GEOTECHNIAL INVESTIGATION REPORT FOR SEWER PIPE BRIDGE IN PAUL ROUX, FREE STATE

MAY 2019

DRAFT

PREPARED FOR:

SELATILE MOLOI CONSULTING ENGINEERS
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GEOTECHNICAL INVESTIGATION REPORT OF SEWER PIPE BRIDGE IN PAUL ROUX, FREE STATE

DATE: APRIL 2019

THIS DOCUMENT WAS COMPILED BY

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QUALITY ASSURANCE ISSUE DATA

Report title:	Geotechnical Investigation Report (FINAL)
Client:	SELATILE MOLOI CONSULTING ENGINEERS
Project Name:	Geotechnical Investigation sewer Pipe Bridge in Paul Roux, Free State
Project Number:	
Revision Number:	00

REVISION HISTORY

Date	Report Status	Written by	Reviewed by	Issued to	
				Name	Institution
25/04/2019	Draft	N. Klaas	W. Badenhorst	N/A	N/A
15/05/2019	Final draft	N. Klaas	W. Badenhorst	R Schaaf	SMCE

SUBMISSION

APPROVED: ____________ **DATE:** 15/05/2019

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EXECUTIVE SUMMARY

Magareng Civil Laboratory was appointed by **SELATILE MOLOI CONSULTING ENGINEERS** to compile a geotechnical investigation report based on the conditions on site. The Investigation was carried out in April 2019.

The following activities were carried out to finalize this report:

- Desktop Study
- Site Visit
- Field mapping
- Soil profiling
- Laboratory testing

The coordinates of the site is 28°18'2.31"S 27°57'32.16"E.

Four (4) test pits were excavated to a depth of 2 meters or shallower refusal and the soil profiles were described according to the standard procedure.

The geological map from the Council for Geosciences indicates that the site is underlain by fine- to medium-grained, yellow and khaki-coloured sandstone, red, purple and green mudstone of the Tarkastad Subgroup as part of the Beaufort Group. The soil horizons consisted of silty, clayey and sandy materials with ferricrete, sandstone, mudstone and dolerite encountered in places. The profiles were recorded in the attached soil profiles included as Annexure A.

Ground water was encountered at a depth of 500mm to 1800mm in all of the test pits.

The potential expansiveness of the material encountered on the site could not be calculated according to the method proposed by Van der Merwe (1964) because the Plasticity Index could not be determined due to the seepage.

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1. INTRODUCTION AND TERMS OF REFERENCE

Magareng Civil Laboratory was appointed by SELATILE MOLOI CONSULTING ENGINEERS to compile a materials report on the proposed sewer bridge in Paul Roux in the Free State Province. The site field investigation was undertaken according to the normal requirements for a pipeline project.

The following aspects were addressed in this report:

1.1 Geology and soil profiles

1.2 Geohydrology

1.3 Engineering properties of soil samples taken

The schedule of services include trial pits (4 for this project), with material classifications (classified according to COLTO/TRH14), grading analysis, Atterberg limits and potential expansiveness of the in-situ material. For the purpose of this study, 4 foundation indicators were sampled with 4 maximum dry density, optimum moisture content and California Bearing Ratio samples.

Table 1: Reference Summary

Description	Quantity	Relevant method or specification
Test Pits Excavated	4 test pits	As per quotation, excavated by hand as TLB broke.
Fieldwork and Sampling	4 samples	Sampled according to TMH 5 with relevance to SAICE Geotechnical Investigations Manual. No deviations were recorded.
Analysis of samples	4 samples	Subjected to analysis according to SANS 3001:2011 GR1, GR3, GR10, GR20, GR30 and GR40
Dynamic Cone Penetration Tests (DCP)	4 tests	As per quotation.
Material Classifications	4 classifications	According to COLTO 1998 and TRH14

Phase 1: Fieldwork, which includes the excavation of 4 Test pits, profiled to at least 2m deep or to shallower refusal for soil profiling and sampling purposes as part of the contract.
Phase 2: Laboratory testing to establish the characteristics of the in-situ materials on site done by **MAGARENG CIVIL LABORATORY (PTY) LTD**

The testing includes:

- Sieve Analysis and Grading
- Moisture content testing
- Atterberg Limits
- Moisture Density Relationship and Californian Bearing Ratio

Phase 3: Assessment Reporting done by N Klaas (Bsc. Civil), which includes the following:

- Geotechnical assessment of the site conditions and recommendations thereon
- Any Precautions to be taken with regards to the geotechnical conditions for the proposed development.
- Other requirements

This report outlines the method of the investigation and describes the geological conditions encountered. The results of the investigation are evaluated and conclusions drawn with regard to the above objectives.

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2. DESCRIPTION OF THE SITE AND ACCESS

Paul Roux is a small town in the Free State province of South Africa that produces poplar wood for the safety match industry. It is situated on the N5 highway just outside Bethlehem. It was named after a well-known Dutch Reformed Church leader – Reverend Paul Roux.

Paul Roux form part of Dihlabeng Local Municipality jurisdiction situated within the Thabo Mofutsanyana District. The site geographical coordinates are 28°18'2.31"S 27°57'32.16"E.

Four (4) test pits were excavated to a depth of 2 meters or shallower encountered underground and the soil profiles were described according to the standard proposed by Jennings, Brink and Williams (1973).

