DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

DUE AT **11:00** ON

22 DECEMBER 2017

BID NO. W11268

NGQAMAKAWE REGIONAL SUPPLY SCHEME PHASE 5

CIVIL/MECHANICAL/ELECTRICAL CONTRACT

BUTTERWORTH EMERGENCY SUPPLY SCHEME

VOLUME 4: SITE INFORMATION

SUBMIT BID DOCUMENTS

TO

POSTAL ADDRESS:
DIRECTOR-GENERAL: DEPARTMENT WATER AND SANITATION
PRIVATE BAG X313
PRETORIA, 0001

OR

TO BE DEPOSITED IN:
THE BID BOX AT THE ENTRANCE
OF ZWAMADAKA BUILDING
157 FRANCIS BAARD STREET
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ATTENTION:
DIVISION: PROCUREMENT AND PSP ADMINISTRATION
ZWAMADAKA BUILDING
ZWAMADAKA ENTRANCE

BIDDER: (Company address and stamp)

NGQAMAKAWE REGIONAL SUPPLY SCHEME PHASE 5

BID NO. W11268

BUTTERWORTH EMERGENCY SUPPLY SCHEME

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THE TENDER

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NGQAMAKWE REGIONAL SUPPLY SCHEME PHASE 5

BID NO. W11268 BUTTERWORTH EMERGENCY SUPPLY SCHEME

VOLUME 4

PART C4 – SITE INFORMATION

PART C4: SITE INFORMATION

PART C4.1: GEOTECHNICAL INVESTIGATION REPORT

CLIENT:	**AURECON SA (PTY) LTD**
PROJECT:	**NGQAMAKHWE RWSS: PHASE 5**
DATE:	**JULY 2017**
REFERENCE:	**MT32019**

Compiled by: **Controlab South Africa (Pty) Ltd**
D Louw Pr Tech Eng, MSc (Civil)

AN ENGINEERING GEOLOGICAL DESKTOP INVESTIGATION FOR THE PROPOSED PHASE 5, NGQAMAKHWE EASTERN CAPE PROVINCE.

REPORT REFERENCE: **MT32019** **JULY 2017**

CONTENTS:

1. INTRODUCTION

1.1 Terms of Reference

Controlab South Africa (Pty) Ltd was appointed by Aurecon SA (Pty) Ltd to perform a geotechnical investigation on the proposed water supply project. The purpose of the project was to install a 16km rising main pipeline from the town of Tsomo to a boundary location for a reservoir. The water would be pumped in two (2) stages to an elevation of approximately 1200m The geotechnical report will focus on three (3) aspects of the project namely the:

- Pump station position (pump station 1, 2 as well as an alternative position)
- Reservoir site position (one (1) site as well as one (1) alternative position)
- Pipeline and alternative pipeline

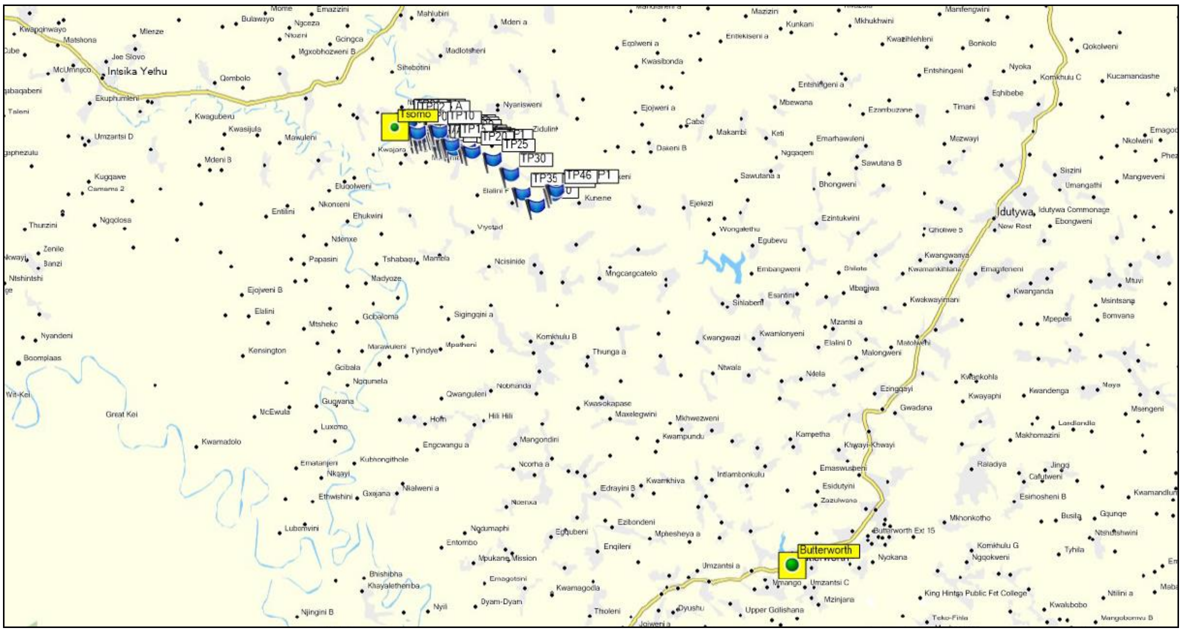
1.2 Available Information

- Site Layout Plan
- Geological Map: 3026 – Aliwal North - Chief Director of Surveys and Mapping: Scale 1:250000

2. SITE DESCRIPTION

2.1 Location

The project was situated in the Amathole District Municipality within the Eastern Cape Province. The project started close to the town of Tsomo and would provide water through a gravity feed pipeline to the entire Ngqamakhwe region. The town of Tsomo was approximately 40km North West of Butterworth.



Locality Map

2.2 Climate

Tsomo normally receives about 536mm of rain per year, with most rainfall occurring mainly during summer. It receives the lowest rainfall (5mm) in July and the highest (85mm) in March. The monthly distribution of average daily maximum temperatures range from 18.1°C in June to 26°C in February. The region is the coldest during July when the temperature drops to 3.7°C on average during the night.

Wienerts climatic N number for the area is between 2 and 5, which should indicate that the rocks would decompose implying that chemical weathering would dominate over mechanical weathering.

3. INVESTIGATION PROCEDURE

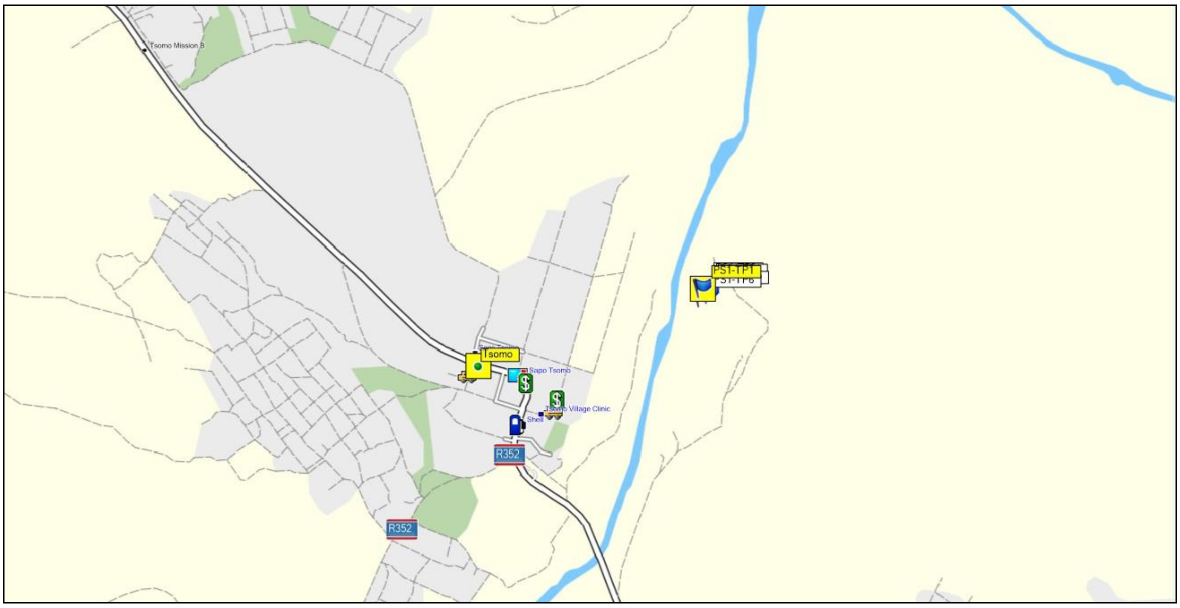
During the field investigations, various trial pits were excavated. At these positions, Dynamic Cone Penetrometer (DCP) tests were performed. The trial pits were profiled by a qualified Engineering Technician utilising "Guidelines for Soil and Rock Logging in South Africa" produced by ABA Brink and RMH Bruin.

Depending on the requirement for the structure or pipeline, samples were taken for various tests including Road Indicator tests, Compactability, Foundation Indicator, Tri-axial and Consolidation tests. Along the pipeline routes, soil resistivity tests were performed to determine the corrosive nature of the soils.

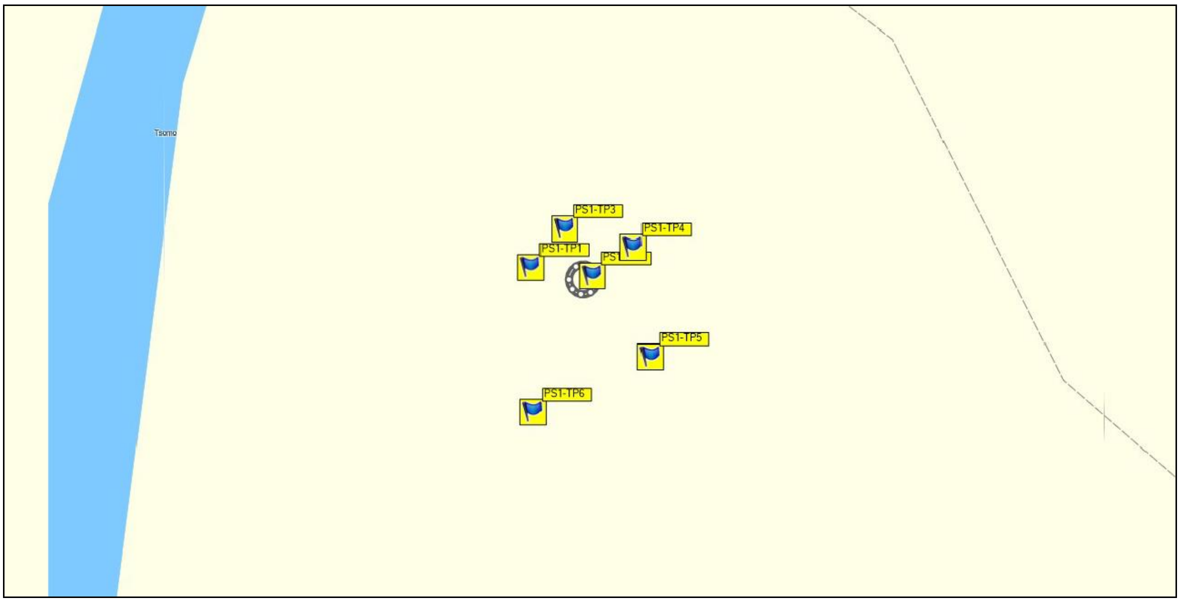
3.1 Pump Station Positions

The co-ordinates for the various trial pits exacted at the pump station positions were as follows:

POSITION	CO-ORDINATE
PUMP STATION 1	
Pump Station 1 Trial Hole 1	S 32°02'07.3" E 27°49'36.3"
Pump Station 1 Trial Hole 2	S 32°02'07.4" E 27°49'36.8"
Pump Station 1 Trial Hole 3	S 32°02'07.0" E 27°49'36.6"
Pump Station 1 Trial Hole 4	S 32°02'07.2" E 27°49'37.1"
Pump Station 1 Trial Hole 5	S 32°02'07.9" E 27°49'37.3"
Pump Station 1 Trial Hole 6	S 32°02'08.3" E 27°49'36.3"



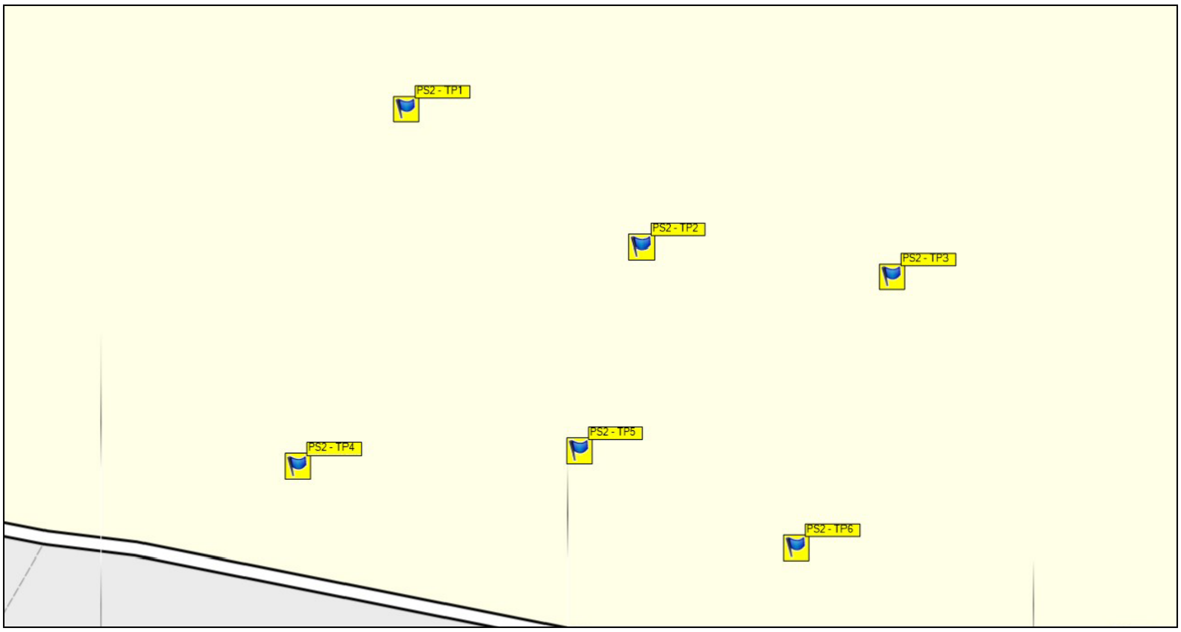
Pump Station 1 - Locality



Pump Station 1 – Test Pit Positions

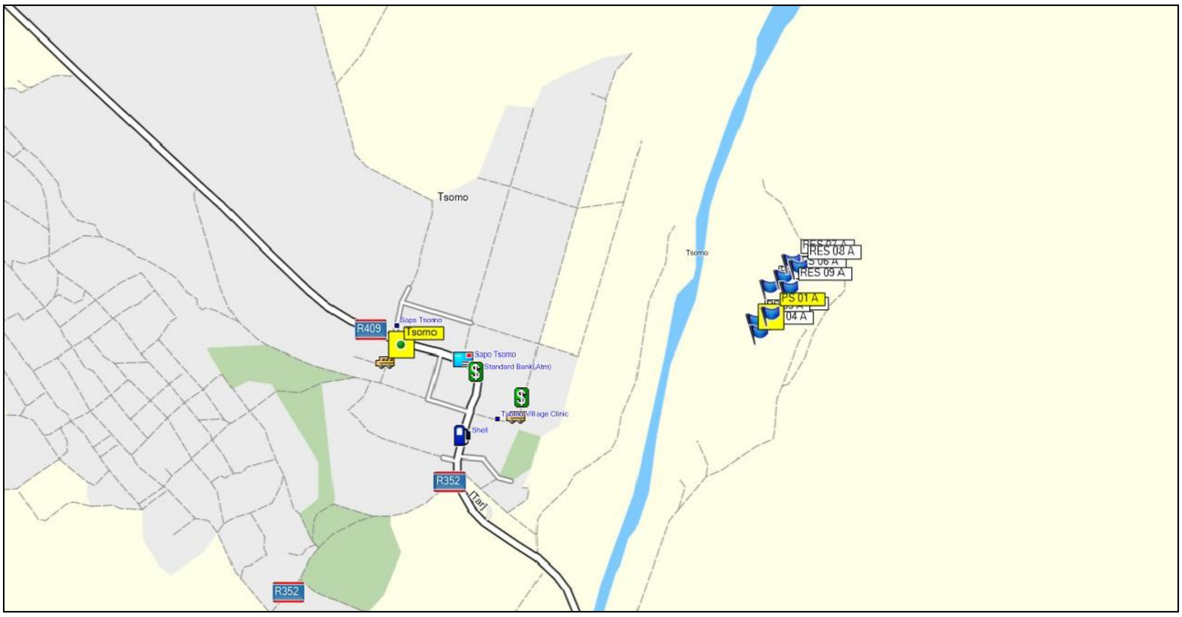
PUMP STATION 2	
Pump Station 2 Trial Hole 1	S 32°03'20.1" E 27°52'37.7"
Pump Station 2 Trial Hole 2	S 32°03'21.0" E 27°52'39.7"
Pump Station 2 Trial Hole 3	S 32°03'21.2" E 27°52'41.9"
Pump Station 2 Trial Hole 4	S 32°03'22.6" E 27°52'36.7"
Pump Station 2 Trial Hole 5	S 32°03'22.5" E 27°52'39.2"
Pump Station 2 Trial Hole 6	S 32°03'23.2" E 27°52'41.1"

Pump Station 2 – Locality

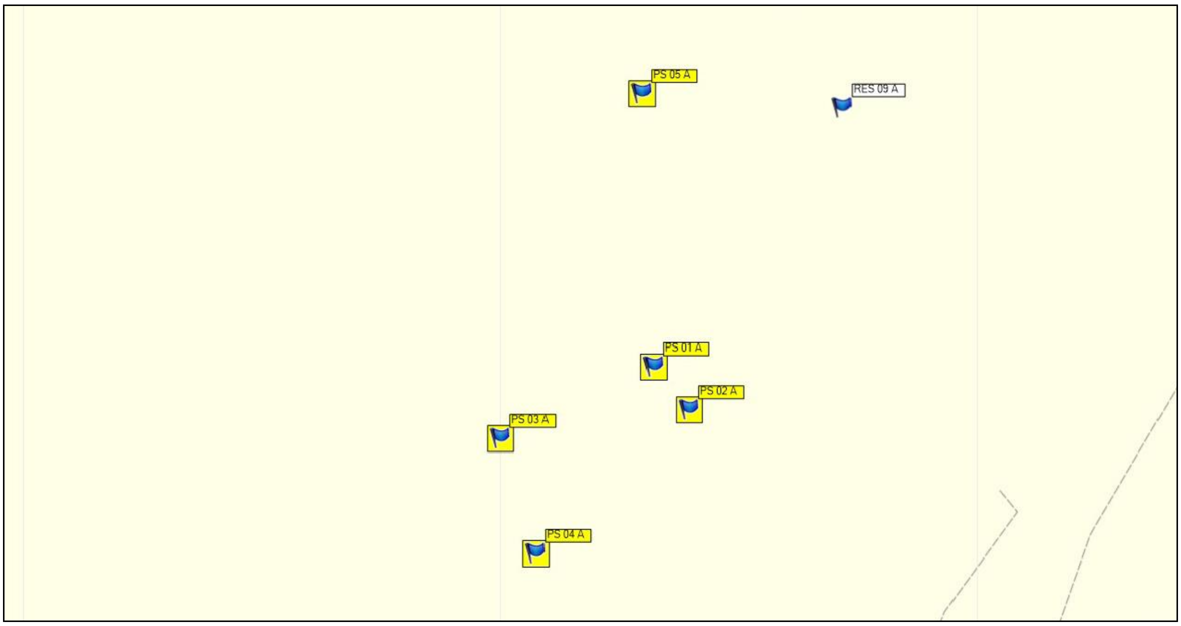


Pump Station 2 – Test Pit Positions

ALTERNATIVE PUMP STATION	
Pump Station 1 Trial Hole 1A	S 32°02'13.7" E 27°49'38.5"
Pump Station 1 Trial Hole 2A	S 32°02'14.0" E 27°49'38.8"
Pump Station 1 Trial Hole 3A	S 32°02'14.2" E 27°49'37.2"
Pump Station 1 Trial Hole 4A	S 32°02'15.0" E 27°49'37.5"
Pump Station 1 Trial Hole 5A	S 32°02'11.8" E 27°49'38.4"



Alternative Pump Station – Locality

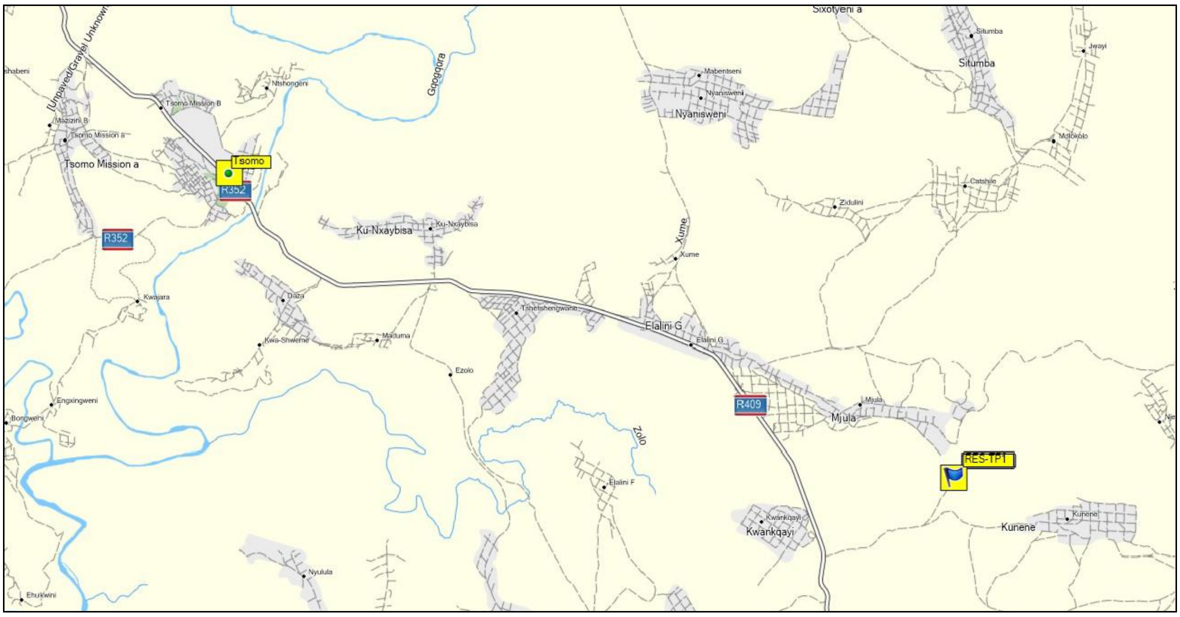


Alternative Pump Station – Test Pit Positions

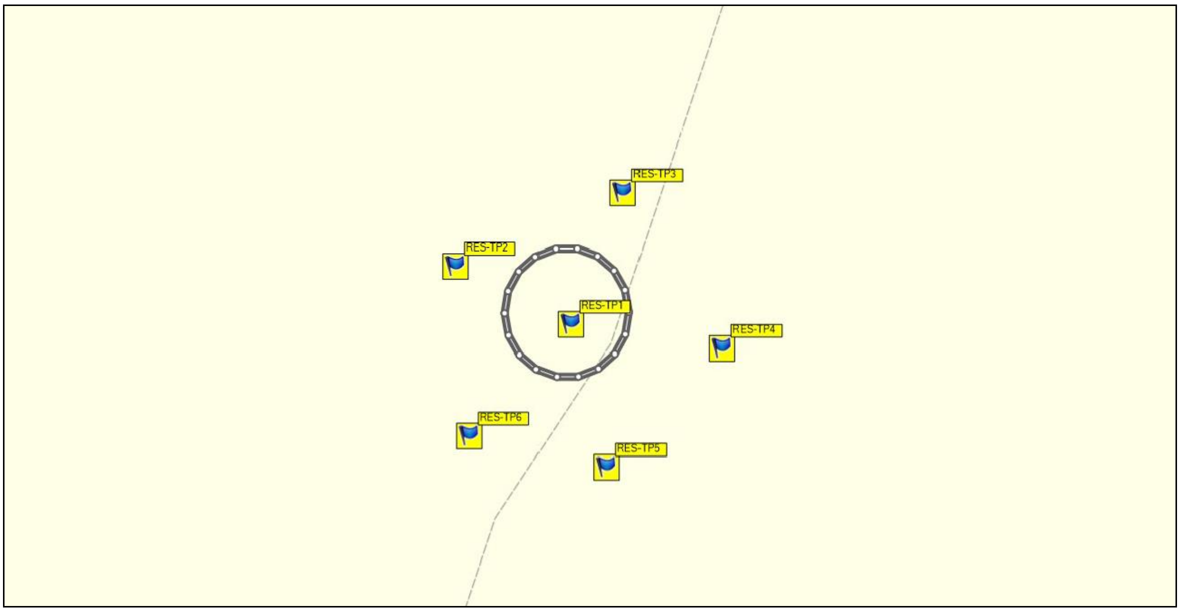
3.2 Reservoir Positions

Two (2) reservoir sites were included in the investigation and the co-ordinates were as follows:

POSITION	CO-ORDINATE
RESERVOIR SITE	
Reservoir Trial Hole 1	S 32°04'56.9" E 27°56'56.9"
Reservoir Trial Hole 2	S 32°04'56.5" E 27°56'55.9"
Reservoir Trial Hole 3	S 32°04'56.0" E 27°56'57.3"
Reservoir Trial Hole 4	S 32°04'57.1" E 27°56'58.2"
Reservoir Trial Hole 5	S 32°04'57.9" E 27°56'57.2"
Reservoir Trial Hole 6	S 32°04'57.7" E 27°56'56.0"

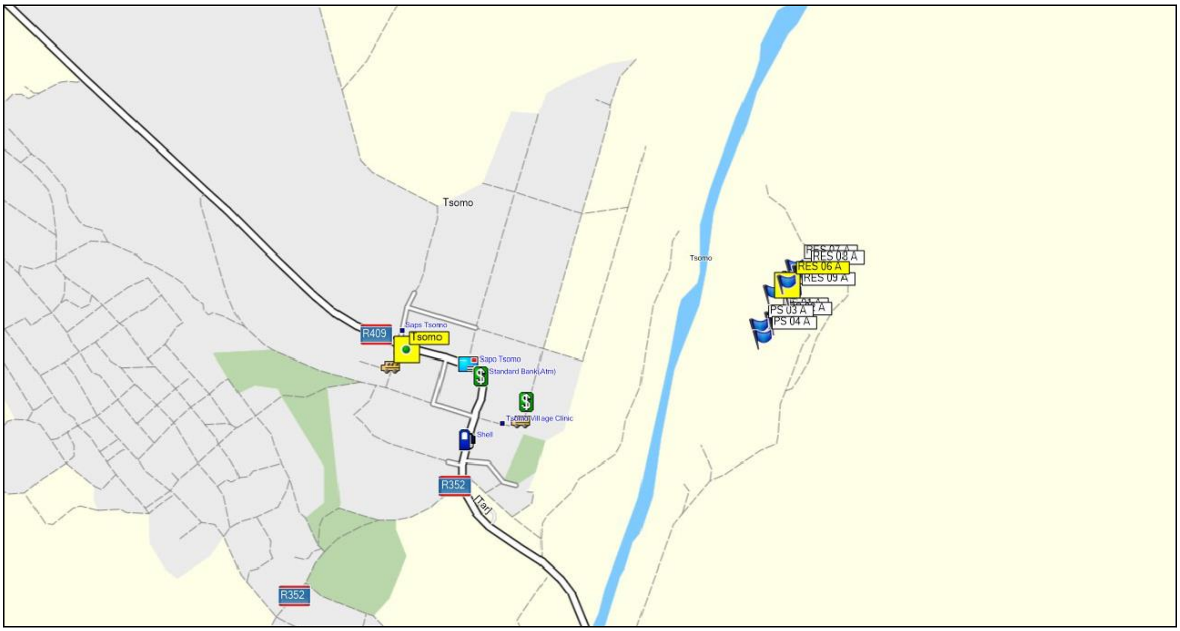


Reservoir Site – Locality

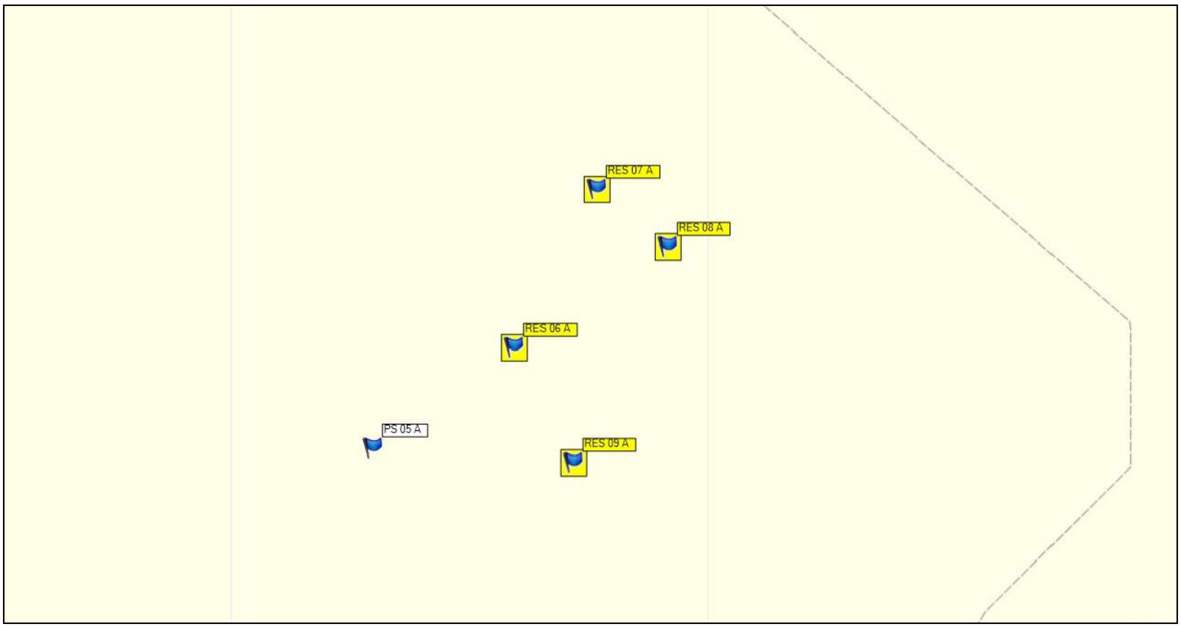


Reservoir Site – Test Pit Position

ALTERNATIVE RESERVOIR SITE	
Reservoir Trial Hole 6A	S 32°02'11.1" E 27°49'39.6"
Reservoir Trial Hole 7A	S 32°02'10.0" E 27°49'40.3"
Reservoir Trial Hole 8A	S 32°02'10.4" E 27°49'40.9"
Reservoir Trial Hole 9A	S 32°02'11.9" E 27°49'40.1"



Alternative Reservoir Site – Locality



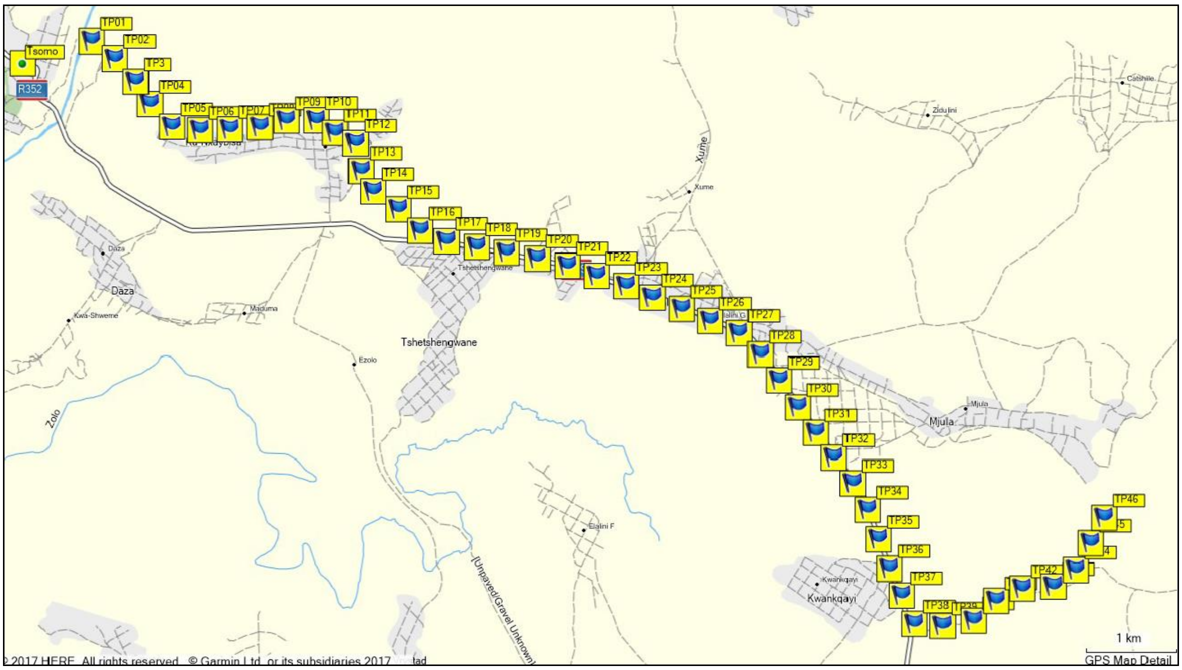
Alternative Reservoir Site – Test Pit Position

3.3 Pipeline Positions

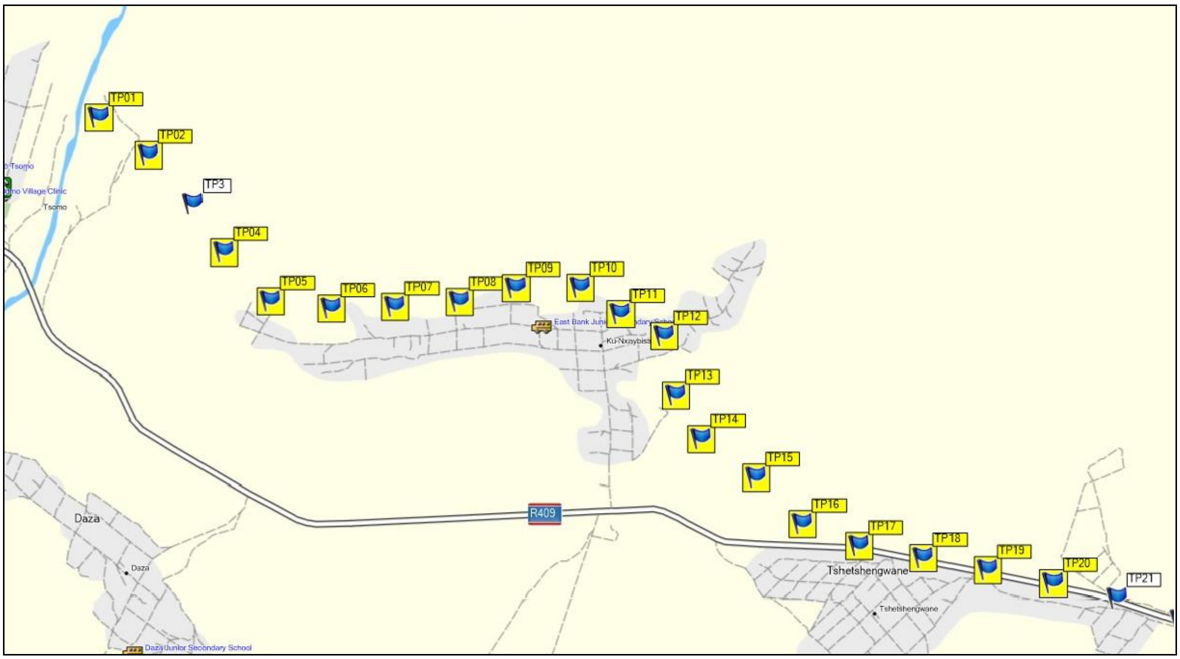
The co-ordinates for the trial pits excavated for the pipeline was as follows:

POSITION	CO-ORDINATE
Main Pipeline Trial Hole 01	S 32°02'07.7" E 27°49'36.7"
Main Pipeline Trial Hole 02	S 32°02'13.9" E 27°49'46.7"
Main Pipeline Trial Hole 03	S 32°02'22.0" E 27°49'55.8"
Main Pipeline Trial Hole 04	S 32°02'30.1" E 27°50'02.0"
Main Pipeline Trial Hole 05	S 32°02'38.2" E 27°50'11.5"
Main Pipeline Trial Hole 06	S 32°02'39.4" E 27°50'23.7"
Main Pipeline Trial Hole 07	S 32°02'39.1" E 27°50'36.8"
Main Pipeline Trial Hole 08	S 32°02'38.2" E 27°50'49.8"
Main Pipeline Trial Hole 09	S 32°02'36.0" E 27°51'01.3"

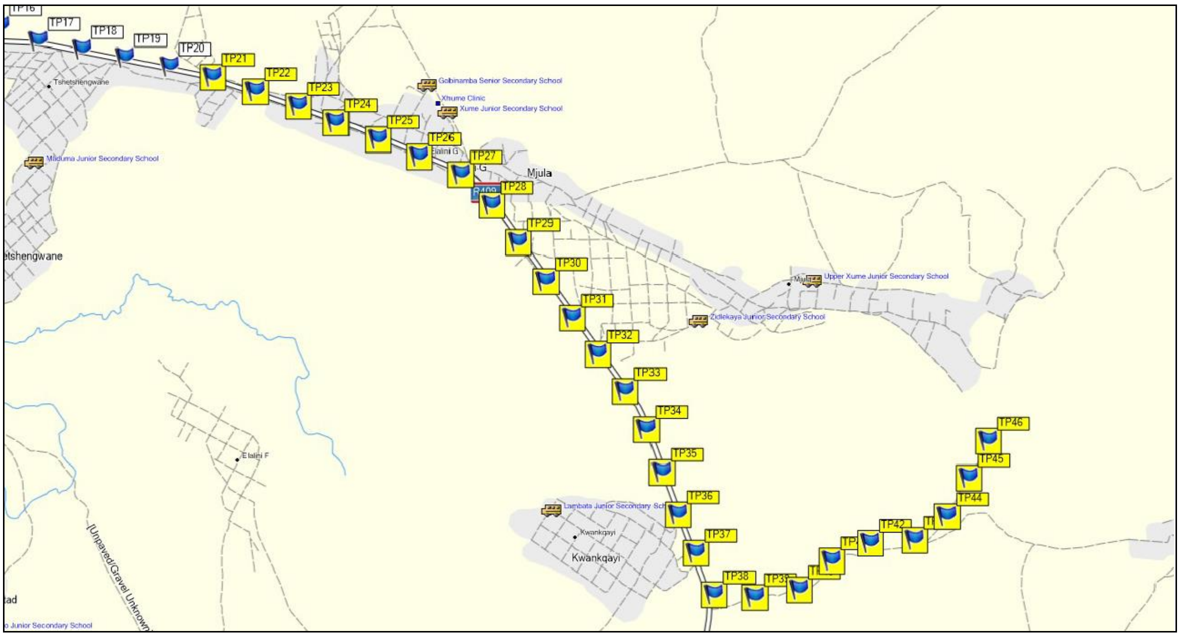
POSITION	CO-ORDINATE
Main Pipeline Trial Hole 10	S 32°02'35.9" E 27°51'14.3"
Main Pipeline Trial Hole 11	S 32°02'40.3" E 27°51'22.5"
Main Pipeline Trial Hole 12	S 32°02'44.0" E 27°51'31.3"
Main Pipeline Trial Hole 13	S 32°02'53.8" E 27°51'33.7"
Main Pipeline Trial Hole 14	S 32°03'01.1" E 27°51'38.9"
Main Pipeline Trial Hole 15	S 32°03'07.5" E 27°51'49.9"
Main Pipeline Trial Hole 16	S 32°03'15.2" E 27°51'59.4"
Main Pipeline Trial Hole 17	S 32°03'18.9" E 27°52'10.8"
Main Pipeline Trial Hole 18	S 32°03'20.9" E 27°52'23.9"
Main Pipeline Trial Hole 19	S 32°03'22.9" E 27°52'37.0"
Main Pipeline Trial Hole 20	S 32°03'25.1" E 27°52'50.3"
Main Pipeline Trial Hole 21	S 32°03'27.6" E 27°53'03.3"
Main Pipeline Trial Hole 22	S 32°03'31.2" E 27°53'16.1"
Main Pipeline Trial Hole 23	S 32°03'34.8" E 27°53'29.0"
Main Pipeline Trial Hole 24	S 32°03'38.9" E 27°53'40.3"
Main Pipeline Trial Hole 25	S 32°03'43.0" E 27°53'53.0"
Main Pipeline Trial Hole 26	S 32°03'47.2" E 27°54'05.4"
Main Pipeline Trial Hole 27	S 32°03'51.6" E 27°54'17.9"
Main Pipeline Trial Hole 28	S 32°03'59.1" E 27°54'27.2"
Main Pipeline Trial Hole 29	S 32°04'08.3" E 27°54'35.2"
Main Pipeline Trial Hole 30	S 32°04'17.9" E 27°54'43.5"
Main Pipeline Trial Hole 31	S 32°04'27.0" E 27°54'51.3"
Main Pipeline Trial Hole 32	S 32°04'35.9" E 27°54'59.1"
Main Pipeline Trial Hole 33	S 32°04'45.0" E 27°55'07.3"
Main Pipeline Trial Hole 34	S 32°04'54.1" E 27°55'13.7"
Main Pipeline Trial Hole 35	S 32°05'05.0" E 27°55'18.4"
Main Pipeline Trial Hole 36	S 32°05'15.4" E 27°55'23.2"
Main Pipeline Trial Hole 37	S 32°05'25.0" E 27°55'28.6"
Main Pipeline Trial Hole 37	S 32°05'35.8" E 27°55'46.4"
Main Pipeline Trial Hole 38	S 32°05'35.1" E 27°55'34.1"
Main Pipeline Trial Hole 40	S 32°05'33.0" E 27°55'59.7"
Main Pipeline Trial Hole 41	S 32°05'26.9" E 27°56'09.6"
Main Pipeline Trial Hole 42	S 32°05'22.5" E 27°56'21.0"
Main Pipeline Trial Hole 43	S 32°05'21.7" E 27°56'34.5"
Main Pipeline Trial Hole 44	S 32°05'15.9" E 27°56'44.2"
Main Pipeline Trial Hole 45	S 32°05'06.4" E 27°56'50.7"
Main Pipeline Trial Hole 46	S 32°04'57.3" E 27°56'56.6"



Main Pipeline – Locality



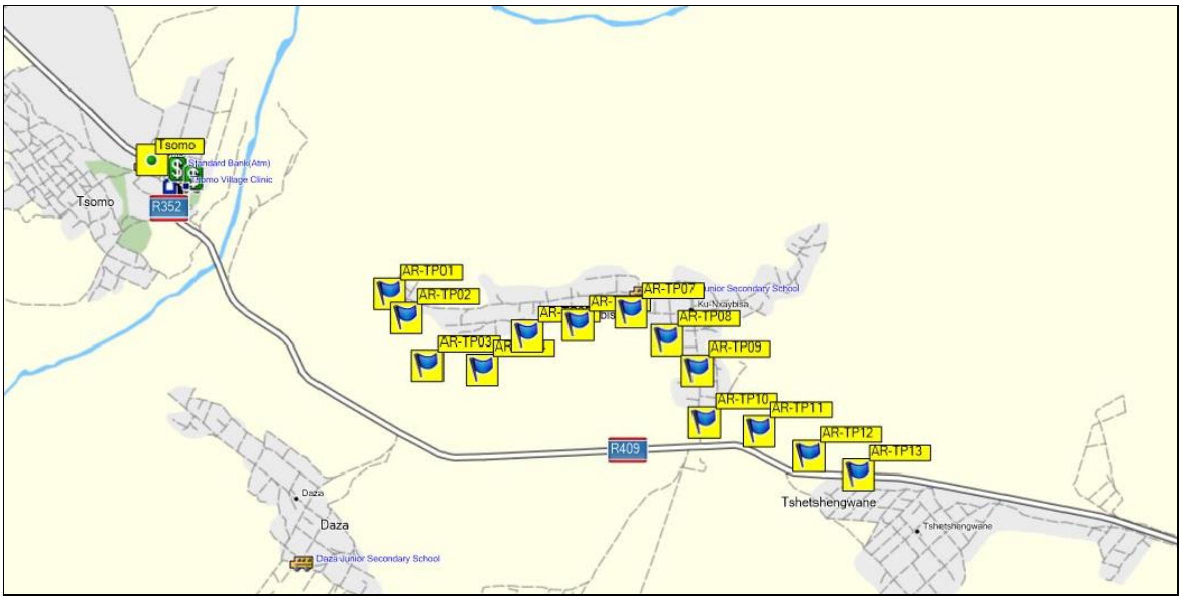
Main Pipeline – Test Pits 1 to 20



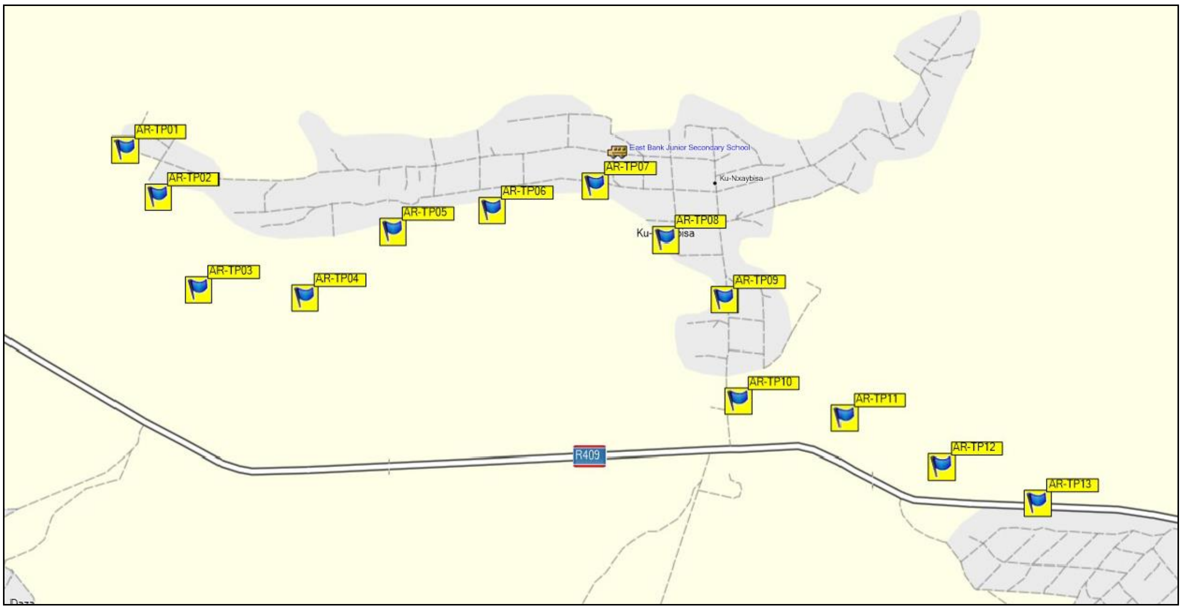
Main Pipeline – Test Pits 21 to 46

The co-ordinates for the alternative pipeline were as follows

POSITION	CO-ORDINATE
AR Trial Hole 01	S 32°02'42.3" E 27°50'04.7"
AR Trial Hole 02	S 32°02'47.1" E 27°50'08.8"
AR Trial Hole 03	S 32°02'56.6" E 27°50'14.0"
AR Trial Hole 04	S 32°02'57.5" E 27°50'27.3"
AR Trial Hole 05	S 32°02'50.7" E 27°50'38.3"
AR Trial Hole 06	S 32°02'45.5" E 27°50'50.8"
AR Trial Hole 07	S 32°02'46.0" E 27°51'03.7"
AR Trial Hole 08	S 32°02'51.5" E 27°51'12.5"
AR Trial Hole 09	S 32°02'57.7" E 27°51'20.0"
AR Trial Hole 10	S 32°03'08.1" E 27°51'21.7"
AR Trial Hole 11	S 32°03'09.8" E 27°51'35.0"
AR Trial Hole 12	S 32°03'14.8" E 27°51'47.2"
AR Trial Hole 13	S 32°03'18.5" E 27°51'59.2"



Alternative Main Pipeline – Locality



Alternative Main Pipeline – Test Pits

4. GEOLOGY

4.1 Regional Geology

The proposed pipeline near Tsomo is set to be implemented within the Katberg Formation. This unit belongs to the Karoo Supergroup.

The Katberg Formation forms part of the Tarkastad Subgroup of the Beaufort Group belonging to the greater Karoo Basin. The Tarkastad Subgroup is characterized by a greater abundance of both sandstone and red mudstone than the Adelaide Subgroup. The boundary between these subgroups is the only line that can be traced with certainty throughout the Karoo Basin.

The Katberg Formation is known to be sandstone rich and constitutes over 90% of the Formations makeup in cases where the Katberg Formation is found in coastal localities near East London. However, inland exposures have a more equal division of sandstone and mudstone. In the North, the mudstone becomes excessive and difficulty in distinguishing it from the Burgersdorp Formation may occur. The Katberg is just over 900m thick in most cases.

Sandstones of the Katberg Formation are fine to medium grained with scattered pebbles up to 150mm in diameter, (common in coastal exposures). Generally, the rocks are light brown to grey or greenish grey in colour with strong horizontal laminations, parting lineations, trough cross bedding and planar cross bedding characteristics.

Oval shaped calcareous concretions between 30 and 100mm in diameter are common with a preferred orientation in a parallel direction to the palaeoslope present at deposition.

Post depositional dolerite intrusions are present as well. The dolerite intrusions may occur as either, horizontal sills and lenses or vertical dykes which cut through the sedimentary layers. Furthermore, the vertical dykes cut through the horizontal sills.

