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Report to Isibuko Development Planners on a Geotechnical Investigation carried out for the Proposed Heroes Acre Memorial Park Cemetery Site, Pietermaritzburg, KwaZulu-Natal

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1. INTRODUCTION

At the request of Petronell Human of Isibuko Development Planners, Gondwana Geo Solutions, (GGS), carried out a geotechnical investigation for the Heroes Acre Memorial proposed new cemetery. The site for the proposed cemetery is approximately 5Ha in extent, situated near Camps Drift in Pietermaritzburg, KwaZulu-Natal.

The geotechnical investigation was carried out during March 2023, and comprised a mapping walkover assessment, the excavation of 10 test pits, execution of 11 Dynamic Cone Penetrometer (Light) tests and 4 percolation tests. Laboratory tests were carried out on selected soil samples.

This report contains an assessment of the geotechnical suitability of the site for development as a cemetery. The site is rated according to several standard geotechnical criteria for the suitability of cemetery sites, comprising site stability, excavation requirements, soil and rock permeability, suitability of backfill materials over graves, groundwater and stability of grave excavations.

2. INFORMATION SUPPLIED

The following was supplied electronically by Isibuko Development Planners for use in the geotechnical investigation:

- Copy of drawing referenced *"heroes 1-draft concept"*
- Copy of *"Heroes-Acre-Memorial-Park-Aerial"*

3. SITE DESCRIPTION

The site is located southwest of Pietermaritzburg CBD near Camps Drift and can be accessed via Archie Gumede Drive from Moses Mabhida Road. The site is bounded on the east by Archie Gumede Drive, on the north by Eden Gardens Private Hospital, and the existing Heroes Acre cemetery on the southwest.

Topographically, the site slopes 9 to13° (or 1V to between 4 and 6 horizontal) to the east, with occasional undulations throughout. There is an average fall of some 10m from west to east across the site. The slope steepens up near the western boundary.

The site is very densely vegetated. Vegetation over the site comprises short to medium grasses, moderately to densely populated with mature trees and bush, and a marshy area towards the southeast corner of the site.

The following plates provide a more detailed perspective of the site.








Plates 1 to 8: Perspectives of the site

The layout of the site is shown in Figure 1 below.

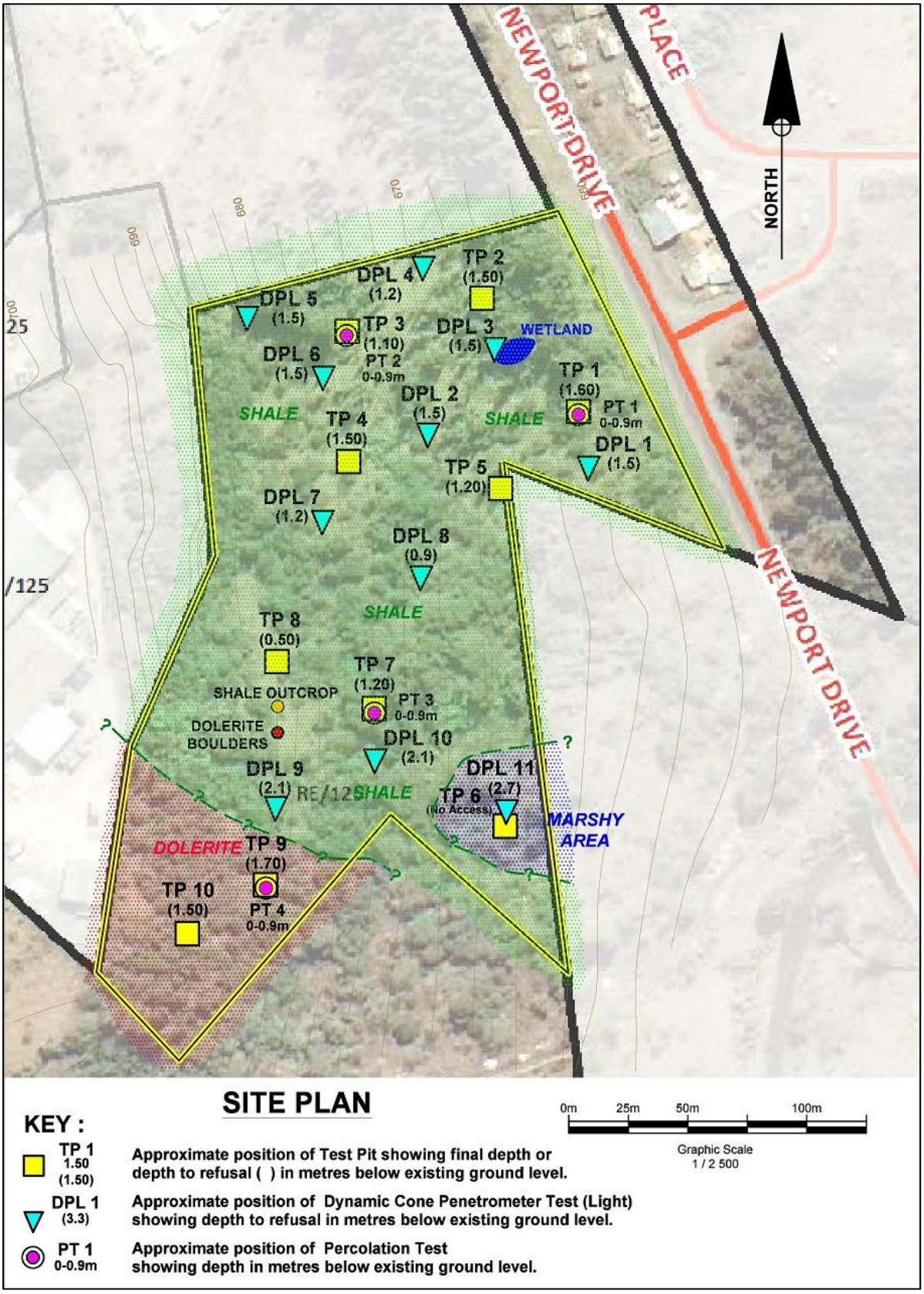


Figure 1: Site Plan showing layout of site and positions of Geotechnical Tests

4. FIELDWORK

The fieldwork was undertaken in March 2023. The approximate positions of the fieldwork carried out for the geotechnical investigation are shown on Figure 1, which comprised the following:

- Walkover site mapping,
- Mechanically excavated test pits,
- Dynamic Penetrometer Light (DPL) tests, and
- Percolation Tests

4.1 Walkover Site Mapping

A walkover site mapping exercise was carried out to identify any geomorphological, geological, and geotechnical constraints which may affect the proposed development. No shallow rock outcrop was visible at surface. The site was also mapped for signs of slope stability problems.

4.2 Mechanically Excavated Test Pits

Ten test pits, designated TP1 through TP10, were dug using a New Holland TLB excavator supplied by Scotty's Plant Hire in Pietermaritzburg. The approximate positions of the test pits, dug to between 0.50 and 1.70 metres below existing ground level (mbegl), are shown in Figure 1.

The soil and rock horizons encountered in the test pits were logged[1] and sampled by an Engineering Geologist.

Note that the designated area for test pit TP6 could not be accessed by the TLB because of marshy ground conditions. As a result, the soils at this location were evaluated from the DPL test results.

Detailed copies of the test pits are provided in Appendix A.

Perspectives of the soil profiles as seen in some of the test pits are given in Plates 7 to 12 below.

Plates 9 & 10: Typical soil profiles encountered beneath the site; clayey residual soils overlying the generally shallow, completely to highly weathered shale rock of the Pietermaritzburg Formation

[1] Geoterminology Workshop (2002) – Guidelines for Soil and Rock Logging, SAIEG-AEG-SAICE (Geotech Div) pp47




Plates 11 to 14: Typical soil profiles encountered beneath the site; clayey residual soils overlying the generally shallow, completely to highly weathered shale rock of the Pietermaritzburg Formation. The general dip and dip direction of the shale beds is 10 to 15^0 to the east.

The information from the test pits logs has been summarised in Table 1 below:

Table 1
Summary of Test Pit Details

TP No.	Depth (mbegl)	Geology
TP1	1.60	0.00-0.90m: Moist dark grey intact slightly gravelly CLAY. Gravel comprises subangular completely weathered fine to medium grained shale fragments. Residual Shale. 0.90-1.20m: Dry greyish brown to dark grey dense intact gravelly CLAY. Gravel comprises subangular completely to highly weathered fine to coarse shale fragments. Residual Shale. 1.20-1.60m: Dark grey completely to highly weathered very soft becoming soft rock SHALE with depth. Pietermaritzburg Formation. **Final depth at 1.60m. Refusal on soft rock shale.** **No groundwater seepage.** **No sidewall collapse.**
TP2	1.50	0.00-0.50m: Moist dark grey soft intact CLAY. Colluvium. 0.50-1.00m: Dry to moist greyish brown firm to stiff intact gravelly CLAY. Gravel comprises subangular to angular completely to highly weathered fine to coarse shale fragments. Residual Shale. 1.00-1.50m: Greyish brown to dark grey completely to highly weathered very closely to closely jointed very soft becoming soft rock SHALE. Pietermaritzburg Formation. **Final depth at 1.50m. Refusal on soft rock shale.** **No groundwater seepage.** **No sidewall collapse.**
TP3	1.10	0.00-0.30m: Moist dark grey soft intact CLAY. Colluvium. 0.30-0.80m: Dry to moist light brown to greyish brown firm to stiff intact very gravelly CLAY. Gravel comprises subangular to angular completely to highly weathered fine to coarse shale fragments. Residual Shale. 0.80-1.10m: Light brown to greyish brown completely weathered very closely to closely jointed very soft rock becoming soft rock SHALE with depth. Pietermaritzburg Formation. **Final depth at 1.10m. Refusal on soft rock shale.** **No groundwater seepage.** **No sidewall collapse.**
TP4	1.50	0.00-0.50m: Moist dark grey soft intact CLAY. Colluvium. 0.50-1.00m: Dry to moist greyish brown firm to stiff intact gravelly CLAY. Gravel comprises subangular to angular completely to highly weathered fine to coarse shale fragments. Residual Shale. 1.00-1.50m: Grey completely weathered becoming highly weathered with depth very closely to closely jointed very soft rock becoming soft rock SHALE with depth. Pietermaritzburg Formation. **Final depth at 1.50m. Refusal on soft rock shale.** **No groundwater seepage.** **No sidewall collapse.**
TP5	1.20	0.00-0.40m: Moist dark grey soft intact CLAY. Colluvium. 0.40-1.05m: Dry to moist greyish brown firm to stiff intact gravelly CLAY. Gravel comprises subangular to angular completely to highly weathered fine to coarse shale fragments. Residual Shale. 1.05-1.20m: Greyish brown to dark grey completely to highly weathered very closely to closely jointed very soft becoming soft rock SHALE. Pietermaritzburg Formation. **Final depth at 1.20m. Refusal on soft rock shale.** **No groundwater seepage.** **No sidewall collapse.**
TP6	0.00	0..00 No access. Area near wetland. Ground conditions evaluated from DPL test
TP7	1.20	0.00-0.30m: Moist dark grey soft intact CLAY. Colluvium. 0.30-0.90m: Moist greyish brown sandy CLAY. Residual Shale. 0.9-1.20m: Greyish brown highly weathered closely jointed very soft becoming soft rock SHALE with depth. Pietermaritzburg Formation. **Final depth at 1.20m. Refusal on soft rock shale.** **No groundwater seepage.** **No sidewall collapse.**
TP8	0.50	0.00-0.10m: Moist dark greyish brown soft intact CLAY. Colluvium. 0.10-0.50m: Greyish brown highly weathered closely jointed very soft to soft rock SHALE. Pietermaritzburg Formation. **Final depth at 0.50m. Refusal on soft rock shale.** **No groundwater seepage.** **No sidewall collapse.**

TP No.	Depth (mbegl)	Geology
TP9	1.70	0.00-0.40m: Moist dark grey soft intact CLAY. Colluvium. 0.40-1.00m: Moist greyish brown to light brown sandy CLAY with rounded soft to hard rock dolerite boulders throughout. Residual Dolerite. 1.00-1.70m: Light brown completely weathered very soft becoming sot rock DOLERITE. **Final depth at 1.70m. Refusal on soft rock dolerite.** **No groundwater seepage.** **No sidewall collapse.**
TP10	1.50	0.00-0.50m: Moist dark grey soft intact CLAY. Colluvium. 0.50-1.10m: Moist greyish brown to light brown sandy CLAY to clayey SAND with dolerite boulders. Residual Dolerite. 1.10-1.50m: Light brown completely weathered very soft rock becoming soft rock DOLERITE with hard rock dolerite boulders throughout. **Final depth at 1.50m. Refusal on soft and hard rock dolerite boulders.** **No groundwater seepage.** **No sidewall collapse.**

Note: mbegl = metres below existing ground level

4.3 Dynamic Cone Penetrometer Light (DPL) tests

Eleven Dynamic Cone Penetrometer (Light) or (DPL) tests, designated DPL1 through DPL11, were carried out at the approximate positions shown in Figure 1 to determine the consistency of the soils underlying the site and possible depth to bedrock.

The DPL test comprises a 25mm diameter solid steel retractable cone driven vertically into the ground using a 10 kg hammer dropped through a height of 550mm. The resistance to penetration is measured in terms of number of blow counts per 300mm advance.

It is important to note that the DPL tests can refuse on boulders, cemented layers as well as bedrock. Due to the nature of the test no soil samples are recovered from the DPL equipment.

The DPL tests were advanced to a refusal depth of between 0.90 and 2.70mbegl.

The results of the DPL tests, consisting of blow count and inferred consistency against depth are attached in Appendix B.

