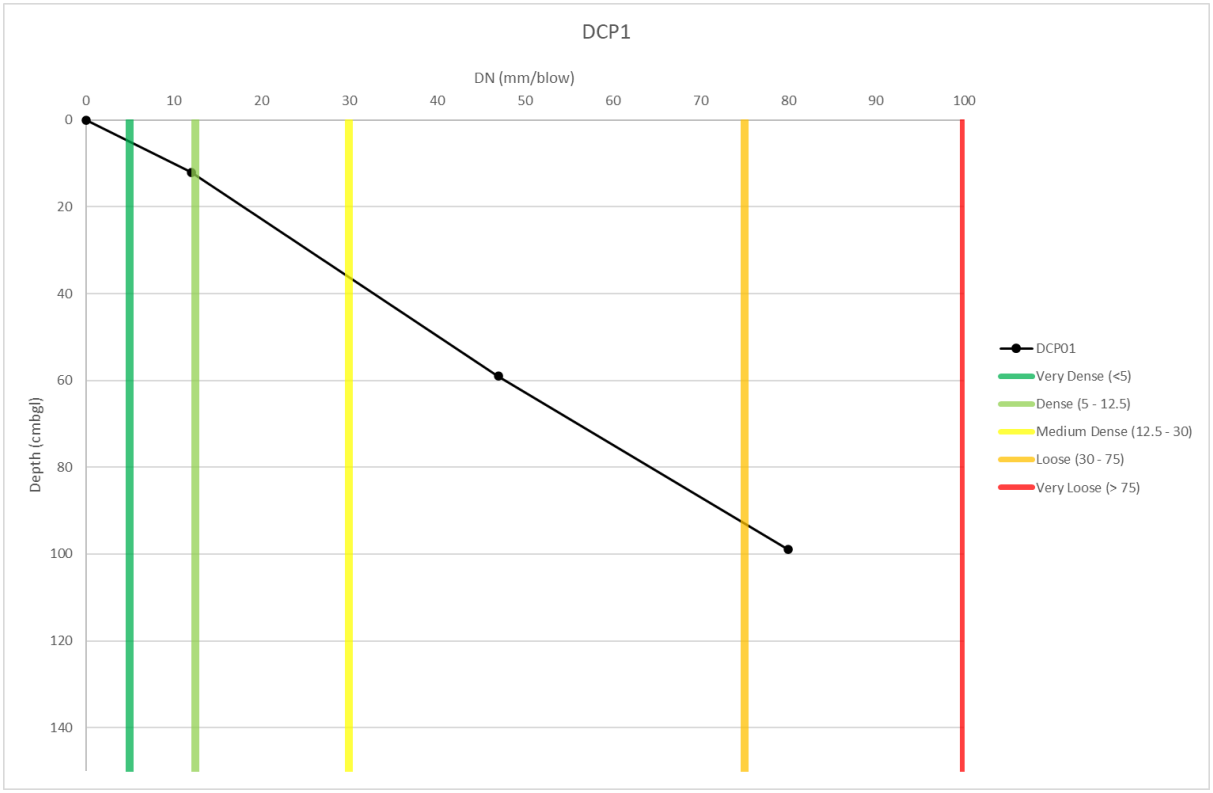
Location:	Melkhoutfontein Cemetery	**Latitude:**	-34.32391897
Date:	24-Jun-20	**Longitude:**	21.42609296
Client:	SES	**Ground Elevation:**	43

Lithological Description	Lithology (mbgl)	Construction	Comments
Unit 1: 0.00 - 0.80 Dry, brown & orange brown, loose, bedded, fine SAND. Transported sediment.			Piezometer Installed
Unit 2: 0.80 - 1.00 Dry, off white, loose, intact, fiine SAND. Transported sediment.			
Unit 3: 1.00 - 2.90 Slighty moist, dark brown, medium dense, intact, clayey silty Fine SAND. Transported sediment.			
			End of Hole = 3.10 mbgl

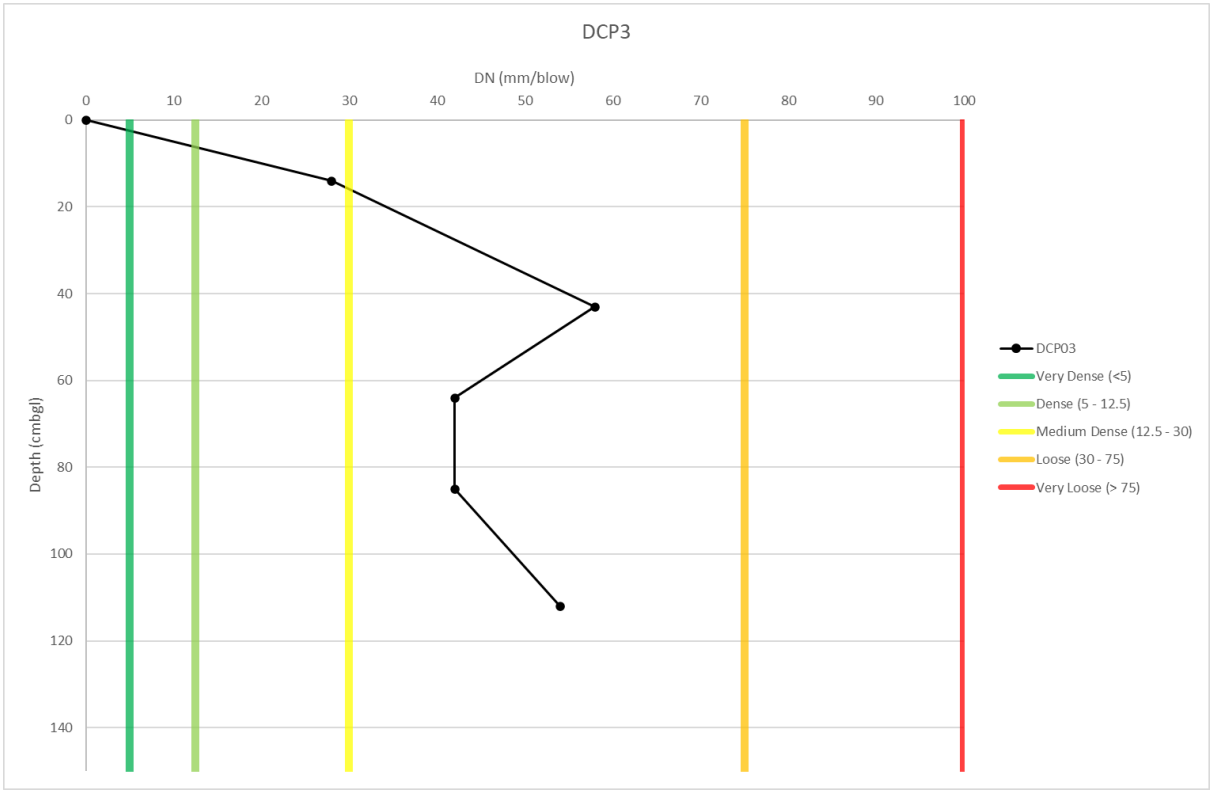
Excavated By:	GEOSS	**Remarks:**	
Drill Method:	TLB Excavator		No groundwater
Logged By:	CM/ MB		

