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UMKHOMAZI WATER PROJECT

MODULE 3 – POTABLE WATER MODULE

Detailed Feasibility Study

Geotechnical Investigation Report - Volume 1

(Raw Water Pipeline)

Revision 1

October 2015

Planning Services
Engineering & Scientific Services
Umgeni Water

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UMGENI WATER **OCTOBER 2015**

uMkhomazi Water Project

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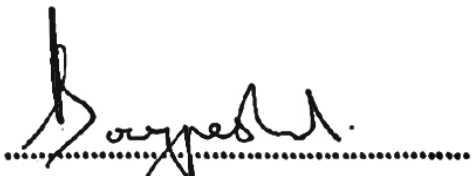

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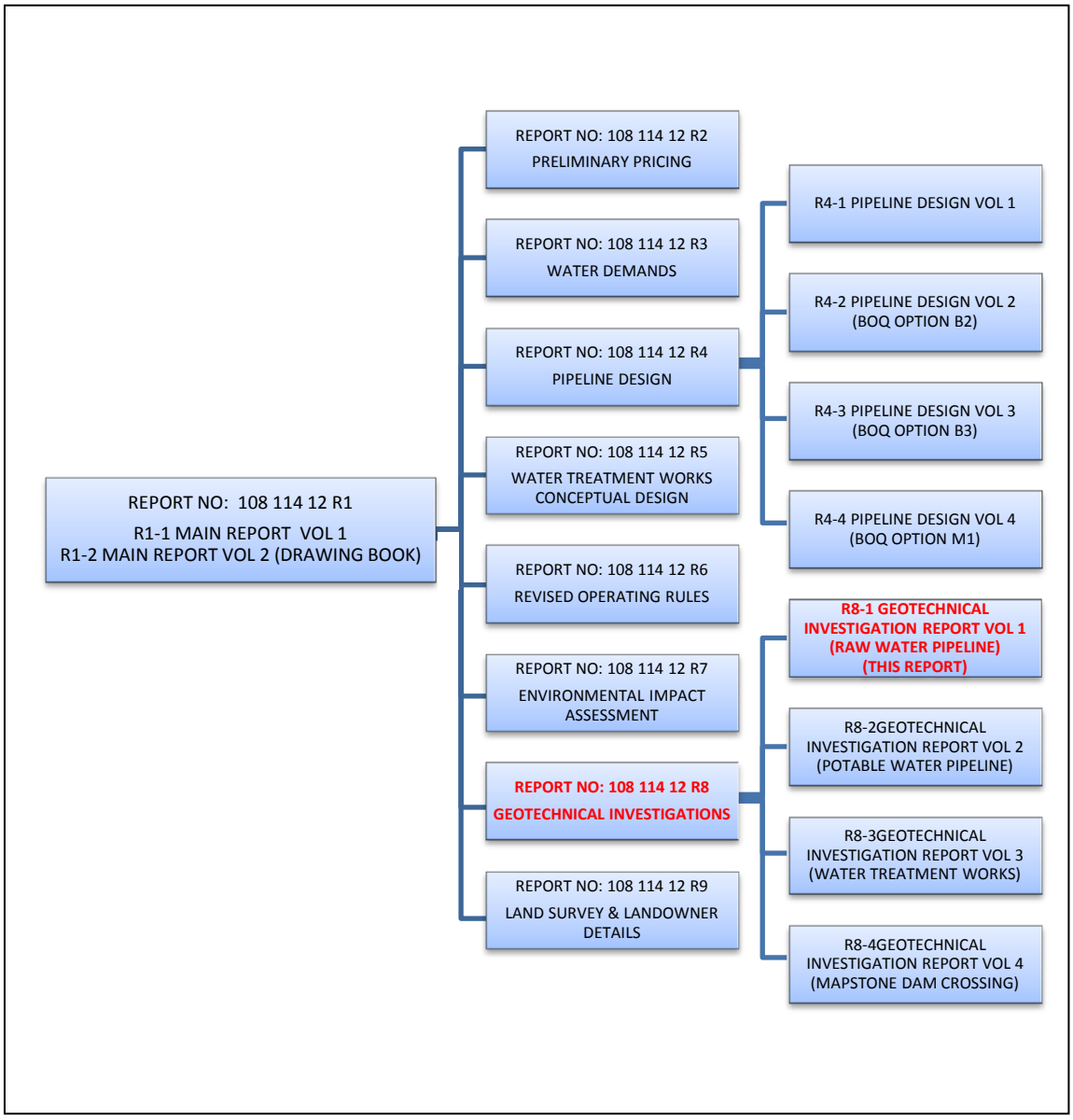
UMKHOMAZI WATER PROJECT

MODULE 3 – POTABLE WATER MODULE

Structure of Suite of Reports



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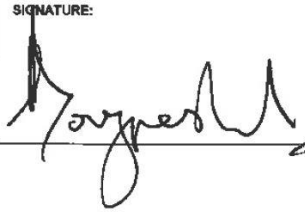
CLIENT APPROVAL	SIGNATURE: 	SIGNATURE: 	SIGNATURE: 

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1. Introduction

Knight Piésold (KP) was appointed by Umgeni Water (UW) to perform a geotechnical investigation for the proposed Umkhomazi Water Project Phase 1 (uMWP-1). The aim of the project is to transfer water from the uMkhomazi River to the existing Mgeni water system to further augment water supply to the Pietermaritzburg and Durban areas. This project deems to provide large volumes of water to fulfil long term water requirements to the Umgeni system by transferring potable water to the Umlaas Road/Cato Ridge Reservoir.

The raw water will be sourced from the proposed 80m high Smithfield Dam on the uMkhomazi River near Boston. The water will be transferred by means of a 34km long tunnel and pipeline to a balancing dam (Langa Balancing Dam) in the Bayensfield area.

The project falls within the uMkhomazi River Catchment and is located west of Camperdown at the Midlands of KwaZulu-Natal Province, South-Africa.

The project entails both potable water and raw water components, including the construction of water treatment works (WTW) in the uMlazi River Valley.

The proposed raw water pipeline will be 2,4m in diameter and will convey water from the Baynesfield Dam over a distance of approximately 4,980 km to the proposed WTW located at the Black Wattle Forest (east). An alternative WTA was also investigated and is located towards the north-eastern portion of Baynesfield.

The objectives of the geotechnical investigation were as follows:

- To determine ground conditions for the design and construction of the raw water pipeline in the Baynesfield Estate.
- To determine suitability of the materials along the pipeline route for bedding/backfill purposes.
- To determine the excavatability of the material along the pipeline route.
- Assessment of groundwater conditions.
- To locate possible borrow pits of bedding materials along the pipeline route.

Separate reports were compiled for the potable water pipeline and waste water treatment works

This report deals with the results of the 4,98km long raw water pipeline geotechnical investigation and contains all supporting documentation.

2. Site Description

The proposed raw water pipeline is situated in the Baynesfield Estate, in the Natal Midlands of the KwaZulu-Natal Province. The Midlands are characteristic of undulating and hilly terrain intersected by numerous water courses and river valleys. The steepest area on the pipeline route occurs

immediately west of the black wattle forest towards the drainage channel located at ch 3700, which has an approximate slope of 6° towards the water channel.

The locality of the site is indicated in Figure 1 at the back of the report.

Drainage takes place by means of sheetwash towards the numerous waterways in the uMkhomazi River Catchment. The route is entirely located within the Baynesfield Estate and intersects maize fields, avocado orchards and a bluegum forest near the Baynesfield Dam. A steep hill occurs on the western perimeter of the Bayenesfield Dam.

The pipeline intersects five water courses, which vary in width between 60m and 250m. The largest of these is a floodplain south-west of the Baynesfield Dam containing a wetland and shallow surface water conditions.

A telephone line intersects the proposed pipeline at the district gravel road located at ch 3200.

3. Regional Geology

According to the 1:250 000 geological map, sheet 2930 DURBAN, the area is underlain by shale, siltstone and sandstone of the Pietermaritzburg Group, Karoo Supergroup. The shale from the Pietermaritzburg Group consists of fissile beds that alternate with hard, dense non-fissile beds. The fissile shale often tends to be more weathered resistant than the non-fissile beds, therefore weathering along bedding planes has given rise to a thin clay layer. This clay layer often has relatively low shear strength with potential planes of weakness along which sliding can occur [1] .The unweathered shale is dark grey, greyish-olive and light olive-brown in colour with mica concentrated on bedding surfaces. Weathered residues of the shale comprise light yellow or khaki coloured silty clay.

According to Weinert's climatic N-value [2], the site falls in an area where the N-value is less than 5, indicating that the area is associated with more humid regions where chemical weathering is the predominant rock weathering mode.

4. Method of Investigation

The geotechnical investigation was conducted by the excavation of twenty five test pits (RW1 to RW23 including RW10A and RW12A) with two Tractor Loaded Backhoes (TLB). Test pits were spaced on average at 200m intervals and excavated to refusal depth or to the maximum reach of the machine. The test pits were logged in situ by two engineering geologists and a geotechnologist from KP according to standard practice [3].

Dynamic Probe Light tests (DPL) were conducted inbetween the test pits to determine the soil consistencies to a depth of 2m below ground surface or refusal depth. Twenty two DPL tests (DPL1 to DPL22) were conducted on the raw water pipeline.

The positions of the test pits and DPL tests were recorded with a hand-held GPS instrument with an accuracy of 5 meters. The coordinates of these positions are in WGS84 Datum and are displayed on the test pit logs. The approximate positions of the test pits and DPL positions are shown in Figure 2. The coordinates and chainages of the test pits and DPL tests are provided in Table 1. The summary of the test pit profiles are contained in Table 2, while the detailed logs are presented in Appendix A.

Soil samples were taken from representative soil horizons and submitted to Geosure in Durban to determine grading, Atterberg limits and compactability characteristics.

The results of the laboratory tests are summarized in Table 3, while the detailed results are displayed in Appendix B.

The DPL tests results are displayed in Appendix C while a photographic record of the site occurs in Appendix D.

5. Subsoil Conditions

5.1 Test Pit Investigation

Two broad geological zones (Zone A and Zone B) were identified and are indicated in Table 2 at the back of the report. The zones are defined as follows:

- Zone A: Areas of generally shallow rock, where bedrock and/or residual soils were encountered within the reach of the TLB (3m)
- Zone B: Transported soils overlying relatively thick residual shale exceeding 3m in thickness

Zone A and Zone B are equally distributed over the site, while Zone A mostly occurs at the central portion of the site from ch 1630 to ch 4180. Zone B mostly occurs at the western and eastern portions of the site at ch 350 to ch 1630 and ch 4180 to ch 4800 respectively. Refer to Figure 2 for the distribution of the various zones.

The table below provides a breakdown of the test pits and DPL test positions, situated within Zones A and B.

Geological Setting	Test Pits Excavated	DPL Tests
Zone A	RW02 RW04 RW09 RW11 to RWRW16 RW18 to RW20	DPL2 to DPL3 DPL10 to DPL19

Zone B	RW01 RW03 RW05 to RW08 RW10 to RW10A RW17 RW21 to RW23	DPL1 DPL4 to DPL9 DPL20 to DPL22

Zone A generally comprises shale bedrock within 3m below ground surface, although a dolerite dyke was intersected at RW18. Thirteen of the twenty five test pits (52%) fall within this zone. The soil profiles derived in Zone A are very similar and is summarized as follows:

5.1.1 The Typical Soil Profile in Zone A

- Colluvium covers the entire area to a depth of between 0,2m to 2,3m, but the layer is usually less than 1m thick. It generally consists of firm or firm to stiff sandy clay or isolated areas of loose clayey sand with rootlets.
- Ferruginous colluvium underlies the colluvium in 38% of the test pits in this zone and occurs at a depth of between 0,2m and 1,3m below surface. The thickness of this layer varies between 0,4m and 1,9m. It generally comprises firm sandy clay/silt with ferricrete nodules, or isolated areas of dense clayey sand, or abundant ferricrete nodules in a matrix of sandy silt.
- Residual shale was encountered in 35% of the test pits and generally comprised soft to firm or stiff clayey silt, or isolated cases containing abundant very soft shale gravel and cobbles in a matrix of sandy silt with an overall medium dense to dense or very dense consistency. In some areas the stiff residual shale transitioned to very soft rock shale. This layer occurred below the colluvium and ferruginous colluvium and had a thickness of between 0,8m and 1,6m. It further occurred at depths of between 0,2m and 1m below surface.

Residual dolerite was only encountered in RW18 between a depth of 0,6m and 1,3m below surface. The material comprised firm sandy clayey silt with hard dolerite gravel and cobbles.

The residual shale was ferruginized in RW20 between a depth of 1m and 1,9m below surface.

The TLB generally refused at a depth of 0,5m to 2,3m below surface. Refusal occurred in the following materials: very soft to soft rock shale, very stiff residual shale, very dense/stiff ferruginous colluvium and on very dense dolerite cobbles and boulders.

No water seepage was encountered in any of the test pits.

Twelve of the twenty five test pits (48%) fall within this zone. Deep weathering (below 3m depth) of the soil profiles characterises Zone B, which is summarized as follows:

5.1.2 The Typical Soil Profile in Zone B

- Colluvium covers the entire area to a depth of between 0,2m to 1,2m and is mostly less than 1m in thickness. It generally consists of firm sandy clay or clayey silt or isolated areas of loose/medium dense clayey sand with rootlets. Fill was only encountered in RW05 from surface to 0,4m depth and comprises firm sandy clay with gravels and cobbles.
- Ferruginous colluvium comprises the base of the colluvium layer in 30% of the test pits in this zone and occurs at a depth of between 0,3m and 0,5m below surface. The thickness varies between 0,6m and 2,7m. This material generally comprises firm sandy clay/silt with ferricrete nodules or isolated areas of dense clayey sand or abundant ferricrete nodules in a matrix of sandy silt.
- A pebble marker layer was encountered in RW01 and RW07 below the colluvium. This material comprised abundant shale and dolerite gravels, cobbles and boulders in a matrix of clayey silty sand with a dense overall consistency.
- Residual shale was encountered in all the test pits in this zone, except RW17. This layer underlies the transported materials and generally comprised firm to stiff clayey silt or sandy clay with some occurrences of soft soil consistencies. Isolated cases were encountered where abundant very soft shale gravel and cobbles occurred in a matrix of sandy silt with an overall dense consistency. This layer had a thickness of between 1,2m and 3m. It occurred at surface level (in a gravel road) to a depth of 1,6m below surface.

The residual shale was ferruginized in RW18 between a depth of 0,9m and 1,7m below surface.

TLB refusal was only encountered in RW05 on soft rock shale at a depth of 3,3m below surface.

Water seepage was only encountered in RW05 at a depth of 3,2m below surface.

5.2 DPL Investigation

Twenty-three DPL tests (DPL01 to DPL23) were conducted along the proposed raw water pipeline route.

The DPL test results show stiff and very stiff soils, with some variation. Generally the upper 0,35m to 0,45m of colluvium (sandy clay material) is firm/medium dense where it becomes stiff/dense with depth. The stiff colluvium extends to an average depth of 0,8m to 1m where it becomes stiff to very stiff with depth. The stiff to very stiff silty/clayey materials often extends beyond the maximum DPL test depth of 2m; however the clay frequently becomes stiff to very stiff where it nears refusal depth. This boundary, where encountered, commonly occurs around 1,5m depth.

6. Laboratory Test Results

6.1 Transported Material (Geological Zones A and B)

The transported colluvium or ferruginous colluvium soil comprises 10% to 34% gravel, 18% to 25% sand, 25% to 34% silt and 16% to 38% clay. It has a Plasticity Index (PI) of 10% and a low potential expansiveness. The Liquid Limit (LL) of the material varies between 42% and 47%. The colluvial or ferruginous colluvium soil classified as ML (Inorganic silt), with an isolated sample classifying as SM (silty sand), according to the Unified Soil Classification (USC).

Soil resistivity tests were conducted on colluvium and ferruginous colluvium. The test results for the colluvium shows a value of 100ohm/m, while the results for the ferruginous colluvium show values of between 35ohm/m to 38ohm/m. According to the table below, the colluvium is mildly corrosive towards steel, while ferruginous colluvium is corrosive towards steel [4].

Resistivity (ohm/m)	Corrosivity
0 – 20	Very corrosive – cathodic protection required
20 – 50	Corrosive – cathodic protection recommended
50 – 100	Mildly corrosive – cathodic protection optional
More than 100	Not corrosive – cathodic protection not required

Compactability tests were conducted on the samples. The compactability factor for the material tested ranges between 0,20 and 0,28.

6.2 Residual Shale

Residual shale, which alters to ferruginous residual shale depending on the cementing component, comprises SM (silty sand) with 15% to 50% gravel, 21% to 37% sand, 18% to 47% silt and a clay content of 6% to 27%. It has a low potential expansiveness and a PI of between 6% and 11%.The LL of the material is 37% with an isolated sample having LL of 47%.

Soil resistivity test results show that the residual shale has values of between 68ohm/m to 90ohm/m (mildly corrosive), while one sample of the ferruginous residual shale tested greater than 499ohm/m (non-corrosive). The residual shale is therefore generally mildly corrosive towards steel.

Compactability tests on the residual shale showed values of between 0,2 and 0,27.

7. Geotechnical Evaluation

7.1 Excavatability

The ease of excavation is a critical financial factor when installing underground services and placement of foundations, since the proposed pipeline floor level is situated at a depth of at least 3m below natural ground surface.

The excavatability of material can be grouped into the following categories, according to SANS 1200D:

- Soft excavation
- Intermediate excavation
- Hard rock excavation

For the required width of the pipe trench (>2,5m), it has been assumed that a large tracked excavator will be used to excavate the pipe trench rather than a TLB, since an excavator will be able to excavate harder materials more readily than a TLB. For example, an excavator would be able to excavate further into a soft rock material whereas a TLB would experience refusal.

Based on the above assumption, the three excavatability categories have been defined as follows:

- ***Soft Excavation***

  For non-cohesive soils, a consistency ranges from very loose to dense and for cohesive materials a consistency ranging from very soft to stiff. This includes all materials that could be excavated with a TLB.

- ***Intermediate Excavation***

  Non-cohesive soils include materials with a consistency in excess of dense (i.e. very dense), and for cohesive materials a consistency in excess of stiff (i.e. very stiff), including boulders and well cemented ferruginised soils. Soft to medium hard rock is also included since the closely to medium spaced joints make it readily rippable with a large excavator.

- ***Hard Rock Excavation***

  Rock that would be difficult to excavate with an excavator and may require blasting and/or the use of rock breaking equipment, typically medium hard to hard rock, or areas where outcrop was encountered, including hardpan pedogenic soil varieties.

  Rock that requires hard ripping with a single ripper, such as a rock bucket on a large excavator, is considered to be classified as hard rock excavation.

Twenty five tests pits were excavated along the proposed raw water pipeline route. Soft to intermediate excavations were encountered to an average depth of 3m in Zone B. Soft to

intermediate excavations were encountered between a depth of 0,8 to 2,3m below surface in Zone A. The excavatability according to chainage is summarised in Table 4.

Hard rock excavation conditions may be experienced in Zone A where tillite, shale and dolerite bedrock were encountered from depths of between 0,3m and 2,1m below surface. It could be possible for a large (30 ton) excavator with a rock bucket to excavate into closely jointed very soft rock tillite, shale and dolerite, but this will be considered to as "hard rock excavation". Rock breaking equipment will be required to break localised zones of harder rock. Rock breaking equipment or blasting will be required for excavations in medium hard to hard rock.

Due to the relatively shallow rock depth in some areas along the route, rock excavation may be required below the intermediate zones, indicated in the above table, depending on the depth of the pipeline. It may be possible to excavate the soft to medium hard rock with a large (30 ton) excavator with a rock bucket. Rock breaking equipment will be required to break localised zones of harder rock. Rock breaking equipment or blasting will be required for excavations in medium hard to hard rock.

7.2 Seepage and Trench Excavation Stability

The in situ materials are generally not expansive and have a low plasticity index.

It was noted from the test pits that the sidewalls, in many of the test pits, of the transported material (colluvium and ferruginous colluvium) was semi stable. Chunks of clayey and silty material did collapse in some of the test pits upon excavation. It is therefore recommended that the temporary sidewalls in the transported materials be excavated at an angle of 1:1 (V:H) for stability, provided the slopes are kept dry.

The presence of ferruginisation in many of the test pits is an indication that fairly shallow groundwater conditions may be present at times. Water seepage was encountered in one test pits (RW05), at a depth of 3,2m below surface. This may have an influence on the stability of pipe trench sidewalls and the required precautionary measures should be taken to ensure the safety of workers in such trenches deeper than 3m, i.e. flatten the slopes to 1V:1,5H or support vertical slopes.

Generally, no serious slope stability problems are foreseen, provided that pipe trench excavations take place in dry conditions.

7.3 Foundations

Zone A: All pipe trench excavations at 3m depth will be situated mostly in very soft to soft rock (shale/dolerite/sandstone) or stiff residual soil (clayey and silty materials). Weathered, very soft to soft rock shale was encountered from depths of between 0,5m and 2,3m below surface. It follows that the trench floor conditions in Zone A will comprise either stiff soil with a safe bearing capacity of at least 250kPa or very

soft to soft rock with bearing capacities of at least 500kPa.

Zone B: This zone comprises deposits of transported and thick residual soils and no TLB refusal was generally encountered in Zone B to a depth of 3m below surface. The floor of the trench at a depth of 3m and 3,3m will generally consist of stiff silty and clayey residual soils. Safe bearing capacity at depths of between 3m and 3,3m in Zone B will amount to between 150kPa and 250kPa.

It follows that no special precautionary measures are required for foundations of structures (e.g. valve chambers, thrust blocks) or for lying bedding materials.

8. Material Usage

8.1 Spoil from Trench Excavations

The spoil materials from the pipe trench excavations were assessed for possible use for bedding and normal backfilling. The types of materials include:

- Colluvium
- Residual Shale
- Random residual dolerite

SANS 1200 LB [6] specifies that bedding material will be free-running selected granular material comprising non-cohesive soil with a grain size distribution of between 0,6mm to 6mm for fine sand or 6mm to 199mm for medium sand. This requires either manufactured sand, screened sand or a clean river sand source. Due to the scarcity of such sand, particularly in areas covered by Karoo strata, Department: Water Affairs (DWA) developed a relaxed bedding specification, as follows [7]:

MATERIAL DESCRIPTION	PERCENTAGE BY MASS PASSING SIEVE SIZE (mm)				ATTERBERG LIMITS SHALL NOT EXCEED (%)		
	9,5	4,75	0,425	0,002	LI	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

Due to the predominant presence of fine-grained soils on site, the relaxed bedding specification above was used to assess the spoil materials.

Based on the laboratory test results, the residual shale, ferruginous colluvium and colluvium are too plastic for compliance with the specifications (Liquid Limit generally >40%).

The Compactability Factors of the colluvium, ferruginous colluvium and residual shale were all below 0,5.

Even with the relaxed bedding specification, the material along the pipeline route cannot be used for bedding in accordance with the relaxed DWA specification. The spoil material comprising transported material, residual shale and residual dolerite can generally be used as normal backfilling material, provided that oversized particles are removed.

Therefore the material along the pipeline route cannot be used as bedding material. The spoil material comprising transported material, residual shale and residual dolerite can generally be used as normal backfilling material, provided that oversized particles are removed.

8.2 Commercial Sources

The following contact person in the vicinity of the site was identified that may provide material suitable for bedding:

Name/ Description	Contact Person	Contact Number	Location
Umlaas Road Cartage	Hansel Moodley	082 4521069	Lot 23, Umlaas Road, Camperdown

It is understood that Umlaas Road Cartage sources sand from nearby rivers, it is not certain whether they will be able to supply large quantities of bedding material.

Sandop is in the vicinity of Cato Ridge, but unfortunately they have closed down and are no longer operational.

9. Conclusion and Recommendations

According to the published geological map, 2930 DURBAN (1:250 000 scale), the site is generally underlain by the Pietermaritzburg Group. This group belongs to the Karoo Supergroup, the most widespread stratigraphic unit in Africa, with strata made up of mostly shale, siltstone and sandstone. Dolerite intrusions in the form of sills and dykes are found scattered in the area.

Two main soils were encountered along the pipeline route, namely colluvial sandy clays and residual shale. The residual shale weathers to a silty and clayey material with minor occurrences of sand and gravel.

Two broad geologic zones were identified at the raw water site, Zones A and B. Both Zone A and Zone B are equally distributed over the area. Zone A is characterized generally shallow rock, where bedrock and/or residual soils were encountered within the reach of the TLB (3m). Transported soils overlying relatively thick residual shale exceeding 3m in thickness was encountered in Zone B.

Slight water seepage was encountered only once along the proposed route at a depth of 3,2m (RW05).

Laboratory tests confirmed that the colluvium comprises clay to silty sand and has a low to medium potential expansiveness. The colluvial soil classified as either sandy clay or clay of low plasticity. The material has a low potential expansiveness.

The residual shale comprises clay and silt and has a low potential expansiveness.

Zone B can easily be excavated to an average depth of 3m across the entire pipeline route, whereas Zone A has a refusal depth between 0,5m and 2,3m. Hard and intermediate excavation will be required occasionally in Zone A.

The material along the pipeline routed was deemed unsuitable for bedding material due to its high plasticity characteristics.

The soils encountered at the potable water pipeline and alternative pipeline route are generally corrosive to mildly corrosive towards steel and therefore requires cathodic protection.

10. References

[1] Brink, A.B.A. (1979).*Engineering Geology of Southern Africa*, Volume 3. Building Publications, Pretoria.

[2] Weinert, H. (1965). *A climatic index of weathering. Geotechnique*, Vol. 24, No. 4, pp. 475-488.

[3] The South African Institute of Engineering Geologists (1996). *Guidelines for Soil and Rock Logging*.

[4] Botha, G. (1997). *Pipeline Maintenance*. Mechanical Technology, Paradigm Projects.

Table 1 Test Pit Coordinates and Chainages

Test Pit	WGS84 D° M' S"		Chainage
	SOUTH	EAST	
RW01	294626.14	301812.09	0
RW02	294629.37	301811.18	150
RW03	294631.32	30189	240
RW04	294632.78	30186.16	325
RW05	294635.24	30184.26	425
RW06	294638.42	301812.79	675
RW07	294632.75	301816.94	880
RW08	294627.58	301820.93	1075
RW09	294624.38	301826.76	1275
RW10	294621.14	301838.05	1600
RW10A	294623.92	301832.78	1440
RW11	294622.82	301848.01	1875
RW12	294625.29	301859.55	2200
RW12A	294623.66	301859.67	2200
RW13	294625.25	30195.64	2350
RW14	294622.12	301919.29	2740
RW15	294625.2	301931.07	3060
RW16	294633.49	301934.82	3300
RW17	294632.97	301942.3	3440
RW18	294637.16	301947.76	3640
RW19	294637.8	301955.19	3900
RW20	294632.07	301959.45	4050
RW21	294633.5	30207.5	4260
RW22	294631.64	302017.15	4520
RW23	294627.66	302022.48	4700

Table 1 Dpl Coordinates and Chainages

DPL #	WGS84 South African Grid (Lo25)		Chainage
	SOUTH	EAST	
DPL1	294627.91	301811.81	100
DPL2	294630.2	301810.18	200
DPL3	294632.16	30187.74	280
DPL4	294634.29	30185.1	380
DPL5	294637.94	301810.47	620
DPL6	294635.32	301815.13	800
DPL7	294630.55	301818.73	980
DPL8	294627.53	301823.9	1180
DPL9	294621.85	301832.38	1440
DPL10	294622.62	301843.9	1720
DPL11	294624.89	301854.18	2040
DPL12	294625.75	30192.5	2300
DPL13	294623.84	301912.67	2560
DPL14	294622.48	301923.73	2780
DPL15	294626.37	301931.96	3140
DPL16	294631.36	301939.16	3340
DPL17	294635.98	301944.79	3575
DPL18	294638.29	301953.35	3740
DPL19	294636.09	301957.27	3960
DPL20	294633.65	30204.66	4220
DPL21	294633.76	302012.69	4400
DPL22	294629.92	302020.28	4620

Table 2: Summary of Test Pit Logs

TEST PIT No.	GEOLOGICAL ZONE	TOTAL DEPTH (m)	FILL	TRANSPORTED SOILS			RESIDUAL SOILS		BEDROCK	DEPTH OF WATER SEEPAGE (m)
				Colluvium	Ferruginous Colluvium	Pebble Marker	Shale	Dolerite	Shale	
RW01	Zone B	3,0	-	0 – 0,2	-	-	1,0 – 3,0 +	-	-	-
RW02	Zone A	2,3	-	0 – 2,3	-	-	-		2,3 + R	-
RW03	Zone B	3,0	-	-	-	-	0 – 3,0 +	-	-	-
RW04	Zone A	2,3	-	0 – 0,9	-	-	0,9 – 2,3	-	2,3 + R	-
RW05	Zone B	3,3	0 – 0,4	0,4 – 1,0	-	-	1,0 – 3,3	-	3,3 + R	3,2
RW06	Zone B	3,0	-	0 – 0,5	0,5 – 1,1	-	1,1 – 3,0* +	-	-	-
RW07	Zone B	3,0	-	0 – 1,2	-	1,2 – 1,6	1,6 – 3,0 +	-	-	-
RW08	Zone B	2,9	-	0 – 0,9	-	-	0,9 – 1,7* 1,7 – 2,9 +	-	-	-
RW09	Zone A	1,8	-	0 – 0,4	0,4 – 0,8	-	0,8 – 1,8 + R	-	-	-
RW10	Zone B	2,8	-	0 – 0,4	0,4 – 1,6	-	1,6 – 2,8 +	-	-	-
RW10A	Zone B	3,0	-	0 – 1,4	-	-	1,4 – 3,0 +			-
RW11	Zone A	1,5	-	0 – 0,5	0,5 – 1,5 +	-	-	-	-	-
RW12	Zone A	1,1	-	0 – 0,2	-	-	-	-	0,2 – 1,1 + R	-
RW12A	Zone A	0,5	-	0 – 0,3	-	-	-	-	0,3–0,5+R	--
RW13	Zone A	2,3	-	0 – 1,1	1,1 – 2,3 + R	-	-	-	-	-
RW14	Zone A	1,7	-	0 – 1.3	1,3 – 1,7 + R	-	-	-	-	-
RW15	Zone A	1,4	-	0 – 0,2	-	-	0,2 – 1,0	-	1,0–1,4+R	-
RW16	Zone A	2,3	-	0 – 0,2	0,2 – 2,3 + R	-	-	-	-	-
RW17	Zone B	3,0	-	0 – 0,3	0,3 – 3,0 +	-	-	-	-	-
RW18	Zone A	1,3	-	0 – 0,6	-	-	-	0,6 – 1,3 + R	-	-
RW19	Zone A	2,0	-	0 – 0,4	-	-	0,4 – 2,0 + R	-	-	-
RW20	Zone A	1,9	-	0 – 1,0	-	-	1,0 – 1,9* + R	-	-	-
RW21	Zone B	3,0	-	0 – 0,8	-	-	0,8 – 3,0 +	-	-	-
RW22	Zone B	3,0	-	0 – 0,5	-	-	0,5 – 3,0 +	-	-	-
RW23	Zone B	3,0	-	0 – 0,5	-	-	0,5 – 3,0 +	-	-	-

