ROCKSOIL CONSULT

SANS634:2012 Phase 1 Detailed Engineering Geological Investigation Conducted on Portion 1 of Erf 6154 Pietersburg, Extension 8, Polokwane Municipality, Limpopo Province, South Africa

SANS634:2012 Phase 1 Detailed Shallow Soil Engineering Geological Assessment

Client: WSM Leshika (Pty) Ltd.

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Document Approval and Quality Control

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1 Introduction

RockSoil Consult (Pty) Ltd. (to be referred to as RSC) was appointed by Mr. Carel Haupt of WSM Leshika (Pty) Ltd. (to be referred to as the client) to conduct a SANS634:2012 guided Phase 1 Detailed shallow soil investigation for a proposed development on Portion 1 of Erf 6154 Pietersburg, Extension 8, Polokwane Municipality, Limpopo Province, South Africa.

The investigation was conducted as per appointed specifications and the findings and recommendations are provided in the relevant report sections.

2 Objectives of the Assessment

The main objectives of a SANS634:2012 Phase 1 Detailed Geotechnical Site Investigation are to (SANS634, 2012):

- Identify any potential geotechnical hazards;
- Comment on the shallow excavation conditions;
- Determine the soil properties for guideline and design purposes;
- Determine the soil properties and comment on the suitability of the on-site soil for potential construction material such as soil mattresses, pipe bedding and backfill;
- Define the ground conditions and provide site classifications including detailed soil profile and groundwater occurrences within the zone of influence of foundation work; and
- Provide the geotechnical basis for safe and appropriate planning and design.

3 Information Used During the Study

The following available information were considered during this investigation:

1) Locality map with provided approximate site boundaries;
2) 1:250 000-scale regional geological sheet (2328 Pietersburg);
3) 1:50 000-scale regional topographical sheet (2329CD);
4) Propose site layout plan supplied by the client (Drawing reference number: 100);

5) Google Earth images;
6) Council for Geoscience Geohazard database; and
7) Local knowledge of the area.

The available information was supplemented with the information obtained during the fieldwork phase of this assessment, as discussed in the relevant report sections.

4 Investigation Methodology

The investigation comprises:

- Desk study of readily available information;
- Site visit and drive-over/walkover survey;
- Trial pit excavation;
- In-situ oil profile logging by a suitably qualified engineering geologist;
- Soil profile photography;
- Selective material sampling;
- Soil testing at an accredited commercial laboratory;
- Evaluation and reporting by a professionally registered engineering geologist.

The number of trial pits, equipment and general investigation procedures/methods are provided in **Table R1**. The soil classification testing, relevant test methods and quantities are provided in **Table R2**. Additional information on the test procedures can be provided upon request.

Table R1: General Investigation Procedures and Information

Description	Information
Number of trial pits excavated	5
Placing Methodology	Infrastructure footprints and site coverage
Machine used for excavation	JCB 3CX (4x2) TLB
Profiling standards used for descriptions	SANS633:2012
Profile logged by	Qualified engineering geologist
Test pit positioning	Hand-Held Garmin E-Trex GPS
Soil profile capturing and illustration	dotPLOT Version 3.22.0
Coordinate system	Decimal Degrees or WGS84 SA Grid

Table R2: Laboratory Tests and Tests Quantities

Laboratory Test	Laboratory	Test Standard	Number of Tests
Screen Analysis	ST Laboratory (Pty) Ltd.	SANS 3001:GR1	4
Hydrometer Analysis	ST Laboratory (Pty) Ltd.	SANS 3001:GR3 & TMH1	4
Atterberg Limits	ST Laboratory (Pty) Ltd.	SANS 3001:GR10	4
Soil Classification 1	ST Laboratory (Pty) Ltd.	AASHTO	4
Soil Classification 2	ST Laboratory (Pty) Ltd.	Unified Soil Classification	4
pH	ST Laboratory (Pty) Ltd.	Refer to lab report	2
Electrical Conductivity	ST Laboratory (Pty) Ltd.	Refer to lab report	2
California Bearing Ratio	ST Laboratory (Pty) Ltd.	SANS 3001 GR40	2
Maximum Dry Density	ST Laboratory (Pty) Ltd.	SANS 3001 GR30	2

ST –> Specialised Testing Laboratory

Refer to the laboratory test reports for investigation procedures/standards followed. More details on the investigation methodology and test standards can be provided upon request.

5 Site Locality and Description

The area of interest is situated at 58 Antimoon Street, Polokwane. The site is accessible from Antimoon Street.

The approximate centre site coordinates are (Decimal Degrees):

- Latitude: -23.871292°
- Longitude: 29.443710°

The site locality is depicted in **Figure A1** and **Figure A2, Appendix A**.

The area of interest is currently undeveloped with commercial developments in the surroundings.

The site is current covered with compacted engineered fill material.

The site is situated between approximately 1 312 and 1 311 mamsl (Google Earth elevations). The site has a natural gentle slope with a fall of approximately 1 m over approximately 120 m.

The site has an average gradient of <1 degree from the south-eastern site corner towards the north-western site corner. The regional topography is sloping in a north easterly direction towards the Sand River. The Sand River drains in a northerly direction.

No site-specific ground elevation survey (ground surface contours) was available at the time of writing this report. A cropped section of the regional 1:50 000-scale topographical sheet is depicted in in **Figure A3**, **Appendix A**.

Identification of underground and aboveground services falls outside the scope of this investigation and the exact locations of services are not known. Existing and planned services should be confirmed in the services reports. The planners/designers should refer to the services report for planning purposes.

A number of site photographs, illustrating the site conditions at the time of this fieldwork assessment, are attached in **Appendix C**.

6 Geology

6.1 Regional Geology

Based on the 1:250 000-scale 2328 Pietersburg geological sheet, the site is underlain by "**Rhr**" with "**Zmp**" to the south and "**di**" potentially at depth, of which the symbols indicate the following geological formations:

- **Rhr**: Leucratic migmatite and gneiss, grey and pink hornblende-biotite of the Hout River Suite.
- **Zmp**: Talc-chlorite and amphibole-chlorite schist, amphibolite, serpentinite of the Mothiba Formation, Pietersburg Group.
- **di**: Diabase.

A cropped section of the regional geology is depicted in **Figure A4**.

According to the available geological sheet, no economical mineral deposits are located in close proximity to the site. Development of these properties are not expected to sterilise any known economic mineral deposits.

No known linear structural features, such as shear zones or faults, exist under or in close proximity to the site.

The site is not underlain by potentially soluble rock formations such as dolomite and limestone. The site is considered non-dolomitic and a dolomite stability investigation is not required.

6.2 Site Specific Geology

The site-specific conditions were evaluated by means of excavation of five (5) shallow soil test pits with a JCB 3XC 4x4 TLB (Backhoe) down to practical reach or restricted refusal conditions.

The test pit positions are indicated in **Figure A5**, **Appendix A**. The detailed soil profile descriptions are attached as **Appendix B**. Photographs of the soil profile and materials encountered are attached as **Appendix C**.

The presence of gneiss, as indicated by the regional geological sheet, were confirmed in the intrusive investigation.

The site is covered with upper engineered fill, covering topsoil/colluvium, underlain by a pebble marker zone, indicating the boundary between the upper transported materials and the lower residuum. The pebble marker layer is underlain by reworked residual gneiss transgressing into completely to moderately weathered gneiss, with a lower limit R0 to R3 rock hardness as per ISRM1981b classification.

A basic summary sheet of the soil horizons and conditions encountered in the soil profiles are provided in **Table R3**.

The **engineered fill** generally has a dense to medium dense in-situ consistency down with depth and exhibits an intact soil structure. The horizon is generally coarse grained with sand and gravel. The topsoil horizon was encountered down to between 0.3 and 0.45 mbgl.

The transported **topsoil/colluvium horizon** generally has a medium dense to dense and occasionally firm to stiff in-situ consistency and exhibits a voided and locally shattered soil structure. The horizon is generally classified as coarse grained with an abundance of sand and traces of fine gravel. The topsoil horizon was encountered down to between 0.5 and 0.65 mbgl.

The **pebble marker horizon** generally has a medium dense to dense in-situ consistency with an open soil structure. The horizon is mainly coarse grained with a high percentage of gravel to cobble size fragments. Very weakly to strongly cemented Fe concretions are present in the horizon. The pebble marker horizon was encountered down to between 0.6 and 0.85 mbgl.

The **reworked residual gneiss** consists of a clayey silty sandy gravel with abundant quartz gravel to cobbles and weathered gneiss. The horizon has a fissured and open soil structure. The horizon transgressed into a jointed, coarse grained, **completely to moderately weathered gneiss rock** (ISRM1981 rock class <R0 to R3, lower limit extremely weak to medium strong rock) at depth down to confined refusal depths.

Weakly to strongly cemented pedogenic formation (ferricrete) was also recorded in the profiles.

No gneiss outcrop and surficial rock boulders (gneiss and diabase) were encountered on site. The intrusive geological setting is however well known for its spheroidal weathering resulting in small to large sized corestones.

The planners should refer to the individual soil profile descriptions attached as **Appendix B**.

Table R3: Simplified Soil Horizons and Conditions Encountered

Test Pit No.	Fill Material		Topsoil or colluvium		Pebble marker		Residuum		Weathered Gneiss		Termination depth	Excavatability down to termination depth	SANS expected excavatability classification at termination depth (Restricted Excavation)	Seepage at time of investigation
	From	To	From	To	From	To	From	To	From	To		Description	(Soft/Intermediate/Hard)	Yes/No
TP01	0.00	0.45	0.45	0.65	0.65	0.85	0.85	1.05	1.05	1.55	1.55	Easy Excavation	Intermediate to Hard	No
TP02	0.00	0.40	0.40	0.60	0.60	0.75	0.75	1.10	1.10	1.70	1.70	Easy Excavation	Intermediate to Hard	No
TP03	0.00	0.40	0.40	0.60	0.60	0.75	0.75	1.20	1.20	2.00	2.00	Easy Excavation	Intermediate to Hard	No
TP04	0.00	0.30	0.30	0.60	0.60	0.80	0.80	1.10	1.10	1.50	1.50	Easy Excavation	Intermediate to Hard	No
TP05	0.00	0.30	0.30	0.50	0.50	0.60	0.60	1.20	1.20	1.60	1.60	Easy Excavation	Intermediate to Hard	No

Min:	0.00	0.30	0.30	0.50	0.50	0.60	0.60	1.05	1.05	1.50	1.50
Max:	0.00	0.45	0.45	0.65	0.65	0.85	0.85	1.20	1.20	2.00	2.00
Average:	0.00	0.37	0.37	0.59	0.59	0.75	0.75	1.13	1.13	1.67	1.67
Std. Dev.:	0.00	0.13	0.13	0.21	0.21	0.27	0.27	0.40	0.40	0.60	0.60

Notes:

1) Depths are indicated as meters below ground level as per the levels on the date of the assessment.

2) Refer to detailed soil profile descriptions attached to the report.

7 Geohydrology

A separate hydrogeological assessment was conducted for the site by WSM Leshika (Pty) Ltd. The planners/designers should refer to this report for planning, guideline and design purposes as from a potential pollutant risk control, management, monitoring and construction precautionary control perspective.

No shallow seepage water conditions were encountered in any of the test pits excavated on 30 July 2021, which falls in the dry season for this region. Slightly moist to moist horizons was however encountered in the upper soils (refer to individual soil profile descriptions).

During and after rainfall events water is expected to flow as mainly sheet/overland flow, with localised areas of concentrated flow and water infiltration into the upper soil profile.

The presence of pedocrete formation (ferricrete) in the transported and residuum materials are however an indicator of the presence of shallow seasonal seepage water conditions. Pedogenic formation was generally encountered between, but not limited to, 0.5 and 2.0 mbgl.

Severe shallow seepage water is expected during and after heavy and/or continuous downpours. The seepage water is expected to be mainly in, but not limited to, the transported materials, lower residuum and weathered gneiss.

Surface and subsurface drainage precautionary measures will be essential for the shallow seasonal seepage water. The design engineers should consider drainage techniques such as cut-off trenches, culverts, drainage channels or subsurface drainage. Proper drainage outlet design should be considered to avoid excessive concentrated water flow and potential erosion.

8 Geotechnical Evaluation

The geotechnical evaluation is based on the available information, site-specific information obtained for this purposes of this assessment, laboratory test results, material correlations and local knowledge of the area.

Five (5) test pits were conducted for the purposes of this assessment the positions of the test pits are depicted in **Figure A5**, **Appendix A**.

The soil profile descriptions, soil profile and material photographs and the laboratory test results are attached as **Appendix B**, **Appendix C** and **Appendix D**, respectively.

8.1 Material Grading and Atterberg Limits

A summarised table of the grading analyses for the on-site materials is provided in **Table R4**.

Table R4: Summarised on-site material grading and Atterberg limits

Test Pit No.	Sample depth (mbgl)	Material description	Soil composition				Atterberg Limits		LS (%)	GM
			Clay (%)	Silt (%)	Sand (%)	Gravel (%)	LL (%)	PI (%)		
TP01	1.00-1.50	Residual and weathered gneiss	4	6	29	61	39	4	8	2.19
TP03	0.75-1.20	Reworked residual gneiss	8	12	29	51	34	6	9	1.90
TP05	0.30-0.45	Colluvium	16	17	34	33	41	11	11	1.40
TP05	1.20-1.60	Highly weathered gneiss	1	3	14	82	34	1	5	2.65

LL - Liquid Limit; PI - Plasticity Index (Whole Sample); LS - Linear Shrinkage; GM - Grading Modulus

8.2 Material Classification

8.2.1 Unified Soil Classification System

The on-site materials tested classify as the following soil classes (Unified Soil Classification System - USCS):

Colluvium and reworked residual gneiss:

SC → Course-grained soils (more than 50% retained on the 0.075 mm sieve), sands (50% or more of course fraction passes the 4.75 mm sieve), sands with fines, clayey sands, sand-clay mixtures.

Weathered gneiss:

GC → Course-grained soils (more than 50% retained on the 0.075 mm sieve), gravels (50% or more of course fraction retained on the 4.75 mm sieve), gravel with fines, clayey gravels, gravel-sand-clay mixtures.

GP → Course-grained soils (more than 50% retained on the 0.075 mm sieve), gravels (50% or more of course fraction retained on the 4.75 mm sieve), clean gravels, poorly graded gravels and gravel-sand mixtures, little or no fines.

8.2.2 AASHTO Classification System

The materials tested classifies as the following soil classes (AASHTO Classification System):

Reworked residual and weathered gneiss:

A-2 → Granular materials (35% or less passing the 0.075 mm sieve), different LL and PI for A-2 variances (refer to A-2-4, A-2-5, A-2-6 and A-2-7 sub-groups) with significant constituent: silty or clayey gravel sand.

Topsoil/colluvium:

A-7 → Silt-clay materials (>35 % passing the 0.075 mm sieve), minimum of 36 % passing the 0.075 mm sieve, LL min of 41%, PI min of 11%, with significant constituent: clayey soils. Note: Plasticity Index of A-7-5 subgroup is equal to or less than the Liquid Limit – 30%. Plasticity Index of A-7-6 subgroup is greater than LL – 30%.

8.2.3 TRH14 or COLTO Classification System

The **weathered gneiss**, classifies as the following class (TRH or COLTO Classification Systems):

G7 → Gravel-soil with a CBR > 15% at 93% Mod. AASHTO density with swell < 1.5% at 100% percent Mod. AASHTO density. Grading Modules (GM) 2.7 ≥ GM ≥ 0.75. Nominal maximum size 2/3 of the compacted layer. PI (-0.425 mm) max. 12% or 3 x GM +10, LS (-0.425 mm) max. 7%. Swell (100% Mod) max. 1.5%.

8.3 Typical Material Properties and Performance Correlations

Typical material properties for the soils encountered are provided in **Table E8** to **Table E10**, **Appendix E**. The planners/designers can refer to the typical material properties and apply applicable coefficients of variation to the materials where and if deemed necessary, depending on the design-philosophy/method applied. The designers should liaise with the engineering geologist during the parameter selection process in material strength and deformation evaluation processes.