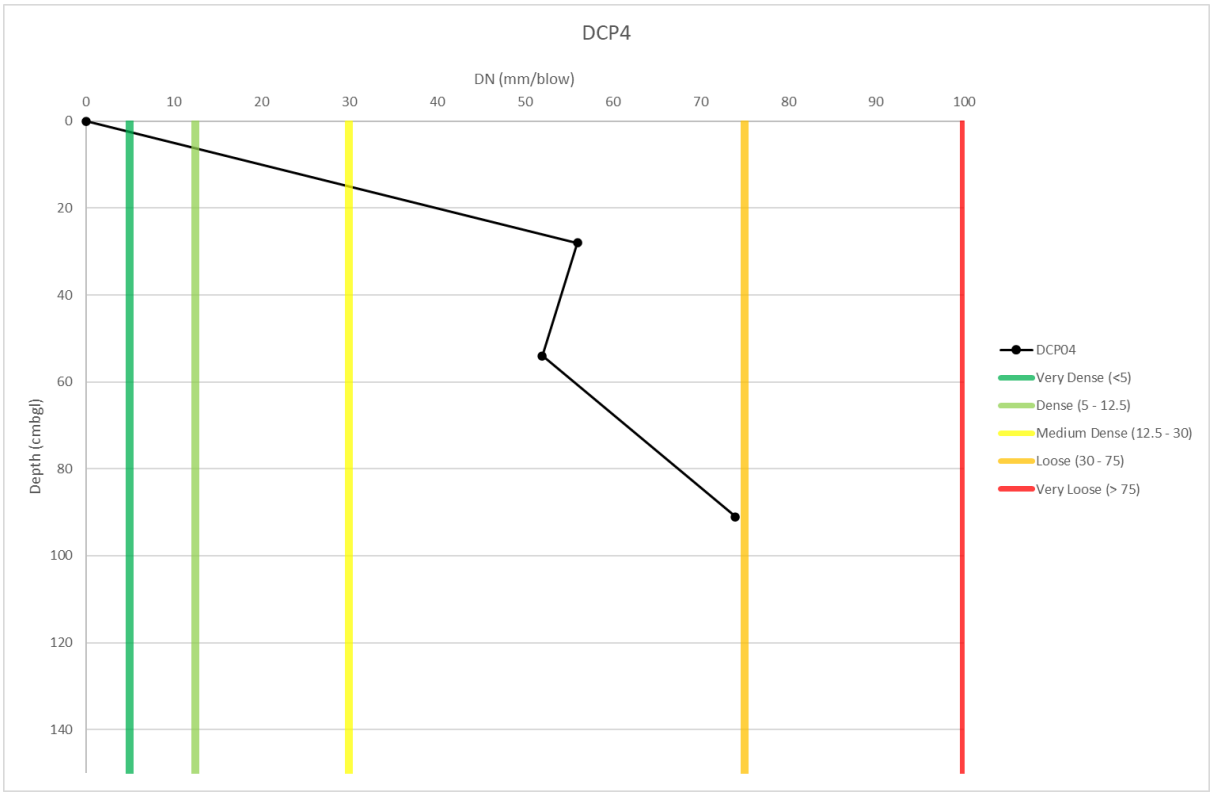
GEOSS SOUTH AFRICA (Pty) Ltd

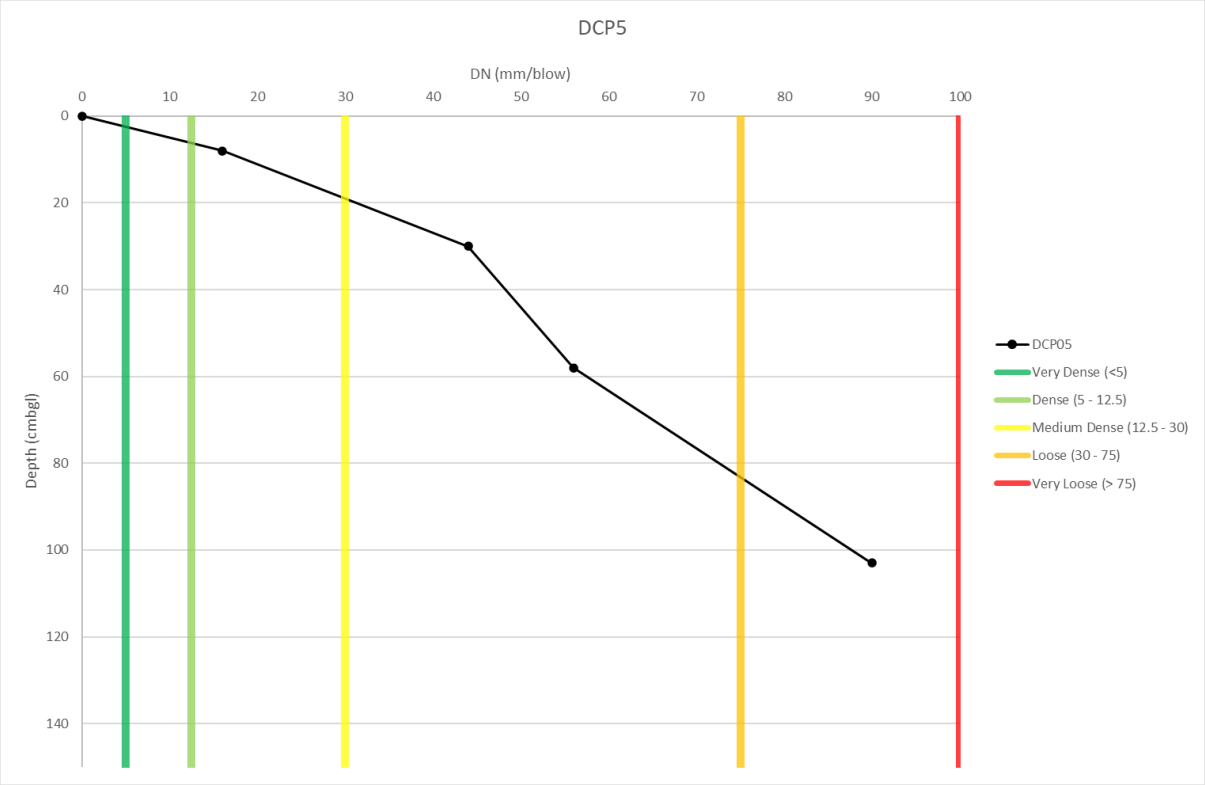
14. APPENDIX B: DCP TESTING LOGS

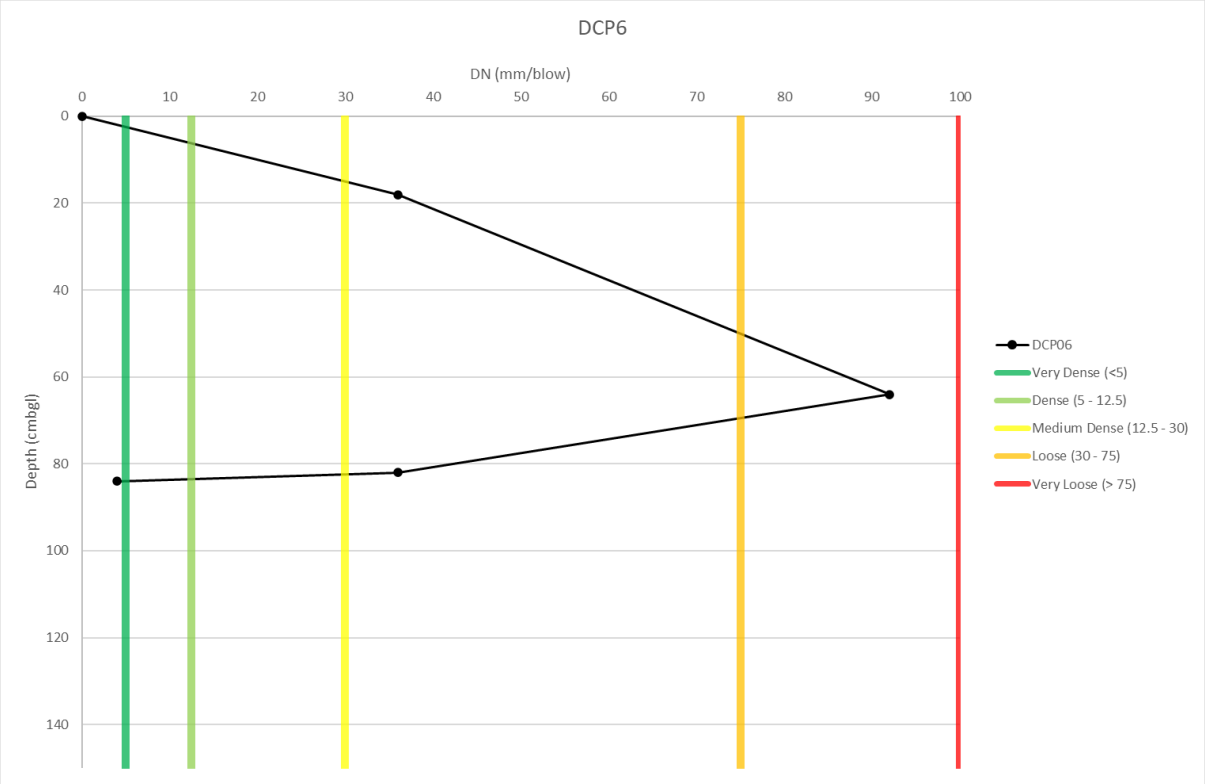

DCP1
DN (mm/blow)
0
10
20
30
40
50
60
70
80
90
100
Depth (cmbgl)
0
20
40
60
80
100
120
140
DCP01
Very Dense (<5)
Dense (5 - 12.5)
Medium Dense (12.5 - 30)
Loose (30 - 75)
Very Loose (> 75)

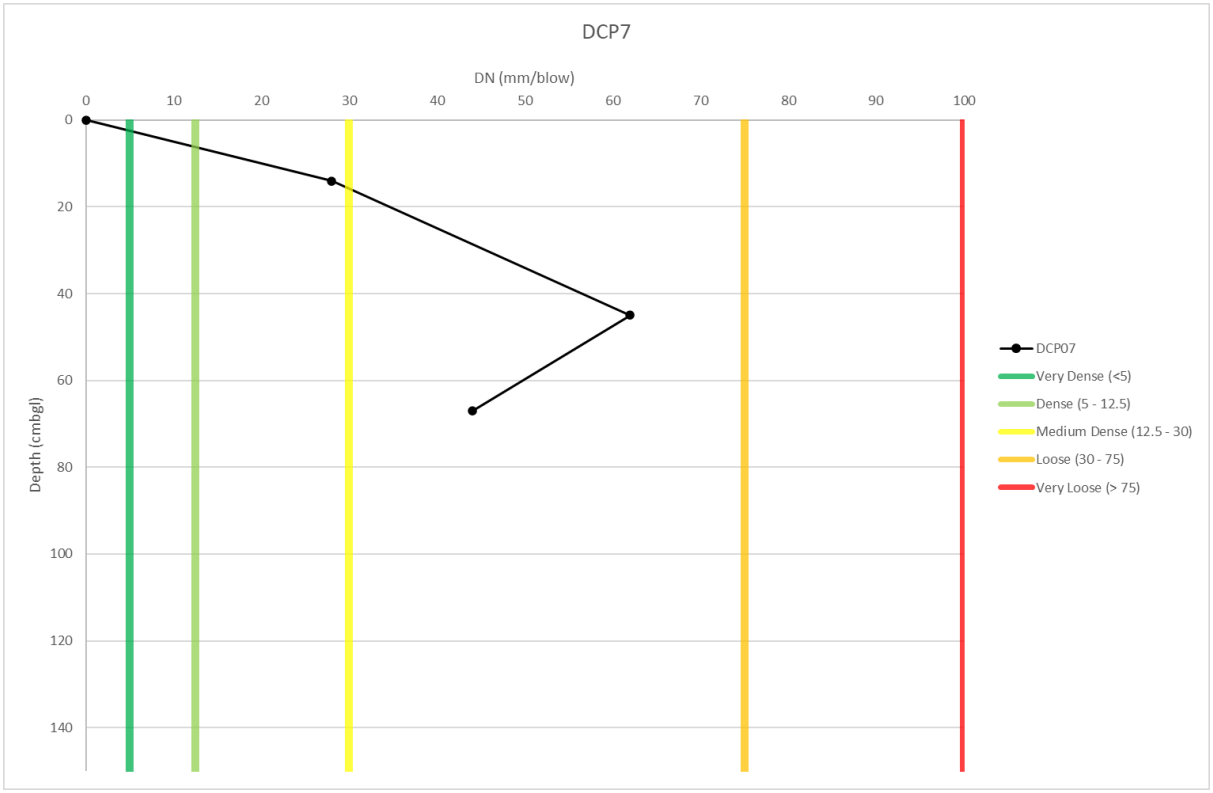

DCP2
DN (mm/blow)
0
10
20
30
40
50
60
70
80
90
100
Depth (cmbgl)
0
20
40
60
80
100
120
140
DCP02
Very Dense (<5)
Dense (5 - 12.5)
Medium Dense (12.5 - 30)
Loose (30 - 75)
Very Loose (> 75)