Table 3: Summary Of Laboratory Test Results

TEST PIT No.	SAMPLE DEPTH (m)	GRADING (% PASSING) SIEVE SIZE (mm)								ATTERBERG LIMITS (%)			STANDARD PROCTOR COMPACTION		GM	PE	USC	COMPACTIBILITY FACTOR	ORIGIN
		19	13,2	4,75	2,0	0,425	0,075	0,060	0,002	LL (%)	PI (%)	LS (%)	MDD (kg/m³)	OMC (%)					
RW02/1	0,9 – 2,3	100	100	97	90	74	72	68	38	47	10	5.0	1587	17.1	0.6	Low	ML	0.28	Colluvium
RW11/1	0,5 – 1,5	100	100	96	66	45	41	38	16	41	10	5.0	2038	10.5	1.5	Low	ML	0.32	Ferruginous colluvium
RW17/1	0,3 – 3,0	100	100	100	82	65	61	56	30	42	10	5.0	1843	11.3	0.9	Low	SM	0.3	Ferruginous colluvium
RW09/1	0,8 – 1,8	100	100	92	81	66	58	54	11	37	11	5.5	1815	11.3	1.0	Low	SM	0.22	Residual shale
RW23/1	0,5 – 2,6	95	86	66	50	35	29	27	11	37	6	3.0	1850	11.4	1.9	Low	SM	0.22	Residual shale
RW20/1	1,0 – 1,9	100	100	100	85	52	48	46	27	47	6	3.0	-	-	1.1	Low	SM	0.24	Ferruginous residual shale

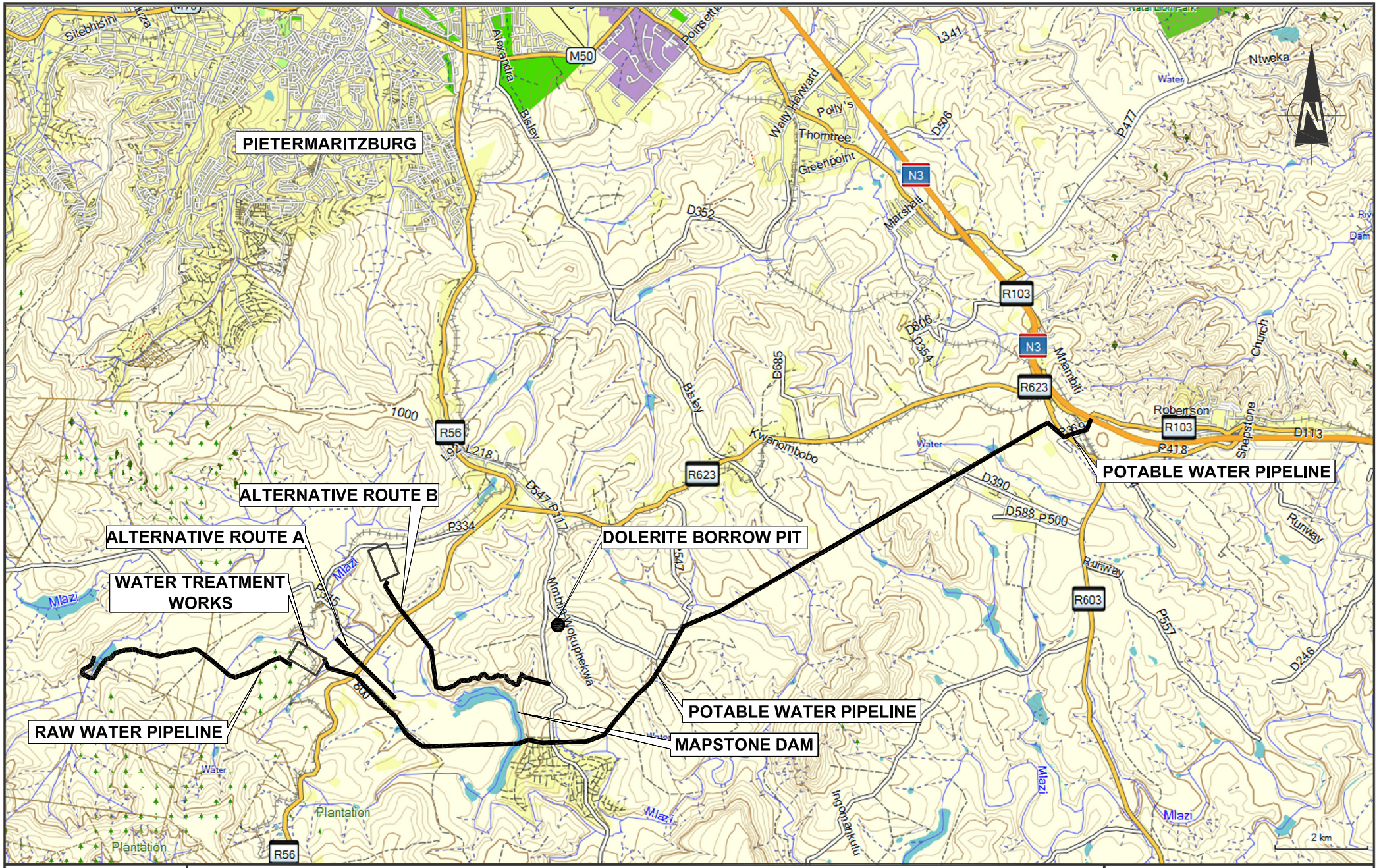
Notes

LL : Liquid Limit
PI : Plasticity Index
LS : Linear Shrinkage
GM : Grading Modulus
PE : Potential Expansiveness
USC : Unified Soil Classification
CBR : California Bearing Ratio
MDD : Maximum Dry Density
OMC : Optimum Moisture Content
SM : Poorly graded silty sand mixture

Table 4: Excavatability

CHAINAGE	DEPTH TO SOFT AND INTERMEDIATE MATERIAL EXCAVATIBILITY[1)]						
	1m - 1,5m	1,5m – 2,0m	2,0m – 2,5m	2,5m – 3m	3,0m-4m	GEOLOGICAL ZONE	COMMENTS
000 – 140	Soft	Soft	Soft	Soft	Soft	Zone A	
140 – 170	Soft	Soft	Soft	Intermediate	Intermediate	Zone B	
	-	-	-	-	-	-	Watercourse
170 – 270	Soft	Soft	Soft	Soft	Soft	Zone B	
270 – 350	Soft	Soft	Soft	Intermediate	Intermediate	Zone A	
350 – 1230	Soft	Soft	Soft	Soft	Soft - Intermediate	Zone B	Slow Water Seepage At RW05 (3,2m)
1230 – 1300	Soft	Soft	Intermediate	Intermediate	Intermediate	Zone A	
1300 – 1630	Soft	Soft	Soft	Soft	Soft	Zone B	
1630 – 2280	Intermediate	Intermediate	Intermediate	-	-	Zone A	
2280 – 2450	Soft	Soft	Soft	Soft	Intermediate	Zone A	
2450 – 3200	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Zone A	
3200 – 3350	Soft	Soft	Intermediate	Intermediate	Intermediate	Zone A	
3350 – 3500	Soft	Soft	Soft	Soft	Soft	Zone B	
3500 – 3720	Intermediate	Intermediate	Intermediate	-	-	Zone A	
3720 – 4180	Soft	Soft	Intermediate	Intermediate	Intermediate	Zone A	
4180 - 4800	Soft	Soft	Soft	Soft	Soft	Zone B	
4800 – 4900	Intermediate	Intermediate	Intermediate	-	-	Zone A	

Figure 1: Locality Map



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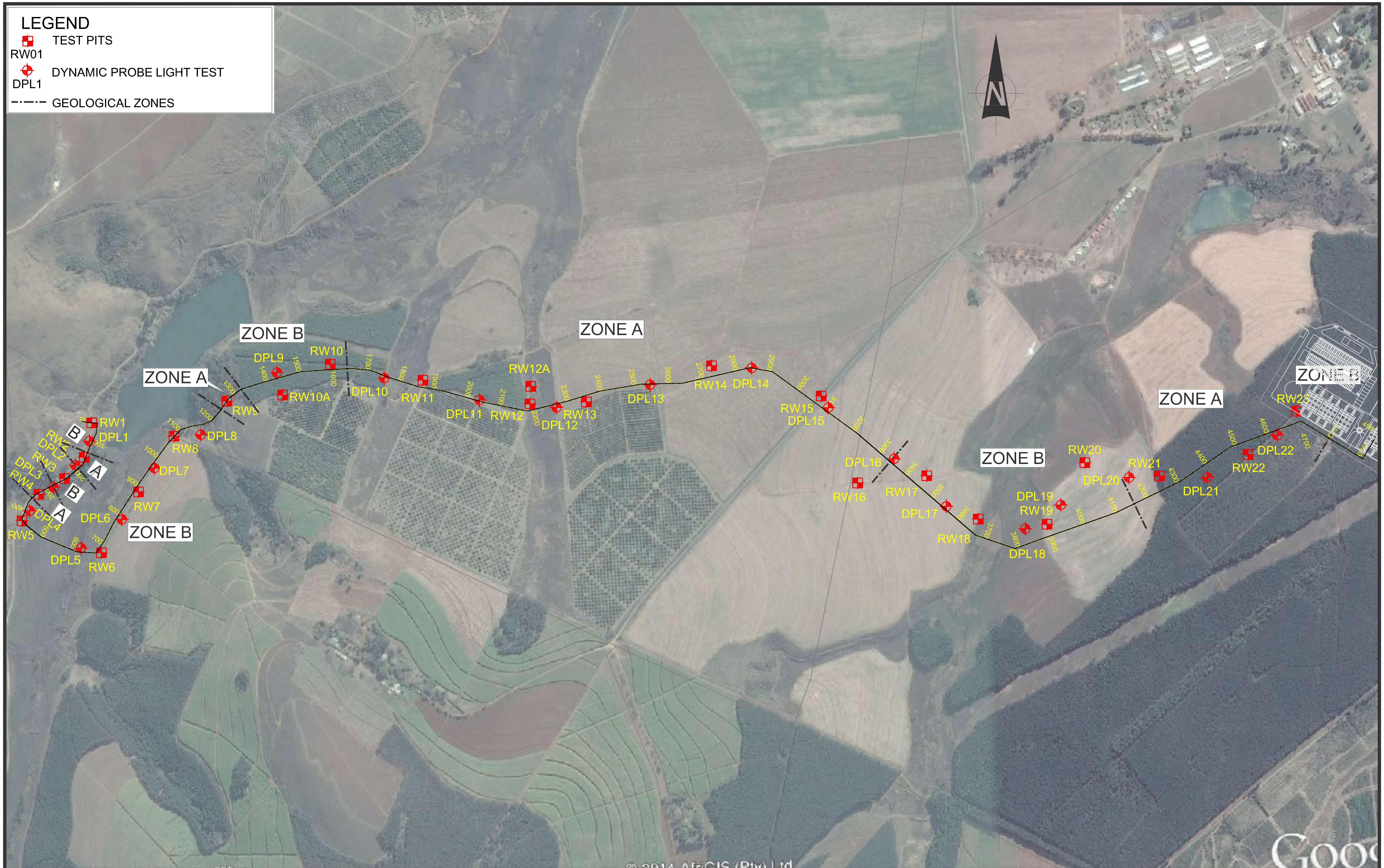
UMKHOMAZI WATER PROJECT
GEOTECHNICAL INVESTIGATION
LOCALITY PLAN

PROJECT NO: 30300413/01
FIGURE NO 1
SCALE N.T.S.

Figure 2: Raw Water Pipeline Route Showing Test Pit and DPL Positions



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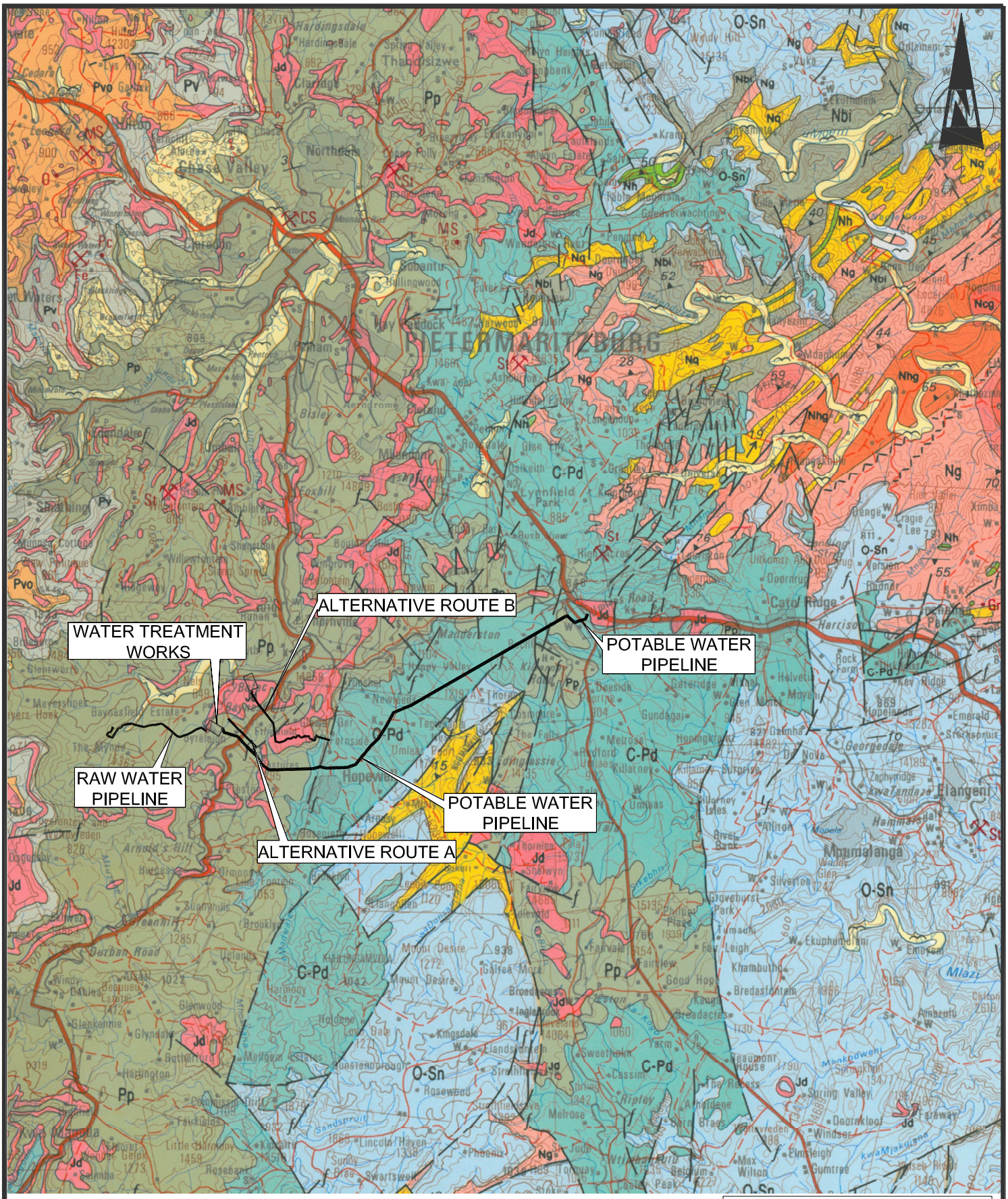
UMKHOMAZI WATER PROJECT
GEOTECHNICAL INVESTIGATION

RAW WATER PIPELINE ROUTE SHOWING TEST PIT AND DPL POSITIONS

PROJECT NO: 30300413/01
FIGURE NO 2
SCALE 1 : 10 000

Figure 3: Geology Map



GEOLOGICAL LEGEND:

C-Pd: Diamictite, shale of the Dwyka Formation, Karoo Supergroup.

Pp : Shale, siltstone, sandstone of the Pietermariztburg Formation, Ecca Group, Karoo Supergroup.

Jd : Dolerite.

REFERENCE MAP
1:250 000 SCALE
GEOLOGICAL SERIES
SHEET: 2930 DURBAN
NOT TO ORIGINAL SCALE

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UMKHOMAZI WATER PROJECT
GEOTECHNICAL INVESTIGATION

GEOLOGY MAP

PROJECT NO: 30300413/01
FIGURE NO 3
SCALE N.T.S.

Appendix A: Soil Profile Logs

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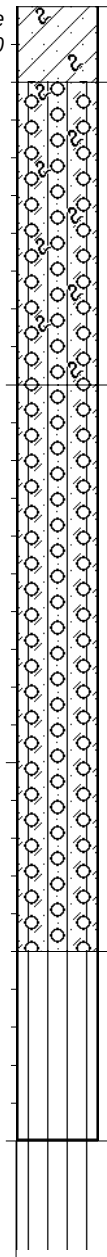
UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW01
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00	Moist, dark brown, firm, pinhole voided, sandy CLAY with roots. **COLLUVIUM**.
0.20	Moist, orange brown spackled yellow, firm, pinhole voided, sandy clayey SILT with numerous sub-angular and angular soft shale gravel with roots. **TALUS**.
1.00	Moist, maroon brown blotched yellow and black, firm to stiff, micro-shattered sandy clayey SILT with numerous very soft shale gravel. RESIDUAL SHALE**.**
2.50	Moist, yellow blotched maroon and red, stiff to very stiff, intact, SILT. RESIDUAL SHALE**.**
3.00	+ EOH: No refusal of TLB in a stiff to very stiff RESIDUAL SHALE.

NOTES

1) No water encountered.

2) Test pit partly profiled from a road cutting.

3) No sample taken.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION : Vertical
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 26.14
Y-COORD : E 30 18 12.09

HOLE No: RW01

D079 E Mouton

dotPLOT 7016 PBpH7

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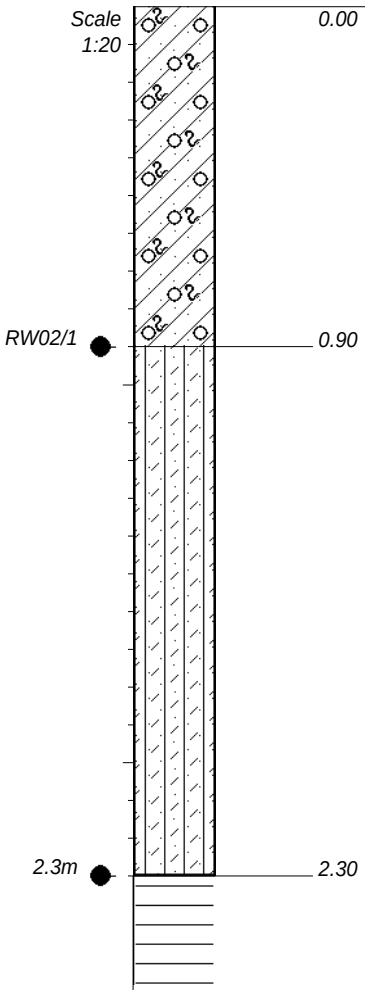
UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW02
Sheet 1 of 1

JOB: 3030041301



Slightly moist, dark brown, stiff, pinhole voided, sandy CLAY with roots and scattered shale gravel. **COLLUVIUM**.

Moist, red, firm, pinhole voided, sandy clayey SILT with isolated termite?s roots (0,4m). **COLLUVIUM**.

EOH: Refusal of TLB in light pink stained orange, thinly bedded, very soft rock SHALE.

NOTES

1) No water encountered.

2) Disturbed bulk sample RW02/1 taken from 0,9m ? 2,3m depth.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 29.37
Y-COORD : E 30 18 11.18

HOLE No: RW02

D079 E Mouton

dotPLOT 7016 PBpH7

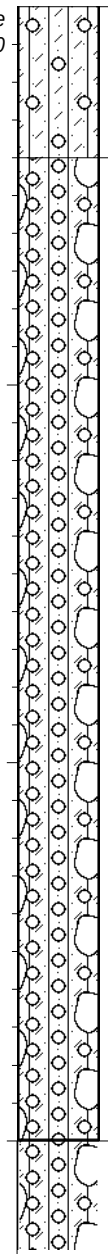
Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW03
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00 Moist, red mottled grey, firm, micro-shattered sandy clayey SILT with scattered shale gravel. **RESIDUAL SHALE**.

0.40 Abundant coarse medium and fine angular and sub-angular, very soft shale GRAVEL and COBBLES in a matrix of sandy clayey SILT. Overall consistency is dense. **RESIDUAL SHALE**.

3.00 EOH: No refusal of TLB in very dense RESIDUAL SHALE.

NOTES

1) No water encountered.

2) Test pit excavated at the foot of road cutting 1m below.

3) Semi-stable sidewall..

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 31.32
Y-COORD : E 30 18 9

HOLE No: RW03

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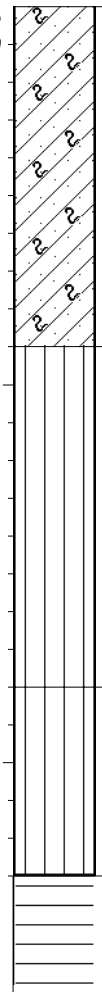
UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW04
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00 Moist, dark brown, firm, micro-shattered sandy CLAY with roots and isolated cobbles at the base. **COLLUVIUM**.

0.90 Very moist, dark grey mottled yellow, soft to firm, slightly slickensided, clayey SILT. **RESIDUAL SHALE**.

1.80 Very moist, orange blotched grey, soft to firm, slightly slickensided, clayey SILT. **RESIDUAL SHALE**.

2.30 EOH: Refusal of TLB in grey stained black, slightly weathered, thinly bedded, very soft rock SHALE.

NOTES

1) No water encountered.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 32.78
Y-COORD : E 30 18 6.16

HOLE No: RW04

D079 E Mouton

dotPLOT 7016 PBpH7

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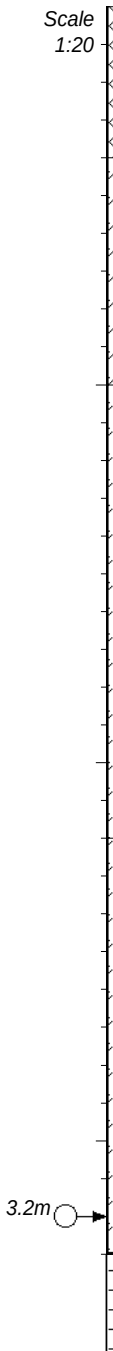
UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW05
Sheet 1 of 1

JOB: 3030041301



0.00	Moist, brown, firm, intact, sandy CLAY with numerous gravels and cobbles. **FILL.**
0.40	Moist, dark brown, firm, micro-shattered sandy CLAY with roots and isolated cobbles at the base. **COLLUVIUM**.
1.00	Very moist, orange blotched grey, soft, pinhole voided, sandy clayey SILT. **RESIDUAL SHALE**.
2.20	Very moist, green blotched grey, soft, intact, clayey sandy SILT. **RESIDUAL SHALE**.
3.30	EOH: Refusal of TLB on soft rock SHALE.

NOTES

1) Slightly water seepage encountered. at 3,2m depth.

2) No sample taken.

3) Semi-stable sidewall.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 35.24
Y-COORD : E 30 18 4.26

HOLE No: RW05

D079 E Mouton

dotPLOT 7016 PBpH7

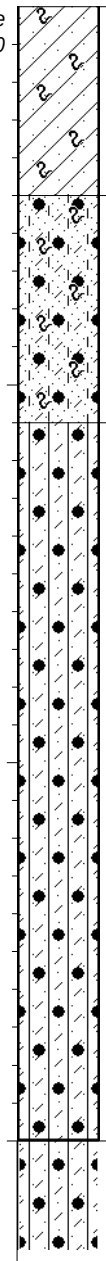
Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW06
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00 Moist, reddish brown, firm, pinhole voided sandy CLAY with roots. **COLLUVIUM**.

0.50 Slightly moist, brown, medium dense, pinhole voided, silty clayey SAND with numerous fine ferricrete nodules and fine roots. **FERRUGINOUS COLLUVIUM**.

1.10 Slightly moist, orange red blotched yellow with greyish blue band, sandy clayey SILT with numerous fine ferricrete nodules. **FERRUGINOUS RESIDUAL SHALE**.

3.00 + EOH: No refusal of TLB in firm FERRUGINOUS RESIDUAL SHALE.

NOTES

1) No water encountered.

2) No sample taken.

3) Semi-side wall.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 38.42
Y-COORD : E 30 18 12.79

HOLE No: RW06

D079 E Mouton

dotPLOT 7016 PBpH7

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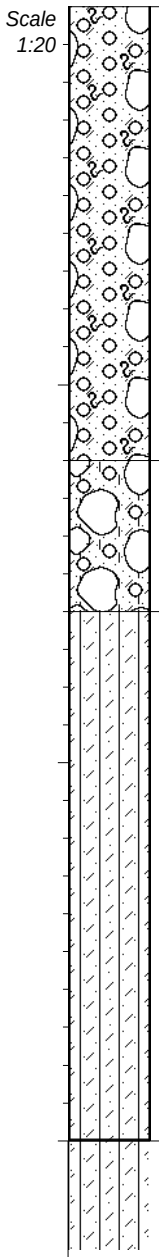
UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW07
Sheet 1 of 1

JOB: 3030041301



0.00

Slightly moist, brown blotched red and yellow, medium dense, pinhole voided, clayey SAND with shale gravels and cobbles (30%) and roots. **COLLUVIUM**.

1.20

Abundant coarse medium and fine, angular to sub-angular shale and dolerite GRAVELS, COBBLES and BOULDERS in a matrix of clayey silty sand. Overall consistency is dense. **PEBBLE MARKER**.

1.60

Slightly moist, reddish yellow speckled grey, firm to stiff, pinhole voided, sandy clayey SILT. **RESIDUAL SHALE**.

3.00

EOH: No refusal of TLB in firm to stiff RESIDUAL SHALE.

NOTES

1) No water encountered.

2) Semi-stable sidewall.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 32.75
Y-COORD : E 30 18 16.94

HOLE No: RW07

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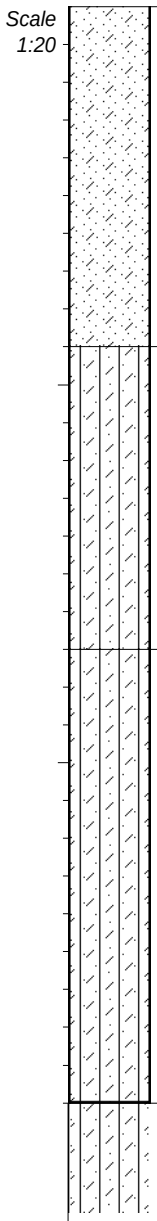
UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW08
Sheet 1 of 1

JOB: 3030041301



0.00

Slightly moist, reddish brown, medium dense, pinhole voided, clayey SAND with minor shale gravels and dolerite boulders. **COLLUVIUM**.

0.90

Slightly moist, reddish brown spackled orange and yellow, firm, pinhole voided, sandy clayey SILT with inclusion of gravel. **FERRUGINOUS RESIDUAL SHALE**.

1.70

Slightly moist, reddish yellow speckled grey, firm to stiff, pinhole voided, sandy clayey SILT. **RESIDUAL SHALE**.

2.90

EOH: No refusal of TLB in firm to stiff RESIDUAL SHALE.

NOTES

1) No water encountered.

2) No sample taken.

3) Semi-stable sidewall.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 27.58
Y-COORD : E 30 18 20.93

HOLE No: RW08

D079 E Mouton

dotPLOT 7016 PBpH7

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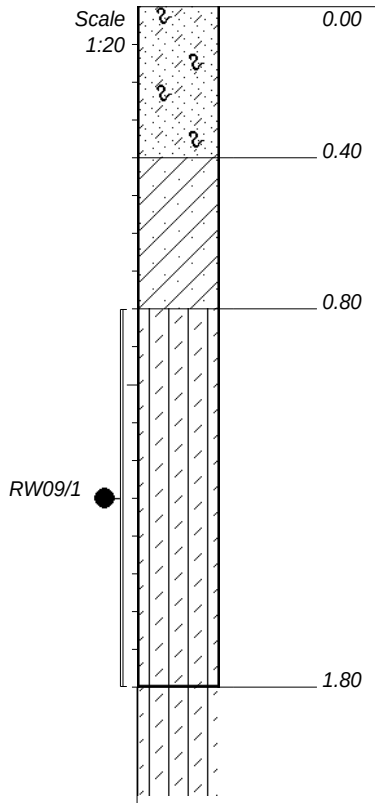
UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW09
Sheet 1 of 1

JOB: 3030041301



0.00	Slightly moist, reddish brown, loose, pinhole voided, clayey SAND with roots. **COLLUVIUM**.
0.40	Slightly moist, reddish brown with grey bends, medium dense, pinhole voided, sandy CLAY with patches of silt and roots. **FERRUGINOUS COLLUVIUM**.
0.80	Slightly moist, grey yellow red band, stiff, intact, clayey SILT. **RESIDUAL SHALE** tending to completely weathered very soft rock shale.
1.80	EOH: Refusal of TLB in very stiff RESIDUAL SHALE tending to completely weathered very soft rock shale.

NOTES

1) No water encountered.

2) Disturbed bulk sample RW09/1 taken from 0,8m--1,8m.

3) Semi-stable sidewall.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 24.38
Y-COORD : E 30 18 26.76

HOLE No: RW09

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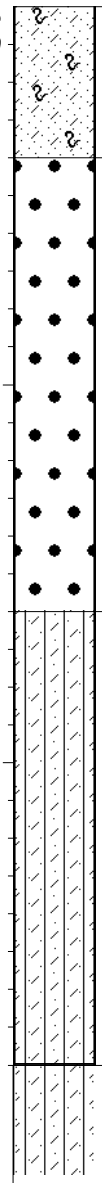
UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW10
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00	Slightly moist, reddish brown, loose, pinhole voided, clayey SAND with roots. **COLLUVIUM**.
0.40	Slightly moist, red, medium dense, pinhole voided, relict jointed with numerous FERRICRETE NODULES and minor roots. **FERRUGINOUS COLLUVIUM**.
1.60	Slightly moist, reddish brown orange blotched yellow, dense, relict jointed, slightly pinhole voided, sandy clayey SILT. **RESIDUAL SHALE**.
2.80	EOH: No refusal of TLB in dense RESIDUAL SHALE.

NOTES

1) No water encountered.

2) Stable side wall.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 21.14
Y-COORD : E 30 18 38.05

HOLE No: RW10

D079 E Mouton

dotPLOT 7016 PBpH7

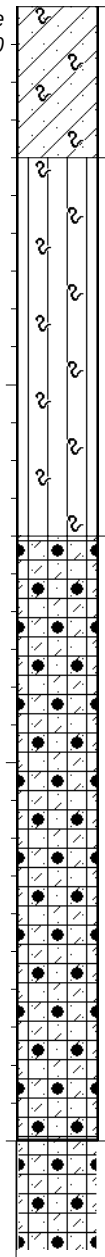
Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW10A
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00	Moist, dark brown, firm, micro-shattered, sandy CLAY with roots. **COLLUVIUM**.
0.40	Moist, red, soft, pinhole voided, sandy SILT with roots. **COLLUVIUM**.
1.40	Moist, red blotched black and yellow, firm, slightly pinhole voided, sandy clayey SILT with numerous ferricrete nodules and completely weathered shale. **RESIDUAL SHALE**.
3.00	EOH: No refusal of TLB in firm RESIDUAL SHALE.

NOTES

1) No water encountered.

2) No sample taken.

3) Stable sidewalls.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 23.92
Y-COORD : E 30 18 32.78

HOLE No: RW10A

D079 E Mouton

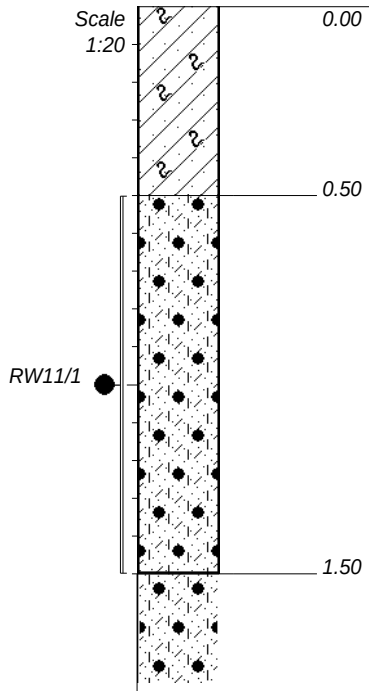
dotPLOT 7016 PBpH7

Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW11
Sheet 1 of 1

JOB: 3030041301



0.00 — Moist, dark brown, firm, pinhole voided, sandy CLAY with roots. **COLLUVIUM**.

0.50 — Moist, orange brown mottled black and yellow, dense, pinhole voided, silty clayey SAND with numerous fine ferricrete nodules. **FERRUGINOUS COLLUVIUM**.