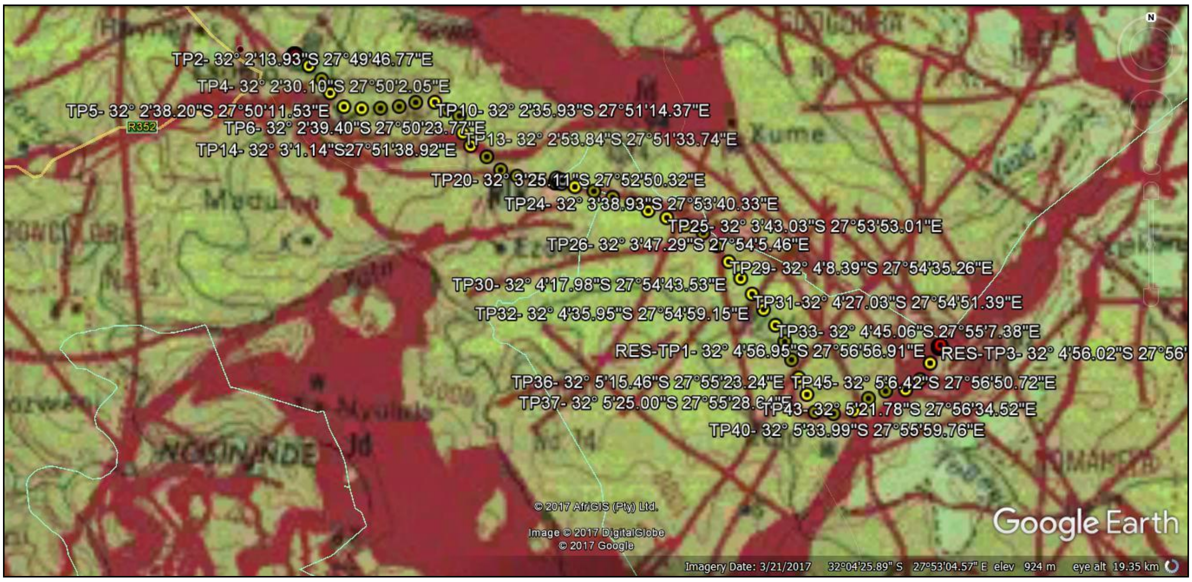
Azimuth and dip of the bedding planes is typical of the Karoo Basin and although area specific, shows a general trend of a north easterly azimuth with a dip of between 1° and 4°

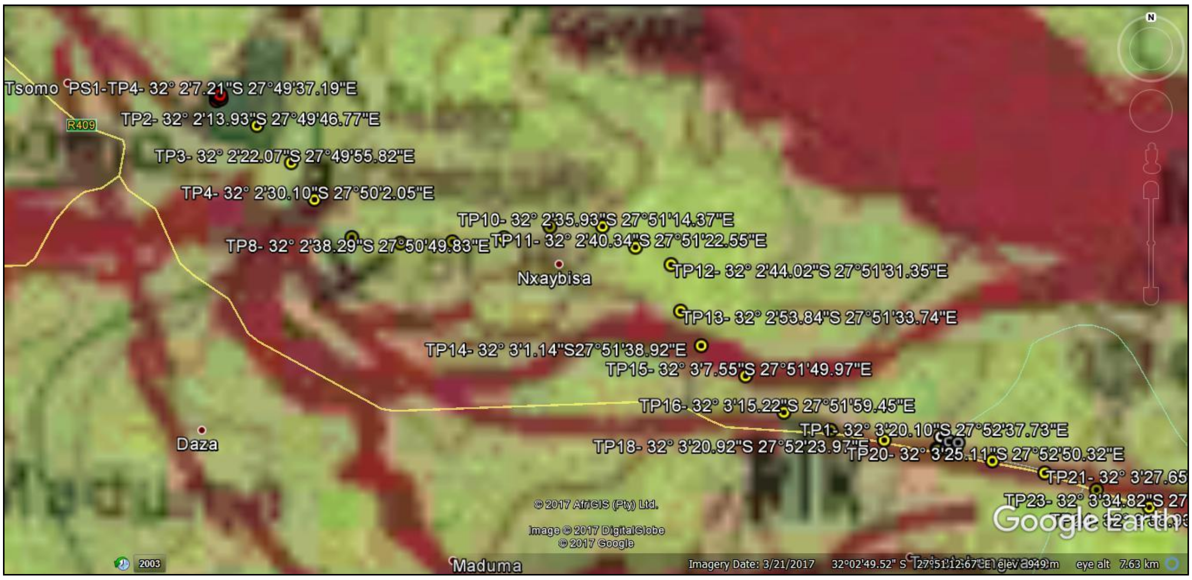
Jointing of the Katberg Formation is not unlike the rest of the Karoo basin and displays distinct jointing planes in three major directions. This results in residual boulders whose size is related to the spacing of the joint patterns. Joint spacing is controlled by the bedding brittleness and degree of deformation experienced.

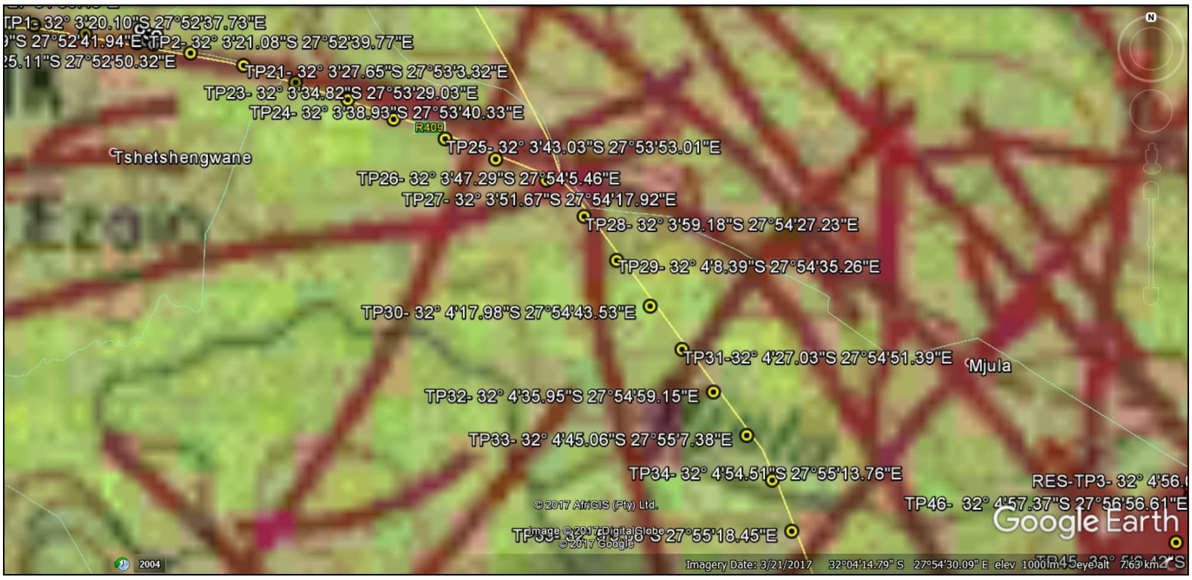
Intrusive dolerite sills are common throughout the Karoo Supergroup and occur as undulating horizontally inclined sheets of mafic, igneous rock forming ring structures at the surface.

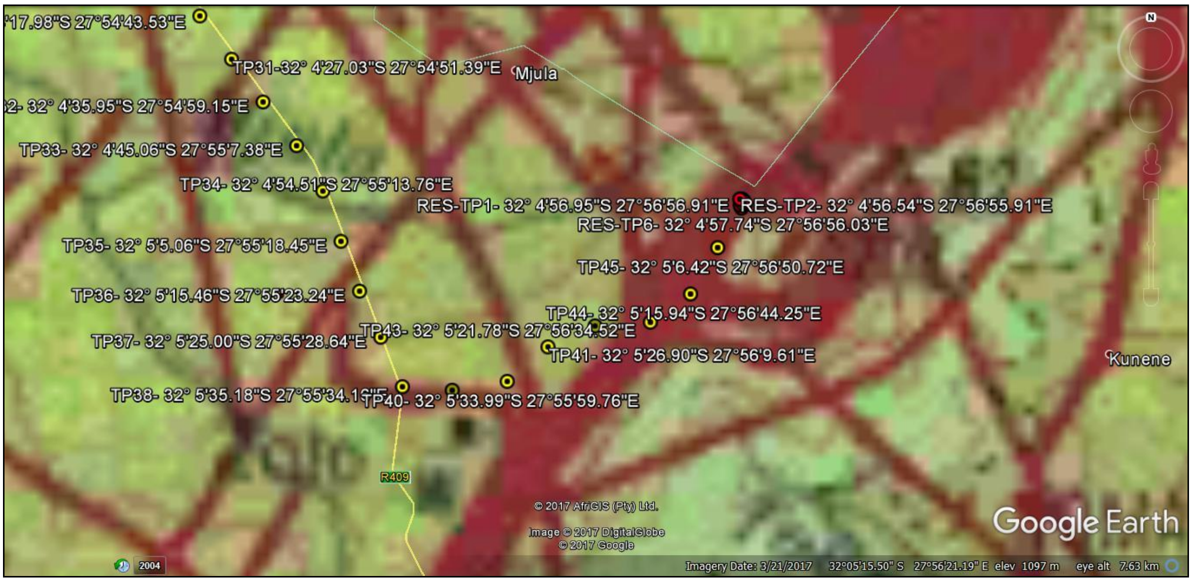
Dolerite is expected to be encountered at TP4, 14, 15, 17 – 28, 43 – 46 as well as at the reservoir site.

No faulting, folding or other deformation events are evident from the 1:250 000 geological map of King Williams Town 3226.









5. ENGINEERING GEOLOGICAL EVALUATION

5.1 Pump Station Position 1

Soil Profiles

The material encountered at the position for the pump station generally consisted of thick horizons of transported silty sand or sandy silt. The moisture conditions were moist, the consistency soft becoming firm and the structures were intact. At TP1, TP2 and TP3 dolerite boulders were profiled within the transported horizons.

Residual material was only encountered at TP6. The material consisted of highly weathered sandstone. The moisture conditions were moist, the consistency soft becoming hard and the structure micro shattered.

No ground water seepage was recorded in any of the trial pits.

Excavation

Excavations were done by machine and the excavation depths were as follows:

➢ Pump Station 1	Trial Hole 1	No refusal @ 3900mm
➢ Pump Station 1	Trial Hole 2	No refusal @ 3900mm
➢ Pump Station 1	Trial Hole 3	No refusal @ 3900mm
➢ Pump Station 1	Trial Hole 4	No refusal @ 2900mm
➢ Pump Station 1	Trial Hole 5	No refusal @ 2900mm
➢ Pump Station 1	Trial Hole 6	No refusal @ 3900mm

Excavations at the pump station position can be classified as being soft.

Test Results

Road Indicator

Six (6) disturbed samples were taken to determine the suitability of the material to be used during construction. The material conformed to a G8 material classification indicating that material similar to the samples tested would be suitable for use as backfill or material required for platforms.

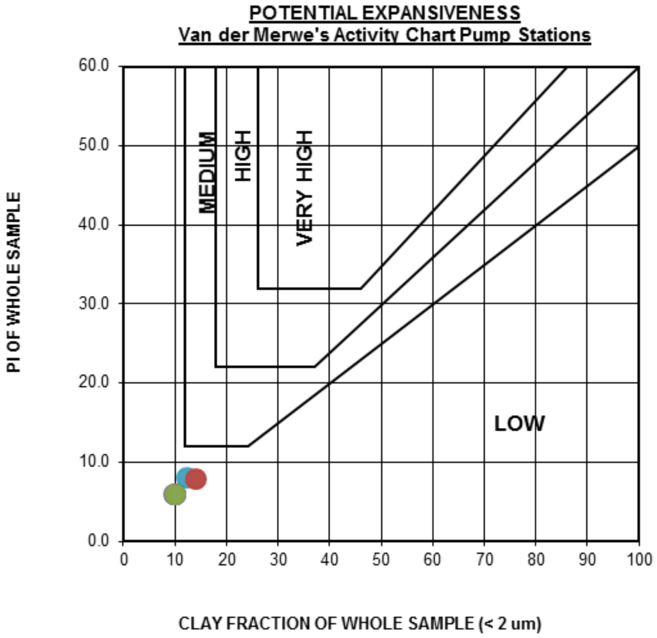
POSITION	DEPTH	DESCRIPTION	G. M.	L L (%)	P I (%)	L S (%)	MDD (kg/m3)	OMC (%)	C.B.R. @ 100%	C.B.R. @ 95 %	C.B.R. @ 90 %	SWELL (%)	TRH14 CLASS
PS1 / TP 1	600 - 2900	lt R sdy st	0.52	20	6	3.5	1934	11.1	63	38	20	0.40	G8
PS1 / TP 2	1200 - 2700	lt R sdy st	0.57	20	5	2.0	1920	10.7	55	26	12	0.60	G8
PS1 / TP 3	950 - 2900	lt R sdy st	0.49	21	8	4.5	1924	12.2	61	25	10	0.60	G8
PS1 / TP 4	400 - 900	lt R sdy st	0.8	22	7	3.0	1947	11.6	50	31	18	0.70	G8
PS1 / TP 5	500 - 2900	lt R sdy st	0.6	23	8	3.5	1951	10.9	60	28	13	0.40	G8
PS1 / TP 6	1200 - 3900	lt R high weath Ss + sdy st	0.7	22	8	3.5	1917	11.0	68	32	15	0.40	G8

Foundation Indicator

Disturbed samples were tested to determine the risk associated with heave. The results indicated that there was a low potential risk for expansive material.

POSITION	DEPTH	DESCRIPTION	0.002 mm	LINEAR SHRINKAGE	PI WHOLE SAMPLE	POTENTIAL EXPANSIVENESS
PS1/TP 4	400 - 900	lt R sdy st	10	3.0	6.0	LOW
PS1/TP 5	500 - 2900	lt R sdy st	14	3.5	8.0	LOW
PS1/TP 6	1200 - 3900	lt R high weath Ss + sdy st	12	3.5	8.0	LOW

The expansiveness of the horizons tested was evaluated using Van der Merwe's method of classification. The PI of the whole sample varied between 6 and 8 with the clay fraction (0.002mm sieve) varied between 10% and 14%.



Tri-axial and Consolidation Tests

Two undisturbed samples were taken of the thick sandy silt horizons to determine the apparent cohesion, internal angle of friction and risk of consolidation.

The tri-axial tests indicated that the apparent cohesion of the silt varied between 85kPa to 320kPa with the corresponding internal angle of frictions 33˚ and 26˚.

The consolidation tests indicated a high risk with regards to collapse / settlement and care must be taken in the platform and foundation design for the pump station.

POSITION	PS1-TH3
DEPTH	950-2900mm
SAMPLE DESCRIPTION	dk Y O sdy st
COLLAPSE	9.72%
POSITION	PS1-TH2
DEPTH	2700-3900mm
SAMPLE DESCRIPTION	dk Y O sdy st
COLLAPSE	3.32%

Pinhole Test

Nine samples were tested according the ASTM D4221-90 test method to determine the dispersive grade classification of the soils. The results indicated the grade of dispersiveness varied between ND1, D1 and D2. It must be noted that due to the collapse risk of the material the dispersive test results should be read in conjunction with the soil parameters such as grading and Atterberg Limits.

Crumb Test

Three samples were tested in the crumb tests and the results indicated a low risk of dispersiveness.

Dynamic Cone Penetrometer Tests

The DCP tests indicated that the estimated safe bearing pressure at depth in excess of 500mm was in excess of 150kPa. The Use and Interpretation of the Dynamic Cone Penetrometer (Dcp) Test by P Paige-Green and L Du Plessis was used to determine the estimated safe bearing pressure from the DCP penetration rate. Note that the DCP penetration rate will change with any changes to the moisture content or density of the material tested.

5.2 Pump Station Position 2

Soil Profiles

The material encountered at the position for the pump station two generally consisted of transported silty sand. The moisture conditions were moist, the consistency soft becoming firm and the structures were intact.

Residual material was encountered at all trial pit positions and consisted of weathered sandstone. The moisture conditions were slightly moist, the consistency hard and the structure micro shattered.

No ground water seepage was recorded in any of the trial pits.

Excavation

Excavations were done by machine and the excavation depths were as follows:

- Pump Station 2 Trial Hole 1 Refusal @ 1100mm on sandstone plate
- Pump Station 2 Trial Hole 2 Refusal @ 660mm on sandstone plate
- Pump Station 2 Trial Hole 3 Refusal @ 400mm on sandstone plate
- Pump Station 2 Trial Hole 4 Refusal @ 300mm on sandstone plate
- Pump Station 2 Trial Hole 5 Refusal @ 960mm on sandstone plate
- Pump Station 2 Trial Hole 6 Refusal @ 1230mm on sandstone plate

Test Results

Road Indicator

Five (5) disturbed samples were taken to determine the suitability of the material to be used during construction.

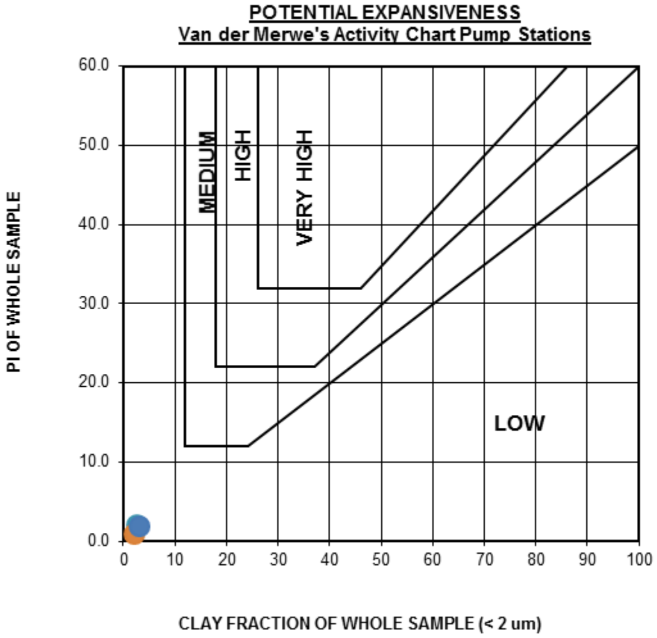
POSITION	DEPTH	DESCRIPTION	G. M.	L L (%)	P I (%)	L S (%)	MDD (kg/m3)	OMC (%)	C.B.R. @ 100%	C.B.R. @ 95 %	C.B.R. @ 90 %	SWELL (%)	TRH14 CLASS
PS 2 - TP 1	850 - 1100	dk R Br Ss + sty s	2.4	23	8	4.5	2124	8.3	81	40	20	0.40	G6
PS2 - TP 2	110 - 350	dk R Br weath Ss + sty s	2.52	CBD	SP	1.5	2061	9.0	76	36	17	0.10	G6
PS 2 - TP 5	600 - 960	lt R O Ss + cly s	2.5	28	15	7.5	2120	9.3	93	40	17	0.6	G6
PS2 - TP 6	580 - 1100	lt R O Ms + cly s	2.69	33	16	8.0	2074	9.7	69	29	13	0.50	G6
PS 2 - TP 6	1100 - 1230	lt R O Ms + cly s	2.4	23	11	5.5							

The material conformed to a G6 material classification indicating that material similar to the samples tested would be suitable for use as backfill or material required for platforms.

Foundation Indicator

Disturbed samples were tested to determine the risk associated with heave. The results indicated that there was a low potential risk for expansive material.

POSITION	DEPTH	DESCRIPTION	0.002 mm	LINEAR SHRINKAGE	PI WHOLE SAMPLE	POTENTIAL EXPANSIVENESS
PS2 - TP 1	850 - 1100	dk R Br Ss + sty s	3	4.5	2.0	LOW
PS2 - TP 5	600 - 960	lt R O Ss + cly s	3	7.5	2.0	LOW
PS2 - TP 6	1100 - 1230	lt R O Ms + cly s	2	5.5	1.0	LOW



The expansiveness of the horizons tested was evaluated using Van der Merwe's method of classification. The PI of the whole sample varied between 1 and 2 with the clay fraction (0.002mm sieve) varied between 2% and 3%.

Dynamic Cone Penetrometer Tests

The DCP tests indicated that the estimated safe bearing pressure at depth in excess of 500mm was in excess of 250kPa. The DCP tests recorded penetration refusals at all test positions. The Use and Interpretation of the Dynamic Cone Penetrometer (Dcp) Test by P Paige-Green and L Du Plessis was used to determine the estimated safe bearing pressure from the DCP penetration rate. Note that the DCP penetration rate will change with any changes to the moisture content or density of the material tested.

5.3 Pump Station Alternative Position

Soil Profiles

The material encountered at the position for the alternative pump station generally consisted of transported clayey or sandy silt. The moisture conditions were slightly moist, the consistency soft becoming firm and the structures varied between intact, slickensided and fissured.

Residual material was encountered at all trial pit positions and varied between sandstone and shale. The moisture conditions were slightly moist, the consistency extremely hard and the structure shattered.

Although no ground water seepage was recorded in any of the trial pits the fissured structure of the transported horizons were indicative of fluctuating water tables.

Excavation

Excavations were done by machine and the excavation depths were as follows:

➢ Pump Station 1	Trial Hole 1A	Refusal @ 2100mm on sandstone
➢ Pump Station 1	Trial Hole 2A	Refusal @ 1200mm on sandstone
➢ Pump Station 1	Trial Hole 3A	Refusal @ 3400mm on shale
➢ Pump Station 1	Trial Hole 4A	Refusal @ 2200mm on sandstone
➢ Pump Station 1	Trial Hole 5A	Refusal @ 1400mm on sandstone

Test Results

Road Indicator

Six (6) disturbed samples were taken to determine the suitability of the material to be used during construction.

POSITION	DEPTH	DESCRIPTION	G. M.	L L (%)	P I (%)	L S (%)	MDD (kg/m3)	OMC (%)	C.B.R. @ 100%	C.B.R. @ 95 %	C.B.R. @ 90 %	SWELL (%)	TRH14 CLASS
PS1/TP 1A	1700 - 2100	lt Br Ss + sty s	2.4	23	11	5.5	2140	8.2	58	27	13	0.20	G6
PS1/TP 2A	400 - 1000	Pale R sdy st	0.6	18	6	3.5	1922	10.8	30	14	7	0.40	G8
PS1/TP 2A	1000 - 1200	lt R Br Ss + sty s	2.3	25	12	6.5							
PS1/TP 3A	2800 - 3400	lt Br Ms + sty s	2.3	24	11	5.5	2154	7.7	75	30	12	0.70	G6
PS1/TP 4A	1800 - 2200	lt Br Ss + sty s	2.3	22	10	5.0							
PS1/TP 5A	1100 - 1400	lt Br Ss + sty s	2.2	24	9	4.5							

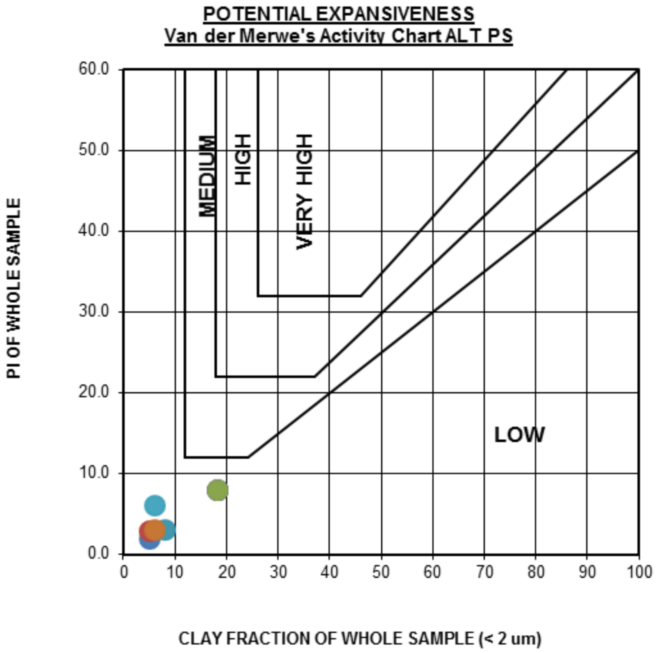
The material varied between a G8 and G6 material classification indicating that material similar to the samples tested would be suitable for use as backfill or material required for platforms.

Foundation Indicator

Disturbed samples were tested to determine the risk associated with heave. The results indicated that there was a low potential risk for expansive material.

POSITION	DEPTH	DESCRIPTION	0.002 mm	LINEAR SHRINKAGE	PI WHOLE SAMPLE	POTENTIAL EXPANSIVENESS
PS 1/TP 1	1600	dk R Br sdy st	18	4	8.0	LOW
PS1/TP 1A	1700 - 2100	lt Br Ss + sty s	5	5.5	3.0	LOW
PS1/TP 2A	400 - 1000	Pale R sdy st	6	3.5	6.0	LOW
PS1/TP 2A	1000 - 1200	lt R Br Ss + sty s	8	6.5	3.0	LOW
PS1/TP 3A	2800 - 3400	lt Br Ms + sty s	5	5.5	2.0	LOW
PS1/TP 4A	1800 - 2200	lt Br Ss + sty s	5	5.0	3.0	LOW
PS1/TP 5A	1100 - 1400	lt Br Ss + sty s	6	4.5	3.0	LOW

The expansiveness of the horizons tested was evaluated using Van der Merwe's method of classification. The PI of the whole sample varied between 2 and 8 with the clay fraction (0.002mm sieve) varied between 5% and 18%.



Tri-axial and Consolidation Tests

One (1) undisturbed sample was taken of the sandy silt horizons to determine the apparent cohesion, internal angle of friction and risk of consolidation.

The tri-axial test indicated that the apparent cohesion 60kPa with the corresponding internal angle of friction 24˚.

The consolidation tests indicated a high risk with regards to collapse / settlement and care must be taken in the platform and foundation design for the pump station.

POSITION	PS1(ALT)-TH1
DEPTH	1.6m
SAMPLE DESCRIPTION	dk R Br sdy st
COLLAPSE	9.79%

Pinhole Test

Three (3) samples were tested according the ASTM D4221-90 test method to determine the dispersive grade classification of the soils. The results indicated the grade of dispersiveness varied between D1 and D2.

Crumb Test

Three samples were tested in the crumb tests and the results indicated a low risk of dispersiveness.

Dynamic Cone Penetrometer Tests

The DCP tests indicated that the estimated safe bearing pressure at depth in excess of 500mm was in excess of 130kPa. The Use and Interpretation of the Dynamic Cone Penetrometer (Dcp) Test by P Paige-Green and L Du Plessis was used to determine the estimated safe bearing pressure from the DCP penetration rate. Note that the DCP penetration rate will change with any changes to the moisture content or density of the material tested.

5.4 Reservoir Position

Soil Profiles

The material encountered at the position for the reservoir generally consisted of transported silty or clayey sand. The moisture conditions were moist, the consistency soft becoming firm and the structures varied between intact and slickensided.

Residual material was encountered at all trial pit positions and varied between sandstone, mudstone and shale. The moisture conditions were moist, the consistency hard and the structure shattered.

No water seepage was recorded in any of the trial pit positions.

Excavation

Excavations were done by machine and the excavation depths were as follows:

➢ Reservoir	Trial Hole 1	No refusal @ 3000mm
➢ Reservoir	Trial Hole 2	No refusal @ 3000mm
➢ Reservoir	Trial Hole 3	No refusal @ 3100mm
➢ Reservoir	Trial Hole 4	Refusal @ 2500mm on sandstone
➢ Reservoir	Trial Hole 5	Refusal @ 2400mm on sandstone
➢ Reservoir	Trial Hole 6	Refusal @ 2400mm on sandstone

Test Results

Road Indicator

Seven (7) disturbed samples were taken to determine the suitability of the material to be used during construction.

POSITION	DEPTH	DESCRIPTION	G. M.	L L (%)	P I (%)	L S (%)	MDD (kg/m3)	OMC (%)	C.B.R. @ 100%	C.B.R. @ 95 %	C.B.R. @ 90 %	SWELL (%)	TRH14 CLASS
RES - TP 1	300 - 1600	dk R Br Sh + sty s	2.55	28	9	4.5	2020	11.8	61	41	19	0.40	G6
RES - TP 1	2500 - 3000	Pale R Sh + sty s	2.4	30	8	4.5							
RES - TP 2	560- 3000	Pale R Sh + sty s	2.4	33	9	4.5	1905	12.9	55	42	33	0.30	G6
RES - TP 3	180 - 3100	Pale R Sh + cly s	2.7	35	11	5.5	2031	12.1	75	43	21	0.60	G6
RES - TP 4	800 - 2500	Pale R Sh + cly s	2.6	33	14	6.5	1997	13.8	62	41	27	0.70	G6
RES - TP 5	1100 - 2400	Pale R Ss + cly s	2.2	42	10	5.0							
RES - TP 6	1050 - 2400	Pale R Sh + cly s	2.3	31	15	7.0	1980	11.4	74	31	13	0.40	G6

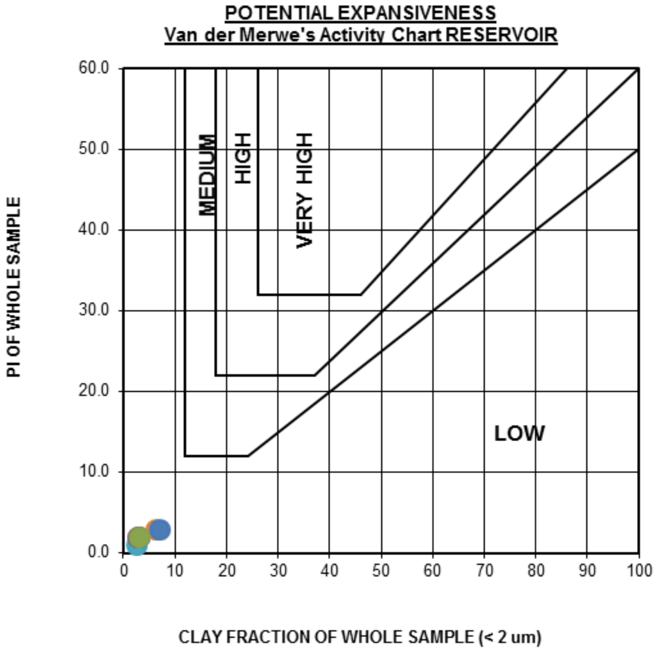
The material conformed to G6 material classification indicating that material similar to the samples tested would be suitable for use as backfill or material required for platforms.

Foundation Indicator

Disturbed samples were tested to determine the risk associated with heave. The results indicated that there was a low potential risk for expansive material.

POSITION	DEPTH	DESCRIPTION	0.002 mm	LINEAR SHRINKAGE	PI WHOLE SAMPLE	POTENTIAL EXPANSIVENESS
RES - TP 1	2500 - 3000	Pale R Sh + sty s	3	4.5	2.0	LOW
RES - TP 2	560- 3000	Pale R Sh + sty s	3	4.5	2.0	LOW
RES - TP 3	180 - 3100	Pale R Sh + cly s	3	5.5	1.0	LOW
RES - TP 4	800 - 2500	Pale R Sh + cly s	3	6.5	2.0	LOW
RES - TP 5	1100 - 2400	Pale R Ss + cly s	7	5.0	3.0	LOW
RES - TP 6	1050 - 2400	Pale R Sh + cly s	6	7.0	3.0	LOW

The expansiveness of the horizons tested was evaluated using Van der Merwe's method of classification. The PI of the whole sample varied between 1 and 3 with the clay fraction (0.002mm sieve) varied between 3% and 7%.



Tri-axial and Consolidation Tests

One (1) undisturbed sample was taken of the clayey horizons to determine the apparent cohesion, internal angle of friction and risk of consolidation.

The tri-axial test indicated that the apparent cohesion 40kPa with the corresponding internal angle of friction 16˚.

The consolidation tests indicated a high risk with regards to free swell.

POSITION	RES-TH5
DEPTH	300-1100mm
SAMPLE DESCRIPTION	dk G cl
SWELL	4.05%

Dynamic Cone Penetrometer Tests

The DCP tests indicated that the estimated safe bearing pressure at depth in excess of 500mm was in excess of 130kPa. DCP penetration refusals were recorded in the residual horizons at all six test position. The Use and Interpretation of the Dynamic Cone Penetrometer (Dcp) Test by P Paige-Green and L Du Plessis was used to determine the estimated safe bearing pressure from the DCP penetration rate. Note that the DCP penetration rate will change with any changes to the moisture content or density of the material tested.

5.5 Alternative Reservoir Position

Soil Profiles

The material encountered at the position for the alternative reservoir generally consisted of transported sandy silt. The moisture conditions were moist, the consistency soft and the structures were intact. At one trial pit (Res-TP8A) a second transported horizon consisting of clayey silt with ferricrete nodules were profiled.

Residual material was encountered at all trial pit positions consisted of sandstone. The moisture conditions were slightly moist, the consistency hard and the structure shattered.

No water seepage was recorded in any of the trial pit positions. However the horizon of ferricrete nodules within the clayey silt was an indication of fluctuating water tables.

Excavation

Excavations were done by machine and the excavation depths were as follows:

➢	Reservoir	Trial Hole 6A	Refusal @ 1250mm on sandstone
➢	Reservoir	Trial Hole 7A	Refusal @ 900mm on sandstone
➢	Reservoir	Trial Hole 8A	Refusal @ 880mm on sandstone
➢	Reservoir	Trial Hole 9A	Refusal @ 1500mm on sandstone

Test Results

Road Indicator

Four (4) disturbed samples were taken to determine the suitability of the material to be used during construction.

POSITION	DEPTH	DESCRIPTION	G. M.	L L (%)	P I (%)	L S (%)	MDD (kg/m3)	OMC (%)	C.B.R. @ 100%	C.B.R. @ 95 %	C.B.R. @ 90 %	SWELL (%)	TRH14 CLASS
RES/TP 6A	900 - 1250	lt Br Ss + sty s	2.4	18	5	2.5							
RES/TP 7A	700 - 900	lt Br Ss + cly s	2.3	30	14	6.5							
RES/TP 8A	700 - 880	lt Br Ss + cly s	2.3	30	14	6.0	2138	7.2	62	30	13	0.50	G6
RES/TP 9A	500 - 1500	lt Br. Ss + sty s	2.2	24	11	5.0							

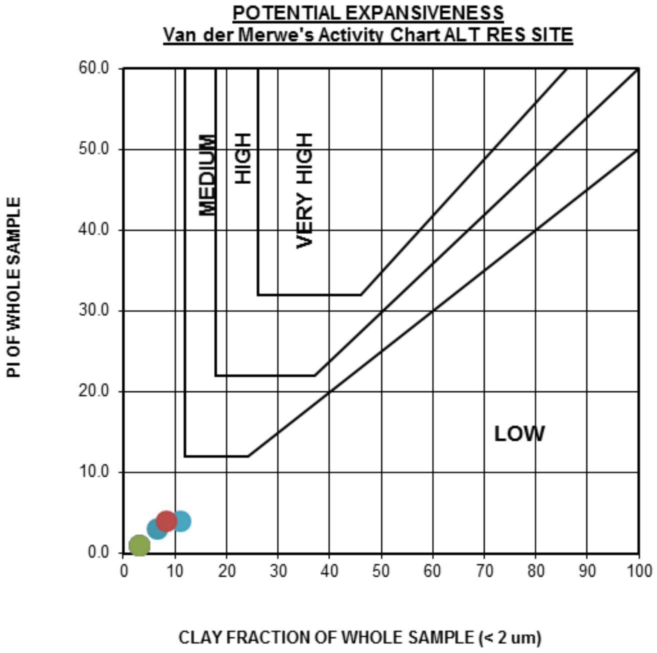
The material conformed to G6 material classification indicating that material similar to the samples tested would be suitable for use as backfill or material required for platforms.

Foundation Indicator

Disturbed samples were tested to determine the risk associated with heave. The results indicated that there was a low potential risk for expansive material.

POSITION	DEPTH	DESCRIPTION	0.002 mm	LINEAR SHRINKAGE	PI WHOLE SAMPLE	POTENTIAL EXPANSIVENESS
RES/TP 6A	900 – 1250	lt Br Ss + sty s	3	2.5	1.0	LOW
RES/TP 7A	700 – 900	lt Br Ss + sty s	8	6.5	4.0	LOW
RES/TP 8A	700 – 880	lt Br Ss + sty s	11	6.0	4.0	LOW
RES/TP 9A	500 - 1500	lt Br Ss + sty s	7	5.0	3.0	LOW

The expansiveness of the horizons tested was evaluated using Van der Merwe's method of classification. The PI of the whole sample varied between 1 and 4 with the clay fraction (0.002mm sieve) varied between 3% and 11%.



Dynamic Cone Penetrometer Tests

The DCP tests indicated that the estimated safe bearing pressure at depth in excess of 500mm was in excess of 200kPa. DCP penetration refusals were recorded in the residual horizons at all test position. The Use and Interpretation of the Dynamic Cone Penetrometer (Dcp) Test by P Paige-Green and L Du Plessis was used to determine the estimated safe bearing pressure from the DCP penetration rate. Note that the DCP penetration rate will change with any changes to the moisture content or density of the material tested.

5.6 Main Pipeline

Soil Profiles

The material along the pipeline route varied. The transported material was generally sandy or silty material. The residual material varied between sandstone, mudstone and shale. At section the excavations indicated that plated sandstone was encountered close to the surface.

Excavation

The excavations were done by means of TLB and the various excavation depths are given below. Based on the excavation depths it can be noted that the sections between trial holes 2 and 29 had shallow excavation depths (less than 1100mm) with the remainder of the pipeline varying between 400mm and 3000mm.

Main Pipeline	Trial Hole 01	No refusal 3100mm
Main Pipeline	Trial Hole 02	Refusal @ 800mm on sandstone
Main Pipeline	Trial Hole 03	Refusal @ 2000mm on mudstone
Main Pipeline	Trial Hole 04	Refusal @ 830mm on sandstone
Main Pipeline	Trial Hole 05	Refusal @ 1000mm on sandstone
Main Pipeline	Trial Hole 06	Refusal @ 280mm on sandstone plate
Main Pipeline	Trial Hole 07	Refusal @ 600mm on sandstone
Main Pipeline	Trial Hole 08	Refusal @ 700mm on sandstone plate
Main Pipeline	Trial Hole 09	Refusal @ 210mm on sandstone plate
Main Pipeline	Trial Hole 10	Refusal @ 1300mm on sandstone
Main Pipeline	Trial Hole 11	Refusal @ 400mm on sandstone plate
Main Pipeline	Trial Hole 12	Refusal @ 1100mm on decomposed
Main Pipeline	Trial Hole 13	Refusal @ 300mm on sandstone plate
Main Pipeline	Trial Hole 14	No refusal @ 3000mm
Main Pipeline	Trial Hole 15	Refusal @ 650mm on sandstone
Main Pipeline	Trial Hole 16	Refusal @ 570mm on sandstone
Main Pipeline	Trial Hole 17	Refusal @ 500mm on sandstone plate
Main Pipeline	Trial Hole 18	Refusal @ 450mm on sandstone plate
Main Pipeline	Trial Hole 19	Refusal @ 800mm on sandstone plate
Main Pipeline	Trial Hole 20	Refusal @ 440mm on sandstone plate
Main Pipeline	Trial Hole 21	Refusal @ 1340mm on sandstone
Main Pipeline	Trial Hole 22	Refusal @ 920mm on sandstone
Main Pipeline	Trial Hole 23	Refusal @ 580mm on sandstone
Main Pipeline	Trial Hole 24	Refusal @ 520mm on sandstone plate
Main Pipeline	Trial Hole 25	Refusal @ 670mm on sandstone plate
Main Pipeline	Trial Hole 26	Refusal @ 1100mm on sandstone plate
Main Pipeline	Trial Hole 27	Refusal @ 800mm on mudstone
Main Pipeline	Trial Hole 28	Refusal @ 1100mm on sandstone
Main Pipeline	Trial Hole 29	Refusal @ 1100mm on dec dolerite
Main Pipeline	Trial Hole 30	Refusal @ 2000mm on sandstone
Main Pipeline	Trial Hole 31	No refusal @ 3000mm
Main Pipeline	Trial Hole 32	Refusal @ 620mm on sandstone plate
Main Pipeline	Trial Hole 33	No refusal @ 3000mm
Main Pipeline	Trial Hole 34	Refusal @ 1240mm on sandstone
Main Pipeline	Trial Hole 35	No refusal @ 3000mm
Main Pipeline	Trial Hole 36	Refusal @ 1900mm on sandstone
Main Pipeline	Trial Hole 37	Refusal @ 400mm on sandstone plate
Main Pipeline	Trial Hole 37	No refusal @ 3000mm
Main Pipeline	Trial Hole 38	No refusal @ 3000mm

- Main Pipeline Trial Hole 40 Refusal @ 2500mm on sandstone
- Main Pipeline Trial Hole 41 Refusal @ 2300mm on dec dolerite
- Main Pipeline Trial Hole 42 Refusal @ 1300mm on sandstone
- Main Pipeline Trial Hole 43 Refusal @ 1200mm on sandstone
- Main Pipeline Trial Hole 44 Refusal @ 2300mm on sandstone
- Main Pipeline Trial Hole 45 Refusal @ 410mm on sandstone plate
- Main Pipeline Trial Hole 46 No refusal @ 2800mm

Depending on the required excavation depth for the pipeline allowance should be made for intermediate to hard excavations.

Test Results

Compactability Indicator

Disturbed samples were taken from the various trial pits. The material was tested to determine the suitability to be used during construction as backfill or bedding.

POSITION	DEPTH	DESCRIPTION	G. M.	L L (%)	P I (%)	L S (%)	COMPACTIBILITY
TP 01	0 - 600	dk Y O sty s	0.71	CBD	NP	0.0	0.18
TP 02	0 - 550	dk R sty s	0.83	20	6	2.5	0.16
TP 04	0 - 300	lt Br sty s	1.02	CBD	NP	0.0	0.18
TP 05	0 - 400	dk R sty s	0.77	CBD	NP	0.0	0.14
TP 07	0 - 200	lt Br sty s	0.85	CBD	NP	0.0	0.14
TP 08	0 - 500	lt Br sty s	0.75	CBD	NP	0.0	0.14
TP 09	0 - 200	lt Br sty s	0.81	CBD	NP	0.0	0.14
TP 10	0 - 460	dk R O sty s	0.71	CBD	NP	0.0	0.18
TP 14	0 - 1150	dk R O sty s	0.65	CBD	NP	0.0	0.18
TP 15	0 - 230	dk R Br sty s	0.78	CBD	NP	0.0	0.21
TP 17	0 - 500	dk R O sty s	0.73	CBD	SP	1.0	0.18
TP 18	0 - 450	dk R O sty s	0.60	CBD	NP	0.0	0.22
TP 21	0 - 400	dk R O sty s	0.86	CBD	SP	1.0	0.21
TP 22	0- 600	dk G sty s	0.63	CBD	SP	0.5	0.20
TP 25	270 - 430	dk Br sty s	0.99	CBD	SP	1.5	0.22
TP 28	140 - 600	dk R O sty st	0.62	CBD	SP	0.5	0.2
TP 29	220 - 500	dk R Br sty s	0.68	CBD	SP	1.5	0.19
TP 30	0 - 600	dk G sty s	0.70	CBD	NP	0.0	0.22
TP 30	600 - 1400	lt Br sty s	0.71	CBD	NP	0.0	0.16
TP 31	250 - 1900	lt Br sdy cl	0.44	39	21	10.5	0.22
TP 32	0 - 620	lt Br sty s	0.79	CBD	NP	0.0	0.22
TP 33	100 - 500	dk G sty s	0.59	CBD	NP	0.0	0.16
TP 33	500 - 1200	lt Br sty s	0.57	CBD	NP	0.0	0.20
TP 34	0 - 900	lt Br sty s	0.71	CBD	NP	0.0	0.14
TP 35	350 - 1200	lt Br sty s	0.58	CBD	NP	0.0	0.18

TP 37	0 - 200	lt Br sty s	0.62	CBD	NP	0.0	0.20
TP 38	0 - 400	lt R sty s	0.42	CBD	NP	0.0	0.22
TP 39	0 - 650	lt R sdy st	0.30	24	10	5.0	0.20
TP 40	0 - 800	dk G sdy st	0.52	CBD	SP	1.5	0.22
TP 42	0 - 300	dk R Br sdy st	0.64	CBD	SP	1.5	0.22
TP 43	0 - 750	dk Br sdy st	0.64	CBD	SP	1.0	0.25
TP 44	0 - 650	dk Br sty s	0.61	CBD	SP	1.0	0.21
TP 45	0 - 390	dk Br sdy st	0.52	20	6	2.5	0.21
TP 46	0 - 700	dk Br sdy st	0.46	27	8	4.0	0.18

When analyzing the results in accordance to SABS1200 LB: Pipe (Bedding) the following notes can be made:

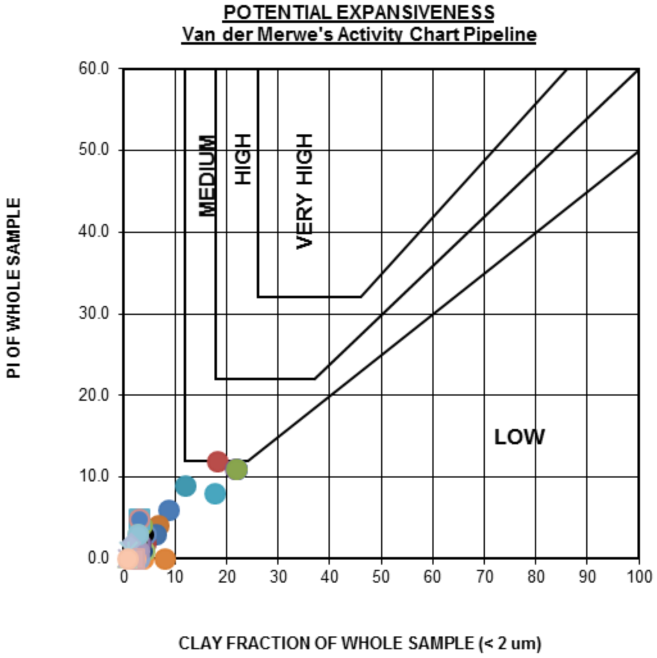
- The SABS specify that the compactibility factor maximum is 0.4 – all material conformed to the requirement.
- The SABS specify that bedding shall be non-cohesive material that falls within the 0.6mm to 19.0mm grading envelope – most material conformed to the requirement.
- The SABS specify that fill material must have a PI less than 10 and that all particle sizes be smaller than 30mm – most material conformed to the requirement.

Foundation Indicator

Foundation indicator tests were done to determine the risk of heave. The results indicated that there was generally a low risk with regards to heave with the only areas with some clayey material at TP31 and TP35.

POSITION	DEPTH	DESCRIPTION	0.002 mm	LINEAR SHRINKAGE	PI WHOLE SAMPLE	POTENTIAL EXPANSIVENESS
PIPELINE						
TP 01	1600 - 3100	dk O sty s	8	1.5	0.0	LOW
TP 02	550 - 800	Pale R Ss + cly s	3	5.5	2.0	LOW
TP 03	0 - 2000	dk R high weath Ms + cly s	7	8.5	4.0	LOW
TP 04	400 - 1000	dk R O Ss + sty s	1	3.0	1.0	LOW
TP 07	400 - 600	lt Br Ss + sty s	4	2.5	1.0	LOW
TP 10	1000 - 1300	lt R Br Ss + cly s	3	5.5	5.0	LOW
TP 11	200 - 400	dk R high weath Ss + cly s	4	6.0	2.0	LOW
TP 12	200 - 1100	dk R Br dec Dol + cly s	4	12.0	3.0	LOW
TP 13	120 - 300	lt Br Ss + sty s	1	1.5	0.0	LOW
TP 14	2300 - 3000	lt R Br high weath Ss + sty s	12	5.0	9.0	LOW
TP 15	230 - 680	dk R O Ss	1	1.0	0.0	LOW
TP 16	250 - 570	dk R O Ss	1	1.0	0.0	LOW
TP 19	430 - 800	dk Br Ss	2	1.5	0.0	LOW

POSITION	DEPTH	DESCRIPTION	0.002 mm	LINEAR SHRINKAGE	PI WHOLE SAMPLE	POTENTIAL EXPANSIVENESS
TP 20	120 - 440	Pale R Ss	1	1.5	0.0	LOW
TP 21	400 - 1340	dk R O Ss	1	1.0	0.0	LOW
TP 22	600 - 920	lt R Br Ss	2	4.5	2.0	LOW
TP 23	130 - 550	dk R Br Ss	1	4.0	1.0	LOW
TP 24	300 - 520	lt Ol Ss	1	1.0	0.0	LOW
TP 25	430 - 670	Pale R Sh + cly s	3	6.0	3.0	LOW
TP 26	120 - 1100	lt R Br Ss	1	1.0	0.0	LOW
TP 27	600 - 800	Pale R Ms	1	6.0	1.0	LOW
TP 28	140 - 660	lt R O Ss	1	1.5	0.0	LOW
TP 29	500 - 1100	lt R O dec Dol + sty cl	1	7.5	1.0	LOW
TP 30	1840 - 2000	lt R Br Ss	3	4.0	3.0	LOW
TP 31	1900 - 3000	dk Y O high weath Ss + cly s	18	5.5	12.0	MED
TP 33	2000 - 3000	Pale R Ss + sdy st	9	4.5	6.0	LOW
TP 34	900 - 1240	lt R Br Ss + sand	2	1.0	0.0	LOW
TP 35	1900 - 3000	lt R Br cly s	22	6.5	11.0	LOW
TP 36	1400 - 1900	lt Br Ss + sty s	3	1.0	0.0	LOW
TP 37	200 - 400	lt R Br Ss	1	1.0	0.0	LOW
TP 38	400 - 3000	lt R O Ss + sty s	18	4.5	8.0	LOW
TP 39	650 - 3000	lt R O dec Dol + sty s	1	1.5	0.0	LOW
TP 41	250 - 2300	dk R Br dec Dol + cly s	1	7.5	1.0	LOW
TP 42	300 - 1300	dk R O Ss + cly s	6	7.5	3.0	LOW
TP 43	750 - 1200	lt Br Ss + sty s	3	1.5	1.0	LOW
TP 44	650 - 2300	dk Y Ss + sty s	4	4.5	4.0	LOW
TP 45	390 - 410	lt Br Ss + sty s	4	1.0	0.0	LOW
TP 46	700 - 2800	Pale R Ss + cly s	3	5.5	2.0	LOW



Dynamic Cone Penetrometer Tests

Dynamic Cone Penetrometer tests were performed adjacent to the trial pit positions. At most test positions the DCP recorded refusal on or within the residual material.

Soil Resistivity Tests

At various positions along the pipeline route soil resistivity and corrosiveness tests were performed to assist in deciding the material to be considered for the pipeline.

Along the route the values varied with the section between the start and approximately test position 42 ranging between moderate and mildly corrosive. The section between test position 42 until the end had more values in the moderate to severe range.

RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

TEST POSITION	DESCRIPTION	SOIL CONDITION:	WEATHER COND:	GPS CO-ORD:	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
SR01	lt Br sty s	SLIGHTLY MOIST	COOL, SUNNY	S 32°02'07.7" E 27°49'36.7"	3.29	62.02
SR02	lt Br sty s	DRY	HOT	S 32°02'11.5" E 27°49'44.7"	7.62	143.60
SR03	lt Br sty s	DRY	HOT	S 32°02'18.5" E 27°49'49.6"	7.86	148.16
SR05	lt Br sty s	DRY	VERY HOT	S 32°02'29.2" E 27°50'00.9"	4.80	90.48
SR06	lt Br sty s	DRY	VERY HOT	S 32°02'34.8" E 27°50'07.5"	15.96	300.84
SR07	lt Br sty s	SLIGHTLY MOIST	COLD	S 32°02'40.3" E 27°50'14.8"	13.80	260.12
SR09	lt Br sty s	SLIGHTLY MOIST	COLD	S 32°02'39.4" E 27°50'33.0"	13.00	245.04
SR10	lt Br sty s	SLIGHTLY MOIST	COLD	S 32°02'38.7" E 27°50'42.4"	4.20	79.17
SR11	lt Br sty s	SLIGHTLY MOIST	COOL	S 32°02'38.1" E 27°50'52.0"	17.60	331.75
SR12	lt Br sty s	SLIGHTLY MOIST	COOL	S 32°02'36.0" E 27°50'59.4"	7.60	143.26
SR13	lt Br sty s	DRY	WARM	S 32°02'35.8" E 27°51'08.9"	11.60	218.65
SR14	lt Br sty s	DRY	HOT	S 32°02'36.0" E 27°51'18.2"	11.40	214.88
SR18	lt Br sty s	DRY	HOT	S 32°02'55.3" E 27°51'32.9"	12.40	233.73
SR19	lt Br sty s	DRY	VERY HOT	S 32°03'00.2" E 27°51'37.5"	19.20	361.91
SR20	lt Br sty s	DRY	VERY HOT	S 32°03'04.8" E 27°51'45.1"	8.20	154.57
SR21	lt Y Br sty s	DRY	VERY HOT	S 32°03'09.5" E 27°51'53.0"	4.57	86.07
SR22	lt Br sty s	MOIST	COLD	S 32°03'15.2" E 27°51'59.4"	12.60	237.50
SR23	lt Br sty s	MOIST	COLD	S 32°03'18.6" E 27°52'07.0"	4.40	82.94
SR24	lt Br sty s	MOIST	COOL	S 32°03'19.1" E 27°52'16.4"	16.00	301.59
SR25	lt Y Br sty s	MOIST	COOL	S 32°03'21.1" E 27°52'25.7"	9.60	180.96
SR26	lt Br sty s	MOIST	COOL	S 32°03'22.6" E 27°52'35.1"	3.80	71.63
SR28	lt Br sty s	MOIST	COOL	S 32°03'25.8" E 27°52'54.0"	3.86	72.83
SR29	lt Br sty s	MOIST	COOL	S 32°03'27.6" E 27°53'03.3"	3.80	71.63
SR30	lt Br sty s	MOIST	COOL	S 32°03'30.3" E 27°53'12.7"	10.60	199.81
SR31	lt Br sty s	MOIST	COLD	S 32°03'32.7" E 27°53'21.5"	7.39	139.37
SR32	lt Br sty s	SLIGHTLY MOIST	COLD	S 32°03'35.4" E 27°53'31.0"	3.80	71.63
SR35	lt Br sty s + dec Dol	SLIGHTLY MOIST	COLD	S 32°03'44.2" E 27°53'56.6"	11.25	212.00
SR36	lt Br sty s + dec Dol	SLIGHTLY MOIST	COLD	S 32°03'47.2" E 27°54'05.4"	8.57	161.50
SR37	lt Br dec Dol	SLIGHTLY MOIST	VERY COLD	S 32°03'50.3" E 27°54'14.3"	6.91	130.30
SR38	lt Br dec Dol	SLIGHTLY MOIST	VERY COLD	S 32°03'53.9" E 27°54'22.7"	13.69	258.10
SR39	lt Br dec Dol	SLIGHTLY MOIST	VERY COLD	S 32°04'00.6" E 27°54'28.4"	14.32	269.90
SR40	lt Br sty s	SLIGHTLY MOIST	VERY COLD	S 32°04'07.0" E 27°54'33.9"	10.02	188.90
SR42	lt Br dec Dol	SLIGHTLY MOIST	VERY COLD	S 32°04'20.7" E 27°54'45.9"	11.12	209.50
SR43	lt Y Br dec Dol	SLIGHTLY MOIST	COLD	S 32°04'27.0" E 27°54'51.3"	0.68	12.90
SR44	lt Br sty s	SLIGHTLY MOIST	COLD	S 32°04'33.5" E 27°54'56.8"	6.61	124.60
SR45	lt Br sty s	SLIGHTLY MOIST	VERY COLD	S32° 04' 39.9" E27° 55' 02.7"	5.33	100.43
SR46	lt Br sty s	SLIGHTLY MOIST	VERY COLD	S32° 04' 46.2" E27° 55' 08.5"	1.00	18.89
SR47	lt Br dec Dol	SLIGHTLY MOIST	VERY COLD	S32° 04' 52.9" E27° 55' 12.9"	10.27	193.62
SR48	lt Br dec Dol	SLIGHTLY MOIST	VERY COLD	S32° 05' 00.5" E27° 55' 16.4"	1.84	34.65
SR49	lt Br sty s	SLIGHTLY MOIST	VERY COLD	S32° 05' 08.0" E27° 55' 19.8"	0.73	13.76
SR50	lt Br sty s	SLIGHTLY MOIST	VERY COLD	S32° 05' 15.4" E27° 55' 23.2"	6.71	126.44
SR52	lt Br sty s	SLIGHTLY MOIST	COLD	S32° 05' 29.3" E27° 55' 30.7"	4.76	89.72
SR53	lt Br sty s	SLIGHTLY MOIST	VERY COLD	S32° 05' 36.9" E27° 55' 35.2"	2.30	43.39
SR54	lt Br sty s	SLIGHTLY MOIST	VERY COLD	S32° 05' 36.1" E27° 55' 44.3"	2.52	47.46
SR55	lt Br sty s	SLIGHTLY MOIST	VERY COLD/WINDY	S32° 05' 34.7" E27° 55' 54.0"	3.83	72.12
SR57	lt Br sty s	SLIGHTLY MOIST	VERY COLD/WINDY	S32° 05' 26.9" E27° 56' 09.6"	2.30	43.35
SR58	lt Br sty s + Ms	SLIGHTLY MOIST	VERY COLD/WINDY	S32° 05' 22.3" E27° 56' 17.7"	32.20	606.96
SR59	lt Br sty s	SLIGHTLY MOIST	VERY COLD/WINDY	S32° 05' 22.0" E27° 56' 27.0"	8.00	150.80
SR60	lt Br sty s	SLIGHTLY MOIST	VERY COLD/WINDY	S32° 05' 21.9" E27° 56' 36.9"	6.40	120.64
SR61	lt Br sty s	SLIGHTLY MOIST	VERY COLD/WINDY	S32° 05' 17.5" E27° 56' 43.1"	3.02	56.93
SR62	lt Br sty s	SLIGHTLY MOIST	VERY COLD/WINDY	S32° 05' 10.7" E27° 56' 47.8"	6.80	128.18
SR63	lt Br sty s	SLIGHTLY MOIST	VERY COLD/WINDY	S32° 05' 03.6" E27° 56' 52.4"	10.80	203.58
SR64	lt Br sty s	SLIGHTLY MOIST	VERY COLD/WINDY	S32° 04' 57.8" E27° 56' 56.3"	8.40	158.34
SR65	lt Br sty s	SLIGHTLY MOIST	VERY COLD/WINDY	S32° 05' 37.2" E27° 56' 03.4"	4.63	87.31
SR66	lt Br sty s	SLIGHTLY MOIST	VERY COLD/WINDY	S32° 05' 44.8" E27° 56' 03.6"	2.87	54.06
SR67	lt Br sty s	SLIGHTLY MOIST	VERY COLD/WINDY	S32° 05' 52.7" E27° 56' 03.8"	3.85	72.57
SR68	lt Br sty s	SLIGHTLY MOIST	VERY COLD/WINDY	S32° 05' 32.2" E27° 56' 12.9"	4.11	77.43

5.7 Alternative Pipeline

Soil Profiles

The material along the pipeline route varied. The transported material was generally silty sand and the residual material sandstone.

Excavation

Excavations were all machine (TLB) excavated and refusals were all less than 1400mm.

➢	AR	Trial Hole 01	Refusal @ 750mm on sandstone
➢	AR	Trial Hole 02	Refusal @ 1800mm on mudstone
➢	AR	Trial Hole 03	Refusal @ 750mm on sandstone
➢	AR	Trial Hole 04	Refusal @ 1000mm on sandstone
➢	AR	Trial Hole 05	Refusal @ 1100mm on sandstone
➢	AR	Trial Hole 06	Refusal @ 1300mm on sandstone
➢	AR	Trial Hole 07	Refusal @ 500mm on sandstone
➢	AR	Trial Hole 08	No trial pit, position within cemetery
➢	AR	Trial Hole 09	Refusal @ 1200mm on sandstone plate
➢	AR	Trial Hole 10	Refusal @ 740mm on sandstone plate
➢	AR	Trial Hole 11	Refusal @ 1400mm on sandstone
➢	AR	Trial Hole 12	No refusal @ 3000mm
➢	AR	Trial Hole 13	Refusal @ 1160mm on sandstone plate

Test Results

Compactability Indicator

Disturbed samples were taken from the various trial pits. The material was tested to determine the suitability to be used during construction as backfill or bedding.

POSITION	DEPTH	DESCRIPTION	G. M.	L L (%)	P I (%)	L S (%)	COMPACTIBILITY
AR TP 1	0 - 500	dk R Br sdy st	0.72	CBD	SP	1.0	0.24
AR TP 10	0 - 500	dk R Br sdy st	0.71	CBD	SP	1.0	0.18
AR TP 11	0 - 320	dk Br sty s	0.71	CBD	SP	1.0	0.14
AR TP 11	320 - 1270	dk Br sdy st	0.62	20	7	3.5	0.16
AR TP 12	0 - 500	dk R Br sdy st	0.79	CBD	NP	0.0	0.16
AR TP 12	500 - 800	dk Br cly s	0.44	33	13	7.0	0.18
AR TP 13	0 - 480	dk R sdy st	0.78	CBD	NP	0.0	0.16
AR TP 2	0 - 200	dk R Br sty s	0.77	CBD	SP	1.0	0.21
AR TP 4	0 - 260	dk R Br sty s	0.78	CBD	NP	0.0	0.14
AR TP 6	0 - 250	dk R Br sdy st	0.80	CBD	NP	0.0	0.16
AR TP 9	0 - 300	dk R Br sdy st	0.82	CBD	NP	0.0	0.14

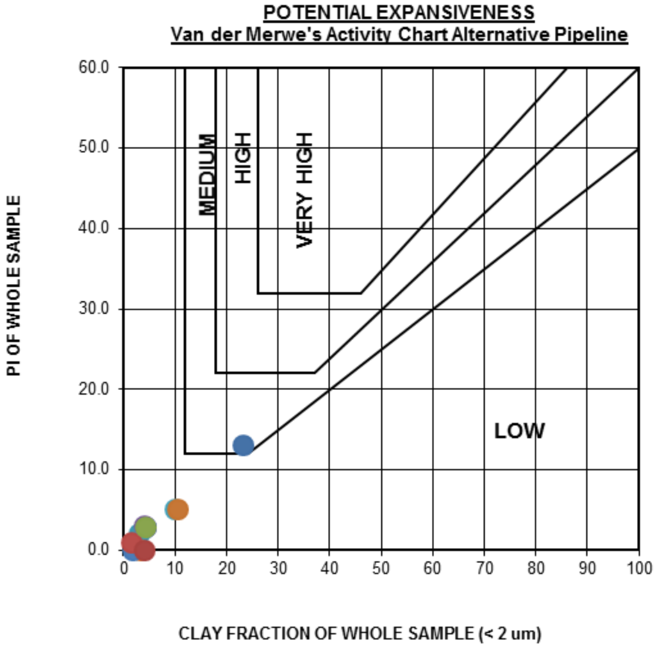
When analyzing the results in accordance to SABS1200 LB: Pipe (Bedding) the following notes can be made:

- The SABS specify that the compactibility factor maximum is 0.4 – all material conformed to the requirement.
- The SABS specify that bedding shall be non-cohesive material that falls within the 0.6mm to 19.0mm grading envelope – most material conformed to the requirement.
- The SABS specify that fill material must have a PI less than 10 and that all particle sizes be smaller than 30mm – most material conformed to the requirement.

Foundation Indicator

Foundation indicator tests were done to determine the risk of heave. The results indicated that there was generally a low risk with regards to heave with the only exception the material at AR-TP12 that indicated a medium risk and high clay content.

POSITION	DEPTH	DESCRIPTION	0.002 mm	LINEAR SHRINKAGE	PI WHOLE SAMPLE	POTENTIAL EXPANSIVENESS
AR TP 02	300 - 1800	Pale R Ms + cly s	4	5.5	3.0	LOW
AR TP 03	180 - 750	dk Y O Ss + sty s	2	2.5	1.0	LOW
AR TP 04	500 - 1000	dk Y O Ss + sdy st	10	4.5	5.0	LOW
AR TP 05	700 - 1100	lt R Br Ss + sty s	3	3.5	2.0	LOW
AR TP 06	1000 - 1300	lt R Br Ss + sty s	2	0.0	0.0	LOW
AR TP 10	700 - 740	lt Br Ss	3	1.5	0.0	LOW
AR TP 11	1270 - 1400	dk Br Sh/Ss + cly s	11	6.5	5.0	LOW
AR TP 12	1400 - 3000	dk Br cly s	23	6.5	13.0	MED
AR TP 13	930 - 1160	lt Br Ss + sty s	4	1.0	0.0	LOW



Dynamic Cone Penetrometer Tests

Dynamic Cone Penetrometer tests were performed adjacent to the trial pit positions. At all test positions the DCP recorded refusal on or within the residual material.

Soil Resistivity

At various positions along the pipeline route soil resistivity and corrosiveness tests were performed to assist in deciding the material to be considered for the pipeline.

At two test positions the material was severely corrosive (AR-SR15 and AR-SR16).

RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

TEST POSITION	DESCRIPTION	SOIL CONDITION:	WEATHER COND:	GPS CO-ORD:	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
AR-SR01	lt Br sty s	VERY MOIST	COLD	S 32°02'40.1" E 27°50'03.1"	10.80	203.58
AR-SR06	lt Y Br sty s	VERY MOIST	COLD	S 32°02'54.0" E 27°50'33.5"	6.69	126.03
AR-SR07	lt Y Br sty s	VERY MOIST	COLD	S 32°02'49.9" E 27°50'41.3"	14.40	271.43
AR-SR08	lt Y Br sty s	VERY MOIST	COOL	S 32°02'38.5" E 27°50'50.8"	10.00	188.50
AR-SR09	lt Br sty s	VERY MOIST	COOL	S 32°02'47.2" E27°51'00.2"	11.68	220.16
AR-SR10	lt Br sty s	VERY MOIST	WARM	S 32°02'48.2" E 27°51'08.2"	6.01	113.32
AR-SR12	lt Br sty s	MOIST	WARM	S 32°02'56.6" E 27°51'19.2"	6.24	117.58
AR-SR13	lt Br sty s	MOIST	WARM	S 32°03'04.4" E 27°51'20.1"	13.60	256.35
AR-SR14	lt Br sty s	MOIST	COLD	S 32°03'08.6" E 27°51'25.5"	8.00	150.80
AR-SR15	lt Br sty s	SLIGHTLY MOIST	COLD	S 32°03'09.8" E 27°51'35.0"	1.91	36.10
AR-SR16	lt Br sty s	SLIGHTLY MOIST	COLD	S 32°03'13.2" E 27°51'43.6"	1.20	22.60
AR-SR17	lt Br sty s	SLIGHTLY MOIST	COLD	S 32°03'17.1" E 27°51'52.1"	11.88	223.90
AR-SR18	lt Br sty s	SLIGHTLY MOIST	COLD	S 32°03'18.6" E 27°52'01.4"	10.40	196.00

6. CONCLUSIONS AND RECOMMENDATIONS

Based on the geotechnical investigation it can be concluded that the following needs to be taken into consideration during the design of the pump stations, reservoirs and pipelines:

Pump station 1: the material profiled generally consisted of thick horizons of transported silty sand or sandy silt with soft excavations up to 3,9m, the G8 material will be usable during construction, the material had a low potential expansiveness and moderate to low risk of dispersiveness. The biggest concern at this position was the high risk of collapse and settlement of the sandy and silty material.

Pump station 2: the material generally consisted of transported silty sand with hard residual sandstone or mudstone, excavation refusals were recorded at all of the positions at depth less than 1,3m. The material at the position generally conformed to a G6 classification and had a low risk with regards to heave.

Alternative Pump station: the material profiled varied between transported sandy or clayey silt and residual sandstone or shale. The excavation depths varied between 1,2m and 3,4m. The material had a low risk with regards to heave and conformed to a G8 material classification. The biggest risk was the high risk of collapse and settlement of the sandy silt horizons.

Reservoir: the material profiled varied between transported silty sand and residual mudstone, sandstone or shale. The depths of excavations were all in excess of 2,4m. The material tested indicated a low risk with regards to heave and the material conformed to a G6 classification. The consolidation tests however indicated a 4% risk with regards to free swell that should be taken into consideration.

Alternative Reservoir: the material profiled at this position varied between transported sandy silt and residual sandstone. The excavation depths was less than 1,5m deep and the material had a low risk with regards to heave and conformed to a G6 material classification.

Main Pipeline: the material profiled along the pipeline route varied but generally consisted of transported sandy or silty material with residual sandstone. Due to the hard residual material within the top 1,5m of the profiles allowance should be made for intermediate and hard excavations. The soil resistivity tests indicated that section of the pipeline will be in corrosive material. All the material conformed to the compactible requirement and most material conformed to the bedding and backfill specifications.

Alternative Pipeline: the material along the alternative route varied between transported sand or silt with residual mudstone or sandstone. Excavation depth were generally less than 1,8m deep. The material conformed to the compactible requirement and most material conformed to the bedding and backfill specifications. The soil resistivity test indicated that a short section of the pipeline will be in corrosive material.

All trial pit profiles and test results are attached to the report.

7. REFERENCES

Byrne G, Everett JP and Schwartz K. 1995. “A Guide to Practical Geotechnical Engineering in Southern Africa” Franki.

Jennings JE, Brink, ABA and Williams AB, “Revised Guide to Soil Profiling for Civil Engineering Purposes in Southern Africa” The Civil Engineer in South Africa, January 1973.

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

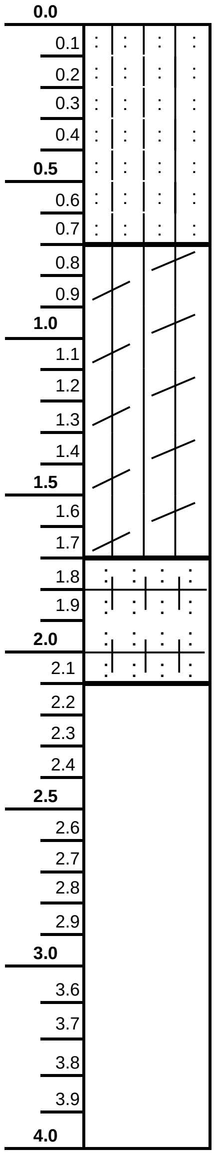
CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
ALTERNATIVE PUMP STATION SITE
REF: MT32019

TRIAL PIT No.'s : 1, 2, 3
EXCAVATED BY: TLB
DATE: 02-06-2017

TEST PIT LOGS

Position: *PS 1 Trial Hole 1A*

S 32°02'13.7" E 27°49'38.5"



Slightly moist, light Brown, soft, intact, sandy silt.
Transported:

Slightly moist, light Red Brown, stiff, slickensided to fissured, clayey silt.
Transported:

Slightly moist, light Brown, extremely hard, shattered, Sandstone + silty sand.
Residual:

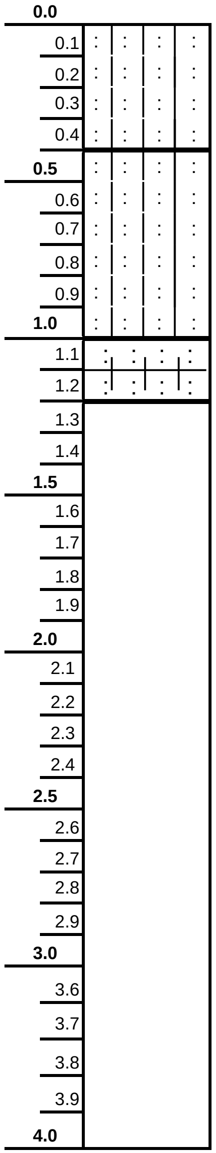
SAMPLE TAKEN: 4017

No ground water

Refusal @ 2100mm on Sandstone

Position: *PS 1 Trial Hole 2A*

S 32°02'14.0" E 27°49'38.8"



Slightly moist, light Brown, soft, intact, sandy silt.
Transported:

Slightly moist, Pale Red, stiff, slickensided to fissured, sandy silt.
Transported:

Slightly moist, light Red Brown, extremely hard, shattered, Sandstone + silty sand.
Residual:

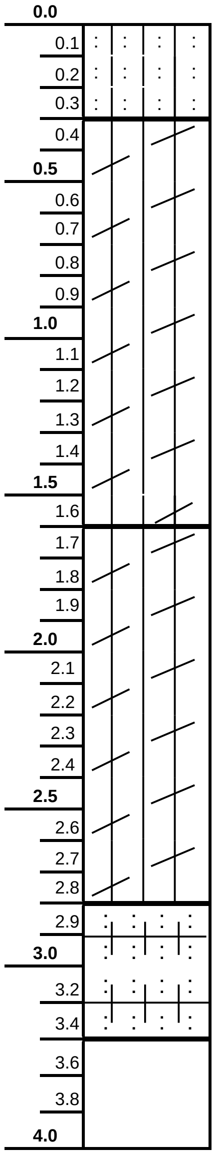
SAMPLES TAKEN: 4018, 4019

No ground water

Refusal @ 1200mm on Sandstone

Position: *PS 1 Trial Hole 3A*

S 32°02'14.2" E 27°49'37.2"



Slightly moist, light Brown, soft, intact, sandy silt.
Transported:

Slightly moist, light Red Brown, stiff, slickensided to fissured, clayey silt.
Transported:

Slightly moist, light Yellow Brown, stiff, slickensided to fissured, clayey sitl.
Transported:

Slightly moist, light Brown, very hard to extremely hard, shattered, Shale + silty sand.
Residual:

SAMPLE TAKEN: 4021

No ground water

Refusal @ 3400mm on Shale

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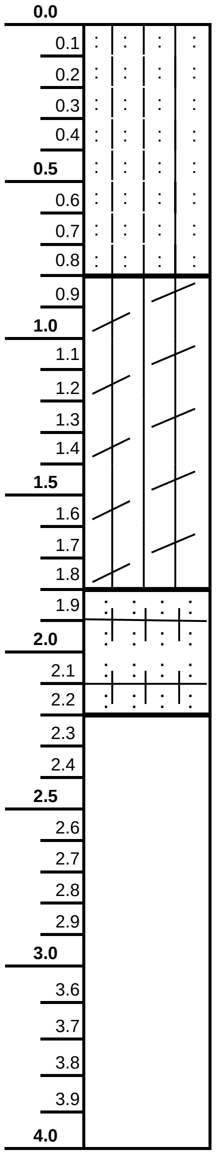
CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
ALTERNATIVE PUMP STATION SITE
REF: MT32019

TRIAL PIT No.'s : 4, 5
EXCAVATED BY: TLB
DATE: 02-06-2017

TEST PIT LOGS

Position: *PS 1 Trial Hole 4A*

S 32°02'15.0" E 27°49'37.5"



Slightly moist, light Brown, soft, intact,
sandy silt.
Transported:

Slightly moist, light Red Brown, stiff,
slickensided to fissured, clayey silt.
Transported:

Slightly moist, light Brown, extremely hard,
shattered, Sandstone + silty sand.
Residual:

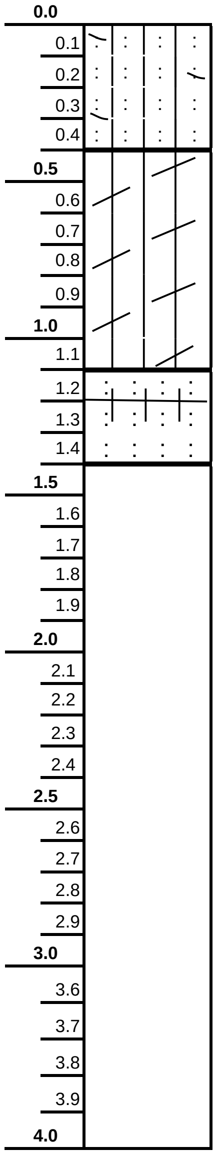
SAMPLE TAKEN: 4022

No ground water

Refusal @ 2200mm on Sandstone

Position: *PS 1 Trial Hole 5A*

S 32°02'11.8" E 27°49'38.4"



Slightly moist, light Brown, soft, intact,
sandy silt + Roots.
Transported:

Slightly moist, light Red Brown, stiff,
slickensided to fissured, clayey silt.
Transported:

Slightly moist, light Brown, extremely hard,
shattered, Sandstone + silty sand.
Residual:

SAMPLE TAKEN: 4023

No ground water

Refusal @ 1400mm on Sandstone

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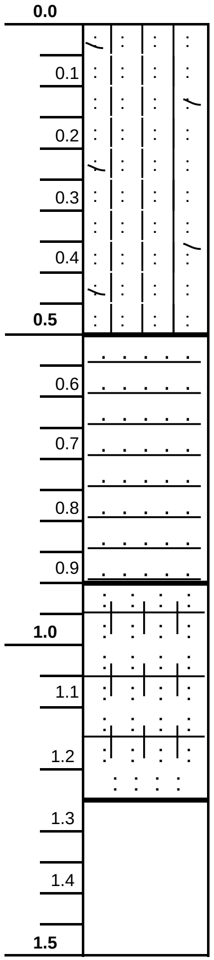
201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	6, 7, 8
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
	ALTERNATIVE RESERVOIR SITE	**DATE:**	02-06-2017
REF:	MT32019		

TEST PIT LOGS

Position: *RES Trial Hole 6A*

S 32°02'11.1"
E 27°49'39.6"



Slightly moist, light Brown, soft, intact, sandy silt + Roots.
Transported:

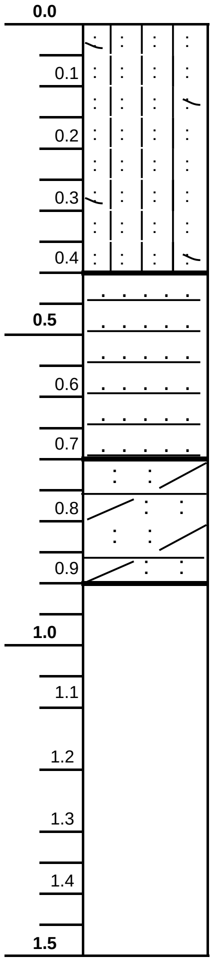
Slightly moist, light Yellow Orange, soft to hard, fissured, highly weathered Sandstone.
Sandstone.
Residual:

Slightly moist, light Brown, extremely hard, shattered, Sandstone + silty sand.
Residual:

SAMPLE TAKEN: 4025
No ground water.
Refusal @ 1250mm on Sandstone

Position: *RES Trial Hole 7A*

S 32°02'10.0"
E 27°49'40.3"



Slightly moist, light Brown, soft, intact, sandy silt + Roots.
Transported:

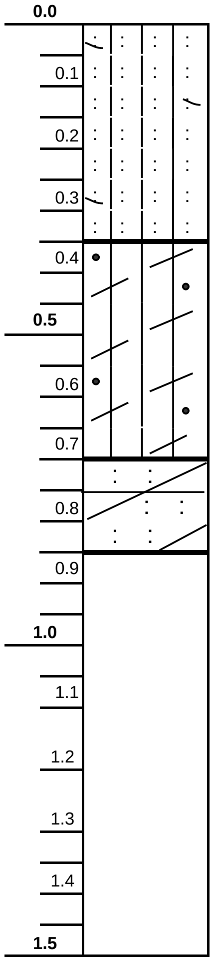
Slightly moist, light Yellow Orange, soft to hard, fissured, highly weathered Sandstone.
Residual:

Slightly moist, light Brown, extremely hard, shattered, Sandstone + clayey sand.
Residual:

SAMPLE TAKEN: 4026
No ground water.
Refusal @ 900mm on Sandstone

Position: *RES Trial Hole 8A*

S 32°02'10.4"
E 27°49'40.9"



Slightly moist, light Brown, soft, intact, sandy silt + Roots.
Transported:

Slightly moist, light Yellow Orange, firm, fissured to slickensided, clayey silt + Ferricrete.
Transported:

Slightly moist, light Brown, extremely hard, shattered, Sandstone + sandy clay.
Residual:

SAMPLE TAKEN: 4027
No ground water.
Refusal @ 880mm on Sandstone

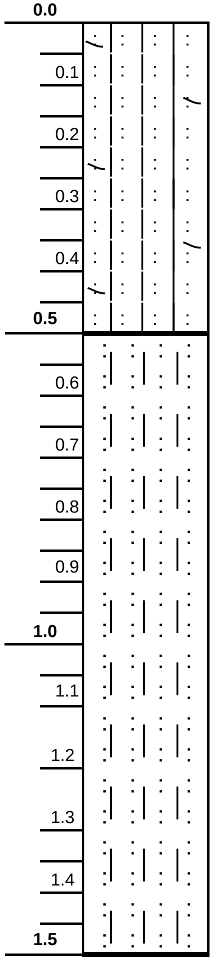
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
ALTERNATIVE RESERVOIR SITE
REF: MT32019

TRIAL PIT No.'s : 9
EXCAVATED BY: TLB
DATE: 02-06-2017

TEST PIT LOGS

Position: ***RES Trial Hole 9A***
S 32°02'11.9"
E 27°49'40.1"



Moist, light Brown, soft, intact,
sandy silt + Roots.
Transported:

Slightly moist, light Brown, extremely hard,
shattered, Sandstone + silty sand.
Residual:

SAMPLE TAKEN: 4028

No ground water.

Refusal @ 1500mm on Sandstone

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

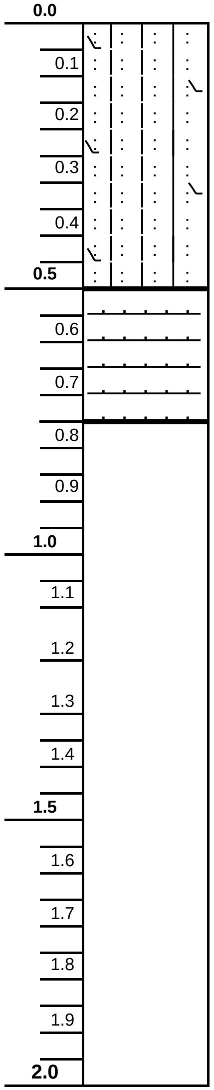
CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 1, 2, 3
EXCAVATED BY: TLB
DATE: 26-04-2017

TEST PIT LOGS

Position: *AR Trial Hole 1*

S 32°02'42.3"
E 27°50'04.7"



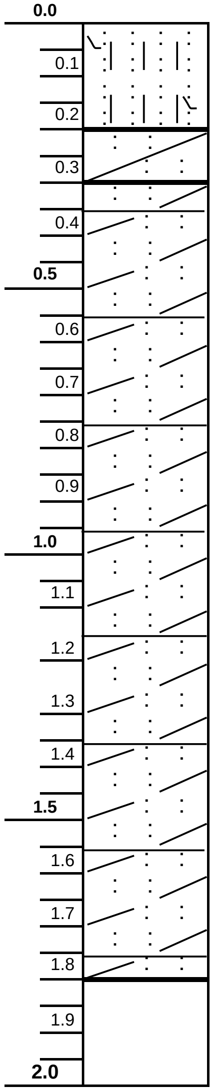
Moist, dark Red Brown, soft, intact, sandy silt + Roots.
Transported:

Moist, light Red Brown, extremely hard, micro-shattered, Sandstone.
Residual:

SAMPLE TAKEN: 3380
No ground water.
Refusal @ 750mm on Sandstone

Position: *AR Trial Hole 2*

S 32°02'47.1"
E 27°50'08.8"



Moist, dark Red Brown, soft, intact, silty sand + Roots.
Transported:

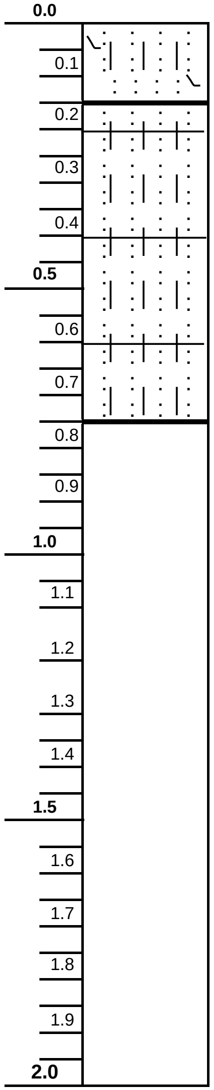
Moist, dark Brown, stiff, slickensided, sandy clay. Transported:

Moist, Purple + light Olive, hard to extremely hard, shattered, Mudstone.
Residual:

SAMPLES TAKEN: 3381, 3382
No ground water.
Refusal @ 1800mm on Mudstone

Position: *AR Trial Hole 3*

S 32°02'56.6"
E 27°50'14.0"



Moist, light Brown, firm, intact, silty sand + Roots + Sandstone gravel.
Transported:

Moist, dark Yellow Orange, very hard to extremely hard, micro-shattered, Sandstone + silty sand.
Residual:

SAMPLE TAKEN: 3383
No ground water.
Refusal @ 750mm on Sandstone

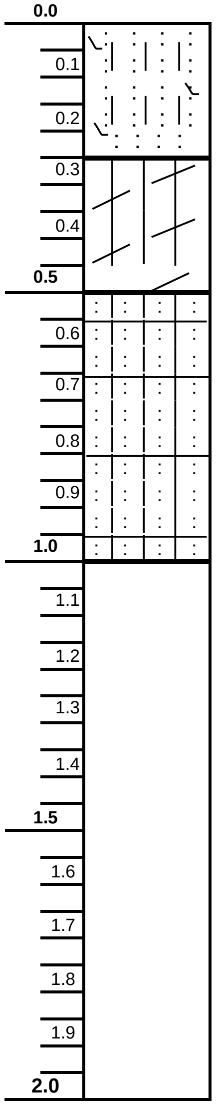
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	4, 5, 6
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	26-04-2017

TEST PIT LOGS

Position: *AR Trial Hole 4*

S 32°02'57.5"
E 27°50'27.3"



Moist, dark Red Brown, soft, intact,
silty sand + Roots.
Transported:

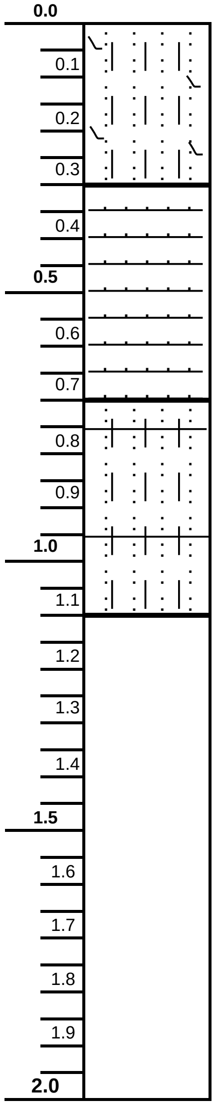
Moist, dark Brown, firm, slickensided,
clayey silt.
Transported:

Moist, dark Yellow Orange, very hard to extremely hard, micro-shattered, Sandstone + sandy silt.
Residual:

SAMPLES TAKEN: 3384, 3385
No ground water.
Refusal @ 1000mm on Sandstone

Position: *AR Trial Hole 5*

S 32°02'50.7"
E 27°50'38.3"



Moist, light Brown, soft, intact,
silty sand + Roots + Sandstone gravel.
Transported:

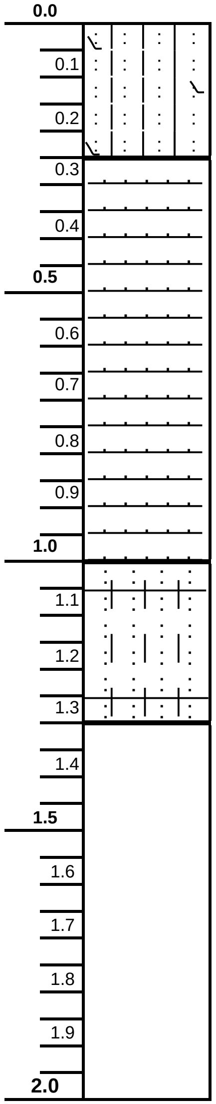
Moist, light Red Brown, hard, micro-shattered, highly weathered Sandstone.
Residual:

Moist, light Red Brown, very hard to extremely hard, micro-shattered, Sandstone + silty sand.
Residual:

SAMPLE TAKEN: 3386
No ground water.
Refusal @ 1100mm on Sandstone

Position: *AR Trial Hole 6*

S 32°02'45.5"
E 27°50'50.8"



Moist, dark Red, soft, intact,
sandy silt + Roots.
Transported:

Moist, light Yellow, soft, micro-shattered, weathered Sandstone.
Residual:

Moist, light Red Brown, very hard to extremely hard, micro-shattered, Sandstone + silty sand.
Residual:

SAMPLES TAKEN: 3387, 3388
No ground water.
Refusal @ 1300mm on Sandstone

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

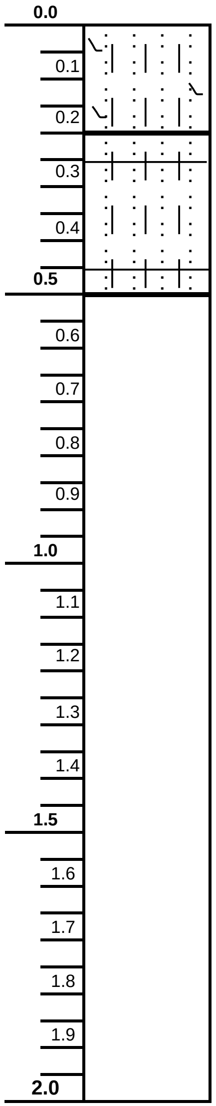
CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019
TRIAL PIT No.'s : 7, 8, 9
EXCAVATED BY: TLB
DATE: 27-04-2017

TEST PIT LOGS

Position:

AR Trial Hole 7

S 32°02'46.0"
E 27°51'03.7"



Moist, light Brown, firm, intact,
silty sand + Roots + Sandstone gravel.
Transported:

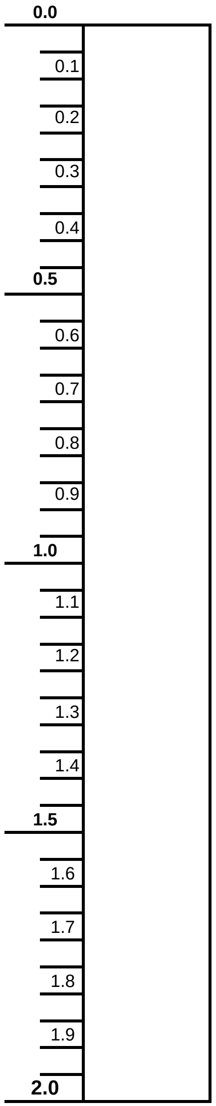
Moist, light Olive, very hard to extremely hard, micro-shattered, Sandstone + silty sand.
Residual:

NO SAMPLES TAKEN:
No ground water.
Refusal @ 500mm on Sandstone

Position:

AR Trial Hole 8

S 32°02'51.5"
E 27°51'12.5"

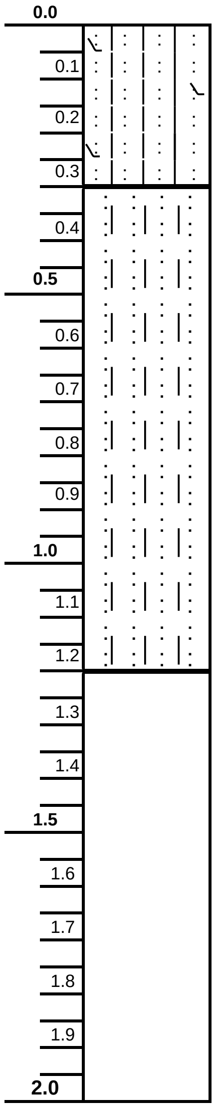


NO TEST PIT DONE - CEMETERY

Position:

AR Trial Hole 9

S 32°02'57.7"
E 27°51'20.0"



Moist, dark Red, soft, intact,
sandy silt + Roots.
Transported:

Moist, light Brown, hard, micro-shattered,
silty sand + some Sandstone gravel.
Transported:

SAMPLE TAKEN: 3389
No ground water.
Refusal @ 1200mm on Sandstone Plate

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

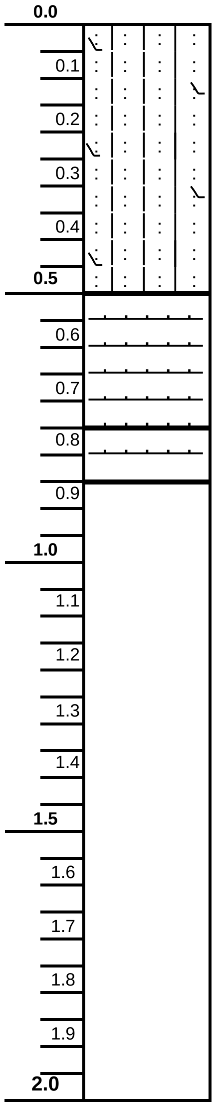
TRIAL PIT No.'s : 10, 11, 12
EXCAVATED BY: TLB
DATE: 27-04-2017

TEST PIT LOGS

Position:

AR Trial Hole 10

S 32°03'08.1"
E 27°51'21.7"



Moist, dark Red Brown, soft, intact, sandy silt + Roots.
Transported:

Moist, light Red Brown, firm, micro-shattered, highly weathered Sandstone.
Residual:

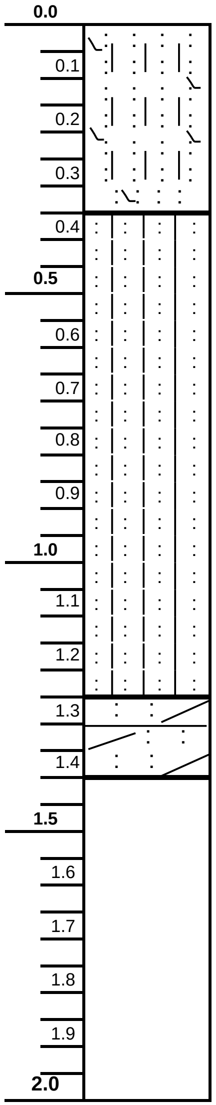
Moist, light Brown, very hard to extremely hard, micro-shattered, Sandstone.
Residual:

SAMPLES TAKEN: 3390, 3391
No ground water.
Refusal @ 740mm on Sandstone Plate

Position:

AR Trial Hole 11

S 32°03'09.8"
E 27°51'35.0"



Moist, dark Brown, soft, intact, silty sand + Roots.
Transported:

Slightly moist, dark Brown, firm, intact, sandy silt.
Transported:

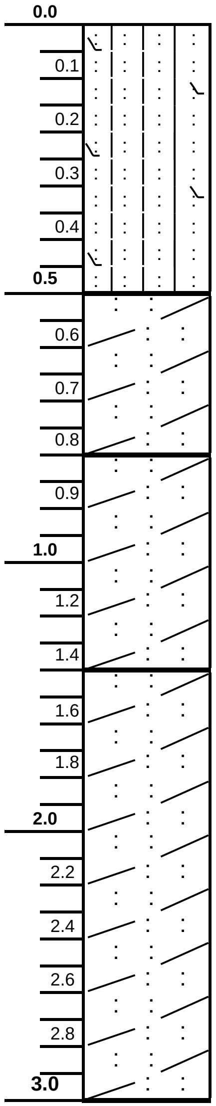
Slightly moist, dark Brown, very hard extremely hard, micro-shattered, Sandstone / Shale + clayey sand.
Residual:

SAMPLES TAKEN:
No ground water.
Refusal @ 1400mm on Sandstone

Position:

AR Trial Hole 12

S 32°03'14.8"
E 27°51'47.2"



Moist, dark Red Brown, soft, intact, sandy silt + Roots.
Transported:

Slightly moist, dark Brown, firm, slickensided, clayey sand.
Transported:

Moist, dark Brown, stiff, slickensided, clayey sand.
Transported:

Moist, dark Brown, stiff, slickensided, clayey sand.
Transported:

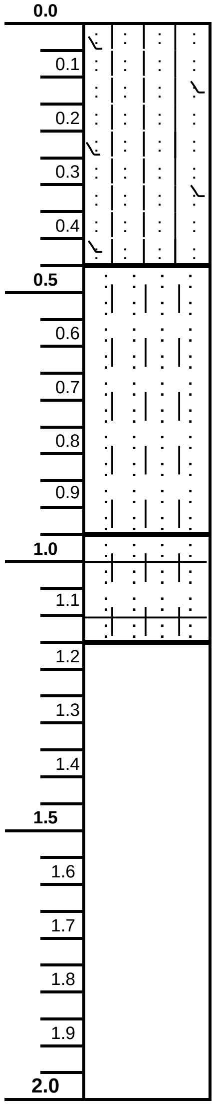
SAMPLES TAKEN: 3395, 3396, 3397
No ground water.
No refusal @ 3000mm

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019
TRIAL PIT No.'s : 13
EXCAVATED BY: TLB
DATE: 27-04-2017

TEST PIT LOGS

Position: ***AR Trial Hole 13***
S 32°03'18.5"
E 27°51'59.2"



Moist, dark Red, soft, intact, sandy silt + Roots.
Transported:

Slightly moist, dark Brown, firm, slickensided, silty sand.
Transported:

Slightly moist, light Brown, very hard to extremely hard, micro-shattered, Sandstone + silty sand.
Residual:

SAMPLES TAKEN: 3398, 3399
No ground water.
Refusal @ 1160mm on Sandstone Plate

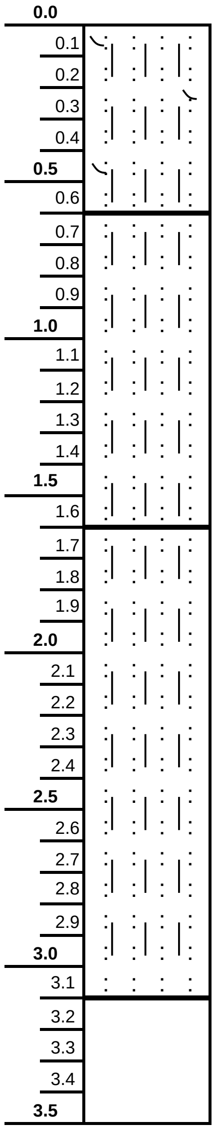
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019
TRIAL PIT No.'s : 1, 2, 3
EXCAVATED BY: TLB
DATE: 25-04-2017

TEST PIT LOGS

Position: Main Pipeline Trial Hole 1

S 32°02'07.7" E 27°49'36.7"



Moist, dark Yellow Orange, soft, intact, silty sand + Roots.
Transported:

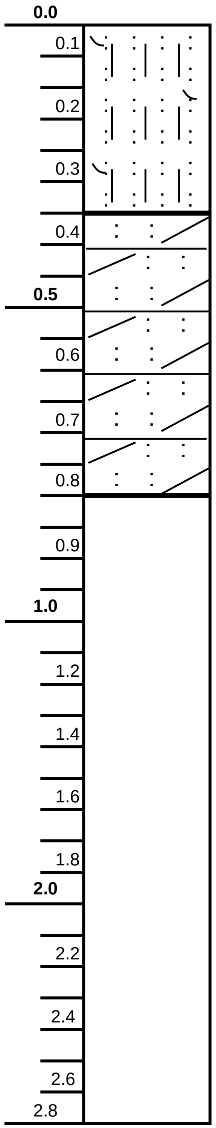
Moist, light Orange, soft to firm, intact, silty sand.
Transported:

Moist, dark Brown Orange, soft to firm, intact, silty sand.
Transported:

SAMPLES TAKEN: 3307A, 3307B
No ground water
No refusal 3100mm

Position: Main Pipeline Trial Hole 2

S 32°02'13.9" E 27°49'46.7"



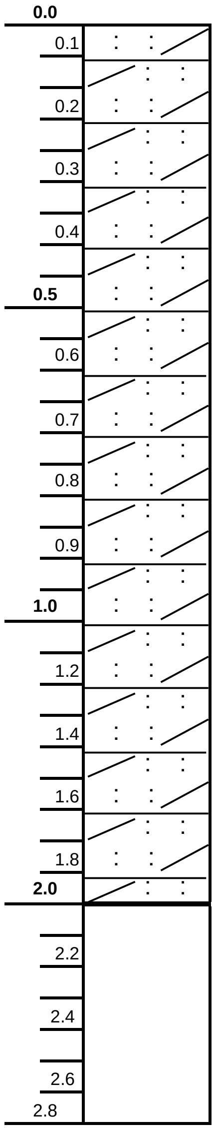
Moist, dark Red, soft, intact, silty sand + Roots.
Transported:

Moist, Pale Red, hard to extremely hard, micro-shattered, Sandstone + clayey sand.
Residual:

SAMPLES TAKEN: 3308A, 3308B
No ground water
Refusal @ 800mm on Sandstone

Position: Main Pipeline Trial Hole 3

S 32°02'22.0" E 27°49'55.8"



Moist, dark Red, hard to extremely hard, shattered, highly weathered Mudstone. clayey sand.
Refusal:

SAMPLE TAKEN: 3309
No ground water
Refusal @ 2000mm on Mudstone

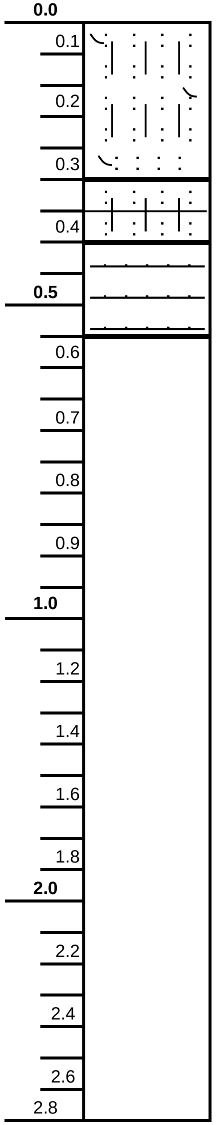
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019
TRIAL PIT No.'s : 4, 5, 6
EXCAVATED BY: TLB
DATE: 26-04-2017

TEST PIT LOGS

Position: *Main Pipeline Trial Hole 4*

S 32°02'30.1" E 27°50'02.0"



Moist, light Brown, soft, intact,
silty sand + Roots.
Transported:

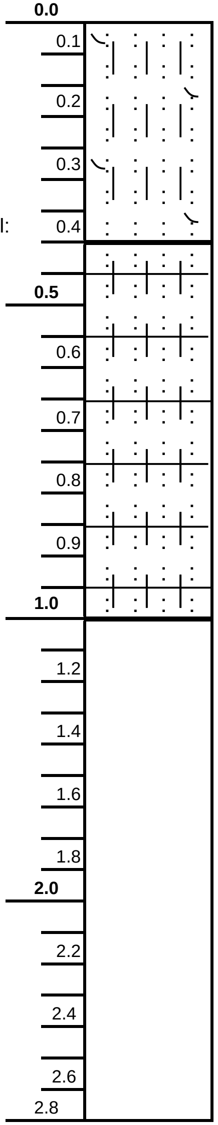
Moist, light Grey, hard, micro-shattered,
highly weathered Sandstone + sitly sand. Residual:

Moist, light Grey, extremely hard,
micro-shattered, Sandstone.
Residual:

SAMPLE TAKEN: 3310
No ground water
Refusal @ 830mm on Sandstone

Position: *Main Pipeline Trial Hole 5*

S 32°02'38.2" E 27°50'11.5"



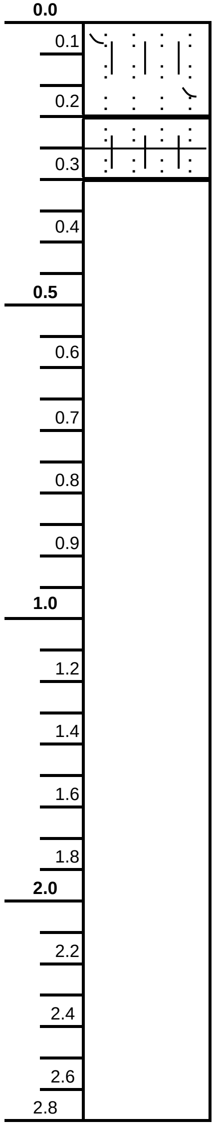
Moist, dark Red, soft, intact,
silty sand + Roots.
Transported:

Moist, dark Red Orange, very hard to
extremely hard, micro-shattered, Sandstone +
silty sand.
Residual:

SAMPLES TAKEN: 3311, 3312
No ground water
Refusal @ 1000mm on Sandstone

Position: *Main Pipeline Trial Hole 6*

S 32°02'39.4" E 27°50'23.7"



Moist, light Brown, soft, intact,
silty sand + Roots + Sandstone gravel.
Transported:

Moist, light Red Brown, extremely hard,
micro-shattered, Sandstone + silty sand.
Residual:

NO SAMPLES TAKEN:
No ground water
Refusal @ 280mm on Sandstone Plate

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

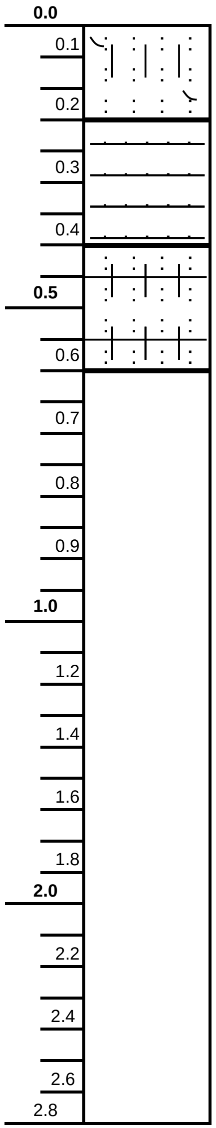
CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 7, 8, 9
EXCAVATED BY: TLB
DATE: 26-04-2017

TEST PIT LOGS

Position: *Main Pipeline Trial Hole 7*

S 32°02'39.1" E 27°50'36.8"



Moist, light Brown, soft, intact,
silty sand + Roots.
Transported:

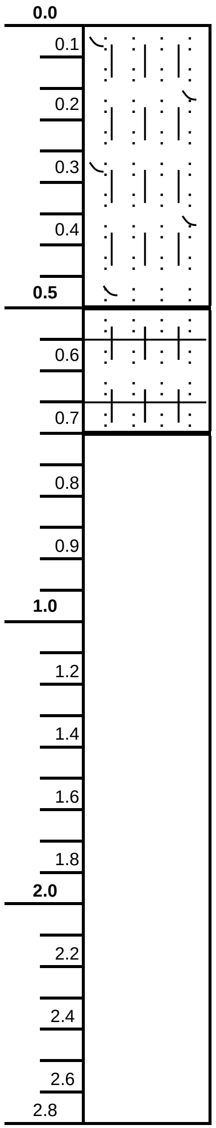
Moist, light Red Brown, hard, micro-shattered, highly weathered Sandstone.
Transported:

Moist, light Brown, very hard to extremely hard, micro-shattered, Sandstone + silty sand.
Residual:

SAMPLES TAKEN: 3313, 3314
No ground water
Refusal @ 600mm on Sandstone

Position: *Main Pipeline Trial Hole 8*

S 32°02'38.2" E 27°50'49.8"



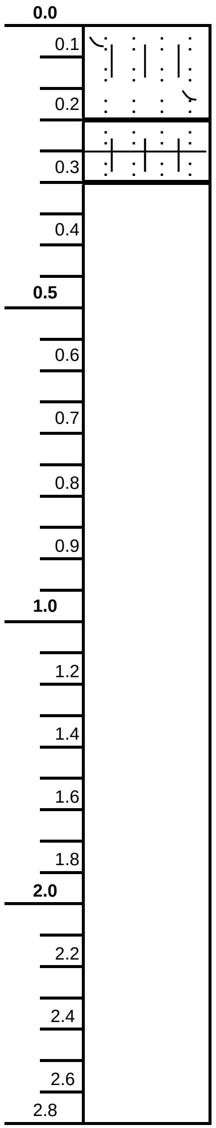
Moist, light Brown, soft, intact,
silty sand + Roots.
Transported:

Moist, light Red Brown, extremely hard, micro-shattered, Sandstone.
Sandstone + silty sand.
Residual:

SAMPLE TAKEN: 3315
No ground water
Refusal @ 700mm on Sandstone Plate

Position: *Main Pipeline Trial Hole 9*

S 32°02'36.0" E 27°51'01.3"



Moist, light Brown, soft, intact,
silty sand + Roots.
Transported:

Moist, light Red Brown, extremely hard, micro-shattered, Sandstone + silty sand.
Residual:

SAMPLE TAKEN: 3316
No ground water
Refusal @ 210mm on Sandstone Plate

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

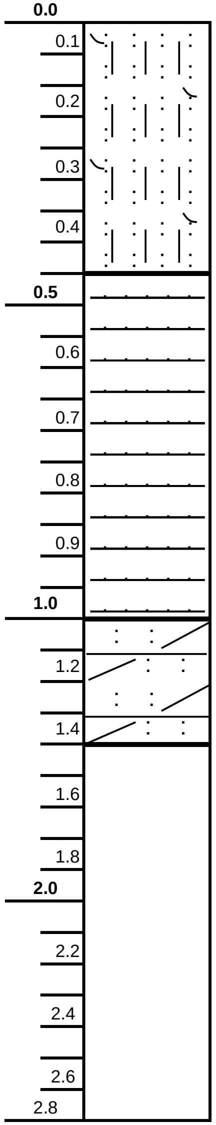
CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 10, 11, 12
EXCAVATED BY: TLB
DATE: 26-04-2017

TEST PIT LOGS

Position: *Main Pipeline Trial Hole 10*

S 32°02'35.9" E 27°51'14.3"



Moist, dark Red Orange, soft, intact,
silty sand + Roots.
Transported:

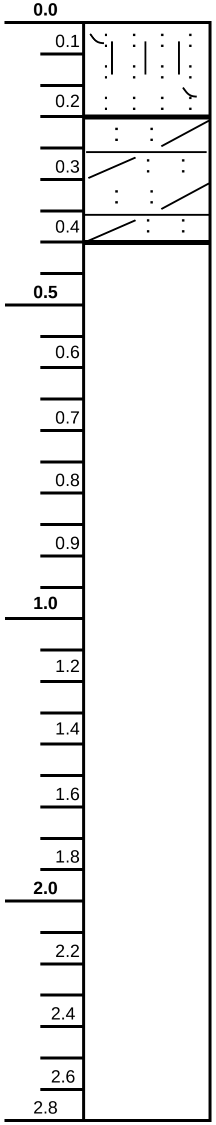
Moist, light Yellow, soft, micro-shattered,
highly weathered Sandstone.
Residual:

Moist, light Red Brown, hard to extremely
hard, micro-shattered, Sandstone +
clayey sand.
Residual:

SAMPLES TAKEN: 3317, 3318
No ground water
Refusal @ 1300mm on Sandstone

Position: *Main Pipeline Trial Hole 11*

S 32°02'40.3" E 27°51'22.5"



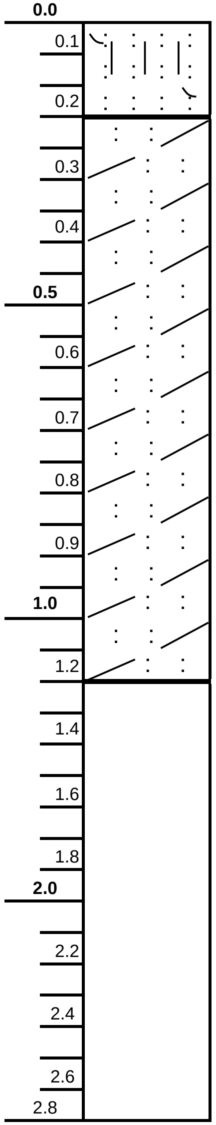
Moist, light Brown, soft, intact,
silty sand + Roots.
Transported:

Moist, dark Red, hard, micro-shattered,
highly weathered Sandstone + clayey sand.
Residual:

SAMPLE TAKEN: 3319
No ground water
Refusal @ 400mm on Sandstone Plate

Position: *Main Pipeline Trial Hole 12*

S 32°02'44.0" E 27°51'31.3"



Moist, light Brown, firm, intact,
silty sand + Roots + Dolerite Boulders.
Transported:

Moist, dark Red Brown, very hard to
extremely hard, shattered, decomposed
Dolerite + clayey sand.
Residual:

SAMPLE TAKEN: 3320
No ground water
Refusal @ 1100mm on decomposed
Dolerite

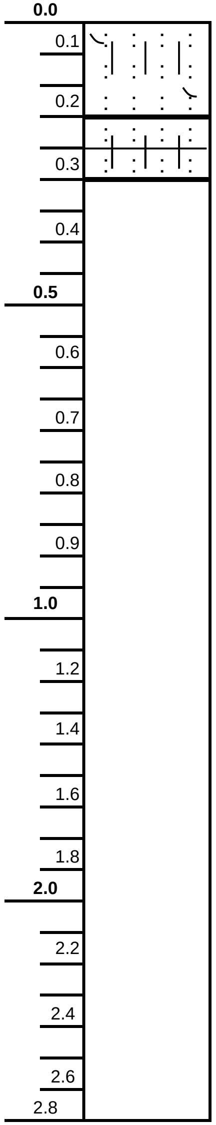
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019
TRIAL PIT No.'s : 13, 14, 15
EXCAVATED BY: TLB
DATE: 26-04-2017 & 27-04-2017

TEST PIT LOGS

Position: *Main Pipeline Trial Hole 13*

S 32°02'53.8" E 27°51'33.7"



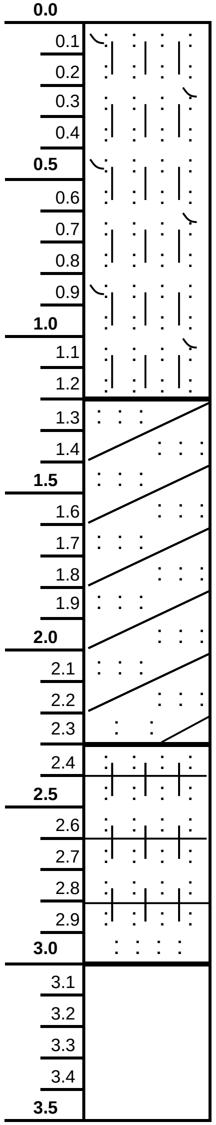
Moist, light Brown, firm, intact,
silty sand + Roots + Sandstone gravel.
Transported:

Moist, light Brown, very hard to extremely hard, micro-shattered, Sandstone + silty sand.
Residual:

SAMPLE TAKEN: 3321
No ground water
Refusal @ 300mm on Sandstone Plate

Position: *Main Pipeline Trial Hole 14*

S 32°03'01.1" E 27°51'38.9"



Moist, dark Red Orange, soft, intact,
silty sand + Roots.
Transported:

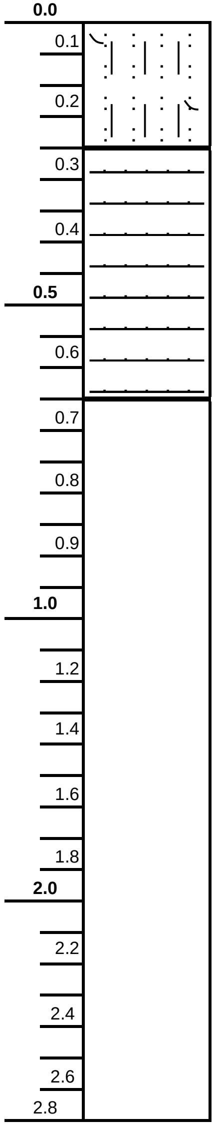
Slightly moist, dark Brown, firm,
slickensided, sandy clay.
Transported:

Slightly moist, light Red Brown, soft to hard,
micro-shattered, highly weathered
Sandstone + silty sand..
Residual:

SAMPLE TAKEN: 3323
No ground water
No refusal @ 3000mm

Position: *Main Pipeline Trial Hole 15*

S 32°03'07.5" E 27°51'49.9"



Moist, dark Red, soft, intact,
silty sand + Roots.
Transported:

Moist, dark Red Orange, very hard to
extremely hard, micro-shattered,
Sandstone.
Residual:

SAMPLES TAKEN: 3324A, 3324B
No ground water
Refusal @ 650mm on Sandstone

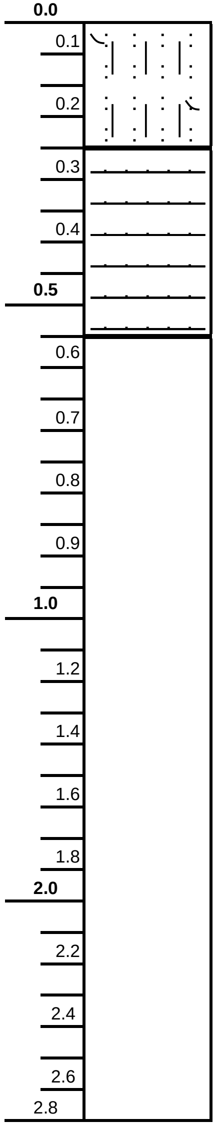
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	16, 17, 18
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	28-04-2017

TEST PIT LOGS

Position: *Main Pipeline Trial Hole 16*

S 32°03'15.2" E 27°51'59.4"



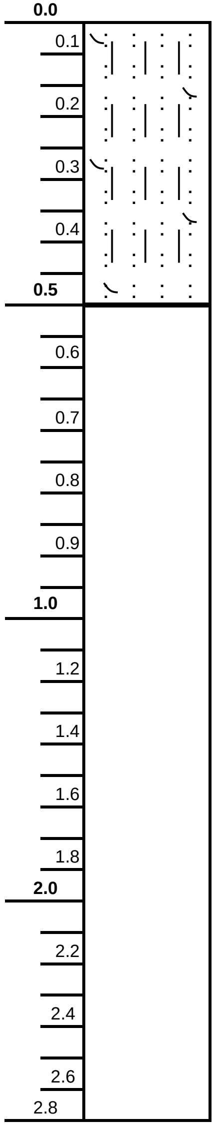
Moist, dark Red Orange, soft, intact,
silty sand + Roots + Sandstone gravel.
Transported:

Moist, dark Red Orange, very hard to
extremely hard, micro-shattered, Sandstone.
Residual:

NO SAMPLE TAKEN:
No ground water
Refusal @ 570mm on Sandstone

Position: *Main Pipeline Trial Hole 17*

S 32°03'18.9" E 27°52'10.8"

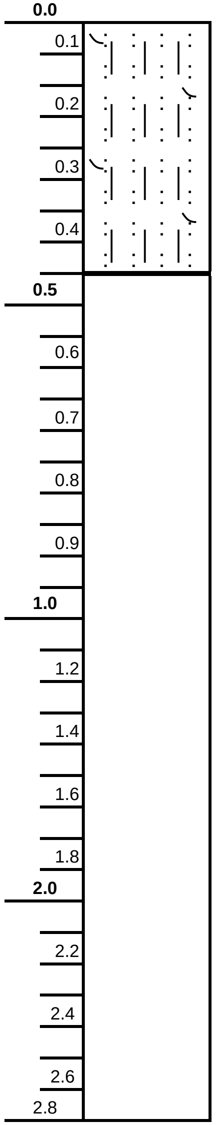


Moist, dark Red Orange, soft, intact,
silty sand + Roots.
Transported:

SAMPLE TAKEN: 3326
No ground water
Refusal @ 500mm on Sandstone Plate

Position: *Main Pipeline Trial Hole 18*

S 32°03'20.9" E 27°52'23.9"



Moist, dark Red Orange, soft, intact,
silty sand + Roots.
Transported:

SAMPLE TAKEN: 3327
No ground water
Refusal @ 450mm on Sandstone Plate

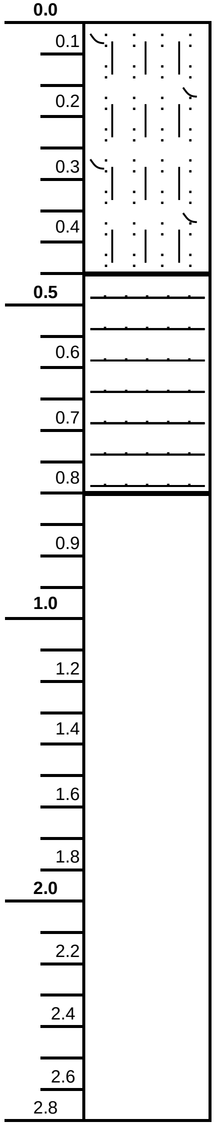
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	19, 20, 21
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	28-04-2017

TEST PIT LOGS

Position: *Main Pipeline Trial Hole 19*

S 32°03'22.9" E 27°52'37.0"



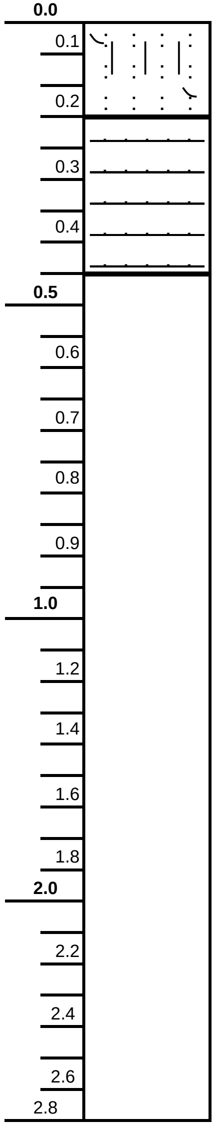
Moist, dark Brown, soft, intact,
silty sand + Roots + Dolerite Boulders.
Transported:

Moist, dark Brown, very hard to extremely
hard, micro-shattered, Sandstone.
Residual:

SAMPLE TAKEN: 3328
No ground water
Refusal @ 800mm on Sandstone Plate

Position: *Main Pipeline Trial Hole 20*

S 32°03'25.1" E 27°52'50.3"



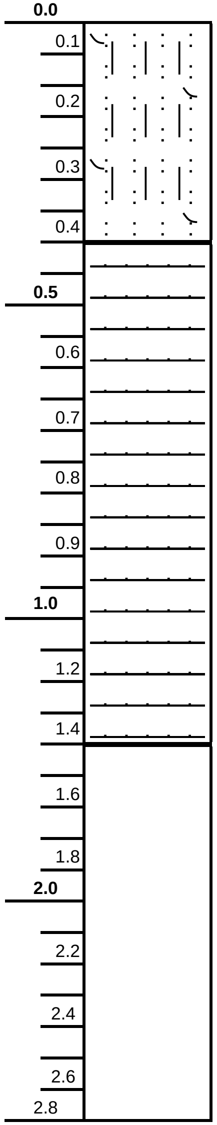
Moist, light Brown, soft, intact,
silty sand + Roots + Dolerite / Sandstone
gravel.

Moist, Pale Red, very hard to extremely
hard, micro-shattered, Sandstone.
Residual:

SAMPLE TAKEN: 3329
No ground water
Refusal @ 440mm on Sandstone Plate

Position: *Main Pipeline Trial Hole 21*

S 32°03'27.6" E 27°53'03.3"



Moist, dark Red Orange, soft, intact,
silty sand + Roots.
Transported:

Moist, dark Red Orange, very hard to
extremely hard, shattered, Sandstone.
Residual:

SAMPLES TAKEN: 3330, 3331
No ground water
Refusal @ 1340mm on Sandstone

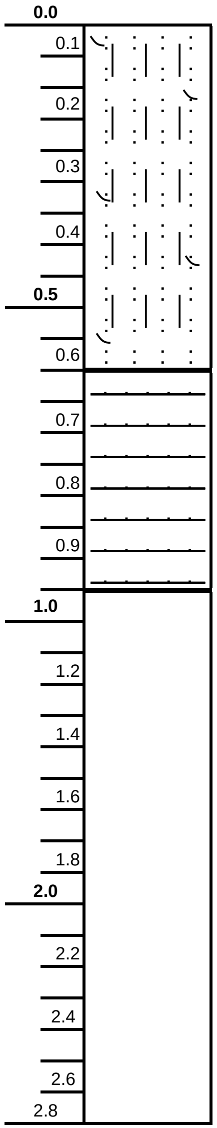
CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 22, 23, 24
EXCAVATED BY: TLB
DATE: 28-04-2017

TEST PIT LOGS

Position: *Main Pipeline Trial Hole 22*

S 32°03'31.2"   E 27°53'16.1"



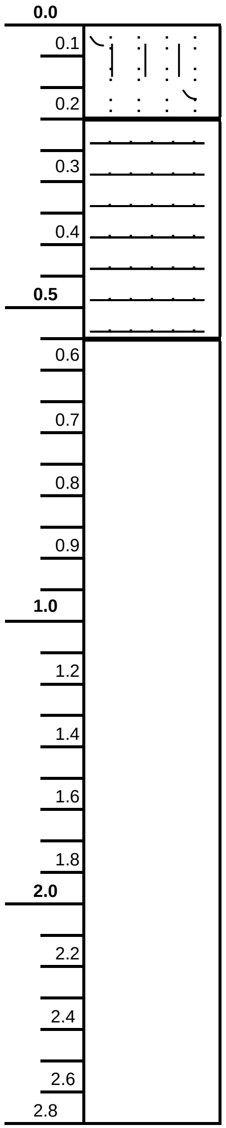
Moist, dark Grey, soft, intact,
silty sand + Roots.
Transported:

Moist, light Red Brown, very hard to
extremely hard, micro-shattered,
Sandstone.
Residual:

SAMPLES TAKEN: 3332, 3333
No ground water
Refusal @ 920mm on Sandstone

Position: *Main Pipeline Trial Hole 23*

S 32°03'34.8"   E 27°53'29.0"



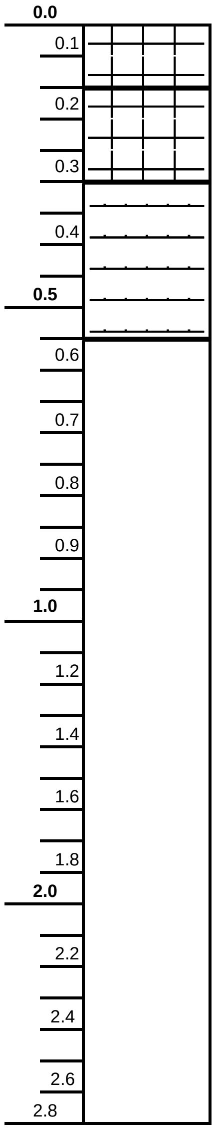
Moist, light Brown, soft, intact,
silty sand + Roots + Sandstone gravel.
Transported:

Moist, dark Red Brown, very hard to
extremely hard, micro-shattered,
Sandstone.
Residual:

SAMPLE TAKEN: 3334
No ground water
Refusal @ 580mm on Sandstone

Position: *Main Pipeline Trial Hole 24*

S 32°03'38.9"   E 27°53'40.3"



Moist, light Brown, medium dense, intact,
silty sand + Roots + Dolerite gravel.
Imported:

Moist, light Yellow Brown, dense, foliated,
decomposed Dolerite.   Imported:

Moist, light Olive, very hard to extremely
hard, micro-shattered, Sandstone
Residual:

SAMPLE TAKEN: 3335
No ground water
Refusal @ 520mm on Sandstone Plate

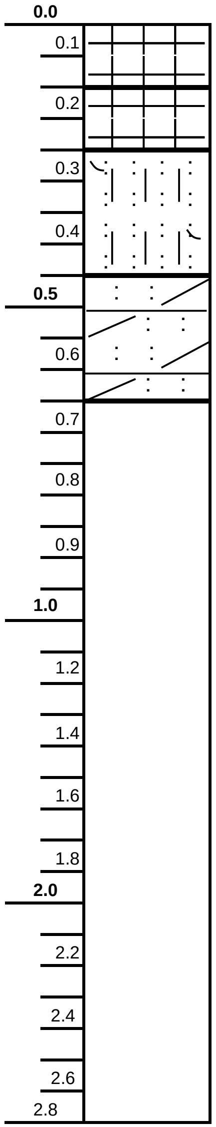
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019
TRIAL PIT No.'s : 25, 26, 27
EXCAVATED BY: TLB
DATE: 28-04-2017 & 29-04-2017

TEST PIT LOGS

Position: *Main Pipeline Trial Hole 25*

S 32°03'43.0" E 27°53'53.0"



Moist, light Brown, soft, intact,
silty sand + Roots + Dolerite gravel. Imported:

Moist, light Yellow Brown, dense, foliated,
decomposed Dolerite. Imported:

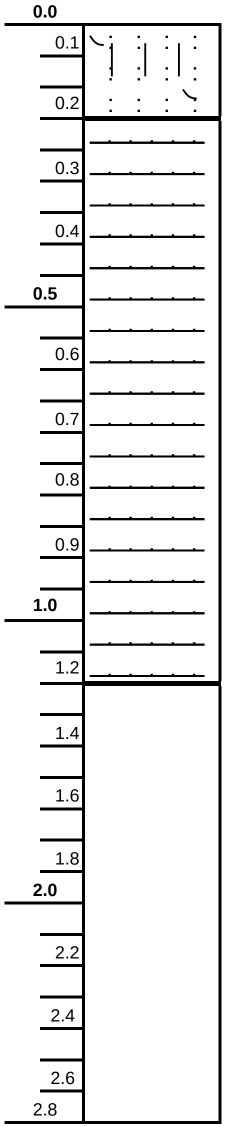
Moist, dark Brown, soft, intact,
silty sand + Roots.
Transported:

Moist, Pale Red, hard to very hard,
micro-shattered, Sandstone / Shale +
clayey sand.
Residual:

SAMPLES TAKEN: 3336, 3337
No ground water
Refusal @ 670mm on Sandstone Plate

Position: *Main Pipeline Trial Hole 26*

S 32°03'47.2" E 27°54'05.4"



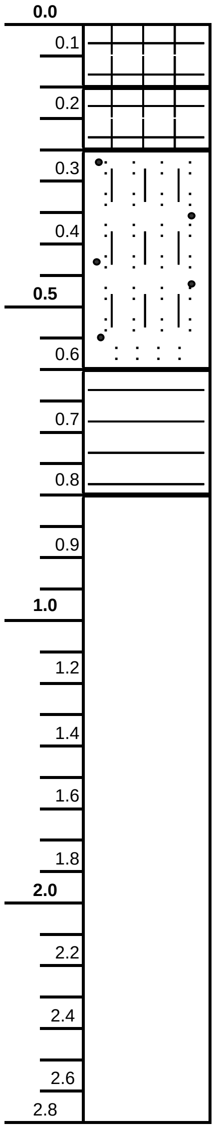
Moist, light Brown, soft, intact,
silty sand + Roots + Sandstone gravel.
Transported:

Moist, light Red Brown, very hard to extremely
hard, micro-shattered, Sandstone.
Residual:

SAMPLE TAKEN: 3338
No ground water
Refusal @ 1100mm on Sandstone Plate

Position: *Main Pipeline Trial Hole 27*

S 32°03'51.6" E 27°54'17.9"



Moist, light Brown, soft, intact,
silty sand + Roots. Imported:

Moist, light Yellow Brown, dense, foliated,
decomposed Dolerite. Imported:

Moist, light Brown, firm, fissured,
silty sand + Ferricrete.
Transported:

Moist, Pale Red, very hard to extremely
hard, shattered, Mudstone.
Residual:

SAMPLE TAKEN: 3339
No ground water
Refusal @ 800mm on Mudstone

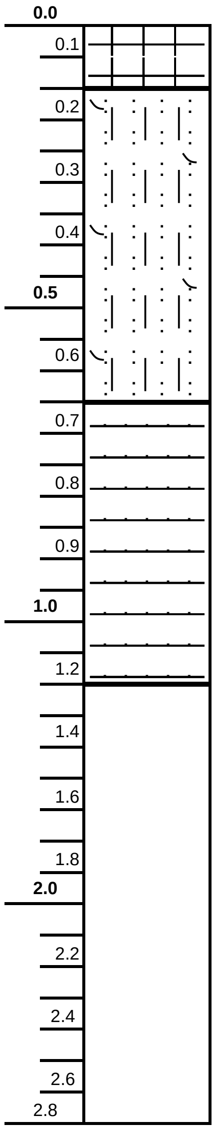
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	28, 29, 30
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	29-04-2017

TEST PIT LOGS

Position: *Main Pipeline Trial Hole 28*

S 32°03'59.1"   E 27°54'27.2"



Moist, light Yellow Brown, medium dense, foliated, decomposed Dolerite.   Imported:

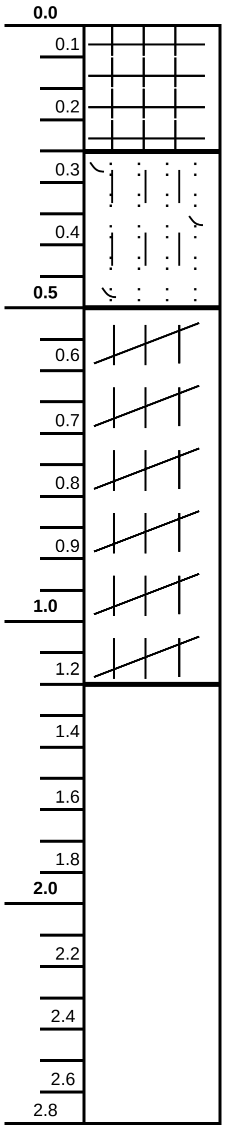
Moist, light Brown, soft, intact, silty sand + Roots.
Transported:

Moist, light Red Orange, very hard to extremely hard, micro-shattered, Sandstone.
Residual:

SAMPLES TAKEN: 3340, 3341
No ground water
Refusal @ 1100mm on Sandstone

Position: *Main Pipeline Trial Hole 29*

S 32°04'08.3"   E 27°54'35.2"



Moist, light Yellow Brown, medium dense, foliated, decomposed Dolerite.
Imported:

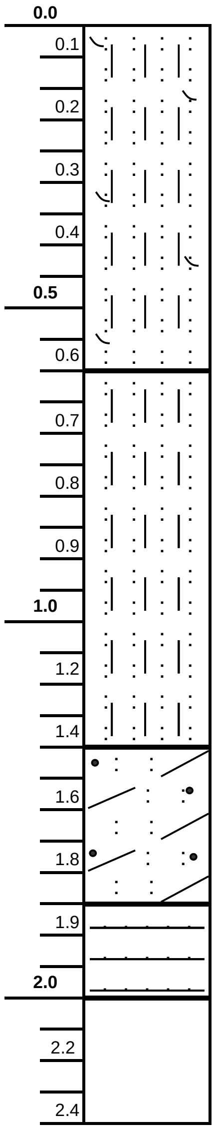
Moist, dark Red Brown, soft, intact, silty sand + Roots.
Transported:

Slightly moist, light Red Orange, very hard, to extremely hard, foliated, decomposed Dolerite + silty clay.
Residual:

SAMPLES TAKEN: 3342A, 3342B
No ground water
Refusal @ 1100mm on decomposed Dolerite

Position: *Main Pipeline Trial Hole 30*

S 32°04'17.9"   E 27°54'43.5"



Moist, light Brown, soft, intact, silty sand + Roots.
Transported:

Moist, light Yellow, soft, intact, cobbles + silty sand.
Transported:

Moist, light Yellow Orange, firm, micro-shattered, clayey sand + Ferricrete.
Transported:

Moist, light Red Brown, very hard to extremely hard, micro-shattered, Sandstone.   Residual:

SAMPLES TAKEN: 3343, 3344A
No ground water
Refusal @ 2000mm on Sandstone

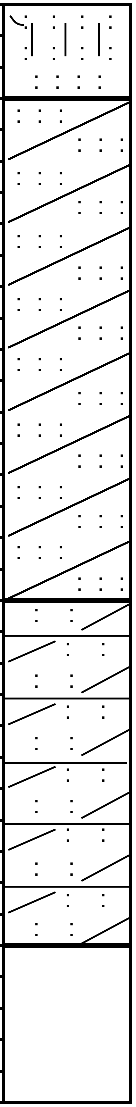
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	31, 32, 33
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	29-04-2017 & 30-04-2017

TEST PIT LOGS

Position: Main Pipeline Trial Hole 31

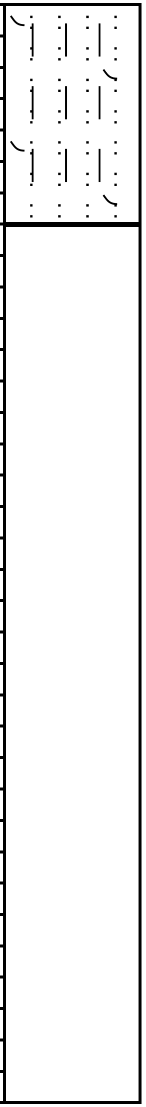
S 32°04'27.0" E 27°54'51.3"



0.0	
0.1	Moist, light Brown, soft, intact,
0.2	silty sand + Roots + Sandstone gravel.
0.3	Transported:
0.4	Moist, light Brown, stiff, slcikensided,
0.5	sandy clay.
0.6	Transported:
0.7	
0.8	
0.9	
1.0	
1.1	
1.2	
1.3	
1.4	
1.5	
1.6	
1.7	
1.8	
1.9	
2.0	Moist, dark Yellow Orange, firm, micro-
2.1	shattered, highly weathered Sandstone +
2.2	clayey sand.
2.3	Residual:
2.4	
2.5	
2.6	
2.7	
2.8	
2.9	
3.0	
3.1	
3.2	
3.3	**SAMPLE TAKEN: 3346, 3347**
3.4	No ground water
3.5	No refusal @ 3000mm

Position: Main Pipeline Trial Hole 32

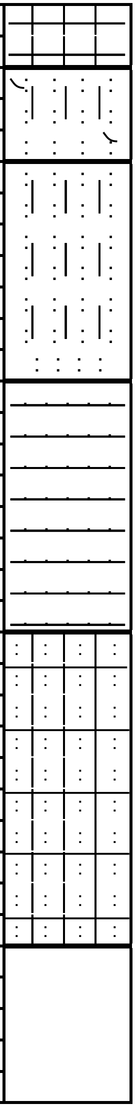
S 32°04'35.9" E 27°54'59.1"



0.0	
0.1	Moist, light Brown, soft, intact,
0.2	silty sand + Roots.
0.3	Transported:
0.4	
0.5	
0.6	
0.7	
0.8	
0.9	
1.0	
1.1	
1.2	
1.3	
1.4	
1.5	
1.6	
1.7	
1.8	
1.9	
2.0	
2.1	
2.2	
2.3	
2.4	
2.5	
2.6	
2.7	
2.8	
2.9	
3.0	
3.1	
3.2	
3.3	**SAMPLE TAKEN: 3348**
3.4	No ground water
3.5	Refusal @ 620mm on Sandstone Plate

Position: Main Pipeline Trial Hole 33

S 32°04'45.0" E 27°55'07.3"



0.0	
0.1	Moist, light Yellow Brown, medium
0.2	dense, foliated, decomposed Dolerite.
0.3	Imported:
0.4	Moist, dark Grey, soft, intact,
0.5	silty sand + Roots. Transported:
0.6	Moist, light Brown, soft, intact,
0.7	silty sand.
0.8	Transported:
0.9	
1.0	
1.1	
1.2	
1.3	Moist, light Yellow Orange, firm, micro-
1.4	shattered, Sandstone.
1.5	Residual:
1.6	
1.7	
1.8	
1.9	
2.0	
2.1	Moist, Pale Red, very hard, micro-
2.2	shattered, Sandstone + sandy silt.
2.3	Residual:
2.4	
2.5	
2.6	
2.7	
2.8	
2.9	
3.0	
3.1	
3.2	
3.3	**SAMPLES TAKEN: 3349, 3350**
3.4	No ground water
3.5	No refusal @ 3000mm

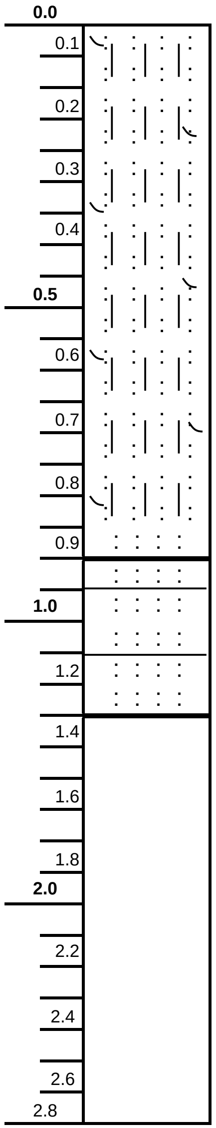
CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 34, 35, 36
EXCAVATED BY: TLB
DATE: 30-04-2017

TEST PIT LOGS

Position: *Main Pipeline Trial Hole 34*

S 32°04'54.1" E 27°55'13.7"



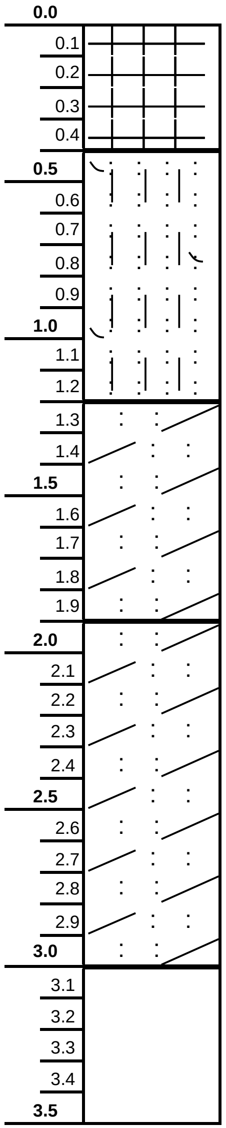
Moist, light Brown, soft, intact, silty sand + Roots.
Transported:

Moist, light Red Brown, very hard to extremely hard, micro-shattered, Sandstone + sand.
Residual:

SAMPLES TAKEN: 3353, 3354
No ground water
Refusal @ 1240mm on Sandstone

Position: *Main Pipeline Trial Hole 35*

S 32°05'05.0" E 27°55'18.4"



Moist, light Yellow Brown, dense, foliated, decomposed Dolerite.
Imported:

Moist, light Brown, soft, intact, silty sand + Roots.
Transported:

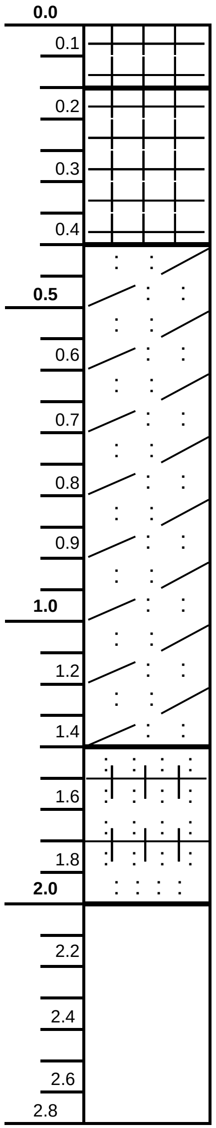
Moist, light Yellow, firm, micro-shattered, clayey sand.
Transported:

Moist, light Red Brown, firm, micro-shattered, clayey sand.
Transported:

SAMPLES TAKEN: 3355, 3357
No ground water
No refusal @ 3000mm

Position: *Main Pipeline Trial Hole 36*

S 32°05'15.4" E 27°55'23.2"



Moist, light Brown, soft, intact, silty sand + Roots + decomposed Dolerite Gravel. Imported:

Moist, light Yellow Brown, medium dense, foliated, decomposed Dolerite.
Imported:

Very moist, light Yellow, firm, micro-shattered, clayey sand.
Transported:

Very moist, light Brown, very hard to extremely hard, micro-shattered, Sandstone + silty sand.
Residual:

SAMPLE TAKEN: 3358
No ground water
Refusal @ 1900mm on Sandstone

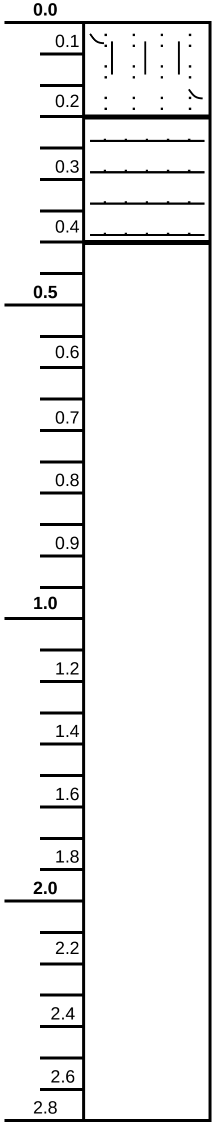
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	37, 38, 39
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	30-04-2017

TEST PIT LOGS

Position: *Main Pipeline Trial Hole 37*

S 32°05'25.0" E 27°55'28.6"



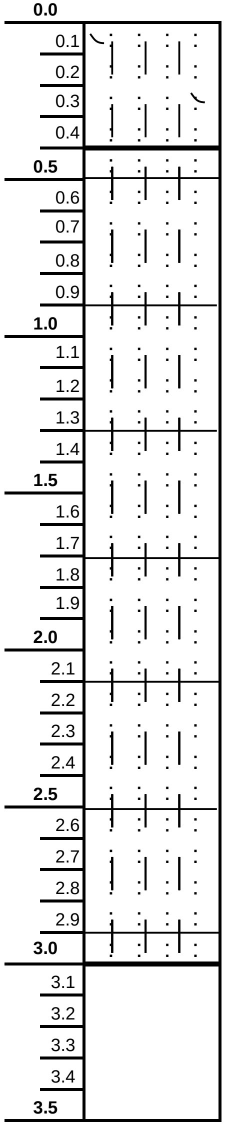
Moist, light Brown, soft, intact,
silty sand + Roots.
Transported:

Moist, light Red Brown, very hard to
extremely hard, micro-shattered, Sandstone.
Residual:

SAMPLES TAKEN: 3359, 3360
No ground water
Refusal @ 400mm on Sandstone Plate

Position: *Main Pipeline Trial Hole 38*

S 32°05'35.1" E 27°55'34.1"



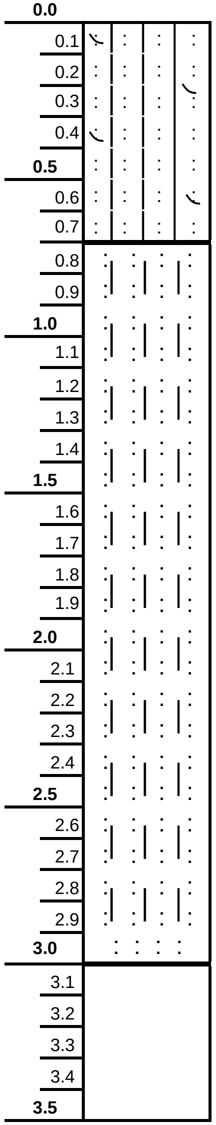
Moist, light Red, soft, intact,
silty sand + Roots.
Transported:

Moist, light Red Orange, soft to hard,
micro-shattered, Sandstone + silty sand.
Residual:

SAMPLES TAKEN:3361, 3362
No ground water
No refusal @ 3000mm

Position: *Main Pipeline Trial Hole 39*

S 32°05'35.8" E 27°55'46.4"



Moist, light Red, soft, intact,
sandy silt + Roots.
Transported:

Moist, light Red Orange, soft to hard,
foliated, decomposed Dolerite + silty sand.
Residual:

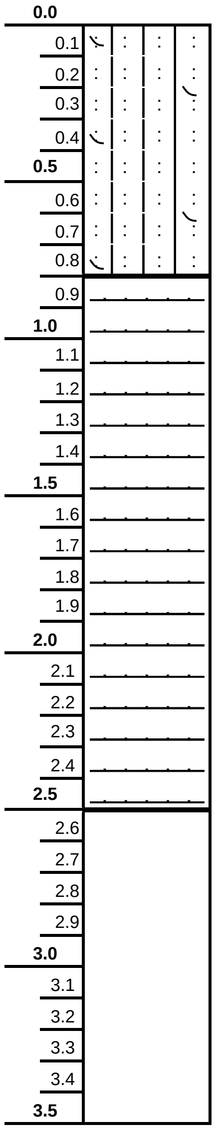
SAMPLES TAKEN: 3364, 3365
No ground water
No refusal @ 3000mm

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019
TRIAL PIT No.'s : 40, 41, 42
EXCAVATED BY: TLB
DATE: 30-04-2017 & 02-05-2017

TEST PIT LOGS

Position: *Main Pipeline Trial Hole 40*

S 32°05'33.0" E 27°55'59.7"



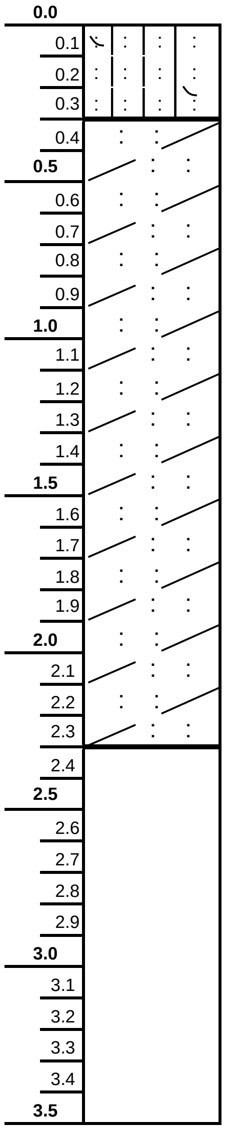
Moist, dark Grey, soft, intact,
sandy silt + Roots.
Transported:

Moist, light Yellow Orange, hard to extremely hard, micro-shattered, Sandstone.
Residual:

SAMPLE TAKEN: 3366
No ground water
Refusal @ 2500mm on Sandstone

Position: *Main Pipeline Trial Hole 41*

S 32°05'26.9" E 27°56'09.6"



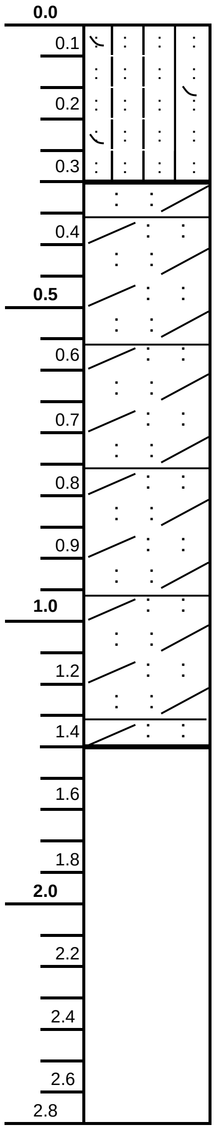
Moist, light Red Brown, soft, intact,
sandy silt + Roots.
Transported:

Moist, dark Red Brown, very hard to extremely hard, foliated, decomposed Dolerite + clayey sand.
Residual:

SAMPLE TAKEN: 3368
No ground water
Refusal @ 2300mm on decomposed Dolerite

Position: *Main Pipeline Trial Hole 42*

S 32°05'22.5" E 27°56'21.0"



Moist, light Red Brown, soft, intact,
sandy silt + Roots.
Transported:

Moist, dark Red Orange, very hard to extremely hard, micro-shattered, Sandstone + clayey sand.
Residual:

SAMPLES TAKEN: 3370, 3371
No ground water
Refusal @ 1300mm on Sandstone

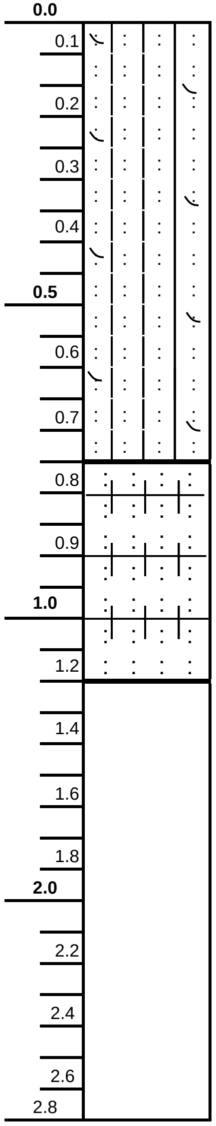
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	43, 44, 45
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	02-05-2017

TEST PIT LOGS

Position: *Main Pipeline Trial Hole 43*

S 32°05'21.7"   E 27°56'34.5"



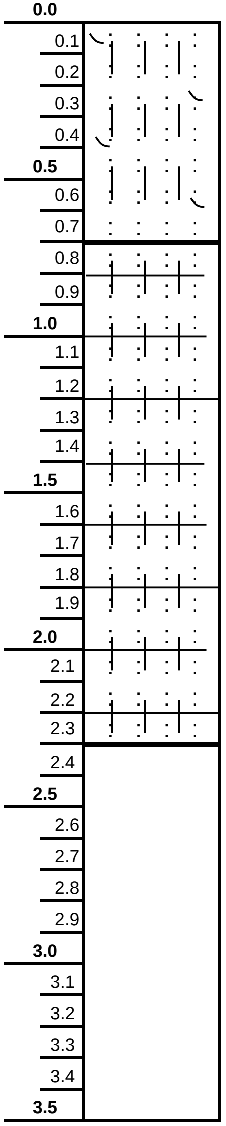
Moist, dark Brown, soft, intact,
sandy silt + Roots.
Transported:

Moist, light Brown, very hard to extremely hard, micro-shattered, Sandstone + silty sand.
Residual:

SAMPLES TAKEN: 3372, 3373
No ground water
Refusal @ 1200mm on Sandstone

Position: *Main Pipeline Trial Hole 44*

S 32°05'15.9"   E 27°56'44.2"



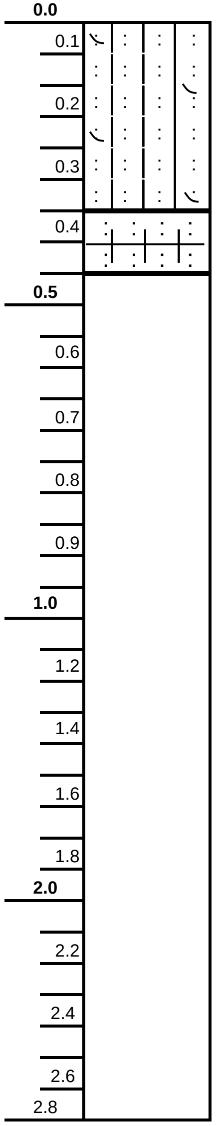
Moist, dark Brown, soft, intact,
silty sand + Roots.
Transported:

Moist, dark Yellow, hard, micro-shattered,
Sandstone + silty sand.
Residual:

SAMPLES TAKEN: 3374, 3375
No ground water
Refusal @ 2300mm on Sandstone

Position: *Main Pipeline Trial Hole 45*

S 32°05'06.4"   E 27°56'50.7"



Moist, dark Brown, soft, intact,
sandy silt + Roots.
Transported:

Slightly moist, dark Yellow, very hard to extremely hard, micro-shattered,
Sandstone + silty sand.   Residual:

SAMPLES TAKEN: 3376, 3377
No ground water
Refusal @ 410mm on Sandstone Plate

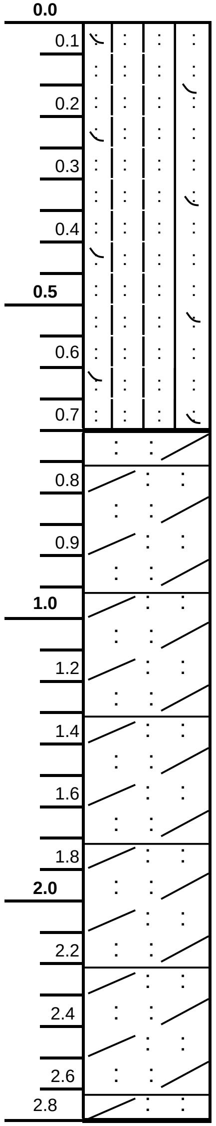
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019
TRIAL PIT No.'s : 46
EXCAVATED BY: TLB
DATE: 07-05-2017

TEST PIT LOGS

Position: ***Main Pipeline Trial Hole 46***

S 32°04'57.3"   E 27°56'56.6"



Moist, dark Brown, soft, intact,
sandy silt + Roots.
Transported:

Moist, Pale Red, hard to very hard,
micro-shattered, Sandstone + clayey sand.
Residual:

SAMPLES TAKEN: 3378, 3379
No ground water
No refusal @ 2800mm

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

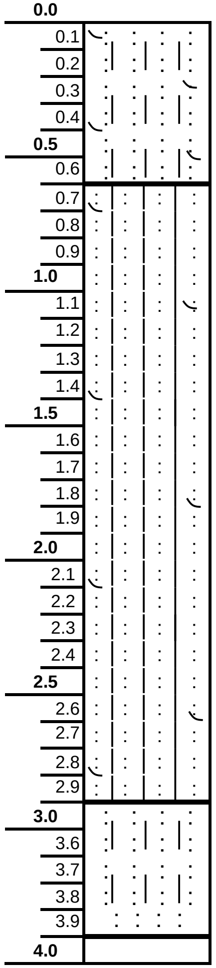
CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 1, 2, 3
EXCAVATED BY: TLB
DATE: 25-04-2017

TEST PIT LOGS

Position: *PS 1 Trial Hole 1*

S 32°02'07.3"
E 27°49'36.3"



Moist, light Brown, soft, intact,
silty sand + Roots.
Transported:

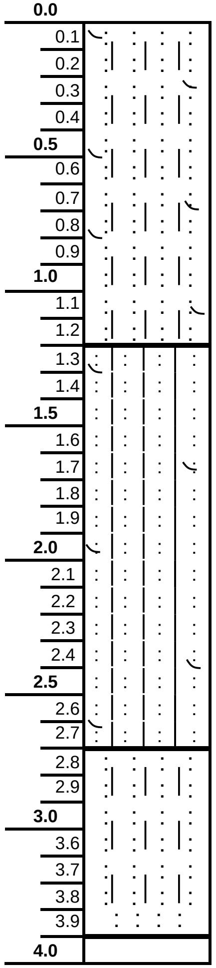
Moist, light Red, soft to firm, intact,
sandy silt + Roots,
Transported:

Moist, light Red Brown, firm, intact,
silty sand + Dolerite cobbles.
Transported:

SAMPLE TAKEN: 3400
No ground water
No refusal @ 3900mm

Position: *PS 1 Trial Hole 2*

S 32°02'07.4"
E 27°49'36.8"



Moist, light Brown, soft, intact,
silty sand + Roots.
Transported:

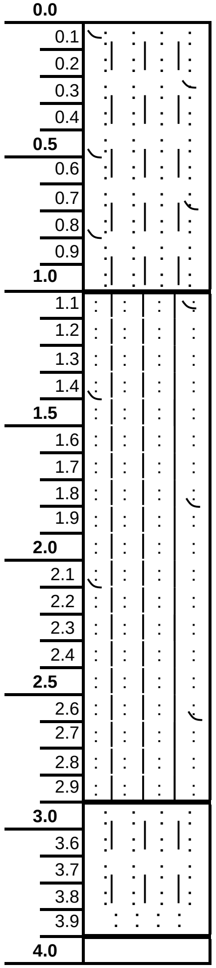
Moist, light Red, soft to firm, intact,
sandy silt + Roots.
Transported:

Moist, light Yellow Orange, soft to firm,
intact, silty sand + Dolerite cobbles.
Transported:

SAMPLE TAKEN: 3402
No ground water
No refusal @ 3900mm

Position: *PS 1 Trial Hole 3*

S 32°02'07.0"
E 27°49'36.6"



Moist, light Brown, soft, intact,
silty sand + Roots.
Transported:

Moist, light Red, soft to firm, intact,
sandy silt + Roots.
Transported:

Moist, light Yellow Orange, soft to firm,
intact, silty sand + Dolerite Boulders.
Transported:

SAMPLE TAKEN: 3404
No ground water
No refusal @ 3900mm

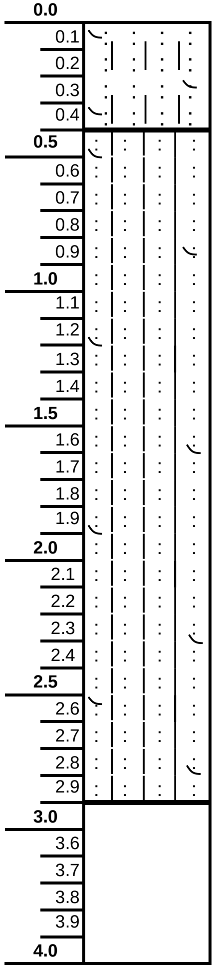
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	4, 5, 6
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	25-04-2017

TEST PIT LOGS

Position: *PS 1 Trial Hole 4*

S 32°02'07.2"
E 27°49'37.1"



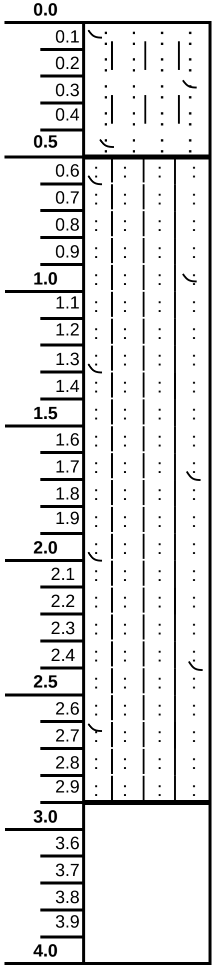
Moist, light Brown, soft, intact, silty sand + Roots.
Transported:

Moist, light Red, firm, intact, sandy silt + Roots,
Transported:

SAMPLE TAKEN: 3406
No ground water
No refusal @ 2900mm

Position: *PS 1 Trial Hole 5*

S 32°02'07.9"
E 27°49'37.3"



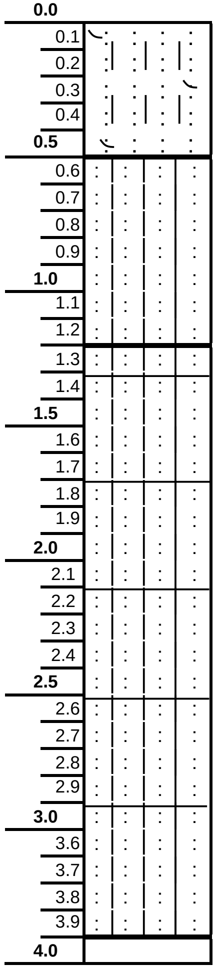
Moist, light Brown, soft, intact, silty sand + Roots.
Transported:

Moist, light Red, firm, intact, sandy silt + Roots,
Transported:

SAMPLE TAKEN: 3407
No ground water
No refusal @ 2900mm

Position: *PS 1 Trial Hole 6*

S 32°02'08.3"
E 27°49'36.3"



Moist, light Brown, soft, intact, silty sand + Roots.
Transported:

Moist, light Orange, soft to firm, intact, sandy silt.
Transported:

Moist, light Red, soft to hard, micro-shattered, highly weathered Sandstone + sandy silt.
Residual:

SAMPLE TAKEN: 3408
No ground water
No refusal @ 3900mm

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

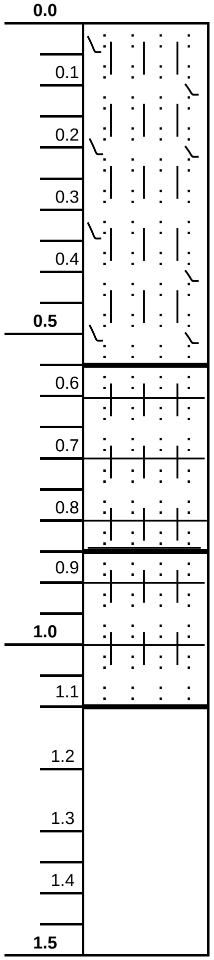
CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 1, 2, 3
EXCAVATED BY: TLB
DATE: 03-05-2017

TEST PIT LOGS

Position: *PS 2 Trial Hole 1*

S 32°03'20.1"
E 27°52'37.7"



Moist, light Brown, soft, intact,
silty sand + Roots.
Transported:

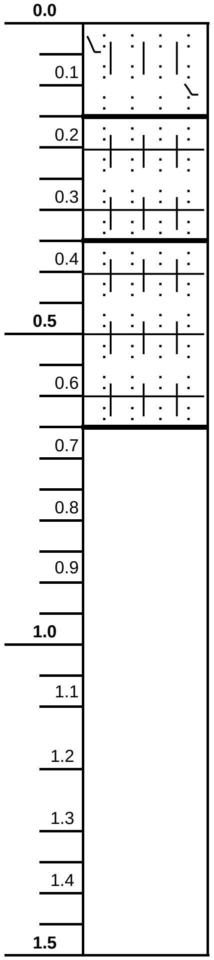
Slightly moist, light Brown, soft to hard,
micro-shattered, weathered Sandstone.
silty sand.
Residual:

Slightly moist, dark Red Brown, very hard to
extremely hard, micro-shattered, Sandstone +
silty sand.
Residual:

SAMPLE TAKEN: 3409
No ground water.
Refusal @ 1100mm on Sandstone Plate

Position: *PS 2 Trial Hole 2*

S 32°03'21.0"
E 27°52'39.7"



Moist, light Brown, soft to firm, intact,
silty sand + Roots + Sandstone gravel.
Transported:

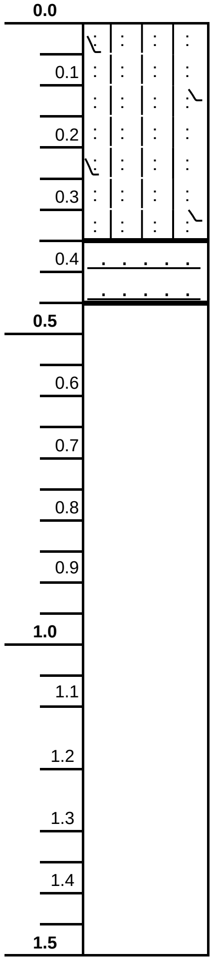
Moist, dark Red Brown, hard, micro-shattered,
weathered Sandstone + silty sand.
Residual:

Slightly moist, light Brown, very hard to
extremely hard, micro-shattered, Sandstone +
silty sand.
Residual:

SAMPLE TAKEN: 3410
No ground water.
Refusal @ 660mm on Sandstone Plate

Position: *PS 2 Trial Hole 3*

S 32°03'21.2"
E 27°52'41.9"



Moist, light Brown, soft, intact,
silty sand + Roots + Sandstone gravel.
Transported:

Moist, light Red Brown, hard, micro-
shattered, weathered Sandstone.
Residual:

NO SAMPLES TAKEN:
No ground water.
Refusal @ 400mm on Sandstone Plate

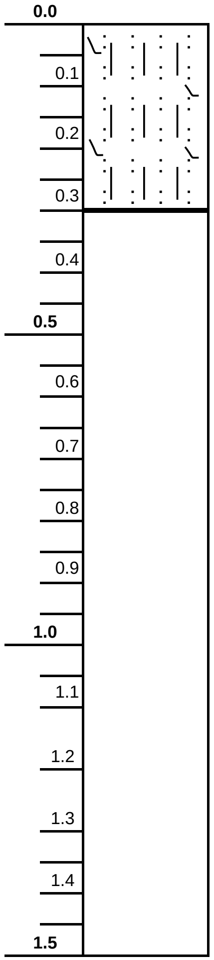
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
2010000682907

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 4, 5, 6
EXCAVATED BY: TLB
DATE: 03-05-2017

TEST PIT LOGS

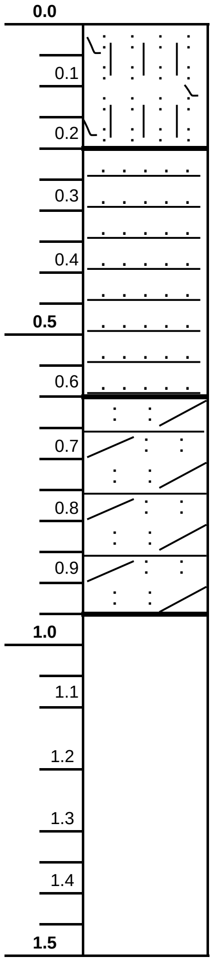
Position: ***PS 2 Trial Hole 4***
S 32°03'22.6"
E 27°52'36.7"



Moist, light Brown, soft, intact,
silty sand + Roots + Sandstone gravel.
Transported:

NO SAMPLE TAKEN:
No ground water.
Refusal @ 300mm on Sandstone Plate

Position: ***PS 2 Trial Hole 5***
S 32°03'22.5"
E 27°52'39.2"



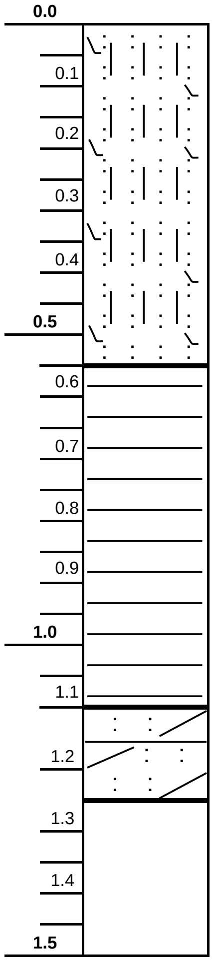
Moist, light Brown, soft, intact,
silty sand + Roots + Sandstone gravel.
Transported:

Slightly moist, light Red Brown, soft to
hard, micro-shattered, weathered
Sandstone.
Residual:

Slightly moist, light Red Orange, very hard,
to extremely hard, micro-shattered,
Sandstone + clayey sand.
Residual:

SAMPLE TAKEN: 3412
No ground water.
Refusal @ 960mm on Sandstone Plate

Position: ***PS 2 Trial Hole 6***
S 32°03'23.2"
E 27°52'41.1"



Moist, light Red Brown, soft, intact,
silty sand + Roots.
Transported:

Moist, light Red Orange, hard, shattered,
Mudstone.
Residual:

Moist, light Yellow, very hard to
extremely hard, micro-shattered,
Mudstone + clayey sand.
Residual:

SAMPLES TAKEN:
No ground water.
Refusal @ 1230mm on Sandstone Plate

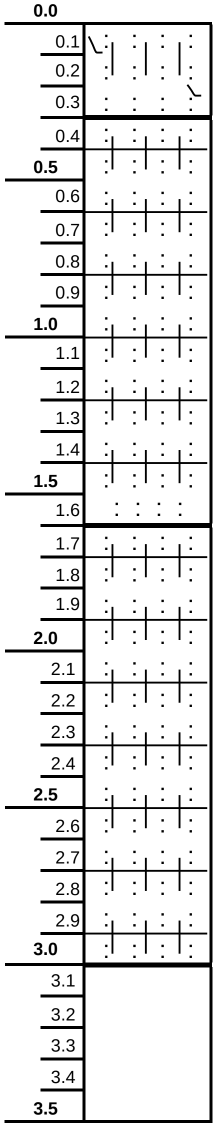
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019
TRIAL PIT No.'s : 1, 2, 3
EXCAVATED BY: TLB
DATE: 01-05-2017

TEST PIT LOGS

Position: RESERVOIR Trial Hole 1

S 32°04'56.9"
E 27°56'56.9"



Moist, light Brown, firm, intact, silty sand + Roots + Mudstone gravel.
Transported:

Slightly moist, dark Red Brown, hard, shattered, Mudstone + silty sand.
Residual:

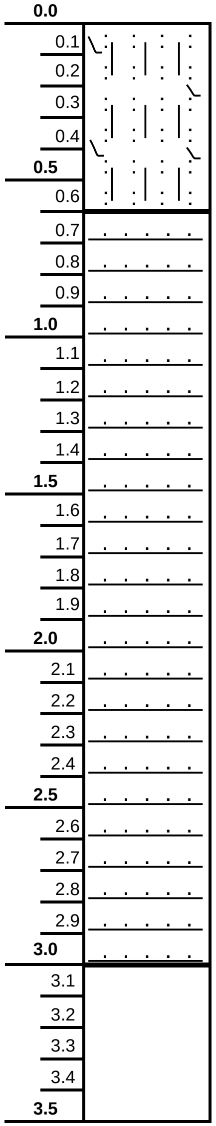
Moist, light Yellow Orange, soft, micro-shattered, Sandstone + silty sand.
Residual:

Moist, Pale Red, soft to hard, shattered, Mudstone + silty sand.
Residual:

SAMPLES TAKEN: 3415, 3416
No ground water
No refusal @ 3000mm

Position: RESERVOIR Trial Hole 2

S 32°04'56.5"
E 27°56'55.9"



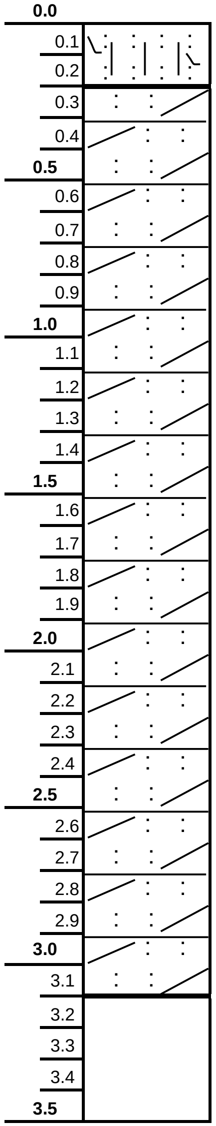
Moist, light Brown, soft, intact, silty sand + Roots.
Transported:

Slightly moist, Purple, hard, micro-shattered, Sandstone.
Residual:

SAMPLE TAKEN: 3417
No ground water
No refusal @ 3000mm

Position: RESERVOIR Trial Hole 3

S 32°04'56.0"
E 27°56'57.3"



Moist, light Brown, soft, intact, silty sand + Roots. Transported:
Slightly moist, Pale Red, hard, shattered, Shale + clayey sand.
Residual:

SAMPLE TAKEN: 3418
No ground water
No refusal @ 3100mm

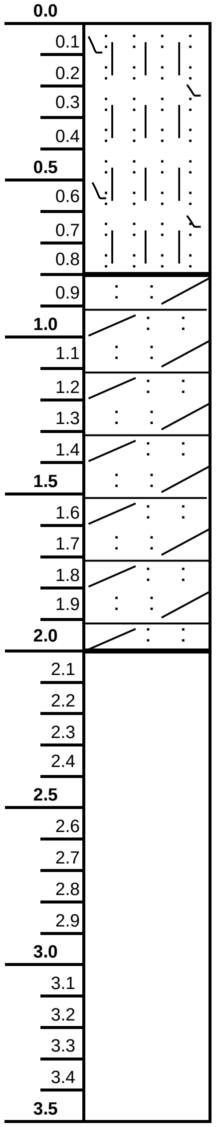
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019
TRIAL PIT No.'s : 4, 5, 6
EXCAVATED BY: TLB
DATE: 01-05-2017

TEST PIT LOGS

Position: *RESERVOIR Trial Hole 4*

S 32°04'57.1"
E 27°56'58.2"



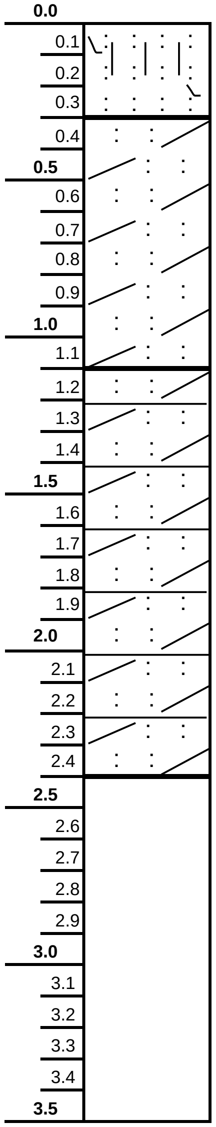
Moist, light Brown, soft, intact, silty sand + Roots.
Transported:

Slightly moist, Pale Red, hard to very hard, micro-shattered, Sandstone + clayey sand.
Residual:

SAMPLE TAKEN: 3419
No ground water
Refusal @ 2500mm on Sandstone

Position: *RESERVOIR Trial Hole 5*

S 32°04'57.9"
E 27°56'57.2"



Moist, light Brown, soft, intact, silty sand + Roots.
Transported:

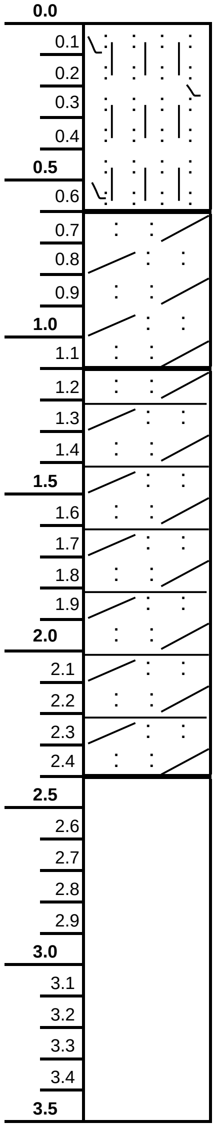
Moist, dark Brown, firm, slickensided, clayey sand.
Transported:

Moist, Pale Red, hard to extremely hard, micro-shattered, Sandstone + clayey sand.
Residual:

SAMPLE TAKEN: 3420
No ground water
Refusal @ 2400mm on Sandstone

Position: *RESERVOIR Trial Hole 6*

S 32°04'57.7"
E 27°56'56.0"



Moist, light Brown, soft, intact, silty sand + Roots.
Transported:

Moist, dark Brown, firm, slickensided, clayey sand.
Transported:

Slightly moist, Pale Red, very hard to extremely hard, micro-shattered, Shale + clayey sand.
Residual:

SAMPLE TAKEN: 3421
No ground water
Refusal @ 2400mm on Sandstone

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	1 - 3
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	26-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 1

TRIAL HOLE 2

TRIAL HOLE 3

ControLab South Africa (Pty) Ltd

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	4 - 6
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	26-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 4

TRIAL HOLE 5

TRIAL HOLE 6

ControLab South Africa (Pty) Ltd

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	7 - 9
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	27-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 7

TRIAL HOLE 8

TRIAL HOLE 9

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	10 - 12
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	27-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 10

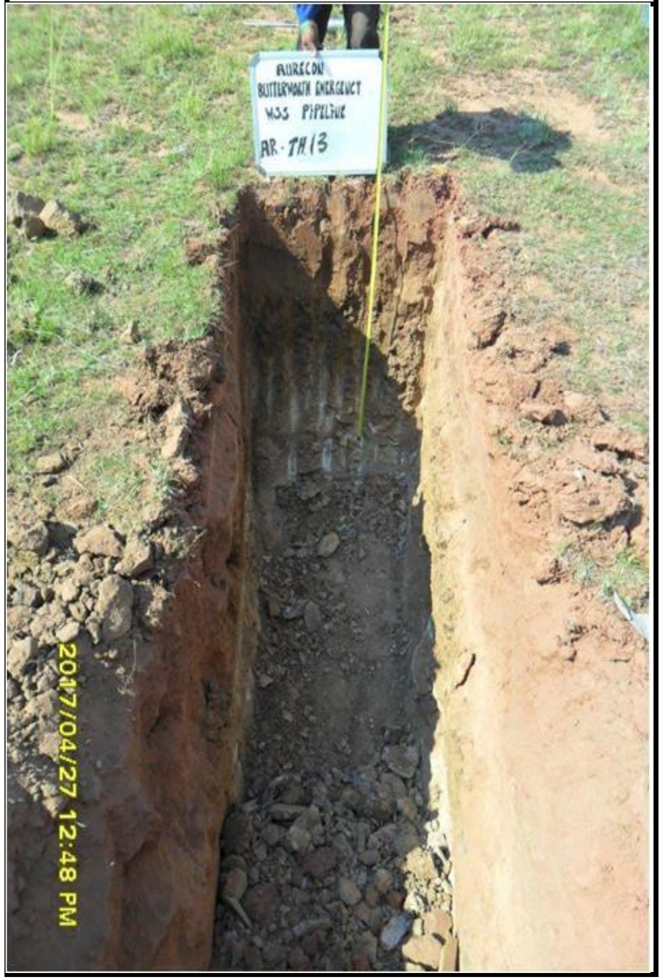
TRIAL HOLE 11

TRIAL HOLE 12

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	13
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	27-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 13



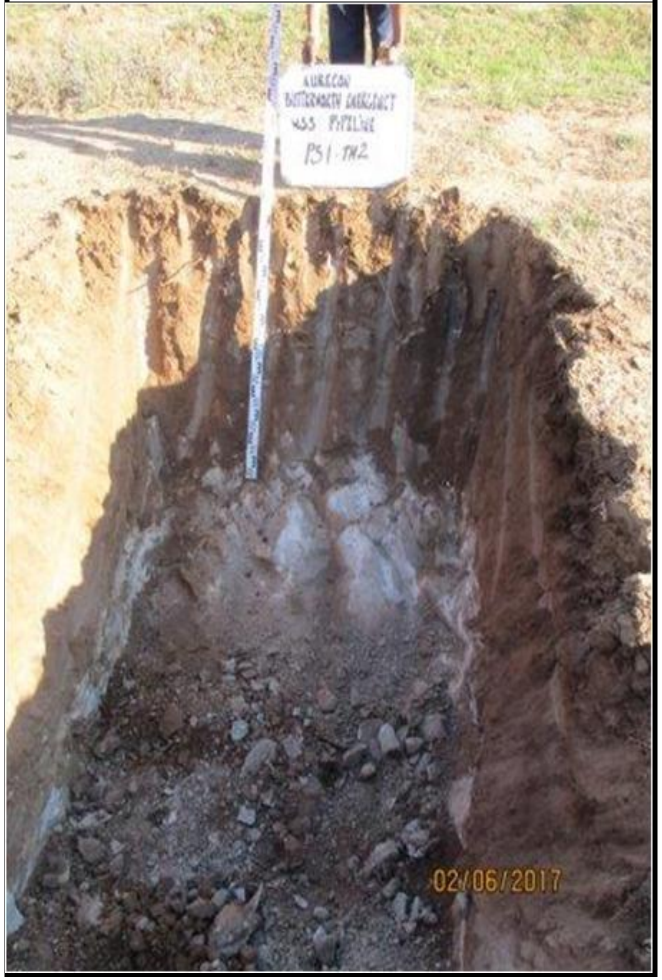
ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	1 - 3
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	02-06-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 1

TRIAL HOLE 2



TRIAL HOLE 3

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	4 - 5
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	02-06-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 4

TRIAL HOLE 5

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	6A - 8A
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	02-06-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 6A

TRIAL HOLE 7A

TRIAL HOLE 8A

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	9A
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	02-06-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 9A

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

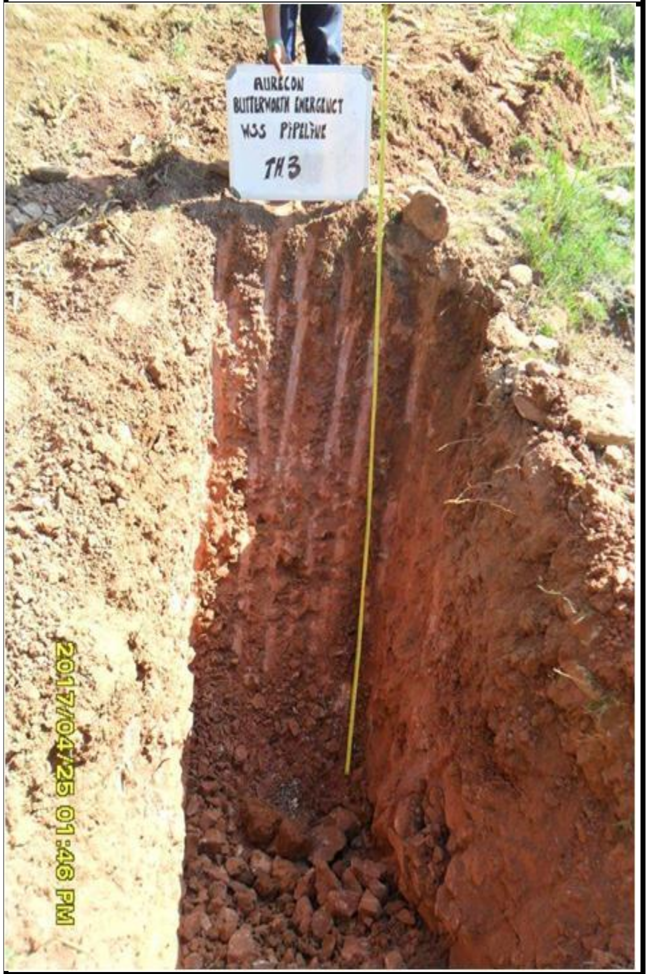
TRIAL PIT No.'s : 1 - 3
EXCAVATED BY: TLB
DATE: 25-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 1

TRIAL HOLE 2

TRIAL HOLE 3



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CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 4 - 6
EXCAVATED BY: TLB
DATE: 26-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 4

TRIAL HOLE 5

TRIAL HOLE 6

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CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
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CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	7 - 9
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	26-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 7

TRIAL HOLE 8

TRIAL HOLE 9

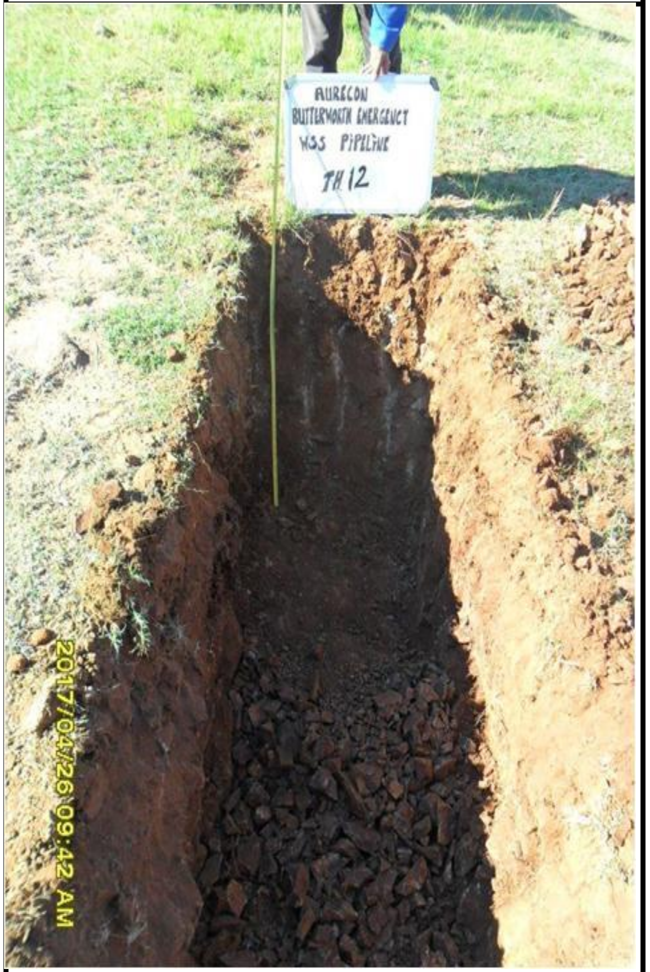
CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019
TRIAL PIT No.'s : 10 - 12
EXCAVATED BY: TLB
DATE: 26-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 10

TRIAL HOLE 11

TRIAL HOLE 12



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CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 13 - 15
EXCAVATED BY: TLB
DATE: 26-04-2017 & 27-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 13

TRIAL HOLE 14

TRIAL HOLE 15

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CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	16 - 18
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	28-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 16

TRIAL HOLE 17

TRIAL HOLE 18

CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 19 - 21
EXCAVATED BY: TLB
DATE: 28-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 19

TRIAL HOLE 20

TRIAL HOLE 21

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CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	22 - 24
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	28-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 22

TRIAL HOLE 23

TRIAL HOLE 24

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	25 - 27
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	28-04-2017 & 29-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 25

TRIAL HOLE 26

TRIAL HOLE 27

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201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	28 - 30
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	29-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 28

TRIAL HOLE 29

TRIAL HOLE 30

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CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019
TRIAL PIT No.'s : 31 - 33
EXCAVATED BY: TLB
DATE: 29-04-2017 & 30-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 31

TRIAL HOLE 32

TRIAL HOLE 33

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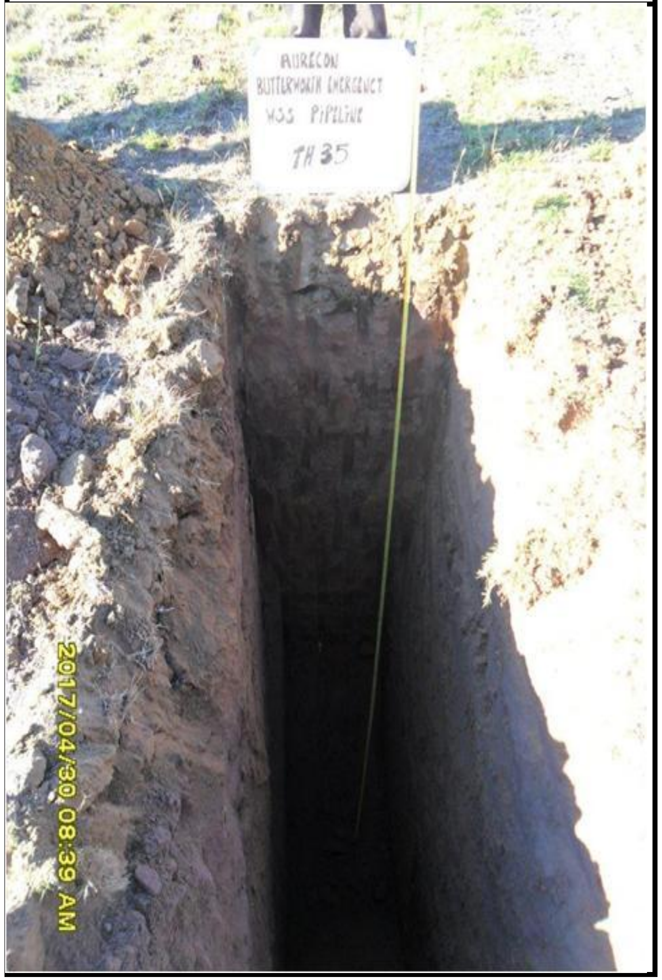
CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	34 - 36
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	30-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 34

TRIAL HOLE 35



TRIAL HOLE 36

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CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 37 - 39
EXCAVATED BY: TLB
DATE: 30-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 37

TRIAL HOLE 38

TRIAL HOLE 39

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CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
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CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 40 - 42
EXCAVATED BY: TLB
DATE: 30-04-2017 & 02-05-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 40

TRIAL HOLE 41

TRIAL HOLE 42

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CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	43 - 45
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	02-05-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 43

TRIAL HOLE 44

TRIAL HOLE 45

ControLab South Africa (Pty) Ltd

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

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CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	46
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	07-05-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 46

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CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	1 - 3
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	25-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 1

TRIAL HOLE 2

TRIAL HOLE 3

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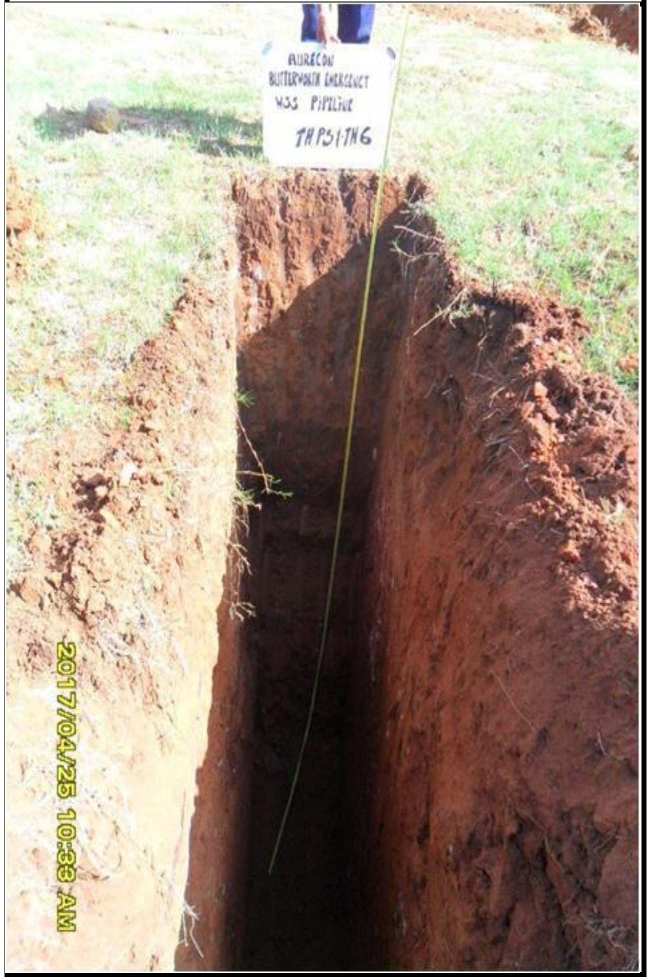
CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	4 - 6
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	25-04-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 4

TRIAL HOLE 5

TRIAL HOLE 6



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201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	1 - 3
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	03-05-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 1

TRIAL HOLE 2

TRIAL HOLE 3

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201000682907

CLIENT:	Aurecon SA (Pty) Ltd	**TRIAL PIT No.'s :**	4 - 6
PROJECT:	NGQAMAKHWE RWSS PHASE 5	**EXCAVATED BY:**	TLB
REF:	MT32019	**DATE:**	03-05-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 4

TRIAL HOLE 5

TRIAL HOLE 6

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CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
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CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 1 - 3
EXCAVATED BY: TLB
DATE: 01-05-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 1

TRIAL HOLE 2

TRIAL HOLE 3

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
201000682907

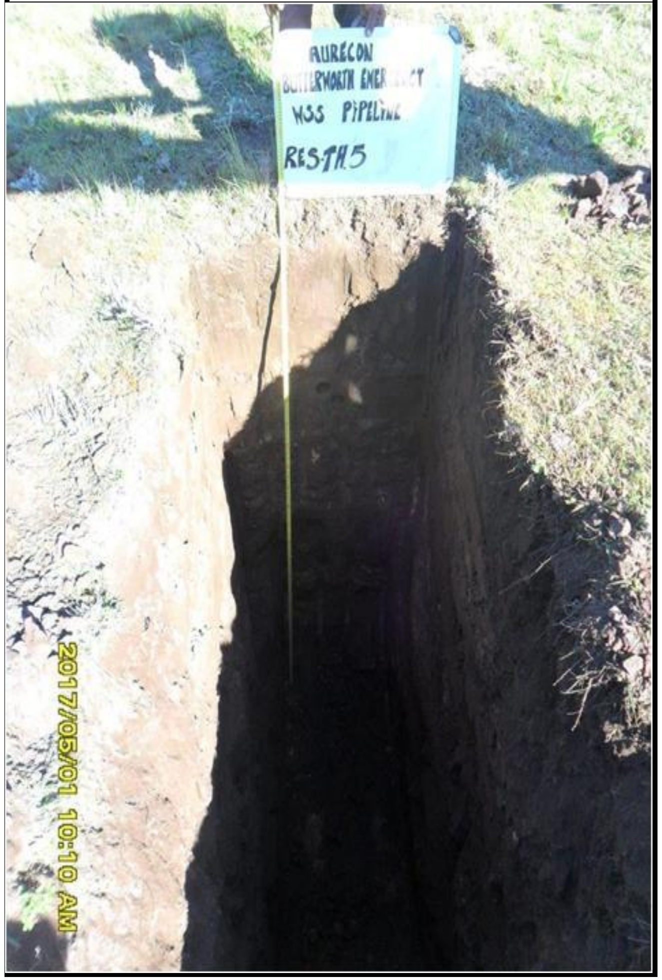
CLIENT: Aurecon SA (Pty) Ltd
PROJECT: NGQAMAKHWE RWSS PHASE 5
REF: MT32019

TRIAL PIT No.'s : 4 - 6
EXCAVATED BY: TLB
DATE: 01-05-2017

TEST PIT PHOTOGRAPHS

TRIAL HOLE 4

TRIAL HOLE 5



TRIAL HOLE 6

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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Queenstown, Lusaka - Zambia

---

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214

ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
ALTERNATIVE PUMP STATION 1
DATE RECEIVED: 2017-06-02
DATE TESTED: 2017-06-14
DATE REPORTED: 2017-06-20
TEST REPORT NO.: MT32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	3896					
POSITION	PS 1					
	TP 1					
DEPTH m	1.6					
DESCRIPTION	dk R Br					
	sdy st					

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm						
37.5 mm						
19 mm						
9.5 mm						
4.75 mm						
2.36 mm						
1.18 mm	100					
0.600 mm	99					
0.425 mm	99					
0.300 mm	95					
0.150 mm	70					
0.075 mm	44.3					

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	39					
0.02 mm	24					
0.006 mm	19					
0.002 mm	18					

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	21					
PLASTICITY INDEX	9					
LINEAR SHRINKAGE	4					

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

DOUBLE HYDROMETER %:	5					
PI WHOLE SAMPLE	8.0					
POTENTIAL EXPANSIVENESS	LOW					

Technical Signatory:
J Atterbury

Remarks:

Samples Delivered by Customer

Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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Testing Laboratory
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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Queenstown, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214

ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
ALTERNATIVE PUMP STATION SITE
DATE RECEIVED: 2017-06-07
DATE TESTED: 2017-06-13
DATE REPORTED: 2017-06-29
TEST REPORT NO.: MT32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	4017	4018	4019	4021	4022	4023
POSITION	PS1/TP 1A	PS1/TP 2A		PS1/TP 3A	PS1/TP 4A	PS1/TP 5A
DEPTH mm	1700 - 2100	400 - 1000	1000 - 1200	2800 - 3400	1800 - 2200	1100 - 1400
DESCRIPTION	lt Br	Pale R	lt R Br	lt Br	lt Br	lt Br
	Ss +	sdy st	Ss +	Ms +	Ss +	Ss +
	sty s		sty s	sty s	sty s	sty s

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm	100		100		100	100
37.5 mm	49		49	100	60	65
19 mm	36		43	70	45	52
9.5 mm	32		37	65	39	44
4.75 mm	29		33	54	34	40
2.36 mm	26	100	30	43	31	37
1.18 mm	25	99	29	28	29	35
0.600 mm	24	97	28	21	27	33
0.425 mm	23	96	27	19	26	32
0.300 mm	23	90	27	18	24	30
0.150 mm	17	72	20	15	15	19
0.075 mm	9.9	39.1	12.8	8.8	8.9	11.2
GRADING MODULUS	2.4	0.6	2.3	2.3	2.3	2.2

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	9	10	12	9	8	10
0.02 mm	7	8	9	8	6	8
0.006 mm	6	7	8	6	6	7
0.002 mm	5	6	8	5	5	6

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	23	18	25	24	22	24
PLASTICITY INDEX	11	6	12	11	10	9
LINEAR SHRINKAGE	5.5	3.5	6.5	5.5	5.0	4.5

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

PI WHOLE SAMPLE	3.0	6.0	3.0	2.0	3.0	3.0
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW	LOW	LOW	LOW

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

Maximum Dry Density (kg/m^3)	2140	1922		2154		
Optimum Moisture Content (%)	8.2	10.8		7.7		
C.B.R. @ 100% COMPACTION	58	30		75		
C.B.R. @ 98 % COMPACTION	43	22		52		
C.B.R. @ 95 % COMPACTION	27	14		30		
C.B.R. @ 93 % COMPACTION	20	10		21		
C.B.R. @ 90 % COMPACTION	13	7		12		
SWELL @ 100% COMP. (%)	0.20	0.40		0.70		
T R H 14 CLASSIFICATION	G6	G8		G6		

The above test results are pertinent to the samples received and tested only.
While the tests are carried our according to recognized standards Controlab shall not be liable for erroneous testing or reporting thereof. This report may not be reproduced except in full without prior consent of Controlab.

Technical Signatory:
J Atterbury

Remarks:
Samples Delivered by Customer
Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

ControLab South Africa (Pty) Ltd
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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Queenstown, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
P O Box 19553
TECOMA
5214
ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS - PHASE 5
ALTERNATIVE PUMP STATION 1
DATE.: 2017-06-20
REF NO.: MT32019

Determination of Crumb Test

SAMPLE NO.	POSITION	SOLUTION	CRUMB CONDITION	TIME	CLASSIFICATION
3896	PUMPSTATION 1-ALT-TP1 @ 1.6m	0.001N NaOH	AIR DRIED	10 min	1
				2 hrs	1
				>16 hrs	1

GRADE CLASSIFICATION FOR A CRUMB TEST (WALKER, 1997)

GRADE	REACTION	DESCRIPTION
1	No Reaction	Crumbs may slake, but no sign of cloudiness by colloids in suspension.
2	Slight Reaction	Bare hint of cloudiness in water at surface of crumb.
3	Moderate Reaction	Easily recognisable cloud of colloids in suspension, usually spreading out in thin streaks on bottom of beaker.
4	Strong Reaction	Colloid cloud covers nearly the whole bottom of the beaker, usually as a thick skin.