8.4 Collapse and Compressibility

The upper engineered fill material is intact and compacted and no collapse is expected for the horizon.

The topsoil/colluvium and residual soils have a voided soil structured, with a **collapse potential**. Soil collapse is expected upon loading and change in moisture content.

Low percentage of fines (silt and clay) was recorded in the transported and lower residuum that are expected to result in a low compressibility potential in the uncompacted and compacted state.

The topsoil/colluvium and residual soils are collapsible and foundation mitigation measures will be required to limit unwanted structural damage, as outlined in the report.

8.5 Potential Expansiveness

Based on the PI_{whole} and clay fraction (Van der Merwe, 1964) the on-site materials generally indicate a low heave potential.

The colluvium in test pit TP05 has a low to borderline medium heave potential, but the colluvium horizon is fairly thin (0.2 m thickness). Swell of 0.1 % was measured on the compacted reworked residual gneiss material. Considering the thickness of the compacted reworked residual gneiss material, low heave is expected.

The potential expansiveness of the on-site soils is considered to be low. Potential heave as for class "**H**" (SAICE, 1995) is assigned to the on-site soils with an estimated total heave of <7.5 mm.

8.6 Susceptibility of Soils Towards Erosion

Considering the site slope, soil classification, in-situ consistency and overall nature of the soil, soil structure and compacted upper engineered fill material, the upper soils can be assigned with a low to intermediate susceptibility to water erosion once exposed and subject to concentrated water flow.

Basic construction phasing and/or stormwater control measures will be required to prevent excessive erosion. Mitigation measures are provided in the relevant report section/s.

8.7 Excavatability

The excavatibility is based on five (5) on-site test pits refused at depths of between 1.5 to 2.0 mbgl across the site.

"Soft excavation" conditions were encountered down to refusal depths in the five (5) test pits across the site.

Shallow TLB refusal (refer to individual log) were experienced within the completely to moderately weathered gneiss. "Intermediate to hard excavation" conditions were encountered at TLB refusal in all the test pits.

Based on the test pit data no excavatability difficulty was experienced down to 1.5 mbgl. Localised large corestones and boulders can be expected due to the nature of the gneiss and regional diabase intrusions.

It is expected that the highly weathered and jointed gneiss might be excavatable/rippable with a larger excavator, dozer and/or excavator with pneumatic tools in unconfined excavation conditions down to 2.5 - 3.0 mbgl.

Refer to individual soil profile logs for the excavation descriptions.

8.8 Soil Corrosiveness

The limited index test results indicate that the materials encountered on-site is "extremely to very corrosive" to ferrous metals. The results are provided in **Appendix D**.

Corrosion protection is recommended for all ferrous services in direct contact with the soils. Alternatives such as PVC/Plastic may also be considered where practical. Refer to the SANS standards for corrosion protection measures.

8.9 Undermined Ground

The site is not undermined. Surface instability due to undermining is not of any concern.

8.10 Dolomite Stability

The site is not underlain by dolomite and or limestone formations. The site is non-dolomitic and a dolomite stability assessment is not required.

8.11 Areas of Unstable Natural Slopes

No steep slopes are present on site. Natural slope instability is not of any concern.

8.12 Seismicity

Seismic hazard zones applicable to South Africa are depicted in **Figure A6**, **Appendix A**. The zones are determined from the seismic hazard map which presents the peak ground acceleration with a 10 % probability of being exceeded in a 50-year period. It included both natural and mining-induced seismicity (SANS10160-4, 2017).

The following zones are considered:

- Zone I: Natural seismic activity
- Zone II: Regions of mining-induced and natural seismic activity

The site falls outside seismic Zone I and Zone II (see **Figure A6, Appendix A.** Seismicity is not considered a concern for this site. The structural engineer should however determine if design precautionary measures are required, as guided by SANS10160-4.

8.13 Flooding

The site is not situated within or in close proximity a flood plain or drainage feature. Natural flooding is not expected to be of any concern.

8.14 Contaminated Land

No indication of contaminated land was noted during the assessment.

8.15 Uncontrolled Fill

No uncontrolled fill was encountered in any of the test pits. The evaluation points are however point data. Actual surface and subsurface conditions may vary between the point data. The planner/designer should treat the data as such.

9 Site Class Designations Type 1 Masonry Buildings

The site is assigned with one (1) site class designation applicable to single-storey and double-storey type 1 masonry building as per SANS10400-H. Refer to the designation presented in **Figure A7**, **Appendix A**.

The residential site class designation is summarized as (SANS10400-H, 2012):

- **Zone I**: C2-P* // 2ABE 2(F)

The assigned designation/s before the "//" represent/s the following (SANS10400-H, 2012):

C → Compressible and potentially collapsible soils.

P* → Controlled engineered fill material.

The assigned designation/s after the "//" represent/s the following (SANS634, 2012):

A → Collapsible soil.

B → Seepage.

E → Erodability of soil.

(F) → Localised excavation difficulty down to 1.5 mbgl.

The severity of the assigned residential designation (symbols before the "//") are summarized in **Table R5**. The severity of the assigned constraints (symbols after the "//") is provided in **Table R6**.

Table R5 Residential Site Class Designation (SANS634, 2012)

Typical founding material / site descriptor	Nature of founding material	Expected range of total soil movements (mm)	Assumed differential movement (% of total)	Site class designation
Rock (excluding mud rocks which may exhibit swelling to some depth).	Stable	Negligible	-	R
Fine grained soils with moderate to very high plasticity (clays, silty clays, clayey silts and sandy clays).	Expansive soils	<7.5 7.5 to 15 15 to 30 >30	50% 50% 50% 50%	H H1 H2 H3
Silty sands, sands, sandy and gravelly soils.	Compressible and potentially collapsible soils	<5 5 to 10 >10	75% 75% 75%	C C1 C2
Fine grained soils (clayey silts and clayey sands of low plasticity), sands, sandy and gravelly soils.	Compressible soils	<10 10 to 20 >20	50% 50% 50%	S S1 S2
Contaminated soils, controlled fill, dolomitic areas, mine waste fill, mining subsidence reclaimed areas, uncontrolled fill and very soft silts /silty clays.	Variable	Variable	-	P

The site class designations are derived from an estimation of the expected range of total soil movements experienced by single-storey and double-storey homes having masonry walls that are not supported by steel, concrete or reinforced masonry columns under the following assumptions:

a) The foundation has a width that does not exceed 0.6 to 0.8 m in respect of single-storey and double-storey buildings respectively;
b) The design soil bearing pressure does not exceed 50 kPa; and
c) The total soil movements are such that the resultant differential movement implied in the table is equal to that which is to be expected in the field.

Table R6: Geotechnical Constraints in Urban Development (SANS634, 2012)

Constraint		Descriptor		
Letter	**Description**	**1 (most favourable)**	**2 (intermediate)**	**3 (least favourable)**
A	Collapsible soil	Any collapsible horizon or consecutive horizons totalling a depth of less than 750 mm in thickness[a]	Any collapsible horizon or consecutive horizons with a depth of more than 750 mm in thickness	A least favourable situation for this constraint does not occur
B	Seepage	Permanent or perched water table more than 1,5 m below ground below	Permanent or perched water table less than 1,5 m ground surface	Swamps and marshes
C	Active soil	Low soil-heave potential anticipated[a]	Moderate soil-heave potential anticipated	High soil-heave potential anticipated
D	Highly compressible soil	Low soil compressibility anticipated[a]	Moderate soil compressibility anticipated	High soil compressibility anticipated
E	Erodability of soil	Low	Intermediate	High
F	Difficulty of excavation to 1,5 m depth	Scattered or occasional boulders less than 10 % of the total volume[a]	Rock or hardpan pedocretes between 10 % and 40 % of the total volume	Rock or hardpan pedocretes more than 40 % of the total volume
G	Undermined ground	Undermining at a depth greater than 200 m below surface (except where total extraction mining has not occurred)	Old undermined areas to a depth of 200 m below surface where stope closure has ceased	Mining within less than 200 m of surface or where total extraction mining has taken place
H	Stability (dolomite land)	Possibly stable. Areas of dolomite overlain by Karoo rocks or intruded by sills. Areas of Black Reef rocks. Anticipated inherent hazard class 1 (see SANS 1936-2)	Potentially characterized by instability. Anticipated inherent classes 2 to 5 (see SANS 1936-2)	Known sinkholes and dolines. Anticipated inherent hazard classes 6 to 8 (see SANS 1936-2)
I	Steep slopes	Between 2° and 6° (all regions)	Slopes between 6° and 18° and less than 2° (Natal and Western Cape) Slopes between 6° and 12°and less than 2° (all other regions)	More than 18° (Natal and Western Cape) More than 12° (all other regions)
J	Areas of unstable natural slopes	Low risk	Intermediate risk	High risk (especially in areas subject to seismic activity)
K	Areas subject to seismic activity	10 % probability of an event less than 100 cm/s² within 50 years	Mining-induced seismic activity more than 100 cm/s²	Natural seismic activity more than 100 cm/s²
L	Areas subject to flooding	A "most favourable" situation for this constraint does not occur	Areas adjacent to a known drainage channel or floodplain with slope less than 1 %	Areas within a known drainage channel or floodplain

Note 1: Areas should be designated by the numeral associated with the most appropriate descriptor in columns 3 to 5 followed by the letter associated with the constraint. For example, an area designated as Zone 2BF would be an intermediate class with anticipated seepage and excavation problems while an area designated as Zone 3B would be least favourable and not recommended for development due to surface water inundation.

Note 2: More detailed information on undermined land can be obtained from Stacey, T.R. and Bakker, D. The erection or construction of buildings and other structures on undermined ground. NOTE 3 Undermining assessments should be carried out by persons with expert knowledge of such conditions.

[a] *These areas are designated as 1A, 1C, 1D, or 1F where localized occurrences of the constraint might arise.*

10 Foundation Options and Recommendations

Single-storey and double-storey type 1 masonry building foundation options and recommendations should be guided by the South African National Standards, Part H on Foundations (SANS10400-H, 2012), considering the assigned soil designation and estimated total and differential movements. Geotechnical and/or structural solutions can be considered. The selection of either a geotechnical or structural solution depends upon the practicality and economy of the solutions in question (SANS10400-H, 2012).

10.1 Geotechnical Solutions (Focus on Materials)

Geotechnical solutions generally eliminate or reduce the total soil movements to within limits which can be tolerated by buildings without distress by means of one of the following (SANS10400-H, 2012):

a) Removal of the soil horizons that cause unacceptable differential movements and replacement of these horizons with inert material suitably compacted or the reuse of the excavated material as founding material in a compacted form;

b) Founding of the wall footings at a deeper level than is commonly associated with normal construction, i.e. a suitable founding horizon below the horizons within which relatively large movements might take place (where soil conditions allow); and

c) Densification of the soil horizons that cause unacceptable differential movement by means of surface compaction.

10.2 Structural Solutions (Focus on Structure)

Structural solutions employ techniques to improve flexibility or stiffness and strength, which reduce the effects of differential soil movements to a level that can be tolerated by a building without significant damage (SANS10400-H, 2012).

10.3 Foundation Solutions (Focus on Foundation Modification)

One site class designation is assigned to the site (report section 9).

Foundation solutions for **Zone I** should be aligned with **class "C2" foundation solutions** as outlined in **Table F11** and **Table F12**, **Appendix F**. One or a combination of the following foundation solutions can be considered for this zone:

a) Stiffened strip footings, stiffened or cellular raft.

b) Compaction of in-situ soils below individual footings.

c) Soil raft.

d) Piled or pier foundations.

Geometric requirements, compaction and other specifications for the class is provided in the relevant tables attached as **Appendix F**.

10.4 Larger Structures

No larger structures are planned. Larger structures should be design by a competent engineer. Input can be provided upon request if load schedules, and allowable structural tolerances are available.

10.5 Foundations for Free-Standing Walls and Retaining Walls

Foundations for free-standing walls and retaining walls that comply with the requirements of SANS 10400-K shall be in accordance with the specifications provided in SANS10400-H. Earthwork and design input can be provided upon request, once conceptual designs are available. Rip and compaction of the in-situ soils below the foundations will be recommended, in order to break down the collapsible soil structure to limit differential movement, in Zone I.

10.6 High Bearing and/or Sensitive Structures

Bearing capacity input should be provided for all high-bearing or sensitive structures. The design engineer should liaise with the engineering geologist for input on all high bearing structures/foundations such as high bearing pad footings, shallow high bearing strip foundations, elevated reservoirs, ground based sensitive concrete dams etc.

11 Construction Materials

11.1 Soil Mattress Construction

The following is typical basic requirements for soil mattress material:

- Material needs to be workable;
- The material must have good to fair compaction characteristics;
- The material must exhibit low heave, or heave within the allowable tolerances of the structure under consideration;
- The material must exhibit low amounts of settlement, or settlement within the allowable tolerances of the structure under consideration once properly compacted;
- The constructed mattress should have a suitable bearing capacity once properly compacted, thus considering the settlement limit and ultimate bearing capacity;
- The mattress material should be resistant to excessive erosion or piping;

- The mattress should have insignificant amounts of organic material to prevent long term deterioration and settlement;
- The mattress should pose no health threats. The use of contaminated soil/material is thus not permitted.

The suitability of the following on-site material horizons for soil mattress construction are:

- **Engineered fill material:** Consider to be a good source for mattress construction dependant on the percentage of fines.
- **Topsoil/Colluvium:** Not ideal due to presence of organic matter and roots. Can be considered if roots and anthropogenic materials are removed.
- **Pebble marker**: Good to excellent performance dependant on the percentage of fines and grading.
- **Reworked residual gneiss**: Consider to be a good source for mattress construction dependant on the percentage of fines and grading.
- W**eathered gneiss**: Consider to be a good to excellent source for mattress construction dependant on the percentage of fines and grading.

11.2 Material for Embankments and Terraces

The requirements for materials suitable for construction of **embankments and terraces**, unless otherwise specified, are that the material shall (2001-BE1, 2008):

a) have a CBR of at least 3% at the minimum specified density (compacted at OMC) and a Plasticity Index (PI) not exceeding 18%; or

b) hard material or rock material with a maximum dimension of 300 mm; or

c) both clay or clayey material of a liquid limit (LL) that exceeds 40%, or PI that exceeds 18% (or both), and rocks or boulders that have a maximum dimension greater than 300 mm, provided that they

d) are not placed against structures, and

e) are placed in predetermined quantities and in specified parts of the fill (where filling is to be placed against or around a structure, such filling (whether it be backfilling or embankment) shall be placed and compacted simultaneously on both sides of the structure to minimize unequal loading); or

f) materials that can be compacted so as to avoid settlement that exceeds 2 mm/m of depth of excavation, and that contain no more than 10% rock or hard fragments retained on a sieve of nominal aperture size 50 mm and that contain no large clay lumps that break up under the action of the compaction equipment used.

The CBR, PI and LL of the on-site materials (except for the colluvial soils) fall within the requirements for material for embankments and terraces. The on-site soils are deemed suitable for embankment and terrace construction if potential oversize fragments are removed.

11.3 Material for Overbreak in Excavations for Foundations

The requirements for materials suitable for **replacing overbreak in excavations for foundations**, unless otherwise specified, are that the material shall (2001-BE1, 2008):

g) be capable of sufficient compaction to avoid settlement and shall be capable of placement without significant voids;

h) not contain appreciable quantities of organic matter or stones of average dimension exceeding the lesser of 150 mm or two-thirds of the thickness of the layer being compacted;

i) be graded material that has a PI not exceeding 10%; and

j) have a CBR of at least 10% at the minimum specified density compacted at OMC.

The weathered gneiss material is generally deemed suitable for placement in potential overbreaks below foundations.

It will however be recommended that selective placing is considered with the aim to avoid materials with high fines content (silt and clay) where the PI may exceed the specified maximum limit.