1.50 — EOH: Excavation becomes very difficult in very dense FERRUGINOUS COLLUVIUM.

NOTES

1) No water encountered.

2) Disturbed bulk sample RW11/1 taken from 0,5m--1,5m.

3) Stable sidewall.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 22.82
Y-COORD : E 30 18 48.01

HOLE No: RW11

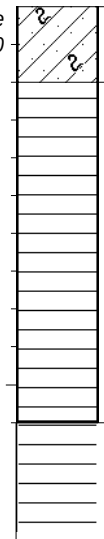
Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW12
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00 Moist, dark brown, firm, pinhole voided, sandy CLAY with roots. **COLLUVIUM**.

0.20 Moist, grey and yellow stained black, moderately weathered, thinly bedded, soft rock to very soft rock SHALE.

1.10 EOH: Refusal of TLB on soft to very soft rock SHALE.

NOTES

1) No water encountered.

2) No sample taken.

3) Semi-stable side walls

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 25.29
Y-COORD : E30 18 59.55

HOLE No: RW12

D079 E Mouton

dotPLOT 7016 PBpH7

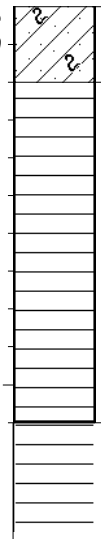
Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW12A
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00 Moist, dark brown, firm, pinhole voided, sandy CLAY with roots. **COLLUVIUM**.

0.20 Moist, grey and yellow stained black, moderately weathered, thinly bedded, soft to very soft rock SHALE.

1.10 EOH: Refusal of TLB on soft rock to very soft rock SHALE.

NOTES

1) No water encountered.

2) No sample taken.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 23.66
Y-COORD : E 30 18 59.67

HOLE No: RW12A

D079 E Mouton

dotPLOT 7016 PBpH7

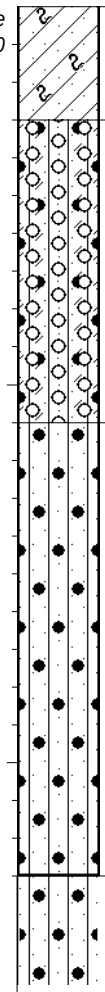
Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW13
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00	Moist, dark brown, firm, pinhole voided, sandy CLAY with roots. **COLLUVIUM**.
0.30	Moist, red, soft to firm, slightly pinhole voided, sandy clayey SILT with fine ferricrete gravel. **COLLUVIUM**.
1.10	Moist, orange brown mottled red, stiff to firm, slightly pinhole voided, sandy SILT with numerous fine ferricrete nodules. **FERRUGINOUS COLLUVIUM**.
2.30	EOH: Refusal of TLB in stiff FERRUGINOUS COLLUVIUM.

NOTES

1) No water encountered.

2) Stable sidewall.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 25.25
Y-COORD : E 30 19 5.64

HOLE No: RW13

D079 E Mouton

dotPLOT 7016 PBpH7

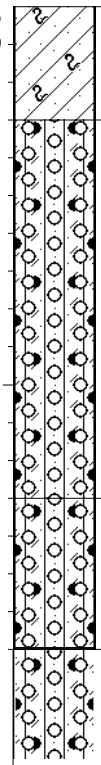
Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW14
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00	Moist, dark brown, firm, pinhole voided, sandy CLAY with roots. **COLLUVIUM**.
0.30	Moist, red, soft to firm, slightly pinhole voided, sandy clayey SILT with fine ferricrete gravel. **COLLUVIUM**.
1.30	Abundant fine ferricrete GRAVEL, clast supported in a matrix as above. Overall consistency is dense. **FERRUGINOUS COLLUVIUM**.
1.70	EOH: Gradual refusal of TLB in very dense FERRUGINOUS COLLUVIUM.

NOTES

1) No water encountered.

2) No sample taken.

3) Stable sidewall.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 22.12
Y-COORD : E 30 19 19.29

HOLE No: RW14

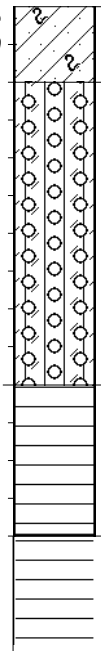
Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW15
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00 Moist, brown, firm, pinhole voided, sandy CLAY with roots. **COLLUVIUM**.

0.20 Abundant and completely weathered, very soft shale GRAVEL, clast supported in a matrix of clayey SILT. **RESIDUAL SHALE**.

1.00 Moist, khaki brown stained red and black, highly to completely weathered, thinly bedded, very soft rock SHALE.

1.40 EOH: Gradual refusal of TLB on very soft rock SHALE.

NOTES

1) No water encountered.

2) No sample taken.

3) Stable sidewalls

4) Test pit shifted 150m towards the???

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 25.2
Y-COORD : E 30 19 31.07

HOLE No: RW15

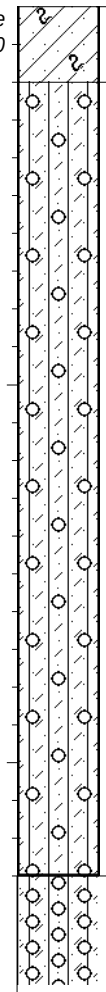
Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW16
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00 Moist, dark brown, firm, pinhole voided, sandy CLAY with roots. **COLLUVIUM**.

0.20 Moist, red speckled black, soft to firm, pinhole voided, sandy clayey SILT with scattered ferricrete gravel. **COLLUVIUM**.

2.30 EOH: Gradual refusal of TLB in abundant, fine ferricrete GRAVEL, clast supported in matrix of sandy clayey silt. Overall consistency is very dense. **FERRUGINOUS COLLUVIUM**.

NOTES

1) No water encountered.

2) No sample taken.

3) Stable sidewall.

4) Position of test pit shifted 170m to the west.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 33.49
Y-COORD : E 30 19 34.82

HOLE No: RW16

D079 E Mouton

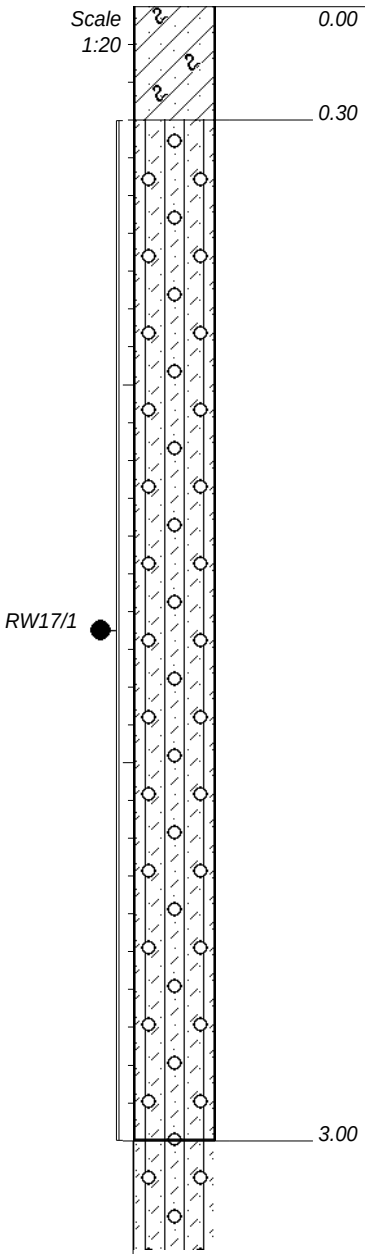
dotPLOT 7016 PBpH7

Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW17
Sheet 1 of 1

JOB: 3030041301



Moist, dark brown, firm, pinhole voided, sandy CLAY with roots. **COLLUVIUM**.

Moist, red spackled black, soft to firm, pinhole voided, sandy clayey SILT with scattered ferricrete gravel. **COLLUVIUM**.

EOH: No refusal of TLB in soft to firm FERRUGINOUS COLLUVIUM.

NOTES

1) No water encountered.

2) Disturbed bulk sample RW17/1 taken from 0,3m--3m.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 32.97
Y-COORD : E 30 19 42.3

HOLE No: RW17

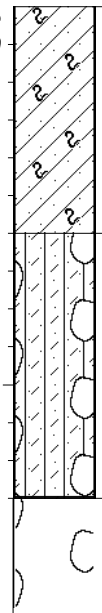
Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW18
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00 Moist, dark brown, firm, micro-shattered sandy CLAY with roots. **COLLUVIUM**.

0.60 Moist, orange brown blotched black, firm, intact, sandy clayey SILT with scattered hard dolerite cobbles. **RESIDUAL DOLERITE**.

1.30 EOH: Refusal of TLB on hard dolerite COBBLES. **RESIDUAL DOLERITE**.

NOTES

1) No water encountered.

2) Semi-stable sidewall.

3) Test pit excavated next to a water course.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 37.16
Y-COORD : E 30 19 47.76

HOLE No: RW18

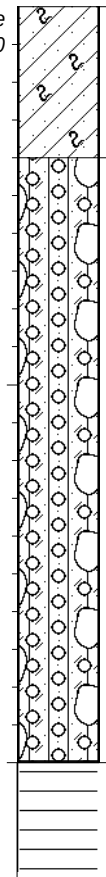
Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW19
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00 Moist, dark brown, stiff to firm, micro-shattered, sandy CLAY with roots. **COLLUVIUM**.

0.40 Abundant (70 **to 80%) coarse medium and fine, soft shale GRAVEL and COBBLES, clast supported in a matrix of sandy clayey SILT. Overall consistency is dense to very dense.** RESIDUAL SHALE**.**

2.00 EOH: Refusal of TLB in very soft rock SHALE.

NOTES

1) No water encountered.

2) Semi-stable side walls

3) No sample taken.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 37.8
Y-COORD : E 30 19 55.19

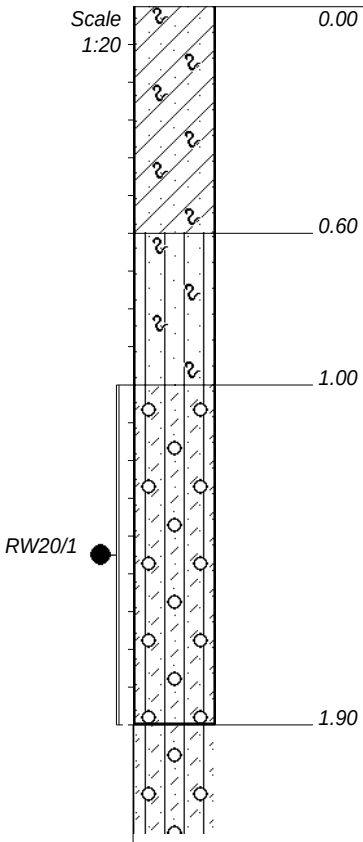
HOLE No: RW19

Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW20
Sheet 1 of 1

JOB: 3030041301



0.00 Moist, dark brown, stiff to firm, micro-shattered, sandy CLAY with roots. **COLLUVIUM**.

0.60 Moist, red, firm, pinhole voided, sandy SILT roots. **COLLUVIUM**.

1.00 Moist, red, speckled yellow and black, stiff, sandy clayey SILT with numerous fine ferricrete gravel. **FERRUGINOUS RESIDUAL SHALE**.

1.90 EOH: Refusal of TLB in very stiff FERUGINOUS RESIDUAL SHALE.

NOTES

1) No water encountered.

2) Disturbed sample RW20/1 taken from 1m--1,9m.

3) Test pit excavated in close proximity 100m north due to maize meal????

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 32.07
Y-COORD : E 30 19 59.45

HOLE No: RW20

D079 E Mouton

dotPLOT 7016 PBpH7

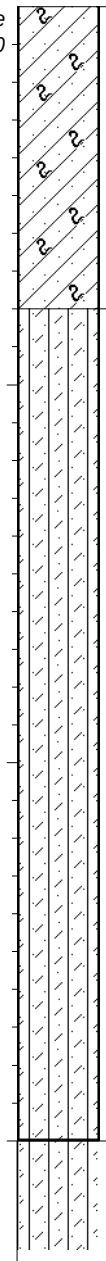
Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW21
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00 Moist, dark brown, stiff to firm, micro-shattered, sandy CLAY with roots. **COLLUVIUM**.

0.80 Moist, red, firm to stiff, slightly pinhole voided, sandy clayey SILT. **RESIDUAL SHALE**.

3.00 EOH: No refusal of TLB in firm to stiff RESIDUAL SHALE.

NOTES

1) No water encountered.

2) No sample taken.

3) Stable sidewall.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 33.5
Y-COORD : E 30 20 7.5

HOLE No: RW21

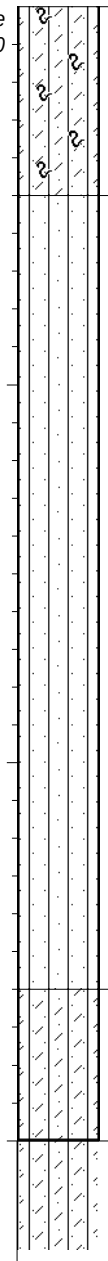
Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW22
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00 Slightly moist to moist, dark brown, firm to stiff, pinhole voided, sandy clayey SILT with roots. **COLLUVIUM**.

0.50 Moist, red, firm, slightly pinhole voided, sandy SILT. **RESIDUAL SHALE**.

2.60 Moist, red blotched orange, firm, pinhole voided, sandy clayey SILT. **RESIDUAL SHALE**.

3.00 EOH: No refusal of TLB in firm RESIDUAL SHALE.

NOTES

1) No water encountered.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 31.64
Y-COORD : E 30 20 17.15

HOLE No: RW22

D079 E Mouton

dotPLOT 7016 PBpH7

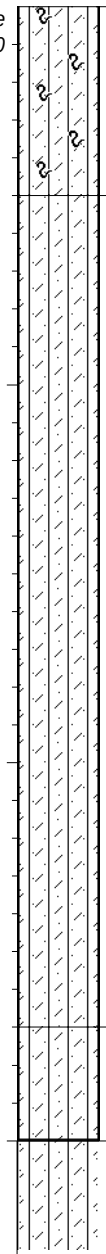
Knight Piésold CONSULTING

UMKHOMAZI PIPELINE
RAW WATER PIPELINE
GEOTECHNICAL INVESTIGATION

HOLE No: RW23
Sheet 1 of 1

JOB: 3030041301

Scale 1:20



0.00 Slightly moist to moist, dark brown, firm to stiff, pinhole voided, sandy clayey SILT with roots. **COLLUVIUM**.

0.50 Moist, red, stiff, slightly pinhole voided, sandy clayey SILT with isolated completely weathered dolerite cobbles. **RESIDUAL SHALE**.

2.70 Moist, red mottled yellow, firm, slightly pinhole voided, sandy clayey SILT. **RESIDUAL SHALE**.

3.00 EOH: No refusal of TLB in firm RESIDUAL DOLERITE.

NOTES

1) No water encountered.

2) No sample taken.

3) Semi-stable sidewall.

CONTRACTOR : Umgeni Water
MACHINE : Bell TLB
DRILLED BY :
PROFILED BY : AvdM / EM

TYPE SET BY : EM1
SETUP FILE : KPTP2.SET

INCLINATION :
DIAM :
DATE :
DATE : 11 March 2014

DATE : 17/04/2014 10:34
TEXT : ..P51\PROFILES\MADAVDM.TXT

COORDINATE SYSTEM : WGS84 (Lo27)
X-COORD : S 29 46 27.66
Y-COORD : E 30 20 22.48

HOLE No: RW23

Appendix B: Laboratory Test Results

Consulting Engineering Geologists, Geotechnical Engineers, Geotechnicians & Geotechnical Quality Assurance Specialists

GEOSURE (Pty) Ltd

sanas Testing Laboratory T0483

CLIENT : Knight Pie Sold (Pty) Ltd
ADDRESS : N/A
ATTENTION : Umkhomazi Water Pipeline
PROJECT : Mr A.VanderMerwe

TEST REPORT REFERENCE NUMBER: 17168

Dear Sir/Madam,
Enclosed herewith, please find the original reports pertaining to the above-mentioned project.

Date Received	**24.03.2014**
Date Tested	24.03.2014 to 08.04.2014
Sample Location	Refer to Report
Sampling Method	N/A
Sample Condition	Moist
Sampling Environmental Condition	N/A
Sampler(s) Name	Client
Total Number of Pages	51

Test Carried Out			
TMH1 Method A1, B4, A5	✓	TMH1 Method C3	
TMH1 Method A2, A3, A4	✓	TMH1 Method C4a	
TMH1 Method A7	✓	TMH1 Method B6	
TMH1 Method A8, A9		Hydrometer Analysis - ASTM D422	✓
TMH1 Method A10(b)		SANS 5863	
TMH1 Method A13T + A14app		SANS 5862-1	
TMH1 Method A15d		SANS 5860, 5861-1, 5861-2, 5861-3	
TMH1 Method A13T + A16T		TMH1 Method B9	

✓ - Tick denotes tests that were carried out.

We would like to take this opportunity of thanking you for your continued support.
Should you have any queries please do not hesitate to contact me.
Yours faithfully

Technical Signatory,
Kris Veeran for Geosure (Pty) Ltd.

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PO Box 1461, Westville, 3630, South Africa
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Gauteng Branch
P. O. Box 32381, Kyalami 1684
Tel.: 0861 GEOSURE / 0861 436 7873
Fax: 086 689 8327
Mobile: 083 377 6559
Email: gauteng@geosure.co.za

Consulting Engineering Geologists, Geotechnical Engineers, Geotechnicians & Geotechnical Quality Assurance Specialists
GEOSURE (Pty) Ltd
Reg.No.: 92/03145/07
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Mobile: +27(0) 82 784 0544 e-mail:geosure@iafrica.com
WEBSITE: www.geosure.co.za

sanas T0483

Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

Our Ref. : 17168
Your Ref. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample No.			28055	28056	28057	28058	28059
Field No.			PL 02/1	PL 05/1	PL 09/1	PL 14/1	PL 15/1
Position in Field							
Depth (m)			1.7-3.0	0.8-1.4	1.5-2.9	0.3-0.9	0.6-1.9
Material Description			Residual Shale	Ferriginous Colluvium	Residual Shale	Colluvium	Residual Tillite
Sieve Analysis (ASTM - D422)							
% Passing	63.0	mm	100	100	100	100	100
	53.0	mm	100	100	100	100	100
	37.5	mm	100	100	100	100	100
	26.5	mm	100	100	100	100	100
	19.0	mm	100	100	100	100	100
	13.2	mm	100	100	100	100	100
	4.75	mm	100	95	100	100	94
	2.00	mm	98	56	98	98	81
	0.425	mm	95	32	96	93	66
	0.075	mm	91	30	84	88	53
Hydrometer Analysis (ASTM - D422)							
% Passing	0.060	mm	86	28	81	82	49
	0.050	mm	82	26	77	75	45
	0.040	mm	75	25	72	71	42
	0.026	mm	71	22	63	66	35
	0.015	mm	66	20	61	60	31
	0.010	mm	60	19	59	55	28
	0.0074	mm	60	19	52	53	25
	0.0036	mm	49	16	41	46	19
	0.0020	mm	46	15	36	44	17
	0.0015	mm	46	15	29	40	16
Soil Mortar Analysis							
Coarse Sand		%	3	42	3	5	19
Coarse Fine Sand		%	1	1	2	1	5
Medium Fine Sand		%	2	1	5	1	6
Fine Fine Sand		%	1	2	5	2	5
Silt & Clay		%	93	53	85	90	66
Grading Modulus			0.2	1.8	0.2	0.2	1.0
Atterberg Limits and Classification							
Liquid Limit		%	43	38	42	37	23
Plasticity Index		%	16	11	13	7	7
Linear Shrinkage		%	8.0	5.5	6.5	3.5	3.5
AASHTO Classification (Group Index)*			A-7-6(17)	A-2-4(0)	A-7-6(12)	A-4(8)	A-4(1)
Unified Classification*			CL	SM	ML	ML	CL
Moisture Content		%	18.6	71.2	30.5	27.1	8.2

Remarks:

*Opinions expressed herein fall outside the scope of SANAS accreditation.

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GEOSURE (Pty) Ltd
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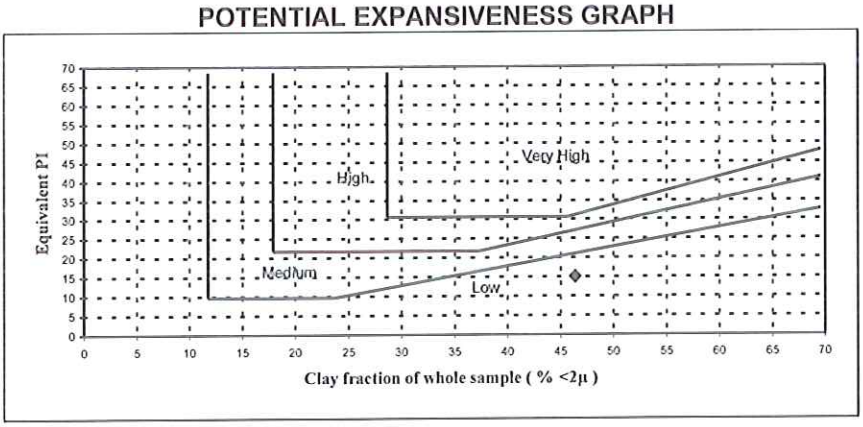
WEBSITE: www.geosure.co.za

Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

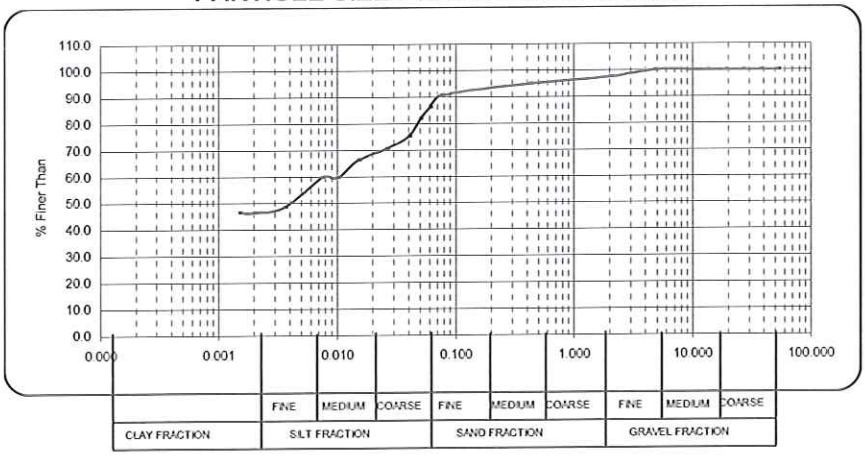
Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample Number : 28055
Field No. : PL 02/1
Sample Description : Residual Shale
Equivalent PI : 15 **Clay fraction of whole sample (% <2μ)** : 46

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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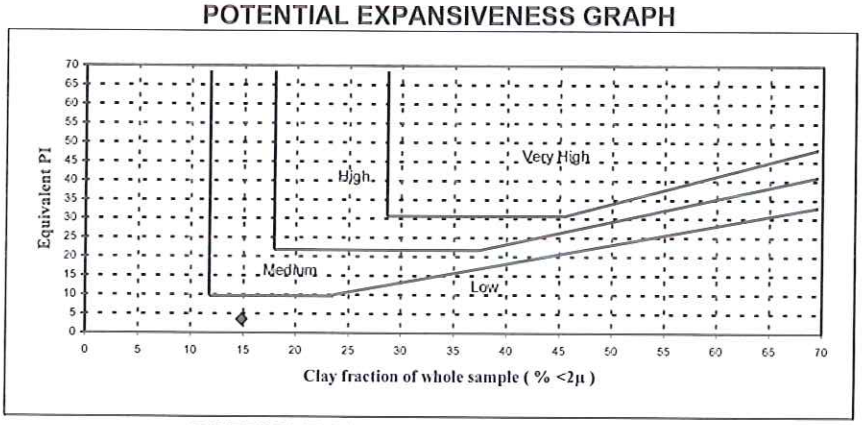
Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

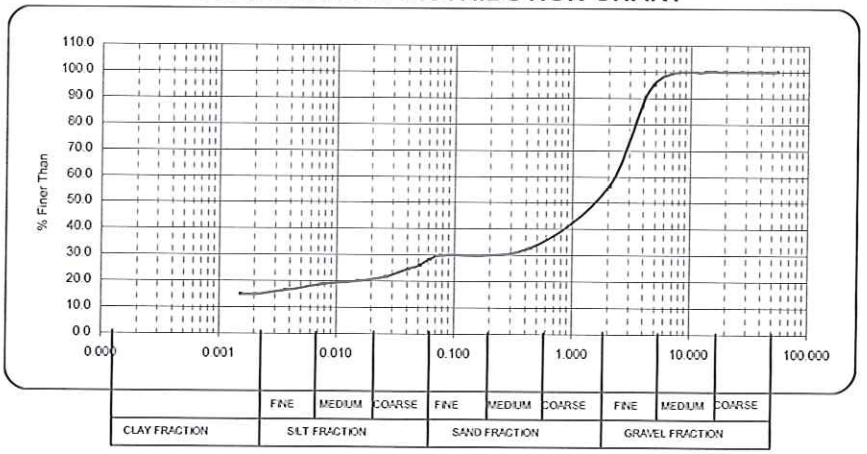
Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample Number : 28056
Field No. : PL 05/1
Sample Description : Ferriginous Colluvium
Equivalent PI : 4 **Clay fraction of whole sample (% <2μ)** : 15

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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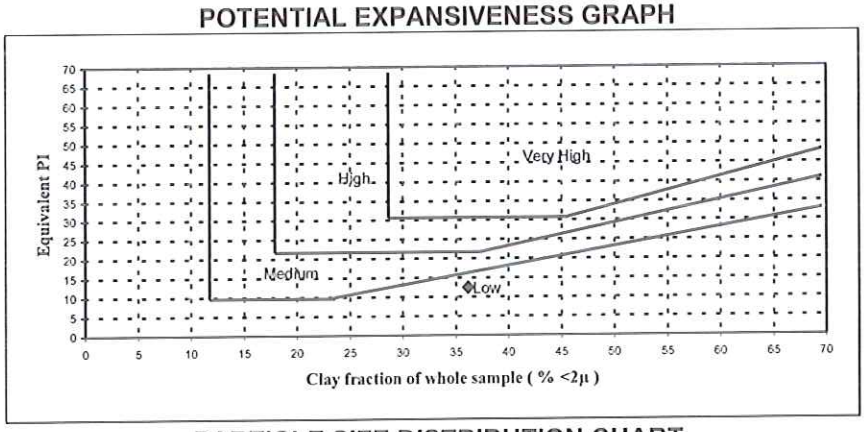
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

Job No. :
Your Ref.No. :
Date Tested :
Date Reported :

Sample Number : 28057
Field No. : PL 09/1
Sample Description : Residual Shale
Equivalent PI : 12 **Clay fraction of whole sample (% <2μ)** : 36

POTENTIAL EXPANSIVENESS GRAPH



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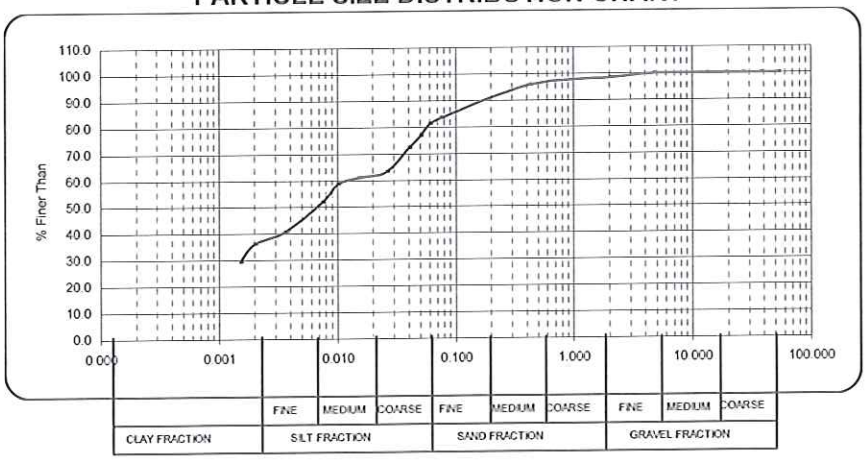

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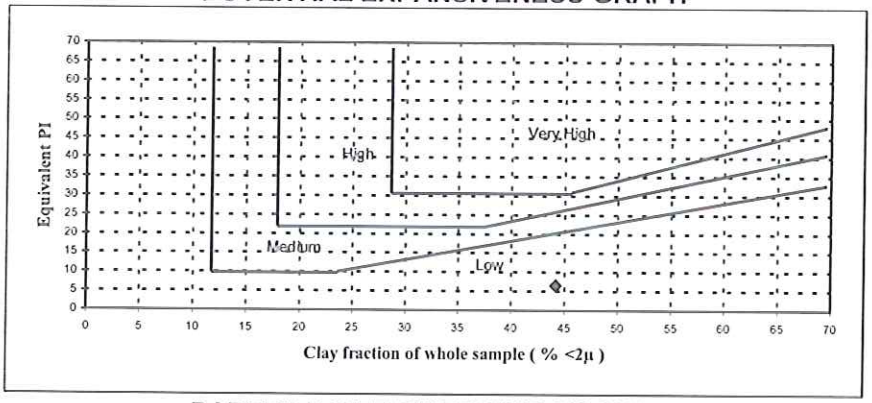
Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

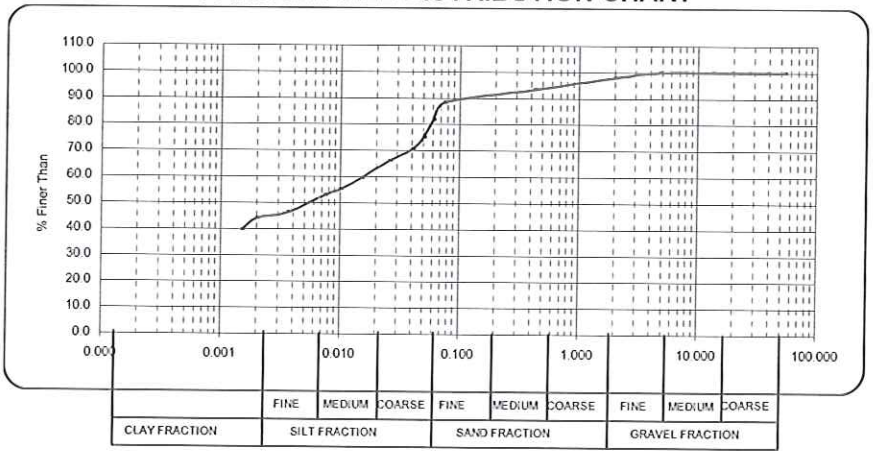
Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample Number : 28058
Field No. : PL 14/1
Sample Description : Colluvium
Equivalent PI : 7 **Clay fraction of whole sample (% <2μ)** : 44

