i. INTRODUCTION

SASA Engineering Civil Material Testing Lab was appointed by Mr S.O Zulu to conduct a geotechnical investigation at the proposed oNkweni Filling Station which is situated in Ulundi Local Municipality under Zululand District Municipality, KwaZulu Natal.

The objective of the investigation was to establish the nature and engineering properties of the underlying soil. As well as to assess the suitability of the proposed areas, from a geotechnical perspective, and give an overview of the founding conditions for the proposed oNkweni Filling Station.

In total, two (2) trial pits were excavated, as directed by oNkweni Filling Station representative, Mr S.O Zulu. All test pits were profiled to a maximum permissible depth of 2100mm. Two (2) Dynamic Cone Penetration tests were carried out to a maximum permissible depth of 1360mm. Six (6) samples were collected from the two (2) trial pits and sent to SASA Engineering's testing lab for analysis.

It must be noted that the interpretation of the overall subsurface conditions across the site is inferred from the interpolation and extrapolation of point information assimilated from the various test positions. In the unlikely event of significant variations from the inferred conditions becoming apparent during subsequent phases of the project then these must be referred to a geotechnical professional for verification.

ii. SITE DESCRIPTION

The site is located in the area of Ward 1 Ulundi Local Municipality under Zululand District Municipality. The proposed oNkweni Filling Station is found approximately 40km south west of the town of KwaNongoma at Mantungwini Isigodi under the Induna Dhlamini in KwaZulu Natal, which is a commercial site.

Site Adresses:

Postal Address
P O Box 356
Nongoma
3950

Address Of Registered Office
Mantungweni Reserve
Ward 1 ULundi Municipality
Mahlabathini
Kwa-Zulu Natal
3865

Topographically, the trial areas are located on a semi-grass covered land that has a gradual south east slope. Please see Annexure E for the site topography.

iii. SITE INVESTIGATIONS

The site investigation was carried out on 19 November 2018, in order to investigate the nature and engineering properties of the underlying soil. This involved:

- The excavation of two trial pits, with the use of a TLB, to the maximum permissible depth of 2100mm and the collection of six samples
- The completion of two Dynamic Cone Penetration (DCP)
- The profiling of two trial pits

Trial Pits

Two trial pits were profiled to a maximum permissible depth of 2100mm. The side walls of all the trial pits were excavated vertically and there was no evidence of any potential collapse within these sidewalls during the logging process of concern. This indicates that the material encountered on all of the trial pits was not too coarse.

The trial pits were profiled in accordance with the standard method of profiling recommended by the Guidelines for Soil and Rock Logging in South Africa. The trial pit profiling is presented as Annexure A.

Table 1 below gives the GPS location of the two trial pits profiled at the proposed Onkweni Filling Station.

TABLE 1

TP No.	LATITUDE	LONGITUDE	ELEVATION (mamsl)
TP1	S27° 56' 49.20"	E31° 29' 58.10"	381.00
TP2	S27° 56' 47.94"	E31° 29' 57.40"	382.52

Dynamic Cone Penetration Testing (DCP)

Two DCP tests were conducted adjacent to the above-mentioned trial pit areas. The DCP tests were conducted to a maximum permissible depth of 1360mm below existing surface. The results are presented as Annexure B.

Table 2 gives an indication of the consistency of the non-cohesive and cohesive soils according to the DCP results. It should be noted that the results are specific to our testing equipment and should be used with caution as it is only provided as a guideline.

TABLE 2

Consistencies of Cohesive and Non-Cohesive Soils

COHESIVE SOILS CLAYEY SANDS		NON-COHESIVE SOILS SANDY COLLUVIUM	
No. of blows/300mm	**Consistency**	**No. of blows/300mm**	**Consistency**
0 - 4	Very Soft	0 – 7	Very Loose
4 - 7	Soft	7 – 18	Loose
8 - 14	Firm	19 – 54	Medium Dense
15 - 28	Stiff	55 – 90	Dense
29 - 54	Very Stiff	>90	Very Dense
>54	Hard		

Material Sampling

Representative disturbed samples were retrieved from the trial pits excavated. These samples were taken to SASA Engineering Civil Material Testing Lab for full indicator analysis. This included: sieve analysis, mechanical analysis, the determination of the atterberg limits and California Bearing Ratio analysis. The laboratory soil test results are reported as Annexure C.

iv. GEOTECHNICAL CONSIDERATIONS

Excavatability

In terms of SANS 1200DA

'Soft excavation' shall be excavation in material that can be efficiently removed and loaded without prior ripping.

'Intermediate excavation' shall be excavation (excluding soft excavation) in material that can be efficiently ripped.

'Hard rock' excavation shall be excavation in material that cannot be efficiently removed without blasting or without wedging and splitting before removal.

Table 3 below gives the excavatability of the materials encountered at certain depths.