Access to the site is obtained as follows: (Figure 1)

Figure 1: Site Access

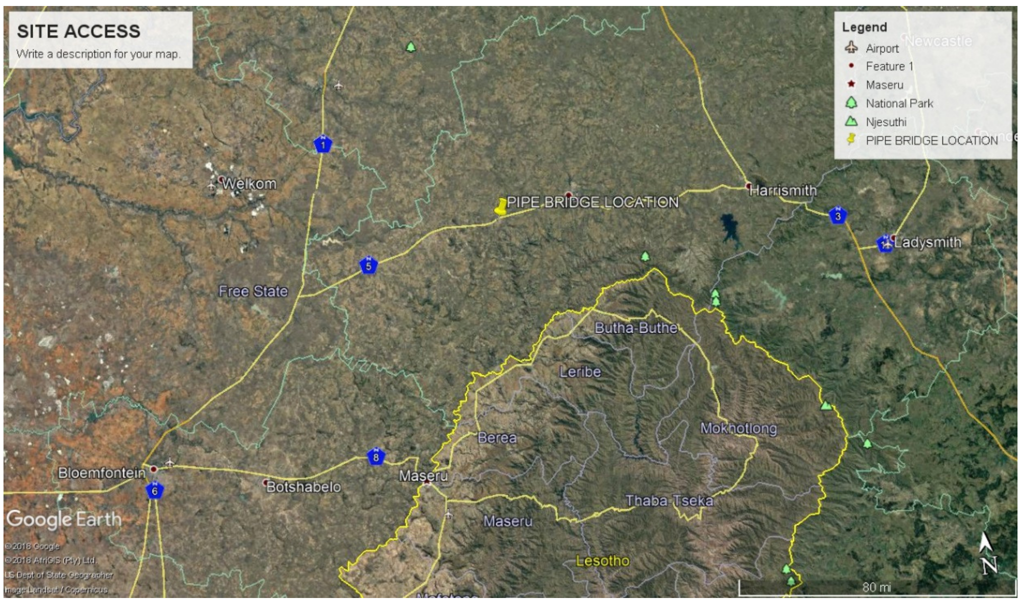
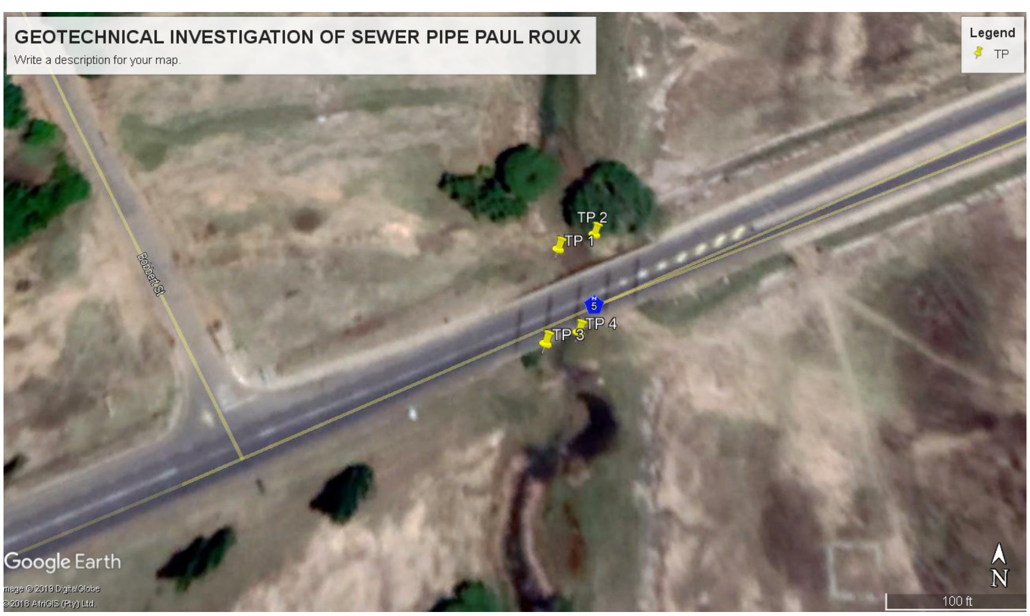


Figure 2: Site Layout Plan



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3. INVESTIGATION PROCEDURE

3.1 DESK STUDY

A desk study involving the perusal of the 1:250 000 geological maps as well as a detailed geological description of the area by Brink (1979) was undertaken to establish broad geological boundaries. Geological information obtained from the Council of Geoscience is depicted in Figure 3 within section 4.1.

3.2 FIELD-WORK

The field-work included the excavation of 4 test pits, TP1 to TP4, across the site, in order to determine the soil formations of the underlying soil and to obtain samples for possible laboratory testing.

The test pits were excavated by hand to a depth of 2 meters or refusal. The test pits positions are indicated on Figure 2. The soil profiling of the 4 test pits was carried out according to the guidelines proposed by Jennings et al (1973). The profile logs of the test pits are given in Appendix A. Soil samples were taken from strategic horizons along the sides of the test pits for laboratory testing (Appendix B).

3.3 LABORATORY TESTING

Soil samples taken during the field-work stage were submitted to the laboratory for the following testing:

a) Foundation Indicator Test: SANS 3001 GR1, GR10
b) Optimum Moisture Content and Maximum Dry Density Test: SANS 3001: GR20 and GR30
c) Californian Bearing Ratio of a Soil Sample: SANS 3001 GR40

The test results are included in Appendix B at the back of the report.