Table 2
Summary of DPL Test Results

DPL No.	Depth (mbegl)	Comments
DPL1	1.50	Soft to 0.30m Firm to 0.90m Stiff to 1.20m Very stiff to 1.50m Refusal
DPL2	1.50	Soft to 0.90m Firm to 1.20m Very stiff to 1.50m Refusal
DPL3	1.50	Very soft to 0.30m Firm to 0.90m Stiff to 1.20m Very stiff to 1.50m Refusal
DPL4	1.20	Firm to 0.30m Soft to 0.60m Stiff to 0.90m Very stiff to 1.20m Refusal
DPL5	1.50	Firm to 0.60m Soft to 0.90m Stiff to 1.20m Very stiff to 1.50m Refusal

DPL No.	Depth (mbegl)	Comments
DPL6	1.50	Soft to 0.30m Firm to 0.90m Stiff to 1.20m Very stiff to 1.50m Refusal
DPL7	1.20	Firm to 0.30m Stiff to 0.90m Very stiff to 1.20m Refusal
DPL8	0.90	Stiff to 0.60m Very stiff to 0.90m Refusal
DPL9	2.10	Soft to 0.30m Firm to 1.20m Stiff to 1.80m Very stiff to 2.10m Refusal
DPL10	2.10	Firm to 0.30m Stiff to 0.60m Firm to 0.90m Stiff to 1.80m Very stiff to 2.10m Refusal
DPL11	2.70	Very soft to 0.30m Soft to 0.90m Firm to 1.50m Soft to 1.80m Stiff to 2.40m Very stiff to 2.70m Refusal

Note: mbegl = metres below existing ground level

4.4 Percolation Tests

Four percolation tests, designated PT1 to PT4, were carried out at the approximate positions shown in Figure 1.

The tests were carried out in accordance with the requirements of eThekwini Municipality[2] and the results are summarised in Table 3 below.

[2] eThekwini Municipality: Guidelines for the Design and Approval of On-site (sub-surface) Disposal of Domestic Sewage. July 2005; Revision E; Guideline No 6

Table 3
Percolation Test Results

Time (min)	PT1 (TP1)	PT2 (TP3)	PT3 (TP7)	PT4 (TP9)
0	300	300	300	300
5	299	298	299	297
10	297	297	298	296
15	296	295	296	295
20	295	294	295	294
25	294	293	294	293
30	293	294	293	25
Depth (m)	0.0 - 0.9	0.0 - 0.9	0.0 - 0.9	0.0 - 0.9
Percolation Rate (mm/hr)	14	12	14	10
Result	Fail	Fail	Fail	Fail
Permissible Application Rate to Soakpit Wall area (l/m^2/day)	Not Permitted	Not Permitted	Not Permitted	Not Permitted
Inferred[3] Soil Permeability Coefficient, ***k***, (cm/sec)	(10^{-4} to 10^{-5})	(10^{-4} to 10^{-5})	(10^{-4} to 10^{-5})	(10^{-4} to 10^{-5})
Classification[3]	Relatively Impermeable	Relatively Impermeable	Relatively Impermeable	Relatively Impermeable

5. GEOLOGY

5.1 Regional Geology

The general geology of the area within which the cemetery site occurs is shown in the extract of the 1:250 000 series regional geology map Durban 2930 published by the Council for Geosciences in Figure 2 below.

The site is underlain by shales of the Pietermaritzburg Formation of the Ecca Group. Localised intrusions of Jurassic- age dolerite can also be expected in the general area.

[3] Hall, B. & Hanbury, R (1990) Some Geotechnical Considerations in the Selection of Cemetery Sites. IMIESA March 1990

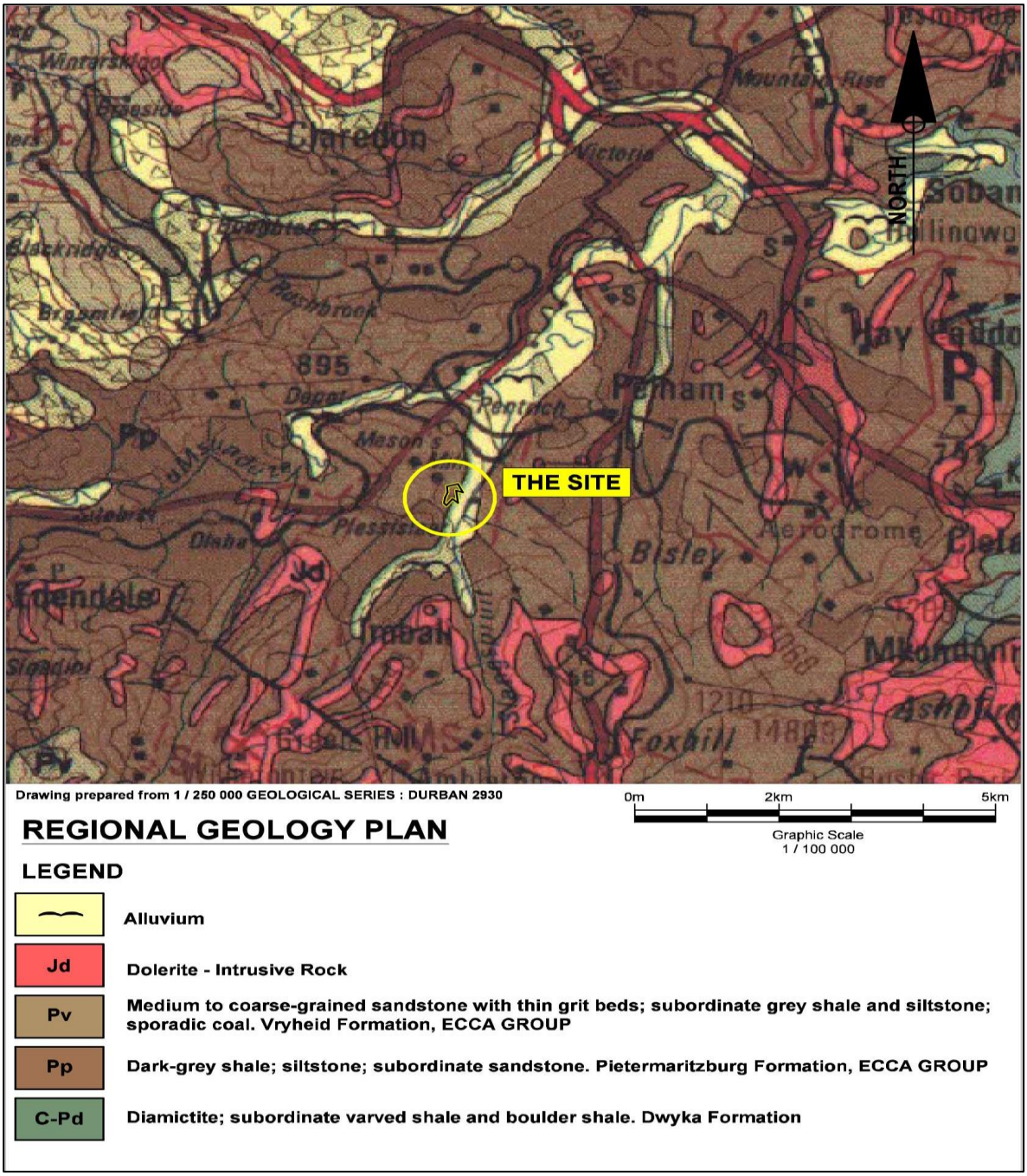


Figure 2: Regional Geology of the Area around the Heroes Acre Memorial proposed cemetery site

5.2 Site Geology

The fieldwork carried out for the geotechnical investigation confirmed that the site geology is characterised by a relatively thin mantle of transported (colluvial) and residual soils, overlying the relatively shallow shale bedrock for the most part. However, the southwestern corner of the site is underlain by dolerite which has locally intruded the shale country rocks.

The findings of the fieldwork are discussed in greater detail below.

5.3 Transported Soils

Transported colluvial soils comprising a slightly moist to moist, dark brown, very soft to soft, silty clay was found to occur to an average depth of about 0.5m below existing ground level (mbegl).

5.4 Residual Soils

Residual soils, derived from the complete insitu weathering of the shale and dolerite bedrock, were encountered beneath the transported soils in all the test pits put down. These residual soils comprise horizons of moist dark orange-brown, generally firm to stiff silty clay to slightly gravelly or sandy clay to a moist light grey to yellowish grey firm to stiff silty clay. Gravel encountered in this horizon comprise dark grey subrounded highly weathered shale fragments.

5.5 Shale

Shale bedrock was encountered in all test pits except TP6, TP9 and TP10. The average depth to shale bedrock is about 1.1m, in the range 0.1 to 1.2m.

Apart from the significant depth to bedrock inferred from DPL11 (i.e. 2.7 mbegl refusal) in the area where TP6 could not access the marshy area, the bedrock occurs at an average depth of 1.1 mbegl, in the range 0.10 to 1.20 mbegl beneath the site

An average TLB refusal depth of 1.5m was achieved across the site.

The shale bedrock is described as light grey completely weathered, and very soft rock grading into soft rock in strength with depth.

The general dip of the shale bedding planes is to the east at 10 to 15° to the horizontal., i.e sub-parallel to slightly steeper, than the natural slope of the ground.

5.6 Dolerite

Dolerite bedrock was encountered in test pits TP9 and TP10 in the southwestern corner of the site. The soil cover in this area is similar to that of the shale, i.e. about 1.1m on average. The soil cover comprises a thin horizon of transported soils underlain by residual dolerite soils comprising moist greyish brown to light brown sandy clay to clayey sand with dolerite boulders.

The dolerite rock could be excavated to refusal depths of between 1.5 and 1.7m below existing ground level.

6. GROUNDWATER

No signs of groundwater were encountered in the test pits or on the rods of the DPL tests put down.

The position of TP6, however, could not be accessed because of a localized marshy area, this being the only area of groundwater and surface water being recorded during the investigation. This area is shown on Figure 1 above.

7. LABORATORY TESTING AND MATERIALS ASSESSMENT

Laboratory tests comprising the following were scheduled on selected soil samples recovered from the test pits:

- Foundation indicator tests (particle size distribution, Atterberg Limit determinations and hydrometer analysis),
- Modified AASHTO tests,
- California Bearing Ratio tests, and
- Soil chemistry tests (pH and conductivity)

The laboratory test results are summarised in Table 4 and Table 5 below. The detailed laboratory test results are included in Appendix C.

Table 4
Summary of Results of Particle Size Distribution Analysis, Atterberg Limit Determinations and CBR tests

TP No.	Depth (m)	Description	Particle Size %				Atterberg Limits			GM	Modified AASHTO		CBR Values (%) Compaction MDD (%)					Swell (%)	Classification & Activity
			Clay	Silt	Sand	Gravel	LL	PI	LS%		MDD (kg/m³)	OMC %	90	93	95	98	100		
TP1	0.00-0.90	Moist dark grey slightly gravelly sandy CLAY. Gravel comprises subangular completely weathered fine to medium grained shale fragments. Residual Shale.	23.3	8.0	36.8	31.9	40	20	10.0	1.65	1749	19.3	1.4	1.9	2.3	3.0	3.6	1.8	A-2-7(2); SC; Low; does not meet G9 quality (COLTO) or G10 quality (TRH14)
TP5	0.40-1.05	Dry to moist greyish brown gravelly CLAY. Gravel comprises subangular to angular completely to highly weathered fine to coarse shale fragments. Residual Shale.	28.3	12.2	7.3	52.2	39	19	9.5	1.65	1792	16.6	1.1	1.4	1.6	2.2	2.8	3.23	A-6(4); SC; Low does not meet G9 quality or G10 quality (TRH14)
TP8	0.00-0.90	Greyish brown highly weathered closely jointed very soft to soft rock SHALE. Excavates as a CLAY.	44.5	14.0	15.3	26.1	38	20	10.0	0.97									A-6(10); CL; Low; Anticipate marginal G10 quality material (TRH14)
TP9	0.40-1.00	Moist greyish brown to light brown sandy CLAY with rounded soft to hard rock dolerite boulders throughout. Residual Dolerite.	67.2	9.2	11.7	11.9	37	17	8.5	0.48									A-6(11); CL; Low. Anticipate less than G10 quality material (TRH14)

LL - Liquid Limit
PI - Plasticity Index
LS - Linear Shrinkage
GM - Grading Modulus
MDD - Maximum Dry Density
OMC - Optimum Moisture Content

Classification in Terms of:
USPRA[4]
Unified Soil Classification System[5]
Van Der Merwe (1964)[6]
COLTO[7]
TRH14:1985[8]

[4] US Public Roads Administration Classification (Modified from Allen 1945)
[5] ASTM D 2487-06 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System). June 2006
[6] D.H. Van Der Merwe (1964). The Prediction of Heave from the Plasticity Index and Percentage Clay Fraction of Soils. The Civil Engineer, pp 103-107
[7] COLTO: Standard Specifications for Roads and Bridge Works for State Road Authorities. Committee of Land Transport Officials (South Africa) 1998
[8] TRH14: Technical Recommendations For Highways - Guidelines for Road Construction Materials. Committee of State Road Authorities 1985

Table 5
Summary of Results of Electrical Conductivity and pH Values - PV Area : Section C

TP No.	Depth (m)	Description	Electrical Conductivity, Ec (Sm-1)	pH Value	Classification[9]
TP2	0.50-1.00	Dry to moist greyish brown firm to stiff intact gravelly CLAY.. Residual Shale.	0.368	5.7	Moderately corrosive; moderately acidic
TP4	0.00-0.50	Moist dark grey soft intact CLAY. Colluvium.	0.313	5.0	

[9] Stapelberg (2005) The Engineering Geology of Cape Town & Environs, South Africa

8. DETERMINATION OF SUITABILITY OF THE SITE FOR CEMETERY DEVELOPMENT

8.1 Criteria for Determination of Site Suitability

Using the information obtained from the fieldwork and previous experience with the geology and general ground conditions of the area, the suitability of the site as a cemetery has been evaluated by the method commonly used in South Africa.