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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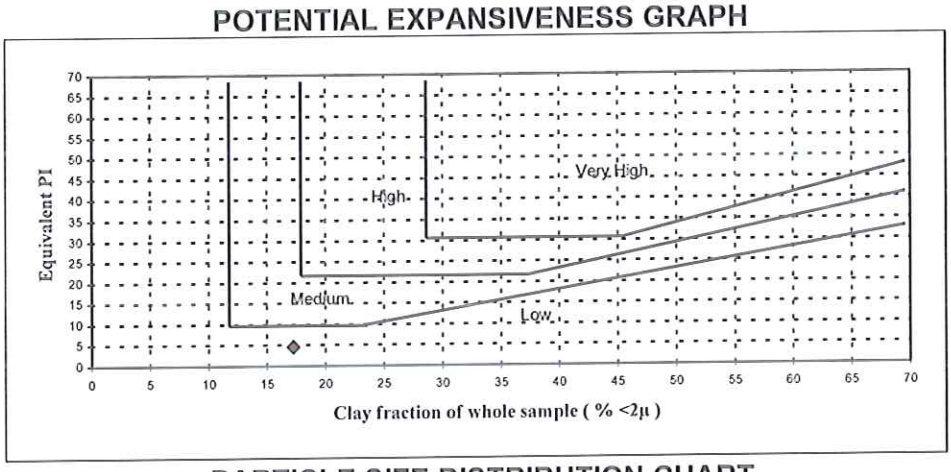
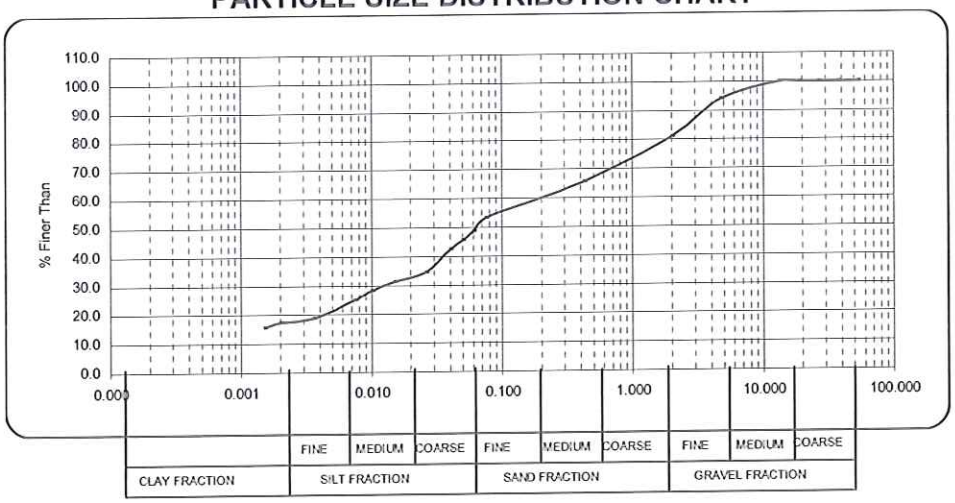
Sample Number : 28059
Field No. : PL 15/1
Sample Description : Residual Tillite
Equivalent PI : 5 **Clay fraction of whole sample (% <2μ)** : 17

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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Attention : Mr A.VanderMerwe

Our Ref. : 17168
Your Ref. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample No.			28060	28061	28062	28063	28064
Field No.			PL 20/1	PL 25/1	PL 28/1	PL 30/1	PL 33/2
Position in Field							
Depth (m)			0.7-2.8	0.5-2.7	1.0-3.0	1.1-2.0	1.0-3.0
Material Description			Deworked Residual Tillite	Residual Tillite	Residual Tillite	Deworked Residual Tillite	Residual Tillite
Sieve Analysis (ASTM - D422)							
% Passing	63.0	mm	100	100	100	100	100
	53.0	mm	100	100	100	100	100
	37.5	mm	100	100	100	100	100
	26.5	mm	100	100	100	100	100
	19.0	mm	100	100	100	100	100
	13.2	mm	100	100	100	100	100
	4.75	mm	100	99	96	92	99
	2.00	mm	99	92	86	73	97
	0.425	mm	96	70	79	56	88
	0.075	mm	84	57	65	43	70
Hydrometer Analysis (ASTM - D422)							
% Passing	0.060	mm	77	50	61	39	64
	0.050	mm	73	45	56	34	57
	0.040	mm	68	27	47	30	50
	0.026	mm	64	25	42	28	44
	0.015	mm	60	23	38	26	42
	0.010	mm	57	20	37	23	37
	0.0074	mm	53	18	35	21	35
	0.0036	mm	44	14	28	18	26
	0.0020	mm	38	9	23	15	22
	0.0015	mm	31	7	21	14	20
Soil Mortar Analysis							
Coarse Sand		%	3	24	9	24	9
Coarse Fine Sand		%	2	3	3	4	5
Medium Fine Sand		%	4	6	4	6	6
Fine Fine Sand		%	6	6	9	9	7
Silt & Clay		%	85	61	75	58	73
Grading Modulus			0.2	0.8	0.7	1.3	0.5
Atterberg Limits and Classification							
Liquid Limit		%	45	28	32	23	35
Plasticity Index		%	24	10	9	7	11
Linear Shrinkage		%	12	5.0	4.5	3.5	5.5
AASHTO Classification (Group Index)*			A-7-6 (21)	A-4(3)	A-4(4)	A-4(0)	A7-6(7)
Unified Classification*			CL	CL	CL	SC	CL
Moisture Content		%	40.4	13.1	9.6	34.2	25.7

Remarks:

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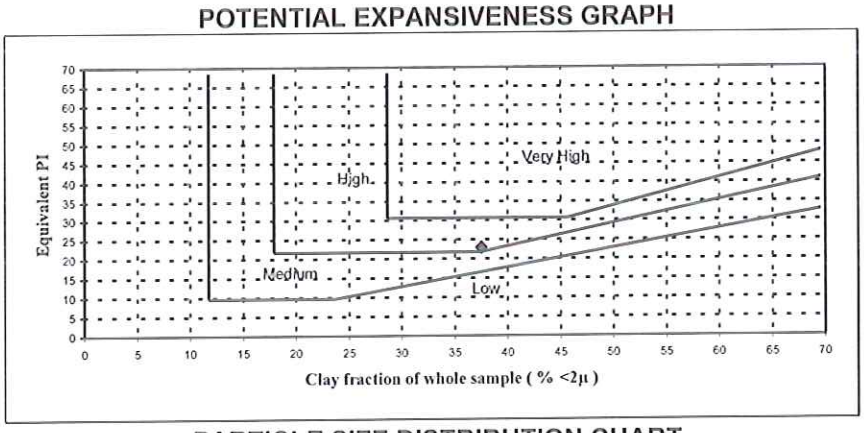
sanas T0483

Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

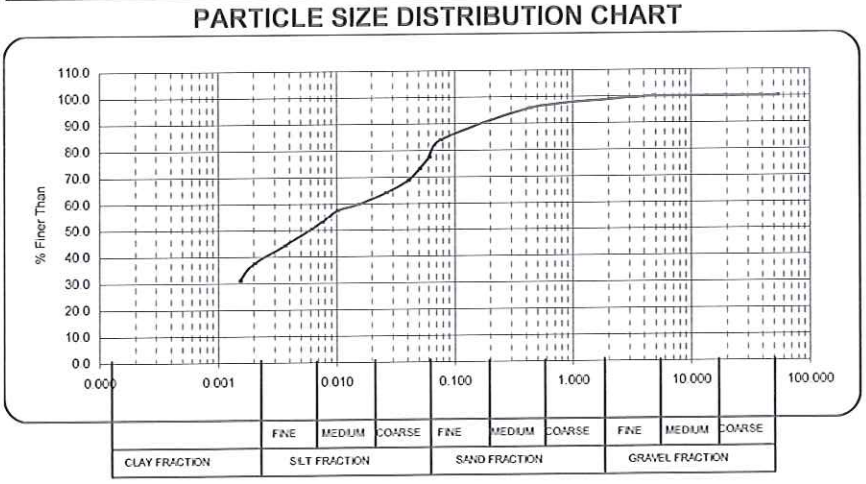
Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample Number : 28060
Field No. : PL 20/1
Sample Description : Deworked Residual Tillite
Equivalent PI : 23 **Clay fraction of whole sample (% <2μ)** : 38

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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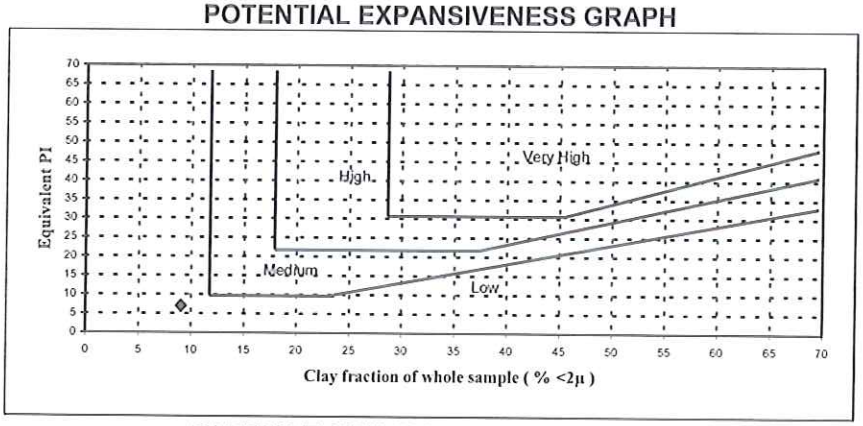
Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

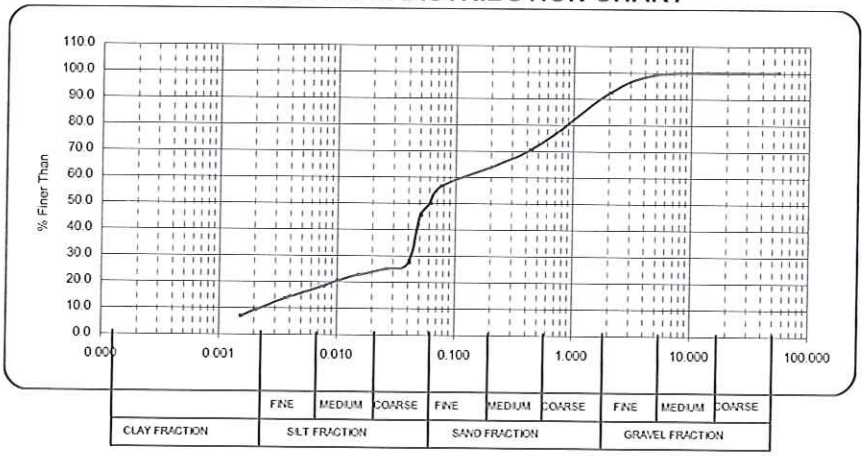
Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample Number : 28061
Field No. : PL 25/1
Sample Description : Residual Tillite
Equivalent PI : 7 **Clay fraction of whole sample (% <2μ)** : 9

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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WEBSITE: www.geosure.co.za

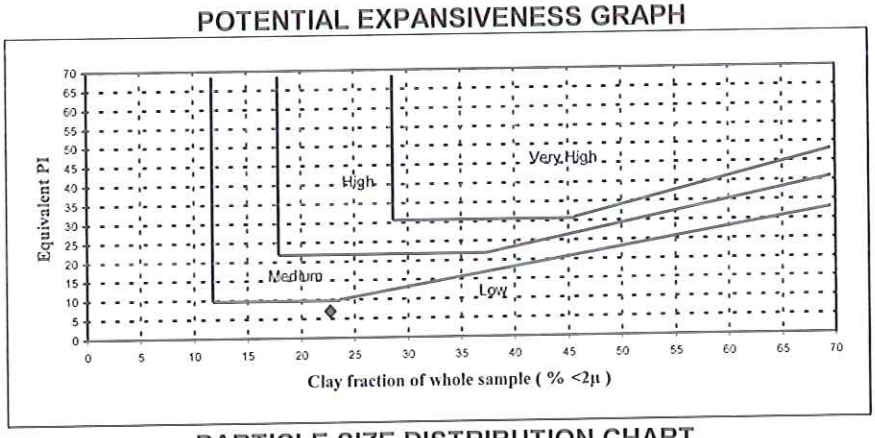
sanas T0483

Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

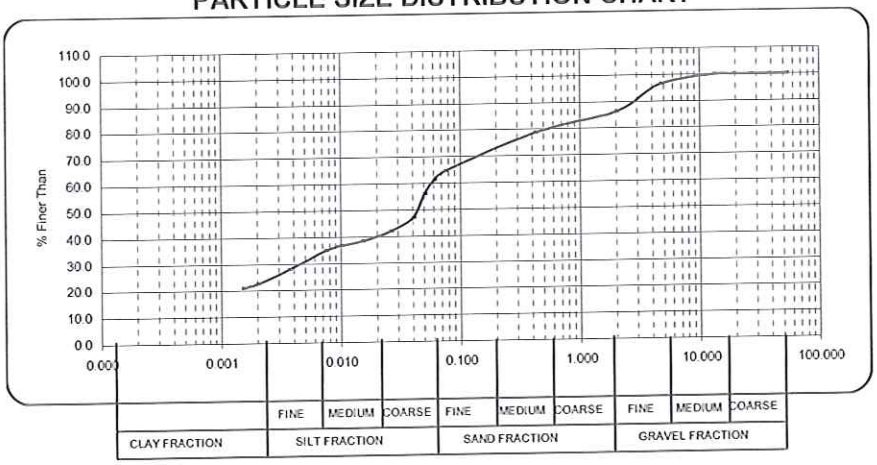
Job No. :
Your Ref.No. :
Date Tested :
Date Reported :

Sample Number : 28062
Field No. : PL 28/1
Sample Description : Residual Tillite
Equivalent PI : 7 **Clay fraction of whole sample (% <2μ)** : 23

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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WEBSITE: www.geosure.co.za

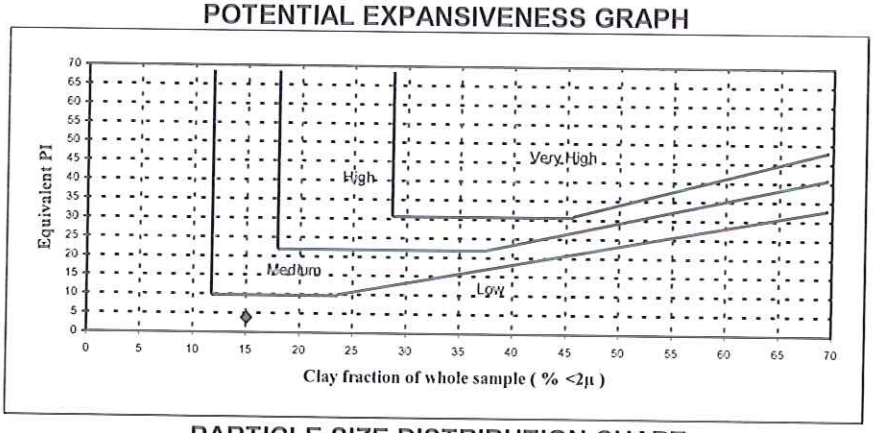
sanas T0483

Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

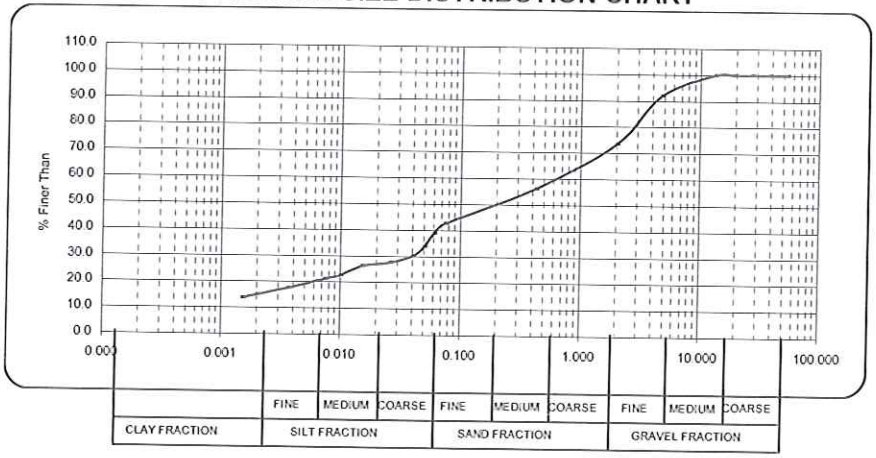
Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample Number : 28063
Field No. : PL 30/1
Sample Description : Deworked Residual Tillite
Equivalent PI : 4 **Clay fraction of whole sample (% <2μ)** : 15

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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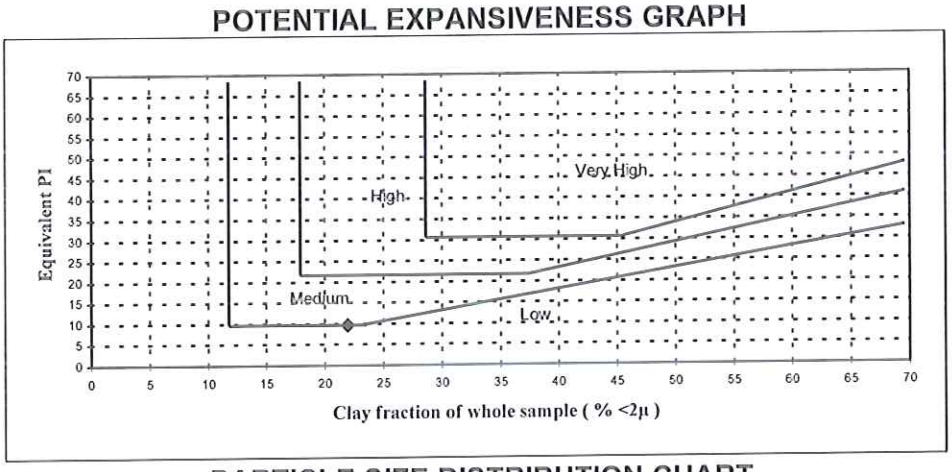
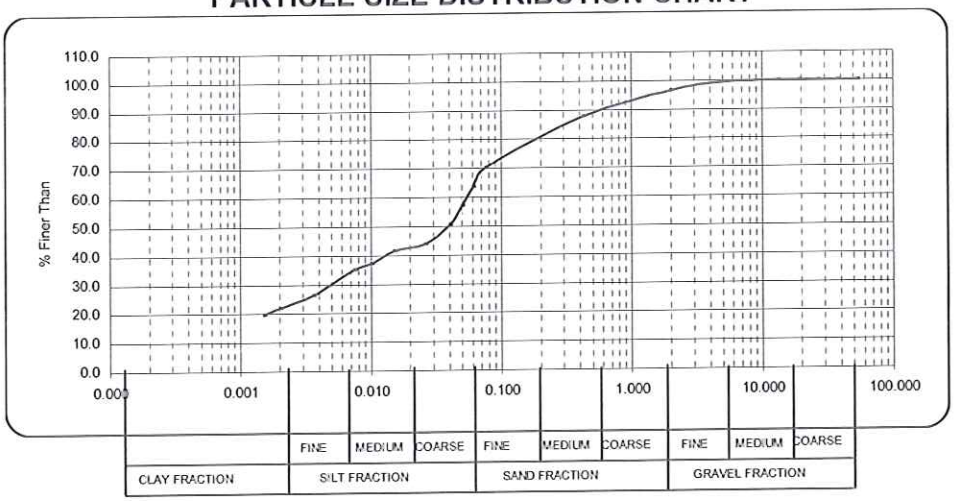
Sample Number : 28064
Field No. : PL 33/2
Sample Description : Residual Tillite
Equivalent PI : 10 **Clay fraction of whole sample (% <2μ)** : 22

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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sanas T0433

Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

Our Ref. : 17168
Your Ref. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample No.			28065	28066	28067	28068	28069
Field No.			PL 35/1	PL 68/1	PL 72/1	PL 74/1	RW 02/1
Position in Field							
Depth (m)			1.2-2.7	0.5-1.5	1.1-1.8	0.5-3.0	0.9-7.3
Material Description			Residual Tillite	Residual Dolerite	Ferruginous Residual Tillite	Ferruginous Colluvium	Colluvium
Sieve Analysis (ASTM - D422)							
% Passing	63.0	mm	100	100	100	100	100
	53.0	mm	100	100	100	100	100
	37.5	mm	100	100	100	100	100
	26.5	mm	100	100	100	100	100
	19.0	mm	100	100	100	100	100
	13.2	mm	100	100	100	100	100
	4.75	mm	99	98	99	99	97
	2.00	mm	88	96	92	77	90
	0.425	mm	69	93	80	55	74
	0.075	mm	43	90	72	48	72
Hydrometer Analysis (ASTM - D422)							
% Passing	0.060	mm	38	86	68	46	68
	0.050	mm	35	82	65	42	65
	0.040	mm	26	78	58	37	60
	0.026	mm	21	74	55	34	57
	0.015	mm	15	70	53	32	53
	0.010	mm	14	66	51	31	51
	0.0074	mm	11	62	50	31	48
	0.0036	mm	9	58	46	30	45
	0.0020	mm	6	54	43	27	38
	0.0015	mm	6	54	34	27	38
Soil Mortar Analysis							
Coarse Sand		%	22	3	13	28	18
Coarse Fine Sand		%	8	2	2	2	1
Medium Fine Sand		%	10	1	3	3	1
Fine Fine Sand		%	13	1	4	4	1
Silt & Clay		%	48	93	78	62	80
Grading Modulus			1.0	0.2	0.6	1.2	0.6
Atterberg Limits and Classification							
Liquid Limit		%	20	52	48	46	47
Plasticity Index		%	7	15	13	12	10
Linear Shrinkage		%	3.5	7.5	6.5	6.0	5.0
AASHTO Classification (Group Index)*			A-4(0)	A-7-5(18)	A-7-5(11)	A-7-5(4)	A-5(9)
Unified Classification*			SC	MH	ML	SM	ML
Moisture Content		%	15.6	22.3	21.7	24.5	27.9

Remarks: Date Received:

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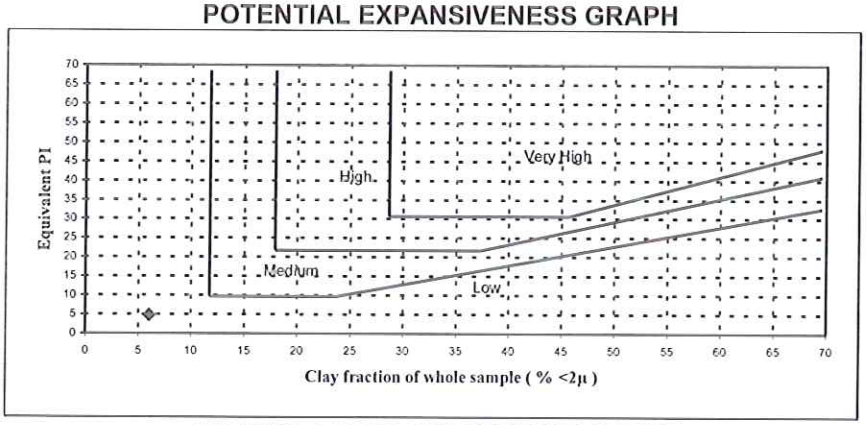
Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

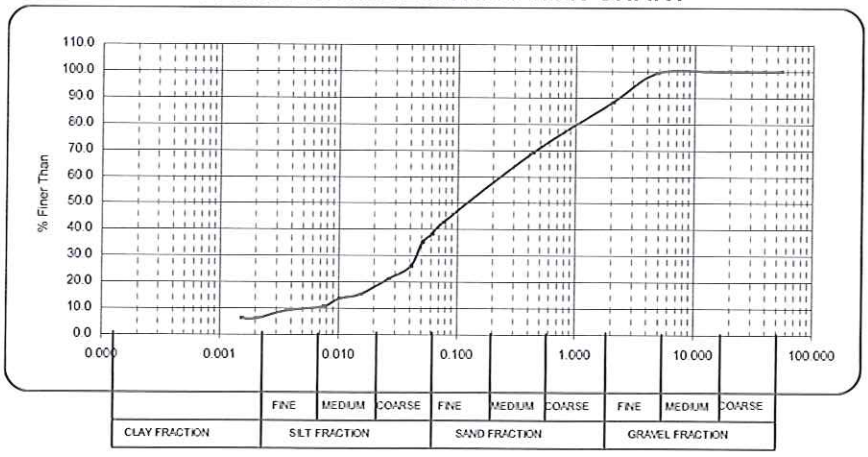
Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample Number : 28065
Field No. : PL 35/1
Sample Description : Residual Tillite
Equivalent PI : 5 **Clay fraction of whole sample (% <2μ)** : 6

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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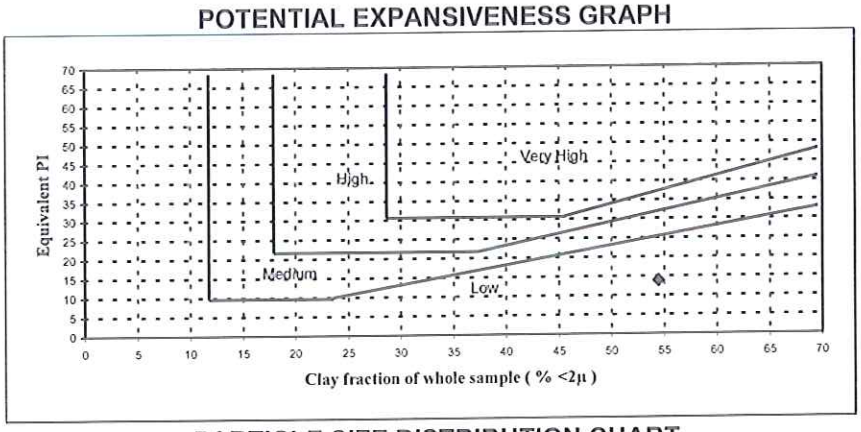
Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

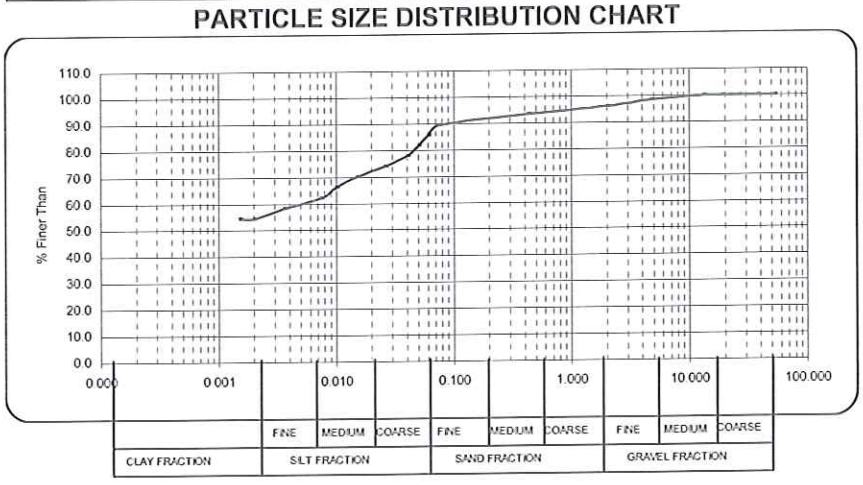
Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample Number : 28066
Field No. : PL 68/1
Sample Description : Residual Dolerite
Equivalent PI : 14 **Clay fraction of whole sample (% <2μ)** : 54

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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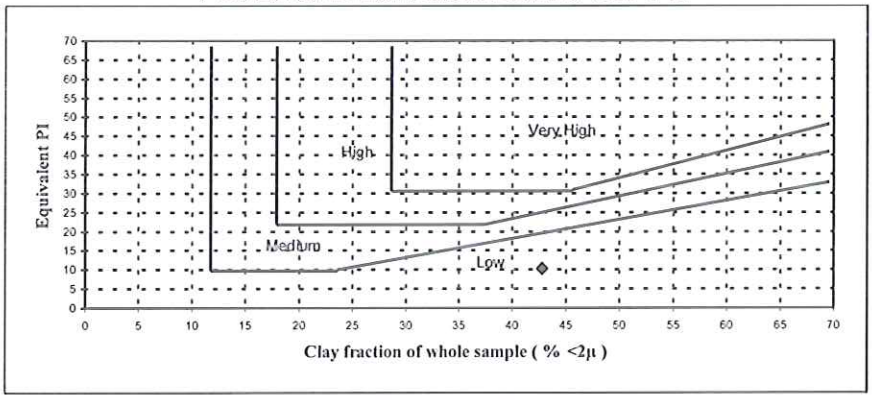
Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

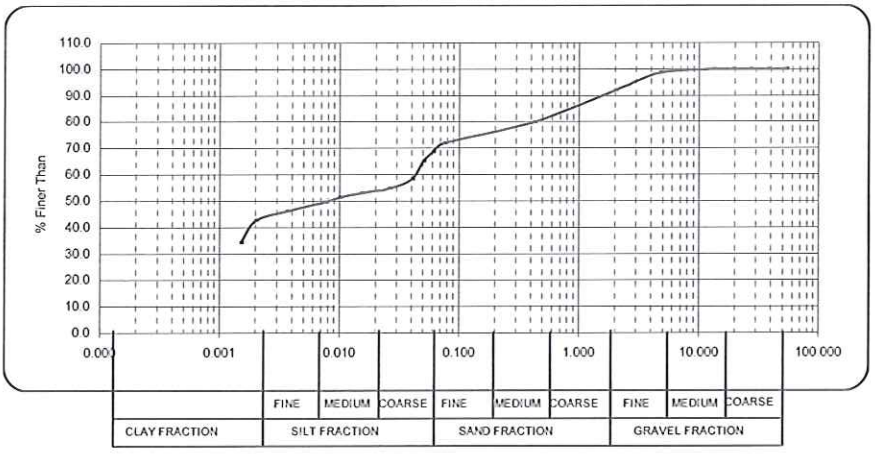
Job No. :
Your Ref.No. :
Date Tested :
Date Reported :

Sample Number : 28067
Field No. : PL 72/1
Sample Description : Ferruginous Residual Tillite
Equivalent PI : 10 **Clay fraction of whole sample (% <2μ)** : 43

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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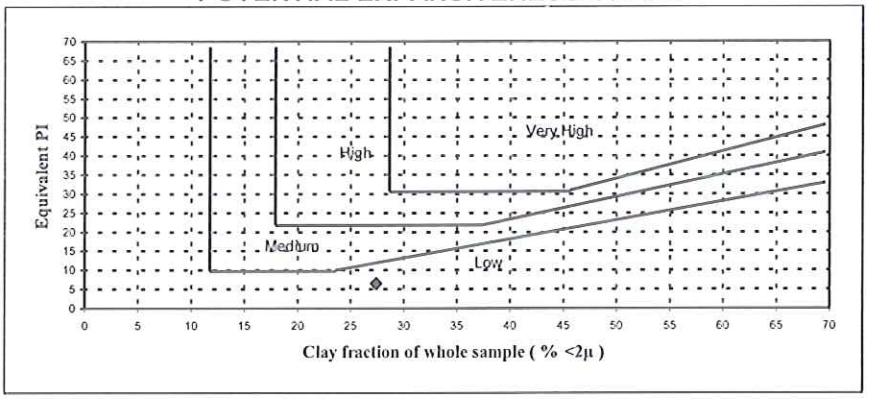
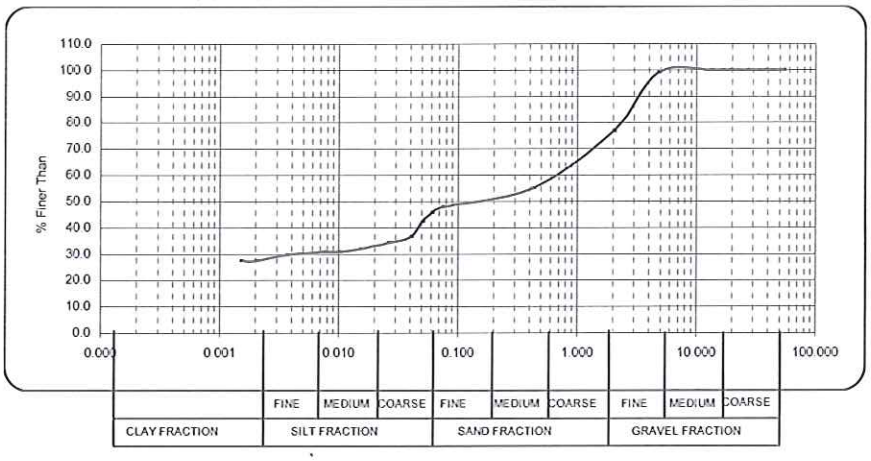
Client	: Knight Pie Sold (Pty) Ltd	**Job No.**	: 17168
Project	: Umkhomazi Water Pipeline	**Your Ref.No.**	: -
		Date Tested	: 08.04.2014
Attention	: Mr A.VanderMerwe	**Date Reported**	: 08.04.2014

Sample Number : 28068
Field No. : PL 74/1
Sample Description : Ferruginous Colluvium
Equivalent PI : 7 **Clay fraction of whole sample (% <2μ)** : 27

