- *Site Investigations*
- *Slope Stability*
- *Rock Mechanics*
- *Soil Mechanics*
- *Foundations*
- *Borrow Pits and Materials*
- *Roads*
- *Groundwater*
- *NHBRC*
- *Geotechnical Instrumentation*

# *Shallow Geotechnical Centreline Investigation for the Proposed Tiershokloof Pipeline near Ceres, Western Cape Province: Final Report*

## *Client: ETL*

***Reference: 22-1047R02***

***Dated: 06 December 2022***


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# *Shallow Geotechnical Centreline Investigation for the Proposed Tiershokloof Pipeline near Ceres, Western Cape Province: Final Report*

**Reference: 22-1047R02** **Date: 06 December 2022**

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# *Shallow Geotechnical Centreline Investigation for the Proposed Tiershokloof Pipeline near Ceres, Western Cape Province: Final Report*

**Reference: 22-1047R02** **Date: 06 December 2022**

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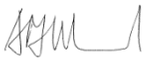
| **Document Reviewer** | Nino Welland |  | 19 December 2022 |
| **Director** | Nino Welland |  | 19 December 2022 |

## LEGAL NOTICE

# *Shallow Geotechnical Centreline Investigation for the Proposed Tiershokloof Pipeline near Ceres, Western Cape Province: Final Report*

**Reference: 22-1047R02** **Date: 06 December 2022**


***EXECUTIVE SUMMARY***

*This report presents the results of a shallow geotechnical centreline investigation for the proposed Tiershokloof pipeline near to Ceres, Western Cape Province, and presents the conclusions and recommendations pertaining to proposed excavations and earthworks, material usage and foundations.*

*The 1:250 000 scale geological map, titled "3319 Worcester (1997)" indicates that the site is underlain by arenaceous sandstone of the Table Mountain Group (Cape Supergroup). Fieldwork indicated that the site is generally underlain by fill material in the far western area of the site and by thick transported hillwash, which thins out eastward. In an easterly direction the transported hillwash material is underlain by residual sandstone, while eventually residual to very soft rock sandstone outcrops at surface.*

*Based on visual and tactile assessments of the in-situ soil conditions, while awaiting the laboratory test results, GCS is of the considered opinion that the fill, transported hillwash and reworked / residual sandstone materials will likely qualify as G8 to G9 (lower selected layer) material quality. These materials may therefore be re-used as such, if required. It is however important to note that if the fill material is to be re-used, then these materials would need to be carefully sorted in order to remove any oversized particles.*

***Conventional pad foundations*** *are considered to be the most practical / economical foundation solution. The spread foundations can be founded at depths varying between surface and 1.5 m below existing ground surface on/within the very dense to very soft rock reworked / residual sandstone horizon. An allowable bearing pressure of* ***150 kPa*** *may be utilised for the design of the foundations. Under the above load conditions, total settlements of less than 5 mm are envisaged. Differential settlements should be taken as 75% of the total settlements.*

*In the areas of the fill and the thick transported hillwash horizons, it is recommended that these soils are over-excavated to a depth of 1.5 x the foundation width. The materials are then to be brought back in engineered layers not exceeding 150 mm thickness at the optimum moisture content, compacted to 93 % of Mod AASHTO density. An allowable bearing pressure of* ***150 kPa*** *may then be utilised for the foundations.*

*For pavement design purposes it is estimated that the fill materials would have a CBR of 7% to 10% if compacted to 90% of Mod AASHTO density at 2% above the optimum moisture content, and of the order of 12 to 15% if compacted to 93% of Mod AASHTO density at 2% above the optimum moisture content.*

*For pavement design purposes it is estimated that the transported hillwash, the reworked and residual sandstone materials would have a CBR of 5% to 7% if compacted to 90% of Mod AASHTO density at 2% above the optimum moisture content, and of the order of 7 to 10% if compacted to 93% of Mod AASHTO density at 2% above the optimum moisture content.*

*G6 (good-quality upper selected layer) material, or better, will need to be imported for the construction of upper selected layers and subbase layers, if required. The final design of the service roads should be undertaken by a competent engineer and should be based on the proposed final layer. It is however recommended that at least two imported stabilised 150 mm thick layers should be considered (upper subbase and basecourse) beneath the final cover layer.*

*For the promotion of a stable site, it is extremely important that suitable conventional drainage, both surface and subsurface, be designed to prevent or reduce the volume of water ingress into the subsurface soil layers beneath the access roads and parking areas as well as beneath the foundations. Drainage should therefore be such that any rainfall is diverted to the nearest stormwater drainage system. Areas of potential pooling or damming of rainfall on site should be carefully designed and sloped in order to sufficiently drain away from the site.*

# *Shallow Geotechnical Centreline Investigation for the Proposed Tiershokloof Pipeline near Ceres, Western Cape Province: Final Report*

**Reference: 22-1047R02** **Date: 06 December 2022**

***Commercial:***

| | |
|---|---|
| ***GCS Geotechnical*** | GCS Geotechnical (Pty.) Ltd. |

***Technical:***

| | |
|---|---|
| CH | Chainage (metres) |
| mbgl | metres below ground level |
| masl | metres above sea level |
| NGL | Natural Ground Level |
| FL | Foundation Level |
| BH | Borehole |
| SPT | Standard Penetration Test |
| N | SPT N value (blows per 300 mm) |
| TLB | Tractor-mounted Loader Backhoe |
| TP | Test Pit |
| DCP | Dynamic Cone Penetrometer |
| EABC | Estimated Allowable Bearing Capacity |
| G1-G10 | Standard classification of natural road building materials (TRH 14) |
| CBR | California Bearing Ratio |
| MDD | Maximum Dry Density (kg/m3) |
| MADD | Modified AASHTO Dry Density |
| OMC | Optimum moisture Content (%) |
| PI | Plasticity Index |
| LL | Liquid Limit |
| LS | Linear Shrinkage |
| RMR | Rock Mass Rating |
| GSI | Geological Strength Index |
| mi | Hoek-Brown Constant (origin & texture dependent) |
| RQD | Rock Quality Designation (%) |
| FF | Fracture frequency |
| UCS | Unconfined Compressive Strength (MPa) |
| C (c') | Cohesion (kPa) – total stress and (effective stress) |
| Φ (Φ') | Friction Angle (degrees) – total stress and (effective stress) |
| Kv | Modulus of Subgrade Reaction (MN/mm or kPa/mm) |
| CFA | Continuous Flight Auger (pile type) |
| DCI | Driven Cast In situ (pile type) |
| Cv | Coefficient of Consolidation (m2/yr) |
| Mv | Modulus of Compressibility (m2/MN) |
| MC1 | Moisture Content Before Test (%) |
| MC2 | Moisture Content After Test (%) |
| ρ | Dry Density (kg/m3) |
| VSR | Very soft rock |
| SR | Soft rock |
| MHR | Medium hard rock |
| HR | Hard rock |
| VHR | Very hard rock |

# *Shallow Geotechnical Centreline Investigation for the Proposed Tiershokloof Pipeline near Ceres, Western Cape Province: Final Report*

**Reference: 22-1047R02** **Date: 06 December 2022**

## 1. INTRODUCTION & TERMS OF REFERENCE

At the request of Mr. Rajesh Sukhlal of ETL (hereafter referred to as *the Client*), ***GCS Geotechnical*** was asked to provide a proposal and cost estimate for the undertaking of a shallow geotechnical investigation for the pproposed Tiershokloof Pipeline near to Ceres, Western Cape Province. The GCS proposal ref. 22-1047L01, dated 14 October 2022, was accepted by the Client via a Letter of Appointment dated 19 October 2022. The fieldwork was conducted on 01 November 2022.

Structural loads were unknown at the time of the investigation.

A detailed preliminary geotechnical report was sent through to the Client on 15 November 2022.

## 2. AVAILABLE INFORMATION

The following information was drawn upon for the purposes of the investigation:

- The 1:250 000 Geological Map titled: "3319 - Worcester (1988)" as compiled by the South African Geological Survey.
- Google Earth Imagery.
- DWAF (1998): The 1:500 000 Hydrogeological Map titled "3126 – Cape Town (1999) - as compiled by DWAF.
- Brink (1985): Engineering Geology of Southern Africa, Vol. 4.
- SANS 1200 D, DA & DB – Earthworks.