Technical Signatory:____________
J Atterbury

ControLab South Africa (Pty) Ltd

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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Queenstown, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
P O Box 19553
TECOMA
5214

PROJECT: NGQAMAKHWE RWSS - PHASE 5
ALTERNATIVE PUMP STATION 1

DATE REPORTED: 2017-06-20

ATT: Mr D Luhring

TEST REPORT NO.: MT32019

PINHOLE TEST - ASTM D4221-90 METHOD

SAMPLE NO: 3896
SOURCE: PUMPSTATION 1 - ALT - TP1 @ 1.6m
TEST CONDITIONS: Remoulded at In-Situ Density

DRY DENSITY (Kg/m3): 1961
MC %: 8.7
DESCRIPTION: dk R Br sdy st

TIME	HEAD	FLOW PARAMETERS		FLOW RATE ml/s	FINAL FLOWRATE ml/s	TURBIDITY FROM SIDE	HOLE SIZE AFTER TEST
		ml.	sec.				
0	55mm	0	60	0.000			
		0	120	0.000			
		0	180	0.000			
		0	240	0.000			
5min		0	300	0.000			
10min		0	600	0.000	0.000		
AVERAGE FLOWRATE		0	600	0.000		COMPLETELY CLEAR	COLLAPSE
0	180mm	0	60	0.000			
		0	120	0.000			
		0	180	0.000			
		0	240	0.000			
5min		0	300	0.000			
10min		0	600	0.000	0.000		
AVERAGE FLOWRATE		0	600	0.000		COMPLETELY CLEAR	COLLAPSE
0	385	0	60	0.000			
		0	120	0.000			
		0	180	0.000			
		0	240	0.000			
5min		0	300	0.000			
10min		10	600	0.017	0.017		
AVERAGE FLOWRATE		10	600	0.002		MODERATLEY DARK	COLLAPSE
						DISPERSIVE GRADE CLASSIFICATION	**D1/D2**

Technical Signatory:
J Atterbury

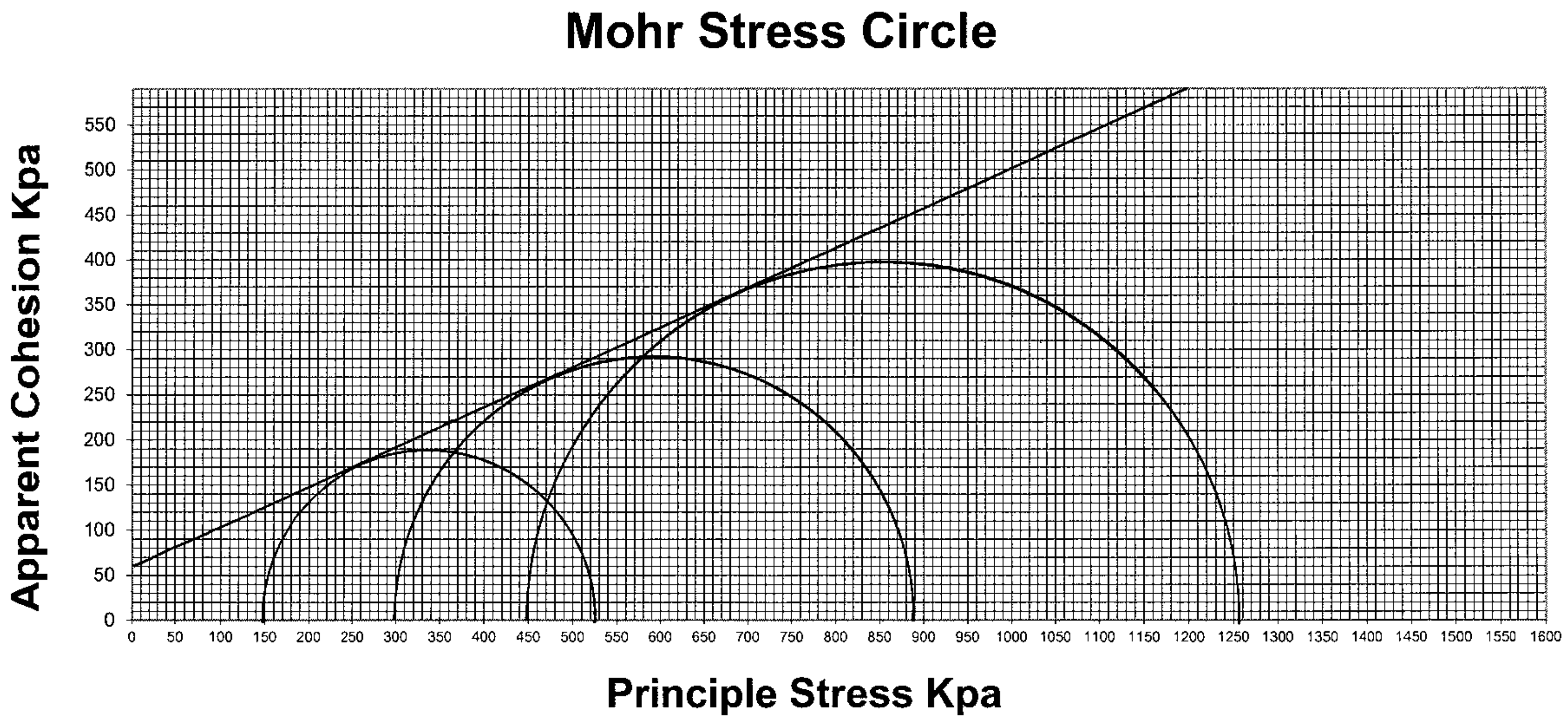
ControLab South Africa (Pty) Ltd

201000682907

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

Date :	June 2017	**Position :**	PUMPSTATION 1 (ALT) - TP1 @ 1.6m - S/No.: 3896
Client :	Aurecon	**Description :**	dk R Br sdy st
Project :	NGQAMAKHWE RWSS	**Test Type :**	Unconsolidated Undrained - Total Stress Analysis
Test Conditions:	Undisturbed	**In-Situ Dry Density : Kg/m3**	1961
		In-Situ MC: %	8.7

Apparent Cohesion (C) = 60Kpa **Angle of Internal Friction (Ø) = 24°**



CONSOLIDATION TEST

SUMMARY OF READINGS

CLIENT: Aurecon SA (Pty) Ltd
PROJECT : NGQAMAKHWE RWSS : PHASE 5
ALTERNATIVE PUMP STATION SITE
INITIAL DIAL READING = 58.055 mm
RING DIAMETER = 79.6 mm

PROJECT NO : MT32019
SAMPLE NO : 3896
POSITION: PS1(ALT)-TH1
DEPTH: 1.6m

H1 = 20 mm
H_S = 13.6045 mm
Dial Gauge Div = 1

OEDOMETER NO : 2
BEAM RATIO : 11

BEAM LOAD	COMMENTS	PRESSURE	DIAL READING	UNCORRECTED DEFLECTION	MACHINE CORRECTION	CORRECTED DEFLECTION	HEIGHT CHANGE	VOID RATIO
(kg)		(Kpa)	(mm)	(mm)	(mm)	(mm)	(mm)	
0.1		2.17	58.055	0.000	0.000	0	20.000	0.4701
1.1		23.85	57.039	1.016	0.000	-1.016	18.984	0.3954
3.1		67.22	56.189	1.866	0.000	-1.866	18.134	0.3329
7.1		153.96	55.340	2.715	0.000	-2.715	17.285	0.2705
7.1	SAT	153.96	53.383	4.672	0.000	-4.672	15.328	0.1267
15.1		327.43	52.447	5.608	0.000	-5.608	14.392	0.0579
31.1		674.38	51.671	6.384	0.000	-6.384	13.616	0.0008
15.1		327.43	51.722	6.333	0.000	-6.333	13.667	0.0046
7.1		153.96	51.774	6.281	0.000	-6.281	13.719	0.0084
3.1		67.22	51.830	6.225	0.000	-6.225	13.775	0.0125
1.1		23.85	51.890	6.165	0.000	-6.165	13.835	0.0169
0.1		2.17	52.063	5.992	0.000	-5.992	14.008	0.0297

% COLLAPSE 9.8

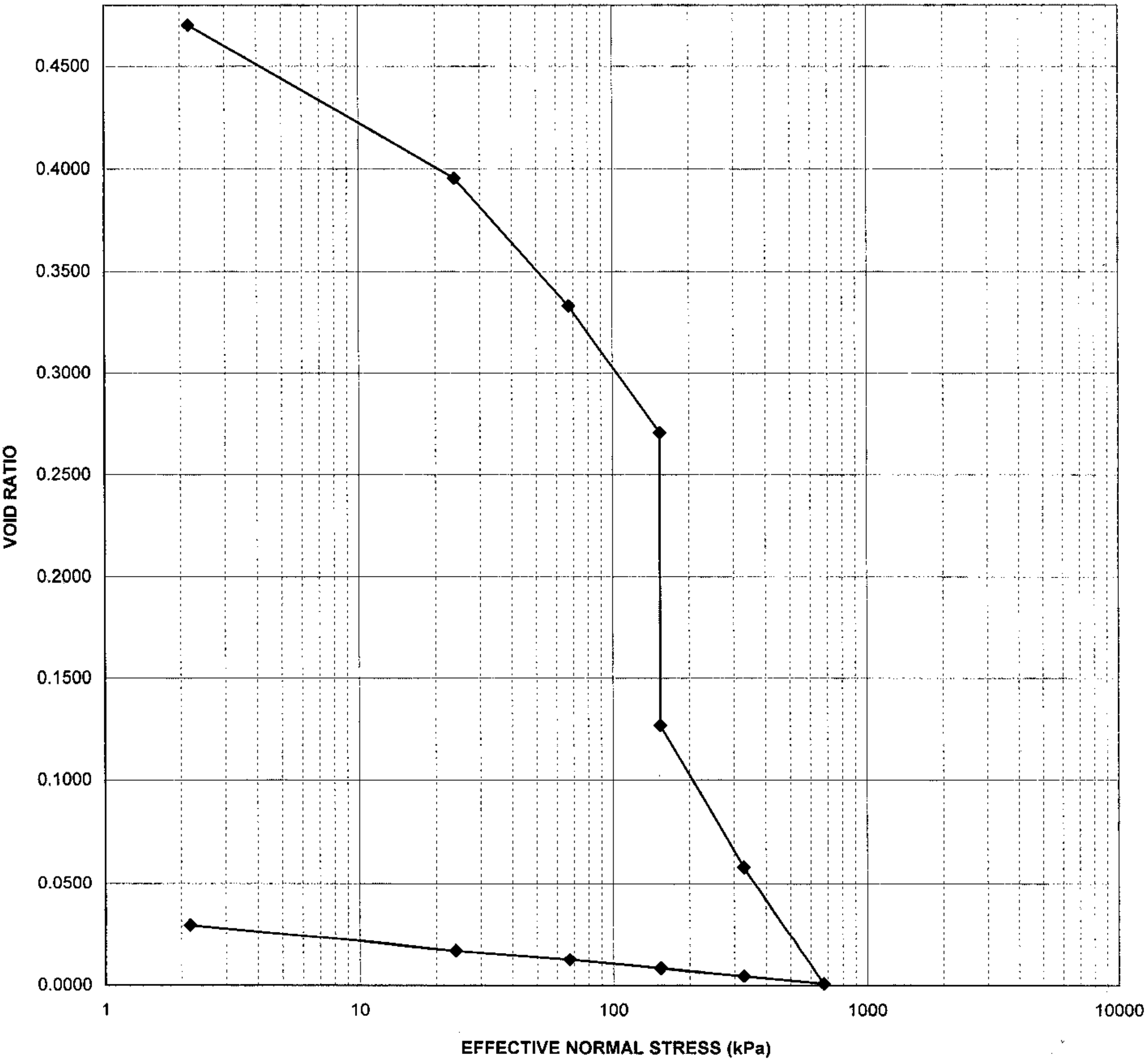
CONSOLIDATION TEST

CLIENT: Aurecon SA (Pty) Ltd
PROJECT : NGQAMAKHWE RWSS : PHASE 5
ALTERNATIVE PUMP STATION SITE

PROJECT NO : MT32019
SAMPLE NO : 3896
POSITION : PS1(ALT)-TH1
DEPTH : 1.6m

SAMPLE DESCRIPTION : dk R Br sdy st
STATE OF SAMPLE : Undisturbed
BULK DENSITY = 1989
DRY DENSITY = 1830 Kg/m3
INITIAL SATURATION = 0.50
INITIAL MOISTURE CONTENT = 8.70 %
INITIAL VOID RATIO = 0.4701
% COLLAPSE 9.8

SPECIFIC GRAVITY est. = 2.69
VOL VOIDS = 0.31977
VOL SOILDS = 0.68023
FINAL SATURATION = 0.85
FINAL MOISTURE CONTENT = 14.9 %
FINAL VOID RATIO = 0.0297



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OTHER BRANCH OFFICES: Cape Town, Kokstad, Johannesburg, Mthatha, Queenstown, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

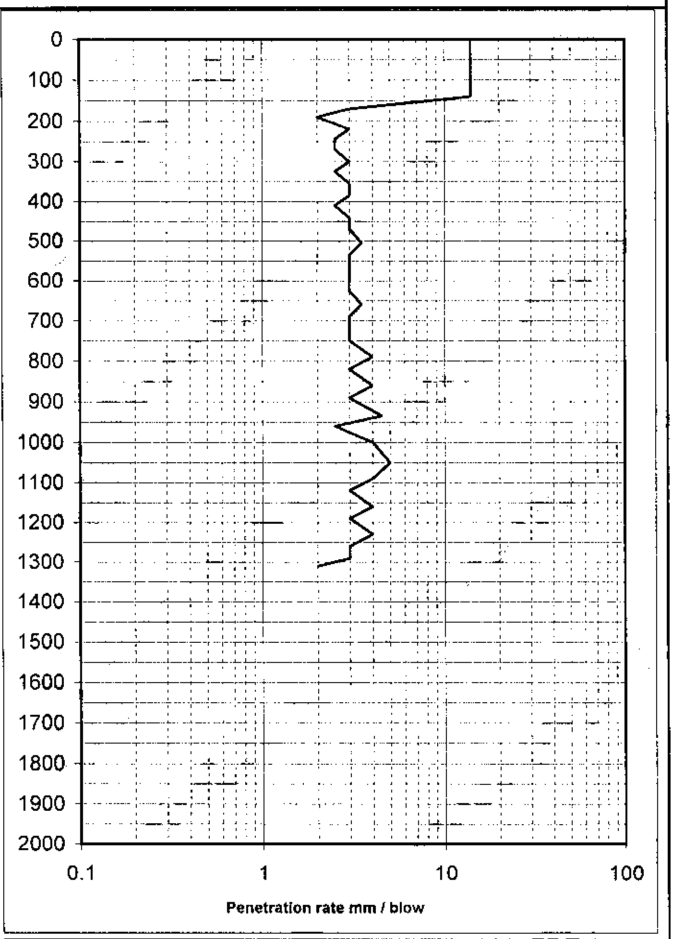
PROJECT: Ngqamakhwe RWSS:
Phase 5
Alternative Pump Station Site
REF: MT32019
DATE: 2017-06-05

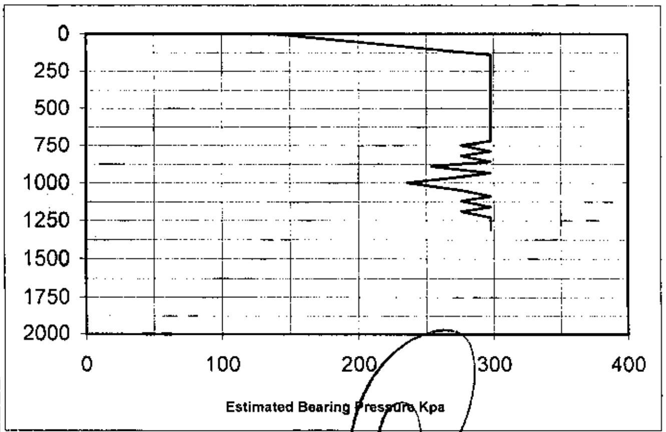
DYNAMIC CONE PENETROMETER DATA

POSITION: PS1 TP 1A
S 32°02'13.7" E 27°49'38.5"

REMARKS: Refusal @ 1310mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0			
140	10	14	15
170	20	3	110
190	30	2	>110
220	40	3	110
245	50	2.5	110
270	60	2.5	110
300	70	3	110
325	80	2.5	110
355	90	3	110
385	100	3	110
410	110	2.5	110
440	120	3	110
470	130	3	110
505	140	3.5	93
535	150	3	110
565	160	3	110
595	170	3	110
625	180	3	110
660	190	3.5	93
690	200	3	110
720	210	3	110
750	220	3	110
790	230	4	75
820	240	3	110
860	250	4	75
890	260	3	110
935	270	4.5	65
960	280	2.5	110
1000	290	4	75
1050	300	5	55
1090	310	4	75
1120	320	3	110
1160	330	4	75
1190	340	3	110
1230	350	4	75
1260	360	3	110
1290	370	3	110
1310	380	2	>110





Technical Signatory: ____________ J Atterbury

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OTHER BRANCH OFFICES: Cape Town, Kokstad, Johannesburg, Mthatha, Queenstown, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

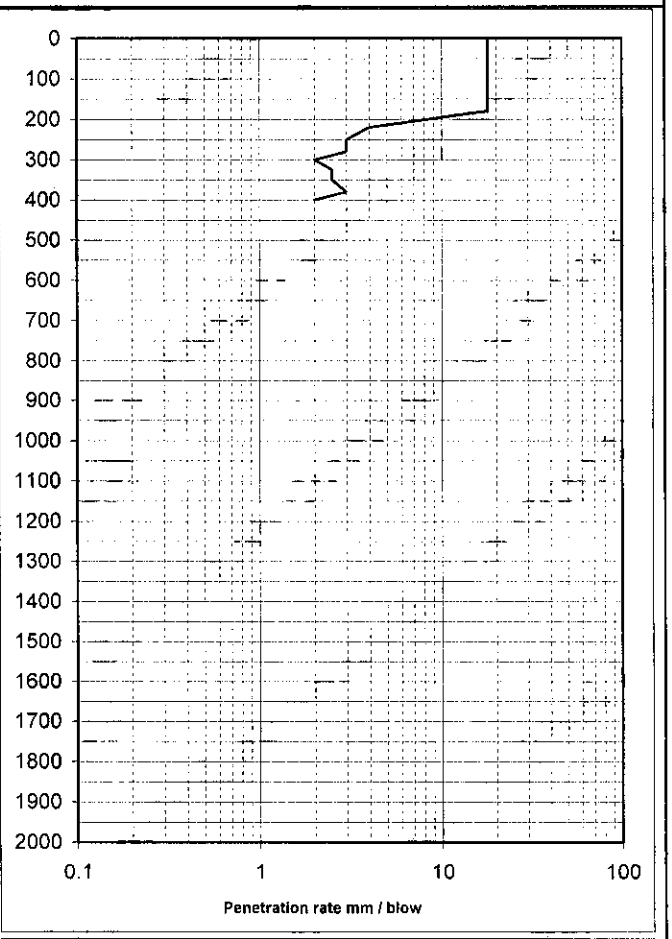
PROJECT: Ngqamakhwe RWSS:
Phase 5
Alternative Pump Station Site
REF: MT32019
DATE: 2017-06-05

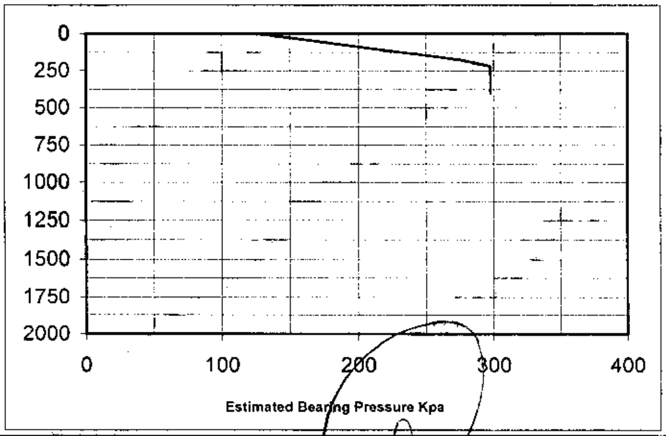
DYNAMIC CONE PENETROMETER DATA

POSITION: PS1 TP 2A
S 32°02'14.0" E 27°49'38.8"

REMARKS: Refusal @ 400mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
180	10	18	11				
220	20	4	75				
250	30	3	110				
280	40	3	110				
300	50	2	>110				
325	60	2.5	110				
350	70	2.5	110				
380	80	3	110				
400	90	2	>110				





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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

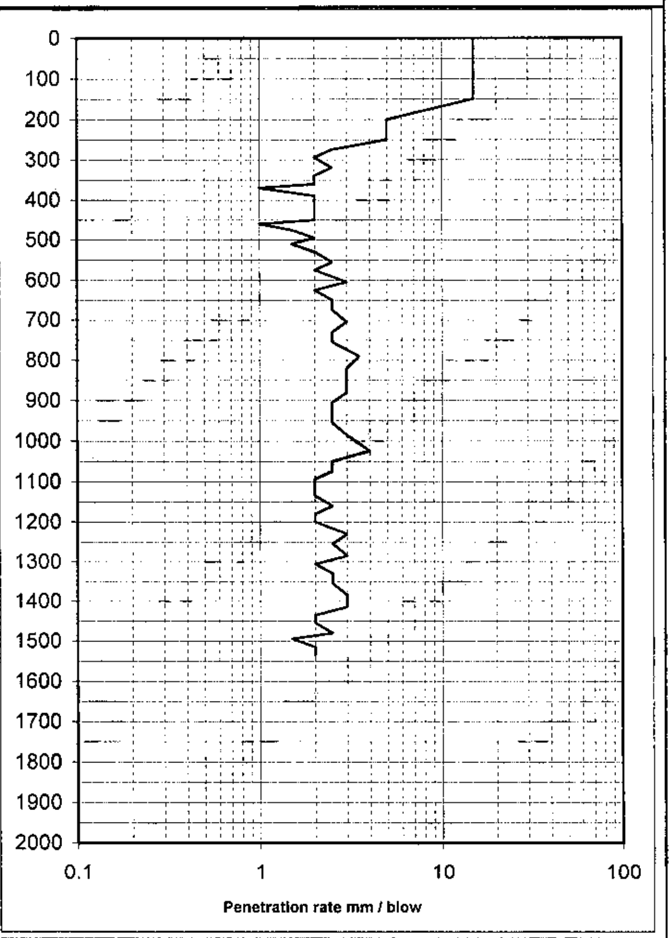
PROJECT: Ngqamakhwe RWSS:
Phase 5
Alternative Pump Station Site
REF: MT32019
DATE: 2017-06-05

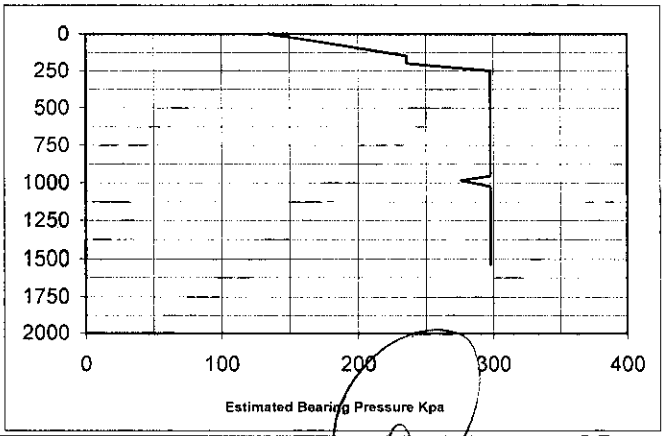
DYNAMIC CONE PENETROMETER DATA

POSITION: PS1 TP 3A
S 32°02'14.2" E 27°49'37.2"

REMARKS: No Refusal

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0			
150	10	15	14
200	20	5	55
250	30	5	55
275	40	2.5	110
295	50	2	>110
320	60	2.5	110
340	70	2	>110
360	80	2	>110
370	90	1	>110
390	100	2	>110
410	110	2	>110
430	120	2	>110
450	130	2	>110
460	140	1	>110
475	150	1.5	>110
495	160	2	>110
510	170	1.5	>110
530	180	2	>110
555	190	2.5	110
575	200	2	>110
605	210	3	110
625	220	2	>110
650	230	2.5	110
675	240	2.5	110
705	250	3	110
730	260	2.5	110
755	270	2.5	110
790	280	3.5	93
820	290	3	110
850	300	3	110
880	310	3	110
905	320	2.5	110
930	330	2.5	110
955	340	2.5	110
985	350	3	110
1025	360	4	75
1050	370	2.5	110
1075	380	2.5	110
1095	390	2	>110
1115	400	2	>110
1135	410	2	>110
1160	420	2.5	110
1180	430	2	>110
1200	440	2	>110
1230	450	3	110
1255	460	2.5	110
1285	470	3	110
1305	480	2	>110
1330	490	2.5	110
1355	500	2.5	110
1385	510	3	110
1415	520	3	110
1435	530	2	>110
1455	540	2	>110
1480	550	2.5	110
1495	560	1.5	>110
1515	570	2	>110
1535	580	2	>110





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OTHER BRANCH OFFICES: Cape Town, Kokstad, Johannesburg, Mthatha, Queenstown, Lusaka - Zambia

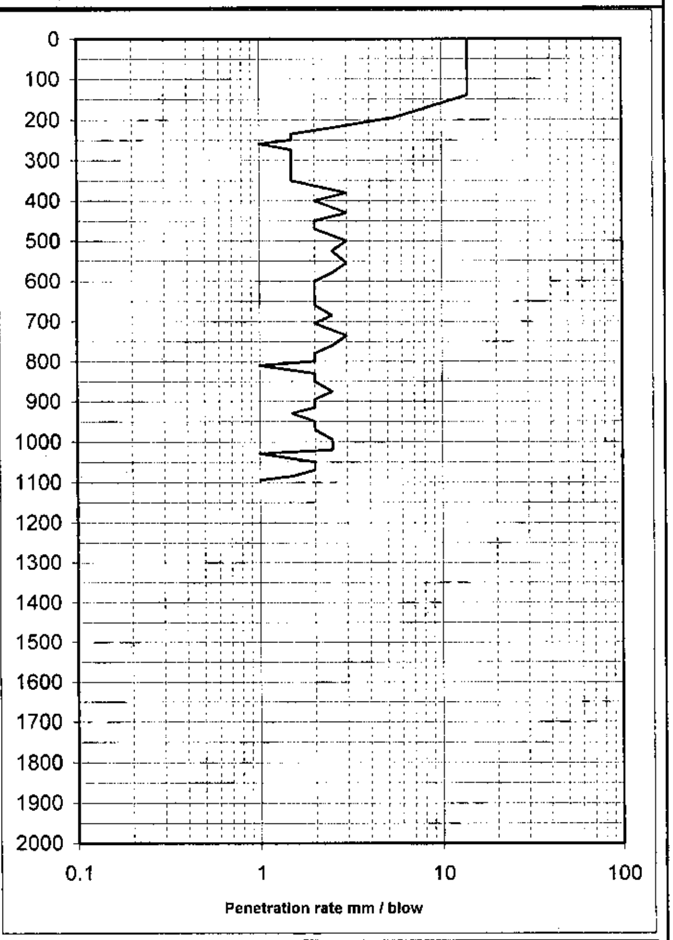
CLIENT:	Aurecon SA (Pty) Ltd PO Box 19553 TECOMA 5214	**PROJECT:**	Ngqamakhwe RWSS: Phase 5 Alternative Pump Station Site
		REF:	MT32019
ATT:	Mr D Luhring	**DATE:**	2017-06-05

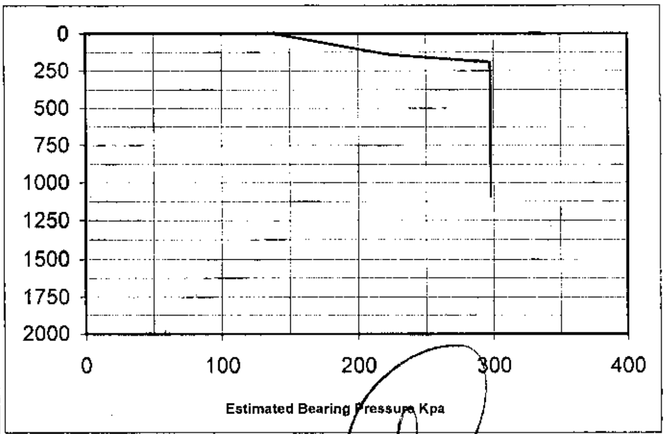
DYNAMIC CONE PENETROMETER DATA

POSITION: PS1 TP 4A
S 32°02'15.0" E 27°49'37.5"

REMARKS: Refusal @ 1095mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0			
140	10	14	15
195	20	5.5	50
220	30	2.5	110
235	40	1.5	>110
250	50	1.5	>110
260	60	1	>110
275	70	1.5	>110
290	80	1.5	>110
305	90	1.5	>110
320	100	1.5	>110
335	110	1.5	>110
350	120	1.5	>110
380	130	3	110
400	140	2	>110
430	150	3	110
450	160	2	>110
470	170	2	>110
500	180	3	110
525	190	2.5	110
555	200	3	110
580	210	2.5	110
600	220	2	>110
620	230	2	>110
640	240	2	>110
660	250	2	>110
685	260	2.5	110
705	270	2	>110
735	280	3	110
760	290	2.5	110
780	300	2	>110
800	310	2	>110
810	320	1	>110
830	330	2	>110
850	340	2	>110
875	350	2.5	110
895	360	2	>110
915	370	2	>110
930	380	1.5	>110
950	390	2	>110
970	400	2	>110
995	410	2.5	110
1020	420	2.5	110
1030	430	1	>110
1050	440	2	>110
1070	450	2	>110
1085	460	1.5	>110
1095	470	1	>110





Technical Signatory: J Atterbury

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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

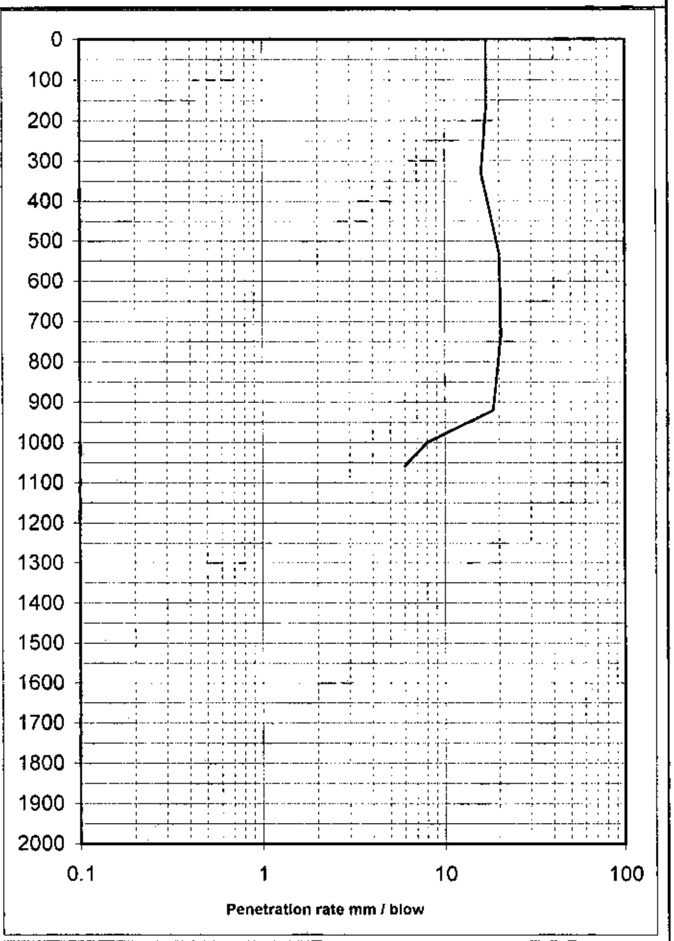
PROJECT: Ngqamakhwe RWSS:
Phase 5
Alternative Pump Station Site
REF: MT32019
DATE: 2017-06-05

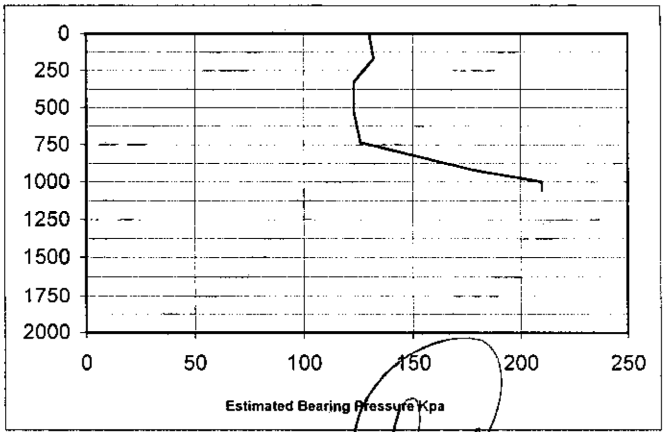
DYNAMIC CONE PENETROMETER DATA

POSITION: PS1 TP 5A
S 32°02'11.8" E 27°49'38.4"

REMARKS: Refusal @ 1060mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
170	10	17	12				
330	20	16	13				
530	30	20	9				
735	40	20.5	9				
920	50	18.5	10				
1000	60	8	30				
1060	70	6	45				





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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Queenstown, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214

ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
ALTERNATIVE RESERVOIR SITE
DATE RECEIVED: 2017-06-07
DATE TESTED: 2017-06-14
DATE REPORTED: 2017-06-29
TEST REPORT NO.: MT32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	4025	4026	4027	4028		
POSITION	RES/TP 6A	RES/TP 7A	RES/TP 8A	RES/TP 9A		
DEPTH mm	900 - 1250	700 - 900	700 - 880	500 - 1500		
DESCRIPTION	lt Br	lt Br	lt Br	lt Br.		
	Ss +	Ss +	Ss +	Ss +		
	sty s	cly s	cly s	sty s		

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm	100	100	100			
37.5 mm	53	72	59	100		
19 mm	40	46	46	67		
9.5 mm	35	39	39	47		
4.75 mm	31	35	35	41		
2.36 mm	29	32	33	38		
1.18 mm	27	30	32	35		
0.600 mm	26	28	31	33		
0.425 mm	25	28	31	31		
0.300 mm	23	26	30	29		
0.150 mm	14	18	22	19		
0.075 mm	7.5	11.9	6.6	10.7		
GRADING MODULUS	2.4	2.3	2.3	2.2		

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	7	11	9	10		
0.02 mm	5	9	14	8		
0.006 mm	4	9	12	7		
0.002 mm	3	8	11	7		

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	18	30	30	24		
PLASTICITY INDEX	5	14	14	11		
LINEAR SHRINKAGE	2.5	6.5	6.0	5.0		

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

PI WHOLE SAMPLE	1.0	4.0	4.0	3.0		
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW	LOW		

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

Maximum Dry Density (kg/m^3)			2138			
Optimum Moisture Content (%)			7.2			
C.B.R. @ 100% COMPACTION			62			
C.B.R. @ 98 % COMPACTION			47			
C.B.R. @ 95 % COMPACTION			30			
C.B.R. @ 93 % COMPACTION			21			
C.B.R. @ 90 % COMPACTION			13			
SWELL @ 100% COMP. (%)			0.50			
T R H 14 CLASSIFICATION			G6			

Technical Signatory: J Atterbury

Remarks:

Samples Delivered by Customer

Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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CLIENT: Aurecon SA (Pty) Ltd
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TECOMA
5214
ATT: Mr D Luhring

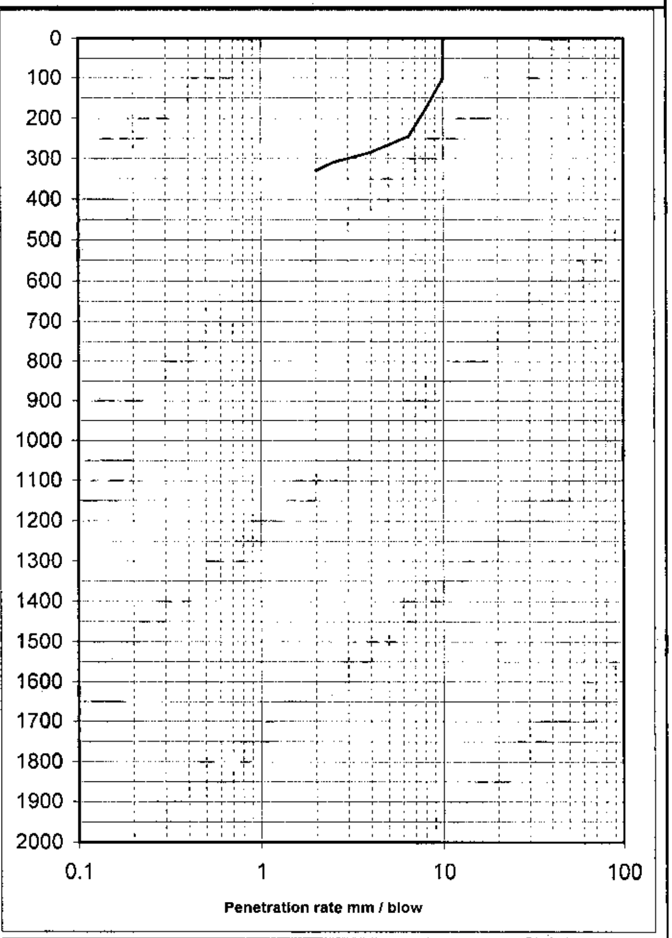
PROJECT: Ngqamakhwe RWSS:
Phase 5
Alternative Reservoir Site
REF: MT32019
DATE: 2017-06-05

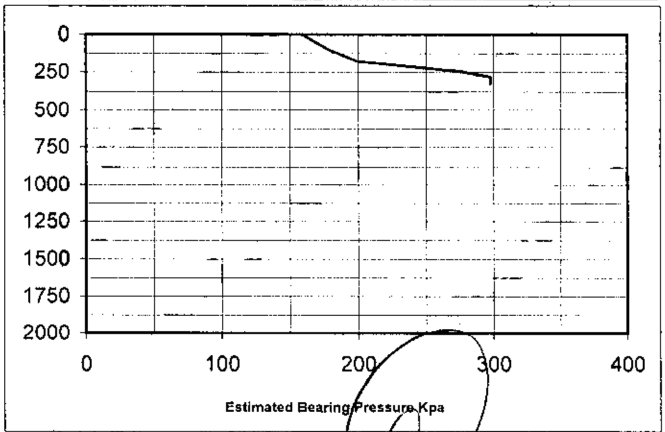
DYNAMIC CONE PENETROMETER DATA

POSITION: RES TP 6A
S 32°02'11.1" E 27°49'39.6"

REMARKS: Refusal @ 330mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0			
100	10	10	22
180	20	8	30
245	30	6.5	40
285	40	4	75
310	50	2.5	110
330	60	2	>110





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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

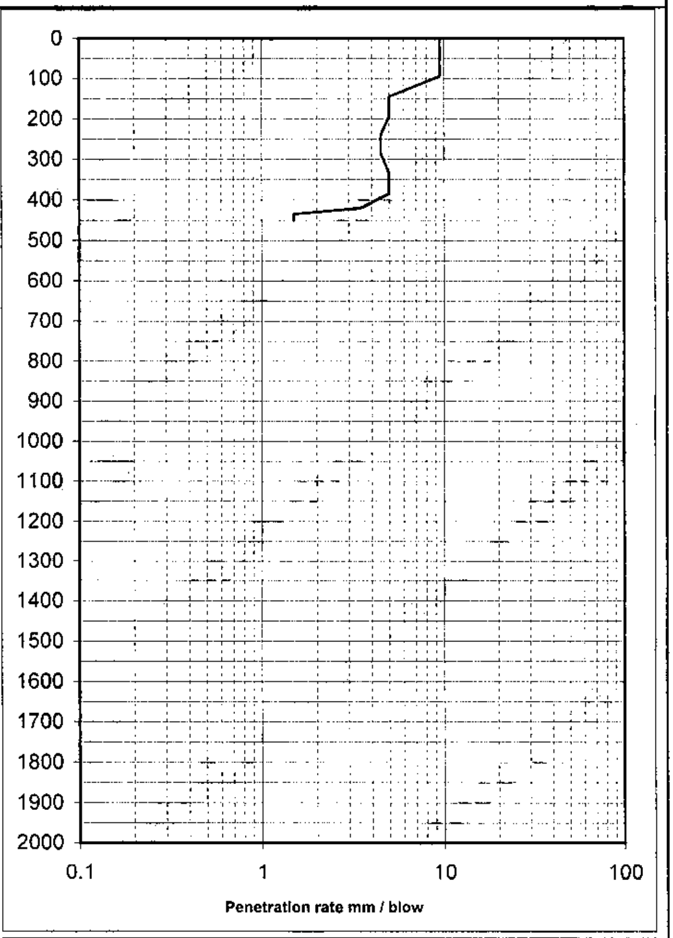
PROJECT: Ngqamakhwe RWSS:
Phase 5
Alternative Reservoir Site
REF: MT32019
DATE: 2017-06-05

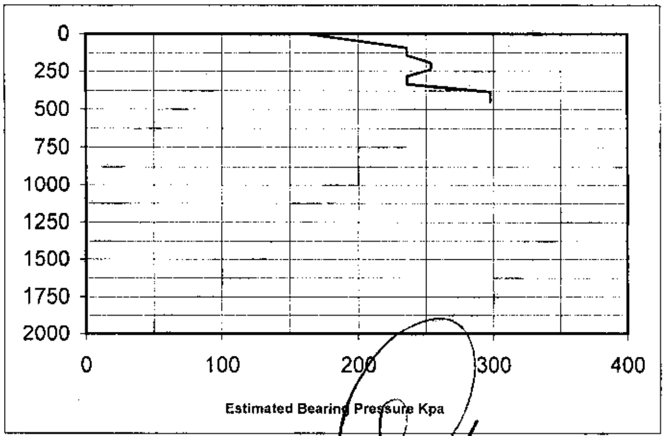
DYNAMIC CONE PENETROMETER DATA

POSITION: RES TP 7A
S 32°02'10.0" E 27°49'40.3"

REMARKS: Refusal @ 450mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
95	10	9.5	24				
145	20	5	55				
195	30	5	55				
240	40	4.5	65				
285	50	4.5	65				
335	60	5	55				
385	70	5	55				
420	80	3.5	93				
435	90	1.5	>110				
450	100	1.5	>110				





Technical Signatory:__________J Atterbury

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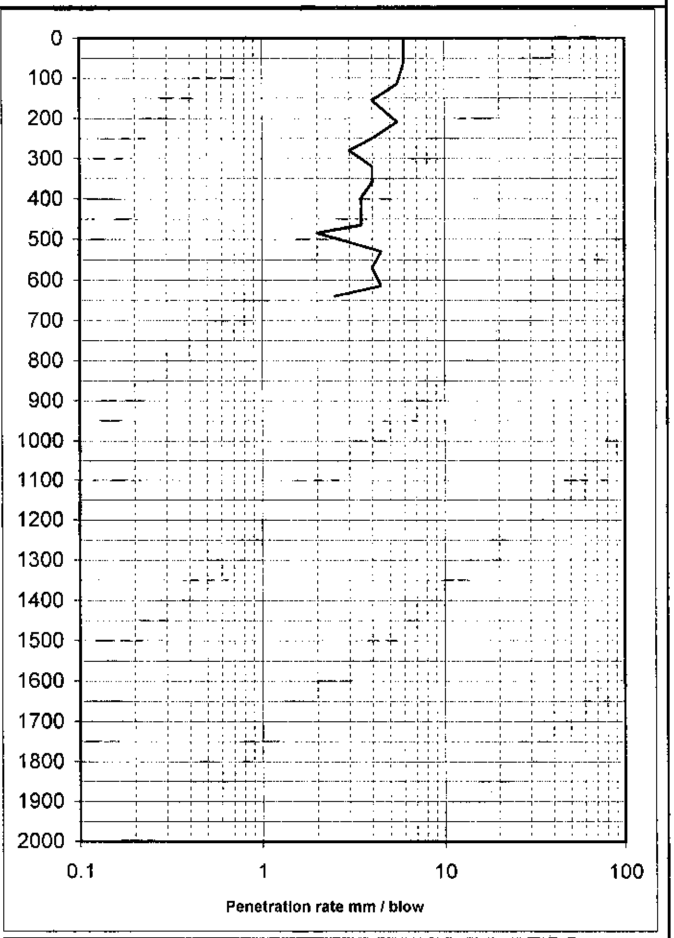
PROJECT: Ngqamakhwe RWSS:
Phase 5
Alternative Reservoir Site
REF: MT32019
DATE: 2017-06-05

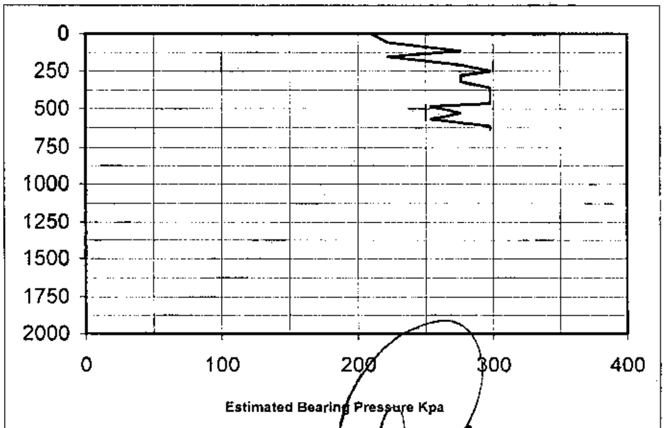
DYNAMIC CONE PENETROMETER DATA

POSITION: RES TP 8A
S 32°02'10.4" E 27°49'40.9"

REMARKS: Refusal @ 640mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
60	10	6	45				
115	20	5.5	50				
155	30	4	75				
210	40	5.5	50				
250	50	4	75				
280	60	3	110				
320	70	4	75				
360	80	4	75				
395	90	3.5	93				
430	100	3.5	93				
465	110	3.5	93				
485	120	2	>110				
530	130	4.5	65				
570	140	4	75				
615	150	4.5	65				
640	160	2.5	110				





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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

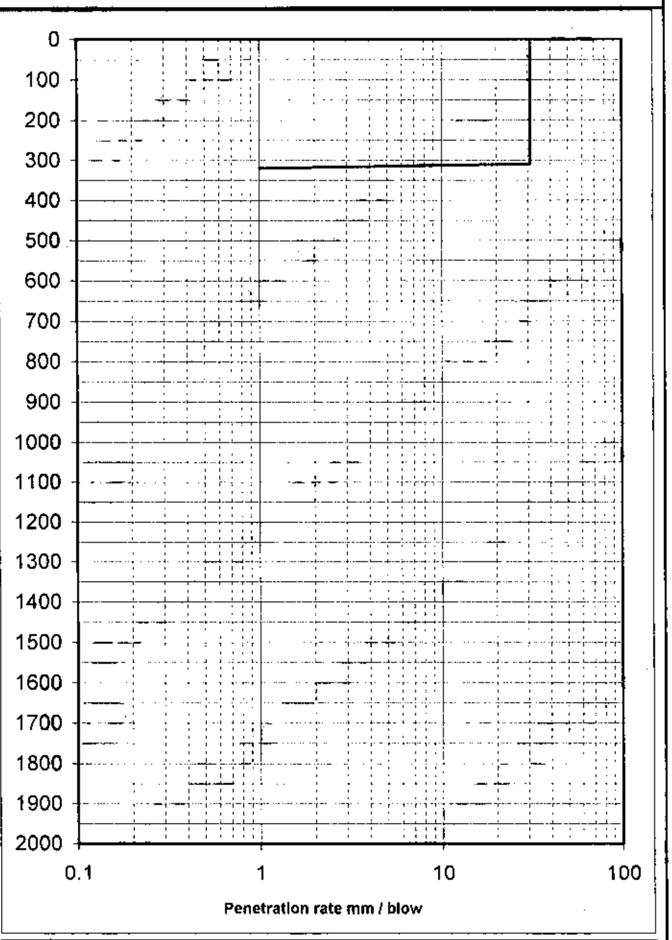
PROJECT: Ngqamakhwe RWSS:
Phase 5
Alternative Reservoir Site
REF: MT32019
DATE: 2017-06-05

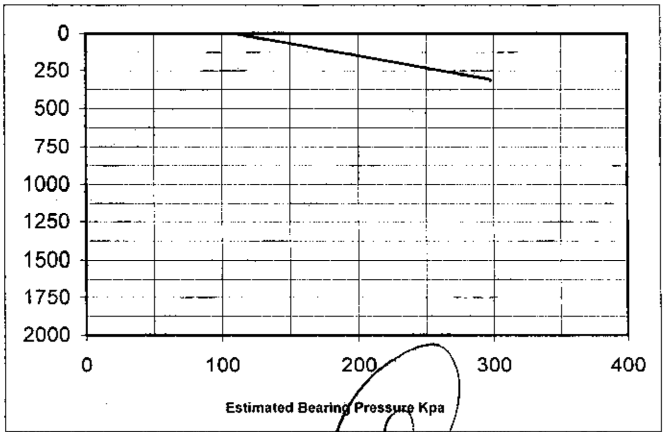
DYNAMIC CONE PENETROMETER DATA

POSITION: RES TP 9A
S 32°02'11.9" E 27°49'40.1"

REMARKS: Refusal @ 320mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
310	10	31	5				
320	20	1	>110				





Technical Signatory ______________ J Atterbury

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CLIENT : Aurecon SA (Pty) Ltd
PO Box 19553
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5214
ATT: Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-31
DATE REPORTED: 2017-06-01
TEST REPORT NO.: MT32019

MATERIALS TEST REPORT

SAMPLE NO:	3380	3381	3384	3387	3389	3390
POSITION / CHAINAGE	AR TP 1	AR TP 2	AR TP 4	AR TP 6	AR TP 9	AR TP 10
	ALTERNATIVE ROUTE					
DEPTH mm	0 - 500	0 - 200	0 - 260	0 - 250	0 - 300	0 - 500
DESCRIPTION	dk R Br	dk R Br	dk R Br	dk R Br	dk R Br	dk R Br
	sdy st	sty s	sty s	sdy st	sdy st	sdy st

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING 75 mm						
63 mm						
53 mm						
37.5 mm						
26.5 mm						
19 mm						100
13.2 mm	100		100	100		99
4.75 mm	99	100	98	99	100	97
2.00 mm	98	98	97	98	98	94
0.425 mm	97	96	95	95	95	91
0.075 mm	33.0	28.8	30.4	26.6	24.7	43.7

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	1	2	2	3	3	
FINE SAND (%)	65	69	67	70	72	
SILT / CLAY (%)	34	29	31	27	25	46
GRADING MODULUS	0.72	0.77	0.78	0.80	0.82	0.71

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	CBD	CBD	CBD	CBD	CBD	CBD
PLASTICITY INDEX (%)	SP	SP	NP	NP	NP	SP
LINEAR SHRINKAGE (%)	1.0	1.0	0.0	0.0	0.0	1.0

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

COMPACTIBILITY %	0.24	0.21	0.14	0.16	0.14	0.18
Optimum Moisture Content (%)						
C.B.R. @ 100% COMPACTION						
C.B.R. @ 98 % COMPACTION						
C.B.R. @ 95 % COMPACTION						
C.B.R. @ 93 % COMPACTION						
C.B.R. @ 90 % COMPACTION						
SWELL @ 100% COMP. (%)						
T R H 14 CLASSIFICATION						

The above test results are pertinent to the samples tested only. While the tests are carried out according to recognized standards, Controlab shall not be liable for erroneous testing or reporting thereof. This report may not be reproduced except in full withour prior consent of Controlab.