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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WEBSITE: www.geosure.co.za

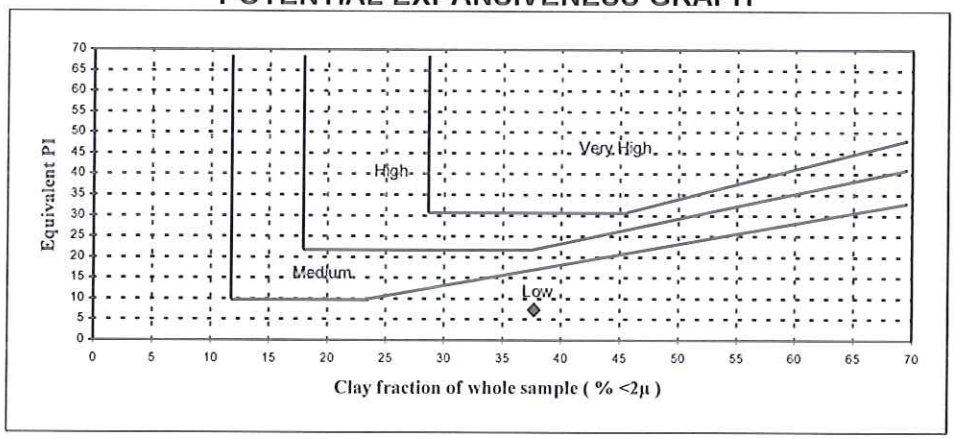
Sample Number : 28069

Field No. : RW 02/1

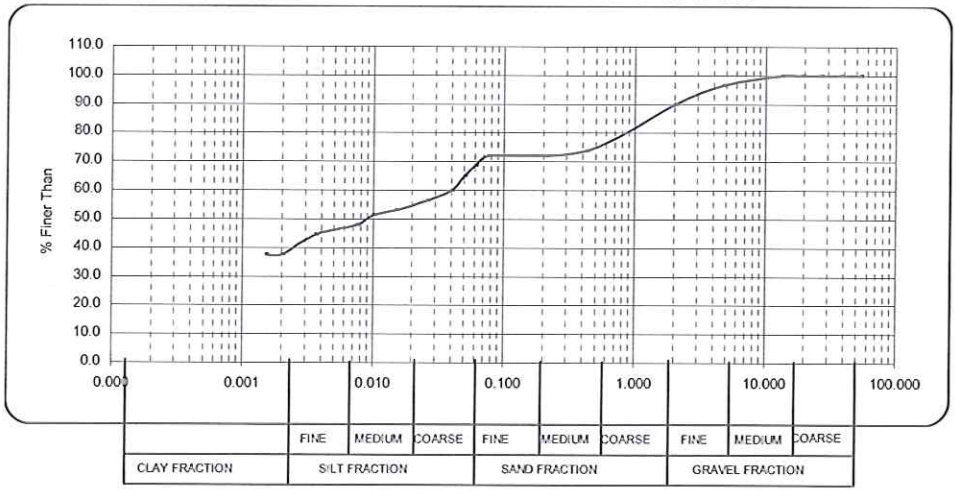
Sample Description : Colluvium

Equivalent PI : 7 **Clay fraction of whole sample (% <2μ)** : 38

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

Our Ref. : 17168
Your Ref. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample No.			28070	28071	28072	28073	28074
Field No.			RW 09/1	RW 11/1	RW 17/1	RW 20/1	RW 23/1
Position in Field							
Depth (m)			0.8-1.8	0.5-1.5	0.3-3.0	1.0-1.9	0.5-2.6
Material Description			Residual Shale	Ferruginous Colluvium	Ferruginous Colluvium	Ferruginous Residual Shale	Residual Shale
Sieve Analysis (ASTM - D422)							
% Passing	63.0	mm	100	100	100	100	100
	53.0	mm	100	100	100	100	100
	37.5	mm	100	100	100	100	100
	26.5	mm	100	100	100	100	100
	19.0	mm	100	100	100	100	95
	13.2	mm	100	100	100	100	86
	4.75	mm	92	96	100	100	66
	2.00	mm	81	66	82	85	50
	0.425	mm	66	45	65	52	36
	0.075	mm	58	41	61	48	29
Hydrometer Analysis (ASTM - D422)							
% Passing	0.060	mm	54	38	56	46	27
	0.050	mm	47	35	51	43	26
	0.040	mm	32	32	48	41	22
	0.026	mm	26	28	45	36	19
	0.015	mm	24	24	40	33	17
	0.010	mm	21	23	39	32	15
	0.0074	mm	17	21	36	31	13
	0.0036	mm	15	18	32	29	11
	0.0020	mm	11	16	30	27	11
	0.0015	mm	11	15	29	26	8
Soil Mortar Analysis							
Coarse Sand		%	18	31	20	39	28
Coarse Fine Sand		%	1	2	2	1	4
Medium Fine Sand		%	2	3	2	1	5
Fine Fine Sand		%	8	2	2	2	4
Silt & Clay		%	72	63	74	57	59
Grading Modulus			1.0	1.5	0.9	1.1	1.9
Atterberg Limits and Classification							
Liquid Limit		%	37	41	42	47	37
Plasticity Index		%	11	10	10	6	6
Linear Shrinkage		%	5.5	5.0	5.0	3.0	3.0
AASHTO Classification (Group Index)*			A-5(5)	A-5(1)	A-5(5)	A-5(2)	A-2-4(0)
Unified Classification*			ML	SM	ML	SM	SM
Moisture Content		%	19.0	14.1	25.8	14.9	9.2

Remarks: Date Received:

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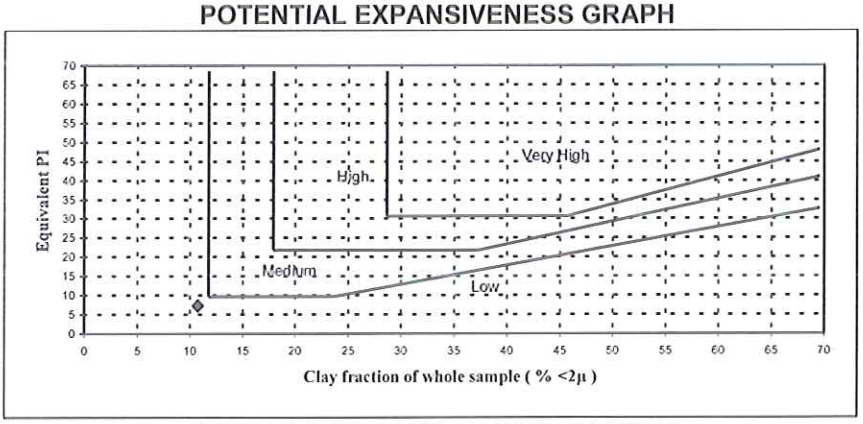
Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

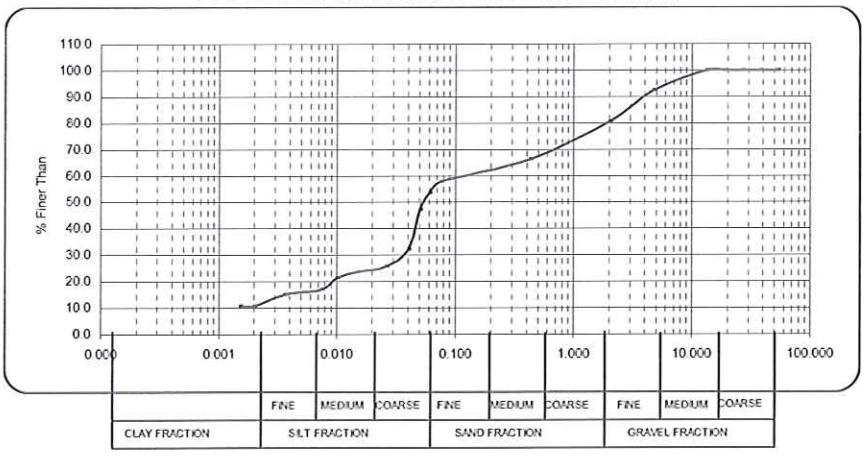
Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample Number : 28070
Field No. : RW 09/1
Sample Description : Residual Shale
Equivalent PI : 7 **Clay fraction of whole sample (% <2μ)** : 11

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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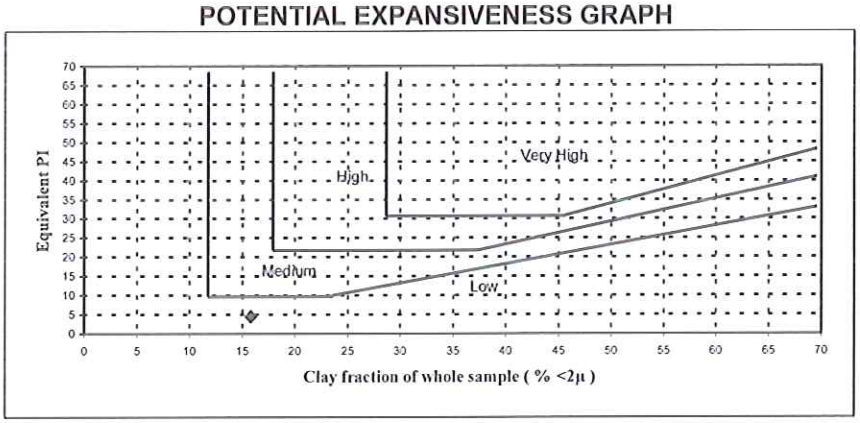
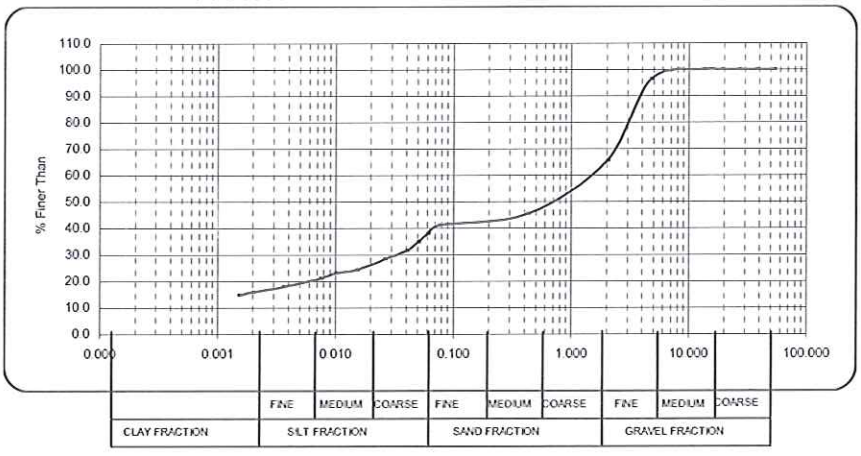
Client	: Knight Pie Sold (Pty) Ltd	**Job No.**	: 17168
Project	: Umkhomazi Water Pipeline	**Your Ref.No.**	: -
		Date Tested	: 08.04.2014
Attention	: Mr A.VanderMerwe	**Date Reported**	: 08.04.2014

Sample Number : 28071
Field No. : RW 11/1
Sample Description : Ferruginous Colluvium
Equivalent PI : 5 **Clay fraction of whole sample (% <2μ)** : 16

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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WEBSITE: www.geosure.co.za

Client : Knight Pie Sold (Pty) Ltd — **Job No.** :

Project : Umkhomazi Water Pipeline — **Your Ref.No.** :

Date Tested :

Attention : Mr A.VanderMerwe — **Date Reported** :

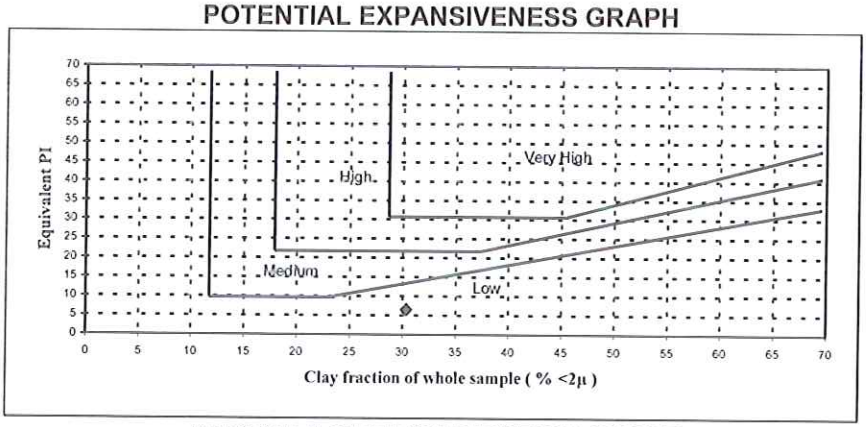
Sample Number : 28072

Field No. : RW 17/1

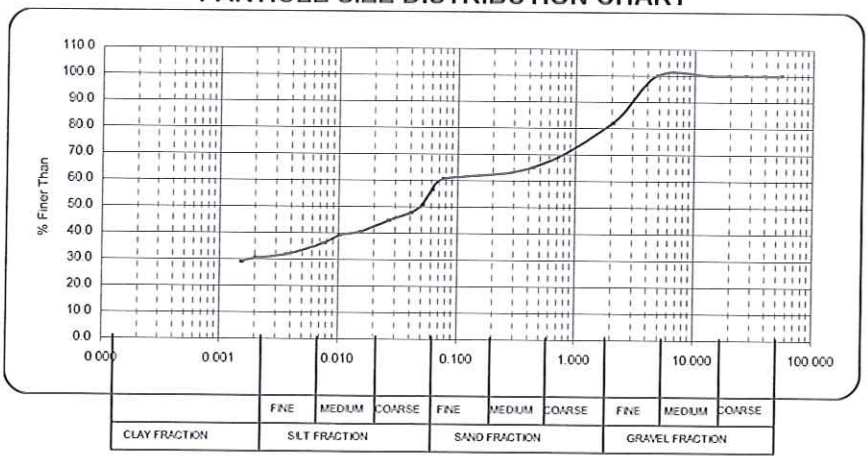
Sample Description : Ferruginous Colluvium

Equivalent PI : 7 **Clay fraction of whole sample (% <2μ)** : 30

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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GEOSURE (Pty) Ltd
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WEBSITE: www.geosure.co.za

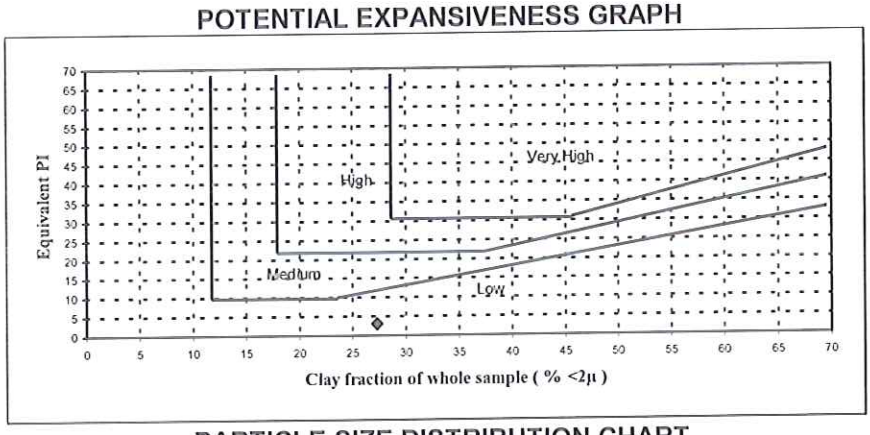
sanas T0455

Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

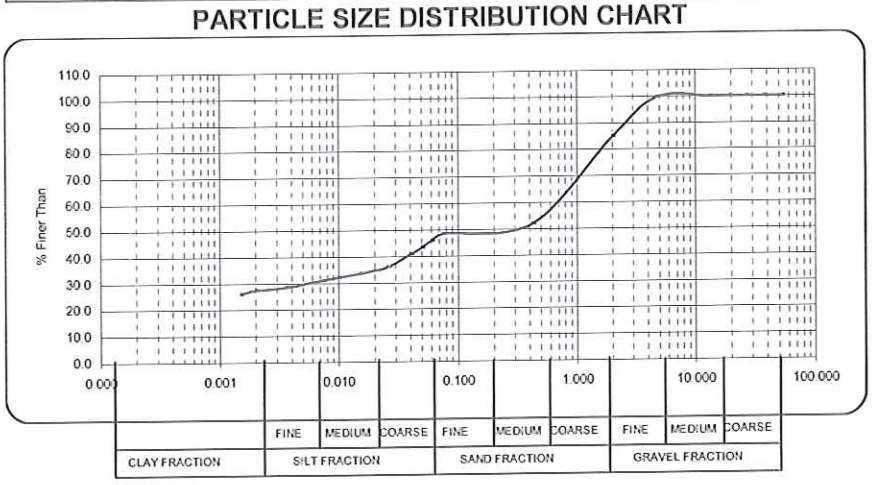
Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample Number : 28073
Field No. : RW 20/1
Sample Description : Ferruginous Residual Shale
Equivalent PI : 3 **Clay fraction of whole sample (% <2μ)** : 27

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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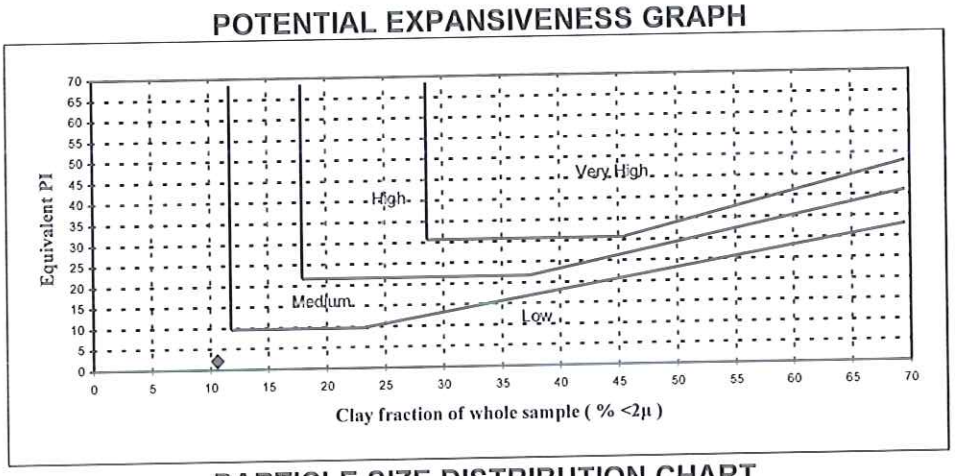
WEBSITE: www.geosure.co.za

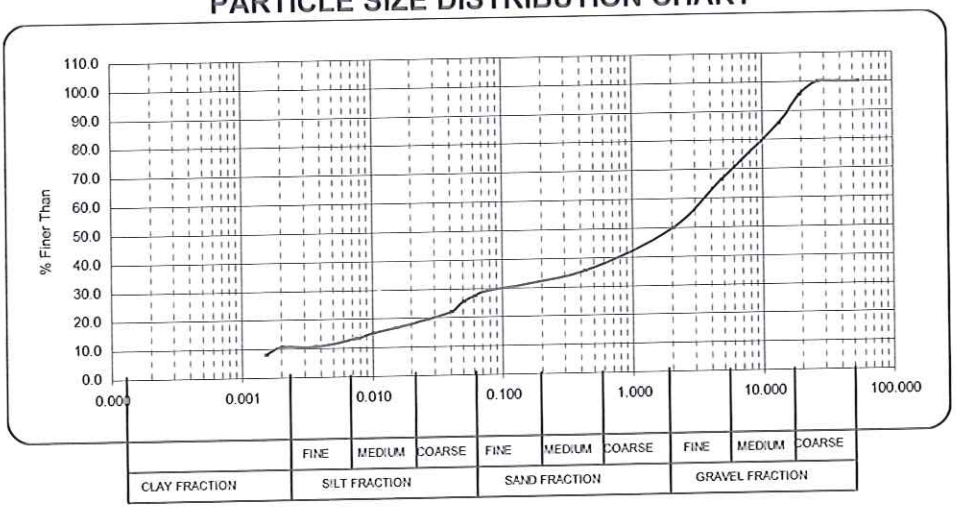
sanas testing laboratory T0483

Sample Number : 28074
Field No. : RW 23/1
Sample Description : Residual Shale
Equivalent PI : 2 **Clay fraction of whole sample (% <2μ)** : 11

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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sanas T0483

Client : Knight Piesold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

Our Ref. : 17168
Your Ref. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample No.			28075	28076	28077	28078	28079
Field No.			MTP 4/1	WTW 01/2	WTW 03/1	WTW 07/1	WTW 10/1
Position in Field							
Depth (m)			0.5-1.1	2.0	0.5-1.4	2.5	1.0
Material Description			Ferruginous Colluvium	Residual Dolerite	Residual Dolerite	Residual Shale	Residual Shale
Sieve Analysis (ASTM - D422)							
% Passing	63.0	mm	100	100	100	100	100
	53.0	mm	100	100	100	100	100
	37.5	mm	100	100	100	100	100
	26.5	mm	100	100	100	100	100
	19.0	mm	100	100	100	100	100
	13.2	mm	100	100	100	100	100
	4.75	mm	100	100	99	100	97
	2.00	mm	99	99	88	100	78
	0.425	mm	94	98	73	99	59
	0.075	mm	63	96	66	98	57
Hydrometer Analysis (ASTM - D422)							
% Passing	0.060	mm	59	93	62	96	53
	0.050	mm	55	91	59	94	49
	0.040	mm	40	89	46	92	46
	0.026	mm	32	82	40	88	42
	0.015	mm	26	80	33	84	36
	0.010	mm	24	75	31	77	35
	0.0074	mm	20	71	27	73	30
	0.0036	mm	12	66	22	61	30
	0.0020	mm	10	64	22	59	28
	0.0015	mm	10	64	20	57	28
Soil Mortar Analysis							
Coarse Sand		%	4	1	17	1	24
Coarse Fine Sand		%	7	1	2	0	1
Medium Fine Sand		%	11	1	3	0	0
Fine Fine Sand		%	14	1	4	0	2
Silt & Clay		%	64	96	75	98	73
Grading Modulus			0.4	0.1	0.7	0.0	1.1
Atterberg Limits and Classification							
Liquid Limit		%	16	53	42	61	47
Plasticity Index		%	4	11	9	13	8
Linear Shrinkage		%	2.0	5.5	4.5	6.5	4.0
AASHTO Classification (Group Index)*			A-4(0)	A-7-5(17)	A-5(6)	A-7-5(22)	A-5(4)
Unified Classification*			CL-ML	MH	ML	MH	ML
Moisture Content		%	10.8	26.1	38.0	31.2	25.2

Remarks: Date Received:

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Consulting Engineering Geologists, Geotechnical Engineers, Geotechnicians & Geotechnical Quality Assurance Specialists

GEOSURE (Pty) Ltd

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sanas T0185

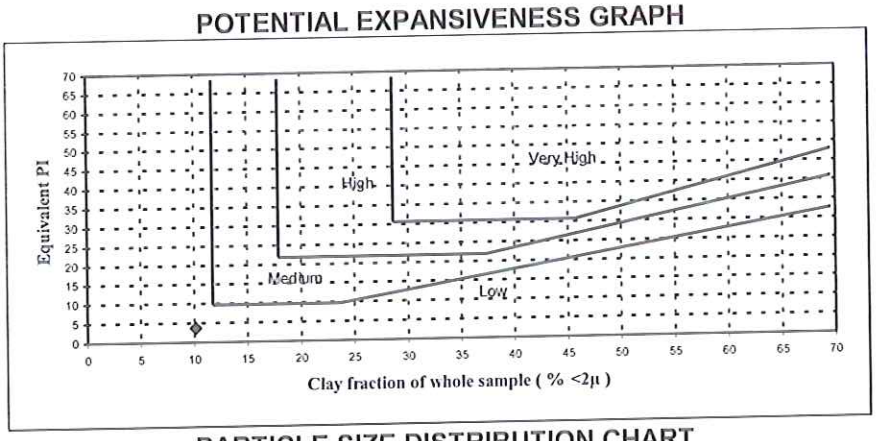
Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline

Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

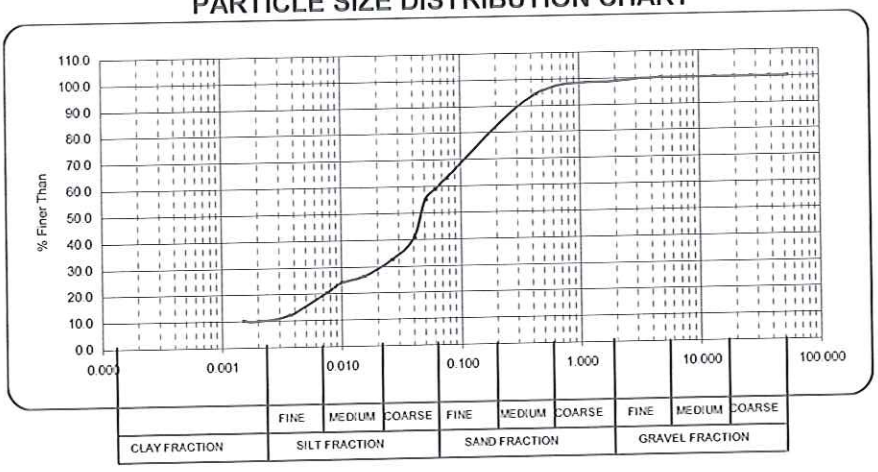
Attention : Mr A.VanderMerwe

Sample Number : 28075
Field No. : MTP 4/1
Sample Description : Ferruginous Colluvium
Equivalent PI : 4 **Clay fraction of whole sample (% <2μ)** : 10

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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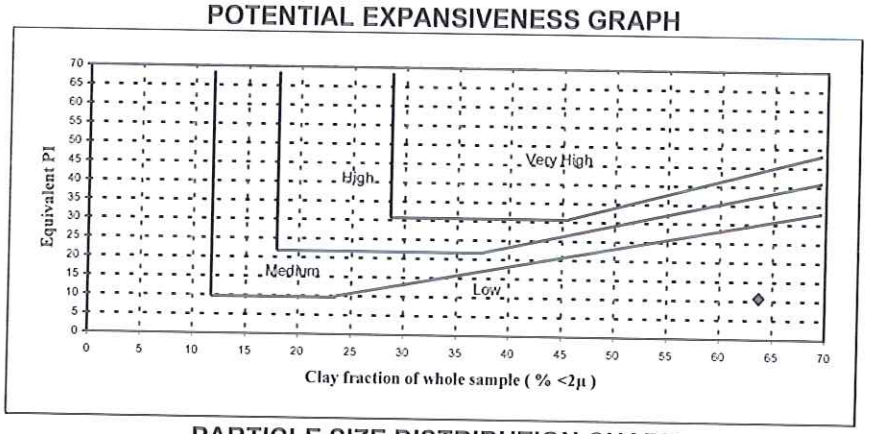
sanas Testing Laboratory T0483

Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

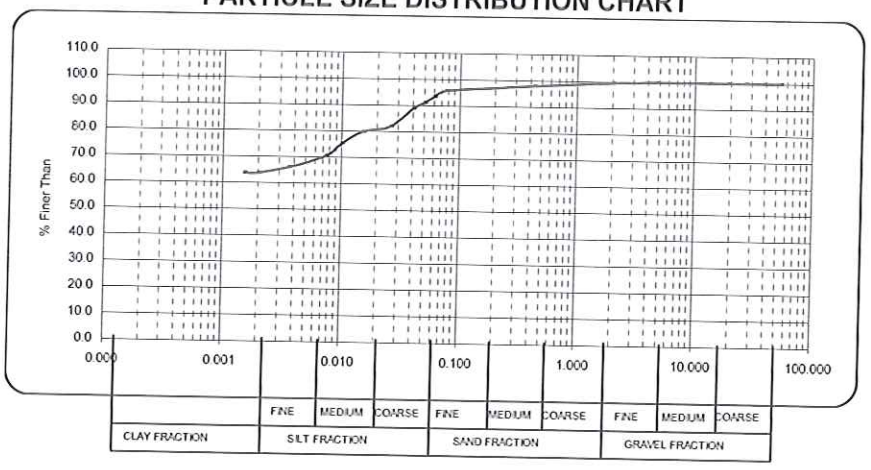
Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample Number : 28076
Field No. : WTW 01/2
Sample Description : Residual Dolerite
Equivalent PI : 11 **Clay fraction of whole sample (% <2μ)** : 64

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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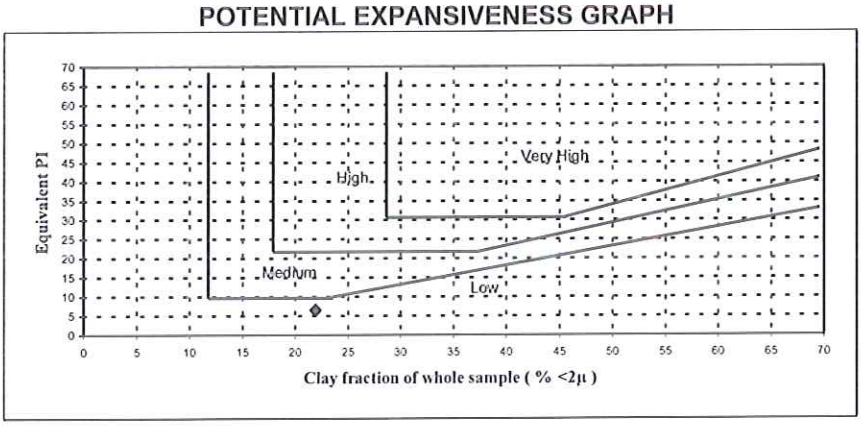
WEBSITE: www.geosure.co.za

Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

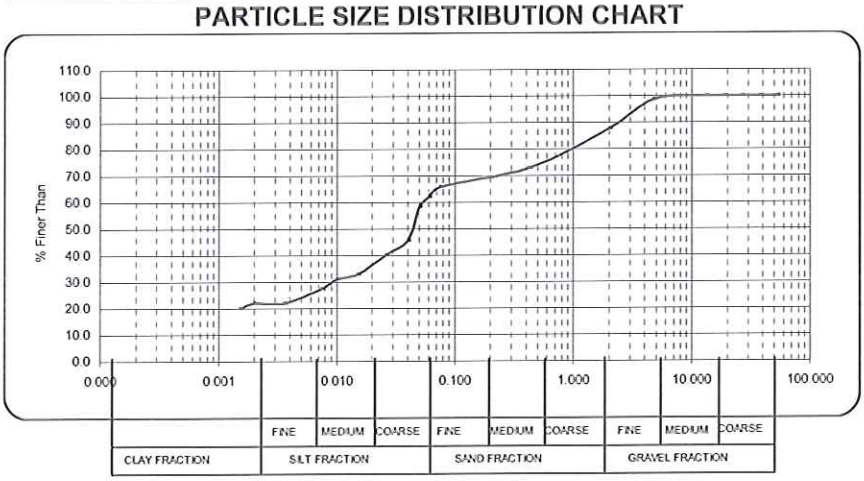
Job No. :
Your Ref.No. :
Date Tested :
Date Reported :

Sample Number : 28077
Field No. : WTW 03/1
Sample Description : Residual Dolerite
Equivalent PI : 7 **Clay fraction of whole sample (% <2μ)** : 22

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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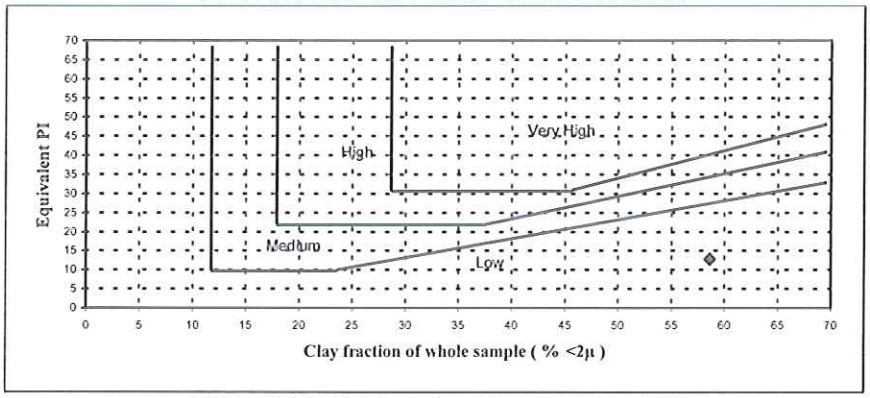
WEBSITE: www.geosure.co.za