**Table 2** below shows the available published physiographical information on the site.

**Table 2: Summary of Available Desk Study Information**

| Parameter | Value | Reference |
|---|---|---|
| Development | Proposed Overland Pipeline | ELT (The Client) |
| Site coordinates | 33°25'16.61"S / 19°16'23.54"E | Google Earth |
| Weinerts N-value | 3 to 4 | Weinert (1974) |
| Climatic Region | Moderate | TRH 2 (1978) |
| Rainfall | 600 to 800 mm | 3126 - Cape Town (1999) 1:500 000 scale |
| Temperature | 2-30°C | https://climatestotravel.com |
| Evaporation | 1400 to 1600 mm | After DWAF (1986) |
| Water Balance | Deficit | Schulze (1985) |
| Weathering Type | Moderate weathering. | Fookes et al (1971) & Embleton et al (1979) |
| General geology | Arenaceous sandstone of the Cape Fold Belt | 3119 Worcester (1988) 1:250 000 scale. |
| Soil cover | Sandy soils of transported hillwash and fill origin | Brink (1985) Vol 4 |
| Origin | Transported (hillwash) / imported (fill) | Brink (1985) Vol 4 |
| Topography | Moderately dipping to the southeast (5-8 %) | Google Earth |
| Quaternary Catchment | H10D | DWAF (1999) |
| Hydrogeology | D3: Fractured (0.5-2.0 L/sec) | 3126 - Cape Town (1999) 1:500 000 scale |
| Depth to groundwater | Unknown although assumed at intermediate depth: 5.0 to 10.0 mbgl | Barnard (2000) |
| Erodibility Index | High 1-8 | WRC (1992) |
| Seismic Intensity | VIII (MMS) | Fernandez et al (1972) |
| Liquefaction Potential | Likely (peak horizontal acceleration >200 cm/s$^2$) | Welland (2002) |

# 3. SITE DESCRIPTION & PROPOSED DEVELOPMENT

The site comprises is situated on the southern side of the Breede River and along the western front of one of its tributaries. The site is covered by small to medium-sized shrubs and trees as well as by short veld grass. The proposed pipeline will traverse a distance of approximately 2.5 km in length along the lower regions of the hill. Due to the uneven terrain, access to the backacter was limited to approximately 1 km along the western side of the proposed pipeline.

Access to the site may be gained by turning off the R43 south of the bridge over the Breede River.

The central coordinates for the site are as follows: 33°25'16.61"S / 19°16'23.54"E.

# 4. GEOLOGY

The 1:250 000 scale geological map, titled "*3119 Worcester (1997)*" indicates that the site is underlain by arenaceous sandstone of the Table Mountain Group (Cape Supergroup). Fieldwork indicated that the site is generally underlain by fill material in the far western area of the site and by thick transported hillwash, which thins out eastward. In an easterly direction the transported hillwash material is underlain by residual sandstone, while eventually residual to very soft rock sandstone outcrops at surface.

# 5. FIELDWORK

## 5.1 Test Pits

5No. test pits were excavated across the site in view of the proposed pipeline development. The test pits were excavated using a JCB 3CX tractor-loader-backhoe (backacter) provided by Coastal Hire. The test pits were profiled in-situ by an engineering geologist according to standard practice. Soil samples were collected and are currently being tested at a soil testing laboratory in order to validate our tactile and visual assessments.

Refusal of the backacter occurred in all of the test pits at depths varying between 0.55 m and 3.2 m below existing ground surface (average depth of 1.85 m). The detailed test pit soil profiles are presented in **Appendix A**, while summaries of the test pit soil horizon depths are presented in **Tables 5.1a** and **5.1d** shown below.

**Table 5.1a: Summary of the soil layers in the test pits.**

| TP No. | Fill (m-m) | Transported Hillwash (m-m) | Reworked Residual Sandstone (m-m) | Residual Sandstone (m-m) |
|---|---|---|---|---|
| 1 | 0-2.0 (Ref) | - | | - |
| 2 | - | 0-2.5 | 2.5-2.8 (Ref) | - |
| 3 | - | 0-3.0 | 3.0-3.2 (Ref) | - |
| 4 | - | 0-0.5 | - | 0.5-0.55 (Ref) |
| 5 | - | 0-0.5 | - | 0.5-0.55 (Ref) |
| **Average Depth (m)** | **2.0** | **1.65** | **3.0** | **0.55** |

**Ref – refusal of the backacter**

**Table 5.1b: General Summary of the Average Fill Soil Profile**

| Depth | | Description | EABC (kPa) | Kv (kPa/mm) | E (MPa) | C (kPa) |
|---|---|---|---|---|---|---|
| From (m) | To (m) | | | | | |
| ***Fill*** | | | | | | |
| 0.0 | 2.0 | Dry to slightly moist cream-white to orange-brown DENSE to VERY DENSE open-voided silty **SAND** with abundant gravels, cobbles and boulders | <50 | 20-25 | - | - |

**EABC = estimated allowable bearing capacity (ignoring collapse potential)**
**Kv = modulus of subgrade reaction**
**E = elastic modulus**
**C = cohesion (kPa)**

**Table 5.1c: General Summary of the Average Hillwash / Reworked Sandstone Soil Profile**

| Depth | | Description | EABC (kPa) | Kv (kPa/mm) | E (MPa) | C (kPa) |
|---|---|---|---|---|---|---|
| From (m) | To (m) | | | | | |
| ***Transported Hillwash*** | | | | | | |
| 0.0 | 2.85 | Dry to slightly moist grey-brown VERY LOOSE to LOOSE pinholed silty **SAND.** | <50 | 20-25 | 10-15 | - |
| ***Reworked residual sandstone*** | | | | | | |
| 2.85 | 3.0+ | Slightly moist grey-brown DENSE to VERY DENSE intact silty **SAND** with abundant cobbles and boulders. | 200-250 | 70-80 | 25-35 | 2-5 |

**EABC = estimated allowable bearing capacity (ignoring collapse potential)**
**Kv = modulus of subgrade reaction**
**E = elastic modulus**
**C = cohesion (kPa)**

**Table 5.1d: General Summary of the Average Residual Sandstone Soil Profile**

| Depth | | Description | EABC (kPa) | Kv (kPa/mm) | E (MPa) | C (kPa) |
|---|---|---|---|---|---|---|
| From (m) | To (m) | | | | | |
| ***Transported Hillwash*** | | | | | | |
| 0.0 | 0.5 | Dry to slightly moist grey-brown VERY LOOSE to LOOSE pinholed silty **SAND** with roots | <50 | 20-25 | 10-15 | - |
| ***Residual sandstone*** | | | | | | |
| 0.5 | 0.55 | Slightly moist cream-white to yellow-brown DENSE to VERY DENSE jointed silty gravelly **SAND**. | 200-250 | 70-80 | 25-35 | 2-5 |

**EABC = estimated allowable bearing capacity (ignoring collapse potential)**
**Kv = modulus of subgrade reaction**
**E = elastic modulus**
**C = cohesion (kPa)**

## 5.2 Surface Mapping

Towards the eastern and south-eastern end of the proposed pipeline, accessibility to the backacter became very limited due to a combination of the road / path width and the relatively steep gradient against the hillside.

In light of the above, surface mapping on a number of outcrops was undertaken, with the results of the exercise summarised in **Table 5.2** below.

| Outcrop Mapping | | | | |
|---|---|---|---|---|
| Outcrop No. | Coordinates | | Dip Angle | Dip Direction |
| | X | Y | | |
| 1 | 33°25'15.61"S | 19°16'38.20"E | 25 | 025 |
| 2 | 33°25'17.22"S | 19°16'47.67"E | 25 | 045 |
| 3 | 33°25'19.51"S | 19°16'55.04"E | 21 | 015 |
| 4 | 33°25'26.13"S | 19°17'0.73"E | 23 | 050 |
| 5 | 33°25'34.49"S | 19°17'3.34"E | 27 | 085 |
| 6 | 33°25'41.49"S | 19°17'2.55"E | 21 | 100 |

# 6. GROUNDWATER

No groundwater seepage was encountered in any of the test pits excavated across the site at the time of the investigation. It should be noted that a perched water table may be anticipated during the summer months and/or after periods of continuous rainfall.

# 7. LABORATORY TESTING

Laboratory testing has been carried out on disturbed soil samples recovered from the test pits. The following tests were conducted:

- Four foundation indicator tests (PSD, Atterberg Limits, and hydrometer).

The detailed laboratory test results are presented in **Appendix B**, and summaries of these results are presented as in **Tables 7a** and **7b**:

**Table 7a: Summary of Foundation Indicators**

| TP No. | Depth (m-m) | LL | PI | GM | PE* | CBR* (%) | Classifications | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | TRH14 | PRA | USCS |
| ***Fill*** | | | | | | | | | |
| 1 | 0-2.0 | NP | NP | 1.53 | None | 40-45 | G7 | A.2.4 | SW |
| ***Transported Hillwash*** | | | | | | | | | |
| 2 | 0-2.5 | NP | NP | 1.18 | None | 30-35 | G8 to G9 | A.2.4 | SW |
| 4 | 0-0.5 | NP | NP | 1.29 | None | 35-40 | G8 to G9 | A.2.4 | SP |
| 5 | 0-0.5 | NP | NP | 1.09 | None | 30-35 | G8 to G9 | A.3 | SP |

***CBR estimated from PI-GM relationship @ 93% MDD.**
***PE – Potential Expansiveness**

**Table 7b: Materials Classification and Recommended Usage**

| Material Description | Classification | Recommended Usage |
|---|---|---|
| ***Fill*** | PI = - NP<br>GM = - 1.53<br>Classification: - A.2.4; SW; Inferred G7; Non PE | Inferred to qualify as G7 (upper selected layer) material. Oversized particles to be carefully sorted and separated. |
| ***Transported Hillwash*** | PI = - NP<br>GM = - 1.09 to 1.29<br>Classification: - A.2.4 to A.3; SW to SP; Inferred G8 to G9; Non PE | Inferred to qualify as G8 to G9 (lower selected layer) material. |
| ***Reworked Residual Sandstone*** | PI = -<br>GM = -<br>Classification: - | Inferred to qualify as G8 to G9 (lower selected layer) material. |
| ***Residual Sandstone*** | PI = -<br>GM = -<br>Classification: - | Inferred to qualify as G8 to G9 (lower selected layer) material. |

# 8. DEVELOPMENT RECOMMENDATIONS

## 8.1 Material Usage

Based on visual and tactile assessments of the in-situ soil conditions, as well as the laboratory test results, GCS is of the considered opinion that the fill material qualifies as G7 (upper selected layer) material, while the transported hillwash and reworked / residual sandstone materials qualifies as G8 to G9 (lower selected layer) material quality. These

materials may therefore be re-used as such, if required. It is however important to note that if the fill material is to be re-used, then these materials would need to be carefully sorted in order to remove any oversized particles.