TABLE 3

TEST PIT NR	DEPTH (mm)	EXCAVATABILITY	MATERIAL DESCRIPTION (as per DCP results)
1	0 – 995	Soft Excavation	Loose Material
	995 – 1195	Intermediate Excavation	Medium Dense Material
	1195 ≥	Hard Rock	Very Dense Material
2	0 – 1030	Soft Excavation	Loose Material
	1030 – 1350	Intermediate Excavation	Dense Material
	1350 ≥	Hard Rock	Very Dense Material

Subsurface Water Conditions

Subsurface Water

At the time of the investigation, subsurface water seepage was not encountered in any of the Trial Pits. Moist conditions were prevalent on the two trial pits. (Refer to Annexure A & D)

Existing Layer Conditions

In order to assess more accurately the engineering properties of the various materials encountered on site and to provide information on their potential behaviour below foundations. The following results were obtained from the retrieved disturbed samples of the trial pits that were investigated. The pertinent test parameters are summarised and the soils classified in terms of the TRH 14 Guidelines for Construction Materials. These are as follows:

TABLE 4

TP	MAT. DEPTH (mm)	SHORT MATERIAL DESCRIPTION	GM	% SILT & CLAY	% LL	% PI	CBR DATA	MOD (kg/m³)	TRH14 CLASS
TP 1	0 – 300	Light brown sandy gravel	1.77	25.9	N/P	N/P	-	-	-
	1100 – 1600	Dark brown rocky shale	2.07	16.9	N/P	N/P	-	-	-
	1600 – 2100	Dark brown red sandstone	2.08	17.0	N/P	N/P	15 @ 93%	2160	G7
TP 2	400 – 900	Light grey sandy gravel	1.81	25.2	N/P	N/P	9 @ 93%	2020	G9
	900 – 1600	Dark grey red laterite	1.75	23.7	N/P	N/P	-	-	-
	1600 – 1700	Dark brown shale	2.10	17.2	N/P	N/P	-	-	-

GM – Grading Modulus
LL – Liquid Limit
PI – Plasticity Index
S/P – Slightly-Plastic
N/P – Non-Plastic

Existing Layer Assessment

Having investigated the Trial Pits and classified the material according to the TRH 14 Manual through laboratory testing. The site classes as per the NHBRC Manual are indicated on table 5 below. We advise that the structural engineer assess and consider the foundation recommendations below.

TABLE 5

TP	SITE CLASS	CHARACTER OF FOUNDING MATERIAL	MATERIAL DESCRIPTION	CONSTRUCTION TYPE	FOUNDATION DESIGN AND BUILDING PROCEDURES
1 (1,6-2,1m)	C1	Compressible & Potentially Collapsible Soil	Soils are subjected to consolidation and collapse settlement	Soil raft	Remove insitu material to 1.0m beyond the perimeters of the structure to a depth 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 reinforced strip footing.
2 (1,6-1,7m)	C1	Compressible & Potentially Collapsible Soil	Soils are subjected to consolidation and collapse settlement	Soil raft	Remove insitu material to 1.0m beyond the perimeters of the structure to a depth 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 reinforced strip footing.

Table 6 below gives the materials that the engineer can consider reusing either as base, subbase or selected layer material.

TABLE 6

TP No	MATERIAL DEPTH (mm)	BASE MATERIAL	SUBBASE MATERIAL	SELECTED LAYER MATERIAL	SUBGRADE
1	1600 - 2100			✓	
2	400 - 900				✓

v. GEOLOGY

According to the 2731 CD St. Lucia, 1:250 000 Geological Map Series, the general area within which the site is located is underlain by sandstone, shale, siltstone and dolerite sediments. From the available literature as well as the observations during the site investigation, it is apparent that the area is underlain by sandstone, shale and siltstone that belong to the Karoo Supergroup that is estimated to be 180 – 300 million years.

Generally these rocks will decompose insitu, forming residual soils that may be silty. These soils are often blanketed by a considerable thickness of transported soils of colluvial and alluvial origin that consist of silty sands.

Traces of sandy laterite were also found during the investigation. Laterites are formed from the leaching of parent sedimentary rock sandstones. A simplified geological map has been attached as Annexure F.

vi. CONCLUSION

The investigation undertaken has established the various founding conditions and material types that are likely to be encountered during the construction of the proposed structure. Two areas were assessed of the likely material to be encountered in the near approximation and their mechanical properties.

Table 4 displayed the degree of plasticity in the soil samples that were extracted from the trial pit areas. To note is the low plasticity found in the soil samples extracted from both trial pits. A minimal degree of movement can be expected as the soil expends or contracts in the case the soil is exposed to precipitation from the rain or over drying from the sun.

Table 5 gives the site class and proposed construction method as advised by the NHBRC. The finding recorded in table 5 are to be considered by a structural engineer when designing of the foundations. Dead loads and live loads that are anticipated will have to be catered for by a nominated structural engineer where the design will also consider, in conjunction, the suggestions made on table 5.

Suitable founding depths are to be on hard materials encountered, as per Annexure B (DCPs'). Hard sandstone material was encountered at a depth of 2100mm on trial pit no.1. Hard shale material was encountered at a depth of 1700mm on trial pit no.2 below the natural ground level respectively. Soft material can be anticipated from the natural ground level to a depth of approximately 1000mm in both trial pits. Should foundations require to be found on other material apart from the hard material depths as noted above, the soft materials must be modified to an average depth of 1400mm. This must be undertaken with the advice from an engineer.

Please note that the above site classifications are not intended for dolomitic areas. We hope that this report meets your requirements. Please do not hesitate to contact us should you have any queries.