8.2 Department of Water Affairs (DWA) Requirements

In terms of DWAF (1998)[10] local authorities must take cognisance of the requirements that graveyards should **not** be:

- *located below the 1 in 50 year floodline of a river;*
- *in close proximity to water bodies such as wetlands, vleis, pans, estuaries and floodplains;*
- *situated on unstable areas, like fault zones, seismic zones, dolomitic or karst areas where sinkholes and subsidence are likely;*
- *situated in or near sensitive ecological areas;*
- *situated in or on areas characterised by flat gradients, shallow or emergent groundwater;*
- *situated in areas characterised by steep gradients, or shallow bedrock with little soil cover, where stability of slopes could be a problem;*
- *situated in areas of ground water recharge on account of topography and/or highly permeable soils; and*
- *situated on areas overlaying or adjacent to important or potentially important aquifer (Parsons aquifier classification), where such aquifers are to be use for water supply purposes.*

Stricter and more detailed refinements to the DWAF guidelines, being the KwaZulu-Natal Health Act 1 of 2009 and Regulations relating to the Management of Human Remains[11] which over-ride the DWAF criteria listed above are given below. These Regulations, however, relate to all aspects of the management of human remains, from mortuary to crematoria and burials. The Regulations clearly state that: S15 (1) '*No land or site shall be identified and used for the purpose of a burial site, unless environmental authorization has been granted in terms of the National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA), Environmental Impact Assessment Regulations, R543 of 2010, as amended (EIA Regulations etc.)'*

However, of more relevance to the engineering and geotechnical constraints for cemetery sites, relevant regulations state further that all burials must comply with the following environmental requirements (S15(2)):

a) be located outside the 1:100 year floodplain;
b) be located at least 350m from groundwater sources used for drinking water purposes and at least 500m from the nearest habitable building;
c) for a preferred burial site with a soil of sandy-clay mix of low porosity and a small and fine grain texture, the water table should be at least 2.5m deep in order to allow for traditional grave depth of six feet (1.8m);
d) for areas with higher water tables, the local government may determine a reasonable depth with additional walling recommendations to protect underground water; and
e) the covering soil shall not be less than 1m, should two bodies be buried in the same grave, 300m of soil shall be maintained between the coffins.

8.2.1 Outside the 1 in 100-year flood line of a river

It is understood that the flood line constraints pertaining to the cemetery site will be evaluated by an appropriately qualified professional.

[10] National Water Act No 36 of 1998. Sections 22(3) and 22(4).
[11] KwaZulu Natal Health Act 1 of 2009 and Regulations relating to the Management of Human Remains (i.t.o. National Health Act, 2003 (Act No 61 of 2003) GNR 363 22 May 2013.

8.2.2 In close proximity to water bodies such as wetlands, vleis, pans and floodplains

It is understood that the existence of wetlands and other water bodies pertaining to the cemetery site will be evaluated by an appropriately qualified professional.

This study must evaluate the status of the marshy area in the vicinity of TP6 / DPL11 shown in Figure 1. For the purposes of the geotechnical report, however, this area must be excluded from cemetery development.

8.2.3 Situated in unstable areas (seismic zones, dolomitic or karst areas)

The site is not underlain by carbonate or dolomite rocks and therefore not affected by associated features such as sinkholes, caverns or karst areas, or related hazards, that are characteristic of dolomite or karst terrains.

The shale beds dip towards the east at dip angles of to the horizontal, i.e. sub-parallel or slightly steeper than, the natural slope of the ground. This suggests that the slope is stable provided no deep cuts are made parallel to the slope contours which may result in the shale beds dipping out of the slope (i.e. daylighting). The digging of small excavations of limited size such as graves will not result in unstable slopes.

Furthermore, no unstable land features, which may indicate unstable slopes or potentially unstable slope areas, were noted from the walkover mapping exercise. The site is thus generally considered stable for the intended development as a cemetery.

The site falls into a very low seismic risk category.

8.2.4 Sensitive ecological areas

It is also understood that this aspect of the site is subject to specialist studies in this regard.

8.2.5 Areas with flat gradients with shallow or emergent groundwater

The site is relatively well elevated and the natural ground slopes towards the eastern part of the site at an angle of between 12° and 15°, indicating a strong drainage potential for surface water across the site. This is a positive feature in that stormwater will drain towards Archie Gumede Drive and eventually discharge into the Wilgefontein River.

No groundwater was encountered, either emerging at ground surface, or in any of the test pits dug. The area for TP6, however, is marshy and must be evaluated in greater detail by specialists in this regard.

8.2.6 Areas characterised by shallow bedrock with little soil cover

The depth to bedrock is a critical constraint on the development of the site as a cemetery. Generally, most Local Authorities stipulate that graves shall not be less than 1.80 m in depth and no body shall be nearer to the surface of the ground than 1.25m.

The shale and dolerite rock were excavated with a New Holland TLB excavator until refusal occurred in the weak rock (very soft to soft rock strength) at an average depth of 1.5mbegl. However , it is considered that excavation for graves to the required 1.8m depth will be possible beneath the site provided a more powerful excavator is used

8.2.7 Areas of groundwater recharge on account of topography and/or highly permeable soils

Generally, very low to low permeability soils (i.e. clays) and bedrock (i.e. tightly bedded shales) can be expected. Coupled with the gradient on the site which encourages drainage to the eastern side, no areas of shallow groundwater recharge are expected to occur.

Furthermore, no areas of groundwater were encountered in any of the test pits dug except for TP6 / DPL11, where a localised marshy area was identified.

8.2.8 Areas overlying or adjacent to important aquifers where these are to be used for water supply purposes

The area within which the site falls is classified as a Minor Aquifer[12] and therefore is not considered to be part of an important groundwater aquifer on which the area is dependent on for general potable water supply. All properties and developments in the area are supplied by the normal municipal water (i.e. Umgeni Water) supply infrastructure.

Further or detailed information required by the Local Authority regarding this aspect will require the input of a specialist hydrogeologist.

9. DETERMINATION OF SITE SUITABILITY INDEX

The suitability of the site for development as a cemetery has been evaluated using the guidelines from the most recently published reference pertaining to cemetery sites, being WRC Report No. 2449/1/18[13].

9.1 Grave Excavations

All materials to the final depths of excavation determined by both Test Pits and DPL tests for the current investigation will classify as Soft Excavation (SABS1200 DM), i.e. the materials that can be dug by TLB excavator such as that used for the investigation work. While an average refusal depth by the TLB excavator to 1.5m depth was achieved, a more powerful excavator is considered necessary to achieve the 1,8 minimum grave depth.

All excavations dug at test pit positions, except TP6, are stable. However, it must be appreciated that when the soils are wet up by precipitation or otherwise, sidewall collapse of open grave excavations is possible.

The recommended stand-up time for open grave excavations is maximum 24 hours, however, rainy periods, accumulations of surface water or shallow groundwater seepage will have a significant effect on the stability of the open graves. Daily inspections of grave excavations by experienced personnel will be necessary during the operation of the cemetery.

9.2 Leachate Migration

The transported and residual soils yield very low percolation rates as confirmed by the percolation tests carried out for the geotechnical investigation, indicating that they are relatively impermeable. The bedrock rock is likewise considered relatively impermeable.

There is thus very low risk of leachate migration from the graves into the groundwater.

9.3 Perched Groundwater Zones

In that no perched groundwater seepage was encountered in any of the test pits (except TP6 – marshy area) the generally poor permeability characteristics of the ground also confirm that the potential of shallow, perched groundwater zones is of very low probability.

9.4 Soil Workability

The insitu materials classify in the range SC to CL The soils beneath the site, being predominantly clayey, will be difficult to compact should they have moisture contents outside of say +/-2% of Optimum Moisture Content, as confirmed by the laboratory test information in Table 1. Thus, they are rated as being of poor workability in terms of the ease of backfill and light compaction over graves.

[12] Aquifer Classification of South Africa Department of Water Affairs 2012

[13] ENVIRONMENTAL RISK ASSESSMENT, MONITORING AND MANAGEMENT OF CEMETERIES: Report to the Water Research Commission. M A Dippenaar et Al. WRC Report No. 2449/1/18 ISBN 978-1-4312-0978-1

9.5 Calculation of Site Suitability Index

In South Africa the geotechnical suitability of a site for a cemetery or burial facility is usually carried out by scoring it against several geotechnical criteria suggested by Hall & Hanbury (1990)[14] . This method arrives at a total score, and therefore a Site Suitability Rating, which provides a useful guideline for planning.

The criteria used for cemetery rating are the following:

- Excavatability
- Grave stability
- Soil workability
- Groundwater
- Soil permeability, and
- Backfill Permeability

The site is scored against the criteria given in the tables (i.e., Table 1 to 6) in Appendix D. In this way, a total score for the site is obtained, as in Table 6 below:

Table 6
Heroes Acre Cemetery Site – Geotechnical Criteria Scores

Criterion	Total Rating Score
Excavatability	0
Grave stability	20
Soil workability	2
Groundwater	15
Subsoil permeability	20
Backfill permeability	10
Total Score	**67**

This score is then evaluated against the Site Suitability Rating in Table 7 below.

Table 7
Site Suitability Rating

Rating Total Score	Site Suitability Rating
>90	Very good
75 to 90	Satisfactory
60 to 75	Poor – precautions needed
<60	Unacceptable

Therefore, the site with a score of 67 is assessed as being ***poor - precautions needed*** for cemetery establishment.

Such precautions relate to the use of more powerful excavating plant than a standard TLB excavator to dig graves to the required 1.8m depth.

10. OTHER ENGINEERING CONSIDERATIONS

The cemetery development will require the construction of buildings (chapel and ablution blocks etc.) roads, parking and paved areas. Recommendations for these aspects of the development are given below.

[14] Hall, B. & Hanbury, R (1990) Some Geotechnical Considerations in the Selection of Cemetery Sites. IMIESA March 1990.

10.1 Buildings

It is assumed that all buildings will be single storey in height and of conventional construction, i.e. brick or block walls, timber trusses with steel sheeting or tiled roofs.

All foundations should be placed on the shale or dolerite bedrock of at least very stiff consistency to soft rock strength where a maximum bearing pressure of 120kPa may be adopted. Differential settlements for normal strip (minimum 0,6m wide) and pad (minimum 1,0m wide) will be less than 10mm.

Founding depths are expected to be on average 0,6m below existing ground level, in the range 0,3 to 1,1mbegl.

It is however recommended that site specific geotechnical investigations be carried out for all proposed buildings to confirm founding requirements.

10.2 Subgrade Treatment beneath Roads, Paving and Parking Areas

The subgrade soils are very clayey in composition and do not meet G10 (TRH14:1985) requirements (Table 1). They will be moisture sensitive and will give compaction problems if the insitu moisture content is greater than about 2% of optimum moisture content. During or after rainfall events the insitu subgrade soils will become slippery and impassable to vehicles until sufficiently dried out.

For the construction of surfaced roads, it is recommended that the insitu subgrade soils be undercut to at least 300mm below top of subgrade level (or as determined by the Engineer) and replaced with a good quality material of at least G8 imported to the site before the placement of the structural road prism is carried out.

The natural or insitu soils in the upper, say 0,5m are not suitable as a gravel wearing course as they will be slippery when wet (Type D gravel wearing course[15]). Therefore, the design of unsurfaced or gravel roads should incorporate an imported layer of G6/G5 quality gravel between up to 300mm thick (or subject to the Engineer's design) and compacted in place over the insitu subgrade.

Where sufficient quantities of weathered shale and dolerite gravel are excavated from graves and not re-used as backfill, this material will make a reasonably good wearing course, however, it will be dusty when dry and slippery when wet. The use of such material as a wearing course is not recommended for roads constructed on gradients for this reason.

Gravel roads will lose gravel surfacing material over time and will therefore require constant maintenance and replenishment, particularly after the wet season.

10.3 Stormwater Management Plan and Earthworks

In that the site is moderately sloping to the east there will be a strong drainage potential across the site. Thus, the control of stormwater via a properly designed stormwater management plan, incorporated with an appropriate earthworks design for the cemetery development, is essential to limit damage to graves and other cemetery park infrastructure by intense and heavy rainfalls which occur annually in this general part of KwaZulu-Natal.

It is recommended that these designs are reviewed by GGS to confirm that they promote site stability in general.

10.4 Onsite Sewage disposal

The results of the percolation tests carried out indicate that the soils beneath the site are not suitable for the use of septic tank soakaway systems. Therefore, the following alternatives exist, should there be no municipality water-borne sewage system available in the area:

[15] TECHNICAL RECOMMENDATIONS FOR HIGHWAYS: Draft TRH 20 THE STRUCTURAL DESIGN, CONSTRUCTION AND MAINTENANCE OF UNPAVED ROADS 1990 ISBN 0 908381 87 5 Pretoria, South Africa, 1990

- Conservancy tank,
- Patented package plant, or
- Septic-soakaway system with specially designed evapo-transpirative bed

The latter will be most economical and of relatively low maintenance; however, it must be designed by an experienced geotechnical engineer.

11. CONCLUSIONS

This report presents the results of the geotechnical investigation conducted for the proposed Heroes Acre Memorial Park Cemetery in Pietermaritzburg, KwaZulu-Natal.

The following conclusions can be made:

- The site is well drained with moderate slopes to the east.
- It is underlain mostly by shales of the Pietermaritzburg Formation and partly by intrusive dolerite (south-western corner).
- The site is considered stable provided the recommendations in this report are adhered to.
- The depth to weathered bedrock is relatively shallow, averaging 1.1m below existing ground level.
- Excavation of the soils and shale/ dolerite bedrock can be carried out to an average depth of 1.5mbegl using a normal TLB excavator.
- To meet the minimum depth excavation requirement for graves (1,8m or 6 feet), a more powerful excavator must be used.
- No shallow groundwater was encountered beneath the site, except at the south-eastern corner.
- Due to the clayey soils and shallow bedrock beneath the site there is very low risk of leachate migration from grave decomposition.
- Contamination of groundwater aquifers or borehole water supply by grave decomposition is therefore also considered to be of very low risk.
- Some of the proposed cemetery area must be excluded from graves, such as the marshy area on the south-eastern corner of the site in Figure 1. The boundaries of this area must be established by a wetland specialist.
- In terms of the Site Suitability Rating for cemetery sites the site scores 67, i.e. it rates as ***poor-precautions needed.*** Such precautions relate to the use of more powerful excavating plant than a standard TLB excavator to dig graves to the required 1.8m depth.

Other important aspects such as building foundations, onsite sewage disposal, road subgrade treatment, stormwater control and general earthworks design are also addressed.

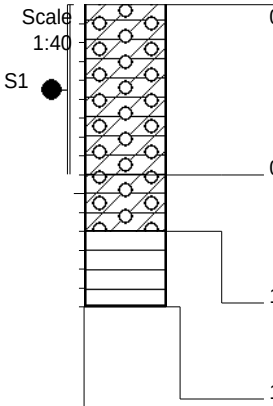
Finally, the information and recommendations provided in this report relates to the location of the test pits and DPL tests put down on site. It is quite possible that variations in the ground conditions will be encountered elsewhere on the site during the digging of grave and other excavations. Any such variations should be brought to the attention of GGS so that an appropriate solution can be arrived at and in doing so avoid unnecessary costs and hardship to the project.