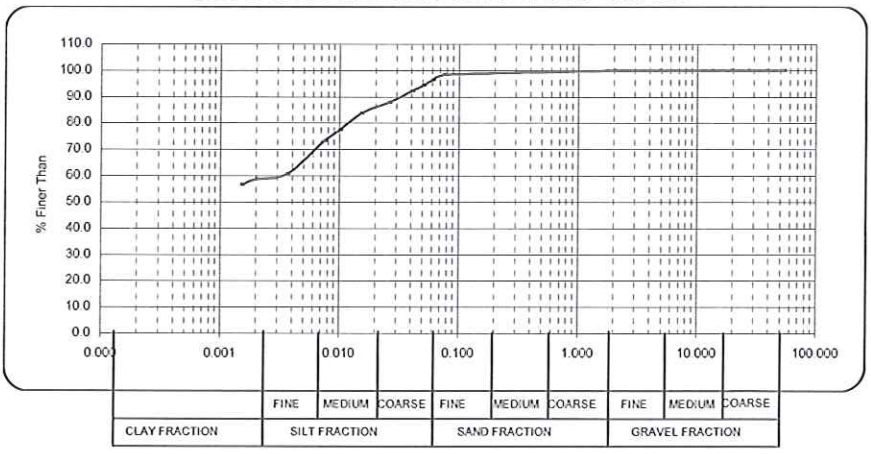
Client	: Knight Pie Sold (Pty) Ltd	**Job No.**	: 17168
Project	: Umkhomazi Water Pipeline	**Your Ref.No.**	: -
		Date Tested	: 08.04.2014
Attention	: Mr A.VanderMerwe	**Date Reported**	: 08.04.2014

Sample Number : 28078
Field No. : WTW 07/1
Sample Description : Residual Shale
Equivalent PI : 13 **Clay fraction of whole sample (% <2μ)** : 59

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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WEBSITE: www.geosure.co.za

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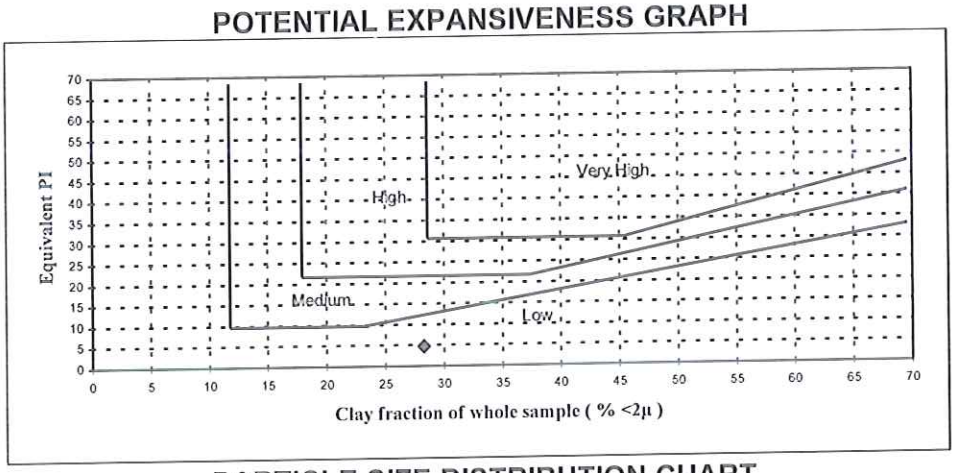
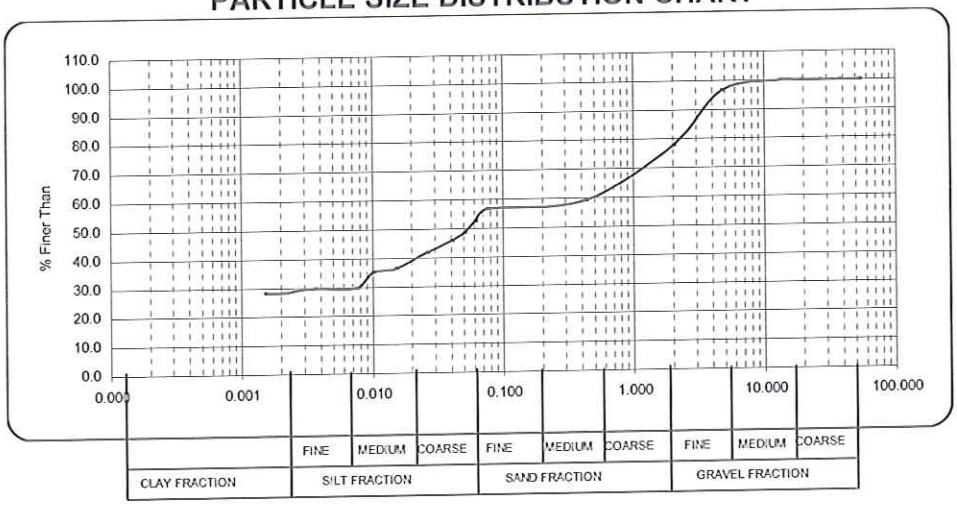
Sample Number : 28079
Field No. : WTW 10/1
Sample Description : Residual Shale
Equivalent PI : 5 **Clay fraction of whole sample (% <2μ)** : 28

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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WEBSITE: www.geosure.co.za

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Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

Our Ref. : 17168
Your Ref. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample No.			28080	28081	28082	28083	28084
Field No.			WTA 01/1	WTA 03/1	WTA 04/1	WTA 04/2	WTW 05/2
Position in Field							
Depth (m)			1.3	1.6	1.8	2.7-3.0	1.7
Material Description			Ferruginous Residual Shale	Ferruginous Residual Dolerite	Residual Dolerite	Residual Shale	Residual Shale
Sieve Analysis (ASTM - D422)							
% Passing	63.0	mm	100	100	100	100	100
	53.0	mm	100	100	100	100	100
	37.5	mm	100	100	100	100	100
	26.5	mm	100	100	100	100	100
	19.0	mm	100	100	100	100	100
	13.2	mm	100	100	100	100	100
	4.75	mm	100	98	98	99	100
	2.00	mm	95	93	96	96	100
	0.425	mm	72	86	90	94	98
	0.075	mm	71	66	88	82	97
Hydrometer Analysis (ASTM - D422)							
% Passing	0.060	mm	66	63	82	78	97
	0.050	mm	62	62	78	74	95
	0.040	mm	60	56	74	64	93
	0.026	mm	44	53	70	54	89
	0.015	mm	38	50	64	50	87
	0.010	mm	34	46	64	47	85
	0.0074	mm	24	43	58	43	74
	0.0036	mm	24	40	56	39	74
	0.0020	mm	22	40	54	35	72
	0.0015	mm	22	39	52	31	70
Soil Mortar Analysis							
Coarse Sand		%	24	8	6	3	1
Coarse Fine Sand		%	1	8	0	8	0
Medium Fine Sand		%	0	10	1	2	1
Fine Fine Sand		%	1	3	1	2	0
Silt & Clay		%	74	71	91	85	97
Grading Modulus			0.6	0.5	0.3	0.3	0.0
Atterberg Limits and Classification							
Liquid Limit		%	45	50	48	41	59
Plasticity Index		%	9	11	10	10	16
Linear Shrinkage		%	4.5	5.5	5.0	5.0	8.0
AASHTO Classification (Group Index)*			A-5(8)	A-7-5(8)	A-5(13)	A-5(10)	A-7-5(23)
Unified Classification*			ML	MH	ML	ML	MH
Moisture Content		%	20.2	31.6	33.5	23.9	25.1

Remarks:

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WEBSITE: www.geosure.co.za

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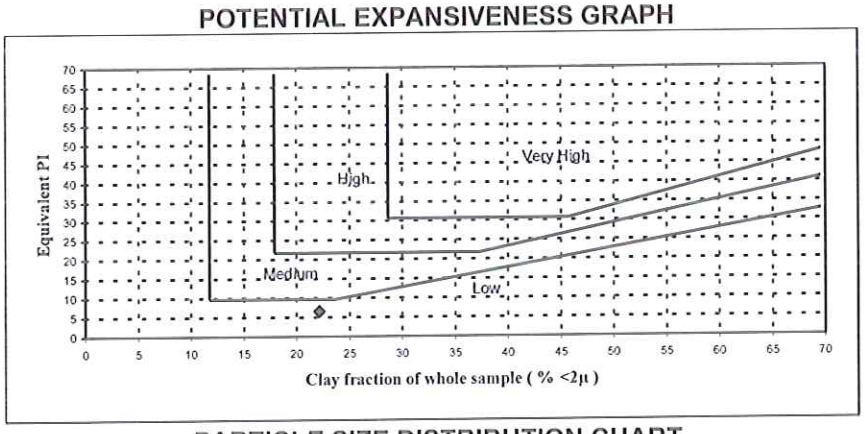
Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

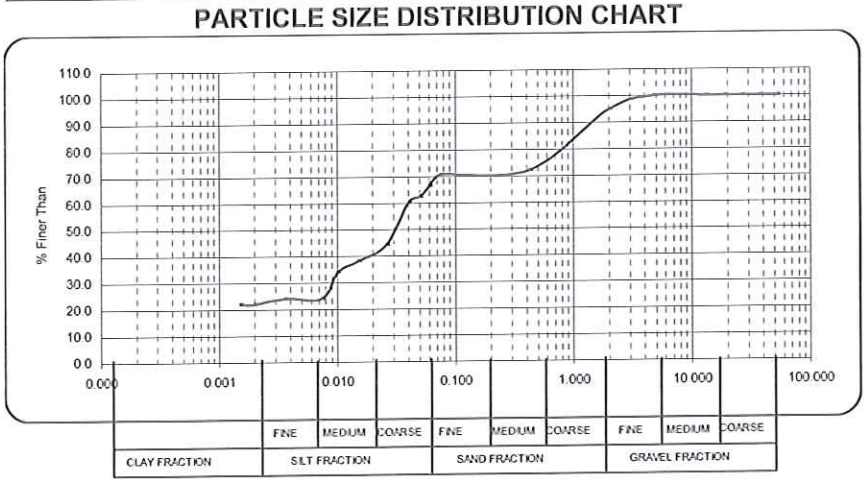
Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample Number : 28080
Field No. : WTA 01/1
Sample Description : Ferruginous Residual Shale
Equivalent PI : 7 **Clay fraction of whole sample (% <2μ)** : 22

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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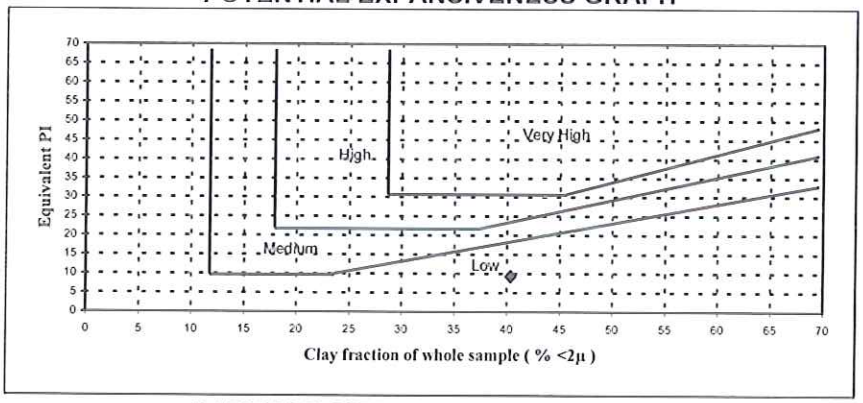
Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

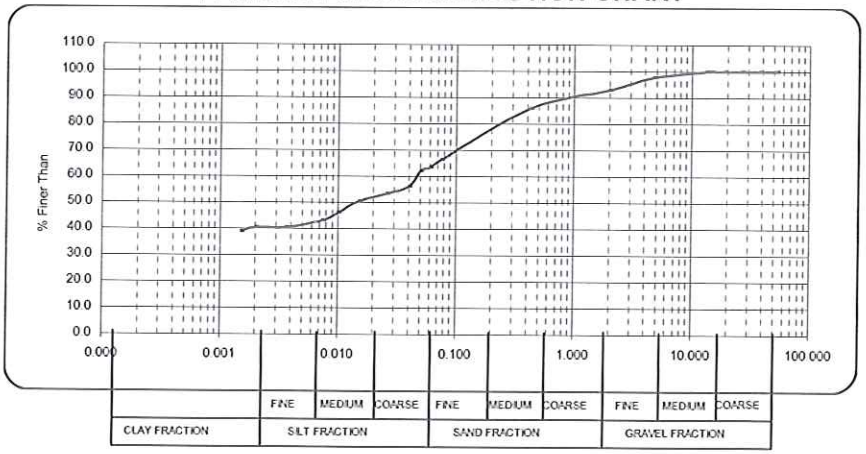
Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample Number : 28081
Field No. : WTA 03/1
Sample Description : Ferruginous Residual Dolerite
Equivalent PI : 9 **Clay fraction of whole sample (% <2μ)** : 40

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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WEBSITE: www.geosure.co.za

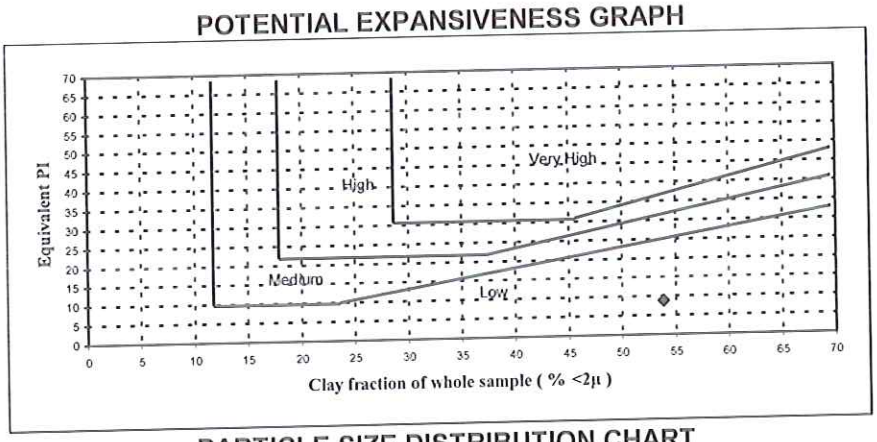
sanas T0483

Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

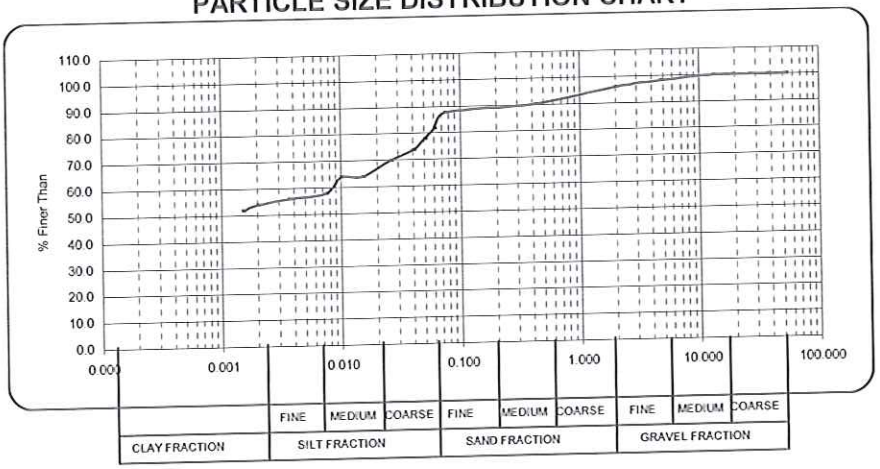
Job No. :
Your Ref.No. :
Date Tested :
Date Reported :

Sample Number : 28082
Field No. : WTA 04/1
Sample Description : Residual Dolerite
Equivalent PI : 9 **Clay fraction of whole sample (% <2μ)** : 54

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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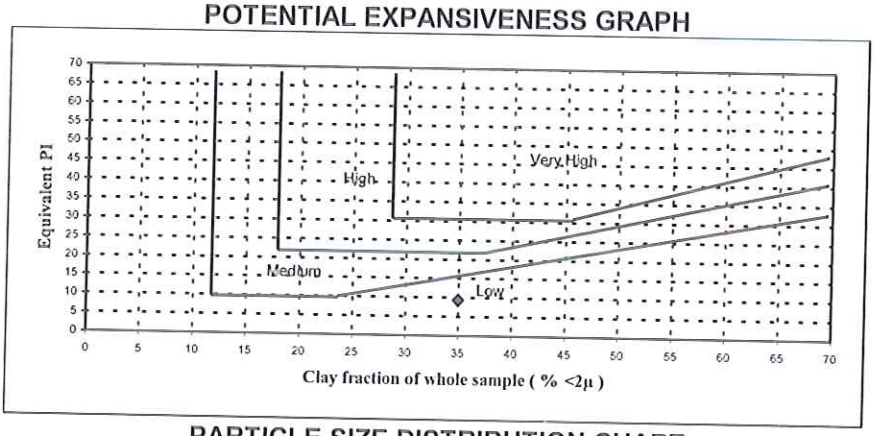
sanas T0483

Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

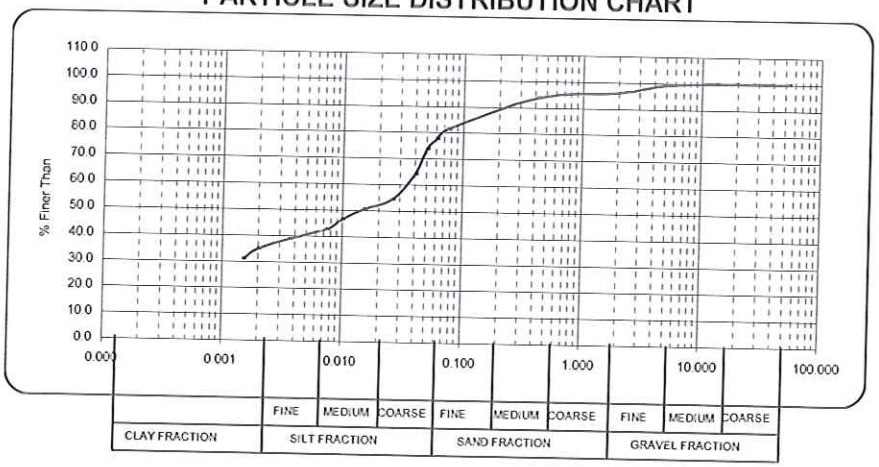
Job No. : 17168
Your Ref.No. : -
Date Tested : 08.04.2014
Date Reported : 08.04.2014

Sample Number : 28083
Field No. : WTA 04/2
Sample Description : Residual Shale
Equivalent PI : 9 **Clay fraction of whole sample (% <2μ)** : 35

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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sanas Testing Laboratory T0483

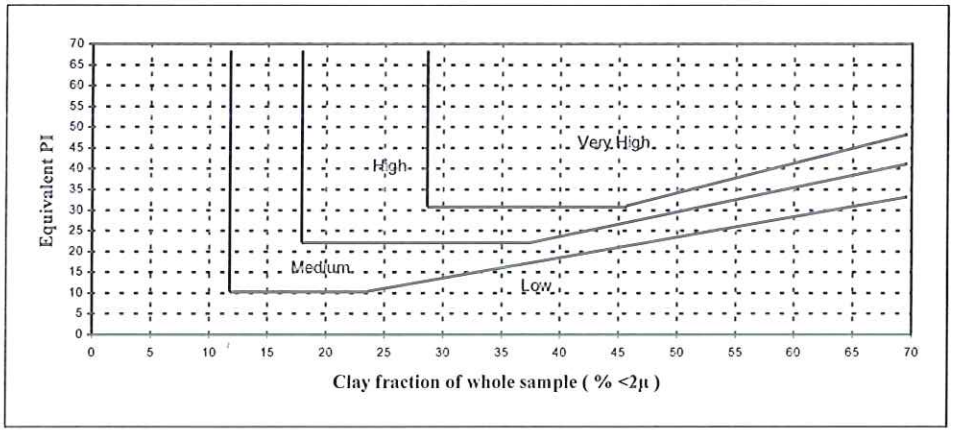
Sample Number : 28084

Field No. : WTW 05/2

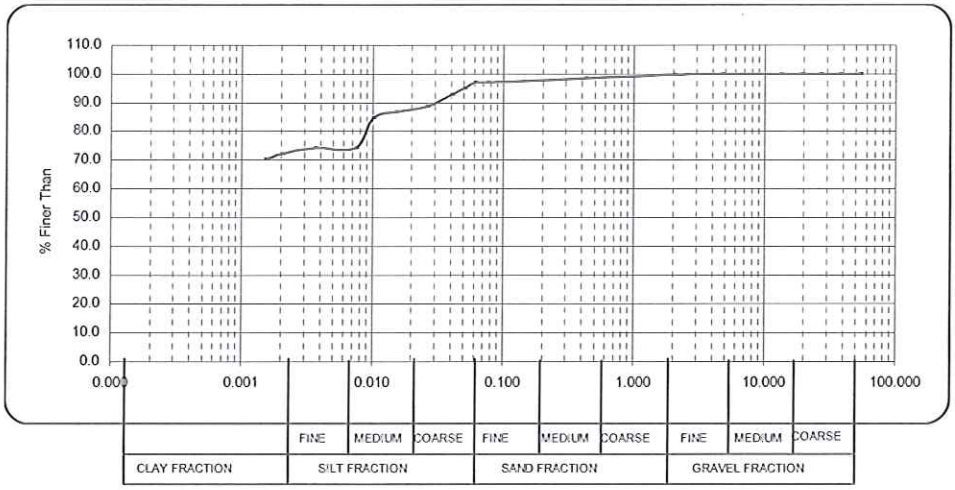
Sample Description : Residual Shale

Equivalent PI : 16 **Clay fraction of whole sample (% <2μ)** : 72

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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Client : **Knight Pie Sold (Pty) Ltd**
Project : **Umkhomazi Water Pipeline**
Attention : **Mr A.VanderMerwe**

Your Ref No. : **-**
Our Ref No. : **17168**
Date Reported : **07.04.2014**

Moisture/Density Relationship (TMH1: Method A7)

Sample No. : 28055
Natural/Stabilised : Natural
Material Description : Residual Shale

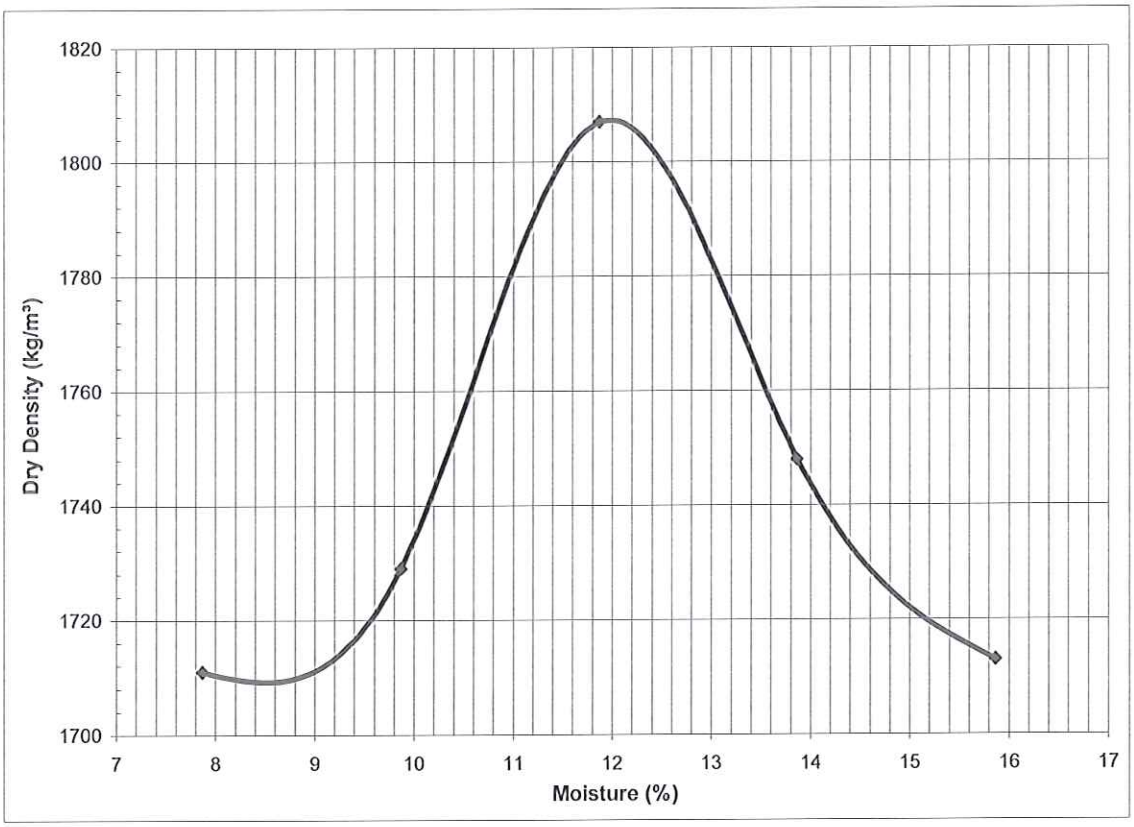
Field No. : PL 02/1
Depth (m) :
Origin :
Compaction Effort : Mod AASHTO

Maximum Dry Density (kg/m³) **1807**

Optimum Moisture Content (%) **12.1**

Plotted Values:

Moisture (%)	7.9	9.9	11.9	13.9	15.9
Dry Density (kg/m³)	1711	1729	1807	1748	1713



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Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

Your Ref No. : -
Our Ref No. : 17168
Date Reported : 07.04.2014

Moisture/Density Relationship (TMH1: Method A7)

Sample No. : 28057

Natural/Stabilised : Natural
Material Description : Residual Shale

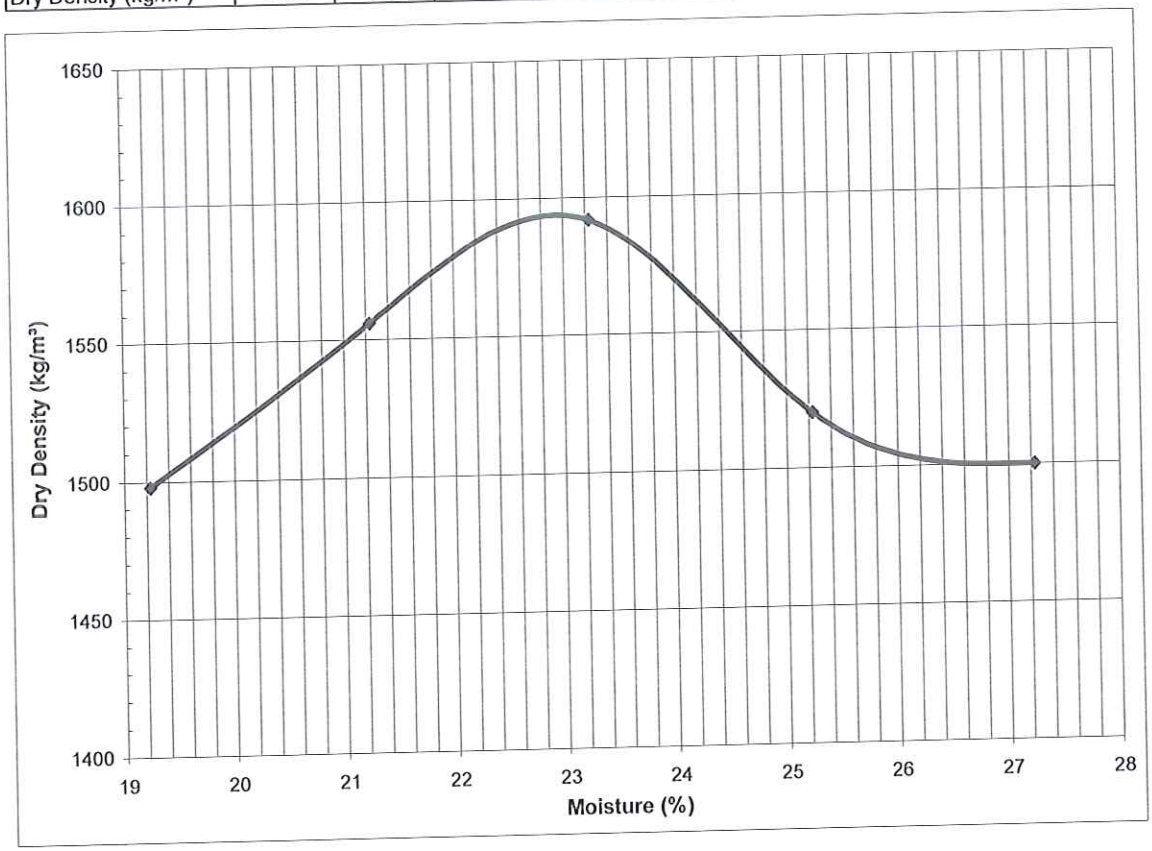
Field No. : PL 09/1
Depth (m) :
Origin :
Compaction Effort : Mod AASHTO

Maximum Dry Density (kg/m³) **1594**

Optimum Moisture Content (%) **22.8**

Plotted Values:

Moisture (%)	19.2	21.2	23.2	25.2	27.2
Dry Density (kg/m³)	1498	1556	1592	1520	1500



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Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

Your Ref No. : -
Our Ref No. : 17168
Date Reported : 07.04.2014

Moisture/Density Relationship (TMH1: Method A7)

Sample No. : 28058

Natural/Stabilised : Natural
Material Description : Colluvium

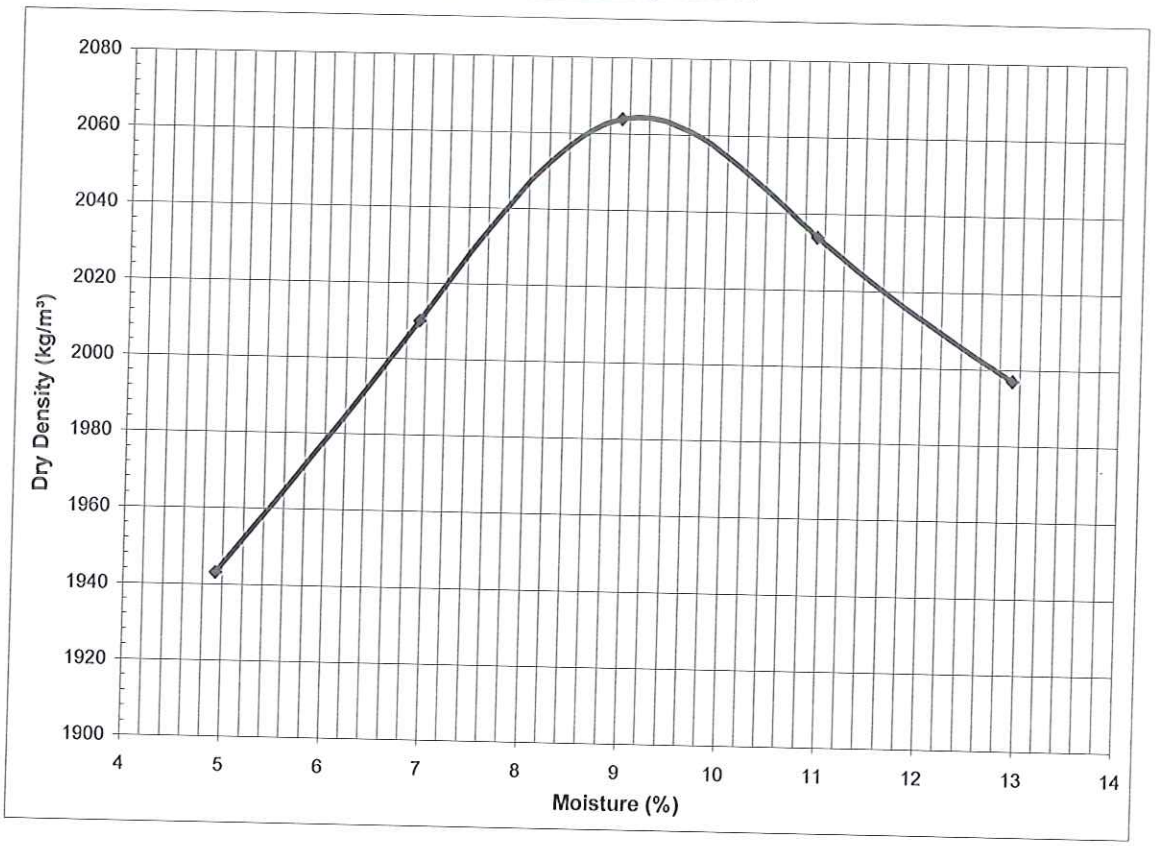
Field No. : PL 14/1
Depth (m) :
Origin :
Compaction Effort : Mod AASHTO