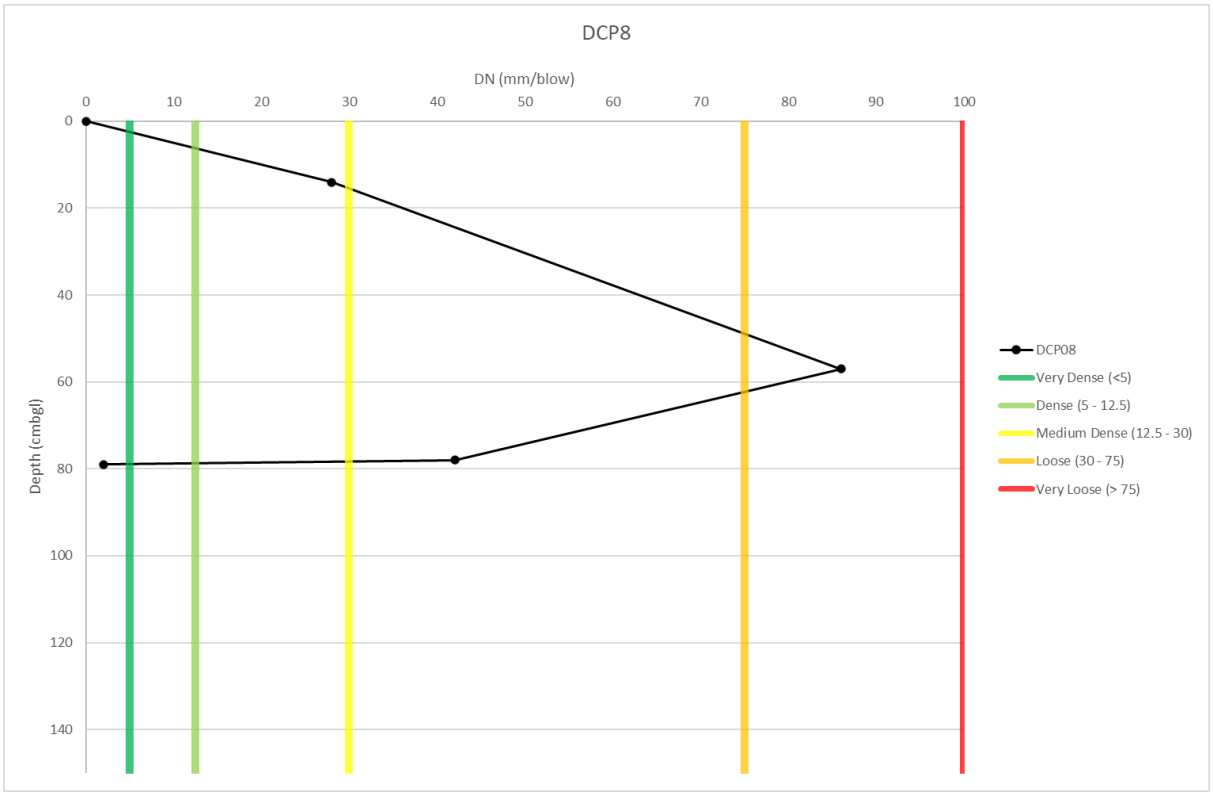

DCP3
DN (mm/blow)
0
10
20
30
40
50
60
70
80
90
100
Depth (cmbgl)
0
20
40
60
80
100
120
140
DCP03
Very Dense (<5)
Dense (5 - 12.5)
Medium Dense (12.5 - 30)
Loose (30 - 75)
Very Loose (> 75)

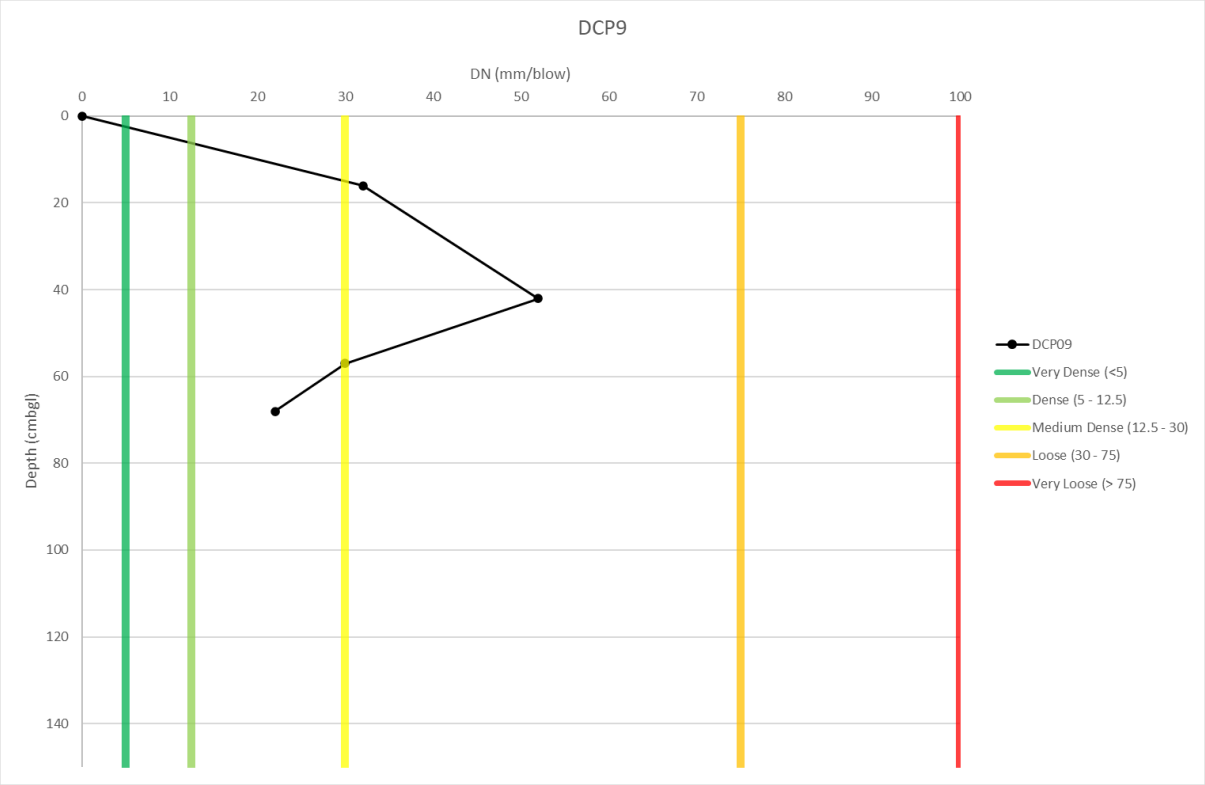

DCP4
DN (mm/blow)
0
10
20
30
40
50
60
70
80
90
100
Depth (cmbgl)
0
20
40
60
80
100
120
140
DCP04
Very Dense (<5)
Dense (5 - 12.5)
Medium Dense (12.5 - 30)
Loose (30 - 75)
Very Loose (> 75)

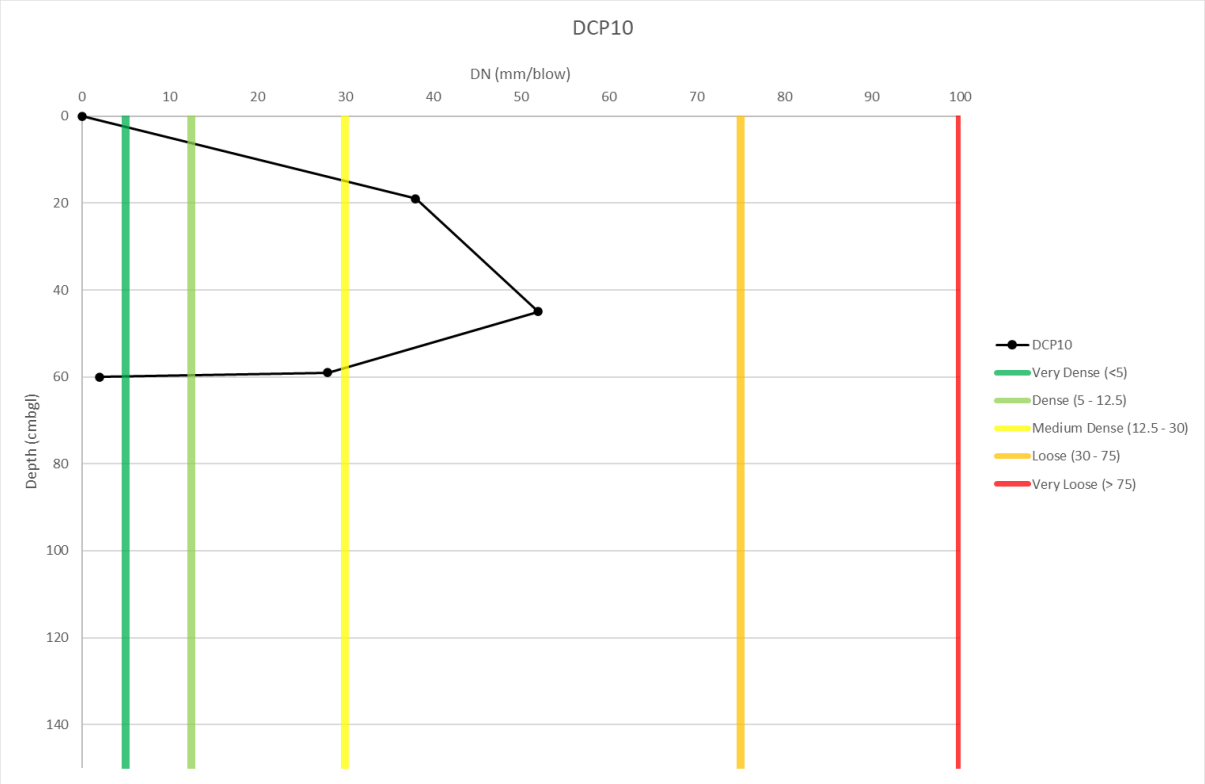

DCP5
DN (mm/blow)
0
10
20
30
40
50
60
70
80
90
100
Depth (cmbgl)
0
20
40
60
80
100
120
140
DCP05
Very Dense (<5)
Dense (5 - 12.5)
Medium Dense (12.5 - 30)
Loose (30 - 75)
Very Loose (> 75)