Kindest Regards

For SASA Eng.:

ANNEXURE A
TRIAL PIT PROFILES

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Fax: 034 312 8887

Client	**Sphamandla Zulu**
Project	**Onkweni Filling Station**
Job Card No.	-
Date	**19-11-2018**
Technician	**Mr S Mathobela**
Position	**Test Pit No.1**
Coordinates	**S27°56′49.2" E031°29′58.1"**

FIELD SOIL SURVEY TEST REPORT

Soil Legend	**Depth (mm)**	**Description** **Moisture, Colour, Consistency, Structure, Soil Type (MCCSSO)**	**Origin (Residual & Transported)**
0 0 0 0 0 0 ~~~~~~~~ 0 0 0 0 0 0 ~~~~~~~~	0 - 300	Moist, White Light Brown, Firm, Soft, Sandy Gravel	Residual
¥ ¥	300 - 1100	Moist, Dark Brown Red, Firm, Hard, Soft Shale And Sand	Residual
¥ ¥ ¥ ¥ ¥ ¥ ¥ 0 0 0 0 0 0 ¥ ¥ ¥ ¥ ¥ ¥ ¥ 0 0 0 0 0 0 ¥ ¥ ¥ ¥ ¥ ¥ ¥ 0 0 0 0 0 0	1100 - 1600	Moist, Dark Brown, Firm, Hard, Rocky Shale	Residual
0 0 0 0 0 0 ~~~~~~~~ 0 0 0 0 0 0 ~~~~~~~~ 0 0 0 0 0 0 ~~~~~~~~	1600 - 2100	Moist, Dark Brown Red, Firm, Hard, Rocky Sandstone	Residual
0 0 0 0 0 0 ~~~~~~~~ 0 0 0 0 0 0 ~~~~~~~~ 0 0 0 0 0 0 ~~~~~~~~	2100>	Hard, Sandstone	Residual

For SASA Eng.: ____________

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Client	**Sphamandla Zulu**
Project	**Onkweni Filling Station**
Job Card No.	**-**
Date	**19-11-2018**
Technician	**Mr S Mathobela**
Position	**Test Pit No.2**
Coordinates	**S27°56´47.94" E031°29´57.40"**

FIELD SOIL SURVEY TEST REPORT

Soil Legend	Depth (mm)	Description	Origin (Residual & Transported)
		Moisture, Colour, Consistency, Structure, Soil Type (MCCSSO)	
√ √	0 - 400	Moist, Dark Grey, Firm, Soft, Top Soil	Residual
o o o o o o o o o o o o o o o o o o	400 - 900	Moist, Light Grey, Firm, Soft, Sandy Gravel	Residual
xxxxxxxxxxxxxx xxxxxxxxxxxxxx xxxxxxxxxxxxxx xxxxxxxxxxxxxx xxxxxxxxxxxxxx xxxxxxxxxxxxxx xxxxxxxxxxxxxx xxxxxxxxxxxxxx xxxxxxxxxxxxxx xxxxxxxxxxxxxx xxxxxxxxxxxxxx xxxxxxxxxxxxxx xxxxxxxxxxxxxx xxxxxxxxxxxxxx	900 - 1600	Moist, Dark Grey Red, Firm, Hard, Laterite	Residual
¥ ¥ ¥ ¥ ¥ ¥ ¥ ¥ ¥ ¥ ¥ ¥ ¥ ¥	1600 - 1700	Moist, Dark Brown, Firm, Hard, Shale	Residual
¥ ¥ ¥ ¥ ¥ ¥ ¥ ¥ ¥ ¥ ¥ ¥ ¥ ¥	1700>	Hard, Shale	Residual

For SASA Eng.: _____

ANNEXURE B
DYNAMIC CONE PENETRATION TEST RESULTS

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DYNAMIC CONE PENETROMETER (DCP)

Test Method TMH 6 – Method ST6

Client : Sphamandla Zulu
Project : Onkweni Filling Station
Position/ Km: TP1

Date Tested: 19-11-2018
Job Number: -

Number of blows	Penetration Readings (Fieldwork- mm)	Penetration (Depth- mm)	Cumulative Penetration (depth – mm)	Calculated Penetration (mm / blow)	In-situ CBR
0	20	0	0	-	-
5	240	220	220	44.0	4
10	330	90	310	18.0	11
15	380	50	360	10.0	22
20	410	30	390	6.0	45
25	470	60	450	12.0	18
30	550	80	530	16.0	13
35	680	130	660	26.0	7
40	770	90	750	18.0	11
45	825	55	805	11.0	20
50	875	50	855	10.0	22
55	925	50	905	10.0	22
60	970	45	950	9.0	25
65	1015	45	995	9.0	25
70	1035	20	1015	4.0	75
75	1070	35	1050	7.0	35
80	1105	35	1085	7.0	35
85	1135	30	1115	6.0	45
90	1165	30	1145	6.0	45
95	1185	20	1165	4.0	75
100	1195	10	1175	2.0	110
105	1210	15	1190	3.0	110
110	1215	5	1195	1.0	110
115	1215	0	1195	0.0	110
120	1215	0	1195	0.0	110

Remarks: The above DCP test shows that the DCP had no difficulty when penetrating through the top layers. Between the depth of 0 - 995mm the layers are soft and this is indicated by the averagely high penetration (depth-mm) readings obtained. Between the depth of 995mm - 1195mm the layer is slightly compact and this is indicated by the averagely low penetration (depth-mm) readings obtained. At the depth of 1195mm the DCP refused to penetrate any further due to hard material encountered.