## 8.2 Geotechnical Site Classification

The western end of the site appears to be covered by a layer of fill (P - fill). East of this location, thick transported hillwash occurs. This horizon is considered potentially collapsible and therefore designated as Site Class (C2). The reworked / residual sandstone horizons are also considered to be very slightly collapsible and therefore also Site Class (C).

In general, the site would classify as Site Class **P(fill)/C2**.

A summary of the Site Classifications (per contributing layer) can be seen below:

**Table 8.2: Geotechnical Site Class Designations**

| Typical founding material | Character of founding material | Range of total soil movements (mm) | Differential movement (% of total) | Geotechnical Site Class |
|---|---|---|---|---|
| Fill | Dense to very dense open-voided silty **SAND** with abundant gravels, cobbles and boulders | Variable | Variable | **P (Fill)** |
| Transported Hillwash | Very loose to loose pinholed silty **SAND** with roots | >10 | 75 | **C2** |
| Reworked Residual Sandstone | Dense to very dense intact silty **SAND** with abundant cobbles and boulders. | <5 | 75 | **C** |
| Residual Sandstone | Dense to very dense jointed silty gravelly **SAND**. | <5 | 75 | **C** |

## 8.3 Excavatability

For the purpose of earthworks and for the installation of services, all of the materials on the site qualify as SOFT excavation material (according to SANS 1200 D, DA & DB) to depths varying between 0.5 m and 3.2 m below existing grounds surface (average depth of 1.85 m), as determined by refusal of the backacter. It should however be noted that traversing in an easterly direction rock outcrop on or near to surface occurs.

## 8.4 Foundation Recommendations

The proposed development is to comprise an overland pipeline. Structural loads were unknown at the time of the investigation and when compiling this report.

The fill and transported hillwash horizons are considered to be potentially collapsible and are therefore not be considered to be suitable founding horizons, unless re-engineered.

In light of the above, in central and eastern portions of the site, **conventional pad foundations** are considered to be the most practical / economical foundation solution. The spread foundations can be founded at depths varying between surface and 1.5 m below existing ground surface on/within the very dense to very soft rock reworked /

residual sandstone horizon. An allowable bearing pressure of **150 kPa** may be utilised for the design of the foundations. Under the above load conditions, total settlements of less than 5 mm are envisaged. Differential settlements should be taken as 75% of the total settlements.

In the areas of the fill and the thick transported hillwash horizons, it is recommended that these soils are over-excavated to a depth of 1.5 x the foundation width. The materials are then to be brought back in engineered layers not exceeding 150 mm thickness at the optimum moisture content, compacted to 93 % of Mod AASHTO density. An allowable bearing pressure of **150 kPa** may then be utilised for the foundations.

## 8.5 Service Roads

The following comments are considered prudent to the design of on-site service roads:

- For pavement design purposes it is estimated that the fill materials would have a CBR of 7% to 10% if compacted to 90% of Mod AASHTO density at 2% above the optimum moisture content, and of the order of 12 to 15% if compacted to 93% of Mod AASHTO density at 2% above the optimum moisture content.

- For pavement design purposes it is estimated that the transported hillwash, the reworked and residual sandstone materials would have a CBR of 5% to 7% if compacted to 90% of Mod AASHTO density at 2% above the optimum moisture content, and of the order of 7 to 10% if compacted to 93% of Mod AASHTO density at 2% above the optimum moisture content.

- G6 (good-quality upper selected layer) material, or better, will need to be imported for the construction of upper selected layers and subbase layers, if required. The final design of the service roads should be undertaken by a competent engineer and should be based on the proposed final layer. It is however recommended that at least two imported stabilised 150 mm thick layers should be considered (upper subbase and basecourse) beneath the final cover layer.

## 8.6 Drainage

For the promotion of a stable site, it is extremely important that suitable conventional drainage, both surface and subsurface, be designed to prevent or reduce the volume of water ingress into the subsurface soil layers beneath the access roads and parking areas as well as beneath the foundations. Drainage should therefore be such that any rainfall is diverted to the nearest stormwater drainage system. Areas of potential pooling or damming of rainfall on site should be carefully designed and sloped in order to sufficiently drain away from the site.

# 9. CONCLUSIONS & RECOMMENDATIONS

***General***

- This report presents the results of a shallow geotechnical centreline investigation for the proposed Tiershokloof pipeline near to Ceres, Western Cape Province, and presents the conclusions and recommendations pertaining to proposed excavations and earthworks, material usage and foundations.

***Geology & Ground Conditions***

- The 1:250 000 scale geological map, titled "*3319 Worcester (1997)*" indicates that the site is underlain by arenaceous sandstone of the Table Mountain Group (Cape Supergroup). Fieldwork indicated that the site is generally underlain by fill material in the far western area of the site and by thick transported hillwash, which thins out eastward. In an easterly direction the transported hillwash material is underlain by residual sandstone, while eventually residual to very soft rock sandstone outcrops at surface.

***Excavatability & Earthworks***

- Based on visual and tactile assessments of the in-situ soil conditions, while awaiting the laboratory test results, GCS is of the considered opinion that the fill, transported hillwash and reworked / residual sandstone materials will likely qualify as G8 to G9 (lower selected layer) material quality. These materials may therefore be re-used as such, if required. It is however important to note that if the fill material is to be re-used, then these materials would need to be carefully sorted in order to remove any oversized particles.

***Foundations***

- **Conventional pad foundations** are considered to be the most practical / economical foundation solution. The spread foundations can be founded at depths varying between surface and 1.5 m below existing ground surface on/within the very dense to very soft rock reworked / residual sandstone horizon. An allowable bearing pressure of **150 kPa** may be utilised for the design of the foundations. Under the above load conditions, total settlements of less than 5 mm are envisaged. Differential settlements should be taken as 75% of the total settlements.

  In the areas of the fill and the thick transported hillwash horizons, it is recommended that these soils are over-excavated to a depth of 1.5 x the foundation width. The materials are then to be brought back in engineered layers not exceeding 150 mm thickness at the optimum moisture content, compacted to 93 % of Mod AASHTO density. An allowable bearing pressure of **150 kPa** may then be utilised for the foundations.

***Service Roads***

- For pavement design purposes it is estimated that the fill materials would have a CBR of 7% to 10% if compacted to 90% of Mod AASHTO density at 2% above the optimum moisture content, and of the order of 12 to 15% if compacted to 93% of Mod AASHTO density at 2% above the optimum moisture content.

- For pavement design purposes it is estimated that the transported hillwash, the reworked and residual sandstone materials would have a CBR of 5% to 7% if compacted to 90% of Mod AASHTO density at 2% above the optimum moisture content, and of the order of 7 to 10% if compacted to 93% of Mod AASHTO density at 2% above the optimum moisture content.

- G6 (good-quality upper selected layer) material, or better, will need to be imported for the construction of upper selected layers and subbase layers, if required. The final design of the service roads should be undertaken by a competent engineer and should be based on the proposed final layer. It is however recommended that at least two imported stabilised 150 mm thick layers should be considered (upper subbase and basecourse) beneath the final cover layer.

***Drainage***

- For the promotion of a stable site, it is extremely important that suitable conventional drainage, both surface and subsurface, be designed to prevent or reduce the volume of water ingress into the subsurface soil layers beneath the access roads and parking areas as well as beneath the foundations. Drainage should therefore be such that any rainfall is diverted to the nearest stormwater drainage system. Areas of potential pooling or damming of rainfall on site should be carefully designed and sloped in order to sufficiently drain away from the site.

***Further Investigations***

- Finally, the ground conditions described in this report refer specifically to those encountered at the test positions advanced on site. The remainder of the investigation has been postponed by the client. It is therefore possible that conditions at variance with those discussed above may be encountered elsewhere on the site. In addition to this, ***GCS Geotechnical*** suggest carrying out periodic inspections during construction to ensure that any variation in the anticipated ground conditions can be assessed and revised recommendations subsequently provided in order to avoid unnecessary delays and expense. Furthermore, it is important that the construction phase of the project be treated as an augmentation of the geotechnical investigation.