APPENDIX A

ISIBUKO DEVELOPMENT PLANNERS
Heroes Acre Memorial Park, Pietermaritzburg

HOLE No: **TP1**
Sheet 1 of 1

JOB NUMBER: 23-035



0.00 Moist dark grey intact slightly gravelly CLAY. Gravel comprises subangular completely weathered fine to medium grained shale fragments. Residual Shale.

0.90 Dry greyish brown to dark grey dense intact gravelly CLAY. Gravel comprises subangular completely to highly weathered fine to coarse shale fragments. Residual Shale.

1.20 Dark grey completely to highly weathered very soft becoming soft rock SHALE with depth. Pietermaritzburg Formation.

1.60

NOTES

1) Final depth at 1.60m. Refusal on soft rock shale.
2) No groundwater seepage.
3) No sidewall collapse.
4) Samples taken :
   S1 0.00--0.90m (3 x Bulk)

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY : SR
TYPE SET BY : MC
SETUP FILE : GGS-ST~1.SET

INCLINATION :
DIAM :
DATE : 13/03/2023
DATE : 13/03/2023
DATE : 22/03/2023 09:05
TEXT : ..itzburg\Logs\TP1TP10.doc

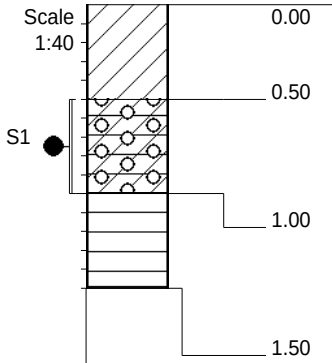
ELEVATION :
X-COORD :
Y-COORD :

HOLE No: **TP1**

ISIBUKO DEVELOPMENT PLANNERS
Heroes Acre Memorial Park, Pietermaritzburg

HOLE No: **TP2**
Sheet 1 of 1

JOB NUMBER: 23-035



Moist dark grey soft intact CLAY. Colluvium.

Dry to moist greyish brown firm to stiff intact gravelly CLAY. Gravel comprises subangular to angular completely to highly weathered fine to coarse shale fragments. Residual Shale.

Greyish brown to dark grey completely to highly weathered very closely to closely jointed very soft becoming soft rock SHALE. Pietermaritzburg Formation.

NOTES

1) Final depth at 1.50m. Refusal on soft rock shale.

2) No groundwater seepage.

3) No sidewall collapse.

4) Samples taken :
S1 0.50--1.00m (1 x Small)

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY : SR

TYPE SET BY : MC
SETUP FILE : GGS-ST~1.SET

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DATE : 13/03/2023

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ELEVATION :
X-COORD :
Y-COORD :

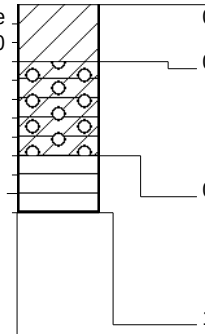
HOLE No: **TP2**

ISIBUKO DEVELOPMENT PLANNERS
Heroes Acre Memorial Park, Pietermaritzburg

HOLE No: **TP3**
Sheet 1 of 1

JOB NUMBER: 23-035

Scale 1:40



0.00	Moist dark grey soft intact CLAY. Colluvium.
0.30	Dry to moist light brown to greyish brown firm to stiff intact very gravelly CLAY. Gravel comprises subangular to angular completely to highly weathered fine to coarse shale fragments. Residual Shale.
0.80	Light brown to greyish brown completely weathered very closely to closely jointed very soft rock becoming soft rock SHALE with depth. Pietermaritzburg Formation.
1.10	

NOTES

1) Final depth at 1.10m. Refusal on soft rock shale.
2) No groundwater seepage.
3) No sidewall collapse.
4) No samples taken.

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY : SR

TYPE SET BY : MC
SETUP FILE : GGS-ST~1.SET

INCLINATION :
DIAM :
DATE : 13/03/2023
DATE : 13/03/2023

DATE : 22/03/2023 09:05
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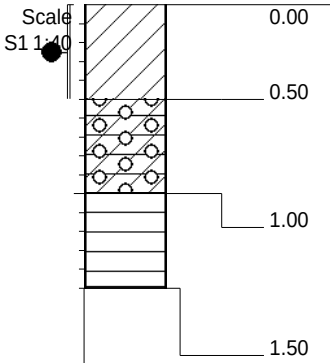
ELEVATION :
X-COORD :
Y-COORD :

HOLE No: **TP3**

ISIBUKO DEVELOPMENT PLANNERS
Heroes Acre Memorial Park, Pietermaritzburg

HOLE No: **TP4**
Sheet 1 of 1

JOB NUMBER: 23-035



0.00 Moist dark grey soft intact CLAY. Colluvium.

0.50 Dry to moist greyish brown firm to stiff intact gravelly CLAY. Gravel comprises subangular to angular completely to highly weathered fine to coarse shale fragments. Residual Shale.

1.00 Grey completely weathered becoming highly weathered with depth very closely to closely jointed very soft rock becoming soft rock SHALE with depth. Pietermaritzburg Formation.

1.50

NOTES

1) Final depth at 1.50m. Refusal on soft rock shale.

2) No groundwater seepage.

3) No sidewall collapse.

4) Samples taken :
S1 0.00--0.50m

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY : SR

TYPE SET BY : MC
SETUP FILE : GGS-ST~1.SET

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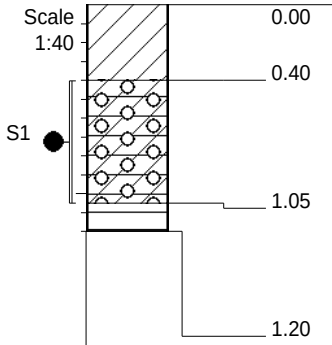
ELEVATION :
X-COORD :
Y-COORD :

HOLE No: **TP4**

ISIBUKO DEVELOPMENT PLANNERS
Heroes Acre Memorial Park, Pietermaritzburg

HOLE No: **TP5**
Sheet 1 of 1

JOB NUMBER: 23-035



0.00 – 0.40	Moist dark grey soft intact CLAY. Colluvium.
0.40 – 1.05	Dry to moist greyish brown firm to stiff intact gravelly CLAY. Gravel comprises subangular to angular completely to highly weathered fine to coarse shale fragments. Residual Shale.
1.05 – 1.20	Greyish brown to dark grey completely to highly weathered very closely to closely jointed very soft becoming soft rock SHALE. Pietermaritzburg Formation.

NOTES

1) Final depth at 1.20m. Refusal on soft rock shale.

2) No groundwater seepage.

3) No sidewall collapse.

4) Samples taken :
S1 0.40--1.05m (3 x Bulk)

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY : SR

TYPE SET BY : MC
SETUP FILE : GGS-ST~1.SET

INCLINATION :
DIAM :
DATE : 13/03/2023
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ELEVATION :
X-COORD :
Y-COORD :

HOLE No: **TP5**

ISIBUKO DEVELOPMENT PLANNERS
Heroes Acre Memorial Park, Pietermaritzburg

HOLE No: **TP6**
Sheet 1 of 1

JOB NUMBER: 23-035

Scale 1:40

0.00 No access.
0.00

NOTES

1) DPL11 taken down at same position.

2) Area near wetland.

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY : SR

INCLINATION :
DIAM :
DATE : 13/03/2023
DATE : 13/03/2023

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: **TP6**

TYPE SET BY : MC
SETUP FILE : GGS-ST~1.SET

DATE : 22/03/2023 09:05
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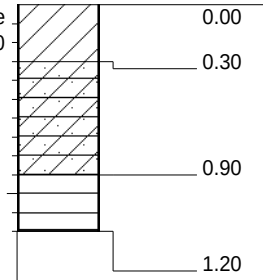
ISIBUKO DEVELOPMENT PLANNERS
Heroes Acre Memorial Park, Pietermaritzburg

HOLE No: **TP7**
Sheet 1 of 1

JOB NUMBER: 23-035

Scale 1:40



0.00	Moist dark grey soft intact CLAY. Colluvium.
0.30	Moist greyish brown sandy CLAY. Residual Shale.
0.90	Greyish brown highly weathered closely jointed very soft becoming soft rock SHALE with depth. Pietermaritzburg Formation.
1.20	

NOTES

1) Final depth at 1.20m. Refusal on soft rock shale.
2) No groundwater seepage.
3) No sidewall collapse.
4) No samples taken.

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY : SR

TYPE SET BY : MC
SETUP FILE : GGS-ST~1.SET

INCLINATION :
DIAM :
DATE : 13/03/2023
DATE : 13/03/2023

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ELEVATION :
X-COORD :
Y-COORD :

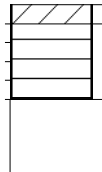
HOLE No: **TP7**

ISIBUKO DEVELOPMENT PLANNERS
Heroes Acre Memorial Park, Pietermaritzburg

HOLE No: **TP8**
Sheet 1 of 1

JOB NUMBER: 23-035

Scale 1:40



0.00	Moist dark greyish brown soft intact CLAY. Colluvium.
0.10	Greyish brown highly weathered closely jointed very soft to soft rock SHALE. Pietermaritzburg Formation.
0.50	

NOTES

1) Final depth at 0.50m. Refusal on soft rock shale.
2) No groundwater seepage.
3) No sidewall collapse.
4) No samples taken.

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY : SR

INCLINATION :
DIAM :
DATE : 13/03/2023
DATE : 13/03/2023

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: **TP8**

TYPE SET BY : MC
SETUP FILE : GGS-ST~1.SET

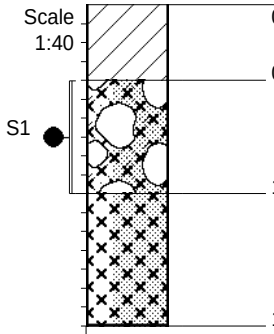
DATE : 22/03/2023 09:05
TEXT : ..itzburg\Logs\TP1TP10.doc

GONDWANA GEO SOLUTIONS

ISIBUKO DEVELOPMENT PLANNERS
Heroes Acre Memorial Park, Pietermaritzburg

HOLE No: **TP9**
Sheet 1 of 1

JOB NUMBER: 23-035



0.00	Moist dark grey soft intact CLAY. Colluvium.
0.40	Moist greyish brown to light brown clayey SAND with rounded soft to hard rock dolerite boulders throughout. Residual Dolerite.
1.00	Light brown completely weathered very soft becoming sot rock DOLERITE.
1.70	

NOTES

1) Final depth at 1.70m. Refusal on soft rock dolerite.
2) No groundwater seepage.
3) No sidewall collapse.
4) Samples taken :
   S1 0.40--1.00m (1 x Small)

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY : SR

TYPE SET BY : MC
SETUP FILE : GGS-ST~1.SET

INCLINATION :
DIAM :
DATE : 13/03/2023
DATE : 13/03/2023

DATE : 22/03/2023 09:05
TEXT : ..itzburg\Logs\TP1TP10.doc

ELEVATION :
X-COORD :
Y-COORD :

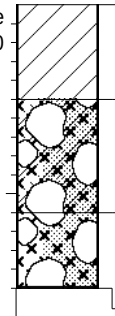
HOLE No: **TP9**

ISIBUKO DEVELOPMENT PLANNERS
Heroes Acre Memorial Park, Pietermaritzburg

HOLE No: **TP10**
Sheet 1 of 1

JOB NUMBER: 23-035

Scale 1:40



0.00	Moist dark grey soft intact CLAY. Colluvium.
0.50	Moist greyish brown to light brown sandy CLAY to clayey SAND with dolerite boulders. Residual Dolerite.
1.10	Light brown completely weathered very soft rock becoming soft rock DOLERITE with hard rock dolerite boulders throughout.
1.50	

NOTES

1) Final depth at 1.50m. Refusal on soft and hard rock dolerite boulders.
2) No groundwater seepage.
3) No sidewall collapse.
4) No samples taken.

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY : SR

TYPE SET BY : MC
SETUP FILE : GGS-ST~1.SET

INCLINATION :
DIAM :
DATE : 13/03/2023
DATE : 13/03/2023

DATE : 22/03/2023 09:05
TEXT : ..itzburg\Logs\TP1TP10.doc

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: **TP10**

APPENDIX B

GONDWANA GEO SOLUTIONS

Consulting Geotechnical Engineers & Engineering Geologists

Cape Town Office:
13 Rocklands Road
Simonstown
CAPE TOWN
7975

Durban Office:
4 Haven Road
Westville
DURBAN
3629

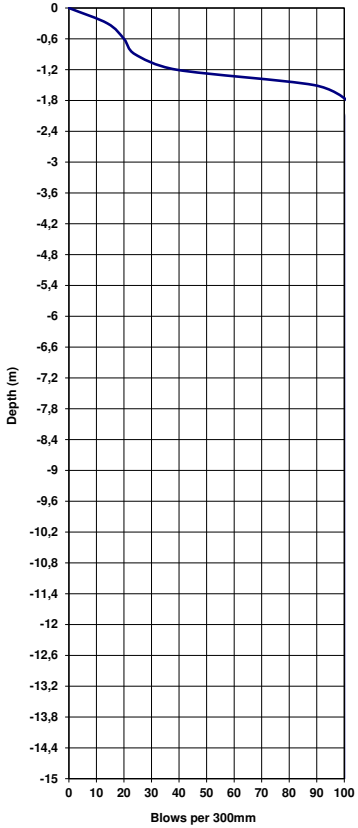
Client: ISIBUKO DEVELOPMENT PLANNERS
Project: Heroes Acre Memorial Park, Pietermaritzburg
Section:

Ref.No. 23-035
Date: March 2023
Operator: EN

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 1***

Depth metres	Blows per 300mm	Inferred Consistency
0		
0,3	14	Soft
0,6	20	Firm
0,9	24	Firm
1,2	39	Stiff
1,5	89	Very Stiff
	Ref	