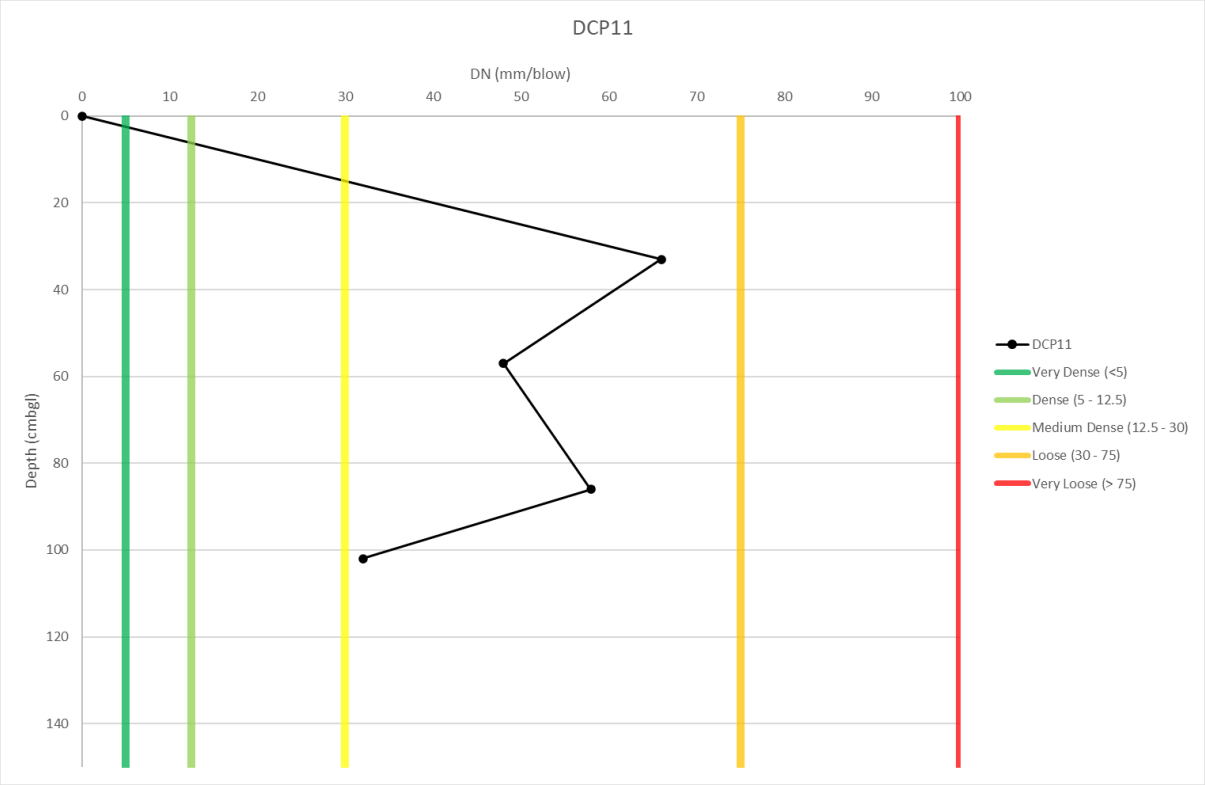

DCP6
DN (mm/blow)
0
10
20
30
40
50
60
70
80
90
100
Depth (cmbgl)
0
20
40
60
80
100
120
140
DCP06
Very Dense (<5)
Dense (5 - 12.5)
Medium Dense (12.5 - 30)
Loose (30 - 75)
Very Loose (> 75)

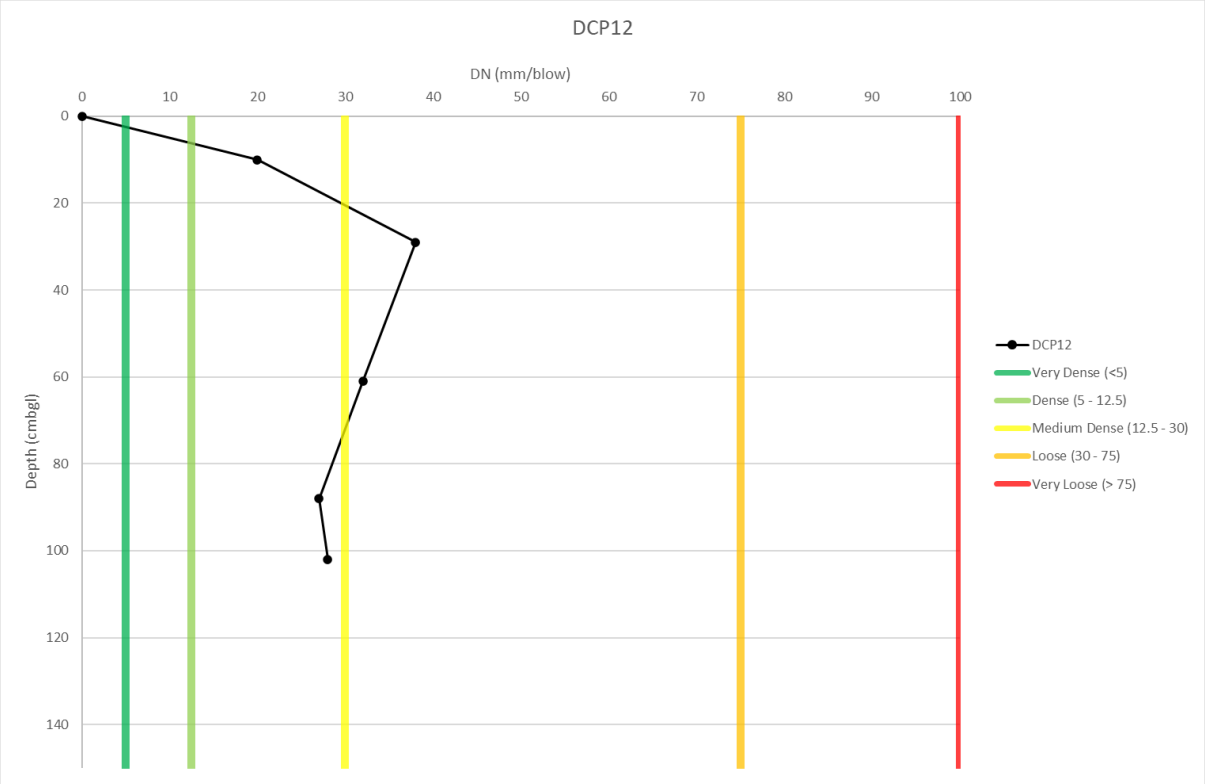

DCP7
DN (mm/blow)
0
10
20
30
40
50
60
70
80
90
100
Depth (cmbgl)
0
20
40
60
80
100
120
140
DCP07
Very Dense (<5)
Dense (5 - 12.5)
Medium Dense (12.5 - 30)
Loose (30 - 75)
Very Loose (> 75)


DCP8
DN (mm/blow)
0
10
20
30
40
50
60
70
80
90
100
Depth (cmbgl)
0
20
40
60
80
100
120
140
DCP08
Very Dense (<5)
Dense (5 - 12.5)
Medium Dense (12.5 - 30)
Loose (30 - 75)
Very Loose (> 75)


DCP9
DN (mm/blow)
0
10
20
30
40
50
60
70
80
90
100
Depth (cmbgl)
0
20
40
60
80
100
120
140
DCP09
Very Dense (<5)
Dense (5 - 12.5)
Medium Dense (12.5 - 30)
Loose (30 - 75)
Very Loose (> 75)


DCP10
DN (mm/blow)
0
10
20
30
40
50
60
70
80
90
100
Depth (cmbgl)
0
20
40
60
80
100
120
140
DCP10
Very Dense (<5)
Dense (5 - 12.5)
Medium Dense (12.5 - 30)
Loose (30 - 75)
Very Loose (> 75)


DCP11
DN (mm/blow)
0
10
20
30
40
50
60
70
80
90
100
Depth (cmbgl)
0
20
40
60
80
100
120
140
DCP11
Very Dense (<5)
Dense (5 - 12.5)
Medium Dense (12.5 - 30)
Loose (30 - 75)
Very Loose (> 75)


DCP12
DN (mm/blow)
0
10
20
30
40
50
60
70
80
90
100
Depth (cmbgl)
0
20
40
60
80
100
120
140
DCP12
Very Dense (<5)
Dense (5 - 12.5)
Medium Dense (12.5 - 30)
Loose (30 - 75)
Very Loose (> 75)

15. APPENDIX C: LABORATORY ANALYSIS

vinlab H2O
Your partner in quality water analysis

Distillery Road
Stellenbosch
Tel 021-8828866/7
info@vinlab.com
www.vinlab.com
2020-06-29

TEST REPORT

Water

Geoss South Africa (Pty) Ltd
Attn: - Alison

P.O.Box 12412
Die Boord, Stellenbosch
7613
-
-

@VinlabSA

Sample Details							
SampleID			W10305	W10306			
Water Type			Drinking Water	Drinking Water			
Water Source			Borehole				
Sample Temperature							
Description			3971_Pz_2	3971_BH01B			
PO Number			3971_Phase A	3971_Phase A			
Date Received			2020-06-25	2020-06-25			
Condition			Good	Good			
Water - Routine							
pH@25C* (Water)		VIN-05-MW01	7.48	7.48			
Conductivity@25C* (Water)	mS/m	VIN-05-MW02	234	139.7			
Turbidity (Water)	ntu		657.00	8.33			
Total dissolved solids (Water)	mg/L		1586.52	947.17			
Free Chlorine (Water)	mg/L		<0.02	0.03			
Ammonia (NH4) as N* (Water)	mg/L	VIN-05-MW08	<0.15	<0.15			
Nitrate as N* (Water)	mg/L	VIN-05-MW08	3.19	3.08			
Nitrite as N* (Water)	mg/L	VIN-05-MW08	<0.05	<0.05			
Chloride (Cl-)* - Water	mg/L	VIN-05-MW08	547.72	284.80			
Sulphates (SO4)* - Water	mg/L	VIN-05-MW08	71.08	47.46			
Fluoride (F)* - Water	mg/L	VIN-05-MW08	<0.15	0.53			
Alkalinity as CaCO3 (Water)	mg/L		366.80	220.20			
Colour (Water)	mg/L Pt-Co		<15	<15			
Cyanide (CN) - Water	µg/L		<10.0	<10.0			
Total Organic Carbon (Water)	mg/L		5.0	1.7			
Date Tested			2020-06-25	2020-06-25			
Water - Metals							
Calcium* (Ca) - Water	mg/L	VIN-05-MW43	176	84			
Magnesium* (Mg) - Water	mg/L	VIN-05-MW43	40	21			
Sodium* (Na) - Water	mg/L	VIN-05-MW43	282	152			
Potassium* (K) - Water	mg/L	VIN-05-MW43	7	5			
Zinc* (Zn) - Water	mg/L	VIN-05-MW43	<0.008	<0.008			
Antimony (Sb) - Water	µg/L		<13.0	<13.0			
Arsenic (As) - Water	µg/L		23.9	<10.0			

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.