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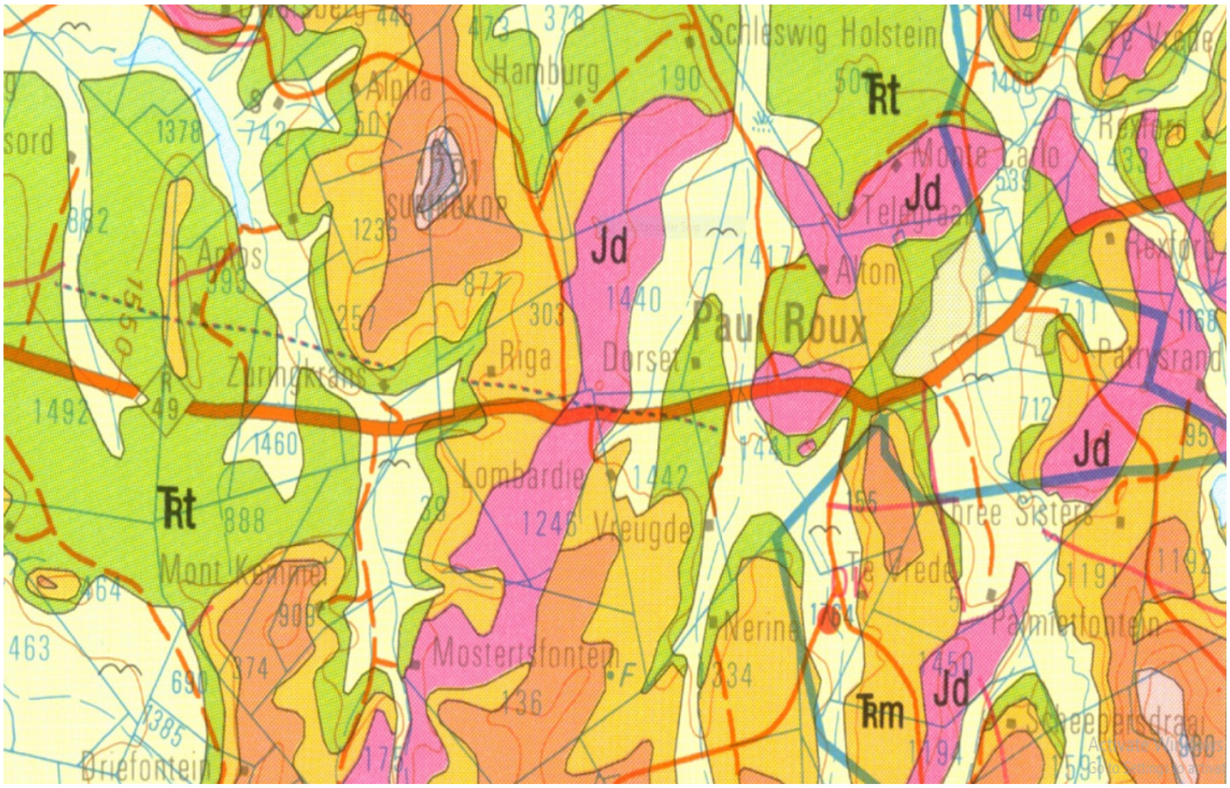
4. SITE GEOLOGY AND CLIMATE

4.1 GENERAL GEOLOGY

The geological map from the Council for Geosciences indicates that the site is underlain by fine- to medium-grained, yellow and khaki-coloured sandstone, red, purple and green mudstone of the Tarkastad Subgroup as part of the Beaufort Group. Post-Karoo dolerite intrusions may be encountered throughout the study area. The soil horizons consisted of silty, clayey and sandy materials with ferricrete, sandstone, mudstone and dolerite encountered in places. The profiles were recorded in the attached soil profiles included as Annexure A.

Figure 2: Geological Map of the Study Area



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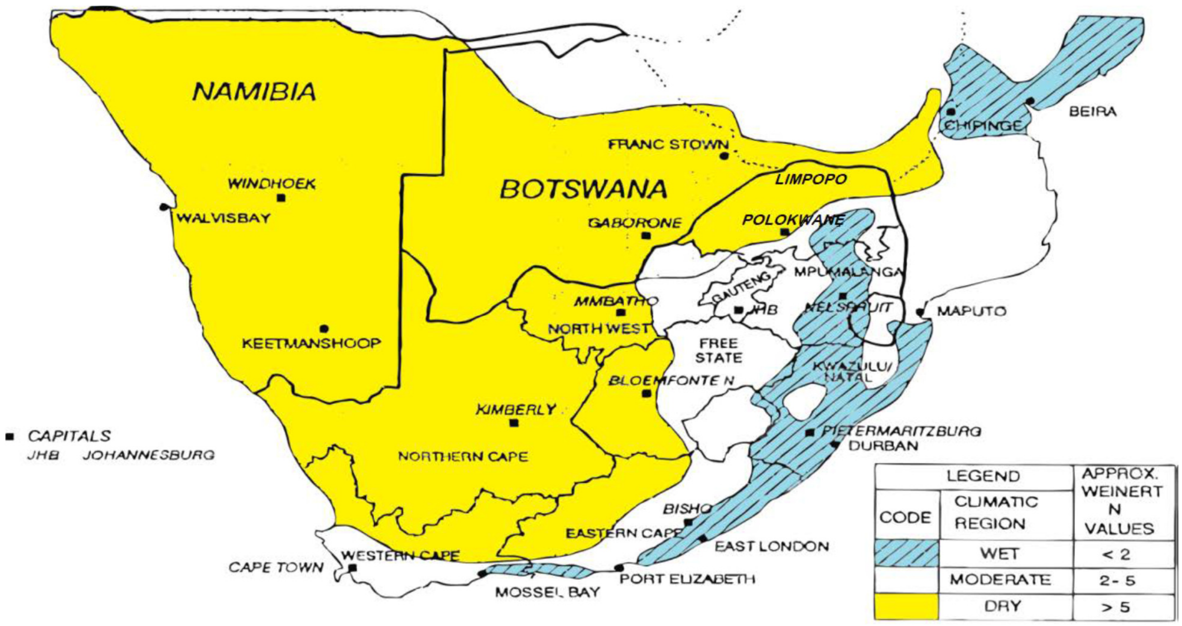
4.2 TOPOGRAPHY, DRAINAGE and SITE CLIMATE

Based on the macro-climatic regions as depicted in Figure 3, the site can be classified as moderate indicating that chemical weathering is the primary weathering mechanism in the warm wet summer periods, while mechanical weathering may be prominent in the cold dry winter periods.