11.4 Material for Backfill or for Fill Against Structures

The requirements for material placed as **backfill or for fill against structures** (or within 500 mm from a structure), unless otherwise specified, shall (2001-BE1, 2008):

a) be capable of sufficient compaction to avoid settlement and shall be capable of placement without significant voids;

b) shall not contain appreciable quantities of organic matter or stones of average dimension exceeding the lesser of 150 mm or two-thirds of the thickness of the layer being compacted;

c) be graded material that has a PI not exceeding 10%;

d) have CBR of at least 10% at the minimum specified density compacted at OMC; and

e) not contain more than 10% rock or hard fragments retained on a sieve of nominal aperture size 50 mm.

The pebble marker, residual gneiss, weathered gneiss and mixes thereof are generally deemed suitable for backfill material or for fill against structures. It will however be recommended that selective placing is considered with the aim to avoid materials with high fines content (silt and clay) where the PI may exceed the specified maximum limit with resulting borderline CBR values.

11.5 Road Construction

The design of the road pavement will depend on the expected induced loads, volumes and overall pavement design with reference to type of materials, horizon thicknesses to be incorporated into the pavement and the drainage precautionary measures. The design engineer should thus evaluate the suitability of the on-site soils taking into consideration the required parameters.

The **weathered gneiss** and **residual gneiss/pebble marker** mixed materials generally classify as "A-2-4" to "A-2-6", "GC/GP to SC/SM" and "G7" material according to the TRB, USCS and TRH14/COLTO classification systems, respectively. The **weathered gneiss** material may be considered for selected layer and subbase construction, if deemed suitable by the pavement engineer. Alternatively, physical and/or chemical stabilisation techniques can be considered.

The **residual gneiss** may be considered for selected layer construction, if deemed suitable by the pavement engineer. The material will not be recommended for surfacing, base or subbase construction.

Suitable material for upper pavement horizon construction will have to be imported. Based on the proximity of local commercial sources, that the importation of suitable road construction material will be the more feasible option.

The laboratory test results are attached as **Appendix D.**

11.6 Pipe Bedding and Backfill

The bedding and blanketing material can be evaluated by SANS or the more relaxed DWA specifications. Department Water Affairs developed a relaxed bedding specification especially for areas where materials with specifications as per SANS cannot be obtained. The specifications are summarized in **Table R7**.

Table R7: Relaxed Pipe Bedding Specifications (DWA)

Material Description	Percentage by Mass Passing Sieve Size (mm)				Atterberg Limits Shall Not Exceed (%)		
	9,5	4,75	0,425	0,002	LL*	PI*	LS*
Finely Graded A	100	100	80 - 100	0 - 45	30	15	5
Medium Graded B	100	80 - 100	60 - 80	0 - 40	35	18	7,5
Granular C	100	70 - 100	30 - 60	0 - 35	40	20	10

*Notes: * LL, PI and LS on material passing the 0,425mm sieve.*

The on-site soils will not be recommended for use as pipe bedding.

The design engineer should consider the recommended specifications for the pipeline/s under consideration for this site.

The on-site materials will be expected to be suitable for backfill material. The upper backfill material should be specified by a competent person if sensitive structures or roads are to cross any backfill material. The design engineer should refer to the laboratory results and conduct additional testing as deemed necessary.

11.7 Fine aggregate for Mortar and Plaster

Evaluation of on-site material for fine aggregate for mortar and plaster falls outside the scope of this investigation. The grading analysis are however provided in **Appendix D** for guideline evaluation purposes. Alternatively, the materials will have to be imported from a commercial source.

11.8 Coarse Aggregate for Concrete

The on-site materials evaluation for the use of coarse aggregate for concrete falls outside the scope of this investigation. The grading analysis are however provided in **Appendix D** for guideline evaluation purposes. Alternatively, the materials will have to be imported from a commercial source.

12 Drainage and Erosion Protection

Shallow seasonal groundwater seepage conditions to surface seepage conditions are expected across the site. The seepage water is expected to be mainly in, but not limited to, the transported materials, lower residuum and weathered gneiss.

The presence of trench/excavation flooding should be considered in the excavation planning phase. Damp proofing should be considered to all foundations/structures that are sensitive to rising damp.

Basic surface drainage precautionary measures will also be required as from an erosion control perspective and may comprise of a combination of the following basic precautionary measures:

- Construction phasing to limit vast exposed areas;
- Proper surface water management to prevent high run-off rates and concentrated water flow;
- Temporary surface protection during construction;
- Permanent surface protection after construction for example grass establishment and/or paving;
- Physical improvement of the upper soils such as compaction in order to increase resistance to erosion;
- Subsurface drainage where pedogenic or expected seasonal perched water contacts are exposed by possible cuts/excavations.

13 Identified Shortcomings

a) This investigation serves as a SANS634:2012 Phase 1 Detailed investigation.

b) The assigned site class designation is based on the five (5) intrusive test pits excavated for the purposes of this assessment, together with the evaluation and interpretation of all available information listed under the relevant report section.

c) The design engineer should liaise with the engineering geologist if any additional input is required, especially for high-bearing foundations and/or any highly sensitive structures with low allowable tolerances with reference to total and/or differential movements.

d) The evaluation points are point data with interpolation and extrapolation of conditions between the data points. Actual surface and subsurface conditions may vary between the point data. The planner/designer should treat the data as such.

14 Conclusions and Recommendations

The following are concluded:

a) The regional geology was confirmed as gneiss and the site is regarded as “non-dolomitic”.

b) The site is mainly covered with upper engineered fill, covering the natural topsoil/colluvium horizons that is underlain by a pebble marker zone, indicating the boundary between the upper transported materials and the lower residuum. The pebble marker is underlain by reworked residual gneiss transgressing into completely to moderately weathered gneiss, with a lower limit R0 to R3 rock hardness as per ISRM1981b classification.

c) The horizon thicknesses are fairly uniform.

d) Weakly to strongly cemented pedogenic formation (ferricrete) are present in the profiles.

e) No rock outcrop or surficial boulders were encountered on site.

f) Soft excavation conditions were encountered in all five (5) test pits excavated across the site down to refusal depth between 1.5 and 2.0 mbgl. “Intermediate to hard” restricted excavation conditions were encountered at TLB refusal depth in all the test pits. “Intermediate to hard excavation” conditions were encountered at TLB refusal in all the test pits. Based on the test pit data no excavatability difficulty down to 1.5 mbgl are expected. Localised large corestones and boulders can however be expected in this geological/geomorphological setting.

g) It is expected that the highly weathered and jointed gneiss might be excavatable/rippable with a larger excavator, dozer and/or excavator with pneumatic tools in unconfined excavation conditions down to 2.5 - 3.0 mbgl.

h) Severe shallow seepage water is expected during and after heavy and/or continuous downpours. The seepage water is expected to be mainly in, but not limited to the transported materials, lower residuum and weathered gneiss horizon. Surface and subsurface drainage precautionary measures will be essential.

i) Four (4) foundation indicators and two (2) compaction tests (MDD and CBR) were performed on the on-site material. The grading analyses indicate fines contents (clay and silt-size grains) of approximately 13.4% with approximately 21.2% sand particles and 45.4% gravel. The on-site soils classify as “GC”, “GP” and “SC” as per the USCS, “A-2” and “A-7” as per the AASHTO system.

j) Typical material properties for the soils encountered are provided in **Table E8** to **Table E10**, **Appendix E**. The planners/designers can refer to the typical material properties and apply applicable coefficients of variation to the materials where and if deemed necessary, depending on the design-philosophy/method applied.

k) The site is assigned with one shallow soil designation namely (see **Figure A7**, **Appendix A**):

- **Zone I**: C2-P* // 2ABE (2F)

l) Earthwork and/or foundation modifications will be required for the proposed structures. Possible foundation solutions that may be considered are provided in the relevant report section (section 10). Foundation solutions should be aligned with class “C2” (**Zone I**).

m) Guidance to construction materials is covered in **section 11**.

n) The general and foundation specific solutions and recommendations outlined in this report should be considered. This investigation serves as a SANS634:2012 Phase 1 detailed investigation.

o) The site is deemed suitable for the proposed development as from a geotechnical perspective.

p) Corrosion protection will be recommended due to the potential corrosiveness of the soils and/or soil-water paste towards ferrous services.

q) Damp proofing will be essential.

r) Pesticide control should be considered below/around all footings/structures.

s) A site-specific ground elevation survey should be considered, and stormwater design input should be provided by a competent engineer.

t) A competent person should inspect all trench and excavations and certify the works safe to enter before any construction shift. If the aforementioned is not implemented, excavations should be supported, or slope angles should be battered back to 1V:1H (Zone I). If any signs of instability are noted, the works should be discontinued, and a competent person should be invited to evaluate and provide guidance on the way forward.

u) A competent person should thus be invited at the time of opening excavations, before backfilling/levelling is conducted and before foundations are constructed, in order to verify the conditions discussed in this report (Phase 2 investigation or construction report). If unexpected discrepancies are exposed during the excavations, the necessary earthwork and/or foundation modifications should be conducted before construction proceeds and noted in the formal construction report.

A registered engineering geologist or engineer should conduct the open excavation/foundation inspections and sign-off on the construction report to verify that no such conditions were exposed/identified during the construction phase. The final individual foundation design can only be supported/launched upon inspection of the open services or structure specific test pit information.

15 Report Provisions

While every effort was made during this basic shallow soil materials assessment investigation to identify the different geological materials, areas subject to a perched water tables, hydrogeological conditions, areas of poor drainage and to estimate their distribution, it is impossible to guarantee that isolated zones of significantly different conditions have not been missed. For this reason, this investigation has sought to highlight the significant issues regarding the influence of the proposed development on the geological environment to provide prior warning to the developer and to suggest precautionary measures.

The trial pits excavated were backfilled without proper compaction in layers and it is recommended for proper re-compaction if foundations are to span the pits excavated in order to prevent composite founding conditions, associated differential movement and potential damage to structures to be erected.

The report may only be distributed in its full context. RockSoil Consult (Pty) Ltd. and/or any of its employees or sub-contractors will not be held liable for any damages caused due to miss-interpretation of the findings and/or recommendations due to selective data presentation or distribution.

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Appendix A: Figures

Figure A1: Locality Map 1

Figure A2: Locality Map 2

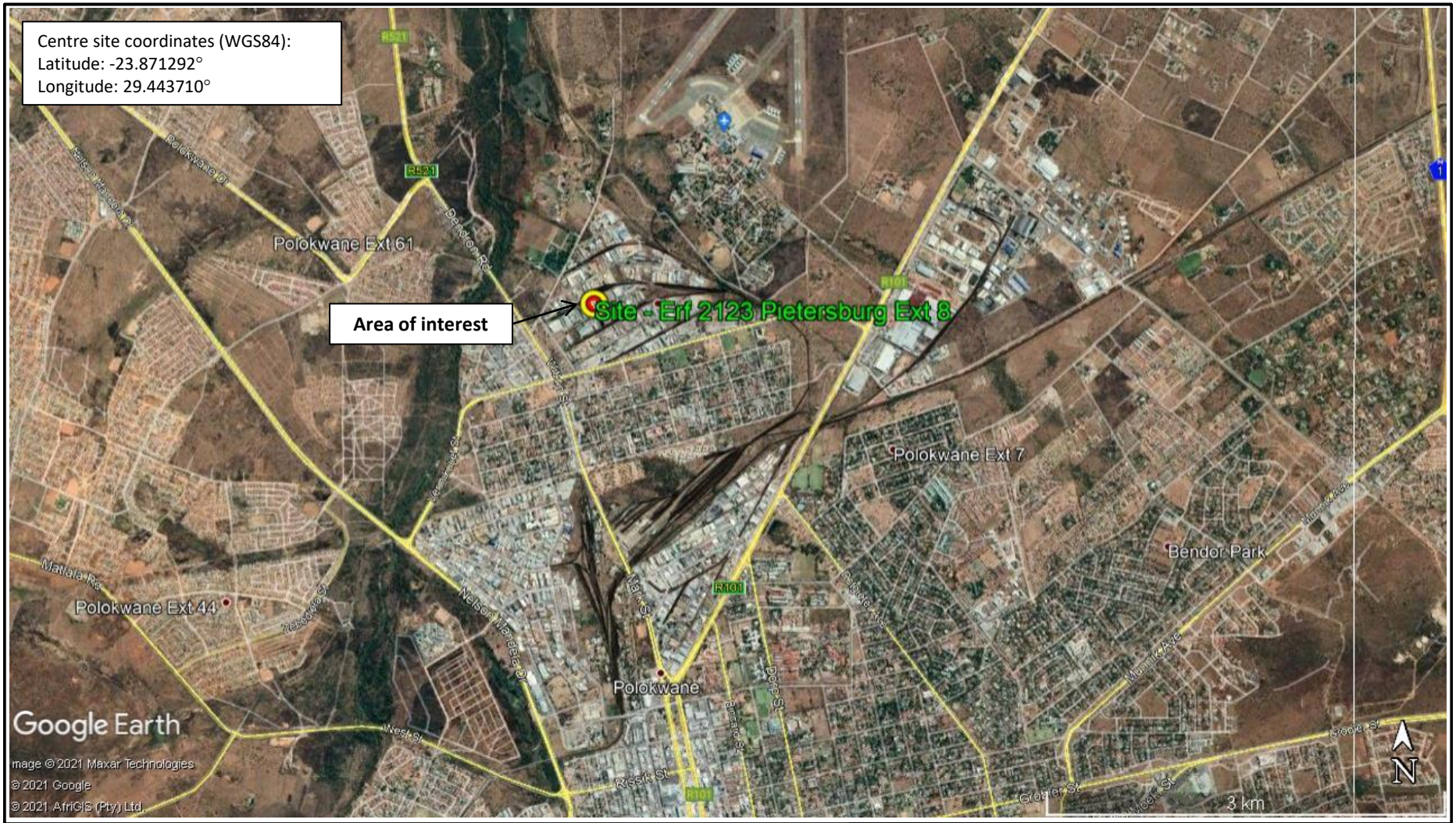
Figure A3: Cropped Section of the 2329CD Topographical Sheet

Figure A4: Regional Geological Sheet (Cropped 1:250 000-scale 2328 Pietersburg Sheet)

Figure A5: Test Pit Positions

Figure A6: Seismic Hazard Zones of South Africa (SANS10160-4, 2017)

Figure A7: Site Class Designation (Geotechnical Zonation Map)



Project Description: Portion 1 of Erf 6154 Pietersburg, Ext 8
Investigation Type: SANS634:2012 Phase 1 Detailed Investigation
Figure A1: Site Locality 1

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Project Description: Portion 1 of Erf 6154 Pietersburg, Ext 8
Investigation Type: SANS634:2012 Phase 1 Detailed Investigation
Figure A2: Site Locality 2

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Project Description: Portion 1 of Erf 6154 Pietersburg, Ext 8
Investigation Type: SANS634:2012 Phase 1 Detailed Investigation
Figure A3: Cropped Section of the 2329CD Topographical Sheet