*Accredited methods. 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; We•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. SO2 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.

VIN 09-01 10-02-20

Doc No
V20726

Visit Vinlab H20

sanas
T0685

vinlab H2O
Your partner in quality water analysis

Distillery Road
Stellenbosch
Tel 021-8828866/7
info@vinlab.com
www.vinlab.com
2020-06-29

TEST REPORT

Water

Geoss South Africa (Pty) Ltd

Attn: - Alison

P.O.Box 12412
Die Boord, Stellenbosch
7613
-
-

@VinlabSA

Boron (B) - Water	µg/L	VIN-05-MW43	255	132			
Cadmium (Cd) - Water	µg/L	VIN-05-MW43	<1	<1			
Chromium* (Cr) - Water	µg/L	VIN-05-MW43	30	4			
Copper* (Cu) - Water	µg/L	VIN-05-MW43	7	7			
Iron* (Fe) - Water	µg/L	VIN-05-MW43	15278	99			
Lead* (Pb) - Water	µg/L	VIN-05-MW43	11	<8			
Manganese* (Mn) - Water	µg/L	VIN-05-MW43	116	<4			
Nickel* (Ni) - Water	µg/L	VIN-05-MW43	<8	<8			
Selenium (Se) - Water	µg/L		<10.0	<10.0			
Aluminium* (Al) - Water	µg/L	VIN-05-MW43	2021	84			
Mercury (Hg) - Water	µg/L		1.4	<1.0			
Barium (Ba) - Water	µg/L	VIN-05-MW43	63	13			
Uranium (U) - Water	µg/L		<28	<28			
Date Tested			2020-06-26	2020-06-25			
Water - Micro							
Total Coliforms (Water)	cfu/100mL		55	2			
E-Coli* (Water)	cfu/100mL	VIN-05-MW07	nd	nd			
Heterotrophic plate count (Water)	cfu/mL		70	10			
Date Tested			2020-06-25	2020-06-25			

Comments
W10305 Two Samples received,
W10306 Two Samples received,

Adelize Fourie
Laboratory Manager (Waterlab)
VIN-05-
MD1,MD2,MD3,MD4,MD5,MD6,MD10,MD8,
MW3, MWD1, MWD2, MWD3, MWD4,
MWD5, MWD6, MWD7, MWD8/9/10

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.

*Accredited methods. 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; A=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. SO2 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.

VIN 09-01 10-02-20

Doc No
V20726

sanas Testing Laboratory T0885

bemlab
www.bemlab.co.za
Part of PathCare

sanas
Testing Laboratory
T0654

16 Van der Berg Crescent
Gant's Centre
Strand

Tel. (021) 853-1490
Fax (021) 853-1423

E-Mail admin@bemlab.co.za

P O Box 684
Somerset Mall,
7137

Vat Reg. Nr. 4200161414

CERTIFICATE OF ANALYSES

Report Nr.: **WT005424.DOC**

Ailene van Niekerk
AB Pumps
99 Main Road
Cronubie
5257

Date received: **04-04-2019**
Time received: **12:54**
Order nr.: **112927**

Sampled by client

Water Analyses Report

SANS241

Origin	Lab. Nr.	pH @ 25°C	EC @ 25°C mS/m	Na mg/l	K mg/l	Ca mg/l	Mg mg/l	Cl mg/l	CO_3^{2-} mg/l	HCO_3^- mg/l	SO_4 mg/l	B mg/l	Cu mg/l	Zn mg/l	P mg/l	NH_4-N mg/l	NO_3-N mg/l	*NO_2-N mg/l
Stillbay P46B	5424	7.5	152	223.8	5.8	94.0	22.2	303.1		337.9	66	<0.08	<0.02	<0.03	0.02	<0.28	5.38	0.02
Melkhoutfontein BH04	5425	7.5	165	254.5	5.1	97.8	29.6	349.4		316.1	43	0.41	<0.02	<0.03	0.07	<0.28	3.23	0.00
Melkhoutfontein BH36	5426	7.6	151	248.4	4.9	94.3	26.7	307.1		319.2	79	0.27	<0.02	<0.03	0.19	<0.28	2.64	0.00
Albertina BH18	5427	6.5	71	122.5	2.7	12.0	11.9	212.7		31.7	25	0.08	<0.02	<0.03	<0.01	<0.28	<0.36	0.33
Norm		≥5.0-≤9.7	≤170	≤200.0				≤300.0			≤500	≤2.40	≤2.00	≤5.00		≤1.50	≤11.00	≤0.90

Origin	Lab. Nr.	*F mg/l	*TDS mg/l	Al µg/l	As µg/l	Ba µg/l	Cd µg/l	Cr µg/l	*Hg µg/l	Ni µg/l	Pb µg/l	Sb µg/l	Se µg/l	*U µg/l	*CN µg/l	Date Tested	Date Sampled
Stillbay P46B	5424	0.5	780.4	<30	<5	11.9	<3.1	<27	<3.1	9.2	<7	3.0	<12	<13.8	4.0	05-04-2019	Unknown
Melkhoutfontein BH04	5425	0.3	1469.0	<30	<5	14.7	<3.1	<27	<3.1	8.7	<7	6.8	<12	<13.8	5.0	05-04-2019	Unknown
Melkhoutfontein BH36	5426	0.3	884.8	<30	<5	13.9	<3.1	<27	<3.1	8.9	<7	2.3	<12	<13.8	6.0	05-04-2019	Unknown
Albertina BH18	5427	0.1	618.4	64.05	<5	17.6	<3.1	<27	<3.1	10.2	<7	2.4	<12	<13.8	79.0	05-04-2019	Unknown
Norm		≤1.5	≤1200.0	≤300.00	≤10.0	≤700.0	≤3.0	≤50.0	≤6.0	≤70.0	≤10.0	≤20.0	≤40.0	≤30.0	≤200.0		

Origin	Lab. Nr.	*Colour True (Filtered) mg/l Pt	*Apparent Colour mg/l Pt	*Turbidity NTU	Temperature at reception (°C)	*TOC mg/l	*Cl_2 (Free) mg/l	*Total Fe mg/l	*Total Mn mg/l	*Dissolved Fe mg/l	*Dissolved Mn mg/l
~~Stillbay P46B~~	~~5424~~	~~5~~	~~9~~	~~0.23~~	~~19.5~~	~~13.20~~	~~0.08~~	~~0.56~~	~~0.01~~	~~0.01~~	~~0.01~~
Melkhoutfontein BH04	5425	0.00	0.00	0.00	19.4	7.90	0.12	0.10	0.00	0.24	0.01
Melkhoutfontein BH36	5426	0.00	0.00	0.00	18.5	8.30	0.08	0.07	0.00	0.39	0.00
~~Albertina BH18~~	~~5427~~	~~8~~	~~>500~~	~~114~~	~~18.5~~	~~10.90~~	~~1.93~~	~~4.39~~	~~0.13~~	~~0.05~~	~~0.03~~
Norm		≤15		≤5		≤10.00	≤5.00	≤2.00	≤0.40		

** = Not SANAS Accredited*

Norms according to SANS 241-1:2015.

Microbiological analyses

Origin	Lab. Nr.	Total Bacteria cfu/1ml	Total Coliforms cfu/100 ml	E. coli cfu/100ml	Date Tested	Date Sampled	Temperature at reception (°C)
~~Stillbay P46B~~	~~5424~~	~~>3000~~	~~130~~	~~<1~~	~~04/04/19~~	~~Unknown~~	~~19.5~~
Melkhoutfontein BH04	5425	>3000	5	<1	04/04/19	Unknown	19.4
Melkhoutfontein BH36	5426	>3000	167	<1	04/04/19	Unknown	18.5
~~Albertina BH18~~	~~5427~~	~~>3000~~	~~1986~~	~~<1~~	~~04/04/19~~	~~Unknown~~	~~18.5~~
Norm		≤1000	≤10	<1			

Norms according to SANS 241-1:2015.

Statement: The reported results may be applied only to samples received. Any recommendations included with this report are based on the assumption that the samples were representative of the source from which they were taken.

Notes:

To ensure sample integrity, samples are stored only for seven days after release of the report. Thereafter it is disposed of and a fresh sample will be required if additional analyses are requested.

Results marked with "**Not SANAS Accredited**" in this report are not included in the SANAS Schedule of Accreditation for this laboratory. These results relate to the items tested.

This test report shall not be reproduced except in full, without written approval of the laboratory.

Opinions and interpretations expressed herein are outside the scope of SANAS accreditation.

Refer to website for uncertainty of measurement and referenced methods.

Sample condition: Water sample temperatures were higher than 10°C. The effect of this on the micro-organisms is not known, treat microbiological results with reserve

Shaun Salie
Technical Signatory (Water chemistry)

Lauren Taylor
Technical Signatory(Microbiology)

29-04-2019
Date reported

————END OF REPORT————

STEYN-WILSON LABORATORIES
CIVIL ENGINEERING TESTING LABORATORIES

11 Gooderson Road Blackheath
PO Box 58 Blackheath 7581
Tel: 021 905 0435
Fax: 086 499 9482
Email: admin@steynwilson.co.za
Web: www.steynwilson.co.za

Client: **GEOSS South Africa**
Project: 3971 - Melkhoutfontein (Stilbaai)
Attention: Mr C Muller
Your Ref. No: -
Date Reported 02.07.20

TEST REPORT REFERENCE NUMBER / JOB NUMBER : SWL11455

Dear Sir / Madam

Herewith please find the original reports pertaining to the above mentioned project.