Figure 3: Macro-Climatic Regions of Southern Africa (Adapted from Weinert, 1980)



4.3 GEOHYDROLOGY

Seepage were encountered in all 4 test pits excavated indicating perched water tables due to the low permeabilities of the clayey materials typically encountered in the second and/or third layers in the soil profiles. It may also be due to the low permeability of bedrock encountered at depths ranging from 500mm to 1800mm.

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5. SUMMARY OF LABORATORY RESULTS

Table 2: Summary of Laboratory Results

TEST PIT	DEPTH (mm)	MATERIAL DESCRIPTION	PLASTICITY INDEX	PASSING 0.425mm	PASSING 0.075mm	GRADING MODULUS	LIQUID LIMIT	MAXIMUM DRY DENSITY	OPTIMUM MOISTURE CONTENT	CBR AT 95% MOD AASHTO
1	980	Light Brown calcrete + sand	8.13	22	22.46	2.5154	26.24	1934	9.9	25
2	1100	River Sand	NP	87	36.34	0.8666	NP	1991	9.7	21
3	1200	Light brown, calcrete + Dolerate stone	NP	63	22.17	1.4283	NP	2139	7.7	21
4	1050	Light brown, calcrete + sand	NP	35	50.28	2.0272	NP	1839	14.7	26

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The relevant engineering characteristics of the materials encountered have been evaluated by visual assessment during profiling and from the results of the field and laboratory testing; these may be summarized as follows:

5.1 POTENTIAL EXPANSIVENESS

The potential expansiveness of the materials encountered on the site was calculated according to the method proposed by Van der Merwe (1964). The following material characteristics are considered when applying this method:

- Clay content
- Plasticity index
- Liquid limit
- Linear shrinkage

The method of Van der Merwe (1964) was used to determine the potential heave of soil samples. In addition to Van der Merwe's method, the plasticity index and linear shrinkage of soil samples were used to indicate the soils potential expansiveness. From the laboratory test results the potential expansiveness of all soils on the site is as follows:

Table 3 : Estimated Potential Heave

Test Pit	Depth (mm)	Plastic Index	Passing 0.045mm	Heave Potential	Estimated Heave (mm)
1	980	8.13	22	Low	0
2	1100	NP	87	N/A	N/A
3	1200	NP	63	N/A	N/A
4	1050	NP	35	N/A	N/A

Low expansive encountered in Test Pit 1. The expansiveness could not be calculated for other Test Pits because the Plastic Index could not be determined.

Based on Van der Merwe's method (1964) heaving clays are considered to be a geotechnical constraint on site. Heaving clays may lead to significant upwards forces which may have an adverse effect on the proposed pipelines. Clayey materials should not be used for backfilling, bedding or blanket materials and should be cut to spoil in-so-far economically feasible.

The site classes are as indicated in Table 5, Section 7.1 of this report.

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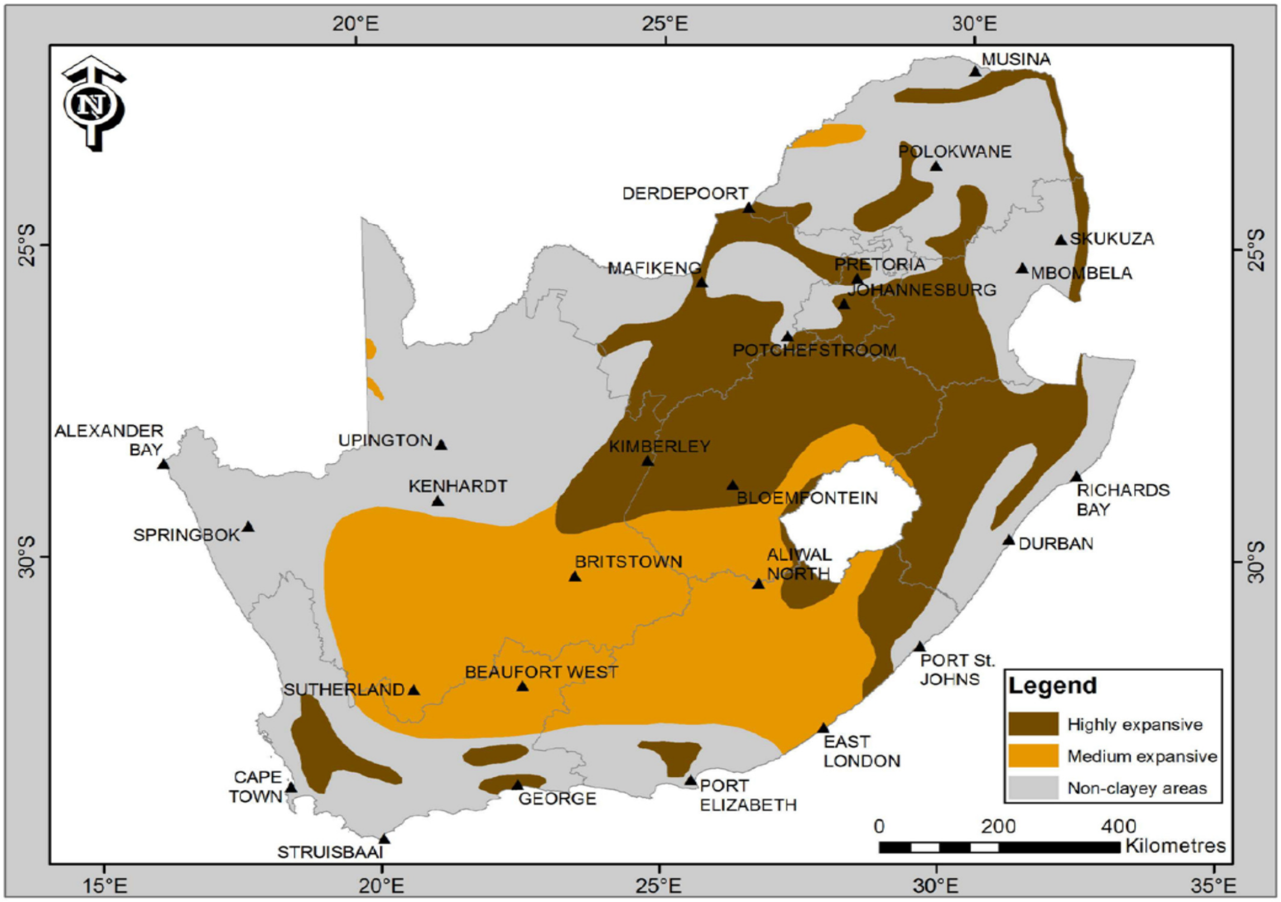
Figure 4: Regional Distribution of Expansive Clays