Maximum Dry Density (kg/m³) **2064**

Optimum Moisture Content (%) **9.1**

Plotted Values:

Moisture (%)	4.9	6.9	8.9	10.9	12.9
Dry Density (kg/m³)	1943	2010	2064	2034	1997



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Client : **Knight Pie Sold (Pty) Ltd**
Project : **Umkhomazi Water Pipeline**
Attention : **Mr A.VanderMerwe**

Your Ref No. : **-**
Our Ref No. : **17168**
Date Reported : **07.04.2014**

Moisture/Density Relationship (TMH1: Method A7)

Sample No. : 28059
Natural/Stabilised : Natural
Material Description : Residual Tillite

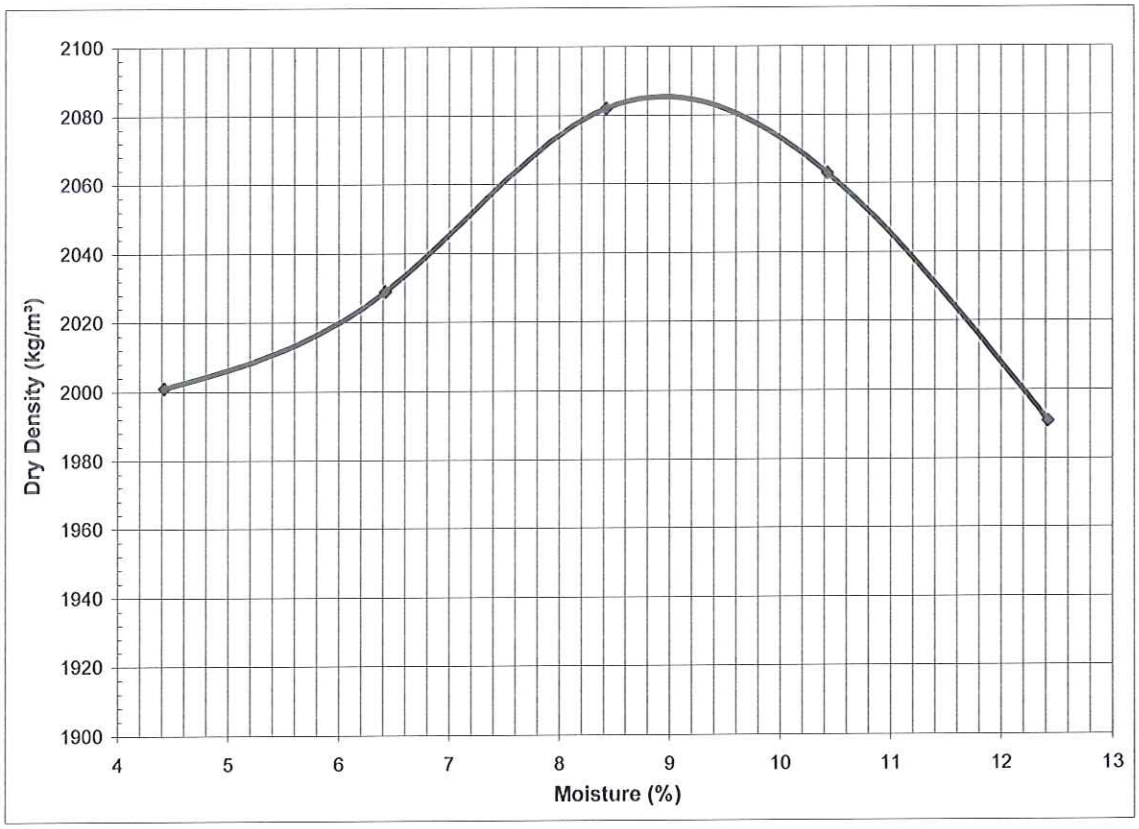
Field No. : PL 15/1
Depth (m) :
Origin :
Compaction Effort : Mod AASHTO

Maximum Dry Density (kg/m³) **2085**

Optimum Moisture Content (%) **9.0**

Plotted Values:

Moisture (%)	4.4	6.4	8.4	10.4	12.4
Dry Density (kg/m³)	2001	2029	2082	2063	1991



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Client	**: Knight Pie Sold (Pty) Ltd**	**Your Ref No.**	**: -**
Project	**: Umkhomazi Water Pipeline**	**Our Ref No.**	**: 17168**
Attention	**: Mr A.VanderMerwe**	**Date Reported**	**: 07.04.2014**

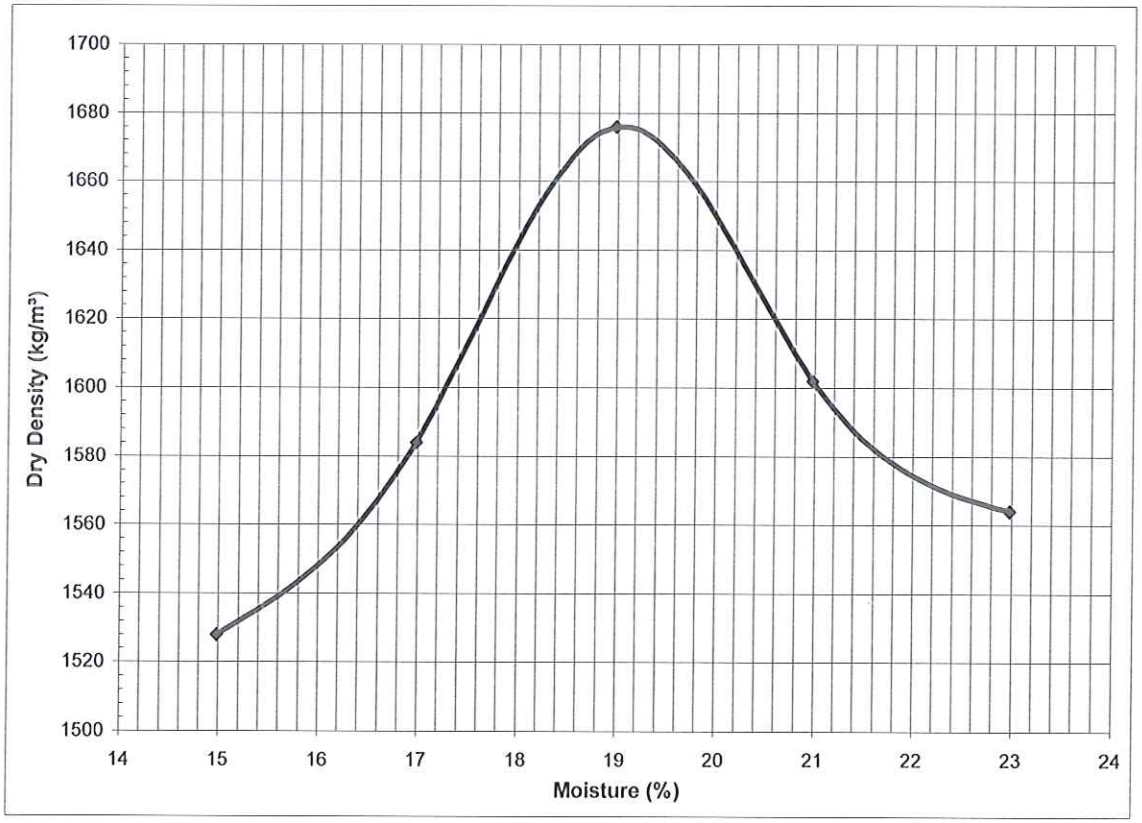
Moisture/Density Relationship (TMH1: Method A7)

Sample No.	: 28060	Field No.	: PL 20/1
		Depth (m)	:
Natural/Stabilised	: Natural	Origin	:
Material Description	: Deworked Residual Tillite	Compaction Effort	: Mod AASHTO

Maximum Dry Density (kg/m³) 1676 **Optimum Moisture Content (%) 19.0**

Plotted Values:

Moisture (%)	15.0	17.0	19.0	21.0	23.0
Dry Density (kg/m³)	1528	1584	1676	1602	1564



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Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

Your Ref No. : -
Our Ref No. : 17168
Date Reported : 07.04.2014

Moisture/Density Relationship (TMH1: Method A7)

Sample No. : 28061

Natural/Stabilised : Natural
Material Description : Residual Tillite

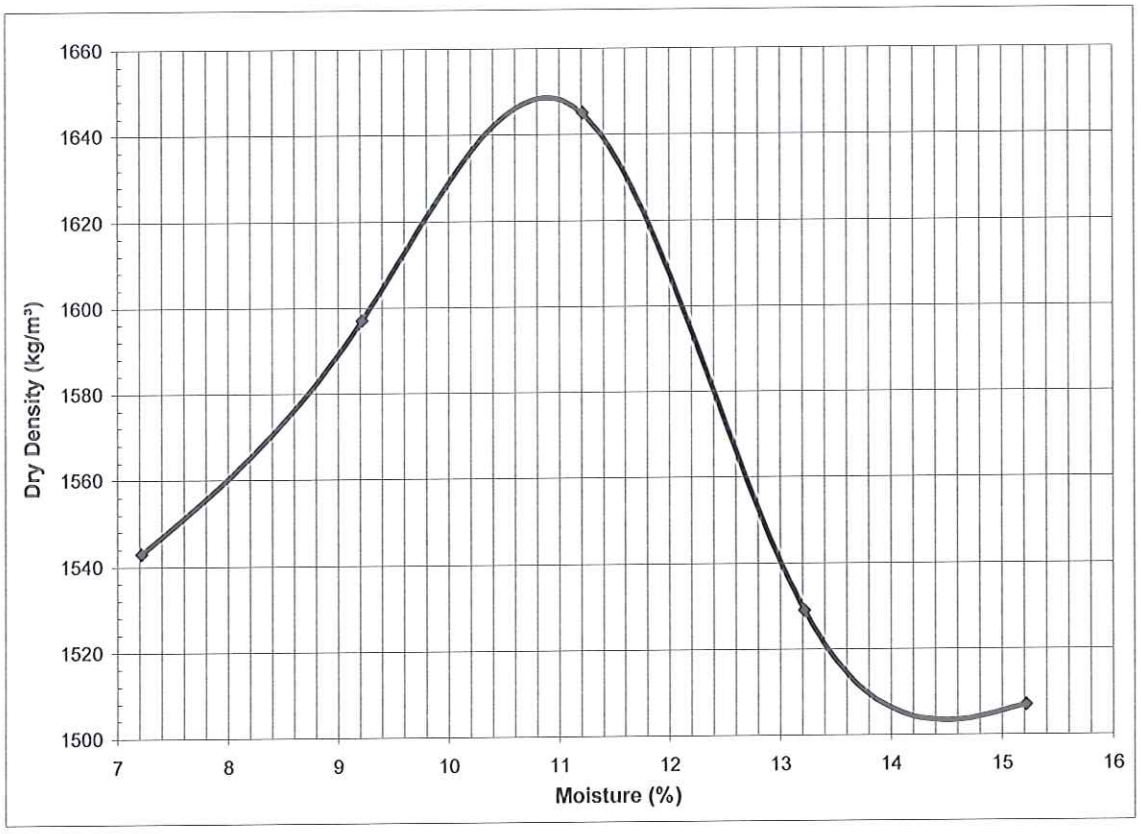
Field No. : PL 25/1
Depth (m) :
Origin :
Compaction Effort : Mod AASHTO

Maximum Dry Density (kg/m³) **1648**

Optimum Moisture Content (%) **10.8**

Plotted Values:

Moisture (%)	7.2	9.2	11.2	13.2	15.2
Dry Density (kg/m³)	1543	1597	1645	1529	1507



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Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

Your Ref No. : -
Our Ref No. : 17168
Date Reported : 07.04.2014

Moisture/Density Relationship (TMH1: Method A7)

Sample No. : 28063
Natural/Stabilised : Natural
Material Description : Deworked Residual Tillite

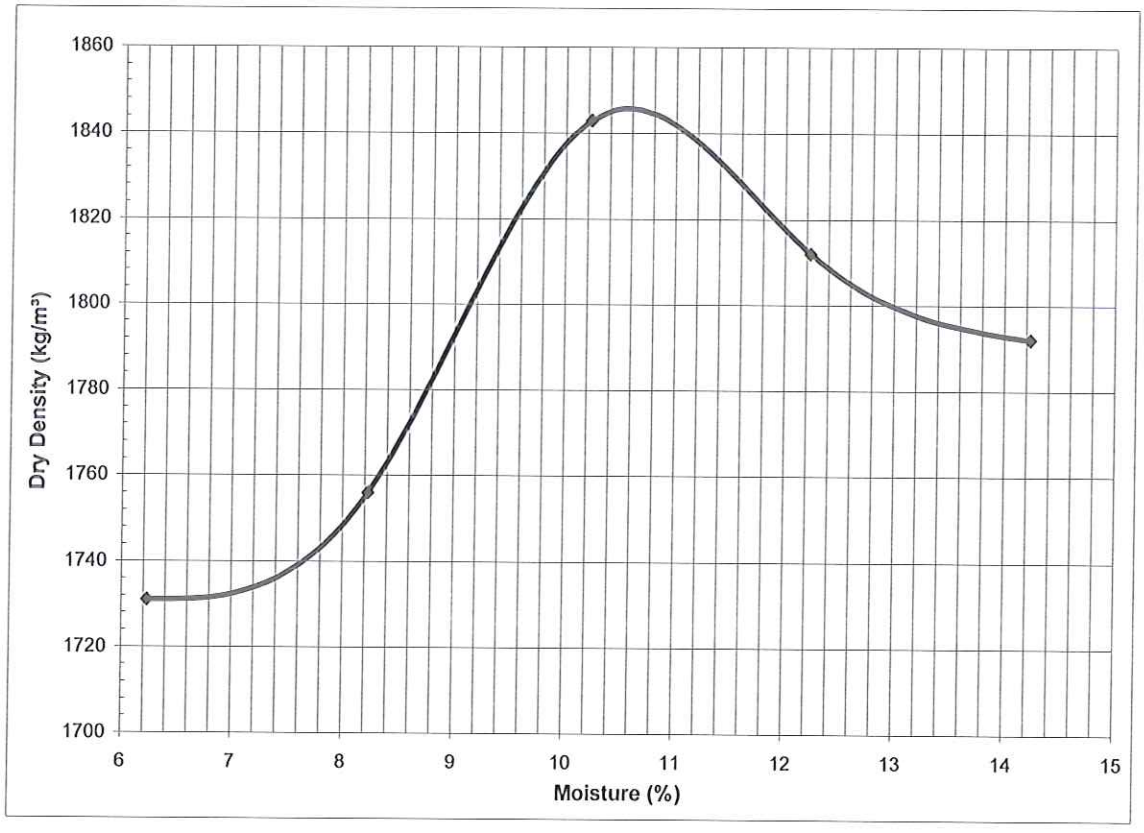
Field No. : PL 30/1
Depth (m) :
Origin :
Compaction Effort : Mod AASHTO

Maximum Dry Density (kg/m³) **1846**

Optimum Moisture Content (%) **10.6**

Plotted Values:

Moisture (%)	6.2	8.2	10.2	12.2	14.2
Dry Density (kg/m³)	1731	1756	1843	1812	1792



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Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

Your Ref No. : -
Our Ref No. : 17168
Date Reported : 07.04.2014

Moisture/Density Relationship (TMH1: Method A7)

Sample No. : 28065
Natural/Stabilised : Natural
Material Description : Residual Tillite

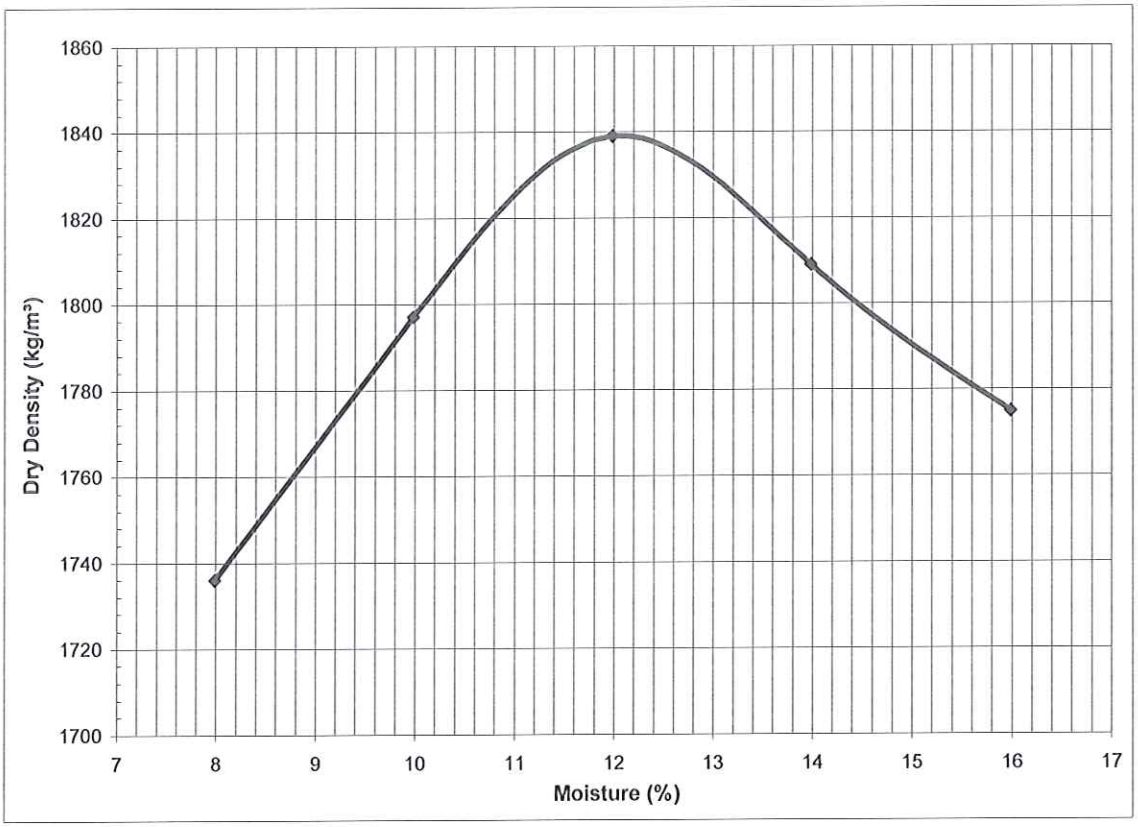
Field No. : PL 35/1
Depth (m) :
Origin :
Compaction Effort : Mod AASHTO

Maximum Dry Density (kg/m³) **1839**

Optimum Moisture Content (%) **12.0**

Plotted Values:

Moisture (%)	8.0	10.0	12.0	14.0	16.0
Dry Density (kg/m³)	1736	1797	1839	1809	1775



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Client : **Knight Pie Sold (Pty) Ltd**
Project : **Umkhomazi Water Pipeline**
Attention : **Mr A.VanderMerwe**

Your Ref No. : **-**
Our Ref No. : **17168**
Date Reported : **07.04.2014**

Moisture/Density Relationship (TMH1: Method A7)

Sample No. : 28068
Natural/Stabilised : Natural
Material Description : Terrugionous Colluvium

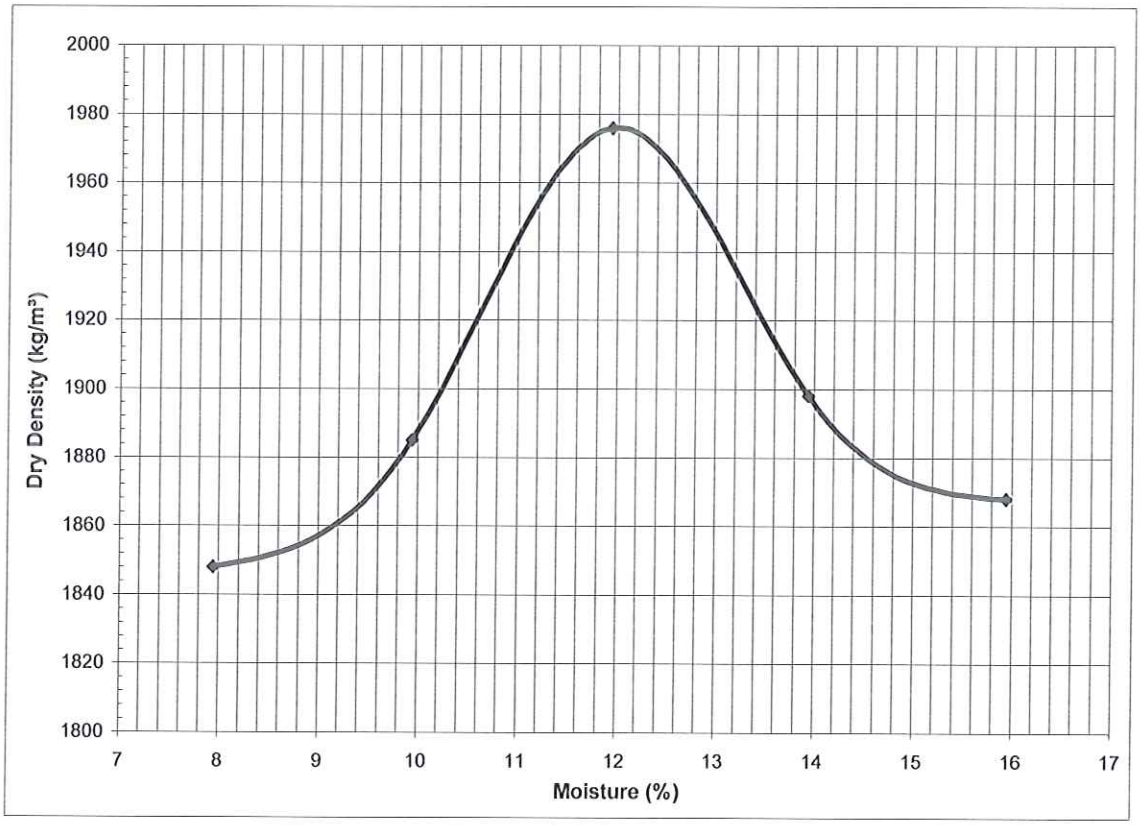
Field No. : PL 74/1
Depth (m) :
Origin :
Compaction Effort : Mod AASHTO

Maximum Dry Density (kg/m³) **1976**

Optimum Moisture Content (%) **11.9**

Plotted Values:

Moisture (%)	7.9	9.9	11.9	13.9	15.9
Dry Density (kg/m³)	1848	1885	1976	1898	1868



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Client : **Knight Pie Sold (Pty) Ltd**
Project : **Umkhomazi Water Pipeline**
Attention : **Mr A.VanderMerwe**

Your Ref No. : **-**
Our Ref No. : **17168**
Date Reported : **07.04.2014**

Moisture/Density Relationship (TMH1: Method A7)

Sample No. : 28069
Natural/Stabilised : Natural
Material Description : Colluvium

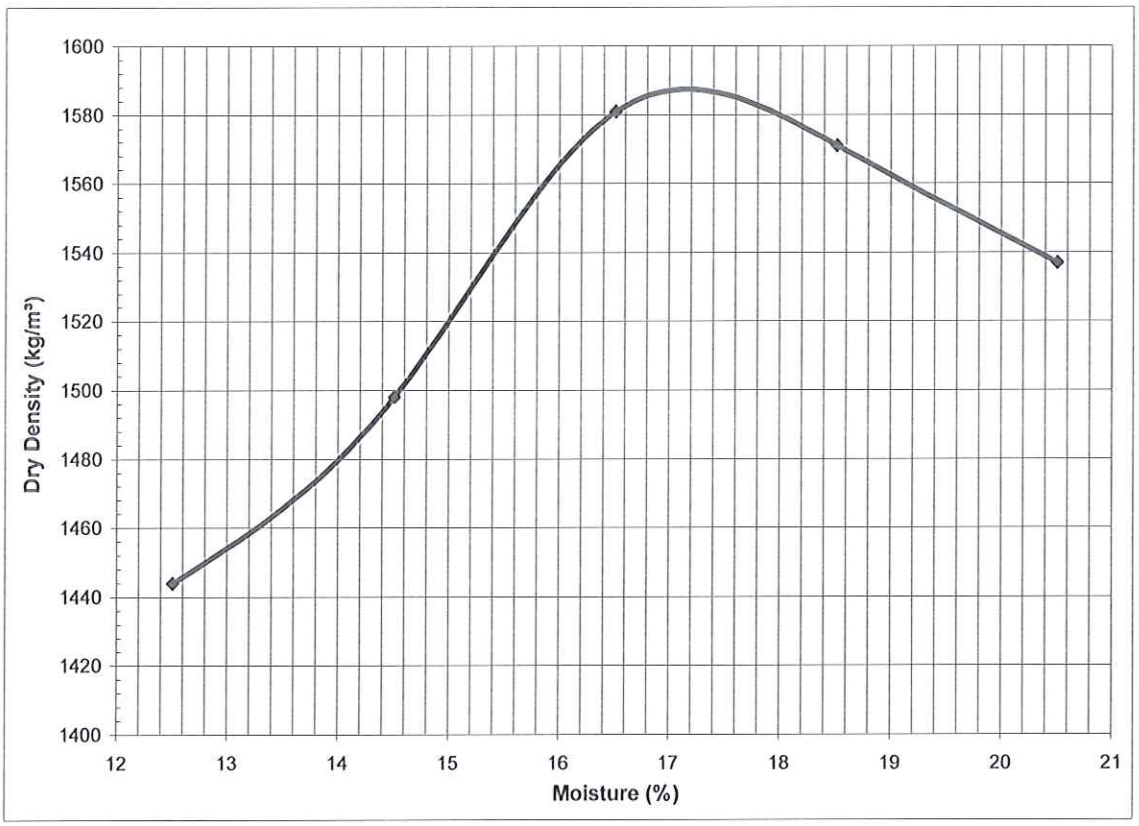
Field No. : RW 02/1
Depth (m) :
Origin :
Compaction Effort : Mod AASHTO

Maximum Dry Density (kg/m³) **1587**

Optimum Moisture Content (%) **17.1**

Plotted Values:

Moisture (%)	12.5	14.5	16.5	18.5	20.5
Dry Density (kg/m³)	1444	1498	1581	1571	1537



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email: geosure@iafrica.com www.geosure.co.za

Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

Your Ref No. : -
Our Ref No. : 17168
Date Reported : 07.04.2014

Moisture/Density Relationship (TMH1: Method A7)

Sample No. : 28070
Natural/Stabilised : Natural
Material Description : Residual Shale

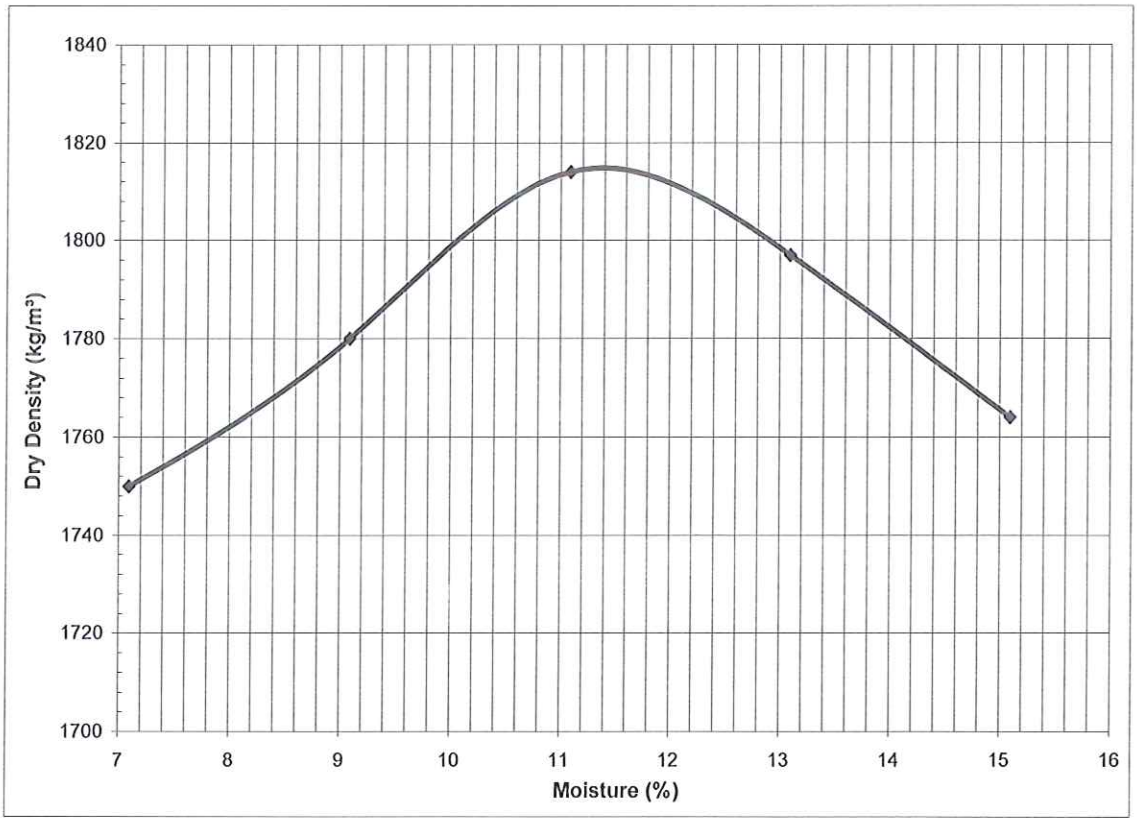
Field No. : RW 09-1
Depth (m) :
Origin :
Compaction Effort : Mod AASHTO

Maximum Dry Density (kg/m³) **1815**

Optimum Moisture Content (%) **11.3**

Plotted Values:

Moisture (%)	7.1	9.1	11.1	13.1	15.1
Dry Density (kg/m³)	1750	1780	1814	1797	1764



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Sampled by Client.