Technical Signatory
J Atterbury

Remarks:
Sample Delivered by Customer ☐
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CLIENT : Aurecon SA (Pty) Ltd
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ATT: Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-31
DATE REPORTED: 2017-06-01
TEST REPORT NO.: MT32019

MATERIALS TEST REPORT

SAMPLE NO:	3392	3393	3395	3396	3398	
POSITION / CHAINAGE	AR TP 11		AR TP 12		AR TP 13	
	ALTERNATIVE ROUTE					
DEPTH mm	0 - 320	320 - 1270	0 - 500	500 - 800	0 - 480	
DESCRIPTION	dk Br	dk Br	dk R Br	dk Br	dk R	
	sty s	sdy st	sdy st	cly s	sdy st	

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING 75 mm						
63 mm						
53 mm						
37.5 mm						
26.5 mm						
19 mm	100		100			
13.2 mm	99	100	98		100	
4.75 mm	97	99	97	100	97	
2.00 mm	94	97	95	99	96	
0.425 mm	91	93	93	97	94	
0.075 mm	43.7	48.4	33.5	60.1	32.0	

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	3	4	2	2	2	
FINE SAND (%)	50	46	63	37	65	
SILT / CLAY (%)	46	50	35	61	33	
GRADING MODULUS	0.71	0.62	0.79	0.44	0.78	

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	CBD	20	CBD	33	CBD	
PLASTICITY INDEX (%)	SP	7	NP	13	NP	
LINEAR SHRINKAGE (%)	1.0	3.5	0.0	7.0	0.0	

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

COMPACTIBILITY %	0.14	0.16	0.16	0.18	0.16	
Optimum Moisture Content (%)						
C.B.R. @ 100% COMPACTION						
C.B.R. @ 98 % COMPACTION						
C.B.R. @ 95 % COMPACTION						
C.B.R. @ 93 % COMPACTION						
C.B.R. @ 90 % COMPACTION						
SWELL @ 100% COMP. (%)						
T R H 14 CLASSIFICATION						

Technical Signatory:
J Atterbury

Remarks:
Sample Delivered by Customer ☐
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CLIENT: Aurecon SA (Pty) Ltd
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ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-25
DATE REPORTED: 2017-06-01
TEST REPORT NO.: MT 32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	3382	3383	3385	3386		
POSITION	AR TP 2	AR TP 3	AR TP 4	AR TP 5		
	ALTERNATIVE ROUTE					
DEPTH mm	300 - 1800	180 - 750	500 - 1000	700 - 1100		
DESCRIPTION	Pale R	dk Y O	dk Y O	lt R Br		
	Ms +	Ss +	Ss +	Ss +		
	cly s	sty s	sdy st	sty s		

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm	100					
37.5 mm	92	100		100		
19 mm	68	91	100	83		
9.5 mm	53	64	78	66		
4.75 mm	38	38	67	53		
2.36 mm	30	28	61	41		
1.18 mm	26	24	58	33		
0.600 mm	24	23	56	29		
0.425 mm	23	22	56	28		
0.300 mm	23	21	55	26		
0.150 mm	20	16	49	19		
0.075 mm	12.9	8.6	30.0	10.9		

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	11	7	25	9		
0.02 mm	6	3	13	5		
0.006 mm	5	2	10	4		
0.002 mm	4	2	10	3		

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	25	21	24	31		
PLASTICITY INDEX	12	6	8	7		
LINEAR SHRINKAGE	5.5	2.5	4.5	3.5		

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

PI WHOLE SAMPLE	3.0	1.0	5.0	2.0		
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW	LOW		

Technical Signatory: J Atterbury

Remarks:
Samples Delivered by Customer
Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-25
DATE REPORTED: 2017-06-01
TEST REPORT NO.: MT 32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	3388	3391	3394	3397	3399	
POSITION	AR TP 6	AR TP 10	AR TP 11	AR TP 12	AR TP 13	
	ALTERNATIVE ROUTE					
DEPTH mm	1000 - 1300	700 - 740	1270 - 1400	1400 - 3000	930 - 1160	
DESCRIPTION	lt R Br	lt Br	dk Br	dk Br	lt Br	
	Ss +	Ss	Sh / Ss +	cly s	Ss +	
	sty s		cly s		sty s	

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm		100	100		100	
37.5 mm	100	96	86		95	
19 mm	84	61	69		84	
9.5 mm	73	48	56		72	
4.75 mm	61	39	49		62	
2.36 mm	54	35	47	100	55	
1.18 mm	50	32	46	99	52	
0.600 mm	47	31	45	99	50	
0.425 mm	45	30	42	99	49	
0.300 mm	42	28	36	95	46	
0.150 mm	24	18	18	68	31	
0.075 mm	12.0	10.8	12.8	46.7	14.9	

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	10	10	12	42	13	
0.02 mm	5	7	13	32	8	
0.006 mm	3	4	12	26	5	
0.002 mm	2	3	11	23	4	

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	CBD	CBD	27	33	CBD	
PLASTICITY INDEX	NP	SP	12	13	SP	
LINEAR SHRINKAGE	0.0	1.5	6.5	6.5	1.0	

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

PI WHOLE SAMPLE	0.0	0.0	5.0	13.0	0.0	
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW	MED	LOW	

Technical Signatory: J Atterbury

Remarks:

Samples Delivered by Customer

Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214

ATT: Mr D Luhring

PROJECT: Ngqamakhwe RWSS:
Phase 5

REF: MT32019

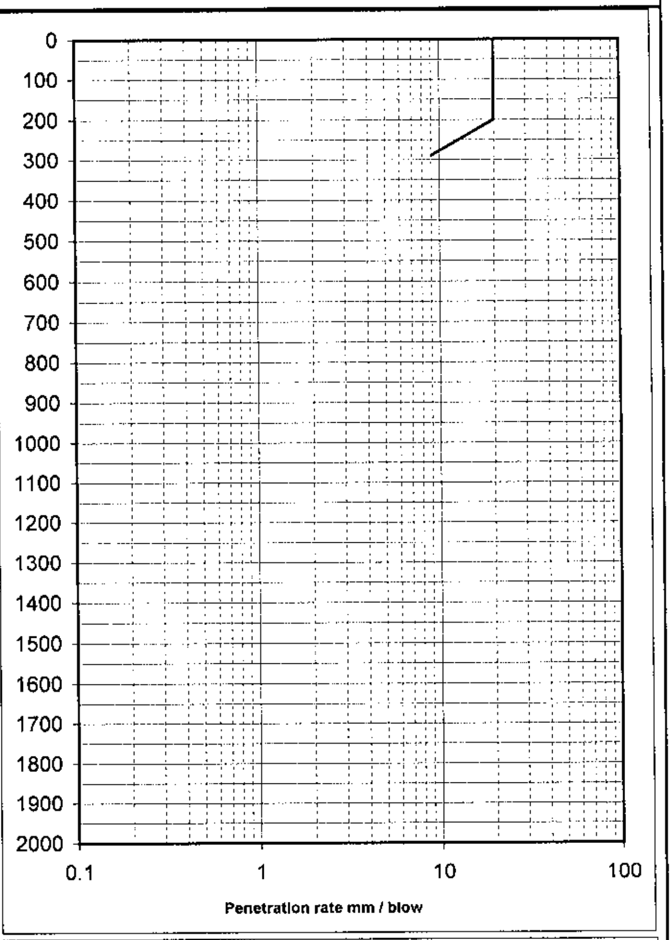
DATE: 2017-04-26

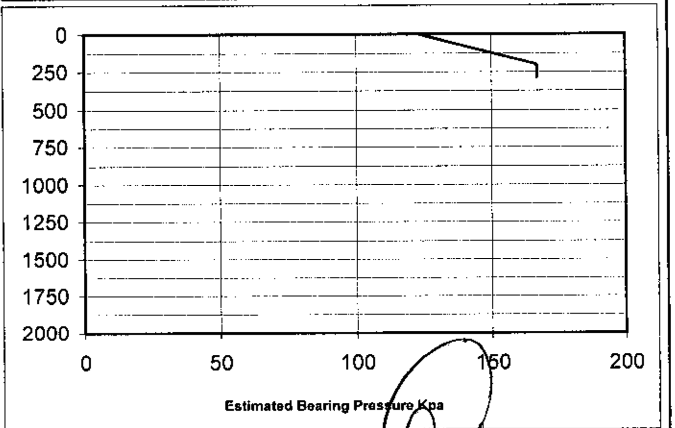
DYNAMIC CONE PENETROMETER DATA

POSITION: AR TP 1
S 32°02'42.3" E 27°50'04.7"

REMARKS: Refusal @ 290mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
200	10	20	9				
290	20	9	25				





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ATT: Mr D Luhring

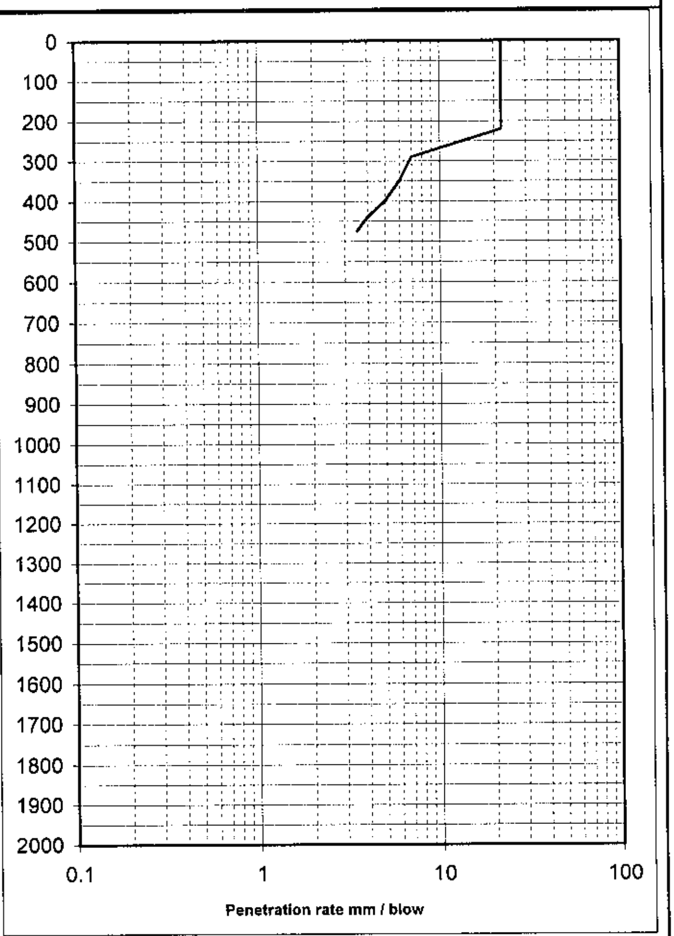
PROJECT: Ngqamakhwe RWSS:
Phase 5
REF: MT32019
DATE: 2017-04-26

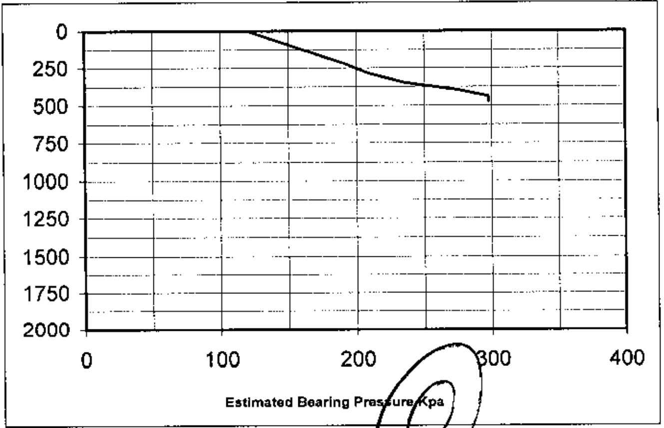
DYNAMIC CONE PENETROMETER DATA

POSITION: AR TP 2
S 32°02'47.1" E 27°50'08.8"

REMARKS: Refusal @ 475mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
220	10	22	8				
290	20	7	35				
350	30	6	45				
400	40	5	55				
440	50	4	75				
475	60	3.5	93				





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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

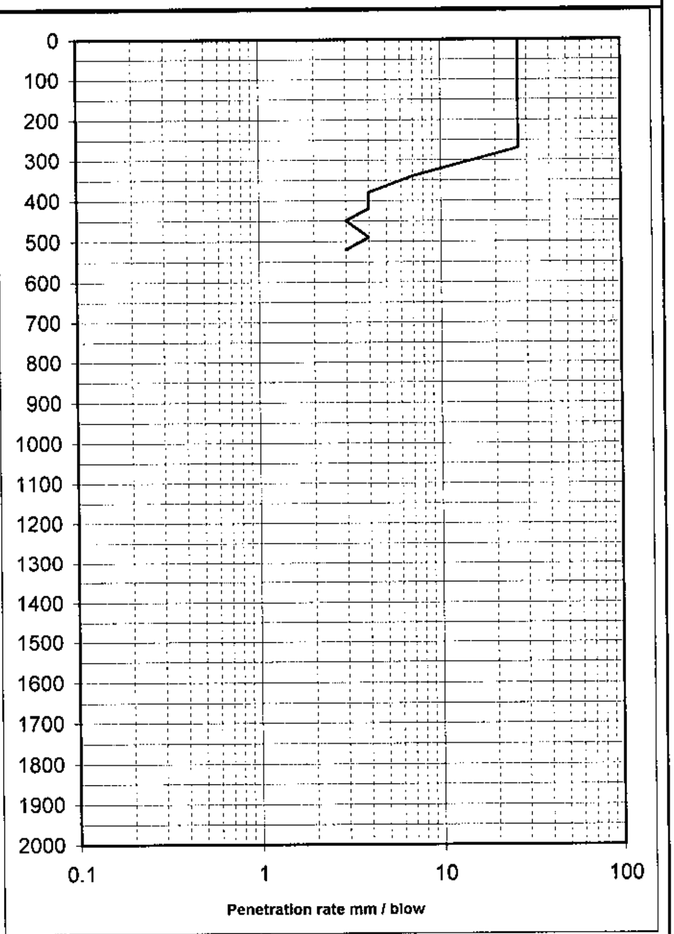
PROJECT: Ngqamakhwe RWSS:
Phase 5
REF: MT32019
DATE: 2017-04-26

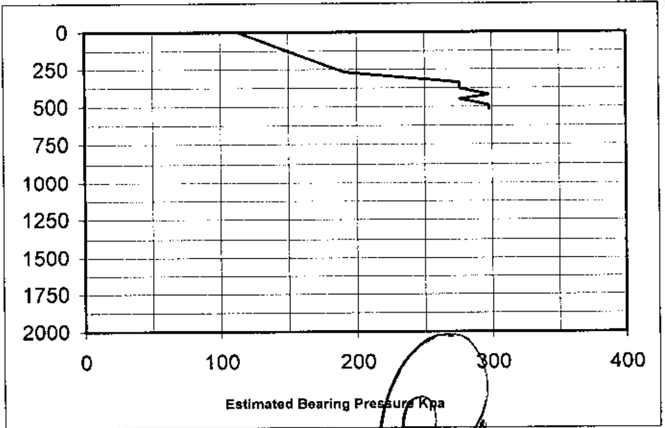
DYNAMIC CONE PENETROMETER DATA

POSITION: AR TP 4
S 32°02'57.5" E 27°50'27.3"

REMARKS: Refusal @ 520mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
270	10	27	7				
340	20	7	35				
380	30	4	75				
420	40	4	75				
450	50	3	110				
490	60	4	75				
520	70	3	110				





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CLIENT: Aurecon SA (Pty) Ltd
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5214
ATT: Mr D Luhring

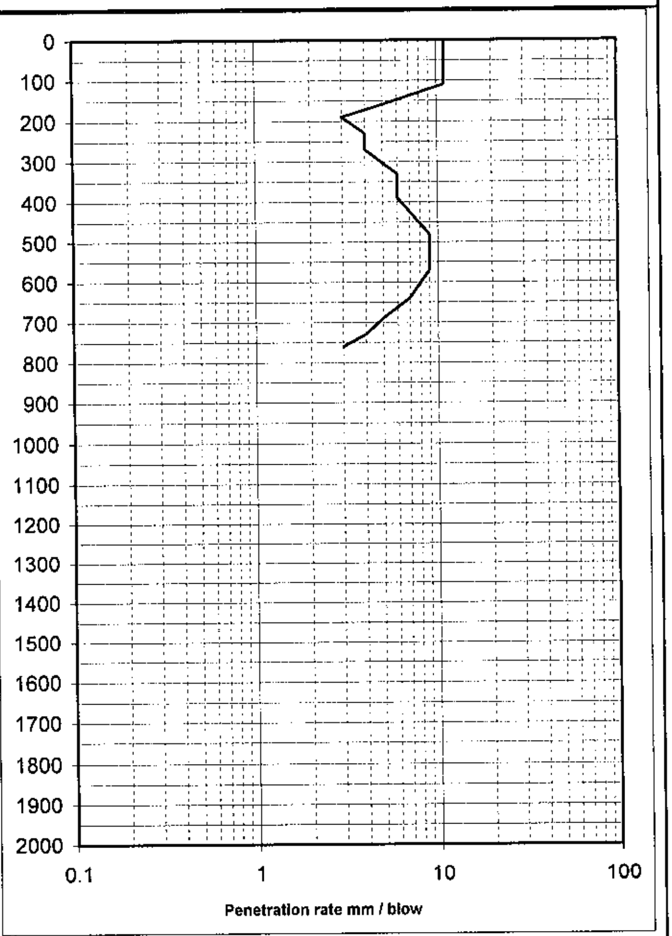
PROJECT: Ngqamakhwe RWSS:
Phase 5
REF: MT32019
DATE: 2017-04-26

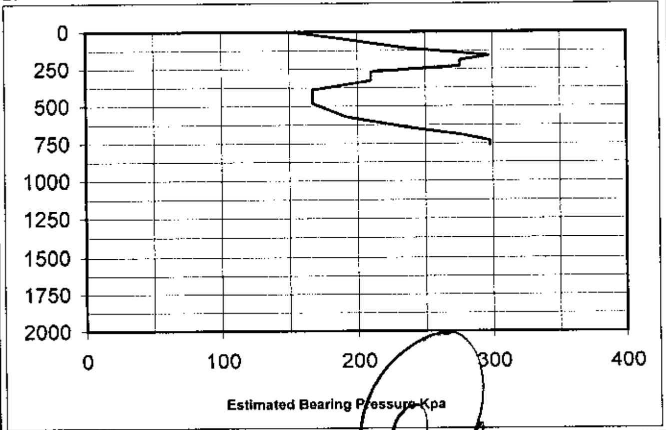
DYNAMIC CONE PENETROMETER DATA

POSITION: AR TP 5
S 32°02'50.7" E 27°50'38.3"

REMARKS: Refusal @ 760mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
110	10	11	20				
160	20	5	55				
190	30	3	110				
230	40	4	75				
270	50	4	75				
330	60	6	45				
390	70	6	45				
480	80	9	25				
570	90	9	25				
640	100	7	35				
690	110	5	55				
730	120	4	75				
760	130	3	110				





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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214

ATT: Mr D Luhring

PROJECT: Ngqamakhwe RWSS: Phase 5

REF: MT32019

DATE: 2017-04-26

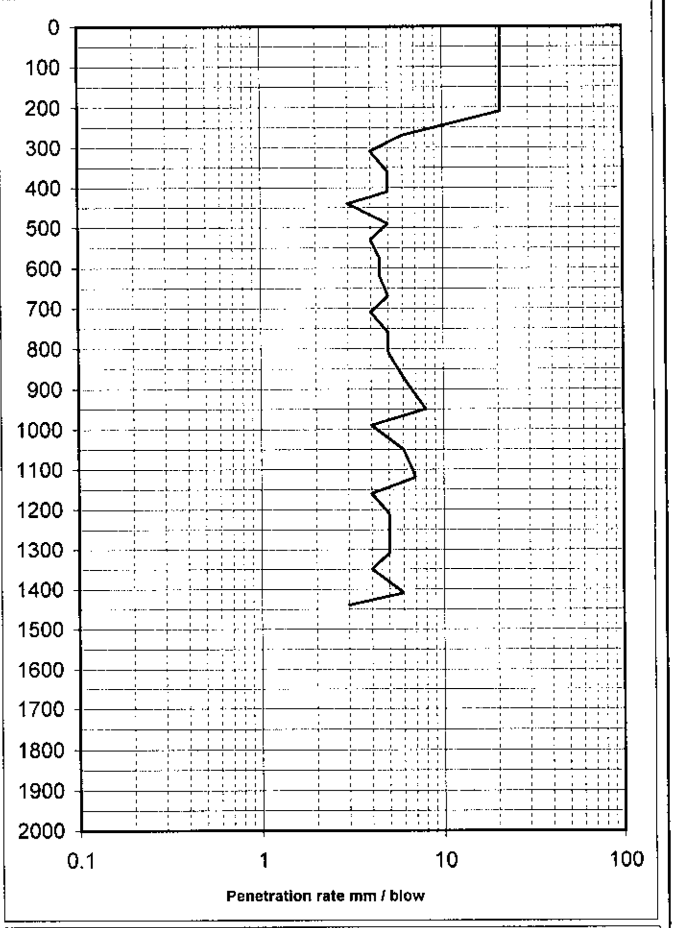
DYNAMIC CONE PENETROMETER DATA

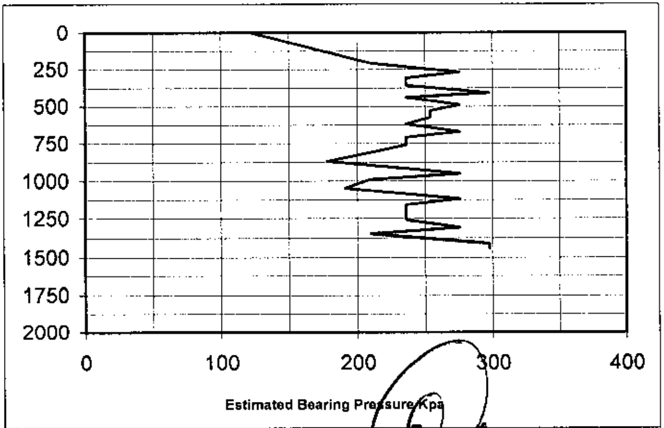
POSITION: AR TP 6
S 32°02'45.5" E 27°50'50.8"

REMARKS: Refusal @ 1440mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0			
210	10	21	9
270	20	6	45
310	30	4	75
360	40	5	55
410	50	5	55
440	60	3	110
490	70	5	55
530	80	4	75
575	90	4.5	65
620	100	4.5	65
670	110	5	55
710	120	4	75
760	130	5	55
810	140	5	55
870	150	6	45
950	160	8	30
990	170	4	75
1050	180	6	45
1120	190	7	35
1160	200	4	75
1210	210	5	55
1260	220	5	55
1310	230	5	55
1350	240	4	75
1410	250	6	45
1440	260	3	110

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR





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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

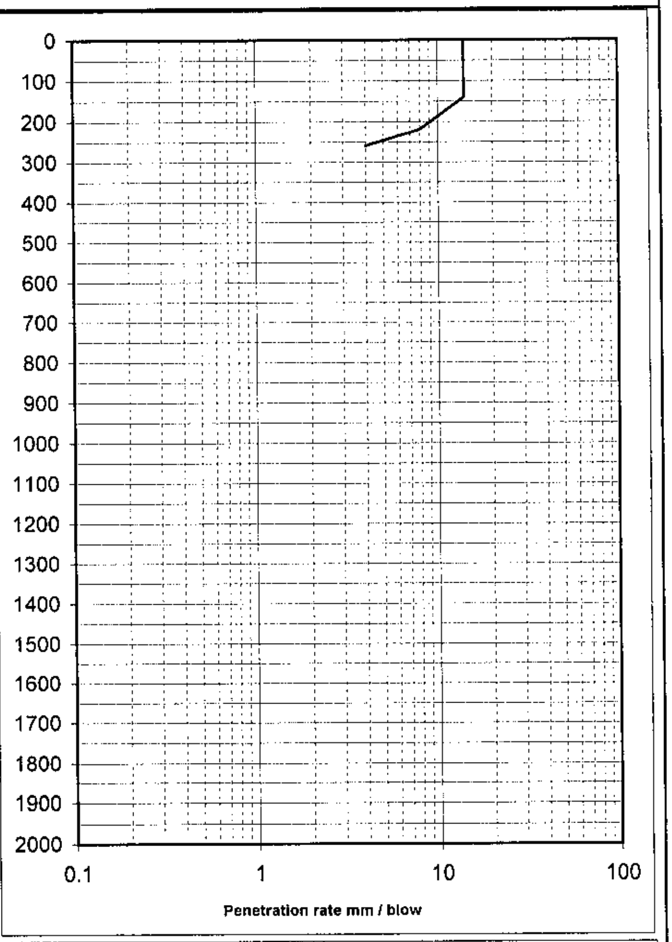
PROJECT: Ngqamakhwe RWSS: Phase 5
REF: MT32019
DATE: 2017-04-26

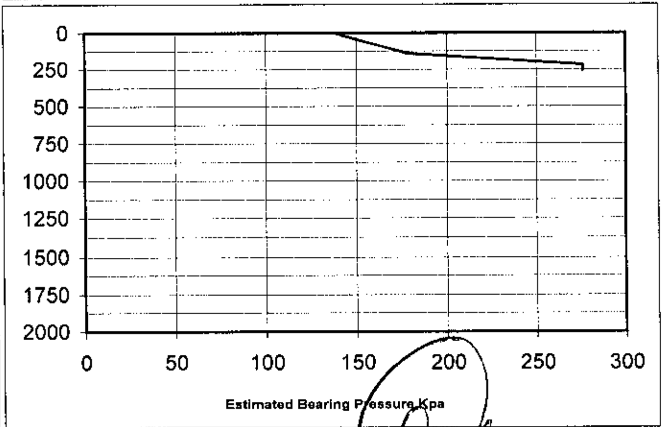
DYNAMIC CONE PENETROMETER DATA

POSITION: AR TP 7
S 32°02'46.0" E 27°51'03.7"

REMARKS: Refusal @ 260mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
140	10	14	15				
220	20	8	30				
260	30	4	75				





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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

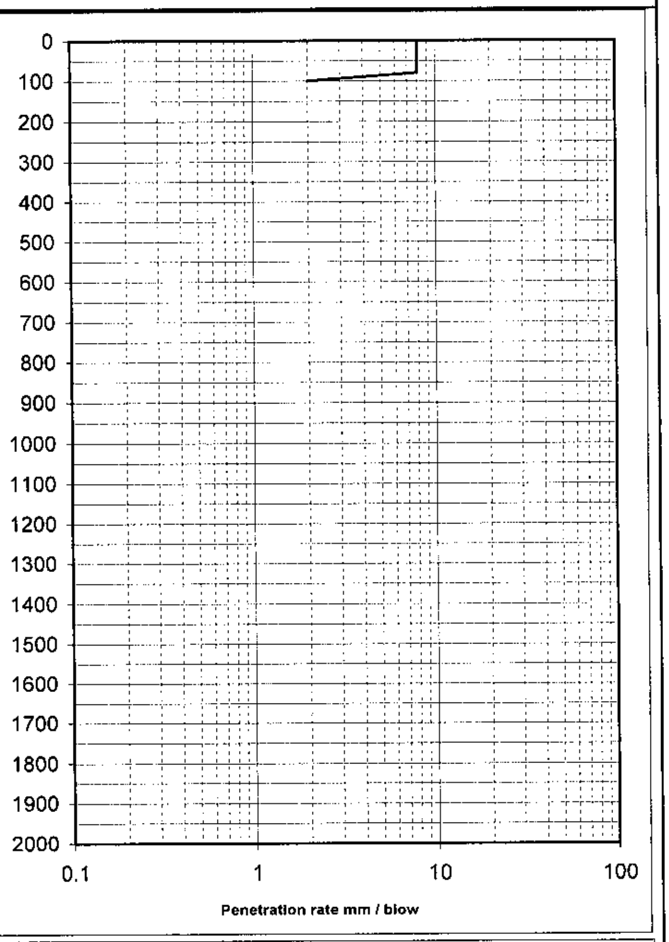
PROJECT: Ngqamakhwe RWSS:
Phase 5
REF: MT32019
DATE: 2017-04-26

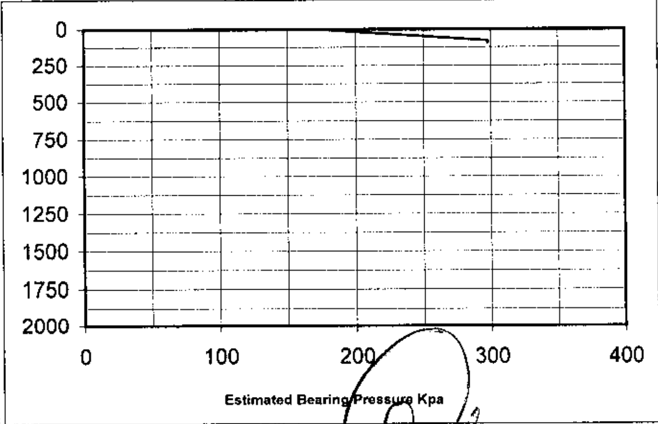
DYNAMIC CONE PENETROMETER DATA

POSITION: AR TP 9
S 32°02'57.7" E 27°51'20.0"

REMARKS: Refusal @ 100mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
80	10	8	30				
100	20	2	>110				





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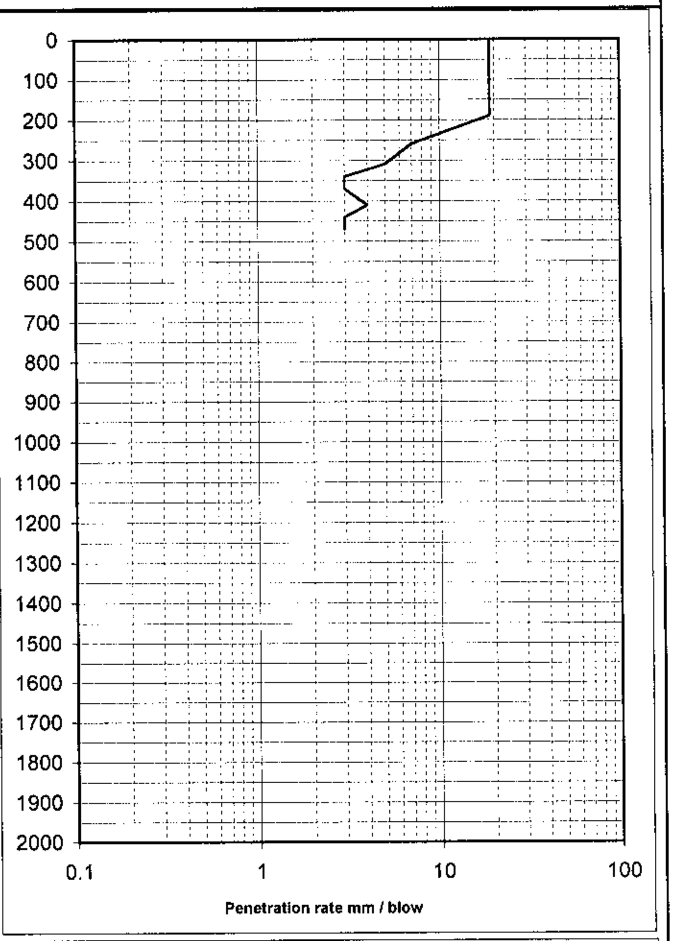
PROJECT: Ngqamakhwe RWSS:
Phase 5
REF: MT32019
DATE: 2017-04-26

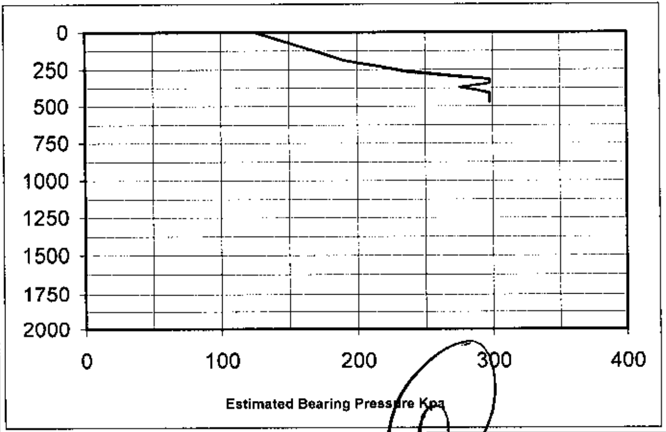
DYNAMIC CONE PENETROMETER DATA

POSITION: AR TP 10
S 32°03'08.1" E 27°51'21.7"

REMARKS: Refusal @ 470mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
190	10	19	10				
260	20	7	35				
310	30	5	55				
340	40	3	110				
370	50	3	110				
410	60	4	75				
440	70	3	110				
470	80	3	110				





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ATT: Mr D Luhring

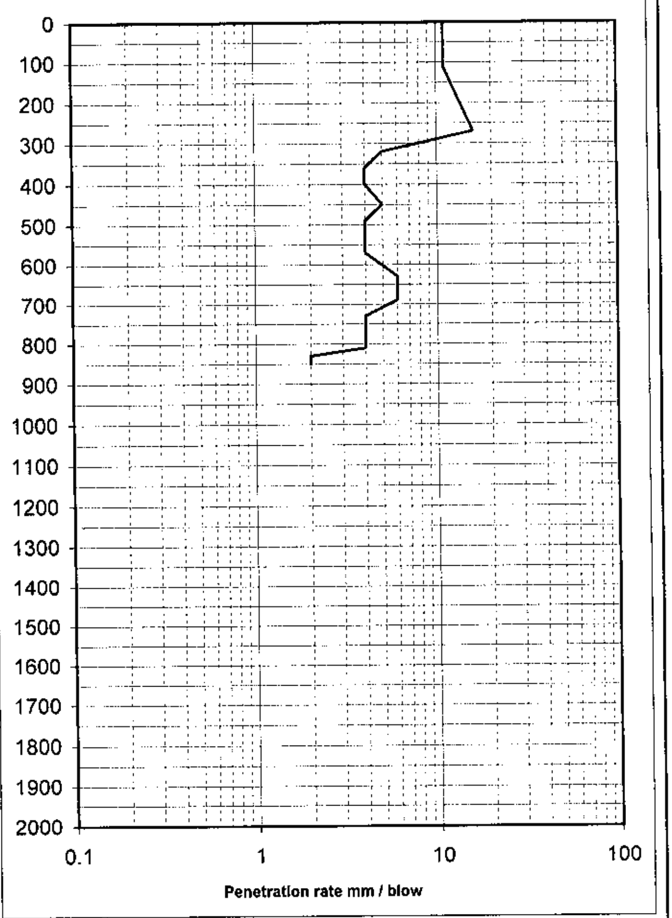
PROJECT: Ngqamakhwe RWSS:
Phase 5
REF: MT32019
DATE: 2017-04-26

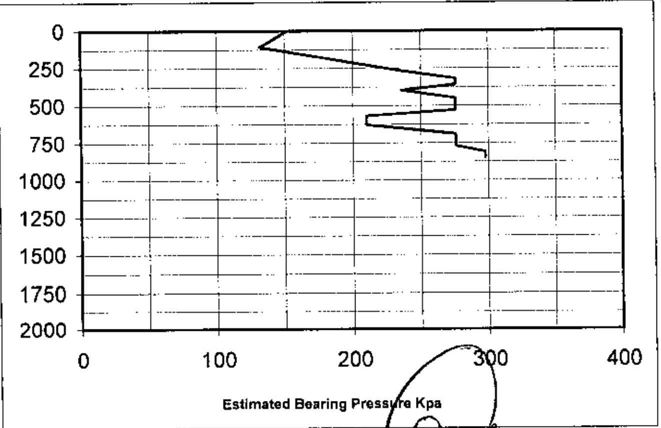
DYNAMIC CONE PENETROMETER DATA

POSITION: AR TP 11
S 32°03'09.8" E 27°51'35.0"

REMARKS: Refusal @ 850mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
110	10	11	20				
270	20	16	13				
320	30	5	55				
360	40	4	75				
400	50	4	75				
450	60	5	55				
490	70	4	75				
530	80	4	75				
570	90	4	75				
630	100	6	45				
690	110	6	45				
730	120	4	75				
770	130	4	75				
810	140	4	75				
830	150	2	>110				
850	160	2	>110				





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ATT: Mr D Luhring

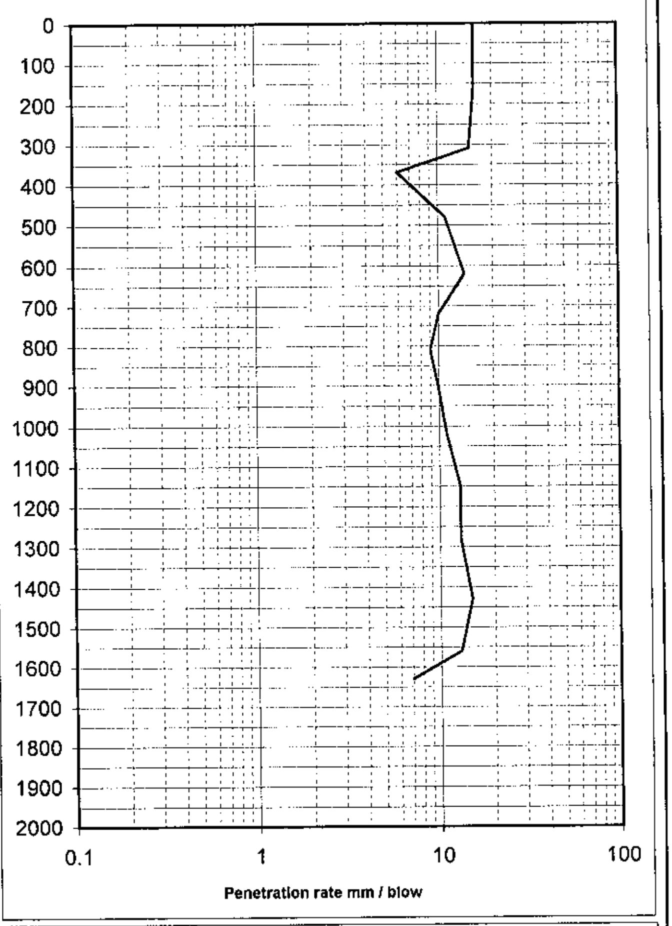
PROJECT: Ngqamakhwe RWSS: Phase 5
REF: MT32019
DATE: 2017-04-26

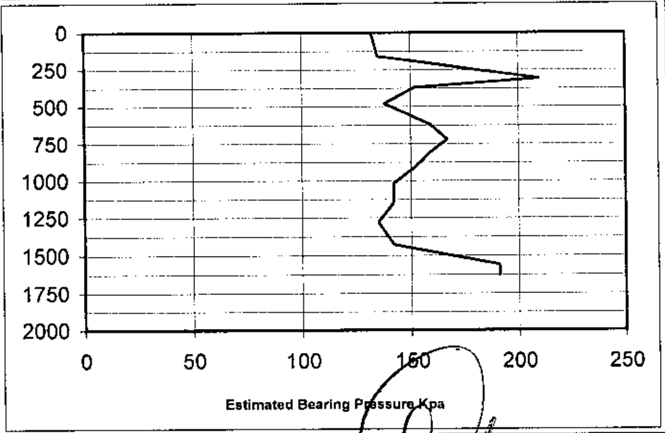
DYNAMIC CONE PENETROMETER DATA

POSITION: AR TP 12
S 32°03'14.8" E 27°51'47.2"

REMARKS: No Refusal

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
160	10	16	13				
310	20	15	14				
370	30	6	45				
480	40	11	20				
620	50	14	15				
720	60	10	22				
810	70	9	25				
910	80	10	22				
1020	90	11	20				
1150	100	13	16				
1280	110	13	16				
1430	120	15	14				
1560	130	13	16				
1630	140	7	35				





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5214
ATT: Mr D Luhring

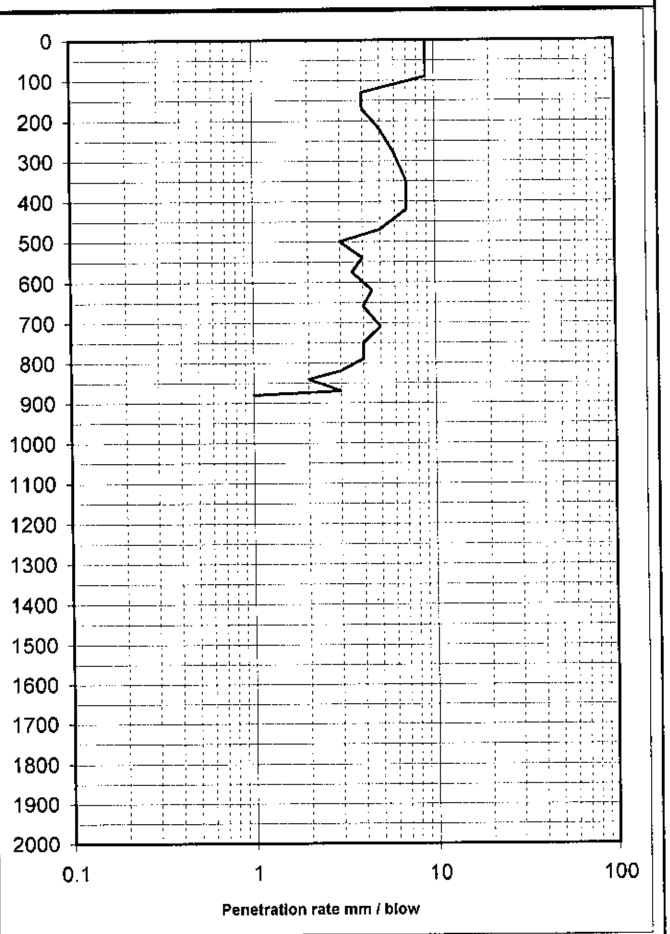
PROJECT: Ngqamakhwe RWSS: Phase 5
REF: MT32019
DATE: 2017-04-26

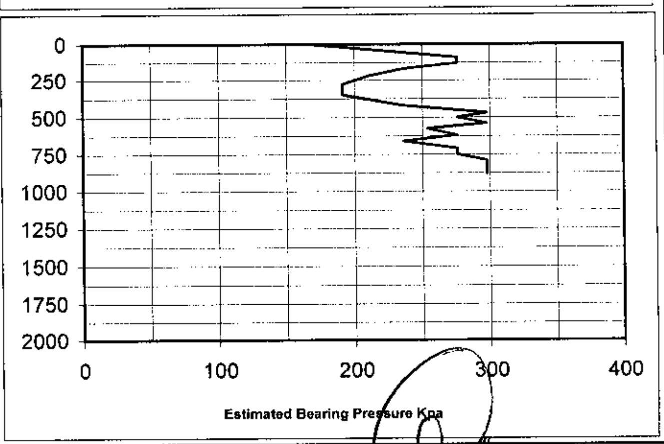
DYNAMIC CONE PENETROMETER DATA

POSITION: AR TP 13
S 32°03'18.5" E 27°51'59.2"

REMARKS: Refusal @ 880mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
90	10	9	25				
130	20	4	75				
170	30	4	75				
220	40	5	55				
280	50	6	45				
350	60	7	35				
420	70	7	35				
470	80	5	55				
500	90	3	110				
540	100	4	75				
575	110	3.5	93				
620	120	4.5	65				
660	130	4	75				
710	140	5	55				
750	150	4	75				
790	160	4	75				
820	170	3	110				
840	180	2	>110				
870	190	3	110				
880	200	1	>110				





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PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-29
DATE REPORTED: 2017-05-30
TEST REPORT NO.: MT32019

MATERIALS TEST REPORT

SAMPLE NO:	3307A	3308A	3310	3311	3313	
POSITION / CHAINAGE	TP 1	TP 2	TP 4	TP 5	TP 7	
	PIPELINE					
DEPTH mm	0 - 600	0 - 550	0 - 300	0 - 400	0 - 200	
DESCRIPTION	dk Y O	dk R	lt Br	dk R	lt Br	
	sty s	sty s	sty s	sty s	sty s	

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING 75 mm						
63 mm						
53 mm						
37.5 mm						
26.5 mm						
19 mm			100			
13.2 mm		100	99		100	
4.75 mm		96	88	100	98	
2.00 mm	100	91	83	98	96	
0.425 mm	99	86	81	95	96	
0.075 mm	29.7	39.6	34.0	30.4	23.0	

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	1	5	2	3	0	
FINE SAND (%)	69	51	57	66	76	
SILT / CLAY (%)	30	44	41	31	24	
GRADING MODULUS	0.71	0.83	1.02	0.77	0.85	

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	CBD	20	CBD	CBD	CBD	
PLASTICITY INDEX (%)	NP	6	NP	NP	NP	
LINEAR SHRINKAGE (%)	0.0	2.5	0.0	0.0	0.0	

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

COMPACTIBILITY %	0.18	0.16	0.18	0.14	0.14	
Optimum Moisture Content (%)						
C.B.R. @ 100% COMPACTION						
C.B.R. @ 98 % COMPACTION						
C.B.R. @ 95 % COMPACTION						
C.B.R. @ 93 % COMPACTION						
C.B.R. @ 90 % COMPACTION						
SWELL @ 100% COMP. (%)						
T R H 14 CLASSIFICATION						

Technical Signatory:
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Remarks:
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PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-29
DATE REPORTED: 2017-05-30
TEST REPORT NO.: MT32019

MATERIALS TEST REPORT

SAMPLE NO:	3315	3316	3317	3322		
POSITION / CHAINAGE	TP 8	TP 9	TP 10	TP 14		
	PIPELINE					
DEPTH mm	0 - 500	0 - 200	0 - 460	0 - 1150		
DESCRIPTION	lt Br	lt Br	dk R O	dk R O		
	sty s	sty s	sty s	sty s		

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING 75 mm						
63 mm						
53 mm						
37.5 mm						
26.5 mm						
19 mm						
13.2 mm						
4.75 mm	100	100		98		
2.00 mm	99	97	100	96		
0.425 mm	97	94	98	93		
0.075 mm	29.1	28.2	31.4	46.5		

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	2	3	2	3		
FINE SAND (%)	69	68	67	48		
SILT / CLAY (%)	29	29	31	48		
GRADING MODULUS	0.75	0.81	0.71	0.65		

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	CBD	CBD	CBD	CBD		
PLASTICITY INDEX (%)	NP	NP	NP	NP		
LINEAR SHRINKAGE (%)	0.0	0.0	0.0	0.0		

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

COMPACTIBILITY %	0.14	0.14	0.18	0.18		
Optimum Moisture Content (%)						
C.B.R. @ 100% COMPACTION						
C.B.R. @ 98 % COMPACTION						
C.B.R. @ 95 % COMPACTION						
C.B.R. @ 93 % COMPACTION						
C.B.R. @ 90 % COMPACTION						
SWELL @ 100% COMP. (%)						
T R H 14 CLASSIFICATION						

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Technical Signatory:
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Remarks:
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ATT: Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-29
DATE REPORTED: 2017-05-30
TEST REPORT NO.: MT32019

MATERIALS TEST REPORT

SAMPLE NO:	3324A	3326	3327	3330	3332	
POSITION / CHAINAGE	TP 15	TP 17	TP 18	TP 21	TP 22	
	PIPELINE					
DEPTH mm	0 - 230	0 - 500	0 - 450	0 - 400	0- 600	
DESCRIPTION	dk R Br	dk R O	dk R O	dk R O	dk G	
	sty s	sty s	sty s	sty s	sty s	

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING 75 mm						
63 mm						
53 mm						
37.5 mm						
26.5 mm						
19 mm	100			100		
13.2 mm	99		100	94	100	
4.75 mm	98	100	99	93	99	
2.00 mm	95	98	98	88	96	
0.425 mm	91	96	96	84	94	
0.075 mm	36.2	32.6	46.1	42.0	47.0	

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	4	2	2	5	2	
FINE SAND (%)	58	65	51	48	49	
SILT / CLAY (%)	38	33	47	48	49	
GRADING MODULUS	0.78	0.73	0.60	0.86	0.63	

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	CBD	CBD	CBD	CBD	CBD	
PLASTICITY INDEX (%)	NP	SP	NP	SP	SP	
LINEAR SHRINKAGE (%)	0.0	1.0	0.0	1.0	0.5	

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

COMPACTIBILITY %	0.21	0.18	0.22	0.21	0.20	
Optimum Moisture Content (%)						
C.B.R. @ 100% COMPACTION						
C.B.R. @ 98 % COMPACTION						
C.B.R. @ 95 % COMPACTION						
C.B.R. @ 93 % COMPACTION						
C.B.R. @ 90 % COMPACTION						
SWELL @ 100% COMP. (%)						
T R H 14 CLASSIFICATION						

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Remarks:
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ATT: Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-29
DATE REPORTED: 2017-05-30
TEST REPORT NO.: MT32019

MATERIALS TEST REPORT

SAMPLE NO:	3336	3340	3342A	3343	3344A	
POSITION / CHAINAGE	TP 25	TP 28	TP 29	TP 30	TP 30	
	PIPELINE					
DEPTH mm	270 - 430	140 - 600	220 - 500	0 - 600	600 - 1400	
DESCRIPTION	dk Br	dk R O	dk R Br	dk G	lt Br	
	sty s	sty st	sty s	sty s	sty s	

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING 75 mm						
63 mm						
53 mm						
37.5 mm						
26.5 mm						
19 mm		100				
13.2 mm	99	99	100	100		
4.75 mm	93	99	98	99	100	
2.00 mm	87	98	96	98	99	
0.425 mm	77	97	92	96	97	
0.075 mm	37.0	42.7	44.2	36.5	33.0	

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	11	1	4	2	2	
FINE SAND (%)	46	55	50	61	65	
SILT / CLAY (%)	43	44	46	37	33	
GRADING MODULUS	0.99	0.62	0.68	0.70	0.71	

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	CBD	CBD	CBD	CBD	CBD	
PLASTICITY INDEX (%)	SP	SP	SP	NP	NP	
LINEAR SHRINKAGE (%)	1.5	0.5	1.5	0.0	0.0	

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

COMPACTIBILITY %	0.22	0.2	0.19	0.22	0.16	
Optimum Moisture Content (%)						
C.B.R. @ 100% COMPACTION						
C.B.R. @ 98 % COMPACTION						
C.B.R. @ 95 % COMPACTION						
C.B.R. @ 93 % COMPACTION						
C.B.R. @ 90 % COMPACTION						
SWELL @ 100% COMP. (%)						
T R H 14 CLASSIFICATION						

Technical Signatory:
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Remarks:

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CLIENT : Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-29
DATE REPORTED: 2017-05-30
TEST REPORT NO.: MT32019

MATERIALS TEST REPORT

SAMPLE NO:	3346	3348	3349	3350	3353	
POSITION / CHAINAGE	TP 31	TP 32	TP 33		TP 34	
	PIPELINE					
DEPTH mm	250 - 1900	0 - 620	100 - 500	500 - 1200	0 - 900	
DESCRIPTION	lt Br	lt Br	dk G	lt Br	lt Br	
	sdy cl	sty s	sty s	sty s	sty s	

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING 75 mm						
63 mm						
53 mm						
37.5 mm						
26.5 mm						
19 mm					100	
13.2 mm	100	100			99	
4.75 mm	98	99	100		98	
2.00 mm	96	98	99	100	96	
0.425 mm	95	95	97	99	94	
0.075 mm	64.6	28.5	44.6	43.6	39.5	

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	1	3	2	1	2	
FINE SAND (%)	32	68	53	55	57	
SILT / CLAY (%)	67	29	45	44	41	
GRADING MODULUS	0.44	0.79	0.59	0.57	0.71	

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	39	CBD	CBD	CBD	CBD	
PLASTICITY INDEX (%)	21	NP	NP	NP	NP	
LINEAR SHRINKAGE (%)	10.5	0.0	0.0	0.0	0.0	

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

COMPACTIBILITY %	0.22	0.22	0.16	0.20	0.14	
Optimum Moisture Content (%)						
C.B.R. @ 100% COMPACTION						
C.B.R. @ 98 % COMPACTION						
C.B.R. @ 95 % COMPACTION						
C.B.R. @ 93 % COMPACTION						
C.B.R. @ 90 % COMPACTION						
SWELL @ 100% COMP. (%)						
T R H 14 CLASSIFICATION						

Technical Signatory:
J Attesbury

Remarks:
Sample Delivered by Customer ☐
Sampled by Controlab ☒

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CLIENT : Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-30
DATE REPORTED: 2017-06-01
TEST REPORT NO.: MT32019

MATERIALS TEST REPORT

SAMPLE NO:	3355	3359	3361			
POSITION / CHAINAGE	TP 35	TP 37	TP 38			
	PIPELINE					
DEPTH mm	350 - 1200	0 - 200	0 - 400			
DESCRIPTION	lt Br	lt Br	lt R			
	sty s	sty s	sty s			

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING 75 mm						
63 mm						
53 mm						
37.5 mm						
26.5 mm						
19 mm						
13.2 mm		100				
4.75 mm	100	99	100			
2.00 mm	98	98	99			
0.425 mm	95	96	98			
0.075 mm	49.4	44.2	60.8			

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	3	2	1			
FINE SAND (%)	47	53	38			
SILT / CLAY (%)	50	45	61			
GRADING MODULUS	0.58	0.62	0.42			