5.2 EXCAVATION CLASSIFICATION

Excavatibility is defined as the ease with which the ground can be dug to a depth of 1,5m. This is of importance for urban development as increased costs are associated with installing services or foundations in areas where difficulty is experienced during the investigation stage.

Generally the excavations on site can be described as **soft to intermediate** with an average depth of 1.082m being reached by hand.

In terms of the SABS 1200 the excavations can be classified as soft to intermediate to 1meter in depth where after it becomes intermediate to hard.

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5.3 ERODABILITY

The erosion of soils is a function of the resistance of slope materials to entrainment and transport, and the potential of slope processes that promotes erosion. The resistance of soil to erosion is also related to the mechanical strength, cohesion and particle size of the material self. There were signs of piping (erosion) on Test Pit 3.

5.4 GROUND SLOPE STABILITY

This refers to an area comprising unstable geological materials that can move either gradually (creep) or suddenly as a slump or a slide. The risk of movement is determined by factors such as the nature of the slope (solid rock, colluvial material), gradient of slope, role of water, type and nature of vegetation cover, seismicity and impact of human activities such as undermining of a slope. No such characteristics were observed during the investigation. The site and the gradient of slope are gentle and relatively flat. No unstable geological materials that can move either gradually (creep) or suddenly as a slump or a slide are visually present.

5.5 CALIFORNIA BEARING RATIO TEST

California Bearing Ratio (CBR) Tests were conducted to determine the estimated ultimate bearing capacity of the saturated material. This serves as a relatively conservative estimation of the bearing capacity of the in-situ material under the worst expected conditions with the assumption that naturally consolidated materials, especially those with overburden in excess of 500mm, will have the same (or higher) degree of consolidation than a MOD AASHTO of 95%.

A paper by W.P.M Black titled “The Calculation of Laboratory and In-situ Values of California Bearing Ratio from Bearing Capacity Data” indicates that the CBR values of material are roughly 10% of the ultimate bearing capacity (q_u) of the material. In the paper W.P.M Black suggests using a lower factor in order to obtain more conservative values.

The CBR values can be summarised as follows:

Table 4: Estimated Ultimate Bearing Capacity (q_u)

Test Pit	Depth (mm)	CBR value at 95% MOD AASHTO	ESTIMATED BEARING CAPACITY (kPa)
1	980	25	212.5
2	1100	21	178.5
3	1200	21	178.5
4	1050	26	221.0

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6. GEOTECHNICAL CONSIDERATIONS

6.1 ENGINEERING USE OF IN-SITU MATERIALS

It is not recommended to use the in-situ materials for bedding or blanket materials. Control testing should be conducted to exercise process control on the materials used for backfilling.

6.2 FLOOD LINE

An exact flood-line should be determined, but in this report it is suggested that 1:50 year flood line is adopted.

6.3 GENERAL

As the area is characterized by a potentially expansive material, good control and drainage of storm water runoff must be ensured to minimize ponding and ingress of water in the bedding profile. Moisture is often the trigger mechanism for swell in heaving soils and ingress of water can lead to significant differential heave and thus the following additional precautions should also be considered:

a) Discharge of storm water/surface water in lined channels;

- It is recommended that site conditions be re-assessed once layout, invert levels and pipe diameters are finalized and where necessary additional geotechnical investigation be undertaken, especially if the material encountered on site varies from those described in this report.
- Please take note that although due care was taken to ensure an accurate and thorough report reflecting on the areas indicated by the design team the report is only applicable to the samples tested and the evaluations made by the on-site team.

- It should be noted that the surrounding area is associated with heaving clays, as is evident in the test results. Care should be taken with the in-situ materials. It is recommended that as much of the in-situ material as is economically feasible be removed from the site and backfilled with inert material, according to the design engineers' specifications.

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LIST OF APPENDICES

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APPENDIX A:

Soil Profile Sheets

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PAUL ROUX GEOTECH Investigation

Magareng Civil Laboratory

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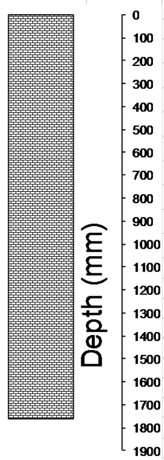
South Africa
Mobile: 078 365 9862

Test Pit : 1 **Coordinates:** 0 **Date Profiled:** 04/03/2019

CLIENT: SELATILE MOLOI CONSULTING ENGINEERS **Starting Depth:** 0mm
PROJECT: PAUL ROUX GEOTECH **End Depth:** 1760mm



0 - 1760mm	Moist Dark brown calcrete +sand
+ 1760mm	Underground Water

Disturbed Samples:
Sample HP01 taken at mm.