For SASA Eng.:

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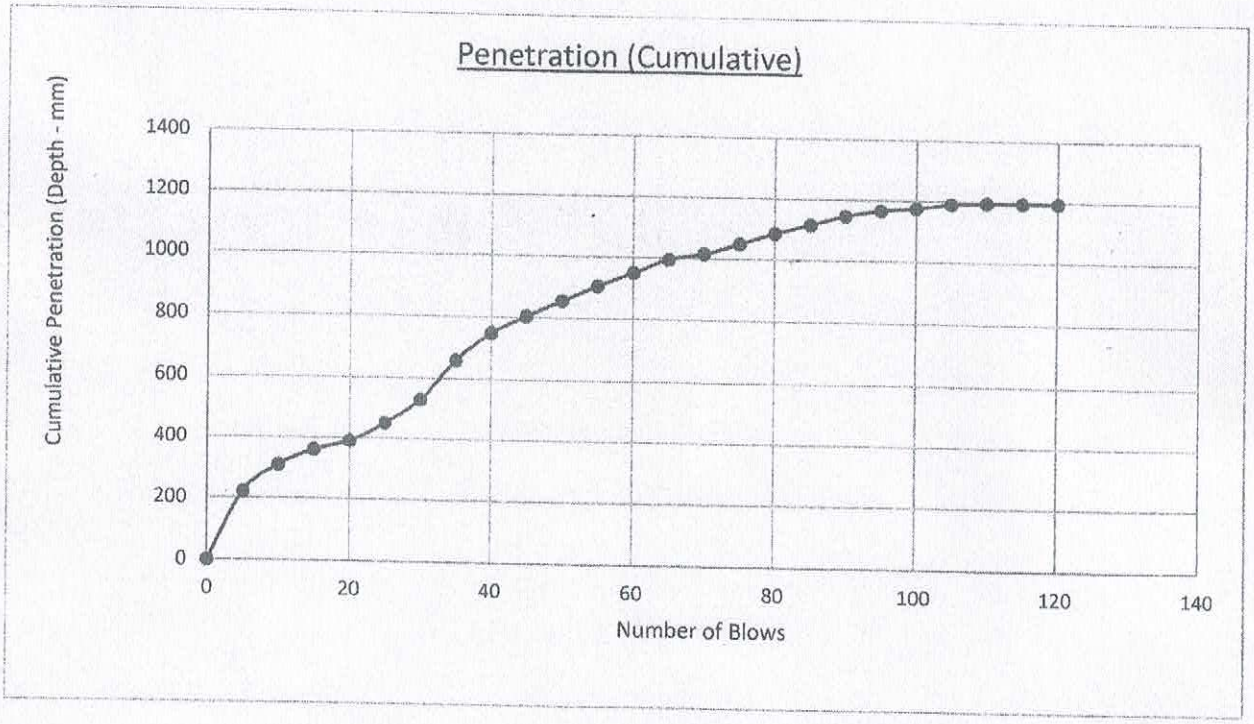
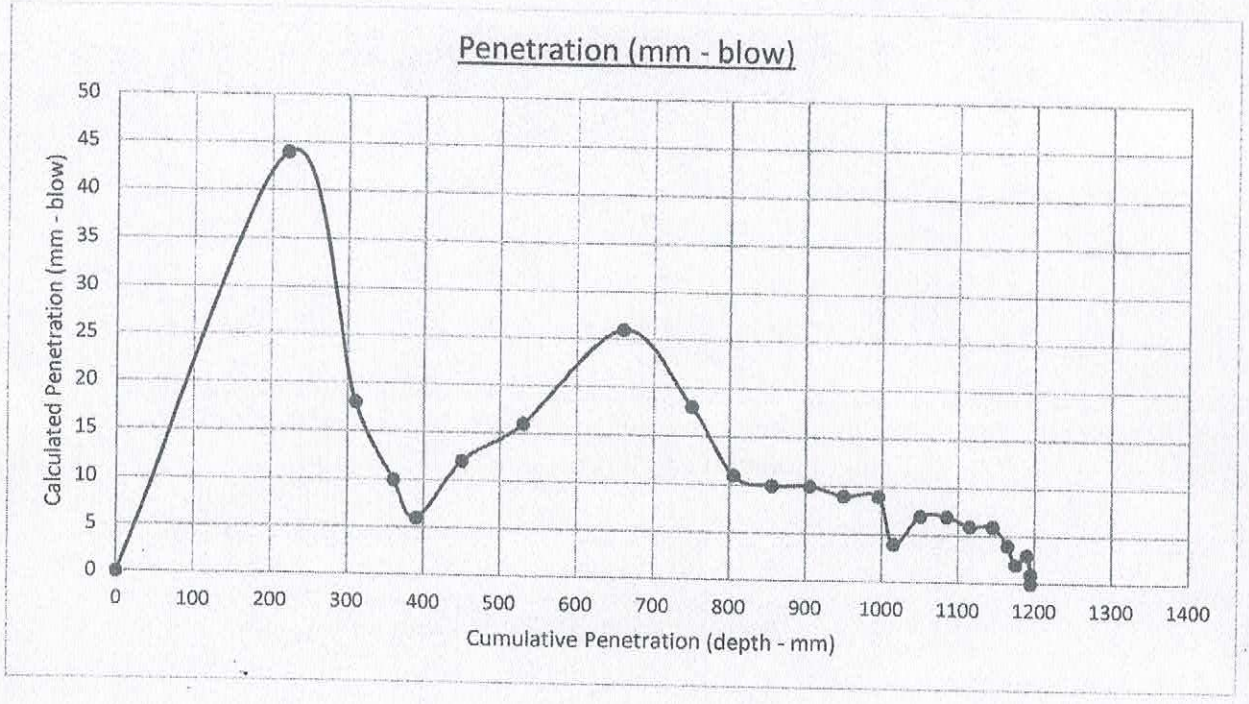
DYNAMIC CONE PENETROMETER (DCP)