N Welland: Pr.Eng. / Pr.Sci.Nat

Warren Kretzinger: Pr.Sci.Nat

06 Dec ember 2022

***For GCS Geotechnical (Pty) Ltd***

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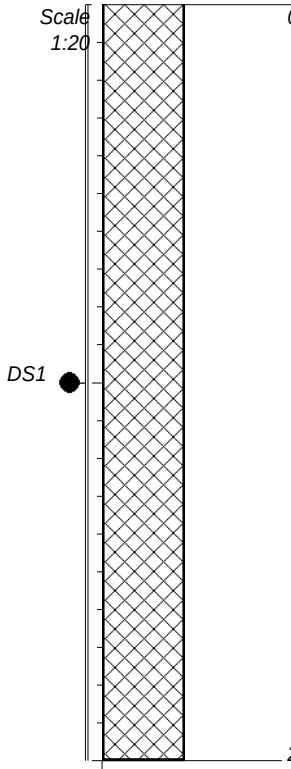
# APPENDIX A:

# Test Pit Soil Profiles

ETL
**Tiershokloof Pipeline**

*HOLE No:* TP01
*Sheet 1 of 1*

*JOB NUMBER:* 22-01047




Dry to slightly moist cream-white to orange-brown DENSE to VERY DENSE open-voided silty SAND with abundant gravels, cobbles and boulders. Fill.

NOTES

1) No Groundwater Seepage.
2) Unstable sidewalls.
3) Final depth at 2.0m (Refusal on very dense boulders).
4) Samples taken: Disturbed sample DS1 at 0.0--2.0m (1S)

*CONTRACTOR :* N/A
*MACHINE :* TLB JCB 3CX
*DRILLED BY :* -
*PROFILED BY :* Warren Kretzinger

*TYPE SET BY :* Warren Kretzinger
*SETUP FILE :* STANDARD.SET

*INCLINATION :* -
*DIAM :* N/A
*DATE :* -
*DATE :* 31/10/2022

*DATE :* 10/11/2022 14:53
*TEXT :* ..okloofPipelineTPLogs.TXT

*ELEVATION :* N/A
*X-COORD :* 19˚15'59.73"E
*Y-COORD :* 33˚25'17.82"S

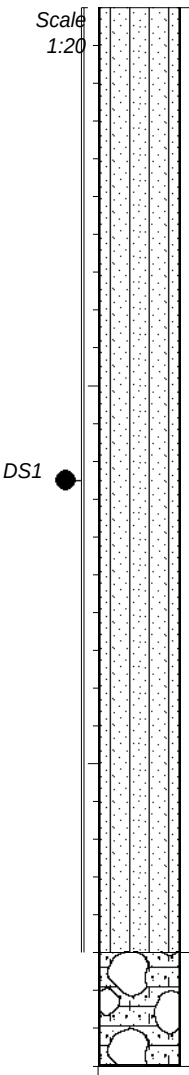
*HOLE No:* TP01

ETL
**Tiershokloof Pipeline**

*HOLE No:* TP02
*Sheet 1 of 1*

*JOB NUMBER:* 22-01047

*Scale 1:20*




*0.00*

Dry to slightly moist grey-brown VERY LOOSE to LOOSE pinholed silty SAND or sandy SILT. Transported Hillwash.

*2.50*

Slightly moist grey-brown DENSE to VERY DENSE intact silty SAND with abundant cobbles and boulders. Reworked Residual Sandstone.

*2.80*

NOTES

1) No Groundwater Seepage.
2) Stable sidewalls.
3) Final depth at 2.8m (Refusal on very dense sandstone boulders).
4) Samples taken: Disturbed sample DS1 at 0.0--2.5m (1S)

*CONTRACTOR :* N/A
*MACHINE :* TLB JCB 3CX
*DRILLED BY :* -
*PROFILED BY :* Warren Kretzinger

*INCLINATION :* -
*DIAM :* N/A
*DATE :* -
*DATE :* 31/10/2022

*ELEVATION :* N/A
*X-COORD :* 19°16'9.34"E
*Y-COORD :* 33°25'20.94"S

*HOLE No:* TP02

*TYPE SET BY :* Warren Kretzinger
*SETUP FILE :* STANDARD.SET

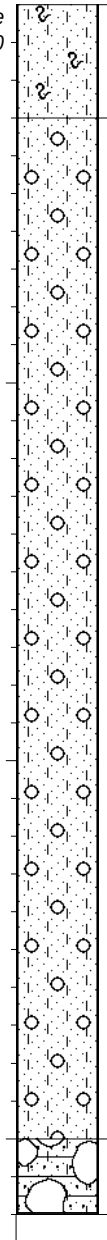
*DATE :* 10/11/2022 14:53
*TEXT :* ..okloofPipelineTPLogs.TXT

ETL
**Tiershokloof Pipeline**

*HOLE No:* TP03
*Sheet 1 of 1*

*JOB NUMBER:* 22-01047

Scale 1:20



0.00 Slightly moist grey-brown VERY LOOSE to LOOSE pinholed silty SAND. Transported Hillwash with roots.

0.30 Slightly moist orange to yellow-brown LOOSE to MEDIUM DENSE pinholed silty gravelly SAND. Transported Hillwash.

3.00 Slightly moist grey-brown DENSE to VERY DENSE intact silty SAND with abundant cobbles and boulders. Reworked Residual Sandstone.

3.20

NOTES

1) No Groundwater Seepage.
2) Stable sidewalls.
3) Final depth at 3.2m (Refusal on very dense sandstone boulders).
4) No samples taken.

*CONTRACTOR :* N/A
*MACHINE :* TLB JCB 3CX
*DRILLED BY :* -
*PROFILED BY :* Warren Kretzinger

*INCLINATION :* -
*DIAM :* N/A
*DATE :* -
*DATE :* 31/10/2022

*ELEVATION :* N/A
*X-COORD :* 9˚16'17.96"E
*Y-COORD :* 3˚25'19.86"S

*HOLE No:* TP03

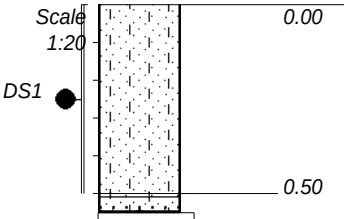
*TYPE SET BY :* Warren Kretzinger
*SETUP FILE :* STANDARD.SET

*DATE :* 10/11/2022 14:53
*TEXT :* ..okloofPipelineTPLogs.TXT

ETL
**Tiershokloof Pipeline**

*HOLE No:* TP04
*Sheet 1 of 1*

*JOB NUMBER:* 22-01047




Slightly moist grey-brown VERY LOOSE to LOOSE pinholed silty SAND. Transported Hillwash.

Slightly moist cream-white to yellow-brown DENSE to VERY DENSE jointed silty gravelly SAND. Residual Sandstone.

NOTES

1) No Groundwater Seepage.
2) Stable sidewalls.
3) Final depth at 0.55m (Refusal on very dense residual sandstone).
4) Samples taken: Disturbed sample DS1 at 0.0--0.5m

*CONTRACTOR :* N/A
*MACHINE :* TLB JCB 3CX
*DRILLED BY :* -
*PROFILED BY :* Warren Kretzinger

*TYPE SET BY :* Warren Kretzinger
*SETUP FILE :* STANDARD.SET

*INCLINATION :* -
*DIAM :* N/A
*DATE :* -
*DATE :* 31/10/2022

*DATE :* 10/11/2022 14:53
*TEXT :* ..okloofPipelineTPLogs.TXT

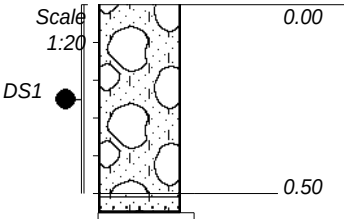
*ELEVATION :* N/A
*X-COORD :* 19˚16'23.54"E
*Y-COORD :* 33˚25'16.61"S

*HOLE No:* TP04

ETL
**Tiershokloof Pipeline**

*HOLE No:* TP05
*Sheet 1 of 1*

*JOB NUMBER:* 22-01047




*0.00* Slightly moist grey-brown VERY LOOSE to LOOSE pinholed silty SAND with abundant cobbles and boulders. Transported Hillwash.

*0.50* Slightly moist cream-white to yellow-brown DENSE to VERY DENSE jointed silty gravelly SAND. Residual Sandstone.

*0.55*

NOTES

1) No Groundwater Seepage.
2) No Sidewall Collapse.
3) Final depth at 0.55m (Refusal on very dense residual sandstone).
4) Samples taken: Disturbed sample DS1 at 0.0--0.5m

*CONTRACTOR :* N/A
*MACHINE :* TLB JCB 3CX
*DRILLED BY :* -
*PROFILED BY :* Warren Kretzinger

*INCLINATION :* -
*DIAM :* N/A
*DATE :* -
*DATE :* 31/10/2022

*ELEVATION :* N/A
*X-COORD :* 19˚16'32.15"E
*Y-COORD :* 33˚25'14.88"S

*HOLE No:* TP05

*TYPE SET BY :* Warren Kretzinger
*SETUP FILE :* STANDARD.SET

*DATE :* 10/11/2022 14:53
*TEXT :* ..okloofPipelineTPLogs.TXT

ETL
**Tiershokloof Pipeline**

**LEGEND**
*Sheet 1 of 1*

*JOB NUMBER:* 22-01047

| | | |
|---|---|---|
|  | BOULDERS | {SA01} |
|  | GRAVELLY | {SA03} |
|  | SAND | {SA04} |
|  | SANDY | {SA05} |
|  | SILT | {SA06} |
|  | SILTY | {SA07} |
|  | SANDSTONE | {SA11} |
|  | FILL | {SA32} |
| Name ● | DISTURBED SAMPLE | {SA38} |
|  | ROOTS | {SA40} |
|  | COBBLES | {SA58} |