PAUL ROUX GEOTECH Investigation

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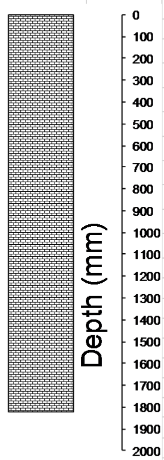
Test Pit : 2 **Coordinates:** 0 **Date Profiled:** 04/03/2019

CLIENT: SELATILE MOLOI CONSULTING ENGINEERS **Starting Depth:** 0mm
PROJECT: PAUL ROUX GEOTECH **End Depth:** 1820mm



0 - 1820mm	Moist Light brown calcrete +sand
+ 1820mm	Underground Water

Disturbed Samples:
Sample HP01 taken at mm.

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PAUL ROUX GEOTECH Investigation

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South Africa
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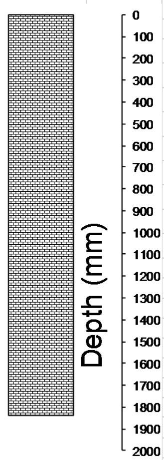
Test Pit : 3 **Coordinates:** 0 **Date Profiled:** 04/03/2019

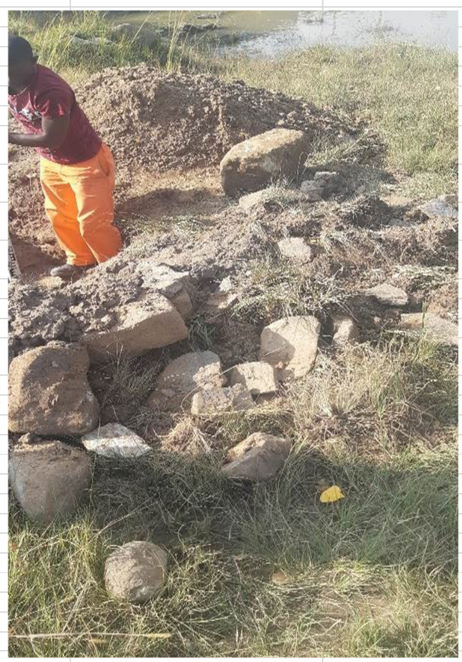
CLIENT: SELATILE MOLOI CONSULTING ENGINEERS **Starting Depth:** 0mm
PROJECT: PAUL ROUX GEOTECH **End Depth:** 1838mm



0 - 1838mm Moist Light brown calcrete + Dolerate stone

+ 1838mm Underground Water

Disturbed Samples:
Sample HP01 taken at mm.



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PAUL ROUX GEOTECH Investigation

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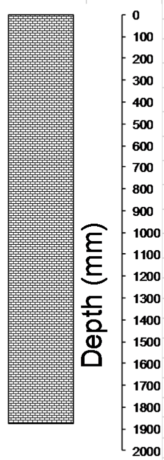
Test Pit : 4	**Coordinates:**	**Date Profiled:**	04/03/2019
CLIENT:	SELATILE MOLOI CONSULTING ENGINEERS	**Starting Depth:**	0mm
PROJECT:	PAUL ROUX GEOTECH	**End Depth:**	1875mm



0 - 1875mm	Moist Dark brown calcrete +sand
+ 1875mm	Underground Water

Disturbed Samples:
Sample HP01 taken at mm.

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APPENDIX B:

Laboratory Test Results

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Magareng Civil Laboratory		Project :	Geotechnical Investigation of Sewer Pipe Bridge Paul Roux			Lab No:	
						Client No :	MCL/SMCE/19
						Date :	30-Apr-19
Km :			GPS XY Coordinates :				
					South	East	Elevation
Layer :		1	1	1	1		
Material description :		Dark Brown Calcrete + Sand	Light Brown Calcrete + Sand	Light Brown Calcrete + Dolerate Stone	Light Brown Calcrete + Sand		
Depth :		980	1100	1200	1050		
Chainage:							
Test Point:		1	2	3	4		
Thickness mm :							
Rd/Sec/BP :							
Indication of stabilisation :	PHTH						
	HCL						
Sieve Analysis SANS 3001 GR1-3	75.0			95			
	63.0			93			
	50.0	31		90			
	37.5		100	86			
	28	79	100	85			
	20.0	74	99	82			
	14	12	95	80			
	5	8	92	76	4		
	2.00	4	90	72	12		
	0.425	22	87	63	35		
	0.075	22.46	36.34	22.17	50.28		
Soil Mortar %	2.0 - 0.425	22	87	63	96		
	0.425 -0.300	2.31	83.17	57.61	94.1		
	0.300 -0.150	13.03	61.9	38.65	84.49		
	0.150 -0.075	22.46	36.34	22.17	50.28		
	<0.075						
Atterberg limits % SANS 3001 GR10	GM	2.5154	0.8666	1.4283	2.0272		
	LL	26.24	NP	NP	NP		
	LS	4	NP	NP	NP		
	PI	8.13	NP	NP	NP		
California bearing Ratio % SANS 3001GR40	100%	55	53	56	59		
	98%	40	36	38	43		
	97%	34	30	31	36		
	95%	25	21	21	26		
	93%	18	15	14	19		
	90%	11	8	8	12		
Swell %	@ 100 %	2.19	0	0	0		
	@ 95 %	2.27	0	0	0		
	@ 90 %	2.39	0	0	0		
MDD SANS 3001 GR30&31	kg/m³	1934	1991	2139	1828		
OMC SANS 3001 GR30&31	%	9.9	9.7	7.7	14.7		
UCS cPa SANS 3001 GR	100%						
	98%						
	97%						
	95%						
ITS cPa	100%						
	98%						
	97%						
	95%						
Insitu Moist cont. %							
COLTO	G-Class						
Remarks :						Date :	30-Apr-19
						Technician :	T. MAGILE

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APPENDIX C:

Dynamic Cone Penetrometer (DCP)