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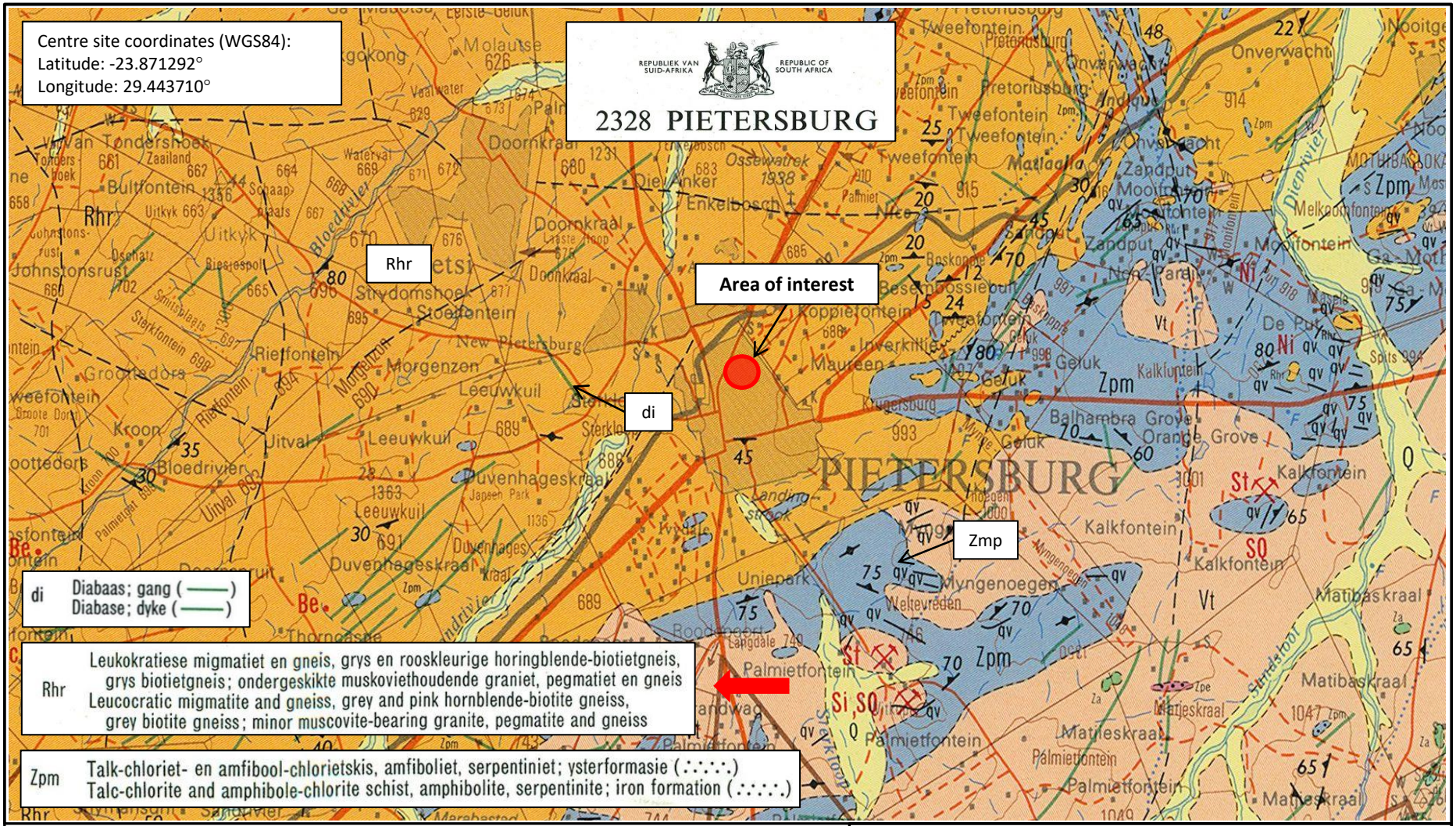

Project Description: Portion 1 of Erf 6154 Pietersburg, Ext 8
Investigation Type: SANS634:2012 Phase 1 Detailed Investigation
Figure A4: Regional Geological Sheet (Cropped 1:250 000-scale 2328 Pietersburg)

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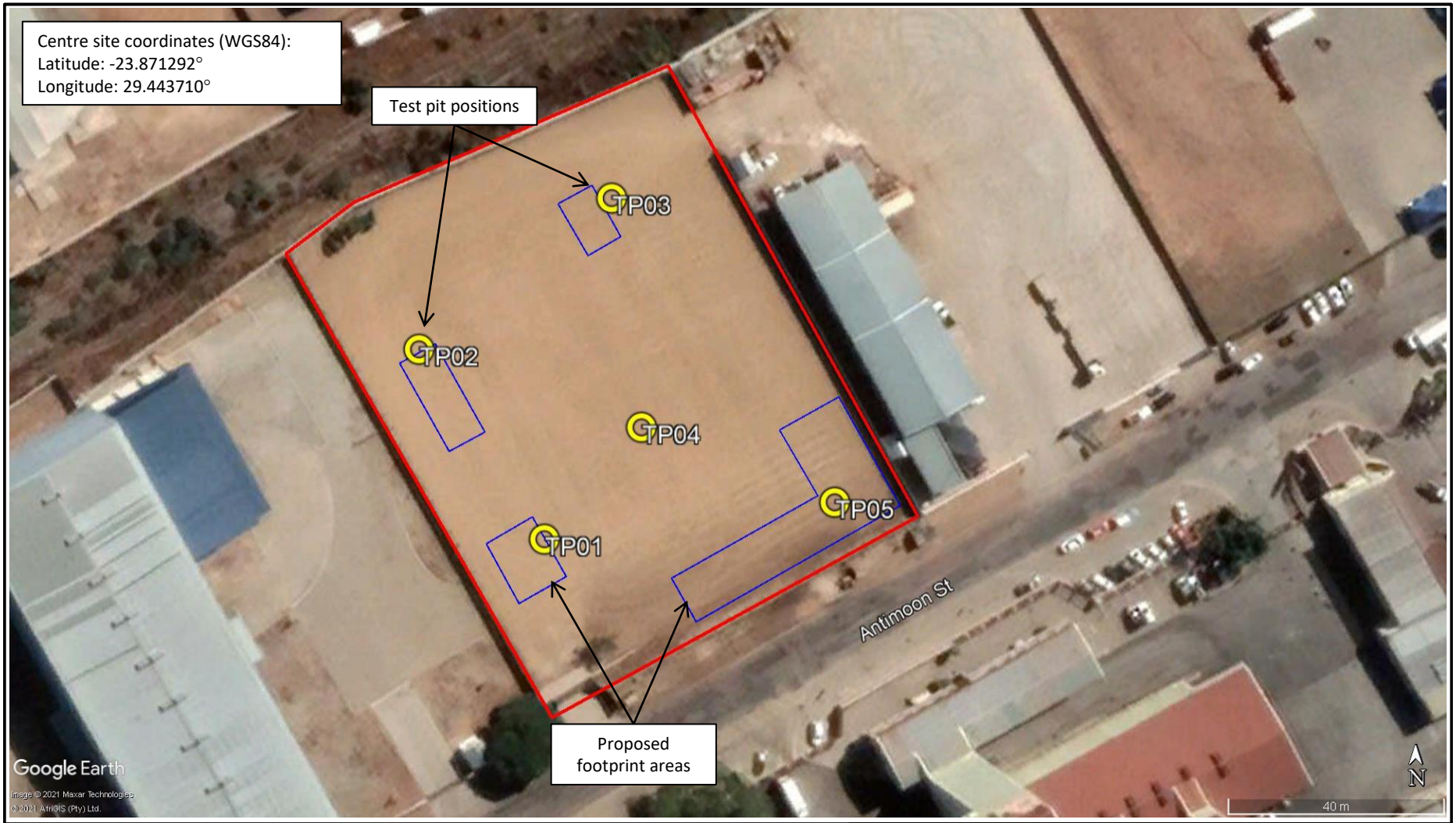
Project no: RS21031



Project Description: Portion 1 of Erf 6154 Pietersburg, Ext 8
Investigation Type: SANS634:2012 Phase 1 Detailed Investigation
Figure A5: Test Pit Positions

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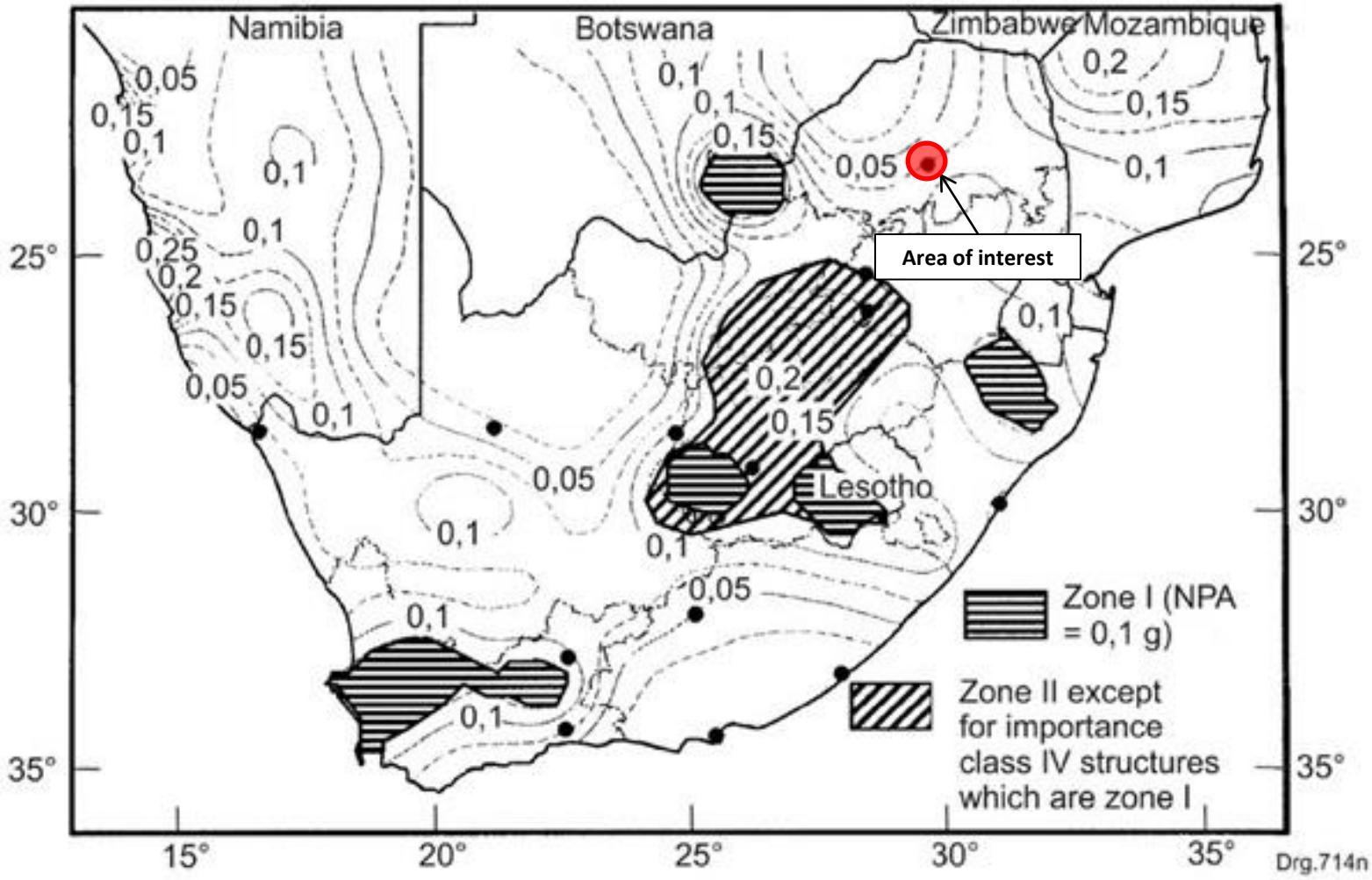
Project no: RS21031



Project Description: Portion 1 of Erf 6154 Pietersburg, Ext 8
Investigation Type: SANS634:2012 Phase 1 Detailed Investigation
Figure A6: Seismic Hazard Zones of South Africa

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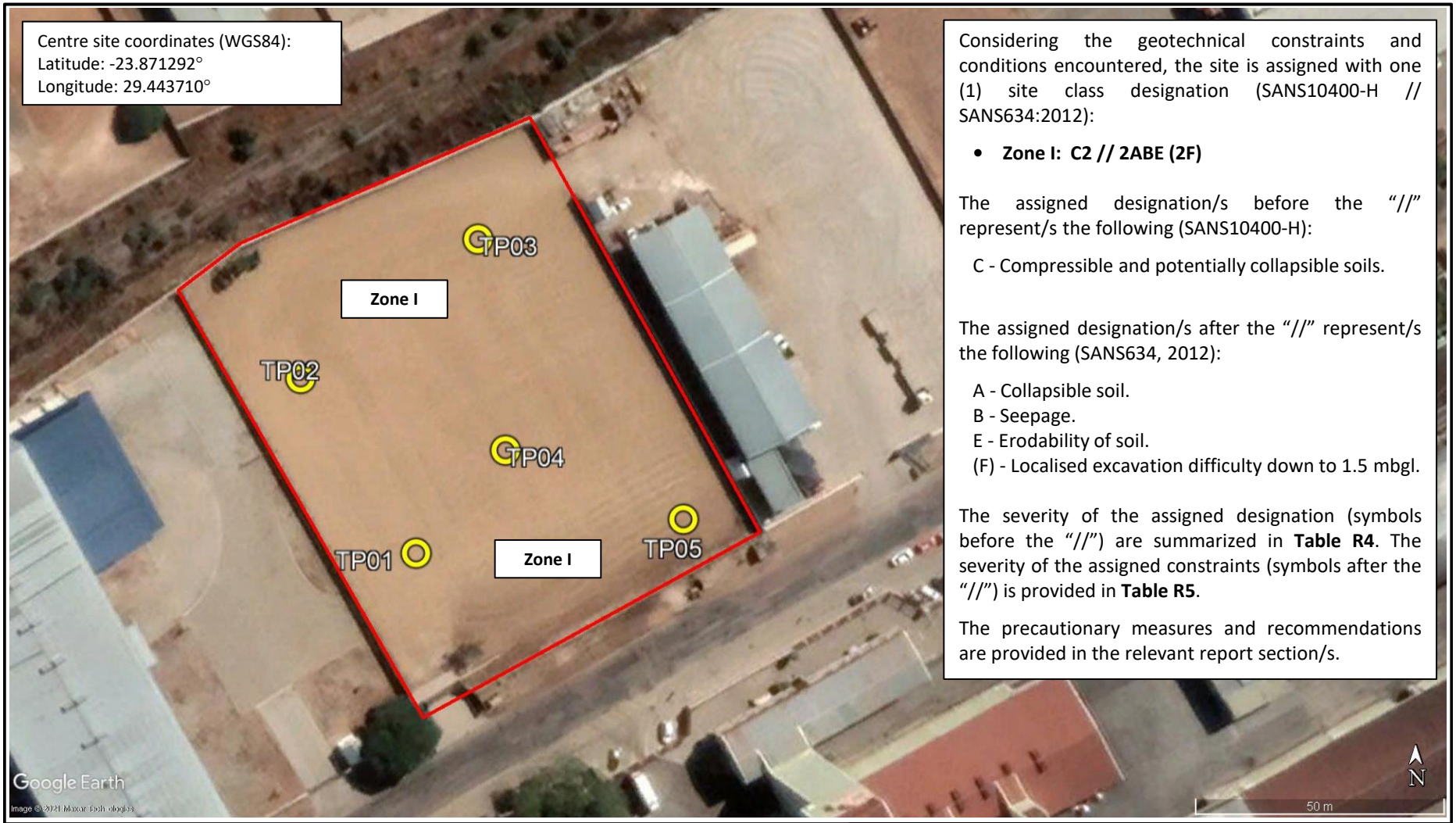
Project no: RS21031



Considering the geotechnical constraints and conditions encountered, the site is assigned with one (1) site class designation (SANS10400-H // SANS634:2012):

- **Zone I: C2 // 2ABE (2F)**

The assigned designation/s before the "//" represent/s the following (SANS10400-H):

C - Compressible and potentially collapsible soils.

The assigned designation/s after the "//" represent/s the following (SANS634, 2012):

A - Collapsible soil.
B - Seepage.
E - Erodability of soil.
(F) - Localised excavation difficulty down to 1.5 mbgl.

The severity of the assigned designation (symbols before the "//") are summarized in **Table R4**. The severity of the assigned constraints (symbols after the "//") is provided in **Table R5**.

The precautionary measures and recommendations are provided in the relevant report section/s.