*CONTRACTOR :*
*MACHINE :*
*DRILLED BY :*
*PROFILED BY :*

*INCLINATION :*
*DIAM :*
*DATE :*
*DATE :*

*ELEVATION :*
*X-COORD :*
*Y-COORD :*

*TYPE SET BY : Warren Kretzinger*
*SETUP FILE : STANDARD.SET*

*DATE : 10/11/2022 14:53*
*TEXT : ..okloofPipelineTPLogs.TXT*

**LEGEND**
*SUMMARY OF SYMBOLS*

# APPENDIX B:

# Laboratory Test Results

STEYN-WILSON LABORATORIES
CIVIL ENGINEERING TESTING LABORATORIES

sanas Testing Laboratory T0835

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

Client: **GCS (Pty) Ltd**

Project: Tiershokloof Pipeline (22-1047)

Attention: Mr W Kretzinger

Your Ref. No: -

Date Reported 08/11/2022

## TEST REPORT REFERENCE NUMBER / JOB NUMBER : SWL24775

Dear Sir / Madam

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

***Test Requested***

*4 x FOUNDATION INDICATOR*

***Site Sampling and Materials Information***

| | |
|---|---|
| *Sampling Method* | *Specimens delivered to Steyn Wilson Laboratory.* |
| *Environmental Condition* | *Sunny* |
| *Deviation from the prescribed test method* | *No deviation from standard test method.* |
| *Responsibility of information disclaimer* | *The sample information was received from the customer. Results apply to the sample as received from the Customer.* |

**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

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Fax: 086 499 9482
Email: info@steynwilson.co.za
Web: www.steynwilson.co.za

| | | | |
|---|---|---|---|
| Customer : | **GCS (Pty) Ltd** | Project : | Tiershokloof Pipeline (22-1047) |
| | 63 Wessel Road, Rivonia | Date Received : | 01/11/2022 |
| | Sandton | Date Reported : | 08/11/2022 |
| | | Req. Number : | - |
| Attention : | Mr W Kretzinger | Date Sampled: | 01/11/2022 |

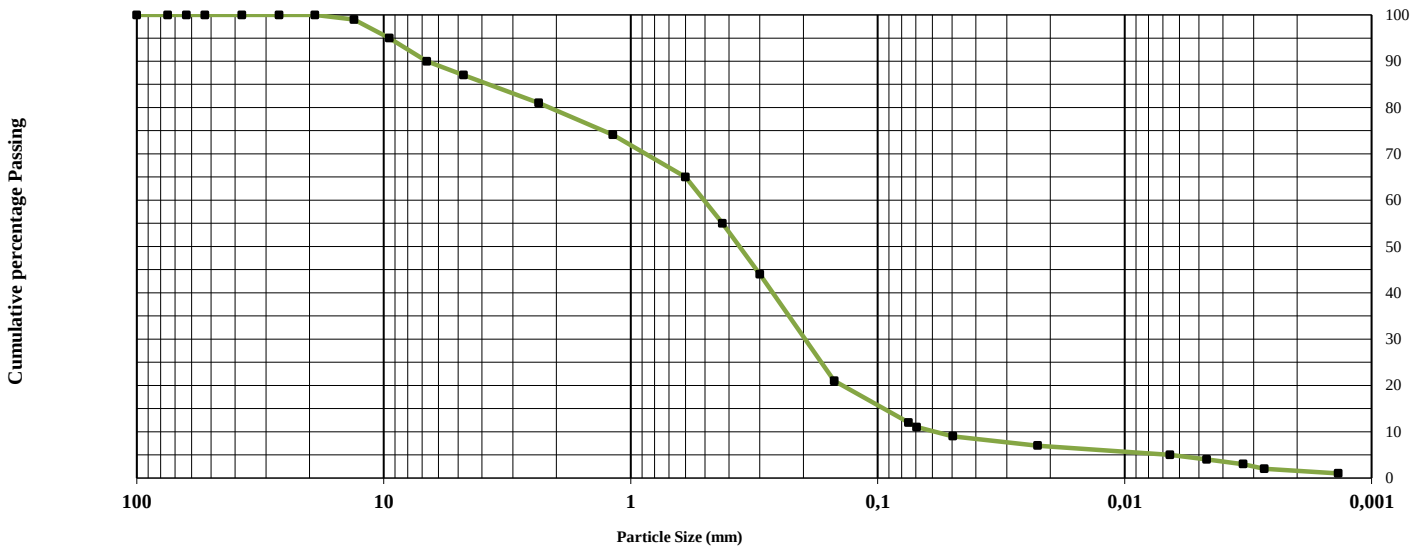
## FOUNDATION INDICATOR ASTM D422

| | | | | | | |
|---|---|---|---|---|---|---|
| Material Description: | Dark Brown Sand | Sample Number: | | 22581 | | |
| Position: | TP1 | Liquid Limit | Cassgranda SANS 3001 GR12 | **N.P** | Linear Shrinkage | **0,0** |
| Depth: | 0,0-2,0m | Plasticity Index | | **N.P** | Insitu M/C% | **2,5** |

| PH (TMH1 A20) | - | (TMH1 A21T) Conductivity $s.m^{-1}$ | - | SG (TMH1 A12T)* | 2,604 |
|---|---|---|---|---|---|

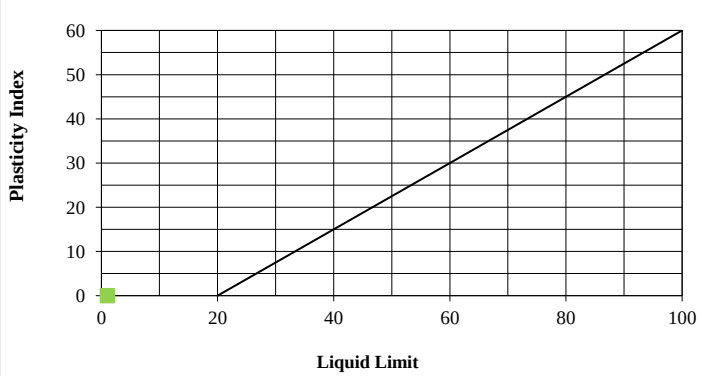
| SIEVE ANALYSIS (TMH 1 A1a)* | | | | | | | | | | | | | | | | | | HYDROMETER ASTM D422 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 75 | 63 | 53 | 37,5 | 26,5 | 19,0 | 13,2 | 9,5 | 6,7 | 4,75 | 2,36 | 1,18 | 0,60 | 0,425 | 0,300 | 0,150 | 0,075 | 0,069 | 0,050 | 0,022 | 0,007 | 0,005 | 0,003 | 0,003 | 0,001 |
| 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 95 | 90 | 87 | 81 | 74,1 | 65 | 55 | 44 | 21 | 12 | 11 | 9 | 7 | 5 | 4 | 3 | 2 | 1 |
| % Passing | | | | | | | | | | | | | | | | | | | | | | | | | |

### Particle Size Distribution

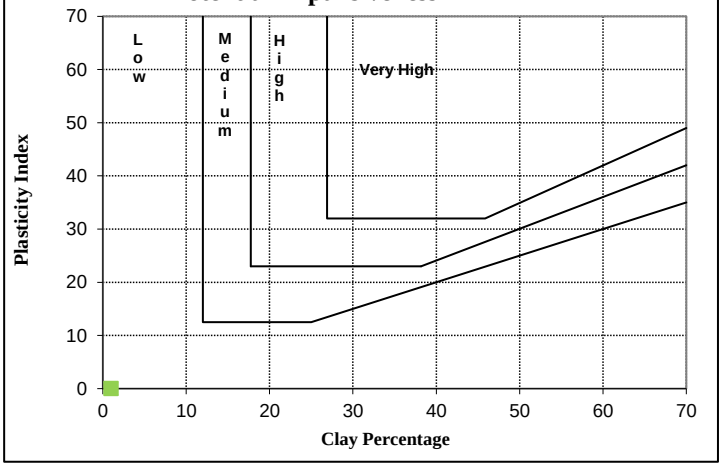



| % Gravel | 21 | % Sand | 69 | % Silt | 9 | % Clay | 1 |
|---|---|---|---|---|---|---|---|

### Plasticity Chart
A Line




### Potential Expansiveness




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

STEYN-WILSON LABORATORIES
CIVIL ENGINEERING TESTING LABORATORIES

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Email: info@steynwilson.co.za
Web: www.steynwilson.co.za