Magareng Civil Laboratory

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Magareng Civil Laboratory	Project :	PAUL ROUX GEO	Lab No:	
	Rd name / No :		Client No :	MCL006
	Section from :		Date :	5/4/2019

DYNAMIC CONE PENETROMETER (DCP)

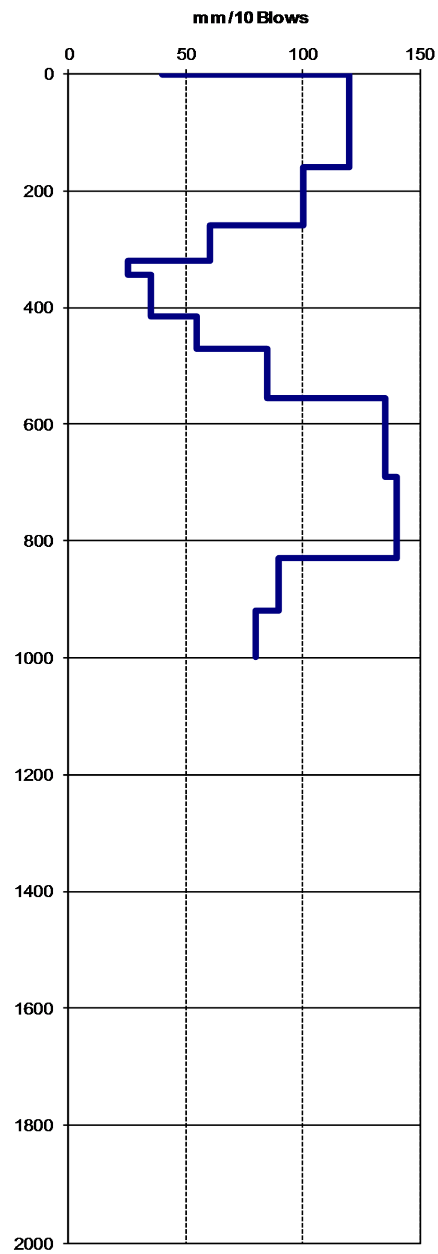
TMH 6 Method ST6

DCP No.	1	**Site**	
Chainage:		**Layer type**	
Offset:		**Carriageway**	

Field Data / **Resolved Parameters**

Depth Gnd Level (mm)	Interval (mm)	Blows	DPI (mm/Blow)	CBR (%)
40	0			
160	120	10	12.0	17
260	100	10	10.0	22
320	60	10	6.0	42
345	25	10	2.5	>110
380	35	10	3.5	84
415	35	10	3.5	84
470	55	10	5.5	47
555	85	10	8.5	27
690	135	10	13.5	15
830	140	10	14.0	14
920	90	10	9.0	25
1000	80	10	8.0	29

Layer Summary



REMARKS		Tech :
		Date :

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Magareng Civil Laboratory

Project :	PAUL ROUX GEO	Lab No:	
Rd name / No :		Client No :	MCL006
Section from :		Date :	30-Apr-19

DYNAMIC CONE PENETROMETER (DCP)

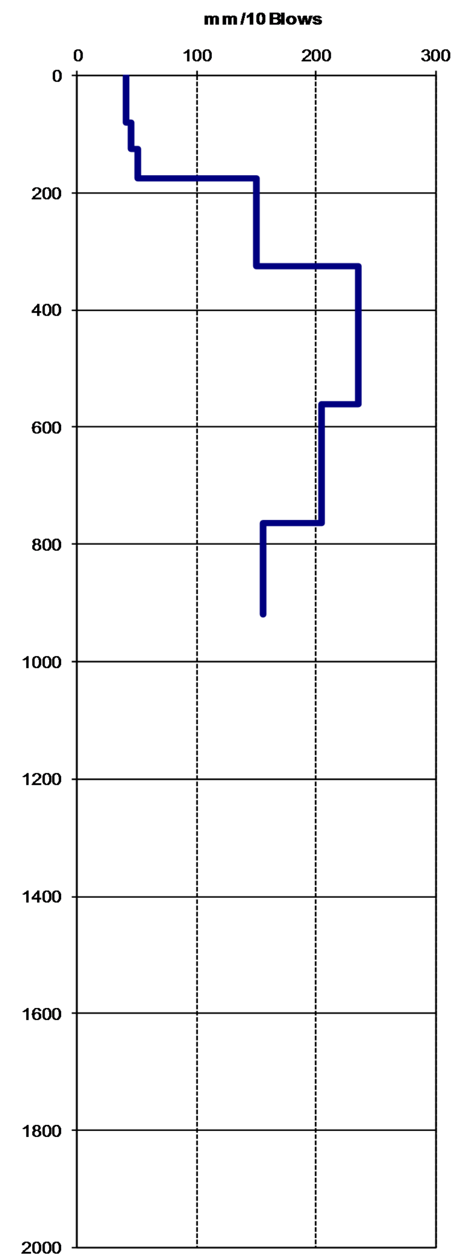
TMH 6 Method ST6

DCP No.	2	**Site**	
Chainage:		**Layer type**	
Offset:		**Carriageway**	

Field Data / **Resolved Parameters**

Depth Gnd Level (mm)	Interval (mm)	Blows	DPI (mm/Blow)	CBR (%)
40	0			
80	40	10	4.0	70
125	45	10	4.5	61
175	50	10	5.0	53
325	150	10	15.0	13
560	235	10	23.5	7
765	205	10	20.5	9
920	155	10	15.5	13

Layer Summary



REMARKS

Tech :

Date :

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Magareng Civil Laboratory

Project :	PAUL ROUX GEO	Lab No:	
Rd name / No :		Client No :	MCL006
Section from :		Date :	30-Apr-19