Test Method TMH 6 – Method ST6

Client : Sphamandla Zulu
Project : Onkweni Filling Station
Position/ Km: TP1

Date Tested: 19-11-2018
Job Number: -





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DYNAMIC CONE PENETROMETER (DCP)

Test Method TMH 6 – Method ST6

Client : Sphamandla Zulu
Project : Onkweni Filling Station
Position/ Km: TP2

Date Tested: 19-11-2018
Job Number: -

Number of blows	Penetration Readings (Fieldwork- mm)	Penetration (Depth- mm)	Cumulative Penetration (depth – mm)	Calculated Penetration (mm / blow)	In-situ CBR
0	10	0	0	-	-
5	150	140	140	28.0	6
10	250	100	240	20.0	9
15	355	105	345	21.0	9
20	500	145	490	29.0	6
25	675	175	665	35.0	5
30	770	95	760	19.0	10
35	820	50	810	10.0	22
40	880	60	870	12.0	18
45	960	80	950	16.0	13
50	1040	80	1030	16.0	13
55	1070	30	1060	6.0	45
60	1090	20	1080	4.0	75
65	1105	15	1095	3.0	110
70	1120	15	1110	3.0	110
75	1135	15	1125	3.0	110
80	1155	20	1145	4.0	75
85	1170	15	1160	3.0	110
90	1185	15	1175	3.0	110
95	1195	10	1185	2.0	110
100	1210	15	1200	3.0	110
105	1230	20	1220	4.0	75
110	1255	25	1245	5.0	55
115	1275	20	1265	4.0	75
120	1290	15	1280	3.0	110
125	1310	20	1300	4.0	75
130	1320	10	1310	2.0	110
135	1340	20	1330	4.0	75
140	1355	15	1345	3.0	110
145	1360	5	1350	1.0	110
150	1360	0	1350	0.0	110
155	1360	0	1350	0.0	110

Remarks: The above DCP test shows that the DCP had no difficulty when penetrating through the top layers. Between the depth of 0 - 1030mm the layers are soft and this is indicated by the high penetration (depth-mm) readings obtained. Between the depth of 1030mm - 1350mm the layers are somewhat compact and this is indicated by the low penetration (depth-mm) readings obtained. At the depth of 1350mm the DCP refused to penetrate any further due to hard material encountered.

For SASA Eng.:

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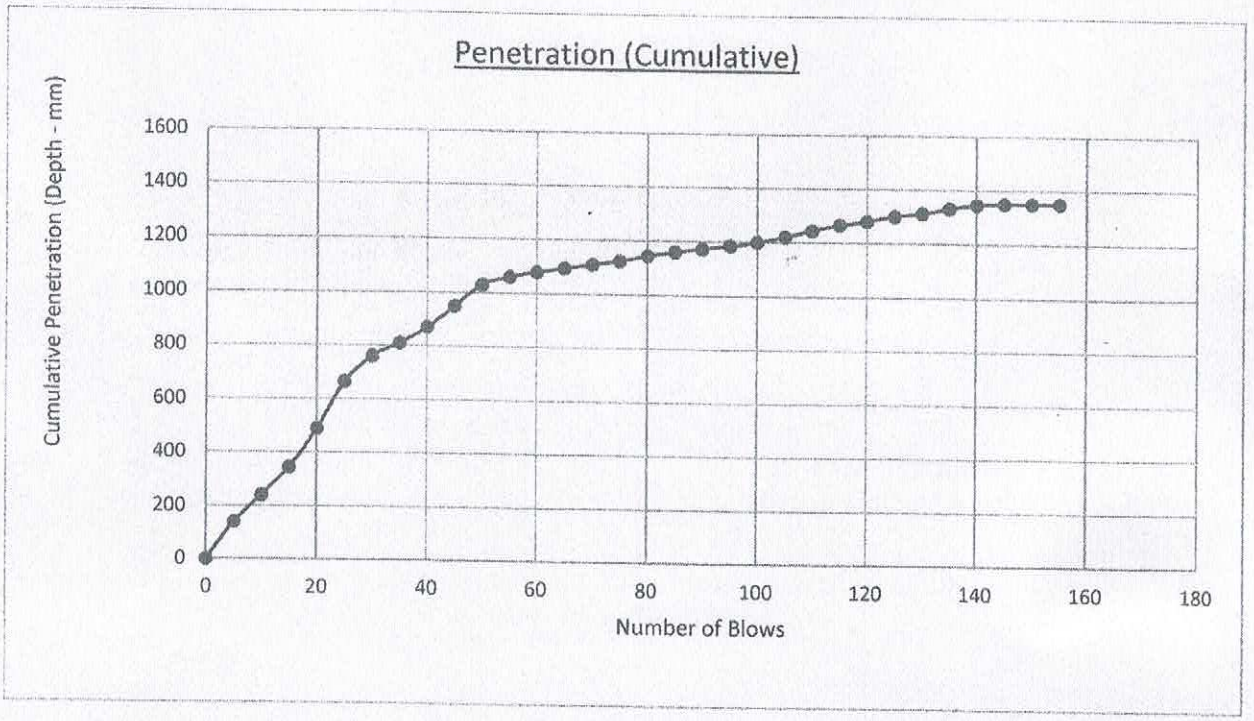
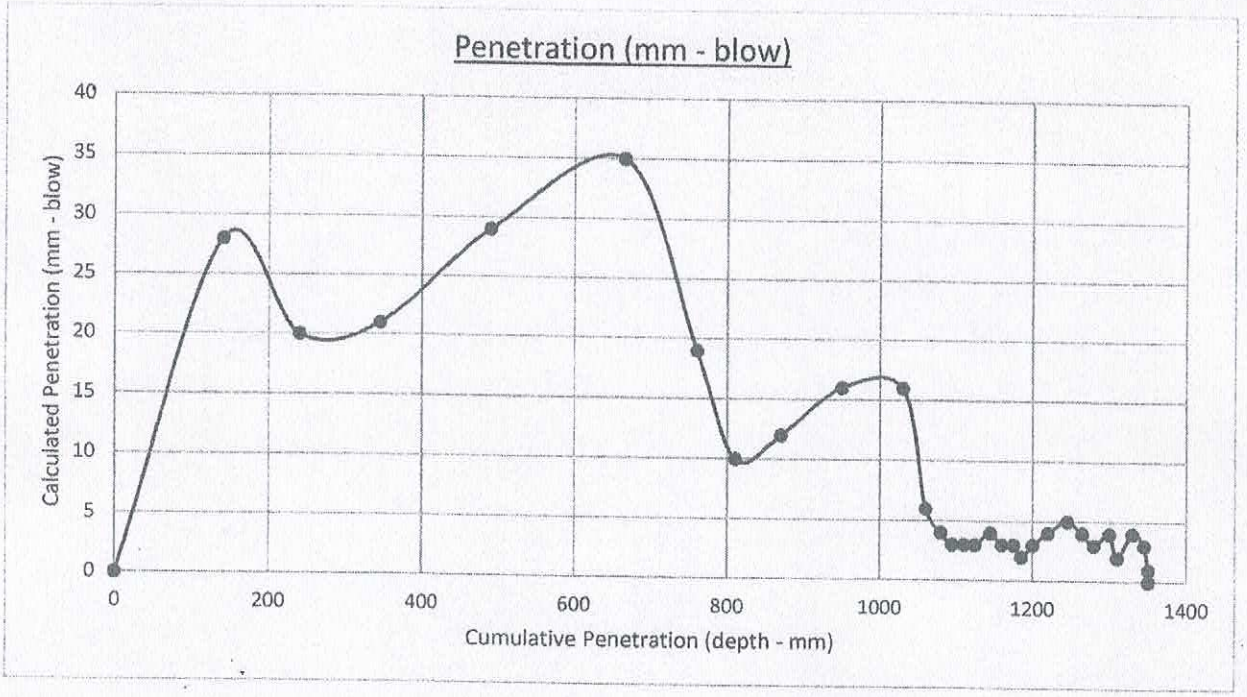
DYNAMIC CONE PENETROMETER (DCP)

Test Method TMH 6 – Method ST6

Client : Sphamandla Zulu
Project : Onkweni Filling Station
Position/ Km: TP2

Date Tested: 19-11-2018
Job Number: -





For SASA Eng.:

ANNEXURE C
LABORATORY SOIL TEST RESULTS

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Client : Sphamandla Zulu
Project: Onkweni Filling Station

Date Received : 19-11-2018
Date Reported : 26-11-2018
Job Card No. : -

MATERIALS TEST REPORT

Laboratory No.	M2267
Position in Field	TP 1 Layer 1
Material Description	White Light Brown Sandy Gravel

Sieve Analysis (Wet Preparation) TMH1- Method A1

75.00 mm	Percentage Passing	-
53.00 mm		-
37.50 mm		-
26.5 mm		100.0
19.00 mm		97.5
13.20 mm		93.4
4.75 mm		75.5
2.00 mm		61.5
0.425 mm		45.8
<0.075 mm		15.9
Grading Modulus		1.77

Mechanical Analysis- TMH1- Method A5

Coarse Sand (%)	25.5
Coarse-Fine Sand (%)	15.4
Medium-Fine Sand (%)	19.2
Fine-Fine Sand (%)	14.0
Silt and Clay (%)	25.9

Atterberg Limits- TMH1- Method A2, A3, A4

Liquid Limit (%)	N/P
Plasticity Index (%)	N/P
Linear Shrinkage (%)	0.0
Classification Group Index	-
TRH 14 Classification (1985)	-

Remarks:

- N/P: Non-Plastic

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Client : Sphamandla Zulu
Project: Onkweni Filling Station

Date Received : 19-11-2018
Date Reported : 26-11-2018
Job Card No. : -

MATERIALS TEST REPORT

Laboratory No.	M2268
Position in Field	TP 1 Layer 3
Material Description	Dark Brown Rocky Shale

Sieve Analysis (Wet Preparation) TMH1- Method A1

75.00 mm	**Percentage Passing**	-
53.00 mm		100.0
37.50 mm		81.2
26.5 mm		70.7
19.00 mm		65.3
13.20 mm		60.6
4.75 mm		53.6
2.00 mm		51.3
0.425 mm		33.4
<0.075 mm		8.7
Grading Modulus		2.07