Project Description: Portion 1 of Erf 6154 Pietersburg, Ext 8
Investigation Type: SANS634:2012 Phase 1 Detailed Investigation
Figure A7: Geotechnical Zonation Map

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Appendix B: Soil Profile Descriptions

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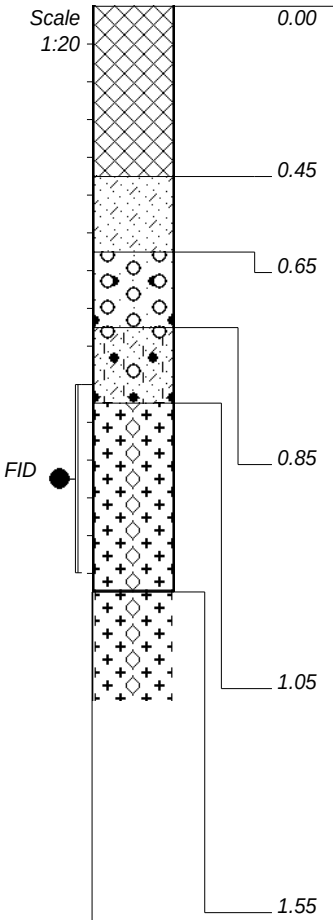
HOLE No: TP01
Sheet 1 of 1

JOB NUMBER: RS21031



0.00 – Dry to moist with depth, light brown to grey mottled orange, dense to medium dense with depth, **intact**, clayey silty gravelly SAND. **ENGINEERED FILL MATERIAL**.

0.45 – Moist, dark brown, firm, **pinholed to slightly voided**, silty clayey sand. **REWORKED COLLUVIUM/TOPSOIL**. Scattered fine roots.

0.65 – Moist, brown speckled to mottled black and orange, medium dense to dense, **open root channels**, (clayey) silty sandy gravel with abundant sub-rounded quartz gravel to cobbles and very weak to moderately cemented Fe concretions. **SLIGHTLY FERRUGINISED PEBBLE MARKER**.

0.85 – Moist, grey to greenish grey mottled black, medium dense to firm, **fissured to open structured**, clayey gravelly silty sand with minor sub-rounded quartz gravel to cobbles and completely weathered gneiss fragments. **SLIGHTLY FERRUGINISED REWORKED RESIDUAL GNEISS**.

Note: Undulating zone locally down to 1.55 mbgl.

1.05 – Slightly moist, brown speckled black to red and streaked orange, dense to very dense, **jointed**, medium to coarse grained, **COMPLETELY TO HIGHLY WEATHERED GNEISS** (ISRM1981 class <R0 to <R1, lower limit extremely weak to very weak rock).

Note:
Highly undulating bedrock and weathering, refer to ranges given.

1.55 – As above becoming **COMPLETELY TO MODERATELY WEATHRED GNEISS** (ISRM1981 class <R1 to R2, lower limit extremely weak to weak rock).

NOTES

1) TLB refusal.
2) Double bucket width trench excavation.
3) Intermediate to hard excavation conditions at TLB refusal depth.
4) No seepage water encountered during the time of inspection.
5) No sidewall instability encountered during the time of inspection.
6) Disturbed samples retrieved at 1.00--1.50m. FID.

CONTRACTOR : Maruma Plant Hire
MACHINE : JCB3CX
DRILLED BY : RockSoil Consult (Pty) Ltd.
PROFILED BY : JI Roux

INCLINATION : Vertical
DIAM : 600mm wide trench
DATE : 2021-07-30
DATE : 2021-07-30

ELEVATION :
X-COORD :
Y-COORD :

TYPE SET BY : JI Roux
SETUP FILE : RSC.SET

DATE : 10/10/2021 12:01
TEXT : ..PB(SP)\RS21031SPV1.0.txt

HOLE No: TP01

ROCKSOIL CONSULT

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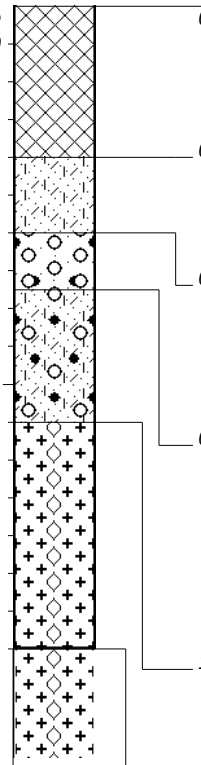
HOLE No: TP02
Sheet 1 of 1

JOB NUMBER: RS21031

Scale 1:20



0.00	Dry to moist with depth, light brown to grey mottled orange, dense to medium dense with depth, **intact**, clayey silty gravelly SAND. **ENGINEERED FILL MATERIAL**.
0.40	Moist, dark brown, medium dense to dense to firm, **pinholed to slightly voided**, (gravelly) clayey silty SAND with traces of sub-rounded gravel of mixed origin. **REWORKED COLLUVIUM/TOPSOIL**. Scattered fine roots.
0.60	Moist, brown speckled to mottled black and orange, medium dense, **open root channels**, (clayey) silty sandy gravel with abundant sub-rounded quartz gravel to cobbles and very weak to moderately cemented Fe concretions. **SLIGHTLY FERRUGINISED PEBBLE MARKER**.
0.75	Moist to very moist, grey to brown mottled black, medium dense to firm, **fissured to open structured**, clayey gravelly silty sand with minor sub-rounded quartz gravel to cobbles and completely weathered gneiss fragments. **SLIGHTLY FERRUGINISED REWORKED RESIDUAL GNEISS**. **Note**: Undulating zone locally down to 1.70 mbgl.
1.10	Slightly moist, brown speckled black to red and streaked orange, dense to very dense, **jointed**, medium to coarse grained, **COMPLETELY TO MODERATELY WEATHERED GNEISS** (ISRM1981 class <R0 to R3, lower limit extremely weak to medium strong rock). **Note**: Highly undulating bedrock and weathering, refer to ranges given.
1.70	As above becoming **HIGHLY TO MODERATELY WEATHRED GNEISS** (ISRM1981 class R0 to <R3, extremely weak to lower limit medium strong rock).

NOTES

1) TLB refusal.
2) Double bucket width trench excavation.
3) Intermediate to hard excavation conditions at TLB refusal depth.
4) No seepage water encountered during the time of inspection.
5) No sidewall instability encountered during the time of inspection.
6) No samples retrieved.

CONTRACTOR : Maruma Plant Hire
MACHINE : JCB3CX
DRILLED BY : RockSoil Consult (Pty) Ltd.
PROFILED BY : JI Roux

TYPE SET BY : JI Roux
SETUP FILE : RSC.SET

INCLINATION :
DIAM : 600mm wide trench
DATE : 2021-07-30
DATE : 2021-07-30

DATE : 10/10/2021 12:01
TEXT : ..PB(SP)\RS21031SPV1.0.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP02

ROCKSOIL CONSULT

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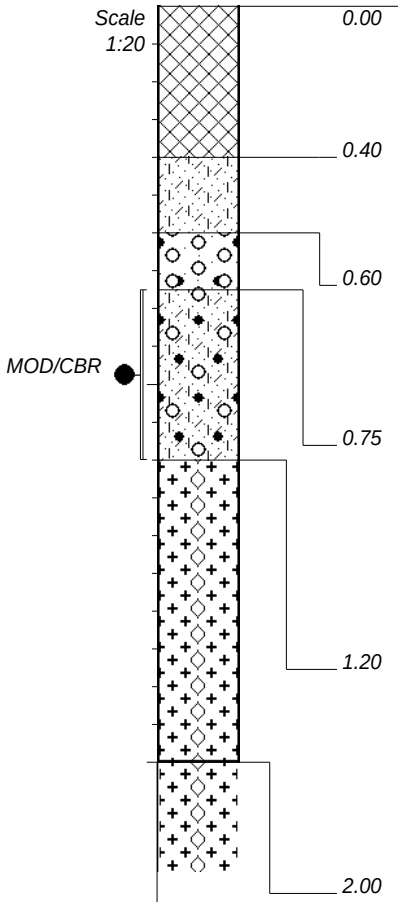
HOLE No: TP03
Sheet 1 of 1

JOB NUMBER: RS21031



Dry to moist with depth, light brown to grey mottled orange, dense to medium dense with depth, **intact**, clayey silty gravelly SAND. **ENGINEERED FILL MATERIAL**.

Moist, dark brown, medium dense to dense to firm, **pinholed to slightly voided**, (gravelly) clayey silty SAND with traces of sub-rounded gravel of mixed origin. **REWORKED COLLUVIUM/TOPSOIL**. Scattered fine roots.

Moist, brown speckled to mottled black and orange, medium dense, **open root channels**, (clayey) silty sandy gravel with abundant sub-rounded quartz gravel to cobbles and very weak to moderately cemented Fe concretions. **SLIGHTLY FERRUGINISED PEBBLE MARKER**.

Moist to very moist, grey mottled black, medium dense to firm, **fissured to open structured**, clayey gravelly silty sand with minor sub-rounded quartz gravel to cobbles and completely weathered gneiss fragments and very weakly to strongly cemented Fe concretions. **SLIGHTLY FERRUGINISED REWORKED RESIDUAL GNEISS**.

Note: Undulating zone locally down to 2.00 mbgl.

Slightly moist, brown speckled black to red and streaked orange, dense to very dense, **jointed**, medium to coarse grained, **COMPLETELY TO MODERATELY WEATHERED GNEISS** (ISRM1981 class <R0 to R3, lower limit extremely weak to medium strong rock).

Note:
Highly undulating bedrock and weathering, refer to ranges given.

As above becoming **HIGHLY TO MODERATELY WEATHRED GNEISS** (ISRM1981 class R0 to <R3, extremely weak to lower limit medium strong rock).

NOTES

1) TLB refusal.
2) Double bucket width trench excavation.
3) Intermediate to hard excavation conditions at TLB refusal depth.
4) No seepage water encountered during the time of inspection.
5) No sidewall instability encountered during the time of inspection.
6) Disturbed samples retrieved at 0.75--1.20m. MOD/CBR.

CONTRACTOR : Maruma Plant Hire
MACHINE : JCB3CX
DRILLED BY : RockSoil Consult (Pty) Ltd.
PROFILED BY : JI Roux

TYPE SET BY : JI Roux
SETUP FILE : RSC.SET

INCLINATION :
DIAM : 600mm wide trench
DATE : 2021-07-30
DATE : 2021-07-30

DATE : 10/10/2021 12:01
TEXT : ..PB(SP)\RS21031SPV1.0.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP03

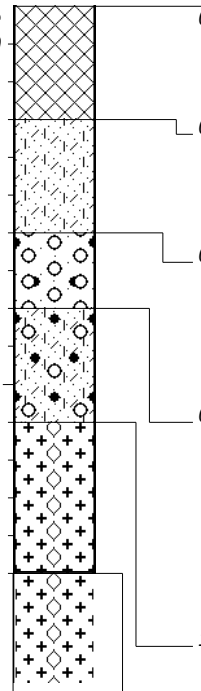
ROCKSOIL CONSULT

WSM Leshika (Pty) Ltd.
Erf 2123 Pietersburg Ext 8

HOLE No: TP04
Sheet 1 of 1

JOB NUMBER: RS21031

Scale 1:20



0.00	Dry to moist with depth, light brown to grey mottled orange, dense to medium dense with depth, **intact**, clayey silty gravelly SAND. **ENGINEERED FILL MATERIAL**.
0.30	Moist, dark brown, medium dense to dense to firm, **pinholed to slightly voided**, (gravelly) clayey silty SAND with traces of sub-rounded gravel of mixed origin. **REWORKED COLLUVIUM/TOPSOIL**. Scattered fine roots.
0.60	Moist, brown speckled to mottled black and orange, medium dense, **open root channels**, (clayey) silty sandy gravel with abundant sub-rounded quartz gravel to cobbles and very weak to moderately cemented Fe concretions. **SLIGHTLY FERRUGINISED PEBBLE MARKER**.
0.80	Moist to very moist, grey to red brown mottled black, medium dense to firm, **fissured to open structured**, clayey gravelly silty sand with minor sub-rounded quartz gravel to cobbles and completely weathered gneiss fragments and very weakly to strongly cemented Fe concretions. **SLIGHTLY FERRUGINISED REWORKED RESIDUAL GNEISS**. **Note**: Undulating zone locally down to 2.00 mbgl.
1.10	Slightly moist, brown speckled black to red and streaked orange, dense to very dense, **jointed**, medium to coarse grained, **COMPLETELY TO MODERATELY WEATHERED GNEISS** (ISRM1981 class <R0 to R3, lower limit extremely weak to medium strong rock). **Note**: Highly undulating bedrock and weathering, refer to ranges given.
1.50	As above becoming **HIGHLY TO MODERATELY WEATHRED GNEISS** (ISRM1981 class R0 to <R3, extremely weak to lower limit medium strong rock).

NOTES

1) TLB refusal.
2) Double bucket width trench excavation.
3) Intermediate to hard excavation conditions at TLB refusal depth.
4) No seepage water encountered during the time of inspection.
5) No sidewall instability encountered during the time of inspection.
6) No sample retrieved.

CONTRACTOR : Maruma Plant Hire
MACHINE : JCB3CX
DRILLED BY : RockSoil Consult (Pty) Ltd.
PROFILED BY : JI Roux

TYPE SET BY : JI Roux
SETUP FILE : RSC.SET

INCLINATION :
DIAM : 600mm wide trench
DATE : 2021-07-30
DATE : 2021-07-30

DATE : 10/10/2021 12:01
TEXT : ..PB(SP)\RS21031SPV1.0.txt

ELEVATION :
X-COORD :
Y-COORD :

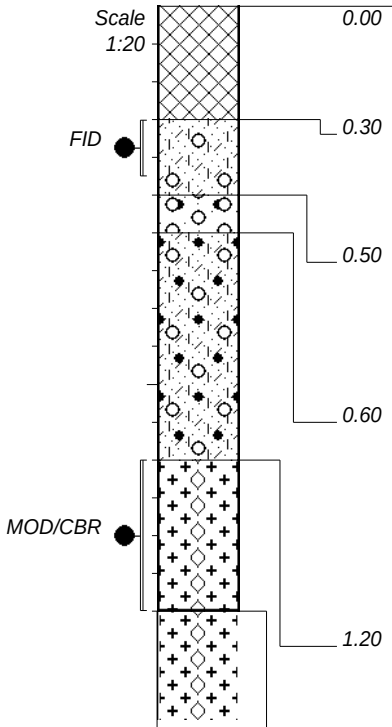
HOLE No: TP04

ROCKSOIL CONSULT

WSM Leshika (Pty) Ltd.
Erf 2123 Pietersburg Ext 8

HOLE No: TP05
Sheet 1 of 1

JOB NUMBER: RS21031



Dry to moist with depth, light brown to grey mottled orange, dense to medium dense with depth, **intact**, clayey silty gravelly SAND. **ENGINEERED FILL MATERIAL**.

Moist, dark brown to black, firm to stiff, **pinholed to slightly shattered**, silty gravelly clayey sand with traces of sub-rounded gravel of mixed origin. **REWORKED COLLUVIUM/TOPSOIL**. Scattered fine roots.

Moist, grey speckled to mottled black and orange, medium dense, **open root channels**, (clayey) silty sandy gravel with abundant sub-rounded quartz gravel to cobbles and very weak to moderately cemented Fe concretions. **SLIGHTLY FERRUGINISED PEBBLE MARKER**.

Moist to very moist, grey to brown mottled black, medium dense to firm, **fissured to open structured**, clayey silty gravelly sand with abundant sub-rounded quartz gravel to cobbles and completely weathered gneiss fragments and very weakly to strongly cemented Fe concretions. **SLIGHTLY FERRUGINISED REWORKED RESIDUAL GNEISS**.

Dry to slightly moist, orange brown to pink speckled black to red and streaked orange, very dense, **closely jointed**, medium to coarse grained, **HIGHLY TO MODERATELY WEATHERED GNEISS** (ISRM1981 class <R1 to R2, lower limit very weak to weak rock).

Note:
Highly undulating bedrock and weathering, refer to ranges given.