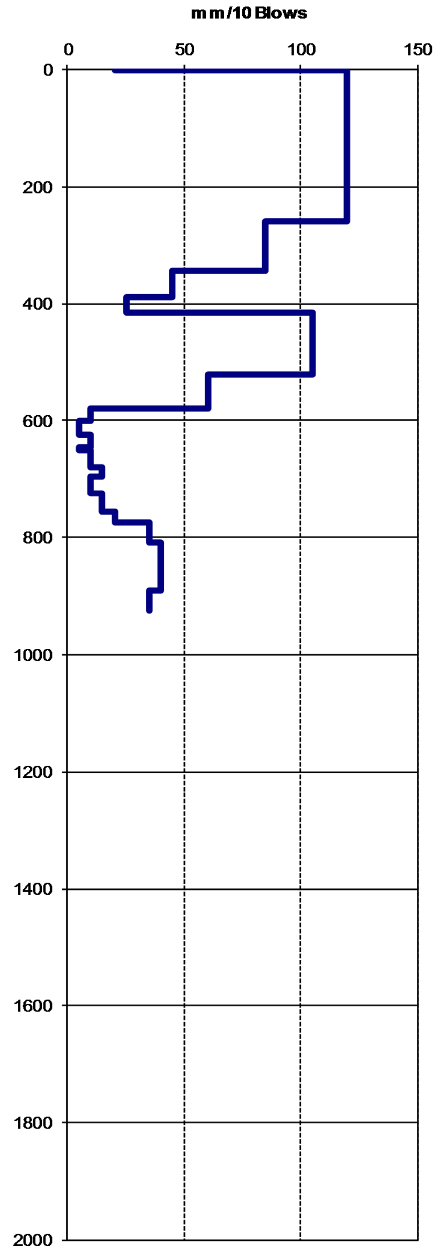
DYNAMIC CONE PENETROMETER (DCP)

TMH 6 Method ST6

DCP No.	3	Site	
Chainage:		Layer type	
Offset:		Carriageway	

Field Data / Resolved Parameters / Layer Summary

Depth Gnd Level (mm)	Interval (mm)	Blows	DPI (mm/Blow)	CBR (%)
20	0			
140	120	10	12.0	17
260	120	10	12.0	17
345	85	10	8.5	27
390	45	10	4.5	61
415	25	10	2.5	>110
520	105	10	10.5	21
580	60	10	6.0	42
590	10	10	1.0	>110
600	10	10	1.0	>110
605	5	10	0.5	>110
610	5	10	0.5	>110
615	5	10	0.5	>110
620	5	10	0.5	>110
625	5	10	0.5	>110
635	10	10	1.0	>110
645	10	10	1.0	>110
650	5	10	0.5	>110
660	10	10	1.0	>110
670	10	10	1.0	>110
680	10	10	1.0	>110
695	15	10	1.5	>110
705	10	10	1.0	>110
715	10	10	1.0	>110
725	10	10	1.0	>110
740	15	10	1.5	>110
755	15	10	1.5	>110
775	20	10	2.0	>110
810	35	10	3.5	84
850	40	10	4.0	70
890	40	10	4.0	70
925	35	10	3.5	84



REMARKS

Tech :

Date :

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Magareng Civil Laboratory	Project :	PAUL ROUX GEO	Lab No:		
	Rd name / No :		Client No :	MCL006	
	Section from :		Date :	30-Apr-19	

DYNAMIC CONE PENETROMETER (DCP)

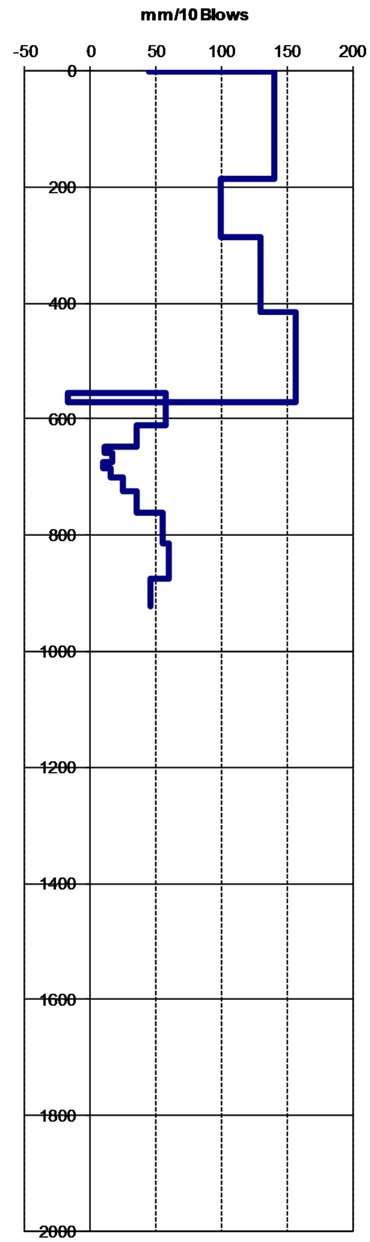
TMH 6 Method ST6

DCP No.	**4**	**Site**	
Chainage:		**Layer type**	
Offset:		**Carriageway**	

Field Data / **Resolved Parameters**

Depth Gnd Level (mm)	Interval (mm)	Blows	DPI (mm/Blow)	CBR (%)
45	0			
185	140	10	14.0	14
285	100	10	10.0	22
415	130	10	13.0	16
572	157	10	15.7	12
555	-17	10	-1.7	>110
612	57	10	5.7	45
647	35	10	3.5	84
658	11	10	1.1	>110
675	17	10	1.7	>110
685	10	10	1.0	>110
700	15	10	1.5	>110
725	25	10	2.5	>110
760	35	10	3.5	84
815	55	10	5.5	47
875	60	10	6.0	42
921	46	10	4.6	59

Layer Summary



REMARKS		Tech :	
		Date :	

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