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings

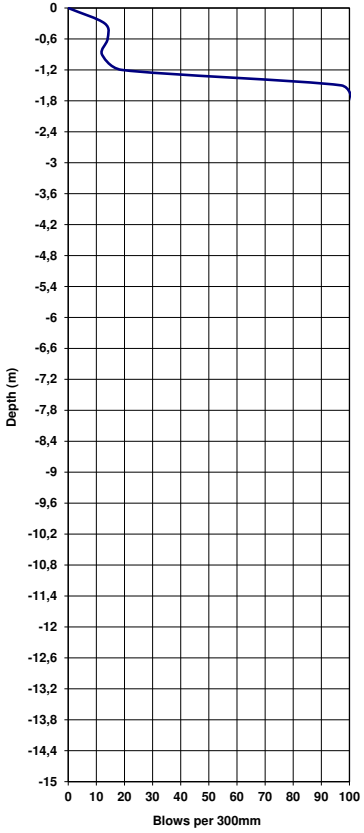


C=1
Phi=0

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 2***

Depth metres	Blows per 300mm	Inferred Consistency	C=1
0			
0,3	13	Soft	1
0,6	14	Soft	1
0,9	12	Soft	1
1,2	19	Firm	1
1,5	97	Very Stiff	1
	Ref		

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings

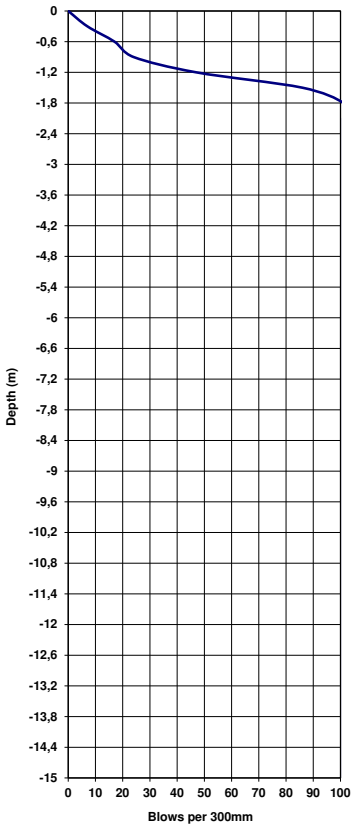


C=1
Phi=0

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 3***

Depth metres	Blows per 300mm	Inferred Consistency	C=1
0			
0,3	7	Very Soft	1
0,6	17	Firm	1
0,9	24	Firm	1
1,2	47	Stiff	1
1,5	86	Very Stiff	1
	Ref		

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings



C=1
Phi=0

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

GONDWANA GEO SOLUTIONS

Consulting Geotechnical Engineers & Engineering Geologists

Cape Town Office:
13 Rocklands Road
Simonstown
CAPE TOWN
7975

Durban Office:
4 Haven Road
Westville
DURBAN
3629

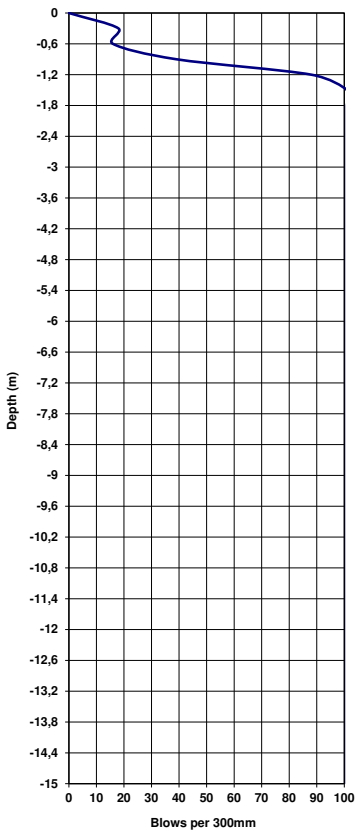
Client: ISIBUKO DEVELOPMENT PLANNERS
Project: Heroes Acre Memorial Park, Pietermaritzburg
Section:

Ref.No. 23-035
Date: March 2023
Operator: EN

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 4***

Depth metres	Blows per 300mm	Inferred Consistency
0		
0,3	18	Firm
0,6	16	Soft
0,9	39	Stiff
1,2	88	Very Stiff
	Ref	

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings

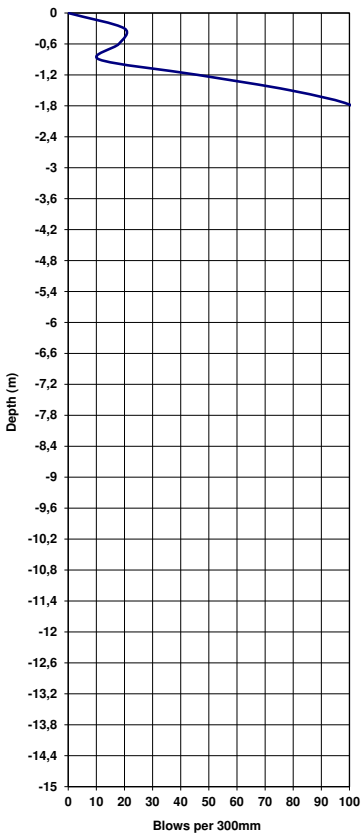


C=1
Phi=0

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 5***

Depth metres	Blows per 300mm	Inferred Consistency	
0			
0,3	20	Firm	1
0,6	18	Firm	1
0,9	11	Soft	1
1,2	46	Stiff	1
1,5	79	Very Stiff	1
	Ref		

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings

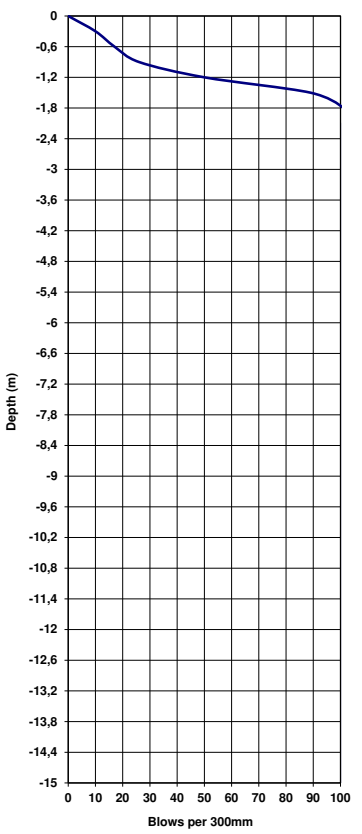


C=1
Phi=0

Light Dynamic Penetrometer Probe ---------- ***Test No. DPL 6***

Depth metres	Blows per 300mm	Inferred Consistency	
0			
0,3	10	Soft	1
0,6	17	Firm	1
0,9	26	Firm	1
1,2	50	Stiff	1
1,5	89	Very Stiff	1
	Ref		

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings



C=1
Phi=0

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

GONDWANA GEO SOLUTIONS

Consulting Geotechnical Engineers & Engineering Geologists

Cape Town Office:
13 Rocklands Road
Simonstown
CAPE TOWN
7975

Durban Office:
4 Haven Road
Westville
DURBAN
3629

Client: ISIBUKO DEVELOPMENT PLANNERS
Project: Heroes Acre Memorial Park, Pietermaritzburg
Section:

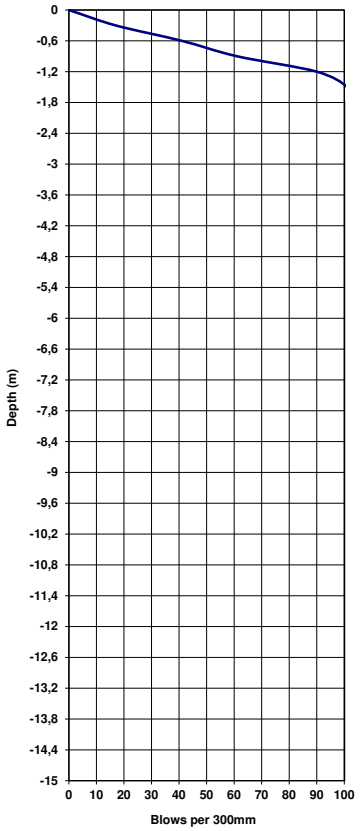
Ref.No. 23-035
Date: March 2023
Operator: EN

Light Dynamic Penetrometer Probe ---------- **Test No. DPL 7**

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings

C=1
Phi=0

Depth metres	Blows per 300mm	Inferred Consistency	
0			
0,3	17	Firm	1
0,6	41	Stiff	1
0,9	61	Stiff	1
1,2	90	Very Stiff	1
	Ref		

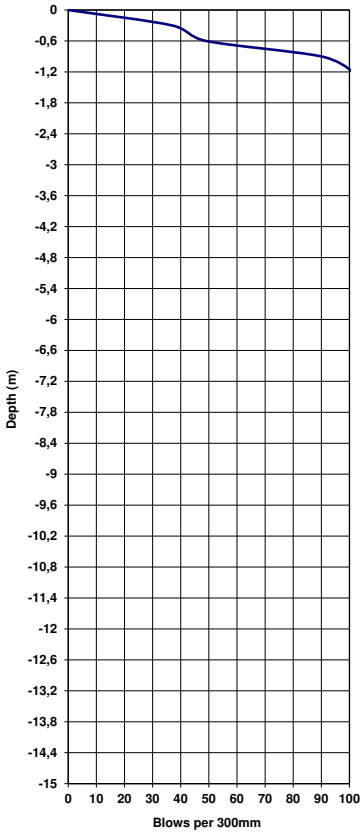


Light Dynamic Penetrometer Probe ---------- **Test No. DPL 8**

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings

C=1
Phi=0

Depth metres	Blows per 300mm	Inferred Consistency	
0			
0,3	37	Stiff	1
0,6	49	Stiff	1
0,9	90	Very Stiff	1
	Ref		

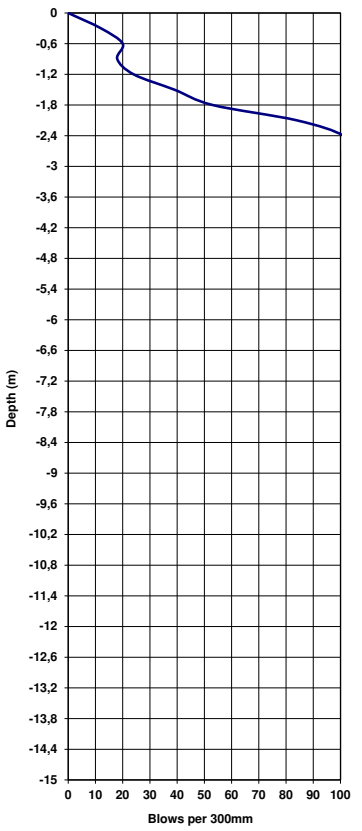


Light Dynamic Penetrometer Probe ---------- **Test No. DPL 9**

Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings

C=1
Phi=0

Depth metres	Blows per 300mm	Inferred Consistency	
0			
0,3	12	Soft	1
0,6	20	Firm	1
0,9	18	Firm	1
1,2	24	Firm	
1,5	39	Stiff	
1,8	53	Stiff	
2,1	84	Very Stiff	
	Ref		



THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

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DURBAN
3629

Client: ISIBUKO DEVELOPMENT PLANNERS
Project: Heroes Acre Memorial Park, Pietermaritzburg
Section:

Ref.No. 23-035
Date: March 2023
Operator: EN

Light Dynamic Penetrometer Probe ---------- **Test No. DPL 10**

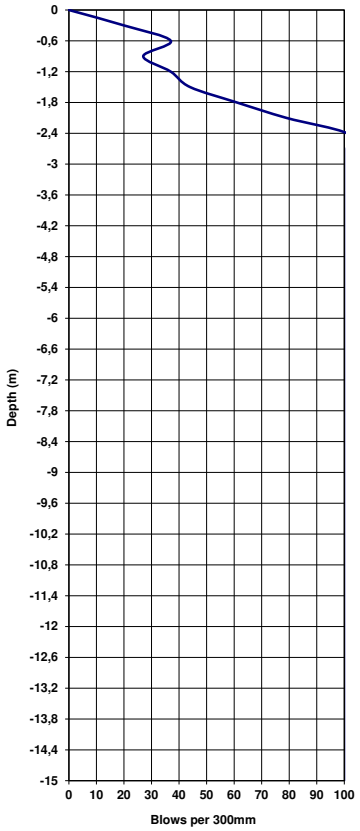
Light Dynamic Penetrometer Probe ---------- **Test No. DPL 11**

Light Dynamic Penetrometer Probe ---------- **Test No. DPL**

THE INSITU STRENGTH DEPENDS ON SOIL MOISTURE CONTENT AND GRAIN STRUCTURE WHICH HAVE NOT BEEN ASSESSED AND MAY CHANGE. THE VALUES GIVEN ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

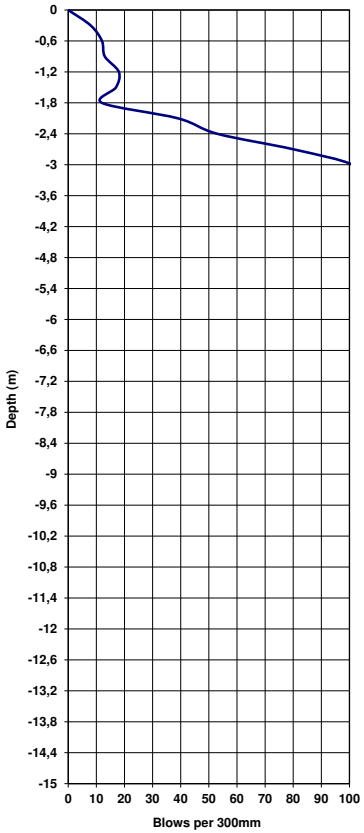
Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings
C=1
Phi=0

Depth metres	Blows per 300mm	Inferred Consistency
0		
0,3	20	Firm
0,6	37	Stiff
0,9	27	Firm
1,2	37	Stiff
1,5	44	Stiff
1,8	61	Stiff
2,1	79	Very Stiff
	Ref	



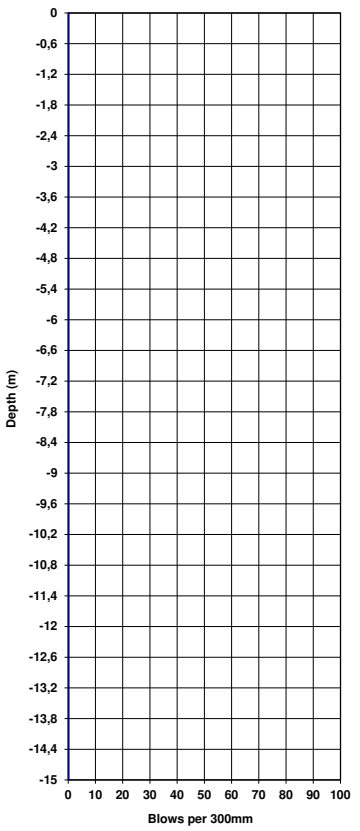
Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings
C=1
Phi=0

Depth metres	Blows per 300mm	Inferred Consistency
0		
0,3	8	Very Soft
0,6	12	Soft
0,9	13	Soft
1,2	18	Firm
1,5	17	Firm
1,8	12	Soft
2,1	39	Stiff
2,4	53	Stiff
2,7	80	Very Stiff
	Ref	



Hammer: 10kg falling 550mm
Cone: 25mm diameter with 60 degree apex angle
Rods: 16mm diameter, 22mm diameter couplings
C=1
Phi=0

Depth metres	Blows per 300mm	Inferred Consistency
0		



APPENDIX C

SGS MATROLAB (PTY) LTD
- CIVIL ENGINEERING SERVICES -
Reg.No.: 2003/029180/07 - VAT. Reg.No.: 4040210587
a SANAS Accredited Testing Laboratory, No. T 0239

60 Columbine Place, Glen Anil, Durban North, 4051

Tel. : (031) 579 1220/1
Fax : (031) 579 1344
Email : rasalis.bhikam@sgs.com

sanas Testing Laboratory T 0239

CLIENT :	Gondwana Geo Solutions (Pty) Ltd	OUR REF.:	47275
ADDRESS :	17 Kingmead Drive Westville, Durban 3629	YOUR REF.:	
ATTENTION :	Mr Mark Richter	DATE :	27.03.2023

PROJECT : Heroes Acre

SGS MATROLAB

a SANAS Accredited Testing Laboratory, No. T 0239

Tests marked * "Not SANAS Accredited" in this Report are not included in the SANAS Schedule of Accreditation for the laboratory.