As above becoming **HIGHLY TO MODERATELY WEATHRED GNEISS** (ISRM1981 class <R1 to R2, lower limit very weak to weak rock).

NOTES

1) TLB refusal.
2) Double bucket width trench excavation.
3) Intermediate to hard excavation conditions at TLB refusal depth.
4) No seepage water encountered during the time of inspection.
5) No sidewall instability encountered during the time of inspection.
6) Disturbed samples retrieved at 0.30--0.45m. FID.
7) Disturbed samples retrieved at 1.20--1.60m. MOD/CBR.

CONTRACTOR : Maruma Plant Hire
MACHINE : JCB3CX
DRILLED BY : RockSoil Consult (Pty) Ltd.
PROFILED BY : JI Roux

TYPE SET BY : JI Roux
SETUP FILE : RSC.SET

INCLINATION :
DIAM : 600mm wide trench
DATE : 2021-07-30
DATE : 2021-07-30

DATE : 10/10/2021 12:01
TEXT : ..PB(SP)\RS21031SPV1.0.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP05

ROCKSOIL CONSULT

WSM Leshika (Pty) Ltd.
Erf 2123 Pietersburg Ext 8

LEGEND
Sheet 1 of 1

JOB NUMBER: RS21031

	GRAVEL	{SA02}
	GRAVELLY	{SA03}
	SAND	{SA04}
	SANDY	{SA05}
	SILTY	{SA07}
	CLAYEY	{SA09}
	PLUTONIC/norite/syenite	{SA17}
	FREE QUARTZ/visible quartz	{SA44}
	SPARSE FERRICRETE NODULES/occasional ferricrete nodu....	{SA25}
	FILL	{SA32}
Name ●	DISTURBED SAMPLE	{SA38}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :

INCLINATION :
DIAM :
DATE :
DATE :

ELEVATION :
X-COORD :
Y-COORD :

TYPE SET BY : JI Roux
SETUP FILE : RSC.SET

DATE : 10/10/2021 12:01
TEXT : ..PB(SP)\RS21031SPV1.0.txt

LEGEND
SUMMARY OF SYMBOLS

Appendix C: Soil Profile Photographs

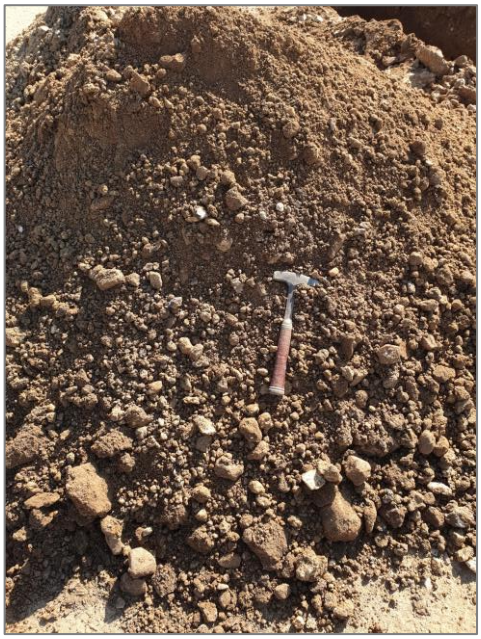
Project reference number: RS21031
Project name: Erf 2123 Pietersburg Ext 8

Test Pit no: TP01  Note: Soil profile down to 1.55 mbgl.	Test Pit no: TP01  Note: Upper colluvium/topsoil?
Test Pit no: TP01  Note: Undulating pebble marker.	Test Pit no: TP01  Note: Residual to weathered gneiss contact.

Project reference number: RS21031
Project name: Erf 2123 Pietersburg Ext 8

Test Pit no: TP02	Test Pit no: TP02
	
Note: Soil profile down to 1.70 mbgl.	Note: Upper engineered fill material.
Test Pit no: TP02	Test Pit no: TP02
	
Note: Completely weathered gneiss.	Note: TLB refusal in weathered gneiss.

Project reference number: RS21031
Project name: Erf 2123 Pietersburg Ext 8

Test Pit no: TP03  Note: Soil profile down to 2.00 mbgl.	Test Pit no: TP03  Note: Reworked residual gneiss.
Test Pit no: TP03  Note: Reworked residual gneiss.	Test Pit no: TP03  Note: Excavated reworked residual gneissweathered gneiss.

Project reference number: RS21031
Project name: Erf 2123 Pietersburg Ext 8

ROCKSOIL CONSULT

Test Pit no: TP04

Note: Soil profile down to 1.50 mbgl.

Test Pit no: TP04

Note: Upper topsoil/colluvium.

Test Pit no: TP04

Note: Pebble marker zone.

Test Pit no: TP04

Note: Reworked residual gneiss.

Project reference number: RS21031
Project name: Erf 2123 Pietersburg Ext 8

Test Pit no: TP05	Test Pit no: TP05
	
Note: Soil profile down to 1.60 mbgl.	Note: Upper topsoil/colluvium.
Test Pit no: TP05	Test Pit no: TP05
	
Note: Moderately weathered gneiss.	Note: Excavated weathered gneiss.

Project reference number: RS21031
Project name: Erf 2123 Pietersburg Ext 8

TLB

Note: JCB 3CX TLB used for the excavation of the trail pits. TLB was in a good condition.

Site Scenery - Test Pit no: TP01

Note: On-site conditions. Photograph taken from the southern site corner in a north-westerly direction.

Project reference number: RS21031
Project name: Erf 2123 Pietersburg Ext 8

Site Scenery - Test Pit no: TP02

Note: On-site conditions. Photograph taken from the north-western site corner in a south-easterly direction.

Site Scenery - Test Pit no: TP03

Note: On-site conditions. Photograph taken from the northern site corner in a south-easterly direction.

Appendix D: Laboratory Test Results

Specialised Testing Laboratory (Pty) Ltd
Asphalt | Aggregate | Bitumen | Geotechnical
Quality | Excellence | On Time

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Gerrie | 082 309 4448 | gerrie@stlab.co.za
www.stlab.co.za

Client Name: RockSoil Consult (Pty) Ltd
Project Name: RS21031: Laboria Depot
Job Number: RSC-44
Date: 2021-09-02
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR

Sheet Reference: R-STL-011 Rev02

Grading & Hydrometer Analysis (Particle Size (mm) & % Passing)				Atterberg Limits & Classification			
Sample	TP01	TP03	TP05	Sample	TP01	TP03	TP05
Depth (m)	1.00 - 1.50	0.75 - 1.20	0.30 - 0.45	Depth (m)	1.00 - 1.50	0.75 - 1.20	0.30 - 0.45
Lab No	RSC-44-544	RSC-44-546	RSC-44-548	Lab No	RSC-44-544	RSC-44-546	RSC-44-548
53.0	**91**	**96**	**100**	Liquid Limit (%)	**39**	**34**	**41**
37.5	**82**	**92**	**100**	Plastic Limit (%)	**23**	**17**	**21**
26.5	**76**	**90**	**100**	Plasticity Index (%)	**16**	**17**	**20**
19.0	**69**	**88**	**100**	Linear Shrinkage (%)	**7.5**	**8.5**	**10.5**
13.2	**64**	**83**	**99**	PI of whole sample	**4**	**6**	**11**
9.5	**59**	**78**	**98**				
6.7	**54**	**72**	**91**	% Gravel	**61**	**51**	**33**
4.75	**50**	**65**	**85**	% Sand	**29**	**29**	**34**
2.00	**39**	**49**	**67**	% Silt	**6**	**12**	**17**
1.00	**34**	**44**	**63**	% Clay	**4**	**8**	**16**
0.425	**28**	**38**	**56**	Activity	**4.0**	**2.1**	**1.3**
0.250	**20**	**33**	**51**				
0.150	**17**	**28**	**46**	% Soil Mortar	**39**	**49**	**67**
0.075	**14**	**23**	**37**				
0.060	**10**	**20**	**33**	Grading Modulus	**2.19**	**1.90**	**1.40**
0.050	**9**	**19**	**32**	Moisture Content (%)	**N / T**	**N / T**	**N / T**
0.035	**8**	**17**	**29**	Relative Density (SG)*	**2.65**	**2.65**	**2.65**
0.020	**7**	**15**	**26**				
0.006	**5**	**10**	**19**	Unified (ASTM D2487)	**GC**	**SC**	**SC**
0.002	**4**	**8**	**16**	AASHTO (M145-91)	**A - 2 - 6**	**A - 2 - 6**	**A - 7 - 6**

Remarks: *: Assumed
N / T: Not Tested

Specialised Testing Laboratory (Pty) Ltd
Asphalt | Aggregate | Bitumen | Geotechnical
Quality | Excellence | On Time

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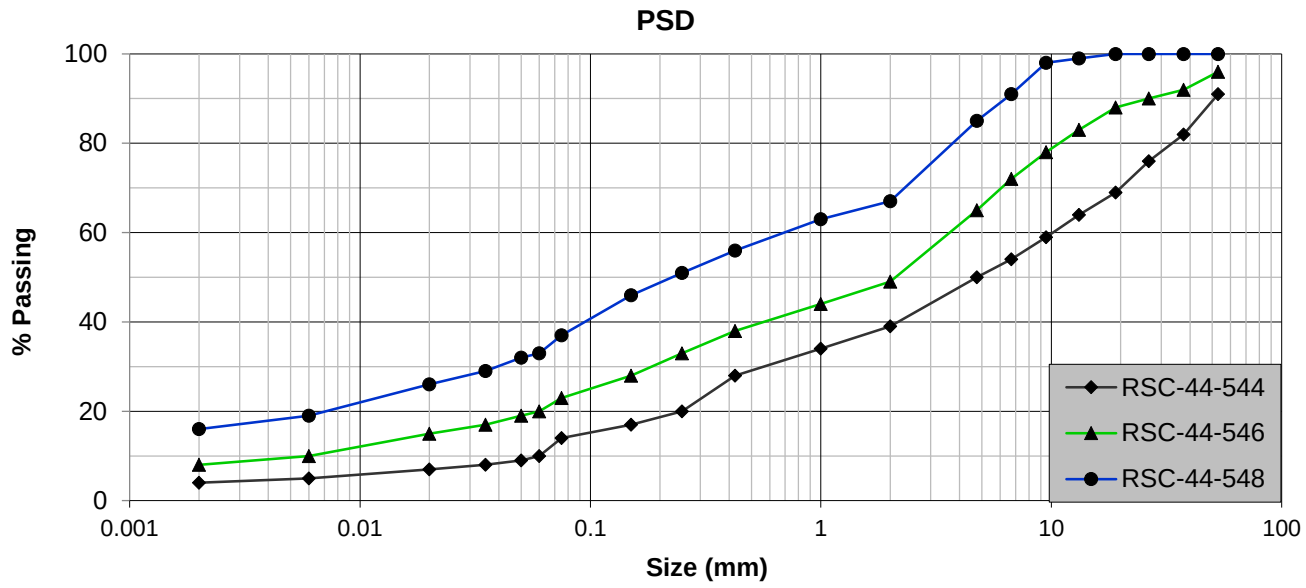
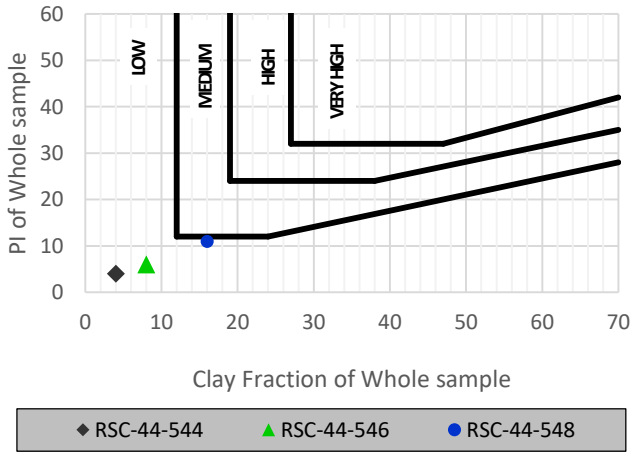
Client Name: RockSoil Consult (Pty) Ltd
Project Name: RS21031: Laboria Depot
Job Number: RSC-44
Date: 2021-09-02
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR

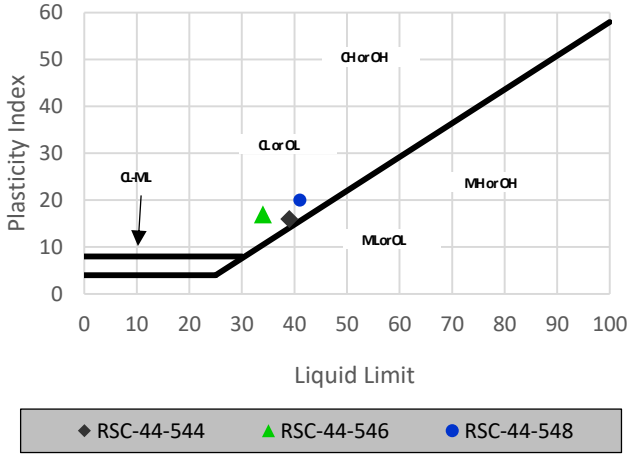
Sheet Reference: R-STL-011 Rev02



Potential Expansiveness



Casagrande Plasticity Chart



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Asphalt | Aggregate | Bitumen | Geotechnical
Quality | Excellence | On Time

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Project Name: RS21031: Laboria Depot
Job Number: RSC-44
Date: 2021-09-02
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR

Sheet Reference: R-STL-011 Rev02

Grading & Hydrometer Analysis (Particle Size (mm) & % Passing)				**Atterberg Limits & Classification**			
Sample	TP05			Sample	TP05		
Depth (m)	1.20 - 1.60			Depth (m)	1.20 - 1.60		
Lab No	RSC-44-549			Lab No	RSC-44-549		
53.0	**91**			Liquid Limit (%)	**34**		
37.5	**85**			Plastic Limit (%)	**25**		
26.5	**70**			Plasticity Index (%)	**9**		
19.0	**57**			Linear Shrinkage (%)	**4.5**		
13.2	**43**			PI of whole sample	**1**		
9.5	**37**						
6.7	**30**			% Gravel	**82**		
4.75	**26**			% Sand	**14**		
2.00	**18**			% Silt	**3**		
1.00	**15**			% Clay	**1**		
0.425	**12**			Activity	**9.0**		
0.250	**9**						
0.150	**7**			% Soil Mortar	**18**		
0.075	**5**						
0.060	**4**			Grading Modulus	**2.65**		
0.050	**4**			Moisture Content (%)	**N / T**		
0.035	**3**			Relative Density (SG)*	**2.65**		
0.020	**2**						
0.006	**1**			Unified (ASTM D2487)	**GP-GC**		
0.002	**1**			AASHTO (M145-91)	**A - 2 - 4**		

Remarks: *: Assumed
N / T: Not Tested

Specialised Testing Laboratory (Pty) Ltd
Asphalt | Aggregate | Bitumen | Geotechnical
Quality | Excellence | On Time