Consulting Engineering Geologists, Geotechnical Engineers,
Geotechnicians & Geotechnical Quality Assurance Specialists

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Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

Your Ref No. : -
Our Ref No. : 17168
Date Reported : 07.04.2014

Moisture/Density Relationship (TMH1: Method A7)

Sample No. : 28071
Natural/Stabilised : Natural
Material Description : Ferrugious Colluvium

Field No. : RW 11/1
Depth (m) :
Origin :
Compaction Effort : Mod AASHTO

Maximum Dry Density (kg/m³) **2038**

Optimum Moisture Content (%) **10.5**

Plotted Values:

Moisture (%)	6.3	8.3	10.3	12.3	14.3
Dry Density (kg/m³)	1926	1988	2037	2017	1984

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Client : Knight Pie Sold (Pty) Ltd
Project : Umkhomazi Water Pipeline
Attention : Mr A.VanderMerwe

Your Ref No. : -
Our Ref No. : 17168
Date Reported : 07.04.2014

Moisture/Density Relationship (TMH1: Method A7)

Sample No. : 28072

Natural/Stabilised : Natural
Material Description : Ferrugious Colluvium

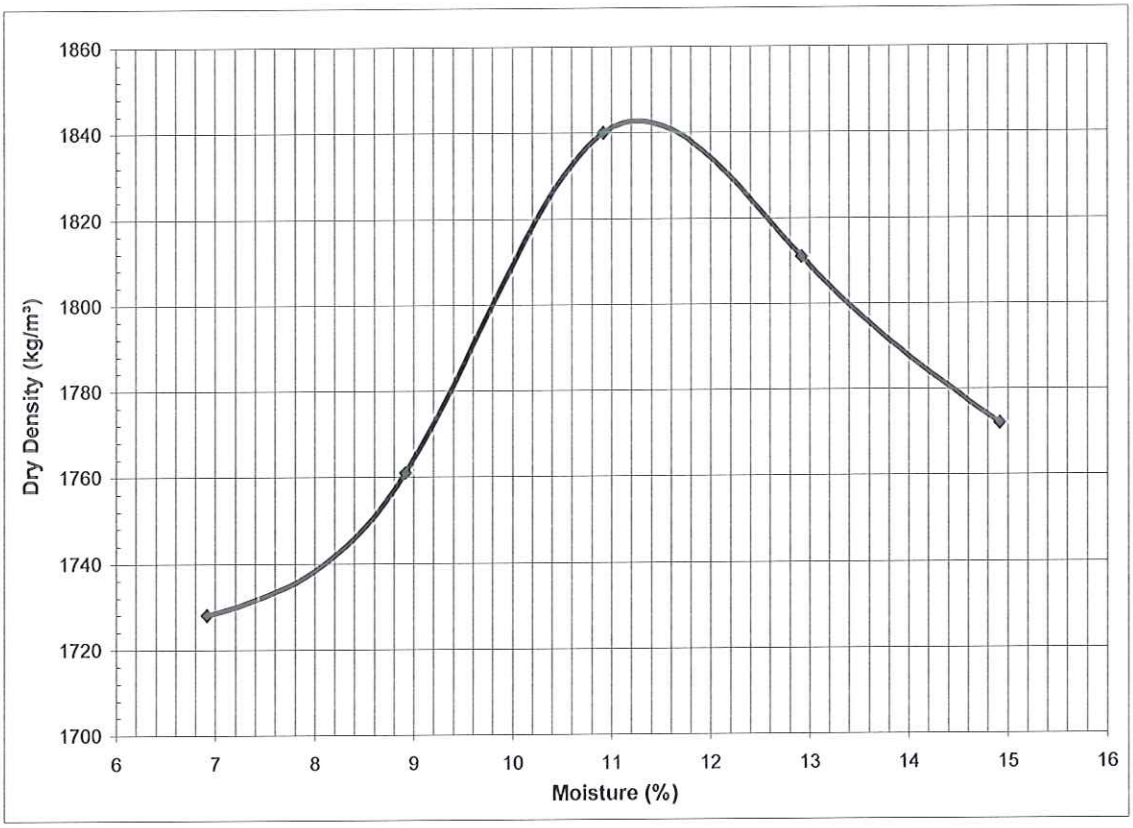
Field No. : RW 17/1
Depth (m) :
Origin :
Compaction Effort : Mod AASHTO

Maximum Dry Density (kg/m³) **1843**

Optimum Moisture Content (%) **11.3**

Plotted Values:

Moisture (%)	6.9	8.9	10.9	12.9	14.9
Dry Density (kg/m³)	1728	1761	1840	1811	1772



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Client : **Knight Pie Sold (Pty) Ltd**
Project : **Umkhomazi Water Pipeline**
Attention : **Mr A.VanderMerwe**

Your Ref No. : **-**
Our Ref No. : **17168**
Date Reported : **07.04.2014**

Moisture/Density Relationship (TMH1: Method A7)

Sample No. : 28074

Natural/Stabilised : Natural
Material Description : Residual Shale

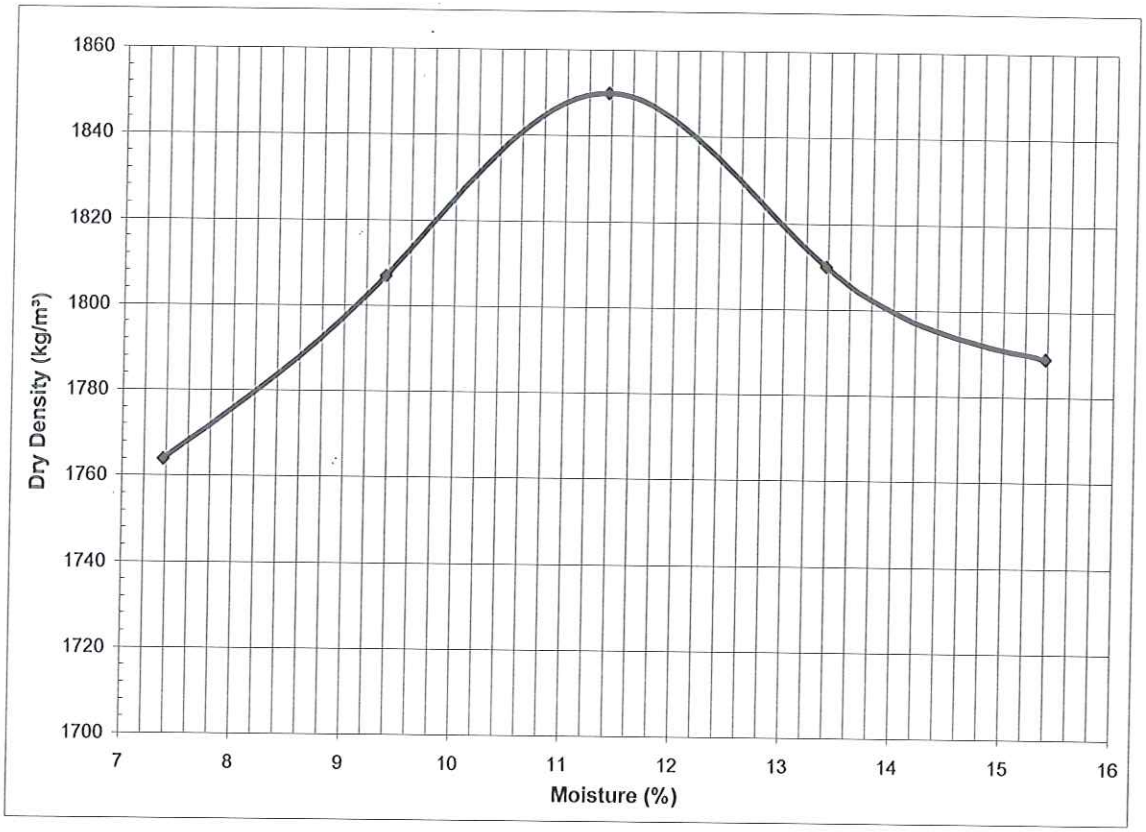
Field No. : RW 23/1
Depth (m) :
Origin :
Compaction Effort : Mod AASHTO

Maximum Dry Density (kg/m³) **1850**

Optimum Moisture Content (%) **11.4**

Plotted Values:

Moisture (%)	7.4	9.4	11.4	13.4	15.4
Dry Density (kg/m³)	1764	1807	1850	1810	1789



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Fax: +27 31 301 1256
Email: info.dbn@alsglobal.com
www.alsglobal.com

Reference №: ALSD 2433 Date: 09 May 2014

CERTIFICATE OF ANALYSIS

Report On:	30 (Thirty)	Samples I.D.:	Sand
Date & Time Received:	30/04/14 – 07:30	Taken By:	Yourselves
Date & Time Analysis Started:	02/05/14 – 10:30	From:	Brayden Govender
Date & Time Analysis Finished:	09/05/14 – 08:30	Ref №:	17168

MARKED: **AS PER BELOW.**

Analysis on an as received basis:

	Resistivity, as ohm.m, [Megger Earth Tester]
1. 28055	80
2. 28056	142
3. 28057	111
4. 28058	131
5. 28059	41
6. 28060	165
7. 28061	72
8. 28062	51
9. 28063	176
10. 28064	33
11. 28065	185
12. 28066	24
13. 28067	31
14. 28068	42
15. 28069	100

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www.alsglobal.com

Reference №: ALSD 2433 Date: 09 May 2014

	Resistivity, as ohm.m, [Megger Earth Tester]
16. 28070.....	90
17. 28071.....	35
18. 28072.....	38
19 28073.....	>499
20. 28074.....	68
21. 28075.....	38
22. 28076.....	174
23. 28077.....	470
24. 28078.....	74
25. 28079.....	74
26. 28080.....	70
27. 28081.....	158
28. 28082.....	43
29. 28083.....	230
30. 28084.....	>499

Technical Signatory: Chemistry _____ Microbiology _____
Mr P. Ramdeen – Supervisor Ms N. Kassim – Supervisor

Branch Manager: _____
Dr A. A. Khan

Geosure
P.O Box 1461
Westville
3630

Appendix C: DPL Test Results

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3030041301**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 01

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	200					200
5	345	145	29	Stiff	56,95586	345
10	430	85	17	Stiff	112,2312	430
15	520	90	18	Stiff	104,3729	520
20	615	95	19	Stiff	97,44662	615
25	745	130	26	Stiff	65,42861	745
30	890	145	29	Stiff	56,95586	890
35	1085	195	39	Firm	39,09595	1085
40	1205	120	24	Stiff	72,42952	1205
45	1285	80	16	Stiff	121,2136	1285
50	1360	75	15	Very Stiff	131,5673	1360
55	1420	60	12	Very Stiff	174,6722	1420
60	1475	55	11	Very Stiff	195,0811	1475
65	1530	55	11	Very Stiff	195,0811	1530
70	1585	55	11	Very Stiff	195,0811	1585
75	1625	40	8	Very Stiff	292,3207	1625
80	1690	65	13	Very Stiff	157,7887	1690
85	1735	45	9	Very Stiff	251,7073	1735
90	1770	35	7	Very Stiff	346,3453	1770

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 02

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	25					25
5	235	210	42	Firm	35,5842	235
10	320	85	17	Stiff	112,231	320
15	395	75	15	Very Stiff	131,567	395
20	460	65	13	Very Stiff	157,789	460
25	525	65	13	Very Stiff	157,789	525
30	600	75	15	Very Stiff	131,567	600
35	660	60	12	Very Stiff	174,672	660
40	795	135	27	Stiff	62,3666	795
45	1000	205	41	Firm	36,6901	1000
50	1050	50	10	Very Stiff	220,183	1050
55	1085	35	7	Very Stiff	346,345	1085
60	1105	20	4	Near Refusal	500	1105
65	1130	25	5	Very Stiff	500	1130
70	1155	25	5	Very Stiff	500	1155
75				Near Refusal		

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL O3

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	100					100
5	360	260	52	Firm	27,13061	360
10	615	255	51	Firm	27,808	615
15	960	345	69	Soft	18,94286	960
20	1100	140	28	Stiff	59,55156	1100
25	1260	160	32	Firm	50,26242	1260
30	1470	210	42	Firm	35,5842	1470
35	1595	125	25	Stiff	68,77016	1595
40	1665	70	14	Very Stiff	143,6155	1665
45	1760	95	19	Stiff	97,44662	1760
50	1855	95	19	Stiff	97,44662	1855
55	1890	35	7	Very Stiff	346,3453	1890
60	1920	30	6	Very Stiff	421,2421	1920
65	1950	30	6	Very Stiff	421,2421	1950

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 04

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	15					15
5	100	85	17	Stiff	112,231	100
10	205	105	21	Stiff	85,8154	205
15	340	135	27	Stiff	62,3666	340
20	505	165	33	Firm	48,336	505
25	670	165	33	Firm	48,336	670
30	805	135	27	Stiff	62,3666	805
35	905	100	20	Stiff	91,301	905
40	965	60	12	Very Stiff	174,672	965
45	1080	115	23	Stiff	76,4521	1080
50	1185	105	21	Stiff	85,8154	1185
55	1275	90	18	Stiff	104,373	1275
60	1375	100	20	Stiff	91,301	1375
65	1485	110	22	Stiff	80,8923	1485
70	1605	120	24	Stiff	72,4295	1605
75	1685	80	16	Stiff	121,214	1685
80	1750	65	13	Very Stiff	157,789	1750
85	1805	55	11	Very Stiff	195,081	1805
90	1850	45	9	Very Stiff	251,707	1850
95	1890	40	8	Very Stiff	292,321	1890
100	1930	40	8	Very Stiff	292,321	1930

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 05

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	35					35
5	120	85	17	Stiff	112,231	120
10	220	100	20	Stiff	91,301	220
15	380	160	32	Firm	50,2624	380
20	545	165	33	Firm	48,336	545
25	695	150	30	Stiff	54,5557	695
30	815	120	24	Stiff	72,4295	815
35	945	130	26	Stiff	65,4286	945
40	990	45	9	Very Stiff	251,707	990
45	1050	60	12	Very Stiff	174,672	1050
50	1105	55	11	Very Stiff	195,081	1105
55	1190	85	17	Stiff	112,231	1190
60	1260	70	14	Very Stiff	143,615	1260
65	1345	85	17	Stiff	112,231	1345
70	1445	100	20	Stiff	91,301	1445
75	1525	80	16	Stiff	121,214	1525
80	1585	60	12	Very Stiff	174,672	1585
85	1640	55	11	Very Stiff	195,081	1640
90	1705	65	13	Very Stiff	157,789	1705
95	1775	70	14	Very Stiff	143,615	1775
100	1830	55	11	Very Stiff	195,081	1830
105	1875	45	9	Very Stiff	251,707	1875
110	1915	40	8	Very Stiff	292,321	1915
115	1950	35	7	Very Stiff	346,345	1950

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3030041301**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 06

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	15					15
5	170	155	31	Firm	52,3305	170
10	330	160	32	Firm	50,2624	330
15	485	155	31	Firm	52,3305	485
20	585	100	20	Stiff	91,301	585
25	705	120	24	Stiff	72,4295	705
30	800	95	19	Stiff	97,4466	800
35	935	135	27	Stiff	62,3666	935
40	1015	80	16	Stiff	121,214	1015
45	1095	80	16	Stiff	121,214	1095
50	1185	90	18	Stiff	104,373	1185
55	1270	85	17	Stiff	112,231	1270
60	1340	70	14	Very Stiff	143,615	1340
65	1385	45	9	Very Stiff	251,707	1385
70	1445	60	12	Very Stiff	174,672	1445
75	1505	60	12	Very Stiff	174,672	1505
80	1565	60	12	Very Stiff	174,672	1565
85	1605	40	8	Very Stiff	292,321	1605
90	1685	80	16	Stiff	121,214	1685
95	1750	65	13	Very Stiff	157,789	1750
100	1810	60	12	Very Stiff	174,672	1810
105	1890	80	16	Stiff	121,214	1890
110	1910	20	4	FALSE	500	1910
115	1985	75	15	Very Stiff	131,567	1985

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 07

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	70					70
5	210	140	28	Stiff	59,5516	210
10	455	245	49	Firm	29,2573	455
15	560	105	21	Stiff	85,8154	560
20	615	55	11	Very Stiff	195,081	615
25	680	65	13	Very Stiff	157,789	680
30	745	65	13	Very Stiff	157,789	745
35	800	55	11	Very Stiff	195,081	800
40	875	75	15	Very Stiff	131,567	875
45	920	45	9	Very Stiff	251,707	920
50	965	45	9	Very Stiff	251,707	965
55	1005	40	8	Very Stiff	292,321	1005
60	1055	50	10	Very Stiff	220,183	1055
65	1115	60	12	Very Stiff	174,672	1115
70	1235	120	24	Stiff	72,4295	1235
75	1325	90	18	Stiff	104,373	1325
80	1395	70	14	Very Stiff	143,615	1395
85	1475	80	16	Stiff	121,214	1475
90	1580	105	21	Stiff	85,8154	1580
95	1710	130	26	Stiff	65,4286	1710
100	1845	135	27	Stiff	62,3666	1845
105	1950	105	21	Stiff	85,8154	1950

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 08

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	60					60
5	220	160	32	Firm	50,2624	220
10	375	155	31	Firm	52,3305	375
15	480	105	21	Stiff	85,8154	480
20	580	100	20	Stiff	91,301	580
25	655	75	15	Very Stiff	131,567	655
30	735	80	16	Stiff	121,214	735
35	885	150	30	Stiff	54,5557	885
40	1000	115	23	Stiff	76,4521	1000
45	1085	85	17	Stiff	112,231	1085
50	1175	90	18	Stiff	104,373	1175
55	1270	95	19	Stiff	97,4466	1270
60	1355	85	17	Stiff	112,231	1355
65	1445	90	18	Stiff	104,373	1445
70	1550	105	21	Stiff	85,8154	1550
75	1645	95	19	Stiff	97,4466	1645
80	1785	140	28	Stiff	59,5516	1785
85	1865	80	16	Stiff	121,214	1865
90	1945	80	16	Stiff	121,214	1945
95	1985	40	8	Very Stiff	292,321	1985

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 09

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	60					60
5	320	260	52	Firm	27,1306	320
10	375	55	11	Very Stiff	195,081	375
15	415	40	8	Very Stiff	292,321	415
20	455	40	8	Very Stiff	292,321	455
25	500	45	9	Very Stiff	251,707	500
30	555	55	11	Very Stiff	195,081	555
35	625	70	14	Very Stiff	143,615	625
40	740	115	23	Stiff	76,4521	740
45	885	145	29	Stiff	56,9559	885
50	1000	115	23	Stiff	76,4521	1000
55	1095	95	19	Stiff	97,4466	1095
60	1190	95	19	Stiff	97,4466	1190
65	1275	85	17	Stiff	112,231	1275
70	1365	90	18	Stiff	104,373	1365
75	1440	75	15	Very Stiff	131,567	1440
80	1525	85	17	Stiff	112,231	1525
85	1615	90	18	Stiff	104,373	1615
90	1700	85	17	Stiff	112,231	1700
95	1785	85	17	Stiff	112,231	1785
100	1865	80	16	Stiff	121,214	1865
105	1940	75	15	Very Stiff	131,567	1940
110	2000	60	12	Very Stiff	174,672	2000

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 10

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	70					70
5	245	175	35	Firm	44,856	245
10	315	70	14	Very Stiff	143,62	315
15	380	65	13	Very Stiff	157,79	380
20	450	70	14	Very Stiff	143,62	450
25	535	85	17	Stiff	112,23	535
30	680	145	29	Stiff	56,956	680
35	820	140	28	Stiff	59,552	820
40	895	75	15	Very Stiff	131,57	895
45	970	75	15	Very Stiff	131,57	970
50	1030	60	12	Very Stiff	174,67	1030
55	1100	70	14	Very Stiff	143,62	1100
60	1155	55	11	Very Stiff	195,08	1155
65	1190	35	7	Very Stiff	346,35	1190
70	1220	30	6	Very Stiff	421,24	1220
75	1250	30	6	Very Stiff	421,24	1250
80	1275	25	5	Very Stiff	500	1275
85	1295	20	4	Near Refusal	500	1295
90	1315	20	4	Near Refusal	500	1315
95	Near Refusal					

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 11

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	70					70
5	235	165	33	Firm	48,336	235
10	355	120	24	Stiff	72,4295	355
15	440	85	17	Stiff	112,231	440
20	520	80	16	Stiff	121,214	520
25	635	115	23	Stiff	76,4521	635
30	710	75	15	Very Stiff	131,567	710
35	770	60	12	Very Stiff	174,672	770
40	835	65	13	Very Stiff	157,789	835
45	900	65	13	Very Stiff	157,789	900
50	975	75	15	Very Stiff	131,567	975
55	1025	50	10	Very Stiff	220,183	1025
60	1100	75	15	Very Stiff	131,567	1100
65	1175	75	15	Very Stiff	131,567	1175
70	1250	75	15	Very Stiff	131,567	1250
75	1315	65	13	Very Stiff	157,789	1315
80	1370	55	11	Very Stiff	195,081	1370
85	1420	50	10	Very Stiff	220,183	1420
90	1460	40	8	Very Stiff	292,321	1460
95	1495	35	7	Very Stiff	346,345	1495
100	1530	35	7	Very Stiff	346,345	1530
105	1555	25	5	Very Stiff	500	1555
110	1585	30	6	Very Stiff	421,242	1585
115	1610	25	5	Very Stiff	500	1610
120	1640	30	6	Very Stiff	421,242	1640
125	1670	30	6	Very Stiff	421,242	1670
130	1695	25	5	Very Stiff	500	1695
135	1720	25	5	Very Stiff	500	1720
140				Near Refusal		

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 12

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	155					155
5	630	475	95	Soft	12,6205	630
10	775	145	29	Stiff	56,9559	775
15	825	50	10	Very Stiff	220,183	825
20	860	35	7	Very Stiff	346,345	860
25	890	30	6	Very Stiff	421,242	890
30	915	25	5	Very Stiff	500	915
35	940	25	5	Very Stiff	500	940
40	970	30	6	Very Stiff	421,242	970
45	1000	30	6	Very Stiff	421,242	1000
50	1030	30	6	Very Stiff	421,242	1030
55	1055	25	5	Very Stiff	500	1055
60	1085	30	6	Very Stiff	421,242	1085
65	1100	15	3	Near Refusal	500	1100
70				Near Refusal		

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 13

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	35					35
5	195	160	32	Firm	50,2624	195
10	310	115	23	Stiff	76,4521	310
15	420	110	22	Stiff	80,8923	420
20	505	85	17	Stiff	112,231	505
25	595	90	18	Stiff	104,373	595
30	725	130	26	Stiff	65,4286	725
35	830	105	21	Stiff	85,8154	830
40	925	95	19	Stiff	97,4466	925
45	1250	325	65	Soft	20,4354	1250
50	1325	75	15	Very Stiff	131,567	1325
55	1380	55	11	Very Stiff	195,081	1380
60	1425	45	9	Very Stiff	251,707	1425
65	1470	45	9	Very Stiff	251,707	1470
70	1520	50	10	Very Stiff	220,183	1520
75	1565	45	9	Very Stiff	251,707	1565
80	1595	30	6	Very Stiff	421,242	1595
85	1620	25	5	Very Stiff	500	1620
90	1640	20	4	Near Refusal	500	1640

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 14

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	95					95
5	185	90	18	Stiff	104,373	185
10	300	115	23	Stiff	76,4521	300
15	455	155	31	Firm	52,3305	455
20	540	85	17	Stiff	112,231	540
25	605	65	13	Very Stiff	157,789	605
30	655	50	10	Very Stiff	220,183	655
35	705	50	10	Very Stiff	220,183	705
40	740	35	7	Very Stiff	346,345	740
45	775	35	7	Very Stiff	346,345	775
50	800	25	5	Very Stiff	500	800
55	825	25	5	Very Stiff	500	825
60	850	25	5	Very Stiff	500	850
65	870	20	4	Near Refusal	500	870

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 15

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	35					35
5	175	140	28	Stiff	59,5516	175
10	260	85	17	Stiff	112,231	260
15	350	90	18	Stiff	104,373	350
20	455	105	21	Stiff	85,8154	455
25	595	140	28	Stiff	59,5516	595
30	735	140	28	Stiff	59,5516	735
35	850	115	23	Stiff	76,4521	850
40	985	135	27	Stiff	62,3666	985
45	1110	125	25	Stiff	68,7702	1110
50	1240	130	26	Stiff	65,4286	1240
55	1365	125	25	Stiff	68,7702	1365
60	1480	115	23	Stiff	76,4521	1480
65	1585	105	21	Stiff	85,8154	1585
70	1655	70	14	Very Stiff	143,615	1655
75	1685	30	6	Very Stiff	421,242	1685
80	1710	25	5	Very Stiff	500	1710
85	1730	20	4	Near Refusal	500	1730

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 16

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	130					130
5	275	145	29	Stiff	56,9559	275
10	440	165	33	Firm	48,336	440
15	590	150	30	Stiff	54,5557	590
20	790	200	40	Firm	37,8589	790
25	805	15	3	Near Refusal	500	805
30	890	85	17	Stiff	112,231	890
35	970	80	16	Stiff	121,214	970
40	1055	85	17	Stiff	112,231	1055
45	1145	90	18	Stiff	104,373	1145
50	1205	60	12	Very Stiff	174,672	1205
55	1260	55	11	Very Stiff	195,081	1260
60	1305	45	9	Very Stiff	251,707	1305
65	1345	40	8	Very Stiff	292,321	1345
70	1385	40	8	Very Stiff	292,321	1385
75	1425	40	8	Very Stiff	292,321	1425
80	1460	35	7	Very Stiff	346,345	1460
85	1495	35	7	Very Stiff	346,345	1495
90	1525	30	6	Very Stiff	421,242	1525
95	1555	30	6	Very Stiff	421,242	1555
100	1590	35	7	Very Stiff	346,345	1590
105	1615	25	5	Very Stiff	500	1615
110	1635	20	4	Near Refusal	500	1635
115	1660	25	5	Near Refusal	500	1660

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 17

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	25					25
5	130	105	21	Stiff	85,8154	105
10	225	95	19	Stiff	97,4466	95
15	355	130	26	Stiff	65,4286	130
20	410	55	11	Very Stiff	195,081	55
25	460	50	10	Very Stiff	220,183	50
30	500	40	8	Very Stiff	292,321	40
35	540	40	8	Very Stiff	292,321	40
40	580	40	8	Very Stiff	292,321	40
45	620	40	8	Very Stiff	292,321	40
50	670	50	10	Very Stiff	220,183	50
55	735	65	13	Very Stiff	157,789	65
60	875	140	28	Stiff	59,5516	140
65	950	75	15	Very Stiff	131,567	75
70	975	25	5	Very Stiff	500	25
75	995	20	4	Near Refusal	500	20
80	1020	25	5	Near Refusal	500	25

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 18

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	75					75
5	165	90	18	Stiff	104,373	165
10	255	90	18	Stiff	104,373	255
15	355	100	20	Stiff	91,301	355
20	395	40	8	Very Stiff	292,321	395
25	455	60	12	Very Stiff	174,672	455
30	505	50	10	Very Stiff	220,183	505
35	535	30	6	Very Stiff	421,242	535
40	560	25	5	Very Stiff	500	560
45	600	40	8	Very Stiff	292,321	600
50	630	30	6	Very Stiff	421,242	630
55	660	30	6	Very Stiff	421,242	660
60	685	25	5	Very Stiff	500	685
65	710	25	5	Very Stiff	500	710
70	735	25	5	Very Stiff	500	735
75	750	15	3	Near Refusal	500	750
80				Near Refusal		

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 19

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	80					80
5	165	85	17	Stiff	112,231	165
10	280	115	23	Stiff	76,4521	280
15	375	95	19	Stiff	97,4466	375
20	450	75	15	Very Stiff	131,567	450
25	520	70	14	Very Stiff	143,615	520
30	605	85	17	Stiff	112,231	605
35	685	80	16	Stiff	121,214	685
40	765	80	16	Stiff	121,214	765
45	845	80	16	Stiff	121,214	845
50	905	60	12	Very Stiff	174,672	905
55	970	65	13	Very Stiff	157,789	970
60	1045	75	15	Very Stiff	131,567	1045
65	1100	55	11	Very Stiff	195,081	1100
70	1145	45	9	Very Stiff	251,707	1145
75	1195	50	10	Very Stiff	220,183	1195
80	1225	30	6	Very Stiff	421,242	1225
85	1255	30	6	Very Stiff	421,242	1255
90	1280	25	5	Very Stiff	500	1280
95	1305	25	5	Very Stiff	500	1305
100	1330	25	5	Very Stiff	500	1330
105	1350	20	4	Near Refusal	500	1350
110				Near Refusal		

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 20

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	25					25
5	130	105	21	Stiff	85,8154	130
10	225	95	19	Stiff	97,4466	225
15	355	130	26	Stiff	65,4286	355
20	410	55	11	Very Stiff	195,081	410
25	460	50	10	Very Stiff	220,183	460
30	500	40	8	Very Stiff	292,321	500
35	540	40	8	Very Stiff	292,321	540
40	580	40	8	Very Stiff	292,321	580
45	620	40	8	Very Stiff	292,321	620
50	670	50	10	Very Stiff	220,183	670
55	735	65	13	Very Stiff	157,789	735
60	875	140	28	Stiff	59,5516	875
65	950	75	15	Very Stiff	131,567	950
70	975	25	5	Very Stiff	500	975
75	995	20	4	Near Refusal	500	995
80	1020	25	5	Near Refusal	500	1020
85				Near Refusal		

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 21

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	25					25
5	240	215	43	Firm	34,5365	240
10	290	50	10	Very Stiff	220,183	290
15	380	90	18	Stiff	104,373	380
20	350	60	12	Very Stiff	174,672	350
25	380	30	6	Very Stiff	421,242	380
30	415	35	7	Very Stiff	346,345	415
35	455	40	8	Very Stiff	292,321	455
40	495	40	8	Very Stiff	292,321	495
45	535	40	8	Very Stiff	292,321	535
50	575	40	8	Very Stiff	292,321	575
55	625	50	10	Very Stiff	220,183	625
60	690	65	13	Very Stiff	157,789	690
65	765	75	15	Very Stiff	131,567	765
70	840	75	15	Very Stiff	131,567	840
75	955	115	23	Stiff	76,4521	955
80	955	115	23	Stiff	76,4521	955
85	1055	100	20	Stiff	91,301	1055
90	1160	105	21	Stiff	85,8154	1160
95	1260	100	20	Stiff	91,301	1260
100	1350	90	18	Stiff	104,373	1350
105	1440	90	18	Stiff	104,373	1440
110	1525	85	17	Stiff	112,231	1525
115	1610	85	17	Stiff	112,231	1610
120	1700	90	18	Stiff	104,373	1700
125	1790	90	18	Stiff	104,373	1790
130	1870	80	16	Stiff	121,214	1870
135	1960	90	18	Stiff	104,373	1960

SITE NAME: **UMKHOMAZI PROJECT**
Job Number **3,03E+09**
Date of Test: 2014/03/10 to 2014/03/15

Test Number: DPL 22

No. of Blows	Penetration Reading (mm)	Depth of Penetration (mm)	mm/ blow	Consistency	Bearing Capacity (kPa)	Depth Below NGL (mm)
0	25					25
5	240	215	43	Firm	34,5365	240
10	355	115	23	Stiff	76,4521	355
15	470	115	23	Stiff	76,4521	470
20	575	105	21	Stiff	85,8154	575
25	675	100	20	Stiff	91,301	675
30	775	100	20	Stiff	91,301	775
35	865	90	18	Stiff	104,373	865
40	955	90	18	Stiff	104,373	955
45	1045	90	18	Stiff	104,373	1045
50	1135	90	18	Stiff	104,373	1135
55	1225	90	18	Stiff	104,373	1225
60	1315	90	18	Stiff	104,373	1315
65	1400	85	17	Stiff	112,231	1400
70	1485	85	17	Stiff	112,231	1485
75	1565	80	16	Stiff	121,214	1565
80	1640	75	15	Very Stiff	131,567	1640
85	1715	75	15	Very Stiff	131,567	1715
90	1780	65	13	Very Stiff	157,789	1780
95	1840	60	12	Very Stiff	174,672	1840
100	1890	50	10	Very Stiff	220,183	1890
105	1940	50	10	Very Stiff	220,183	1940
110	1980	40	8	Very Stiff	292,321	1980

Appendix D: Site Photographs

Plate 1: Typical soil profile encountered throughout the site (RW09) with clayey sand colluvium overlying clayey silt residual shale.
(13 March 2014).

Plate 2: Shallow refusal of TLB on completely weathered very soft rock shale. (13 March 2014).

Plate 3: Over head powerlines intersect the site in a east to west direction. (13 March 2014, western view)

Plate 4:

Deep soil profiles were encountered in Zone B, with clayey transported material overlying residual shale.
(13 March 2014)

Plate 5: Grass cover many areas of the Raw Water Pipeline site. A black wattle

forest also occurs near Baynesfield Estate dam site.

Plate 6:

Dynamic Probe Light (DPL) penetration tests were conducted on a proposed raw water pipeline to determine the consistency of the in situ material.
(13 March 2014, northwestern view)