TEST REPORT / RESULTS

Sample/s:

Sampled by : -
Date Received / Sampled : 23.03.2023
Date Tested : 23.03.2023

Sampling method :

Section / Position tested identified by : Customer

Number of pages in this Report : 9

General :

Opinions and interpretations expressed herein are outside the Scope of SANAS Accreditation.
Results only have bearing on the samples tested.
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Sections may only be reproduced with written approval from SGS MATROLAB

Technical Signatory : Rasalis Bhikam

SGS MATROLAB

sanas Testing Laboratory T 0239

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60 Columbine Place, Glen Anil, Durban North, 4051

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Fax : (031) 579 1344
Email : rasalis.bhikam@sgs.com

TEST RESULTS

Gondwana Geo Solutions (Pty) Ltd
17 Kingmead Drive
Westville, Durban
3629
Attention: Mr Mark Richter

Project : Heroes Acre

Your Ref :
Our Ref : 47275
Date Reported : 28.03.2023

SIEVE ANALYSIS, ATTERBERG LIMITS, CBR(SANS 3001:GR1,GR10,GR12,GR20,GR30,GR40)

SAMPLE NO.	17735	17738			Preparation Method:
HOLE NO.	TP1	TP5			Sample was scalped on the 37.5mm sieve
ROAD NO.	-	-			
DEPTH	0 - 0.90	0.40 - 1.05			
CHAINAGE	-	-			
LAYER TYPE	-	-			
STABILISED WITH	Natural	Natural			
SUPPLIER	-	-			
CURING METHOD	-	-			
DATE TESTED	23.03.2023	23.03.2023			
DESCRIPTION	Mst Dk Gr Slightly Gravlley Clay	Dry to Mst Br Frm to Stff Intct Grvl Clay			Specification Min : Max
SIEVE ANALYSIS (% PASSING)					
100 mm					
75 mm		100			
63 mm		89			
50 mm		87			
37.5 mm		82			
28.0 mm		78			
20.0 mm		73			
14.0 mm	100	70			
5.0 mm	94	56			
2.0 mm	68	48			
0.425 mm	34	44			
0.075 mm	33	43			
SOIL MORTAR					
COARSE SAND <2.0mm >0.425mm	50	9			
FINE SAND <0.425mm >0.075mm	1	1			
MATERIAL <0.075mm	49	90			
CONSTANTS					
GRADING MODULUS	1,65	1,65			
PRA CLASSIFICATION	A-2-7(2)	A-6(4)			
COLTO CLASSIFICATION	---	---			
TRH Class.(INSITU |93%|90%|)	- | -	- | -			
LIQUID LIMIT (%)	40	39			
PLASTICITY INDEX (0.425mm)	20	19			
LINEAR SHRINKAGE (%)	10,0	9,5			
MDD					
MAXIMUM DRY DENSITY (kg/m^3)	1749	1792			
OPTIMUM MOISTURE CONTENT(%)	19,3	16,6			
MOULDING MOISTURE (%)	19,0	16,3			
TYPE OF TEST	CBR	CBR			
CBR-UCS @ 100% MDD	3,6	2,8			
CBR-UCS @ 98% MDD	3,0	2,2			
CBR-UCS @ 97% MDD	2,8	2,0			
CBR-UCS @ 95% MDD	2,3	1,6			
CBR-UCS @ 93% MDD	1,9	1,4			
CBR-UCS @ 90% MDD	1,4	1,1			

CBR-UCS @ % MDD derived from calculation.

% SWELL MOULD [A][B][C]	1,70	1,80	1,90	3,20	3,20	3,30									

Remarks :

FORM: GR40

4.4.1(SGS)(2019.12.04)

Technical Signatory : Rasalis Bhikam

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T 0239

TEST RESULTS

Gondwana Geo Solutions (Pty) Ltd
17 Kingmead Drive
Westville, Durban
3629
Attention: Mr Mark Richter

Project : Heroes Acre

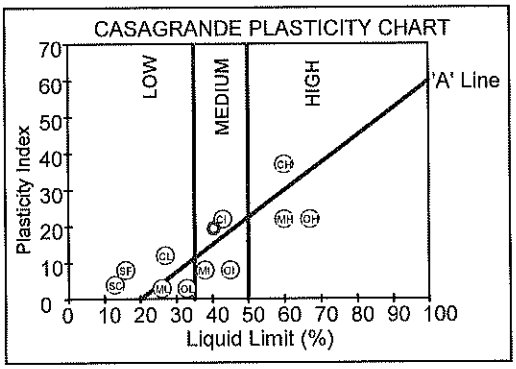
Your Ref : 23-035/1
Our Ref : 47275
Date Reported : 28.03.2023

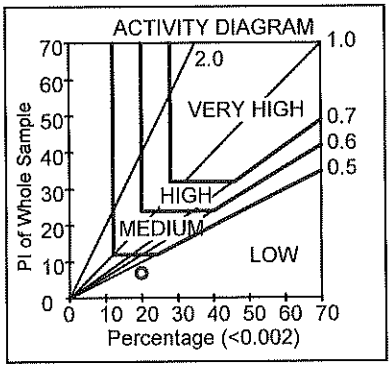
FOUNDATION INDICATOR (ASTM: D422)

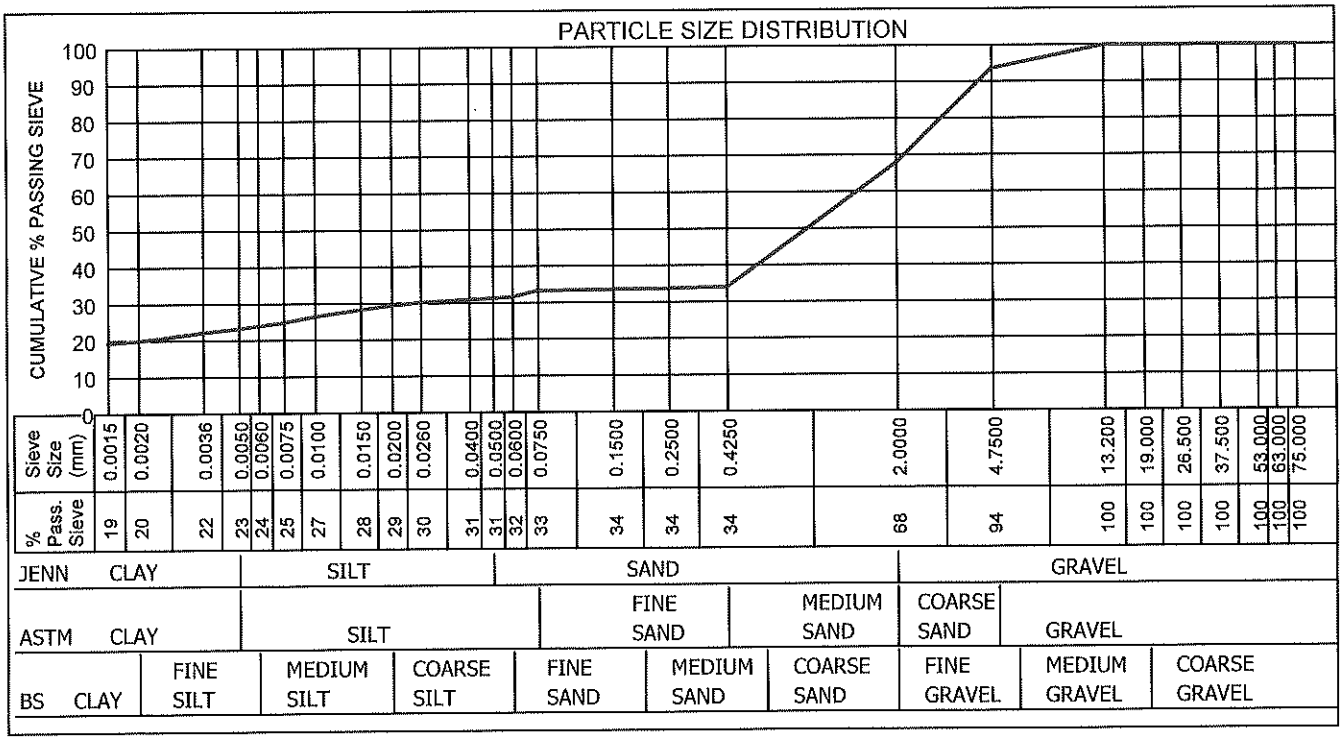
Sample No.	: 17735
Hole No.	: TP 1
Depth	: 0 - 0.90m
Liquid Limit (%)	: 40
Plasticity Index	: 20
Linear Shrinkage (%)	: 10,0
PI of Whole Sample	: 7
P.R.A. Classification	: A-2-7(2)
Unified Soil Classificati	: SC
Activity	: 0,35
Heave Classification	: LOW
Grading Modulus	: 1,65
Percentage (<0.002)	: 20,0
Moisture Content (%)	: 13,6

Material Description : Dark Grey CLAYEY SAND

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	23,3	8,0	36,8	31,9	SANDY CLAY
Astm	23,3	10,1	60,2	6,4	CLAYEY SAND
British Standard	20,1	11,6	36,5	31,9	CLAYEY SAND







Sieve Size (mm)	0.0015	0.0020	0.0036	0.0050	0.0060	0.0075	0.0100	0.0150	0.0200	0.0260	0.0400	0.0500	0.0600	0.0750	0.1500	0.2500	0.4250	2.0000	4.7500	13.200	19.000	26.500	37.500	53.000	63.000	75.000
% Pass. Sieve	19	20	22	23	24	25	27	28	29	30	31	31	32	33	34	34	34	68	94	100	100	100	100	100	100	100

JENN	CLAY	SILT			SAND			GRAVEL		
ASTM	CLAY	SILT			FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL		
BS	CLAY	FINE SILT	MEDIUM SILT	COARSE SILT	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	MEDIUM GRAVEL	COARSE GRAVEL

Remarks :

FORM: A6

4.4.1(SGS)(2019.12.04)

Technical Signatory : Rasalis Bhikam

MATROLAB IS NOW PART OF SGS, THE WORLDS'S LEADING INSPECTION, VERFICATION, TESTING AND CERTIFICATION COMPANY.

SGS MATROLAB (PTY) LTD
- CIVIL ENGINEERING SERVICES -
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Tel. : (031) 579 1220/1
Fax : (031) 579 1344
Email : rasalis.bhikam@sgs.com

T 0239

TEST RESULTS

Gondwana Geo Solutions (Pty) Ltd
17 Kingmead Drive
Westville, Durban
3629
Attention: Mr Mark Richter

Project : Heroes Acre

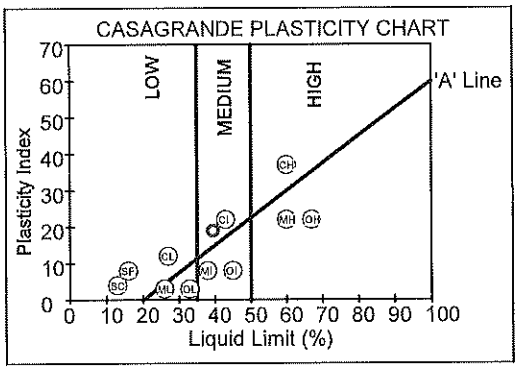
Your Ref :
Our Ref : 47275
Date Reported : 28.03.2023

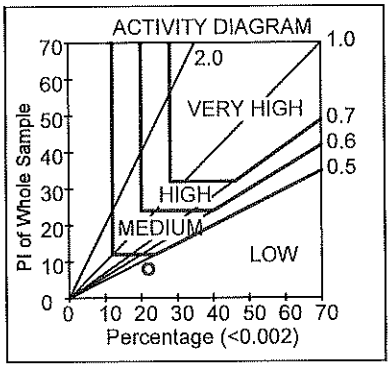
FOUNDATION INDICATOR (ASTM: D422)