Mechanical Analysis- TMH1- Method A5

Coarse Sand (%)	34.9
Coarse-Fine Sand (%)	15.0
Medium-Fine Sand (%)	20.2
Fine-Fine Sand (%)	13.0
Silt and Clay (%)	16.9

Atterberg Limits- TMH1- Method A2, A3, A4

Liquid Limit (%)	N/P
Plasticity Index (%)	N/P
Linear Shrinkage (%)	0.0
Classification Group Index	-
TRH 14 Classification (1985)	-

Remarks:

- **N/P: Non-Plastic**

For SASA Eng.: _____

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Client : Sphamandla Zulu
Project: Onkweni Filling Station

Date Received : 19-11-2018
Date Reported : 26-11-2018
Job Card No. : -

MATERIALS TEST REPORT

Laboratory No.	M2269
Position in Field	TP 1 Layer 4
Material Description	Dark Brown Red Sandstone

Sieve Analysis (Wet Preparation) TMH1- Method A1

75.00 mm	**Percentage Passing**	-
53.00 mm		100.0
37.50 mm		81.7
26.5 mm		69.3
19.00 mm		64.2
13.20 mm		59.8
4.75 mm		53.1
2.00 mm		50.6
0.425 mm		32.9
<0.075 mm		8.6
Grading Modulus		2.08

Mechanical Analysis- TMH1- Method A5

Coarse Sand (%)	35.0
Coarse-Fine Sand (%)	14.5
Medium-Fine Sand (%)	21.2
Fine-Fine Sand (%)	12.3
Silt and Clay (%)	17.0

Atterberg Limits- TMH1- Method A2, A3, A4

Liquid Limit (%)	N/P
Plasticity Index (%)	N/P
Linear Shrinkage (%)	0.0
Classification Group Index	G7
TRH 14 Classification (1985)	**G7**

Maximum Dry Density and Optimum Moisture Content- TMH1- Method A7

Optimum Moisture Cont. (%)	9.4
Max. Dry Density (kg/m³)	2160

California Bearing Ratio- TMH1 – Method A8

CBR @ 100% Compaction	2160	**CBR Load**	50
CBR @ 98% Compaction	2117	**CBR Load**	34
CBR @ 95% Compaction	2052	**CBR Load**	20
CBR @ 93% Compaction	2009	**CBR Load**	15
CBR @ 90% Compaction	1944	**CBR Load**	8
Swell @ 100% Comp. (%)	1.4		

The above test results are pertinent only to the samples received and tested at the laboratory. Deviation from TMH1, A8; 90% compaction 19 blows, with 3 layers, with tamper mass of 4.536kg and drop of 457.2mm. Compaction of CBR specimens were done using Optimum Nominal Moisture Content and Wet Density, referred to as **"the wet curve method".**

Remarks:

- **N/P: Non-Plastic**

For SASA Eng.: _____

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MR S.O ZULU

oNkweni Filling Station

Geotechnical Investigation Report
December 2018

N. Dube
admin@sasaengineering.co.za

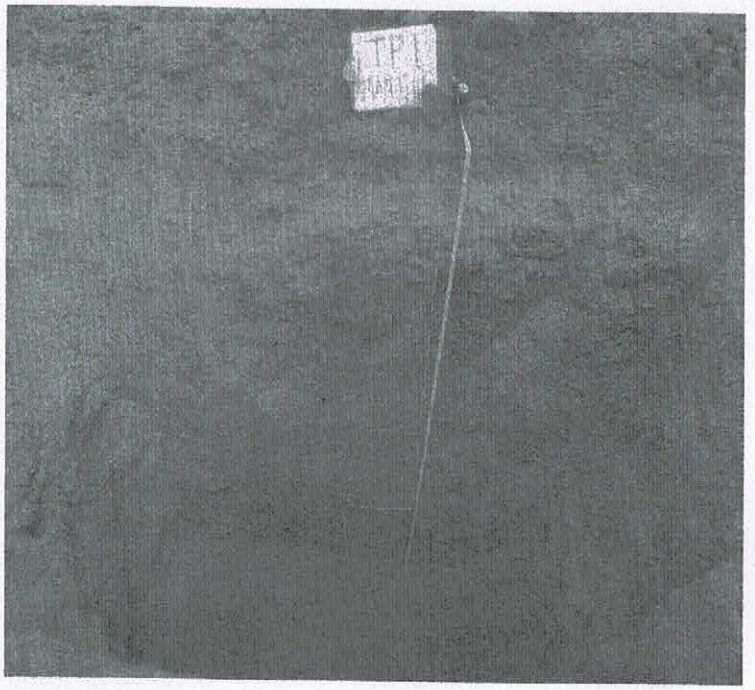
TABLE OF CONTENTS

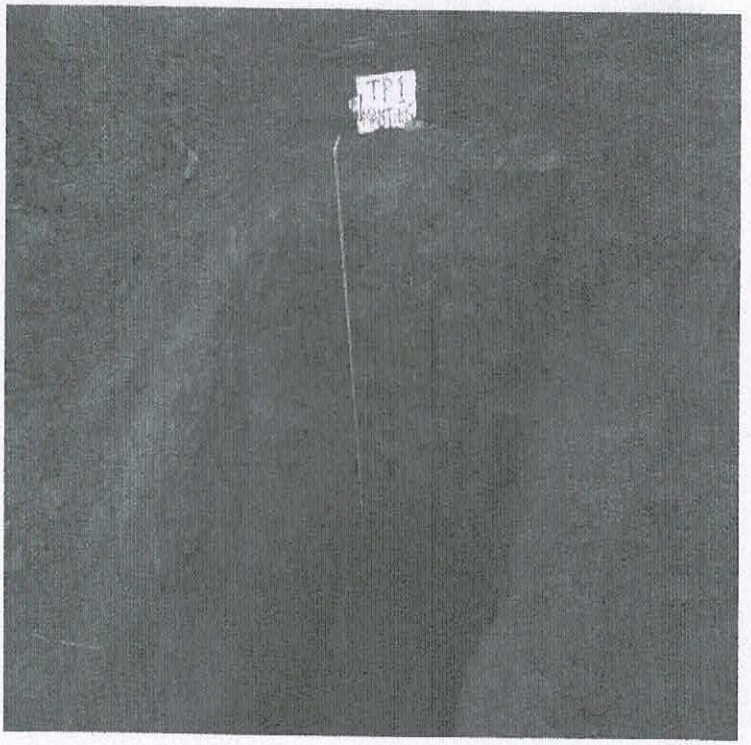
Pg.

ANNEXURES

ANNEXURE D
MEDIA – TRIAL PITS

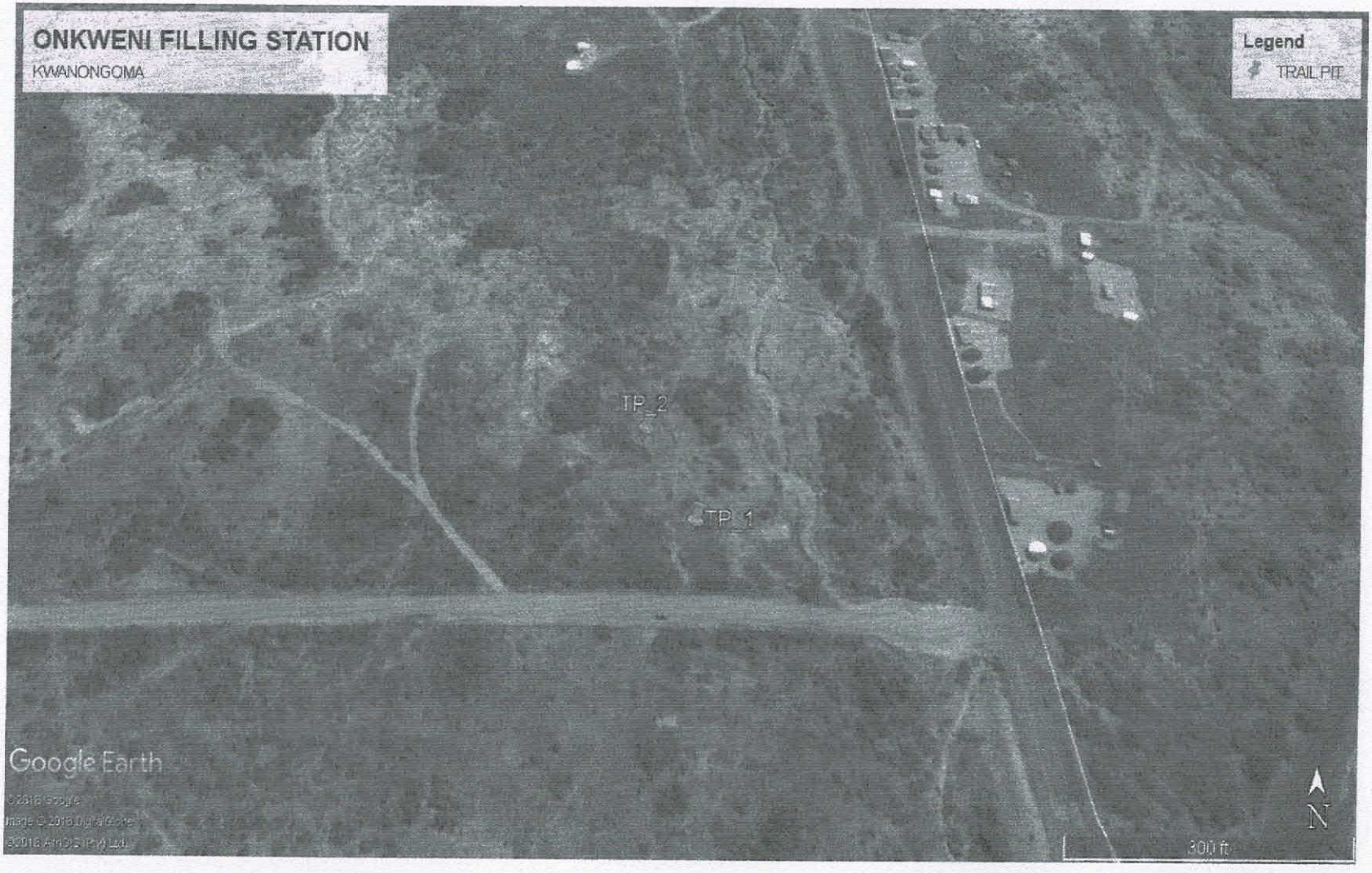
TRIAL PIT 1





TRIAL PIT 2

ANNEXURE E
TOPOGRAPHY


ONKWENI FILLING STATION
KWANONGOMA
Legend
TRAIL PIT
TP_2
TP_1
Google Earth
N
300 ft

ANNEXURE F
GEOLOGICAL MAP

KZN GEOLOGICAL MAP