Customer : **GCS (Pty) Ltd**
63 Wessel Road, Rivonia
Sandton

Attention : Mr W Kretzinger

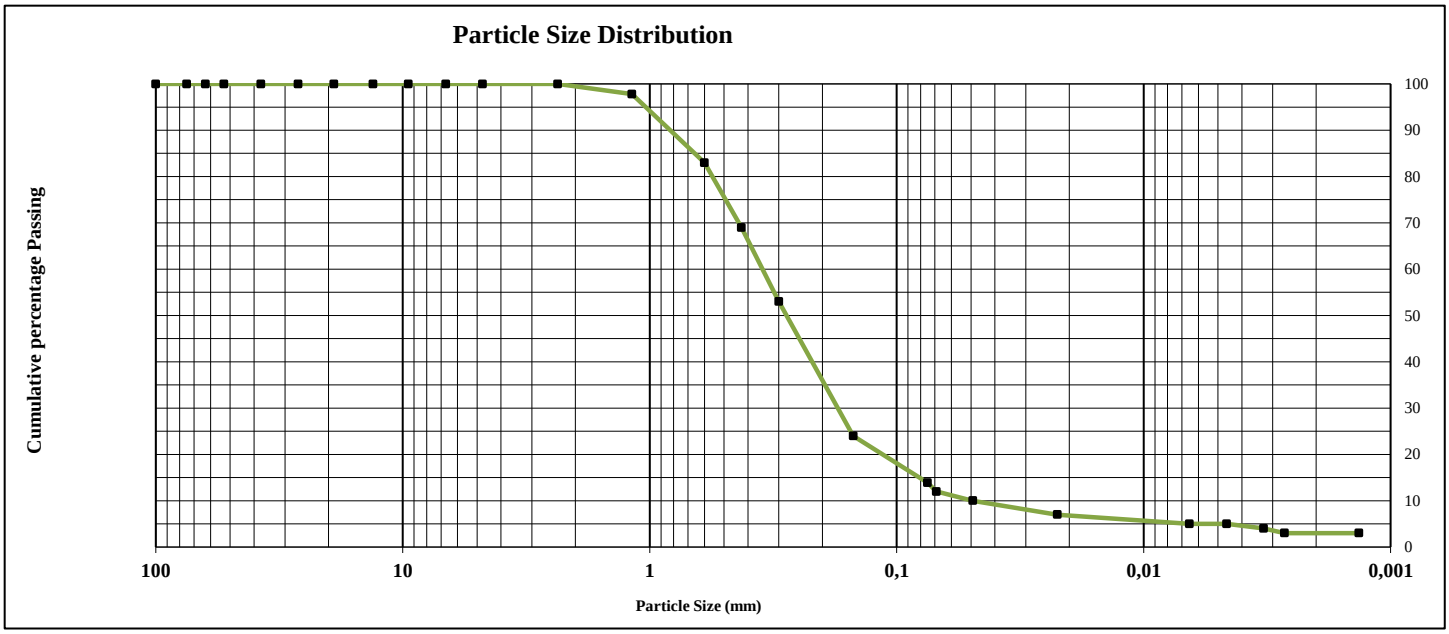
Project : Tiershokloof Pipeline (22-1047)
Date Received : 01/11/2022
Date Reported : 08/11/2022
Req. Number : -

## FOUNDATION INDICATOR ASTM D422

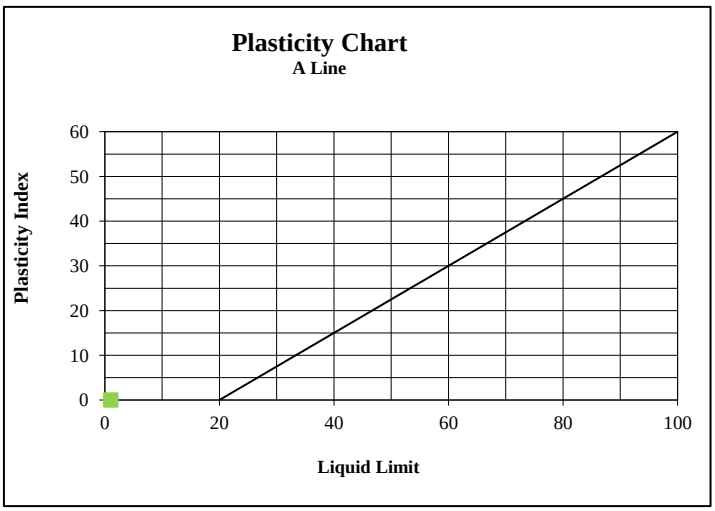
| | | | | | |
|---|---|---|---|---|---|
| Material Description: | Light Brown Sand | Sample Number: | | 22582 | |
| Position: | TP2 | Liquid Limit (Cassgranda SANS 3001 GR12) | **N.P** | Linear Shrinkage | **0,0** |
| Depth: | 0,0-2,5m | Plasticity Index | **N.P** | Insitu M/C% | **3,1** |

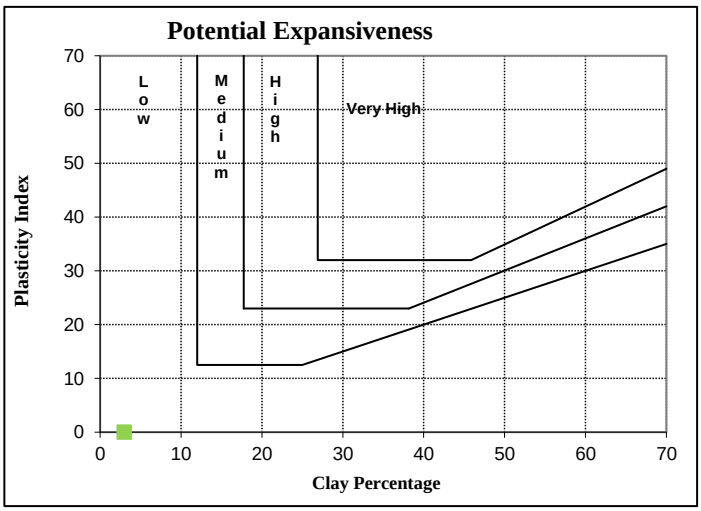
| PH (TMH1 A20)* | - | (TMH1 A21T)* Conductivity $s.m^{-1}$ | - | SG (TMH1 A12T)* | 2,66 |
|---|---|---|---|---|---|

| 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 | 0,069 | 0,049 | 0,022 | 0,007 | 0,005 | 0,003 | 0,003 | 0,001 |
| 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 97,8 | 83 | 69 | 53 | 24 | 13,9 | 12 | 10 | 7 | 5 | 5 | 4 | 3 | 3 |
| % Passing | | | | | | | | | | | | | | | | | | | | | | | | | |




| % Gravel | 1 | % Sand | 88 | % Silt | 8 | % Clay | 3 |
|---|---|---|---|---|---|---|---|




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

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CIVIL ENGINEERING TESTING LABORATORIES

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Customer : **GCS (Pty) Ltd**
63 Wessel Road, Rivonia
Sandton

Attention : Mr W Kretzinger

Project : Tiershokloof Pipeline (22-1047)
Date Received : 01/11/2022
Date Reported : 08/11/2022
Req. Number : -

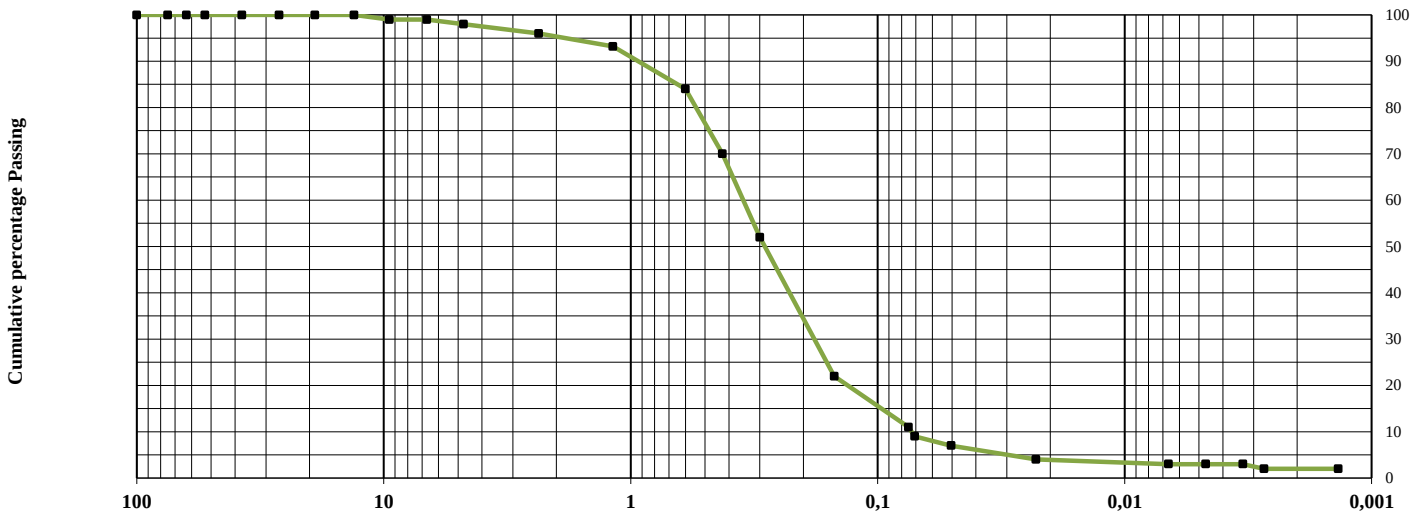
## FOUNDATION INDICATOR ASTM D422

| | | | | | |
|---|---|---|---|---|---|
| Material Description: | Dark Brown Sand | Sample Number: | 22583 | | |
| Position: | TP4 | Liquid Limit (Cassgranda SANS 3001 GR12) | N.P | Linear Shrinkage | 0,0 |
| Depth: | 0,0-0,5m | Plasticity Index | N.P | Insitu M/C% | 1,7 |

| PH (TMH1 A20)* | - | (TMH1 A21T)* Conductivity $s.m^{-1}$ | - | SG (TMH1 A12T)* | 2,632 |
|---|---|---|---|---|---|