Test Requested

4 x MOD / CBR
4 x Foundation Indicator

Site Sampling and Materials Information

Sampling Method Specimens delivered to Steyn Wilson Laboratory.
Environmental Condition Cloudy
Deviation from the prescribed test method
Responsibility of information disclaimer

● **FINAL REPORT**

We would like to take this opportunity to thank you for your valued support.
Should you have any further enquiries please don't hesitate to contact me.

Yours Faithfully
STEYN-WILSON LABORATORIES (PTY) LTD

Mr. R.Wilson
Technical Signatory

Remarks:
1. Information contained herein is confidential to STEYN-WILSON PTY LTD and the addressee
2. Opinions & Interpretations are not included in our schedule of Accreditation.
3. The samples where subjected and analysed according to ASTM.
4. The results reported relate only to the sample tested, Further use of the attached information is not the responsibility or liability of STEYN-WILSON LABORATORIES (PTY) LTD.
5. This document is the correct record of all measurements made, and may not be reproduced other than with full written approval from a director of STEYN-WILSON LABORATORIES (PTY) LTD.
6. Measuring equipment is traceable to national standards (Where applicable).
7. Should there be any deviation from the prescribed test method comments will be made thereof, pertaining to the test on the relevant materials report.
8. Uncertainty of measurement is calculated and corresponds to a coverage probability of approximately 95%. Available on request.
9. The decision rule states that the measurement of uncertainty can be applied by the customer to the test results, on request. It is not the responsibility or liability of STEYN-WILSON LABORATORIES (PTY) LTD.

STEYN-WILSON LABORATORIES
CIVIL ENGINEERING TESTING LABORATORIES

11 Gooderson Road Blackheath
PO Box 58 Blackheath 7581
Tel: 021 905 0435
Fax: 086 499 9482
Email: admin@steynwilson.co.za
Web: www.steynwilson.co.za

Customer :	**GEOSS South Africa**	Project :	3971 - Melkhoutfontein (Stilbaai)
	9 Quantum Street, Techno Park, Unit 12 Technostell Building	Date Received :	25.06.20
	Stellenbosch	Date Reported :	02.07.20
	7600	Req. Number :	-
Attention :	Mr C Muller		

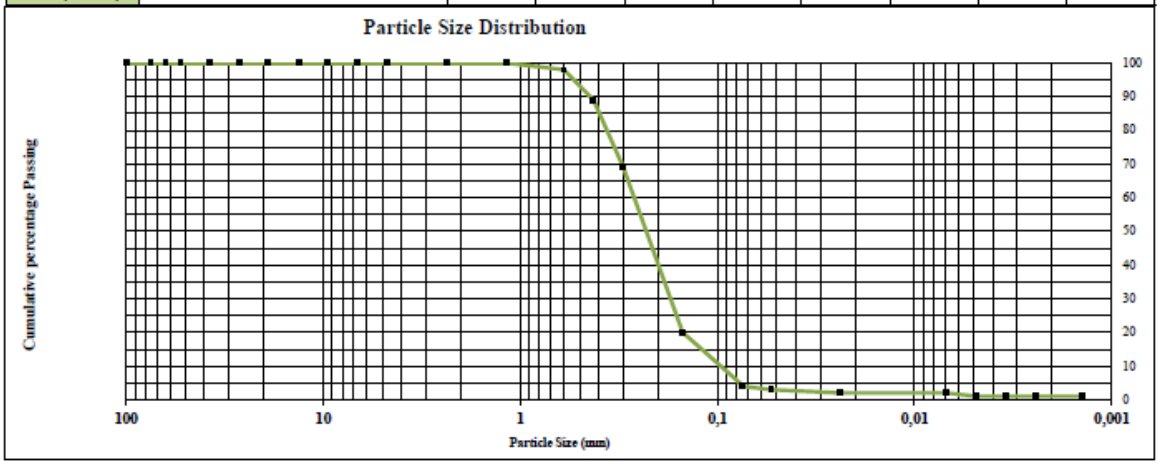
MOD / CBR / FOUNDATION INDICATOR - TMH1 A1* / ASTM D422 / SANS 3001 GR30 / SANS 3001 GR40

Material Description:	Dark Brown Reddish Sand	Sample Number:	13276		
Position:	Sample 1	Liquid Limit	**NP**	Linear Shrinkage	**0.0**
Depth:	-	Plasticity Index	**NP**	Insitu M/C%	**1,9**

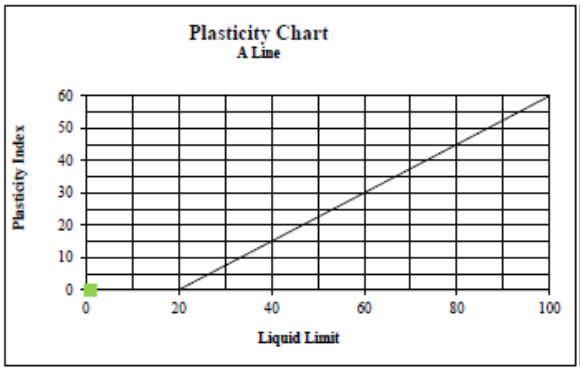
pH (TMH1 A20)*	-	Conductivity s.m^{-1} (TMH1 A21T)*	-	SG (TMH1 A12T)*	2,568

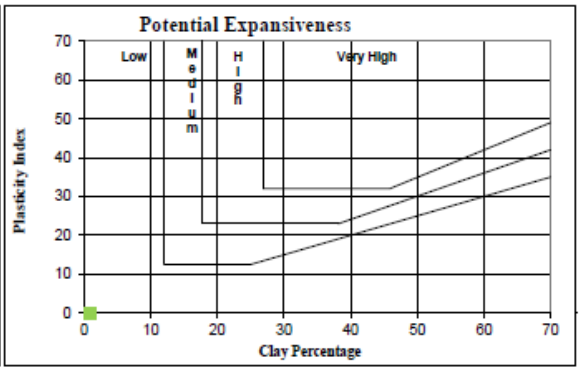
SIEVE ANALYSIS (TMH 1 A1a)*																	HYDROMETER ASTM D422							
100	75	63	53	37,5	26,5	19,0	13,2	9,5	6,7	4,75	2,36	1,18	0,60	0,425	0,300	0,150	0,075	0,075	0,053	0,024	0,007	0,005	0,003	0,002	0,001
100	100	100	100	100	100	100	100	100	100	100	100	100	98	89	69	20	4,4	4	3	2	2	1	1	1	1
% Passing																									

MOD AASHTO SANS 3001 GR30		CBR SANS 3001 GR40						
OMC%	11,3	COMP MC	% SWELL	100%	98%	97%	95%	93%	90%
MDD(KG/M^3)	1770	11,6	0,0	14	13	12	10	9	7



% Gravel		% Sand	97	% Silt	2	% Clay	1





STEYN-WILSON LABORATORIES
CIVIL ENGINEERING TESTING LABORATORIES

11 Gooderson Road Blackheath
PO Box 58 Blackheath 7581
Tel: 021 905 0435
Fax: 086 499 9482
Email: admin@steynwilson.co.za
Web: www.steynwilson.co.za

Customer :	**GEOSS South Africa**	Project :	3971 - Melkhoutfontein (Stilbaai)
	9 Quantum Street, Techno Park, Unit 12 Technostell Building	Date Received :	25.06.20
	Stellenbosch	Date Reported :	02.07.20
	7600	Req. Number :	-
Attention :	Mr C Muller		

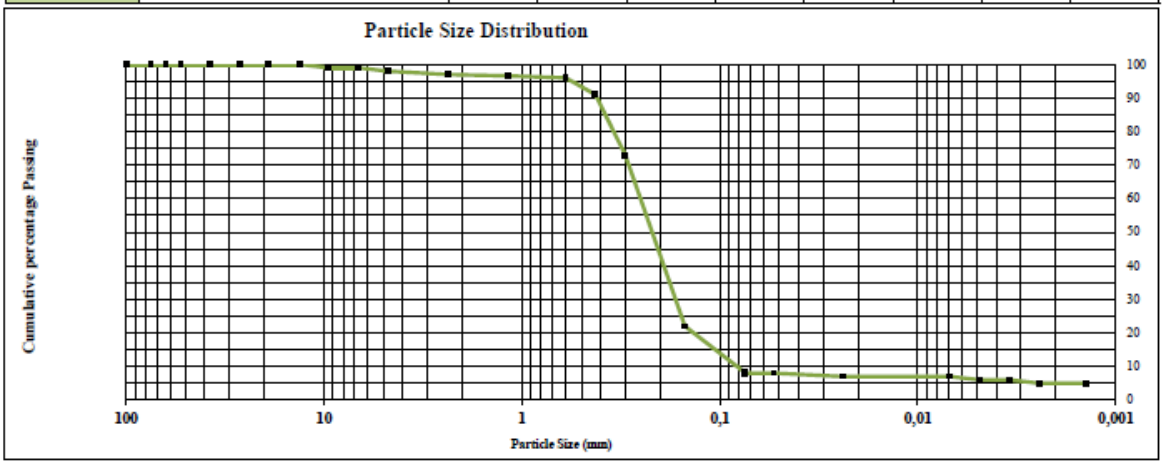
MOD / CBR / FOUNDATION INDICATOR - TMH1 A1* / ASTM D422 / SANS 3001 GR30 / SANS 3001 GR40

Material Description:	Light Brown Sand with Sandstone	Sample Number:	13277		
Position:	Sample 2	Liquid Limit	NP	Linear Shrinkage	0.0
Depth:	-	Plasticity Index	NP	Insitu M/C%	3,7