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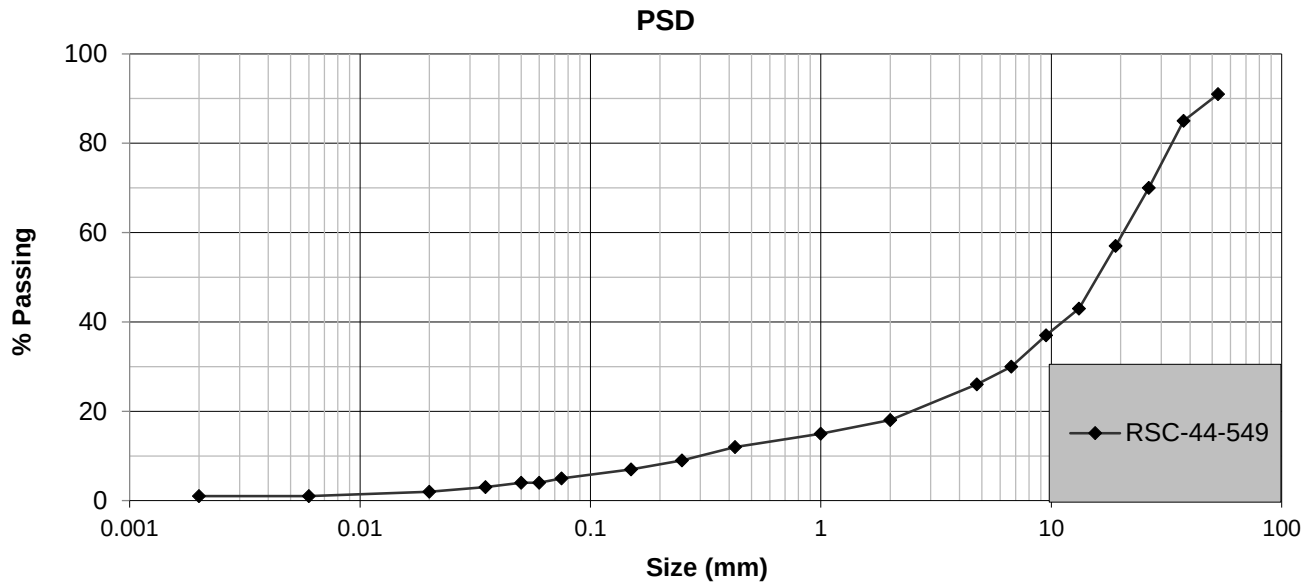
Client Name: RockSoil Consult (Pty) Ltd
Project Name: RS21031: Laboria Depot
Job Number: RSC-44
Date: 2021-09-02
Method: SANS 3001 GR1, GR3, GR10 GR12 & BS 1377 (where applicable)

FOUNDATION INDICATOR

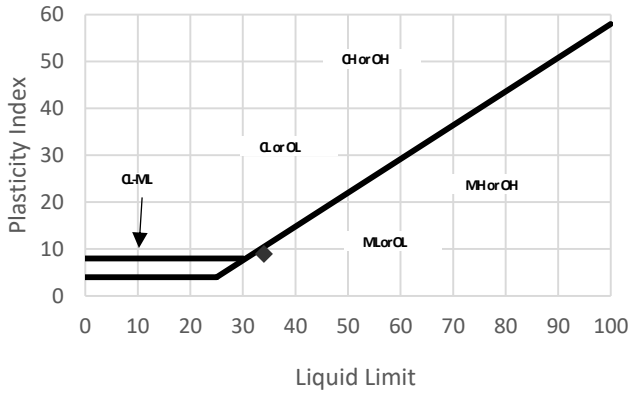
Sheet Reference: R-STL-011 Rev02



Potential Expansiveness

◆ RSC-44-549

Casagrande Plasticity Chart



◆ RSC-44-549

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Asphalt | Aggregate | Bitumen | Geotechnical
Quality | Excellence | On Time

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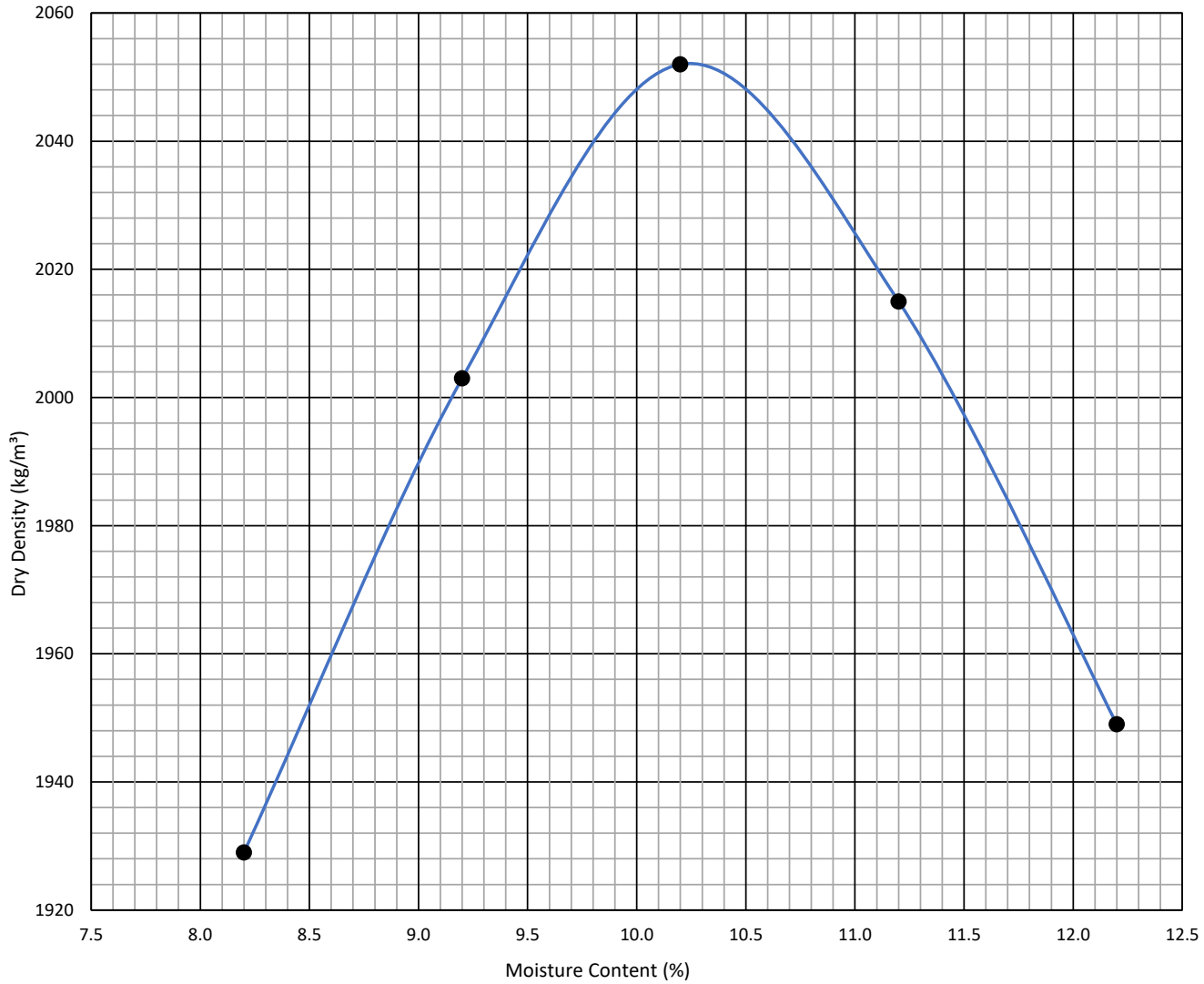
Client Name:	RockSoil Consult (Pty) Ltd	**Job Number:**	RSC-44
Project Name:	RS21031: Laboria Depot	**Lab Number:**	RSC-44-546
Sample:	TP03	**Method:**	SANS 3001 GR30
Depth: (m)	0.75 - 1.20	**Date:**	02-Sep-21

MDD & OMC DETERMINATION (Mod. AASHTO)

Sheet Reference: R-STL-013 Rev01

Maximum Dry Density: **2052** kg/m³ Optimum Moisture Content: **10.2** %

Moisture Content (%)	8.2	9.2	10.2	11.2	12.2			
Dry Density (kg/m³)	1929	2003	2052	2015	1949			



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Asphalt | Aggregate | Bitumen | Geotechnical
Quality | Excellence | On Time

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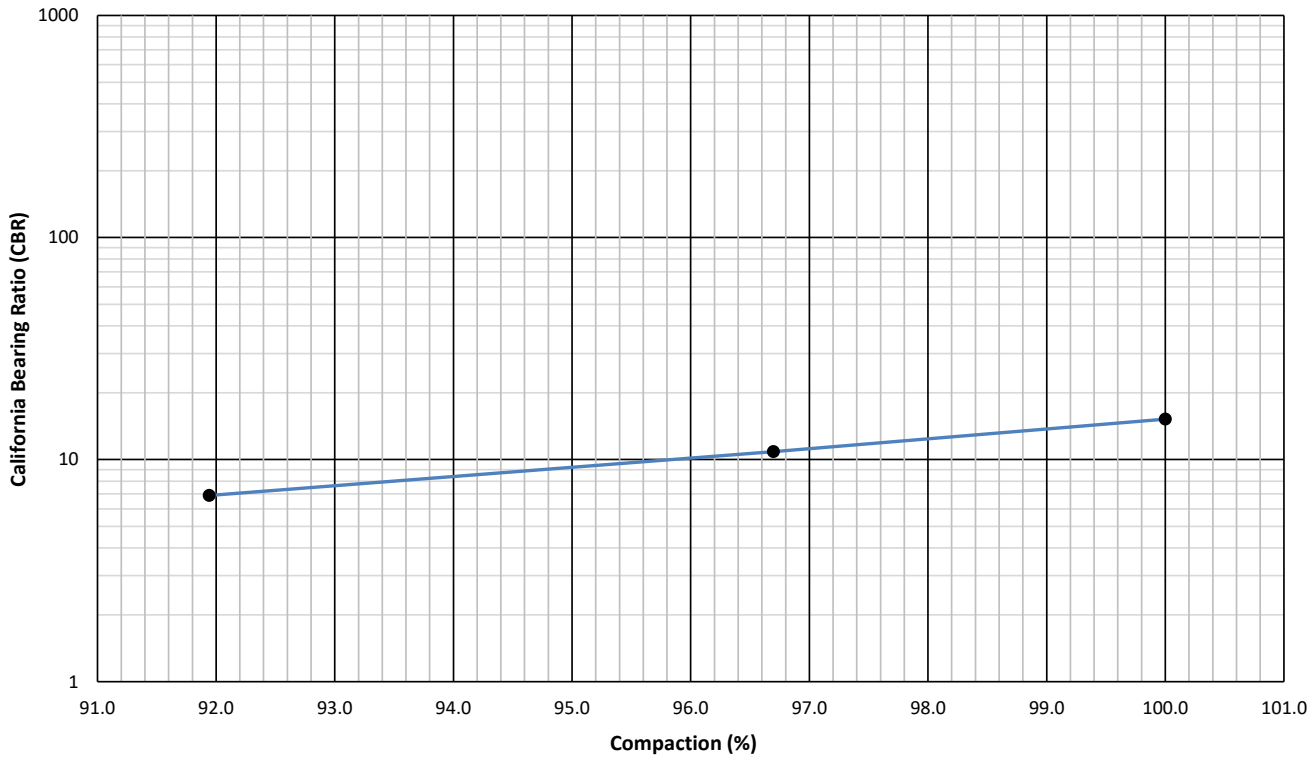
Client Name:	RockSoil Consult (Pty) Ltd	**Job Number:**	RSC-44
Project Name:	RS21031: Laboria Depot	**Lab Number:**	RSC-44-546
Sample:	TP03	**Method:**	SANS 3001 GR40
Depth: (m)	0.75 - 1.20	**Date:**	02-Sep-21

CALIFORNIA BEARING RATIO

Sheet Reference: R-STL-014 Rev01

Mod. AASHTO Values		Compaction Data: CBR			Swell	CBR at (mm)			CBR Values	
MDD	OMC	Dry Dens.	MC	Comp.						
(kg/m³)	(%)	(kg/m³)	(%)	(%)	(%)	2.5	5.0	7.5	Compaction (%)	CBR
									100	**15**
2052	10.2	1998	10.1	100.0	0.1	15	14	12	98	**12**
									97	**11**
2052	10.2	1932	10.1	96.7	0.2	11	11	11	95	**9**
									93	**8**
2052	10.2	1837	10.1	91.9	0.2	7	6	6	90	**6**



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Asphalt | Aggregate | Bitumen | Geotechnical
Quality | Excellence | On Time

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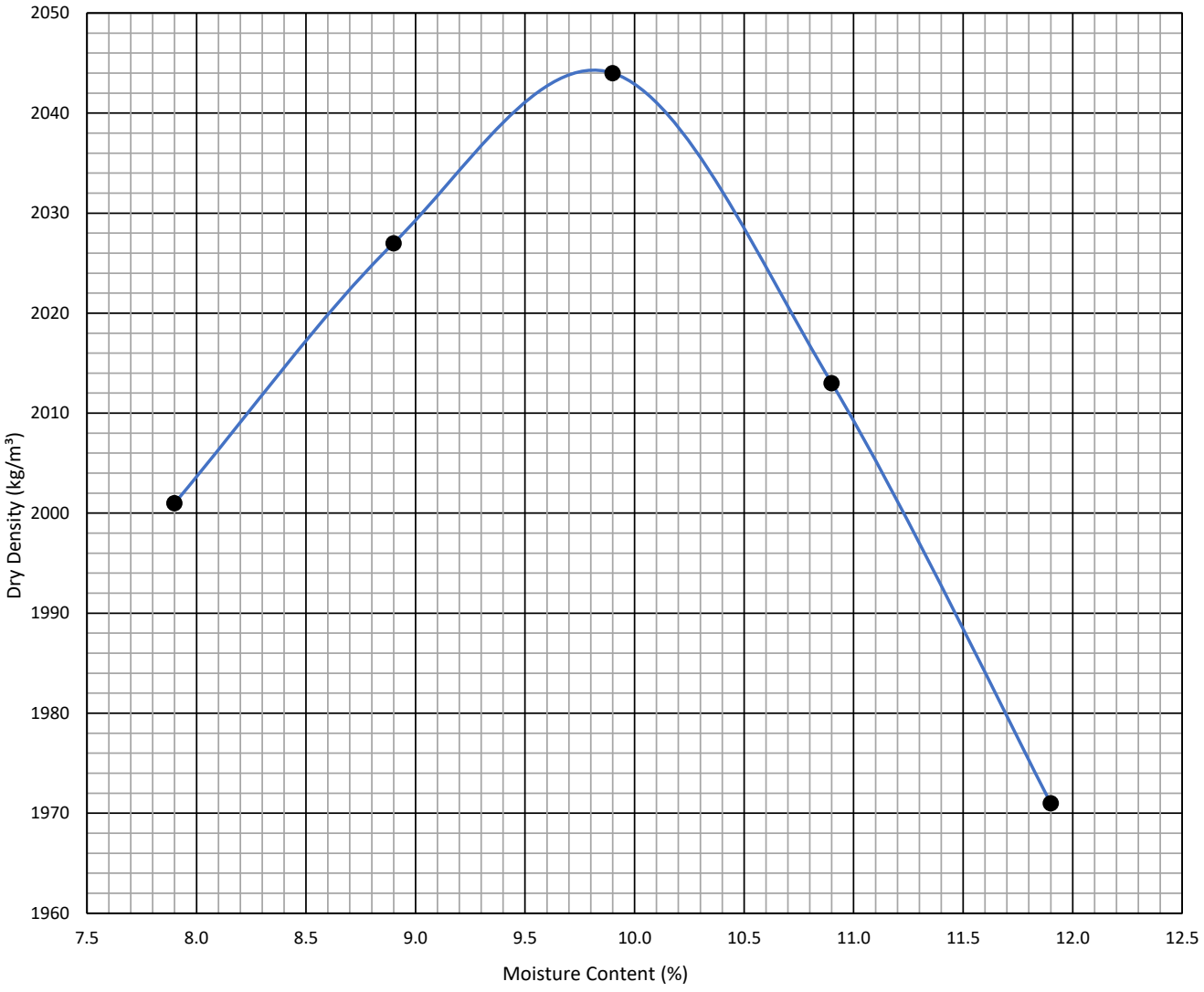
Client Name:	RockSoil Consult (Pty) Ltd	**Job Number:**	RSC-44
Project Name:	RS21031: Laboria Depot	**Lab Number:**	RSC-44-549
Sample:	TP05	**Method:**	SANS 3001 GR30
Depth: (m)	1.20 - 1.60	**Date:**	02-Sep-21

MDD & OMC DETERMINATION (Mod. AASHTO)

Sheet Reference: R-STL-013 Rev01

Maximum Dry Density: **2048** kg/m³ Optimum Moisture Content: **9.8** %

Moisture Content (%)	7.9	8.9	9.9	10.9	11.9			
Dry Density (kg/m³)	2001	2027	2044	2013	1971			