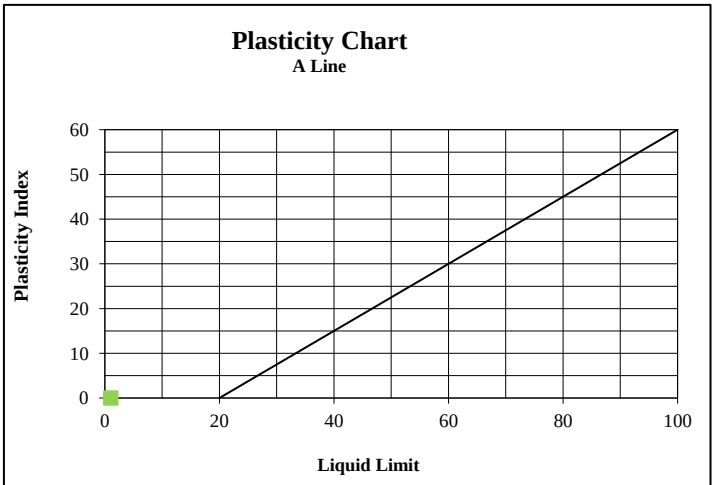
| SIEVE ANALYSIS (TMH 1 A1a)* | | | | | | | | | | | | | | | | | | HYDROMETER ASTM D422 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 75 | 63 | 53 | 37,5 | 26,5 | 19,0 | 13,2 | 9,5 | 6,7 | 4,75 | 2,36 | 1,18 | 0,60 | 0,425 | 0,300 | 0,150 | 0,075 | 0,071 | 0,050 | 0,023 | 0,007 | 0,005 | 0,003 | 0,003 | 0,001 |
| 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 99 | 98 | 96 | 93,2 | 84 | 70 | 52 | 22 | 11 | 9 | 7 | 4 | 3 | 3 | 3 | 2 | 2 |
| % Passing | | | | | | | | | | | | | | | | | | | | | | | | | |

### Particle Size Distribution

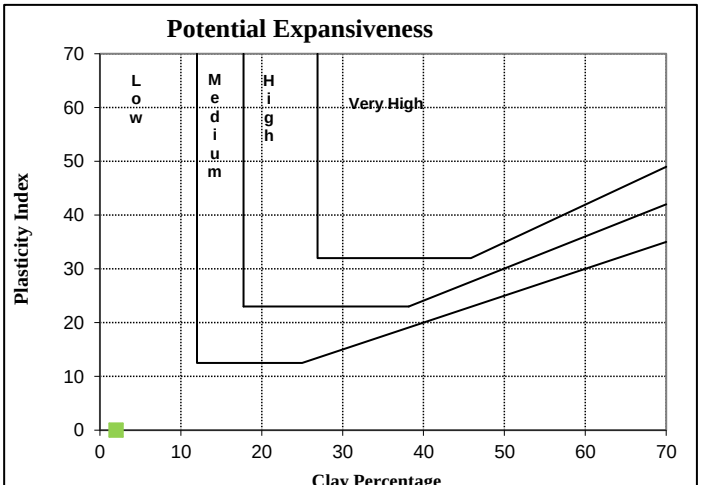



| % Gravel | 5 | % Sand | 87 | % Silt | 6 | % Clay | 2 |
|---|---|---|---|---|---|---|---|

### Plasticity Chart




### Potential Expansiveness




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

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Customer : **GCS (Pty) Ltd**
63 Wessel Road, Rivonia
Sandton

Attention : Mr W Kretzinger

Project : Tiershokloof Pipeline (22-1047)
Date Received : 01/11/2022
Date Reported : 08/11/2022
Req. Number : -

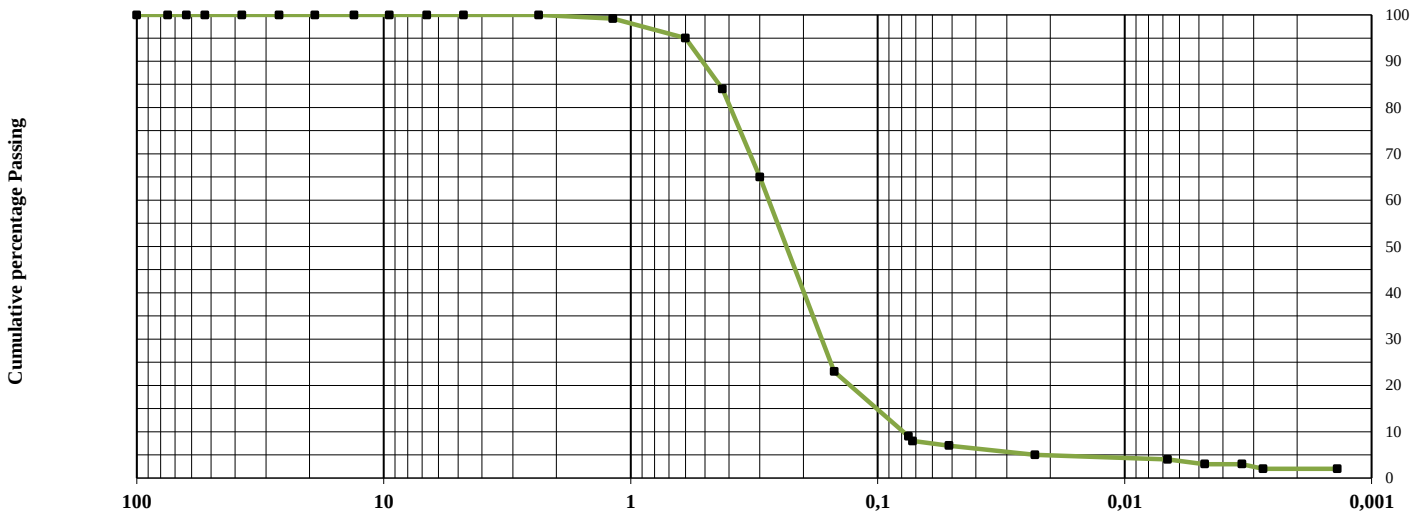
## FOUNDATION INDICATOR ASTM D422

| | | | | | |
|---|---|---|---|---|---|
| Material Description: | Dark Brown Sand | Sample Number: | | 22584 | |
| Position: | TP5 | Liquid Limit (Cassgranda SANS 3001 GR12) | **N.P** | Linear Shrinkage | **0,0** |
| Depth: | 0,0-0,5m | Plasticity Index | **N.P** | Insitu M/C% | **5,4** |

| PH (TMH1 A20)* | - | (TMH1 A21T)* Conductivity $s.m^{-1}$ | - | SG (TMH1 A12T)* | 2,604 |
|---|---|---|---|---|---|

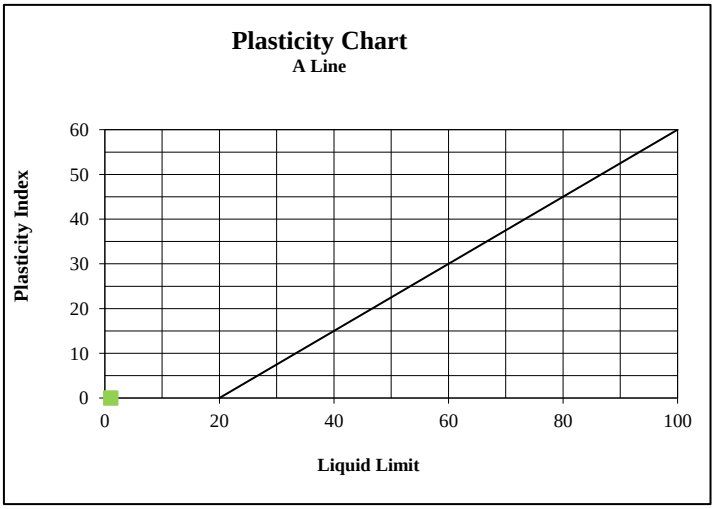
| SIEVE ANALYSIS (TMH 1 A1a)* | | | | | | | | | | | | | | | | | | HYDROMETER ASTM D422 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 75 | 63 | 53 | 37,5 | 26,5 | 19,0 | 13,2 | 9,5 | 6,7 | 4,75 | 2,36 | 1,18 | 0,60 | 0,425 | 0,300 | 0,150 | 0,075 | 0,072 | 0,051 | 0,023 | 0,007 | 0,005 | 0,003 | 0,003 | 0,001 |
| 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99,2 | 95 | 84 | 65 | 23 | 9 | 8 | 7 | 5 | 4 | 3 | 3 | 2 | 2 |
| % Passing | | | | | | | | | | | | | | | | | | | | | | | | | |