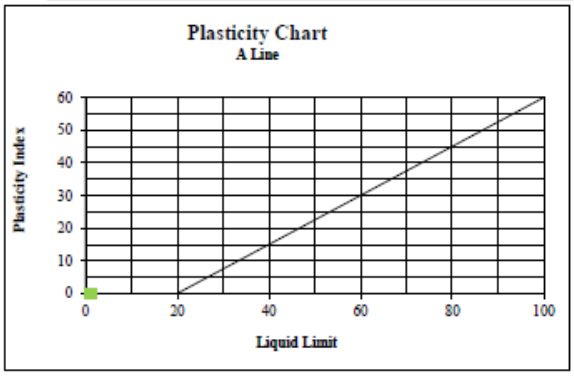
PH (TMH1 A20)*	-	(TMH1 A21T)* Conductivity s.m^{-1}	-	SG (TMH1 A12T)*	2,623

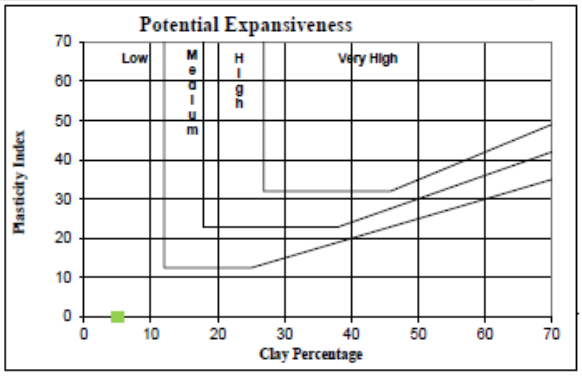
SIEVE ANALYSIS (TMH 1 A1a)*																	HYDROMETER ASTM D422							
100	75	63	53	37,5	26,5	19,0	13,2	9,5	6,7	4,75	2,36	1,18	0,60	0,425	0,300	0,150	0,075	0,075	0,053	0,024	0,007	0,005	0,003	0,002	0,001
100	100	100	100	100	100	100	100	99	99	98	97	96,6	96	91	73	22	8,3	8	8	7	7	6	6	5	5
% Passing																									

MOD AASHTO SANS 3001 GR30		CBR SANS 3001 GR40						
OMC%	11,6	COMP MC	% SWELL	100%	98%	97%	95%	93%	90%
MDD(KG/M^3)	1769	11	0,0	17	14	14	11	9	7



% Gravel	3	% Sand	89	% Silt	3	% Clay	5





NOTE: All tests marked with (*) means that these test methods are not accredited

STEYN-WILSON LABORATORIES
CIVIL ENGINEERING TESTING LABORATORIES

11 Gooderson Road Blackheath
PO Box 58 Blackheath 7581
Tel: 021 905 0435
Fax: 086 499 9482
Email: admin@steynwilson.co.za
Web: www.steynwilson.co.za

Customer :	**GEOSS South Africa**	Project :	3971 - Melkhoutfontein (Stilbaai)
	9 Quantum Street, Techno Park, Unit 12 Technostell Building	Date Received :	25.06.20
	Stellenbosch	Date Reported :	02.07.20
	7600	Req. Number :	-
Attention :	Mr C Muller		

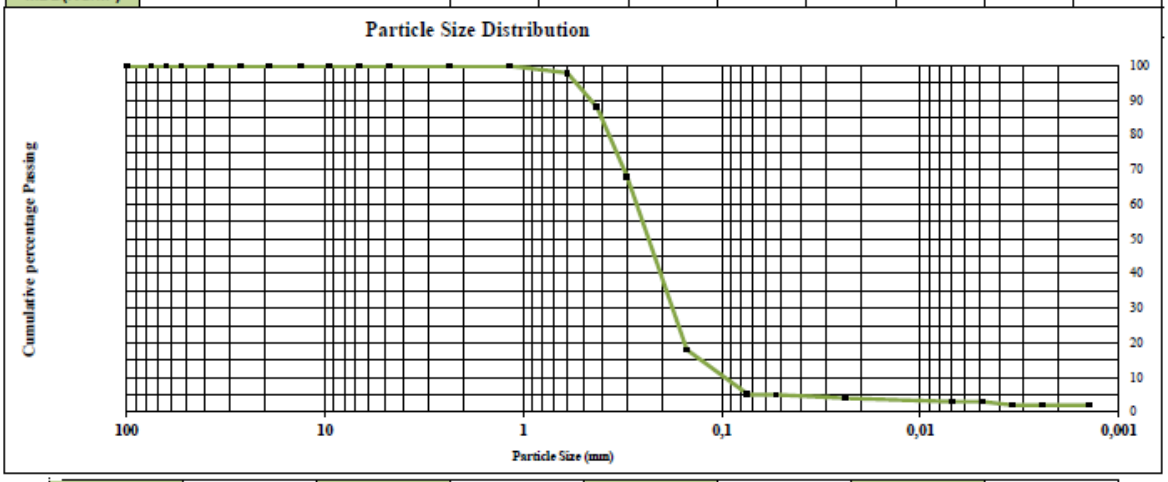
MOD / CBR / FOUNDATION INDICATOR - TMH1 A1* / ASTM D422 / SANS 3001 GR30 / SANS 3001 GR40

Material Description:	Dark Brown Reddish Sand	Sample Number:	13278		
Position:	Sample 3	Liquid Limit	NP	Linear Shrinkage	0.0
Depth:	-	Plasticity Index	NP	Insitu M/C%	3,7

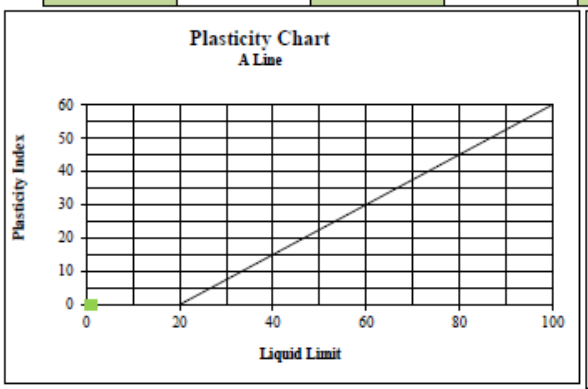
PH (TMH1 A20)*	-	(TMH1 A21T)* Conductivity s.m^{-1}	-	SG (TMH1 A12T)*	2,568

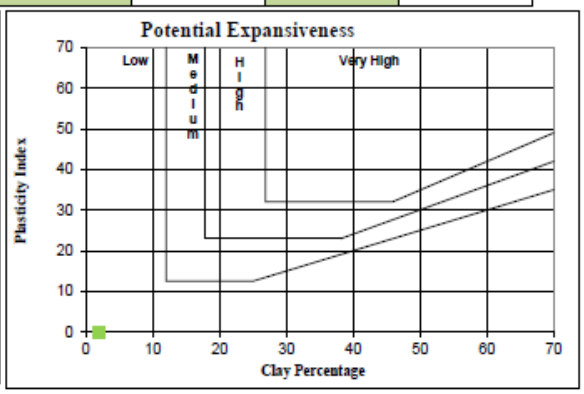
SIEVE ANALYSIS (TMH 1 A1a)*																	HYDROMETER ASTM D422							
100	75	63	53	37,5	26,5	19,0	13,2	9,5	6,7	4,75	2,36	1,18	0,60	0,425	0,300	0,150	0,075	0,075	0,053	0,024	0,007	0,005	0,003	0,002	0,001
100	100	100	100	100	100	100	100	100	100	100	100	100	98	88	68	18	5,4	5	5	4	3	3	2	2	2
% Passing																									

MOD AASHTO SANS 3001 GR30		CBR SANS 3001 GR40						
OMC%	11,1	COMP MC	% SWELL	100%	98%	97%	95%	93%	90%
MDD(KG/M^3)	1773	11	0,0	14	12	10	8	2	5



% Gravel		% Sand	95	% Silt	3	% Clay	2





STEYN-WILSON LABORATORIES
CIVIL ENGINEERING TESTING LABORATORIES

11 Gooderson Road Blackheath
PO Box 58 Blackheath 7581
Tel: 021 905 0435
Fax: 086 499 9482
Email: admin@steynwilson.co.za
Web: www.steynwilson.co.za

Customer :	**GEOSS South Africa**	Project :	3971 - Melkhoutfontein (Stilbaai)
	9 Quantum Street, Techno Park, Unit 12 Technostell Building	Date Received :	25.06.20
	Stellenbosch	Date Reported :	02.07.20
	7600	Req. Number :	-
Attention :	Mr C Muller		

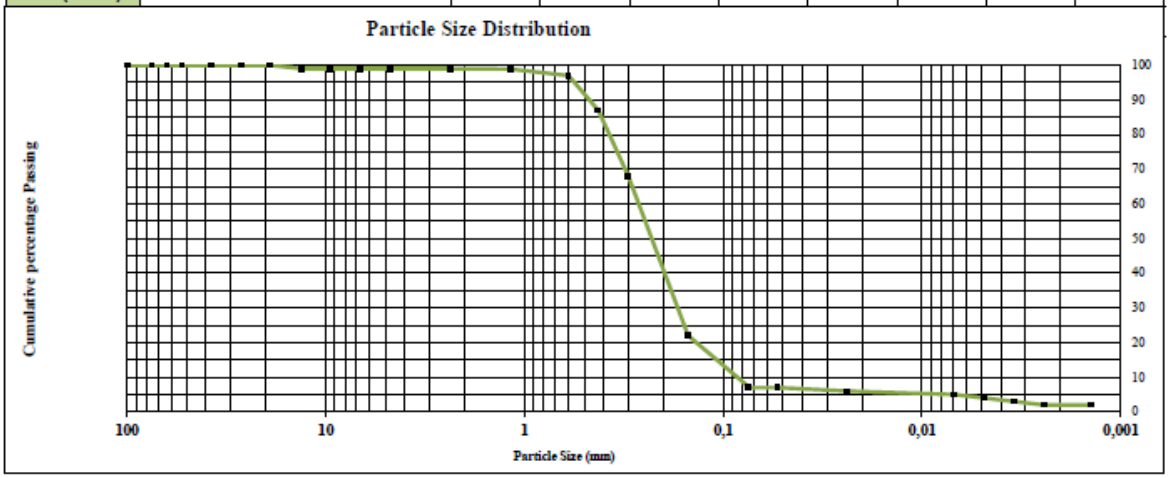
MOD / CBR / FOUNDATION INDICATOR - TMH1 A1* / ASTM D422 / SANS 3001 GR30 / SANS 3001 GR40