Specialised Testing Laboratory (Pty) Ltd
Asphalt | Aggregate | Bitumen | Geotechnical
Quality | Excellence | On Time

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Gerrie | 082 309 4448 | gerrie@stlab.co.za
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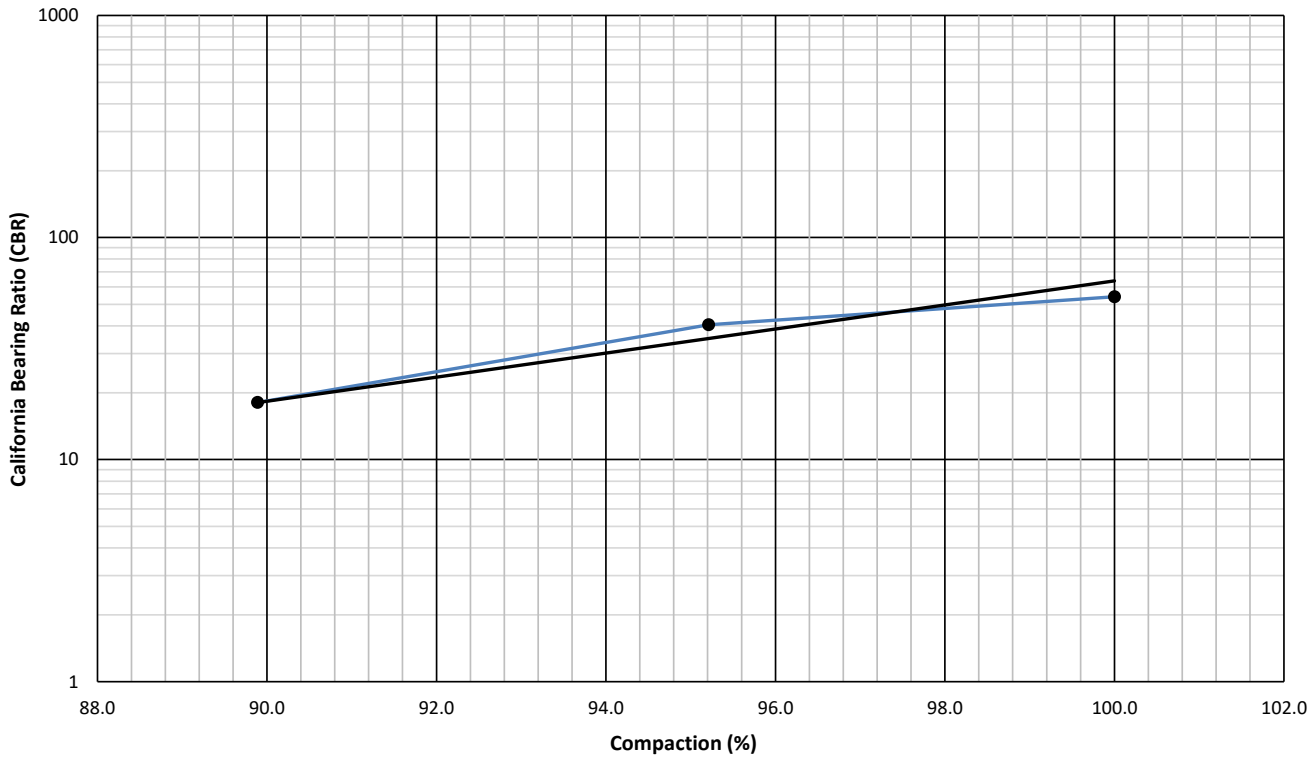
Client Name:	RockSoil Consult (Pty) Ltd	**Job Number:**	RSC-44
Project Name:	RS21031: Laboria Depot	**Lab Number:**	RSC-44-549
Sample:	TP05	**Method:**	SANS 3001 GR40
Depth: (m)	1.20 - 1.60	**Date:**	02-Sep-21

CALIFORNIA BEARING RATIO

Sheet Reference: R-STL-014 Rev01

Mod. AASHTO Values		Compaction Data: CBR			Swell	CBR at (mm)			CBR Values	
MDD	OMC	Dry Dens.	MC	Comp.						
(kg/m³)	(%)	(kg/m³)	(%)	(%)	(%)	2.5	5.0	7.5	Compaction (%)	CBR
									100	**54**
2048	9.8	2047	10.2	100.0	0.0	54	66	72	98	**48**
									97	**45**
2048	9.8	1949	10.2	95.2	0.0	40	50	52	95	**39**
									93	**29**
2048	9.8	1840	10.2	89.9	0.0	18	20	20	90	**18**



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Client Name: RockSoil Consult (Pty) Ltd
Project Name: RS21031: Laboria Depot
Job Number: RSC-44
Date: 02-Sep-21
Method: SANS 3001 GR1, GR3, GR10, GR12 GR20, GR30, GR31, GR40, GR50, GR53, GR54 & BS 1377 (where applicable)

SUMMARY OF TEST DATA

Grading & Hydrometer Analysis (% Passing)

Sample	TP01	TP03	TP05	TP05				
Depth (m)	1.00 - 1.50	0.75 - 1.20	0.30 - 0.45	1.20 - 1.60				
Lab No	RSC-44-544	RSC-44-546	RSC-44-548	RSC-44-549				
53.0	**91**	**96**	**100**	**91**				
37.5	**82**	**92**	**100**	**85**				
26.5	**76**	**90**	**100**	**70**				
19.0	**69**	**88**	**100**	**57**				
13.2	**64**	**83**	**99**	**43**				
9.5	**59**	**78**	**98**	**37**				
6.7	**54**	**72**	**91**	**30**				
4.75	**50**	**65**	**85**	**26**				
2.00	**39**	**49**	**67**	**18**				
1.00	**34**	**44**	**63**	**15**				
0.425	**28**	**38**	**56**	**12**				
0.250	**20**	**33**	**51**	**9**				
0.150	**17**	**28**	**46**	**7**				
0.075	**14**	**23**	**37**	**5**				
0.060	**10**	**20**	**33**	**4**				
0.050	**9**	**19**	**32**	**4**				
0.035	**8**	**17**	**29**	**3**				
0.020	**7**	**15**	**26**	**2**				
0.006	**5**	**10**	**19**	**1**				
0.002	**4**	**8**	**16**	**1**				
GM	**2.19**	**1.90**	**1.40**	**2.65**				

Atterberg Limits

LL (%)	**39**	**34**	**41**	**34**				
PI (%)	**16**	**17**	**20**	**9**				
LS (%)	**7.5**	**8.5**	**10.5**	**4.5**				

pH & Conductivity

pH	**7.0**			**8.7**				
EC (S/m)	**0.056**			**0.038**				

MDD / OMC

MDD (kg/m^3)		**2052**		**2048**				
OMC (%)		**10.2**		**9.8**				

CBR

100%		**15**		**54**				
98%		**12**		**48**				
97%		**11**		**45**				
95%		**9**		**39**				
93%		**8**		**29**				
90%		**6**		**18**				
Swell (%)		**0.1**		**0.0**				

UCS (MPa)

100%								
97%								
90%								

COLTO Classification

		*		**G7**				

Remarks:

Appendix E: Typical Material Properties

Table E8: Typical Properties of Compacted Soils (NAVFAC, 1986)

Group Symbol	Soil Type	Range of Maximum Dry Density (kg/m³)	Range of Optimum Moisture Content (%)	Typical Cohesion (Compacted State)	Typical Cohesion (Saturated)	Typical Effective Stress Envelope (°)	Range of CBR Value (%)
SC	Clayey sands, poorly graded sand-clay mix.	1682 – 2002	11 – 19	74	11	31	5 - 20
GP	Poorly graded clean gravel, gravel-sand mix.	1842 – 2002	11 - 14	0	0	>37	30 - 60
GC	Clayey gravels, poorly graded gravel-sand-clay.	1842 – 2082	9 -14	0	0	>31	20 - 40

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical strength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown.
5. "…." Indicates insufficient data available for an estimate.

Table E9: Typical Properties of Compacted Soils (Franki, 2008, pp. 51-52)

Group Symbol	Soil Type	Max γ_d (kN/m³)	Optimum Moisture (%)	Typical Strength Characteristics			
				c_u (kPa)	c' (kPa)	ϕ' (°)	tanϕ'
SC	Clayey sands, poorly graded sand-clays.	16.5 - 19.7	11 - 19	75	10	31	0.60
GC	Clayey gravels, poorly graded gravel-sand-clay	18.1 - 20.5	9 - 14	0	0	>31	>0.60

Notes:

1. Values summarized after NAVFAC DM7, 1971.
2. The values should be taken as the upper bound values for natural soils.
3. It is necessary to point out that for most soils caution must be exercised if an effective cohesion value greater than zero is to be used for design purposes.

Table E10: Typical Construction Performance based on Unified Soil Classification System

Class	Material description	Subgrade	Subbase	Base	Drainage when compacted	Compaction characteristics	Embankment material	Compressibility when compacted
GP	Poorly grade gravel (<5% fines)	Good to Excellent	Good	Fair to good	Excellent	Good	Reasonably stable	Low
GC	Clayey gravel (>12% fines)	Good	Fair	Poor to not suitable	Poor to practically impervious	Good to fair	Reasonably stable	Low
SC	Clayey sand (>12% fines PI>7)	Fair	Poor	Not suitable	Poor, impervious when compacted	Good to fair	Reasonably stable	Low

** To be used for planning and guideline purposes only. Refer to design-level reports for design input.*

Appendix F: Reference Tables

Table F11: Residential Site Class Designations (SAICE, 1995)

Typical Founding Material	Character of Founding Material	Expected Range of Total Soil Movements (mm)	Assumed Differential Movement (% of total)	Site Class
Rock (excluding mud rocks which exhibit swelling to some depth)	Stable	NEGLIGIBLE	-	R
Fine-grained soils with moderate to very high plasticity (clays, silty clays, clayey silts and sandy clays)	Expansive Soils	< 7,5 7,5 – 15 15 – 30 > 30	50% 50% 50% 50%	H H1 H2 H3
Silty sands, sands, sandy and gravelly soils	Compressible and Potentially Collapsible Soils	< 5,0 5,0 – 10 > 10	75% 75% 75%	C C1 C2
Fine-grained soils (clayey silts and clayey sands of low plasticity), sands, sandy and gravelly soils	Compressible Soils	< 10 10 – 20 > 20	50% 50% 50%	S S1 S2
Contaminated soils Controlled fill Dolomitic areas Land fill Marshy areas Mine waste fill Mining subsidence Reclaimed areas Very soft silt/silty clays Uncontrolled fill	Variable	Variable		P

Notes:

1. The classifications C, H, R and S are not intended for dolomitic area sites unless specific investigations are carried out to assess the stability (risk of sinkholes and doline formation) of the dolomites. Where this risk is found to be acceptable, the site shall be designated as Class P (dolomitic areas).
2. Site classes are based on the assumption that differential movements, experienced by single-storey residential buildings, expressed as a percentage of the total movements are equal to about 50% for soils that exhibit expansive or compressive characteristics and 75% for soils that exhibit both compressible and collapse characteristics. Where this assumption is incorrect or inappropriate, the total soil movements must be adjusted so that the resultant different movements implied by the table are equal to that which is expected in the field.
3. In some instances, it may be more appropriate to use a composite description to describe a site mote fully e.g. C1/H2 or S1 and/or H2. Composite Site Classes may lead to higher differential movements and result in design solutions appropriate to a higher range of differential movement e.g. a Class R/C1 site. Alternatively, a further site investigation may be necessary since the final design solution may depend on the location of the building on a particular site.
4. Where it is not possible to provide a single site designation and a composite description is inappropriate, sites may be given multiple descriptions to indicate the range of possible conditions e.g. H-H1-H2 or C1-C2.
5. Soft silts and clays usually exhibit high consolidation and low bearing characteristics. Structures founded on these horizons may experience high settlements and such sites should be designated as being Class S1 or S2 as relevant and appropriate.
6. Sites containing contaminated soils include those associated with reclaimed mine land, land down-slope of mine tailings and old land fills.
7. Where a site is designated as Class P, full particulars relating to the founding conditions on the site must be provided.
8. Where sites are designated as being Class P, the reason for such classification shall be placed in brackets immediately after the suffix – i.e. P(contaminated soils). Under certain circumstances, composite description may be more appropriate – e.g. P(dolomite areas)-C1.
9. Certain fills may contain contaminates which present a health risk. The nature of such fill should be evaluated and should be clearly demarcated as such.

Table F12: Foundation design, building procedures and precautionary measures for single-storey residential buildings founded on horizons subject to both consolidation and collapse settlement (SAICE, 1995)

Site Class	Estimated Total Settlement	Construction Type	Foundation Design and Building Procedures
C	**<5** mm	Normal	- Normal construction (strip footing or slab-on-the-ground foundations) - Good site drainage
C1	**5 – 10** mm	Modified normal	- Reinforced strip footings - Articulation joints at some internal and all external doors - Light reinforcement in masonry - Site drainage and service/plumbing precautions - Foundation pressure not to exceed 50 kPa
		Compaction of in situ soils below individual footings	- Remove in situ material below foundations to a depth and width of 1,5 times the foundation width or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at –1% to +2% of optimum moisture content. - Normal construction with lightly reinforced strip foundations and light reinforcement in masonry.
		Deep strip foundations	- Normal construction with drainage requirements. - Founding on a competent horizon below the problem horizon
		Soil raft	- Remove in situ material to 1,0m beyond perimeter of building to a depth and width of 1,5 times the widest foundation or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at –1% to +2% of optimum moisture content. - Normal construction with lightly reinforced strip footings and light reinforcement in masonry.
C2	**>10** mm	Stiffened strip footings, stiffened or cellular raft	- Stiffened strip footing or stiffened or cellular raft with articulation joints or solid lightly reinforced masonry. - Bearing pressure not to exceed 50kPa. - Fabric reinforcement in floor slabs. - Site drainage and service/plumbing precautions.
		Deep strip foundations	- As for C1 but with fabric reinforcement in floor slabs
		Compaction of in situ soils below individual footings	- As for C1.
		Piled or pier foundations	- Reinforced concrete ground beams or solid slabs on piled or pier foundations. - Ground slabs with fabric reinforcement. - Good site drainage.
		Soil raft	- As for C1.

Notes:

1. Differential settlement assumed to equal 75% of total settlement
2. The relaxation of some of these requirements, e.g. the reduction or omission of steel or articulation joints, may result in a Category 2 level of expected damage.

Table F13: Classification of Rock and Soil Strengths (ISRM, 1981b)

Grade	Description	Field identification	Approx. range of uniaxial compressive strength (MPa)
R6	Extremely strong rock	Specimen can only be chipped with geological hammer. UCS testing required.	>250
R5	Very strong rock	Specimen requires many blows of geological hammer to fracture it. UCS testing required.	100-250
R4	Strong rock	Specimen requires more than one blow of geological hammer to fracture it. UCS testing required.	50-100
R3	Medium strong rock	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer.	25-50
R2	Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer.	5.0-25
R1	Very weak rock	Crumbles under firm blows with point of geological hammer and can be peeled by a pocket knife.	1.0-5.0
R0	Extremely weak rock	Indented by thumbnail.	0.25-1.0
S6	Hard clay	Indented with difficulty by thumbnail.	>0.5
S5	Very stiff clay	Readily indented by thumbnail.	0.25-0.50
S4	Stiff clay	Readily indented by thumb nail but penetrated only with great difficulty.	0.1-0.25
S3	Firm clay	Can be penetrated several inches by thumb with moderate effort.	0.05-0.1
S2	Soft clay	Easily penetrated several inches by thumb.	0.025-0.05
S1	Very soft clay	Easily penetrated several inches by fist.	<0.025

NOTES: Discontinuity wall strength will generally be characterized by grades R0-R6 (rock). Some rounding of strength values has been made when converting to SI units (ISRM, 1981b).