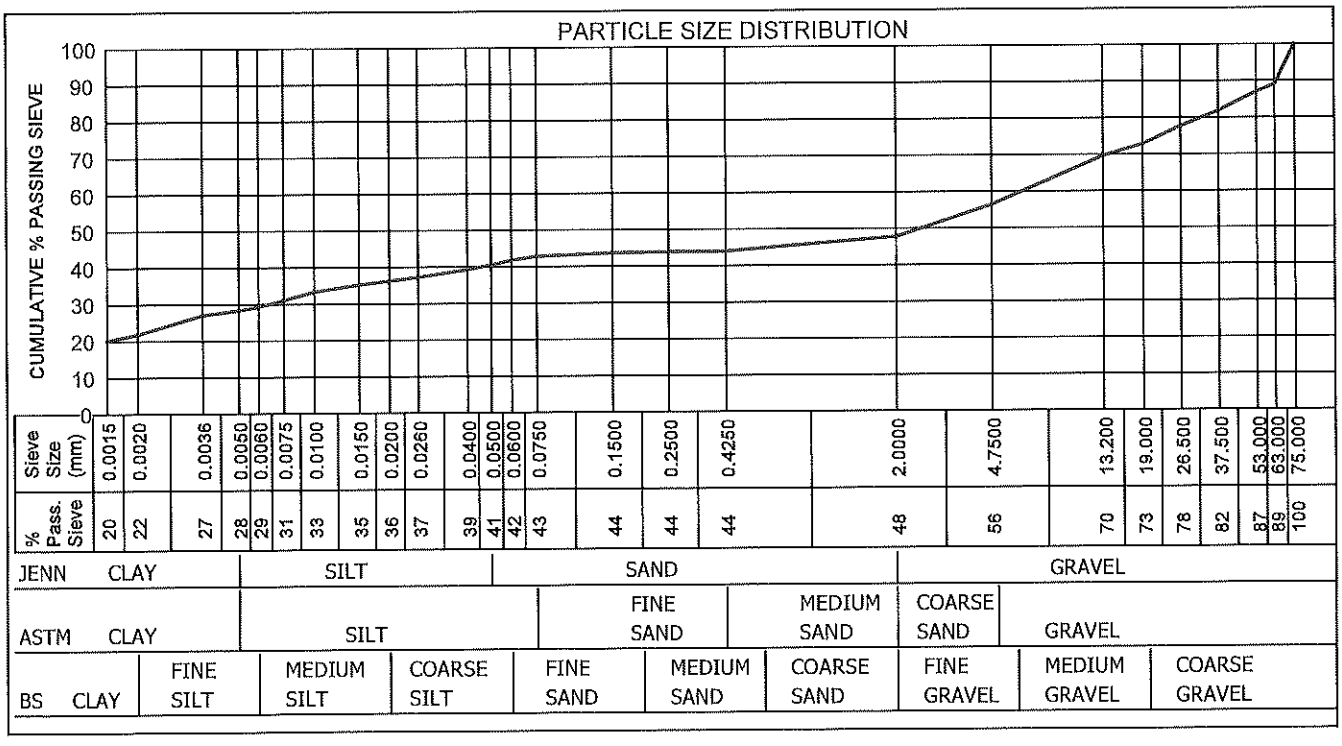
Sample No.	: 17738
Hole No.	: TP5
Depth	: 0.40 - 1.05
Liquid Limit (%)	: 39
Plasticity Index	: 19
Linear Shrinkage (%)	: 9,5
PI of Whole Sample	: 8
P.R.A. Classification	: A-6(4)
Unified Soil Classificati	: SC
Activity	: 0,36
Heave Classification	: LOW
Grading Modulus	: 1,65
Percentage (<0.002)	: 22,0
Moisture Content (%)	: 0,0

Material Description : Grey Brown CLAY

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	28,3	12,2	7,3	52,2	CLAY
Astm	28,3	14,6	13,6	43,6	CLAY
British Standard	21,8	20,0	6,0	52,2	SILTY CLAY







Remarks :

FORM: A6

4.4.1(SGS)(2019.12.04)

Technical Signatory : Rasalis Bhikam

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T 0239

TEST RESULTS

Gondwana Geo Solutions (Pty) Ltd
17 Kingmead Drive
Westville, Durban
3629
Attention: Mr Mark Richter

Project : Heroes Acre

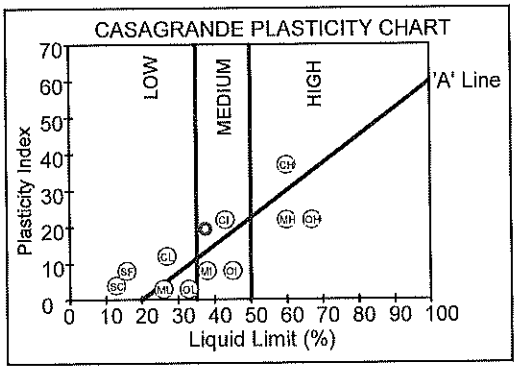
Your Ref : 23-035/1
Our Ref : 47275
Date Reported : 28.03.2023

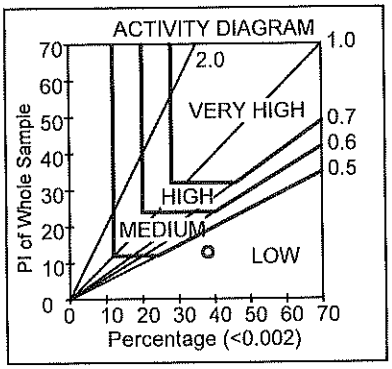
FOUNDATION INDICATOR (ASTM: D422)

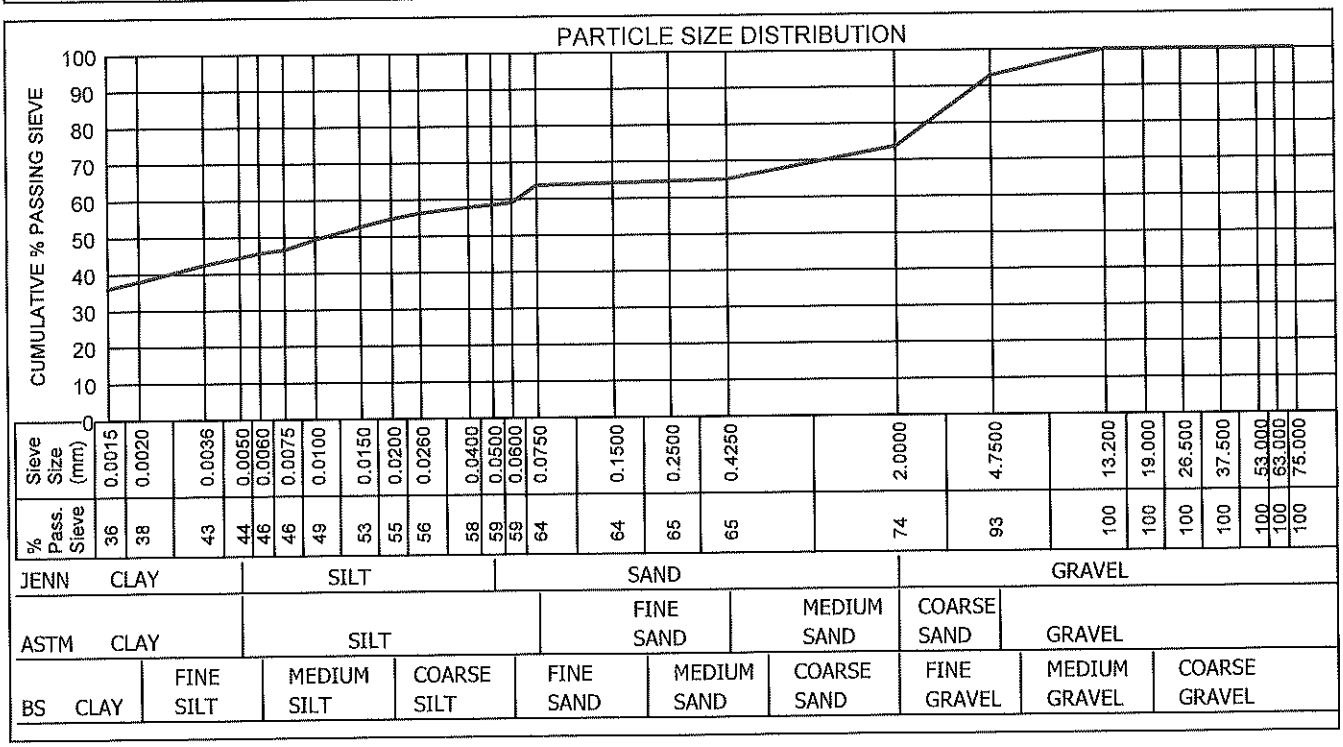
Sample No.	: 17739
Hole No.	: TP 8
Depth	: 0 - 0.90m
Liquid Limit (%)	: 38
Plasticity Index	: 20
Linear Shrinkage (%)	: 10,0
PI of Whole Sample	: 13
P.R.A. Classification	: A-6(10)
Unified Soil Classificati	: CL
Activity	: 0,34
Heave Classification	: LOW
Grading Modulus	: 0,97
Percentage (<0.002)	: 38,0
Moisture Content (%)	: 13,7

Material Description : Dark Grey SANDY CLAY

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	44,5	14,0	15,3	26,1	CLAY
Astm	44,5	19,3	29,2	7,1	SANDY CLAY
British Standard	38,0	21,1	14,7	26,1	CLAY







Sieve Size (mm)	0.0015	0.0020	0.0036	0.0050	0.0060	0.0075	0.0100	0.0150	0.0200	0.0260	0.0400	0.0500	0.0600	0.0750	0.1500	0.2500	0.4250	2.0000	4.7500	13.200	19.000	26.500	37.500	53.000	63.000	75.000
% Pass. Sieve	36	38	43	44	46	46	49	53	55	56	58	59	59	64	64	65	65	74	93	100	100	100	100	100	100	100

JENN	CLAY		SILT		SAND				GRAVEL	
ASTM	CLAY		SILT			FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL	
BS	CLAY	FINE SILT	MEDIUM SILT	COARSE SILT	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	MEDIUM GRAVEL	COARSE GRAVEL

Remarks :

FORM: A6

4.4.1(SGS)(2019.12.04)

Technical Signatory : Rasalis Bhikam

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sanas Testing Laboratory T 0239

TEST RESULTS

Gondwana Geo Solutions (Pty) Ltd
17 Kingmead Drive
Westville, Durban
3629
Attention: Mr Mark Richter

Project : Heroes Acre

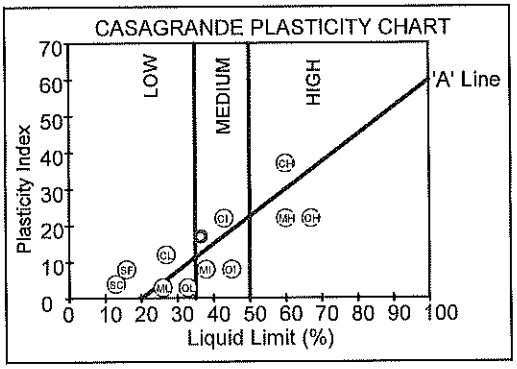
Your Ref : 23-035/1
Our Ref : 47275
Date Reported : 28.03.2023

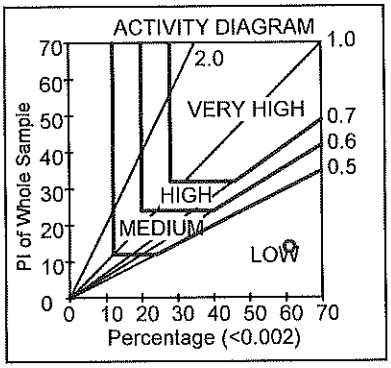
FOUNDATION INDICATOR (ASTM: D422)

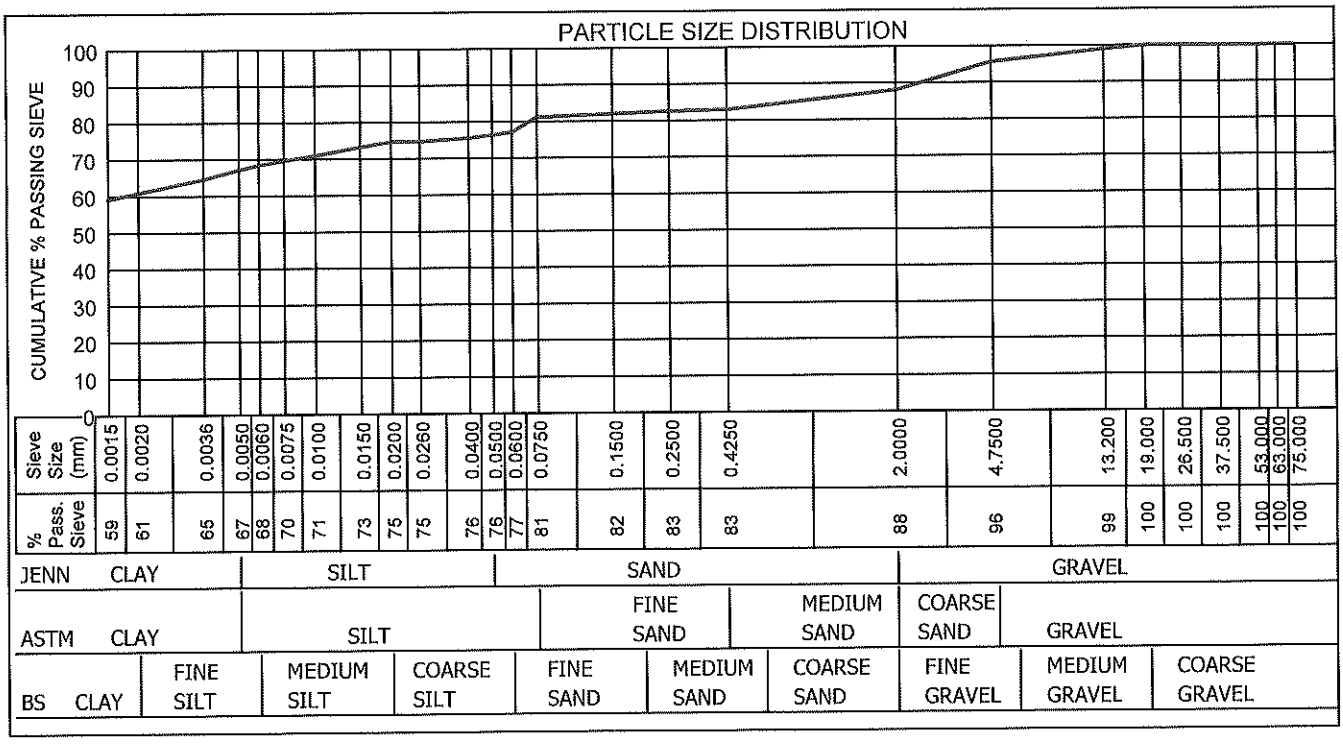
Sample No.	: 17740
Hole No.	: TP 9
Depth	: 0.40 - 1.00m
Liquid Limit (%)	: 37
Plasticity Index	: 17
Linear Shrinkage (%)	: 8,5
PI of Whole Sample	: 14
P.R.A. Classification	: A-6(11)
Unified Soil Classificati	: CL
Activity	: 0,23
Heave Classification	: LOW
Grading Modulus	: 0,48
Percentage (<0.002)	: 61,0
Moisture Content (%)	: 21,6