Material Description:	Dark Brown Sand	Sample Number:	13279		
Position:	Sample 4	Liquid Limit	NP	Linear Shrinkage	0.0
Depth:	-	Plasticity Index	NP	Insitu M/C%	3,8

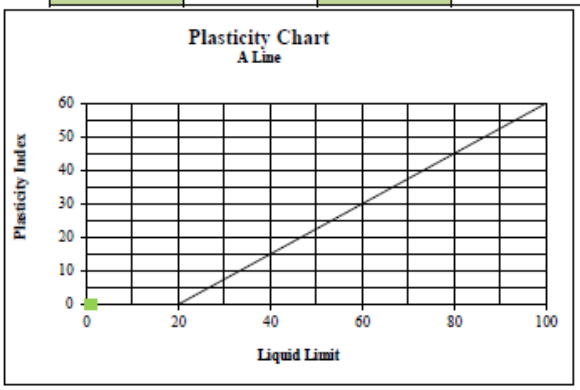
PH (TMH1 A20)*	-	(TMH1 A21T)* Conductivity s.m^{-1}	-	SG (TMH1 A12T)*	2,532

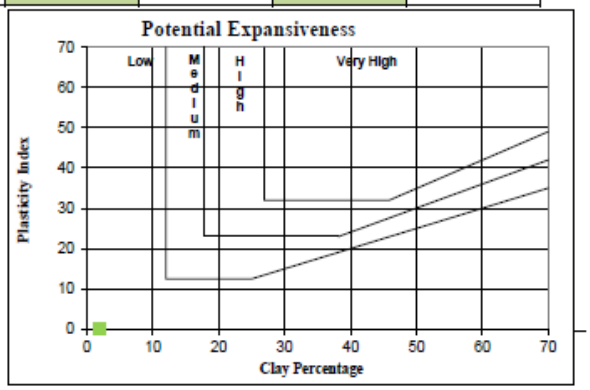
SIEVE ANALYSIS (TMH 1 A1a)*																	HYDROMETER ASTM D422							
100	75	63	53	37,5	26,5	19,0	13,2	9,5	6,7	4,75	2,36	1,18	0,60	0,425	0,300	0,150	0,075	0,075	0,053	0,024	0,007	0,005	0,003	0,002	0,001
100	100	100	100	100	100	100	99	99	99	99	99	98,9	97	87	68	22	7,4	7	7	6	5	4	3	2	2
% Passing																									

MOD AASHTO SANS 3001 GR30		CBR SANS 3001 GR40							
OMC%	11,1	COMP MC	% SWELL	100%	98%	97%	95%	93%	90%
MDD(KG/M^3)	1812	12	0,0	16	14	13	10	9	7



% Gravel	1	% Sand	92	% Silt	5	% Clay	2





STEYN-WILSON LABORATORIES
CIVIL ENGINEERING TESTING LABORATORIES

11 Gooderson Road Blackheath
PO Box 58 Blackheath 7581
Tel: 021 905 0435
Fax: 086 499 9482
Email: admin@steynwilson.co.za
Web: www.steynwilson.co.za

Client: **GEOSS South Africa**
Project: 3971 Melkhoutfontein - Stilbaai
Attention: Mr C Muller
Your Ref. No: -
Date Reported 02.07.20

TEST REPORT REFERENCE NUMBER / JOB NUMBER : SWL11455

Dear Sir / Madam

Herewith please find the original reports pertaining to the above mentioned project.

Test Requested

1 x *MOD / CBR*
1 x *FOUNDATION INDICATOR*

Site Sampling and Materials Information

Sampling Method Specimens delivered to Steyn Wilson Laboratory.
Environmental Condition Cloudy
Deviation from the prescribed test method
Responsibility of information disclaimer

● **FINAL REPORT**

We would like to take this opportunity to thank you for your valued support.
Should you have any further enquiries please don't hesitate to contact me.

Yours Faithfully
STEYN-WILSON LABORATORIES (PTY) LTD

Mr. R.Wilson
Technical Signatory

Remarks:
1. Information contained herein is confidential to STEYN-WILSON PTY LTD and the addressee
2. Opinions & Interpretations are not included in our schedule of Accreditation.
3. The samples where subjected and analysed according to ASTM.
4. The results reported relate only to the sample tested, Further use of the attached information is not the responsibility or liability of STEYN-WILSON LABORATORIES (PTY) LTD.
5. This document is the correct record of all measurements made, and may not be reproduced other than with full written approval from a director of STEYN-WILSON LABORATORIES (PTY) LTD.
6. Measuring equipment is traceable to national standards (Where applicable).
7. Should there be any deviation from the prescribed test method comments will be made thereof, pertaining to the test on the relevant materials report.
8. Uncertainty of measurement is calculated and corresponds to a coverage probability of approximately 95%. Available on request.
9. The decision rule states that the measurement of uncertainty can be applied by the customer to the test results, on request. It is not the responsibility or liability of STEYN-WILSON LABORATORIES (PTY) LTD.

STEYN-WILSON LABORATORIES
CIVIL ENGINEERING TESTING LABORATORIES

11 Gooderson Road Blackheath
PO Box 58 Blackheath 7581
Tel: 021 905 0435
Fax: 086 499 9482
Email: admin@steynwilson.co.za
Web: www.steynwilson.co.za

Customer :	**GEOSS South Africa**	Project :	3971 Melkhoutfontein - Stilbaai
	9 Quantum Street, Techno Park, Unit 12 Technostell Building	Date Received :	25.06.20
	Stellenbosch	Date Reported :	02.07.20
	7600	Req. Number :	-
Attention :	Mr C Muller		

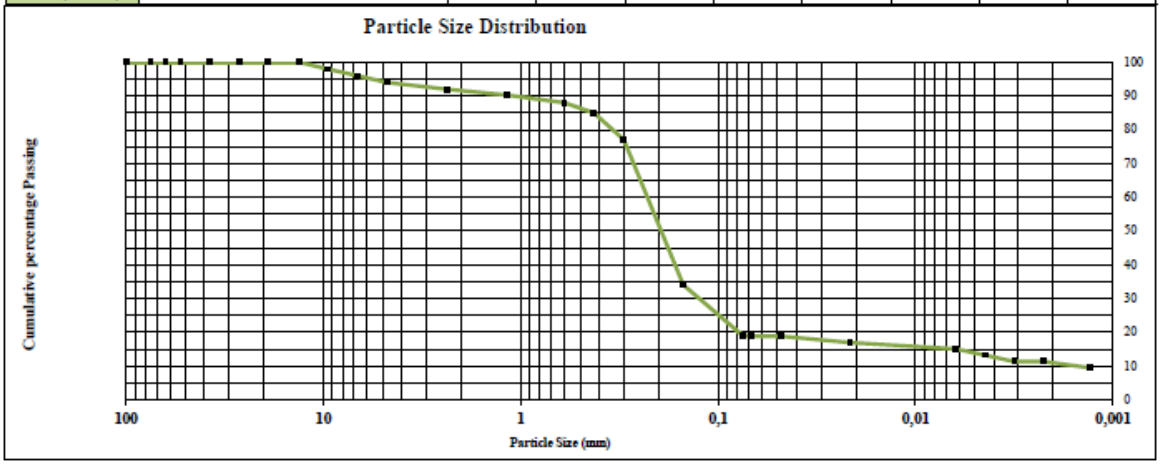
MOD / CBR / FOUNDATION INDICATOR - TMH1 A1* / ASTM D422 / SANS 3001 GR30 / SANS 3001 GR40

Material Description:	Light Yellowish Silty Soil with Calcrete	Sample Number:	13280		
Position:	Sample 5	Liquid Limit	NP	Linear Shrinkage	0.0
Depth:	-	Plasticity Index	NP	Insitu M/C%	0,1

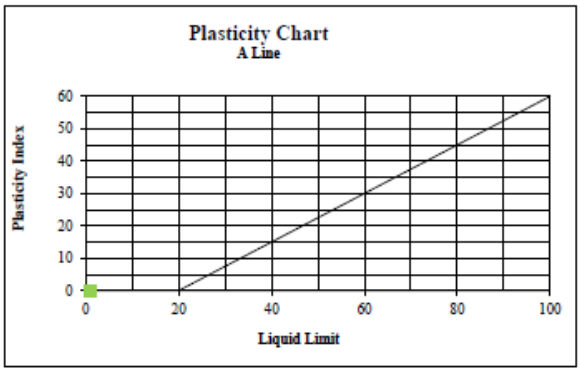
pH (TMH1 A20)*	-	Conductivity s.m^{-1} (TMH1 A21T)*	-	SG (TMH1 A12T)*	2,757

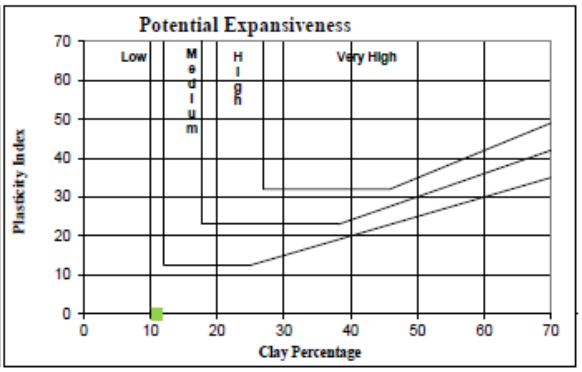
SIEVE ANALYSIS (TMH 1 A1a)*																		HYDROMETER ASTM D422							
100	75	63	53	37,5	26,5	19,0	13,2	9,5	6,7	4,75	2,36	1,18	0,60	0,425	0,300	0,150	0,075	0,068	0,048	0,021	0,006	0,004	0,003	0,002	0,001
100	100	100	100	100	100	100	100	98	96	94	92	90,3	88	85	77	34	19	18,8	18,8	16,92	15,04	13,16	11,28	11,28	9,4
% Passing																									

MOD AASHTO SANS 3001 GR30		CBR SANS 3001 GR40						
OMC%	10,5	COMP MC	% SWELL	100%	98%	97%	95%	93%	90%
MDD(KG/M^3)	2042	10,1	0,0	21	18	16	14	11	9



% Gravel	9	% Sand	72	% Silt	8	% Clay	11





(last page)