### Particle Size Distribution

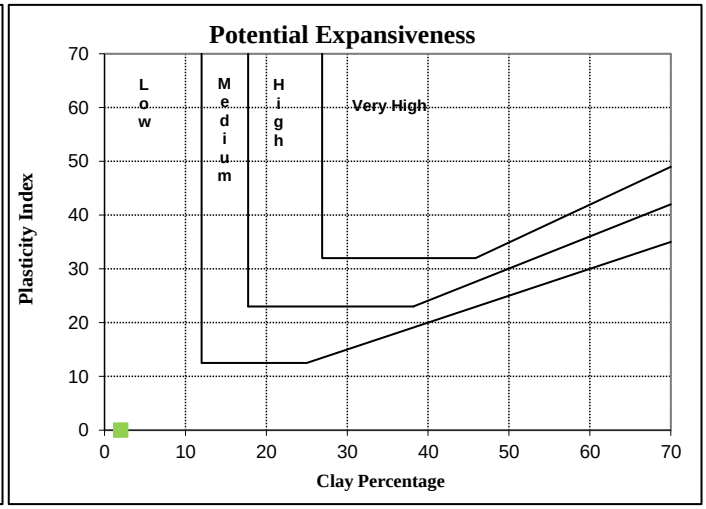



| % Gravel | | % Sand | 93 | % Silt | 5 | % Clay | 2 |
|---|---|---|---|---|---|---|---|

### Plasticity Chart



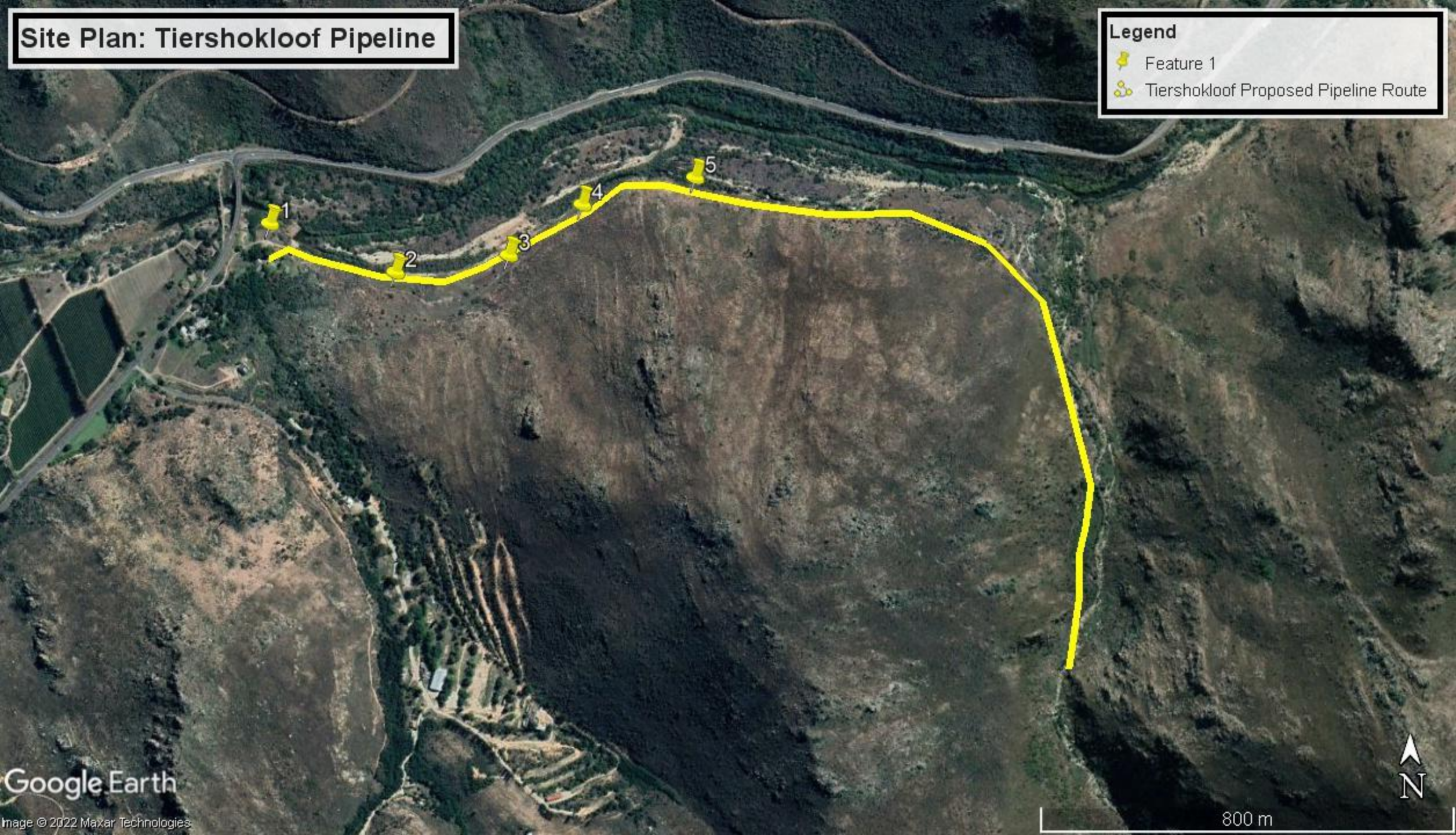

### Potential Expansiveness




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

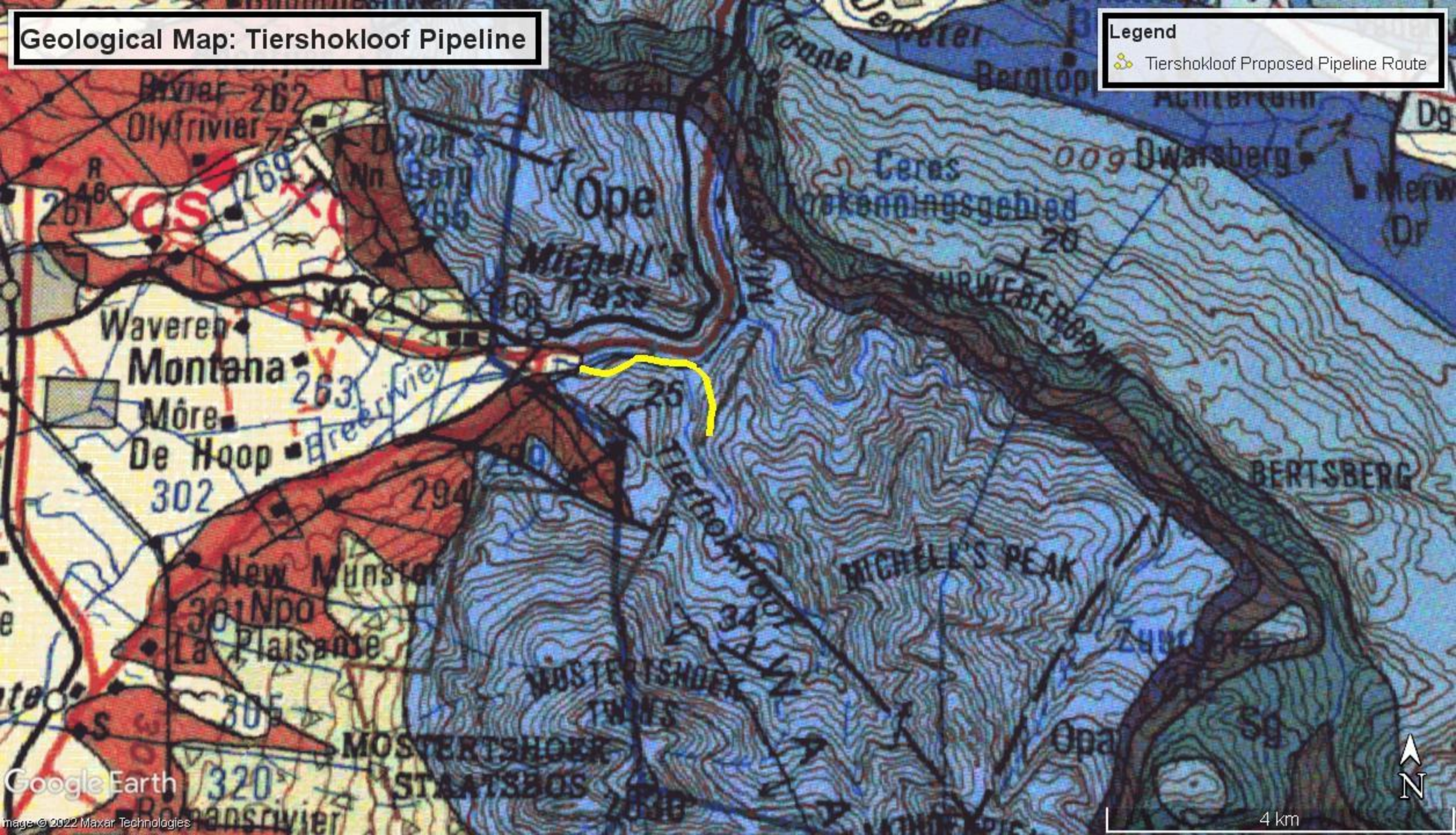
# FIGURE 1:

# Site Plan


Site Plan: Tiershokloof Pipeline
Legend
Feature 1
Tiershokloof Proposed Pipeline Route
1
2
3
4
5
Google Earth
Image © 2022 Maxar Technologies
N
800 m

# FIGURE 2:

# Geological Plan


Geological Map: Tiershokloof Pipeline
Legend
Tiershokloof Proposed Pipeline Route
Ope
Mitchell's Pass
Ceres
Wavereh
Montana
Môre
De Hoop
New Munster
La Plaisance
MOSTERTSHOEK
STAATSBOS
BERTSBERG
MICHELL'S PEAK
Google Earth
image © 2022 Maxar Technologies
4 km
N