Material Description : Greyish Brown to Light Brown CLAY

	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Classification
Jennings	67,2	9,2	11,7	11,9	CLAY
Astm	67,2	14,0	14,5	4,4	CLAY
British Standard	61,0	16,2	10,9	11,9	CLAY







Sieve Size (mm)	0.0015	0.0020	0.0036	0.0050	0.0060	0.0075	0.0100	0.0150	0.0200	0.0260	0.0400	0.0500	0.0600	0.0750	0.1500	0.2500	0.4250	2.0000	4.7500	13.200	19.000	26.500	37.500	53.000	63.000	75.000
% Pass. Sieve	59	61	65	67	68	70	71	73	75	75	76	76	77	81	82	83	83	88	96	99	100	100	100	100	100	100

JENN	CLAY	SILT		SAND			GRAVEL			
ASTM	CLAY	SILT		FINE SAND	MEDIUM SAND	COARSE SAND	GRAVEL			
BS	CLAY	FINE SILT	MEDIUM SILT	COARSE SILT	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	MEDIUM GRAVEL	COARSE GRAVEL

Remarks :

FORM: A6

4.4.1(SGS)(2019.12.04)

Technical Signatory : Rasalis Bhikam

SGS MATROLAB

sanas Testing Laboratory T 0239

SGS MATROLAB (PTY) LTD
- CIVIL ENGINEERING SERVICES -
Reg.No.: 2003/029180/07 - VAT. Reg.No.: 4040210587
a SANAS Accredited Testing Laboratory, No. T 0239

60 Columbine Place, Glen Anil, Durban North, 4051

Tel. : (031) 579 1220/1
Fax : (031) 579 1344
Email : rasalis.bhikam@sgs.com

TEST RESULTS

Gondwana Geo Solutions (Pty) Ltd
17 Kingmead Drive
Westville, Durban
3629
Attention: Mr Mark Richter

Project : Heroes Acre

Your Ref : 23-035/1
Our Ref : 47275
Date Reported : 28.03.2023

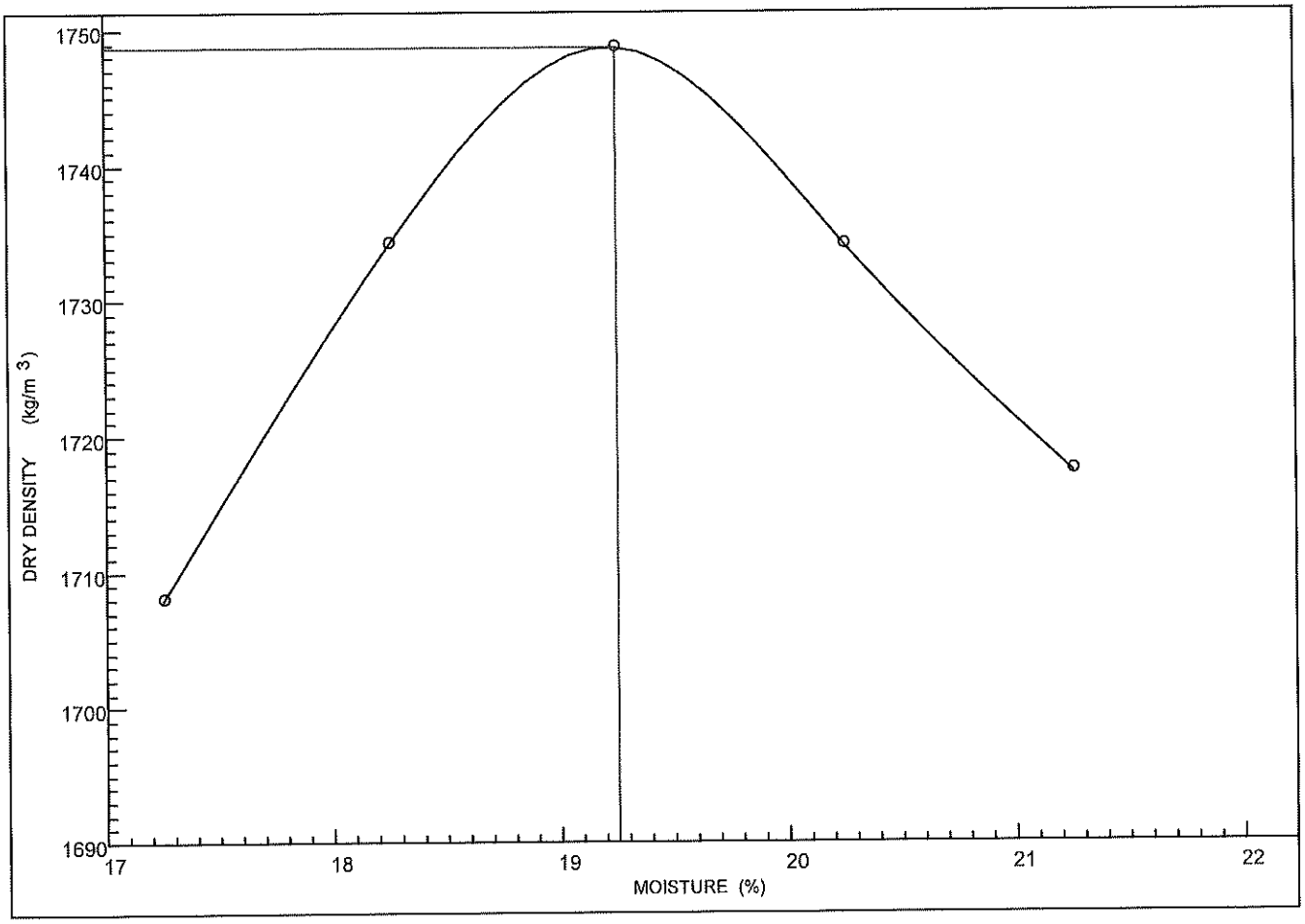
MOISTURE / DENSITY RELATIONSHIP(SANS 3001: GR30)

Sample No.: 17735	Hole No. : TP 1	Depth (mm) : 0 - 0.90m
Origin : TP 1	Stabilized With : Natural	Compaction Energy :
Material Description : Dark Grey Slightly Gravelly Clay		

Maximum Dry Density (kg/m^3): 1749

Optimum Moisture Content (%) : 19,3

Point No.	1	2	3	4	5			
Moisture (%)	17,3	18,3	19,3	20,3	21,3			
Density (kg/m^3)	1708	1734	1749	1734	1717			



Remarks :

FORM: GR30

4.4.1(SGS)(2019.12.04)

Technical Signatory : Rasalis Bhikam

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Email : rasalis.bhikam@sgs.com

T 0239

TEST RESULTS

Gondwana Geo Solutions (Pty) Ltd 17 Kingmead Drive Westville, Durban 3629 Attention: Mr Mark Richter	Project : Heroes Acre Your Ref : 23-035/1 Our Ref : 47275 Date Reported : 28.03.2023

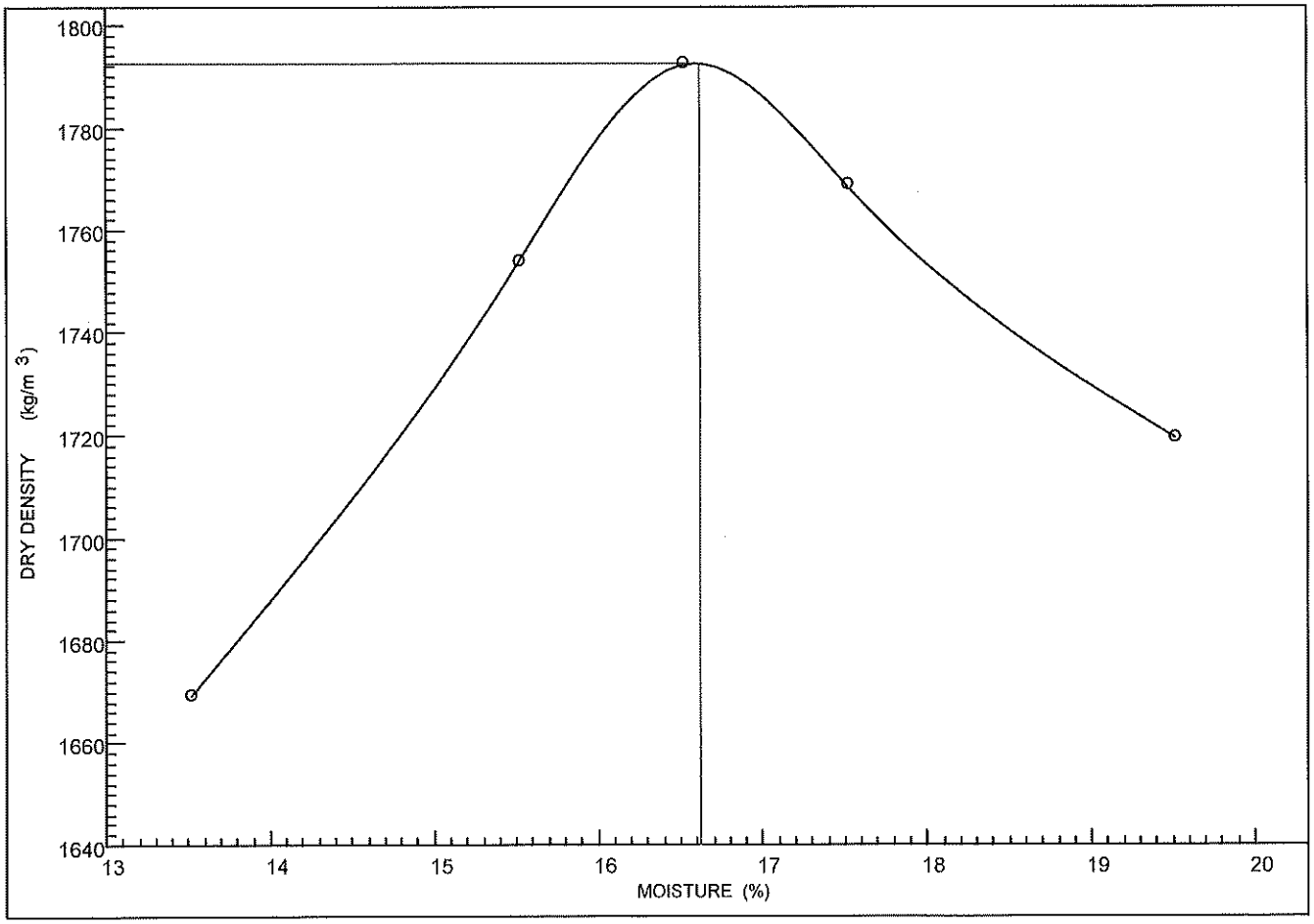
MOISTURE / DENSITY RELATIONSHIP(SANS 3001: GR30)

Sample No.: 17738	Hole No. : TP 5	Depth (mm) : 0.40 - 1.05m
Origin : TP 5	Stabilized With : Natural	Compaction Energy :
Material Description : Dark Greyish Brown Gravelly Clay		

Maximum Dry Density (kg/m^3): 1792

Optimum Moisture Content (%) : 16,6

Point No.	1	2	3	4	5			
Moisture (%)	13,5	15,5	16,5	17,5	19,5			
Density (kg/m^3)	1669	1754	1792	1769	1719			



Remarks :

FORM: GR30

4.4.1(SGS)(2019.12.04)

Technical Signatory : Rasalis Bhikam

SGS MATROLAB (PTY) LTD
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Fax : (031) 579 1344
Email : rasalis.bhikam@sgs.com

TEST RESULTS

Gondwana Geo Solutions (Pty) Ltd
17 Kingmead Drive
Westville, Durban
3629
Attention: Mr Mark Richter

Project : Hereos Acre

Your Ref :
Our Ref : 47275
Date Reported : 28.03.2023

Sample Number		Hole Number		Depth:	Temparature	PH Value	E.Conductivity mS/cm
17736		TP2		0.50 - 1.00	22.5	5.7	0.368
17737		TP4		0 - 0.50	22.7	5.0	0.313

Remarks :
FORM: C1

4.4.1(SGS)(2019.12.04)

Technical Signatory : Rasalis Bhikam

APPENDIX D

TABLE 1
EXCAVATABILITY RATINGS

DESCRIPTION	ASSESSMENT	RATING
Easy Spade	Pick point to 50mm	15
Pick and Spade	Slight indentation	10
Machine	Firm blows (1-3mm)	5
Blasting	Backactor refusal	0

TABLE 2
STABILITY RATINGS

DESCRIPTION	ASSESSMENT	RATING
Stable	Excavation can be profiled safely	20
Overbreak	Excavation stable: Overbreak 1.3 - 1.8 *	15
Slightly unstable	Minor falls of material	8
Unstable	Collapse of hole likely	F

Note: Overbreak = Ratio of widths top of trench to base
F = Fatal flaw

TABLE 3
WORKABILITY RATINGS

DESCRIPTION	UNIFIED CLASS	MDD (kg/m^3)	RATING
Excellent / Good	GW / SW / GP	+1800	10
Fair	SP / SM	<1800	5
Poor	OL / CL / ML	<1700	2
Very poor	OH / CH / MH	>1800	0

TABLE 4
WATER TABLE RATINGS

DESCRIPTION	WATER TABLE DEPTH (m) *	RATING
Deep water table	+8	25
Intermediate	4 - 8	15
Possible perched water	0 - 4	5
Water logged soil	0 - 4	F

TABLE 5
SUBSOIL PERMEABILITY RATINGS

DESCRIPTION	PERCOLATION RATE (mm/hr)	APPROX. PERMEABILITY (cm/sec)	RATING
Impermeable	Not measurable	$<10^{-5}$	15
Relatively impermeable	10 - 15	10^{-4} to 10^{-5}	20
Relatively permeable	15 - 50	10^{-3} to 10^{-4}	10
Permeable	50 - 1000	$>10^{-3}$	0

TABLE 6
BACKFILL PERMEABILITY RATINGS

DESCRIPTION	ASSESSMENT	RATING
Impermeable	OH / CI / CH	5
Relatively impermeable	GC / SC / MH	10
Relatively permeable	GP / SP / GW	7
Very permeable	SW / SP	0

Note: * Measured from ground level