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	CBD	CBD	CBD			
PLASTICITY INDEX (%)	NP	NP	NP			
LINEAR SHRINKAGE (%)	0.0	0.0	0.0			

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

COMPACTIBILITY %	0.18	0.20	0.22			
Optimum Moisture Content (%)						
C.B.R. @ 100% COMPACTION						
C.B.R. @ 98 % COMPACTION						
C.B.R. @ 95 % COMPACTION						
C.B.R. @ 93 % COMPACTION						
C.B.R. @ 90 % COMPACTION						
SWELL @ 100% COMP. (%)						
T R H 14 CLASSIFICATION						

Technical Signatory:
J Atterbury

Remarks:
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Sampled by Controlab ☒

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DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-30
DATE REPORTED: 2017-06-01
TEST REPORT NO.: MT32019

MATERIALS TEST REPORT

SAMPLE NO:	3364	3366	3370	3372		
POSITION / CHAINAGE	TP 39	TP 40	TP 42	TP 43		
	PIPELINE					
DEPTH mm	0 - 650	0 - 800	0 - 300	0 - 750		
DESCRIPTION	lt R	dk G	dk R Br	dk Br		
	sdy st	sdy st	sdy st	sdy st		

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING 75 mm						
63 mm						
53 mm						
37.5 mm						
26.5 mm						
19 mm						
13.2 mm			100	100		
4.75 mm		100	98	99		
2.00 mm	100	99	96	96		
0.425 mm	98	97	92	92		
0.075 mm	72.5	52.4	47.8	47.8		

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	2	2	4	4		
FINE SAND (%)	26	45	46	46		
SILT / CLAY (%)	73	53	50	50		
GRADING MODULUS	0.30	0.52	0.64	0.64		

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	24	CBD	CBD	CBD		
PLASTICITY INDEX (%)	10	SP	SP	SP		
LINEAR SHRINKAGE (%)	5.0	1.5	1.5	1.0		

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

COMPACTIBILITY %	0.20	0.22	0.22	0.25		
Optimum Moisture Content (%)						
C.B.R. @ 100% COMPACTION						
C.B.R. @ 98 % COMPACTION						
C.B.R. @ 95 % COMPACTION						
C.B.R. @ 93 % COMPACTION						
C.B.R. @ 90 % COMPACTION						
SWELL @ 100% COMP. (%)						
T R H 14 CLASSIFICATION						

Technical Signatory
J Atterbury

Remarks:

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PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-31
DATE REPORTED: 2017-06-01
TEST REPORT NO.: MT32019

MATERIALS TEST REPORT

SAMPLE NO:	3374	3376	3378			
POSITION / CHAINAGE	TP 44	TP 45	TP 46			
	PIPELINE					
DEPTH mm	0 - 650	0 - 390	0 - 700			
DESCRIPTION	dk Br	dk Br	dk Br			
	sty s	sdy st	sdy st			

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING 75 mm						
63 mm						
53 mm						
37.5 mm						
26.5 mm						
19 mm						
13.2 mm						
4.75 mm	100	100	100			
2.00 mm	99	97	98			
0.425 mm	96	92	85			
0.075 mm	44.2	58.9	71.4			

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	3	5	13			
FINE SAND (%)	52	34	14			
SILT / CLAY (%)	45	61	73			
GRADING MODULUS	0.61	0.52	0.46			

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	CBD	20	27			
PLASTICITY INDEX (%)	SP	6	8			
LINEAR SHRINKAGE (%)	1.0	2.5	4.0			

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

COMPACTIBILITY %	0.21	0.21	0.18			
Optimum Moisture Content (%)						
C.B.R. @ 100% COMPACTION						
C.B.R. @ 98 % COMPACTION						
C.B.R. @ 95 % COMPACTION						
C.B.R. @ 93 % COMPACTION						
C.B.R. @ 90 % COMPACTION						
SWELL @ 100% COMP. (%)						
T R H 14 CLASSIFICATION						

Technical Signatory:
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Remarks:
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DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-23
DATE REPORTED: 2017-05-30
TEST REPORT NO.: MT 32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	3307	3308	3309	3312	3314	
POSITION	TP 1	TP 2	TP 3	TP 4	TP 7	
	PIPELINE					
DEPTH mm	1600 - 3100	550 - 800	0 - 2000	400 - 1000	400 - 600	
DESCRIPTION	dk O	Pale R	dk R	dk R O	lt Br	
	sty s	Ss +	high weath	Ss +	Ss +	
		cly s	Ms + cly s	sty s	sty s	

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm		100				
37.5 mm		95	100	100	100	
19 mm		67	85	54	64	
9.5 mm		43	57	35	46	
4.75 mm		29	39	28	37	
2.36 mm		23	29	24	30	
1.18 mm	100	21	24	23	27	
0.600 mm	99	20	22	21	25	
0.425 mm	98	20	21	20	24	
0.300 mm	95	19	21	19	22	
0.150 mm	73	14	20	12	14	
0.075 mm	37.2	9.2	17.3	7.0	8.4	

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	31	8	15	6	8	
0.02 mm	15	5	10	4	6	
0.006 mm	10	4	8	2	4	
0.002 mm	8	3	7	1	4	

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	CBD	23	31	20	19	
PLASTICITY INDEX	SP	12	17	6	4	
LINEAR SHRINKAGE	1.5	5.5	8.5	3.0	2.5	

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

PI WHOLE SAMPLE	0.0	2.0	4.0	1.0	1.0	
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW	LOW	LOW	

Technical Signatory:
J Atterbury

Remarks:

Samples Delivered by Customer

Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-23
DATE REPORTED: 2017-05-30
TEST REPORT NO.: MT 32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	3318	3319	3320	3321	3323	
POSITION	TP 10	TP 11	TP 12	TP 13	TP 14	
	PIPELINE					
DEPTH mm	1000 - 1300	200 - 400	200 - 1100	120 - 300	2300 - 3000	
DESCRIPTION	lt R Br	dk R	dk R Br	lt Br	lt R Br	
	Ss +	high weath	dec Dol +	Ss +	high weath	
	cly s	Ss + cly s	cly s	sty s	Ss + sty s	

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm	100		100			
37.5 mm	82	100	88	100		
19 mm	67	94	51	68		
9.5 mm	58	65	33	45	100	
4.75 mm	53	36	23	33	93	
2.36 mm	50	25	18	27	91	
1.18 mm	48	21	16	24	90	
0.600 mm	46	20	15	22	90	
0.425 mm	44	19	14	21	90	
0.300 mm	41	19	14	17	88	
0.150 mm	27	15	13	11	68	
0.075 mm	14.1	10.7	9.9	5.7	42.8	

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	12	10	9	5	37	
0.02 mm	7	7	6	2	22	
0.006 mm	4	5	5	1	15	
0.002 mm	3	4	4	1	12	

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	24	28	52	CBD	22	
PLASTICITY INDEX	12	12	24	SP	10	
LINEAR SHRINKAGE	5.5	6.0	12.0	1.5	5.0	

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

PI WHOLE SAMPLE	5.0	2.0	3.0	0.0	9.0	
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW	LOW	LOW	

Technical Signatory:
J Atterbury

Remarks:
Samples Delivered by Customer
Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-23
DATE REPORTED: 2017-05-30
TEST REPORT NO.: MT 32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	3324B	3325	3328	3329	3331	3333
POSITION	TP 15	TP 16	TP 19	TP 20	TP 21	TP 22
	PIPELINE					
DEPTH mm	230 - 680	250 - 570	430 - 800	120 - 440	400 - 1340	600 - 920
DESCRIPTION	dk R O	dk R O	dk Br	Pale R	dk R O	lt R Br
	Ss	Ss	Ss	Ss	Ss	Ss

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm						
37.5 mm	100	100	100	100	100	100
19 mm	88	72	74	64	88	86
9.5 mm	77	51	52	45	77	60
4.75 mm	70	39	38	23	70	44
2.36 mm	65	30	30	16	65	35
1.18 mm	60	25	27	13	60	28
0.600 mm	47	22	25	13	47	23
0.425 mm	40	21	25	12	40	22
0.300 mm	31	18	23	12	31	21
0.150 mm	18	11	17	11	18	17
0.075 mm	9.7	4.7	9.2	5.5	9.7	11.0

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	8	4	8	5	8	9
0.02 mm	4	2	4	2	4	4
0.006 mm	2	1	3	1	2	2
0.002 mm	1	1	2	1	1	2

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	CBD	CBD	CBD	CBD	CBD	33
PLASTICITY INDEX	SP	SP	SP	SP	SP	10
LINEAR SHRINKAGE	1.0	1.0	1.5	1.5	1.0	4.5

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

PI WHOLE SAMPLE	0.0	0.0	0.0	0.0	0.0	2.0
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW	LOW	LOW	LOW

The above test results are pertinent to the samples received and tested only.
While the tests are carried our according to recognized standards Controlab shall not be liable for erroneous testing or reporting thereof. This report may not be reproduced except in full without prior consent of Controlab.

Technical Signatory:
J Atterbury

Remarks:

Samples Delivered by Customer

Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-24
DATE REPORTED: 2017-05-30
TEST REPORT NO.: MT 32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	3334	3335	3337	3338	3339	
POSITION	TP 23	TP 24	TP 25	TP 26	TP 27	
	PIPELINE					
DEPTH mm	130 - 550	300 - 520	430 - 670	120 - 1100	600 - 800	
DESCRIPTION	dk R Br	lt Ol	Pale R	lt R Br	Pale R	
	Ss	Ss	Sh +	Ss	Ms	
			cly s			
SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5						
% PASSING 75 mm				100	100	
37.5 mm	100	100		87	97	
19 mm	68	60	100	75	62	
9.5 mm	44	38	77	50	30	
4.75 mm	29	27	48	36	17	
2.36 mm	20	20	31	25	10	
1.18 mm	17	17	24	16	7	
0.600 mm	15	16	22	9	6	
0.425 mm	15	15	21	4	5	
0.300 mm	14	14	20	4	5	
0.150 mm	11	10	19	2	4	
0.075 mm	6.1	5.0	15.6	1.3	3.3	
HYDROMETER ANALYSIS: Method ASTM D422						
0.06 mm	5	4	13	1	3	
0.02 mm	2	2	7	1	2	
0.006 mm	1	1	4	1	1	
0.002 mm	1	1	3	1	1	
ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4						
LIQUID LIMIT	28	CBD	25	CBD	28	
PLASTICITY INDEX	8	SP	12	SP	12	
LINEAR SHRINKAGE	4.0	1.0	6.0	1.0	6.0	
PREDICTION OF HEAVE (VAN DER MERWE METHOD)						
PI WHOLE SAMPLE	1.0	0.0	3.0	0.0	1.0	
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW	LOW	LOW	

Technical Signatory:
J Atterbury

Remarks:
Samples Delivered by Customer
Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-24
DATE REPORTED: 2017-05-30
TEST REPORT NO.: MT 32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	3341	3342B	3345	3347	3352	3354
POSITION	TP 28	TP 29	TP 30	TP 31	TP 33	TP 34
	PIPELINE					
DEPTH mm	140 - 660	500 - 1100	1840 - 2000	1900 - 3000	2000 - 3000	900 - 1240
DESCRIPTION	lt R O	lt R O	lt R Br	dk Y O	Pale R	lt R Br
	Ss	dec Dol +	Ss	high weath	Ss +	Ss +
		sty cl		Ss + cly s	sdy st	sand

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm	100		100			100
37.5 mm	92	100	79			93
19 mm	69	64	51		100	74
9.5 mm	46	42	42		92	67
4.75 mm	32	25	38		83	60
2.36 mm	26	17	37	100	76	57
1.18 mm	23	12	36	98	68	55
0.600 mm	21	9	35	97	63	53
0.425 mm	20	8	34	96	62	50
0.300 mm	18	7	33	96	62	46
0.150 mm	12	6	24	89	61	27
0.075 mm	5.3	4.3	11.4	37.2	51.1	12.0

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	5	4	10	34	42	10
0.02 mm	2	2	5	25	22	4
0.006 mm	1	1	3	20	11	3
0.002 mm	1	1	3	18	9	2

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	CBD	48	23	25	25	CBD
PLASTICITY INDEX	SP	15	8	12	9	SP
LINEAR SHRINKAGE	1.5	7.5	4.0	5.5	4.5	1.0

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

PI WHOLE SAMPLE	0.0	1.0	3.0	12.0	6.0	0.0
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW	MED	LOW	LOW

Technical Signatory: J Atterbury

Remarks:

Samples Delivered by Customer

Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Queenstown, Lusaka - Zambia

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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-24
DATE REPORTED: 2017-05-30
TEST REPORT NO.: MT 32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	3357	3358	3360	3362		
POSITION	TP 35	TP 36	TP 37	TP 38		
	PIPELINE					
DEPTH mm	1900 - 3000	1400 - 1900	200 - 400	400 - 3000		
DESCRIPTION	lt R Br	lt Br	lt R Br	lt R O		
	cly s	Ss +	Ss	Ss +		
		sty s		sty s		

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm		100	100			
37.5 mm		90	87			
19 mm		75	54			
9.5 mm	100	63	41	100		
4.75 mm	96	58	34	99		
2.36 mm	91	54	30	98		
1.18 mm	89	52	28	96		
0.600 mm	89	51	26	95		
0.425 mm	88	50	25	94		
0.300 mm	87	46	22	93		
0.150 mm	72	30	14	76		
0.075 mm	52.0	15.5	5.2	50.6		

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	45	13	5	43		
0.02 mm	28	8	4	24		
0.006 mm	23	4	2	19		
0.002 mm	22	3	1	18		

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	26	CBD	CBD	21		
PLASTICITY INDEX	12	SP	SP	8		
LINEAR SHRINKAGE	6.5	1.0	1.0	4.5		

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

PI WHOLE SAMPLE	11.0	0.0	0.0	8.0		
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW	LOW		

Technical Signatory:
J Atterbury

Remarks:

Samples Delivered by Customer

Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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CLIENT: Aurecon SA (Pty) Ltd
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ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-25
DATE REPORTED: 2017-06-01
TEST REPORT NO.: MT 32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	3365	3368	3371	3373		
POSITION	TP 39	TP 41	TP 42	TP 43		
	PIPELINE					
DEPTH mm	650 - 3000	250 - 2300	300 - 1300	750 - 1200		
DESCRIPTION	lt R O	dk R Br	dk R O	lt Br		
	dec Dol +	dec Dol +	Ss +	Ss +		
	sty s	cly s	cly s	sty s		

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm		100		100		
37.5 mm		90	100	90		
19 mm		58	70	62		
9.5 mm	100	38	48	37		
4.75 mm	97	27	34	30		
2.36 mm	70	20	27	26		
1.18 mm	50	14	23	24		
0.600 mm	38	9	21	23		
0.425 mm	33	7	20	22		
0.300 mm	30	6	20	20		
0.150 mm	25	5	18	14		
0.075 mm	15.2	3.6	14.7	9.5		

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	12	3	13	8		
0.02 mm	4	2	9	6		
0.006 mm	1	1	7	4		
0.002 mm	1	1	6	3		

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	CBD	38	31	17		
PLASTICITY INDEX	SP	16	16	4		
LINEAR SHRINKAGE	1.5	7.5	7.5	1.5		

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

PI WHOLE SAMPLE	0.0	1.0	3.0	1.0		
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW	LOW		

Technical Signatory:
J Atterbury

Remarks:
Samples Delivered by Customer
Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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CLIENT: Aurecon SA (Pty) Ltd
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ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-25
DATE REPORTED: 2017-06-01
TEST REPORT NO.: MT 32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	3375	3377	3379			
POSITION	TP 44	TP 45	TP 46			
	PIPELINE					
DEPTH mm	650 - 2300	390 - 410	700 - 2800			
DESCRIPTION	dk Y	lt Br	Pale R			
	Ss +	Ss +	Ss +			
	sty s	sty s	cly s			

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm			100			
37.5 mm	100	100	92			
19 mm	83	87	69			
9.5 mm	73	78	47			
4.75 mm	63	68	34			
2.36 mm	55	63	25			
1.18 mm	49	60	19			
0.600 mm	46	58	16			
0.425 mm	44	56	14			
0.300 mm	44	53	14			
0.150 mm	44	37	12			
0.075 mm	34.3	18.6	9.8			

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	28	16	9			
0.02 mm	12	8	6			
0.006 mm	5	5	4			
0.002 mm	4	4	3			

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	26	CBD	33			
PLASTICITY INDEX	8	SP	13			
LINEAR SHRINKAGE	4.5	1.0	5.5			

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

PI WHOLE SAMPLE	4.0	0.0	2.0			
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW			

Technical Signatory: J Atterbury

Remarks:
Samples Delivered by Customer
Sampled by Controlab: YES

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ATT: Mr D Luhring

PROJECT: Ngqamakhwe RWSS:
Phase 5

REF: MT32019

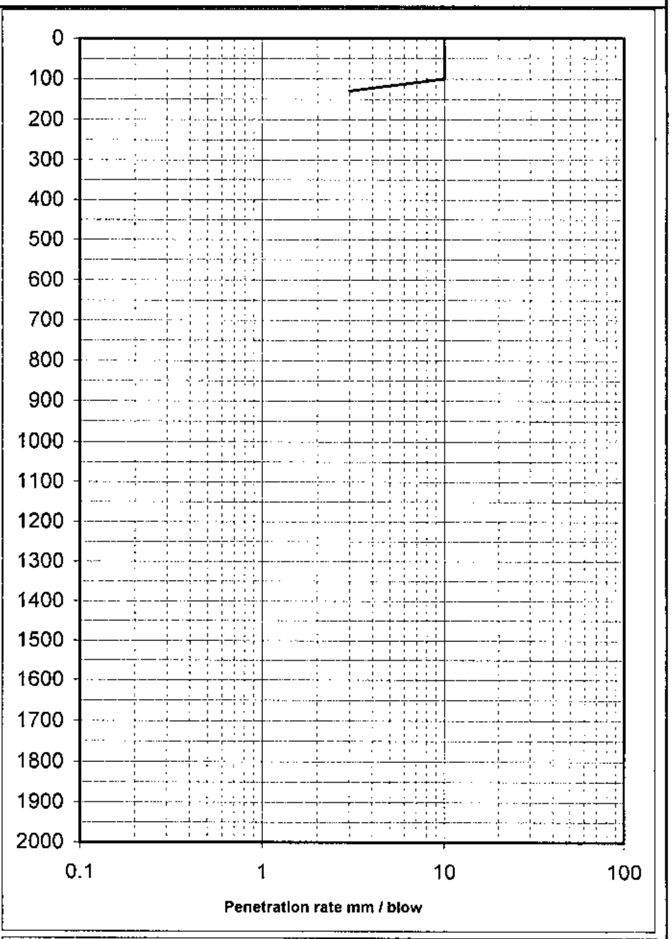
DATE: 2017-04-26

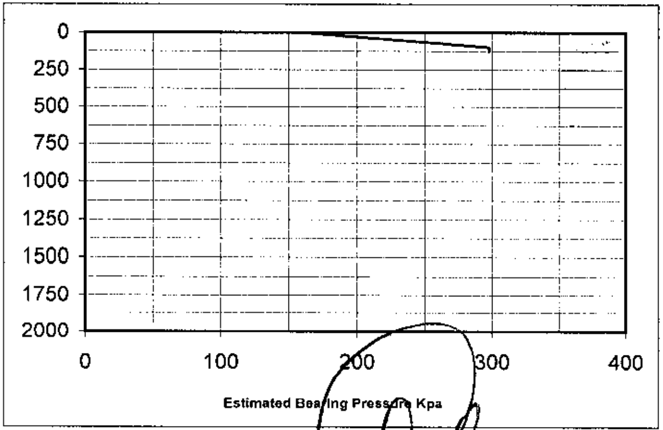
DYNAMIC CONE PENETROMETER DATA

POSITION: TP 1 MAIN PIPELINE
S 32°02'07.7" E 27°49'36.7"

REMARKS: Refusal @ 130mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
100	10	10	22				
130	20	3	110				





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ATT: Mr D Luhring

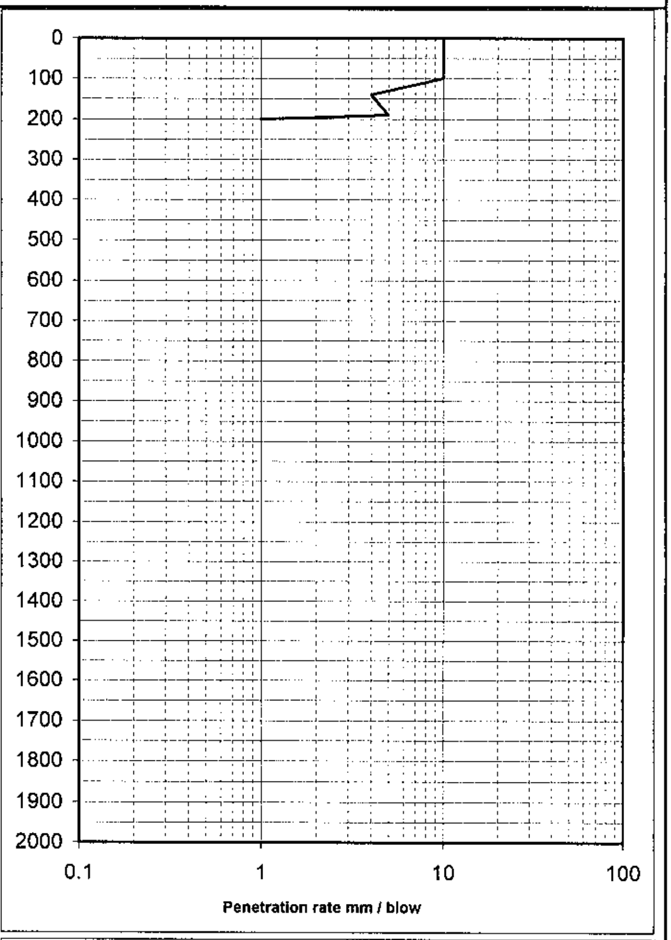
PROJECT: Ngqamakhwe RWSS: Phase 5
REF: MT32019
DATE: 2017-04-26

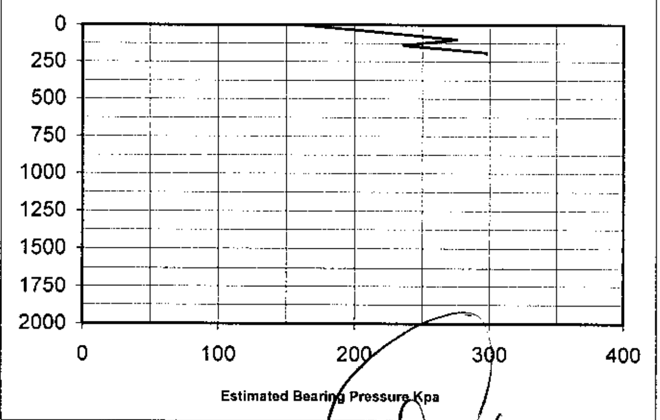
DYNAMIC CONE PENETROMETER DATA

POSITION: TP 2 MAIN PIPELINE
S 32°02'13.9" E 27°49'46.7"

REMARKS: Refusal @ 200mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
100	10	10	22				
140	20	4	75				
190	30	5	55				
200	40	1	>110				





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ATT: Mr D Luhring

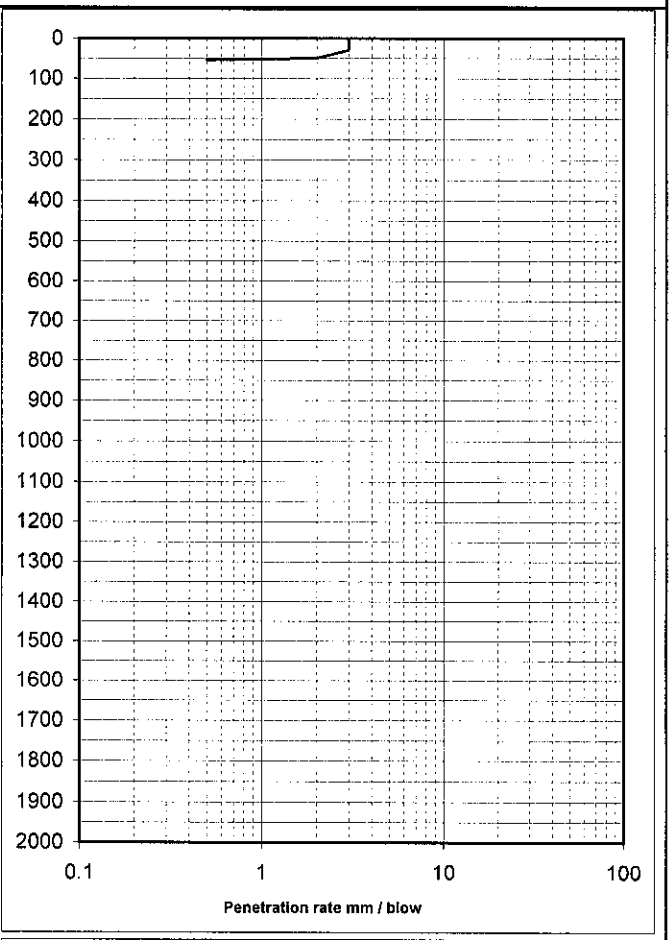
PROJECT: Ngqamakhwe RWSS:
Phase 5
REF: MT32019
DATE: 2017-04-26

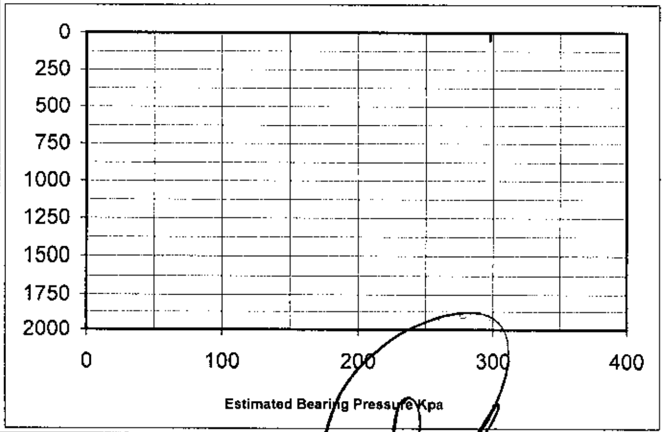
DYNAMIC CONE PENETROMETER DATA

POSITION: TP 3 MAIN PIPELINE
S 32°02'22.0" E 27°49'55.8"

REMARKS: Refusal @ 55mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
30	10	3	110				
50	20	2	>110				
55	30	0.5	>110				





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CLIENT: Aurecon SA (Pty) Ltd
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ATT: Mr D Luhring

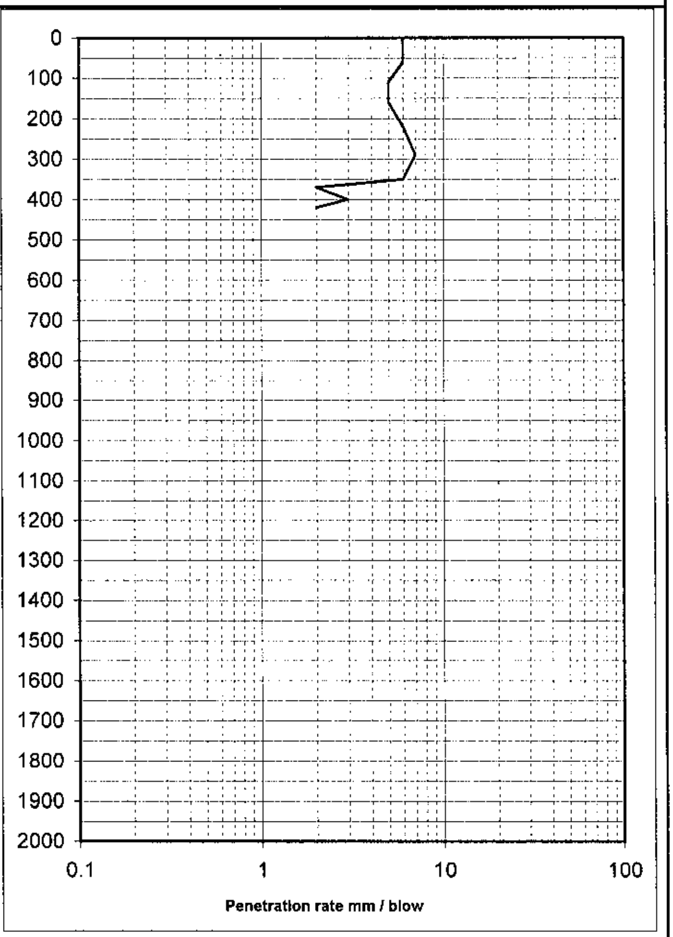
PROJECT: Ngqamakhwe RWSS:
Phase 5
REF: MT32019
DATE: 2017-04-26

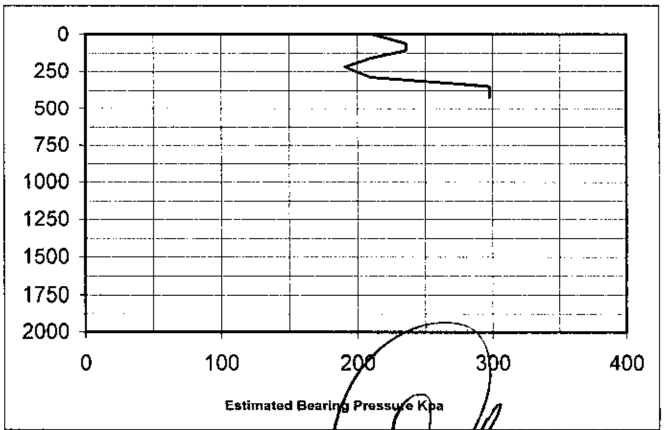
DYNAMIC CONE PENETROMETER DATA

POSITION: TP 4 MAIN PIPELINE
S 32°02'30.1" E 27°50'02.0"

REMARKS: Refusal @ 420mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
60	10	6	45				
110	20	5	55				
160	30	5	55				
220	40	6	45				
290	50	7	35				
350	60	6	45				
370	70	2	>110				
400	80	3	110				
420	90	2	>110				





Technical Signatory:________________D Louw

CLIENT: Aurecon SA (Pty) Ltd
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ATT: Mr D Luhring

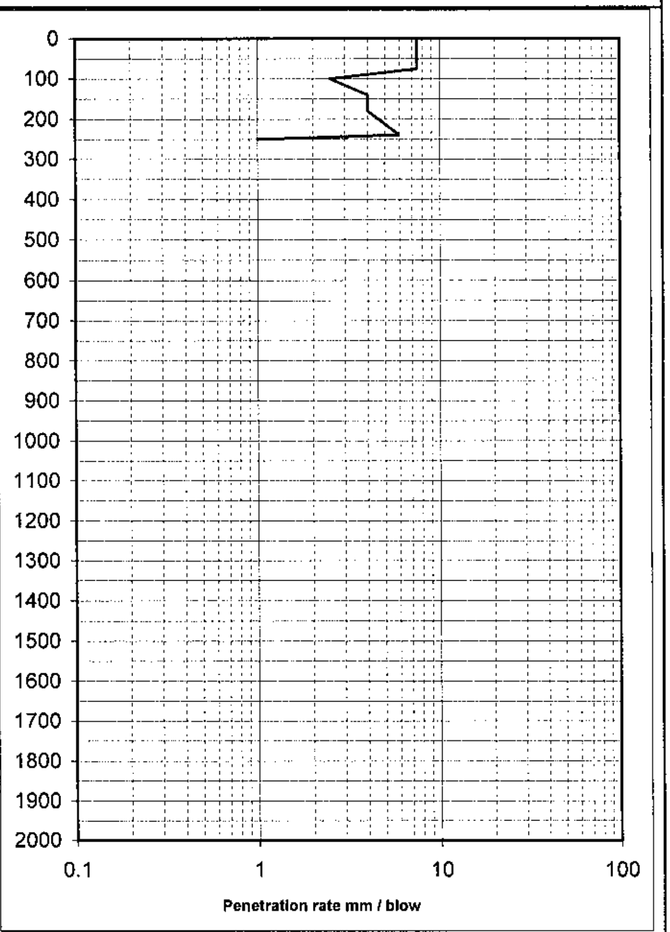
PROJECT: Ngqamakhwe RWSS:
Phase 5
REF: MT32019
DATE: 2017-04-26

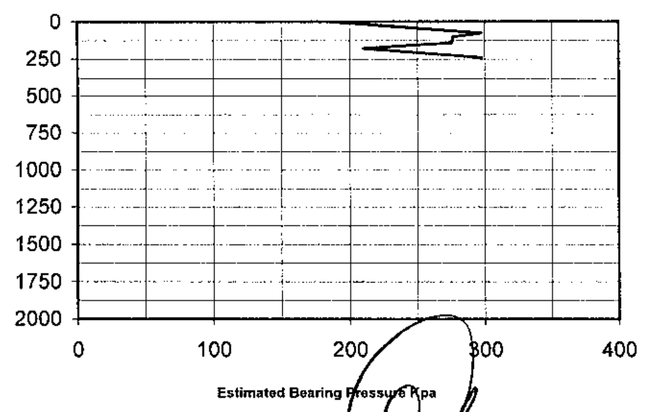
DYNAMIC CONE PENETROMETER DATA

POSITION: TP 5 MAIN PIPELINE
S 32°02'30.2" E 27°50'11.5"

REMARKS: Refusal @ 250mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0			
75	10	7.5	33
100	20	2.5	110
140	30	4	75
180	40	4	75
240	50	6	45
250	60	1	>110





Technical Signatory:________D Louw

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CLIENT: Aurecon SA (Pty) Ltd
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ATT: Mr D Luhring

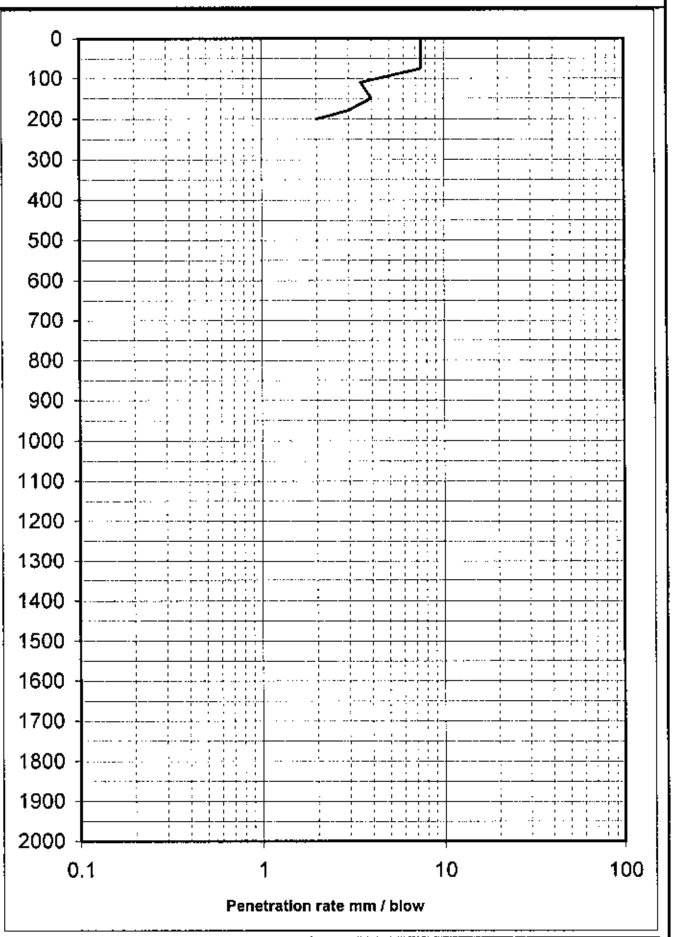
PROJECT: Ngqamakhwe RWSS: Phase 5
REF: MT32019
DATE: 2017-04-26

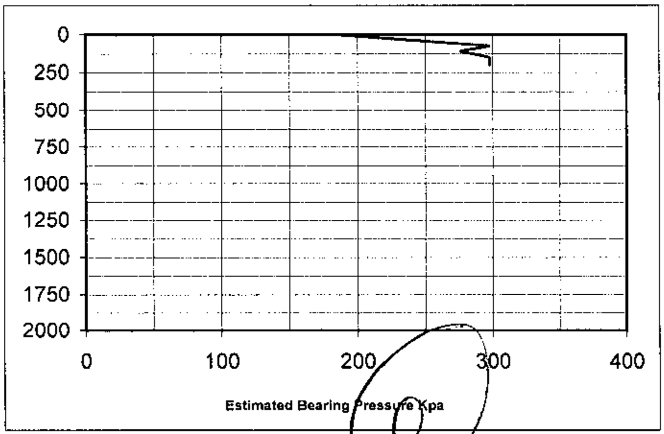
DYNAMIC CONE PENETROMETER DATA

POSITION: TP 6 MAIN PIPELINE
S 32°02'39.4" E 27°50'23.7"

REMARKS: Refusal @ 200mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
75	10	7.5	33				
110	20	3.5	93				
150	30	4	75				
180	40	3	110				
200	50	2	>110				





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CLIENT: Aurecon SA (Pty) Ltd
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5214
ATT: Mr D Luhring

PROJECT: Ngqamakhwe RWSS:
Phase 5
REF: MT32019
DATE: 2017-04-26

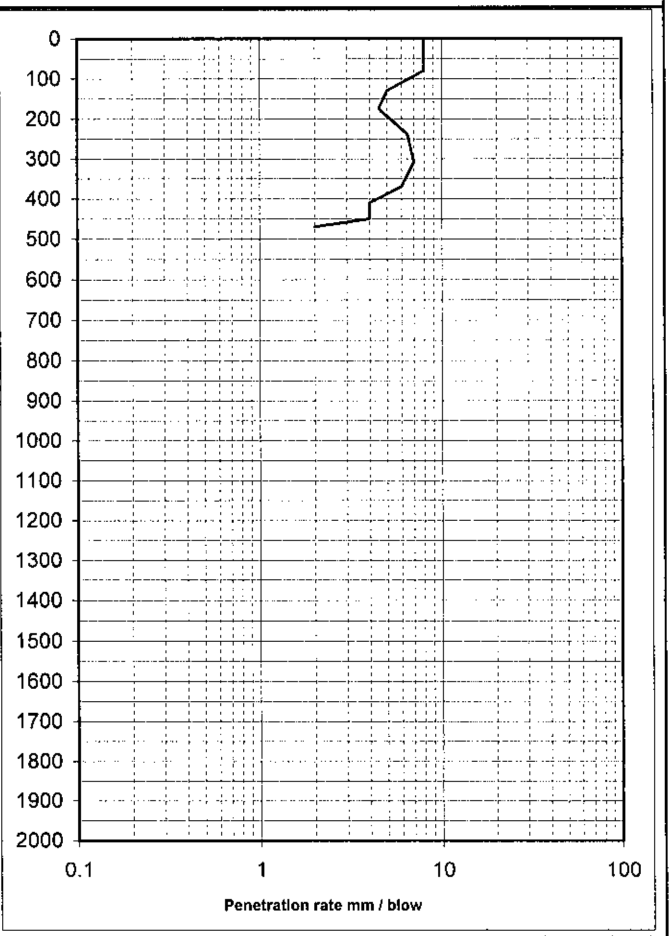
DYNAMIC CONE PENETROMETER DATA

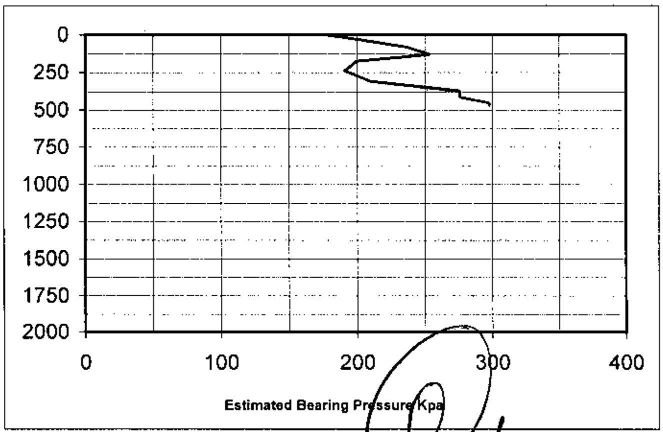
POSITION: TP 7 MAIN PIPELINE
S 32°02'39.1" E 27°50'36.8"

REMARKS: Refusal @ 470mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0			
80	10	8	30
130	20	5	55
175	30	4.5	65
240	40	6.5	40
310	50	7	35
370	60	6	45
410	70	4	75
450	80	4	75
470	90	2	>110

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR





Technical Signatory: D Louw

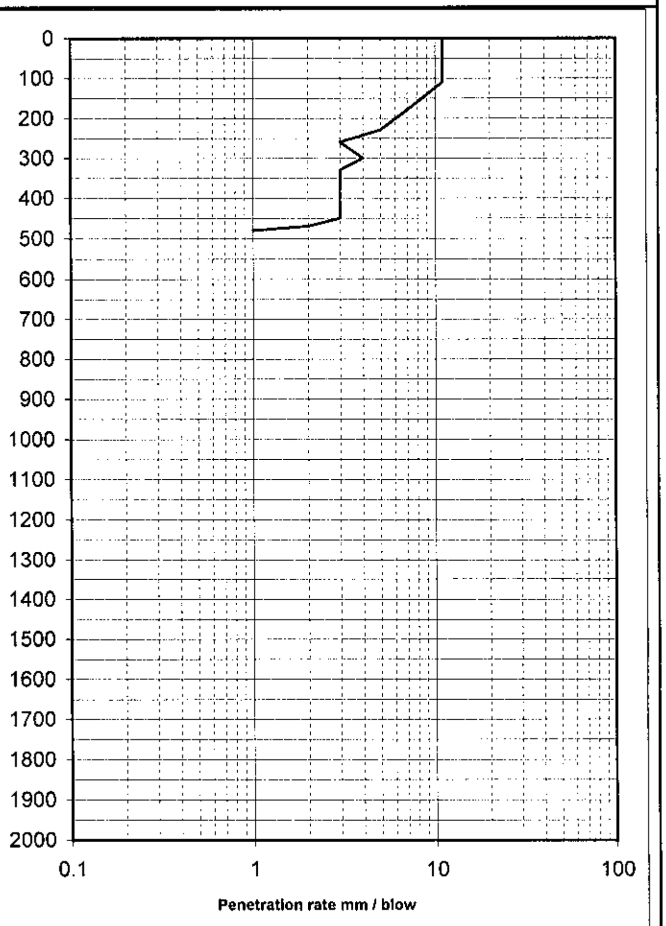
CLIENT:	Aurecon SA (Pty) Ltd PO Box 19553 TECOMA 5214	**PROJECT:**	Ngqamakhwe RWSS: Phase 5
		REF:	MT32019
ATT:	Mr D Luhring	**DATE:**	2017-04-26

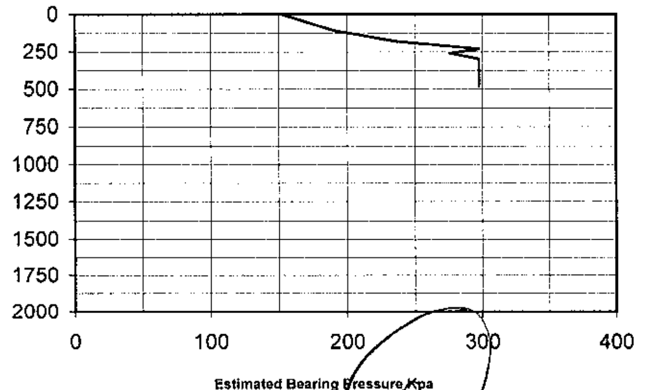
DYNAMIC CONE PENETROMETER DATA

POSITION: TP 8 MAIN PIPELINE
S 32°02'38.2" E 27°50'49.8"

REMARKS: Refusal @ 480mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
110	10	11	20				
180	20	7	35				
230	30	5	55				
260	40	3	110				
300	50	4	75				
330	60	3	110				
360	70	3	110				
390	80	3	110				
420	90	3	110				
450	100	3	110				
470	110	2	>110				
480	120	1	>110				





Technical Signatory: D Louw

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ATT: Mr D Luhring

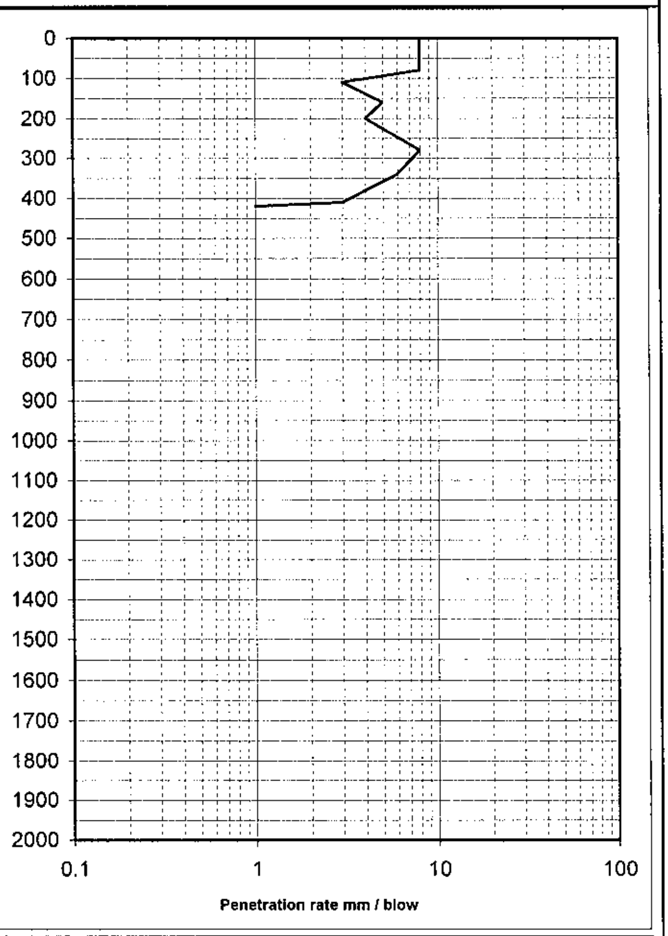
PROJECT: Ngqamakhwe RWSS:
Phase 5
REF: MT32019
DATE: 2017-04-26

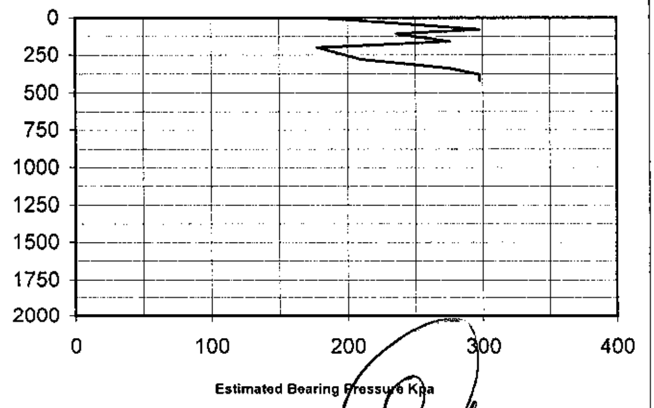
DYNAMIC CONE PENETROMETER DATA

POSITION: TP 9 MAIN PIPELINE
S 32°02'36.0" E 27°51'01.3"

REMARKS: Refusal @ 420mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
80	10	8	30				
110	20	3	110				
160	30	5	55				
200	40	4	75				
280	50	8	30				
340	60	6	45				
380	70	4	75				
410	80	3	110				
420	90	1	>110				





Technical Signatory: D Louw

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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

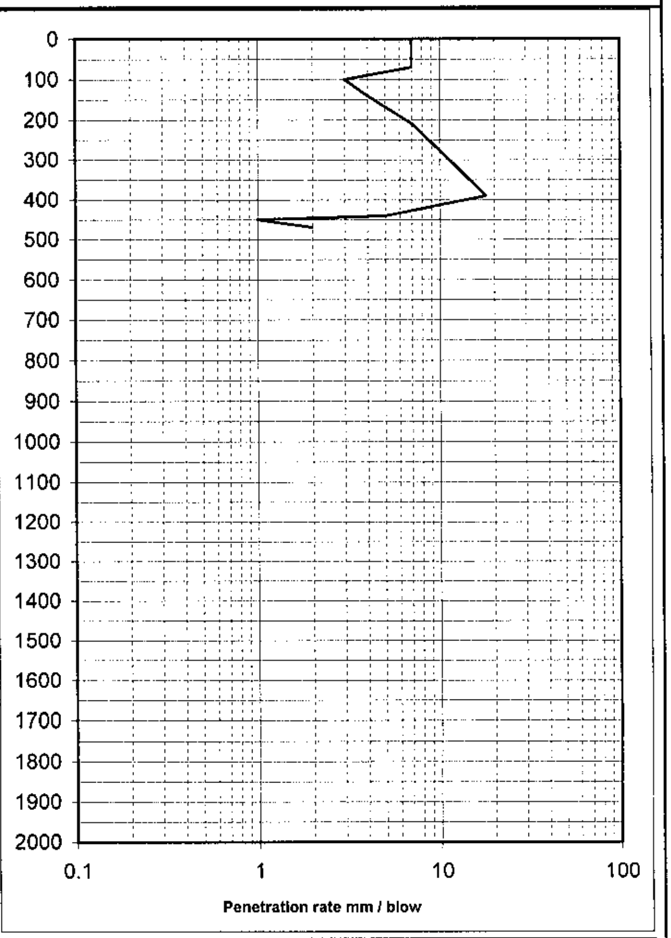
PROJECT: Ngqamakhwe RWSS:
Phase 5
REF: MT32019
DATE: 2017-04-26

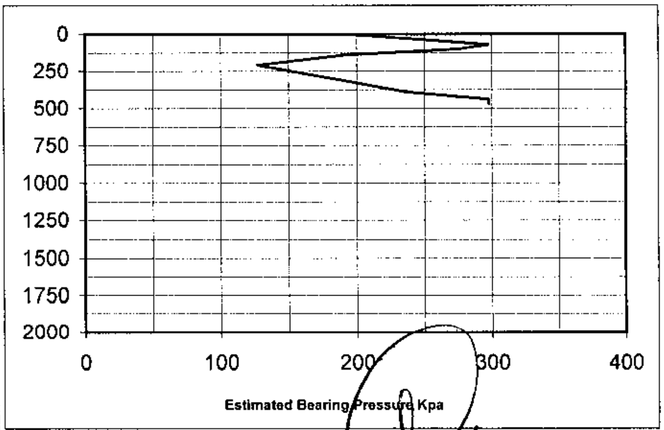
DYNAMIC CONE PENETROMETER DATA

POSITION: TP 10 MAIN PIPELINE
S 32°02'35.9" E 27°51'14.3"

REMARKS: Refusal @ 470mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
70	10	7	35				
100	20	3	110				
140	30	4	75				
210	40	7	35				
390	50	18	11				
440	60	5	55				
450	70	1	>110				
470	80	2	>110				





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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
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5214
ATT: Mr D Luhring

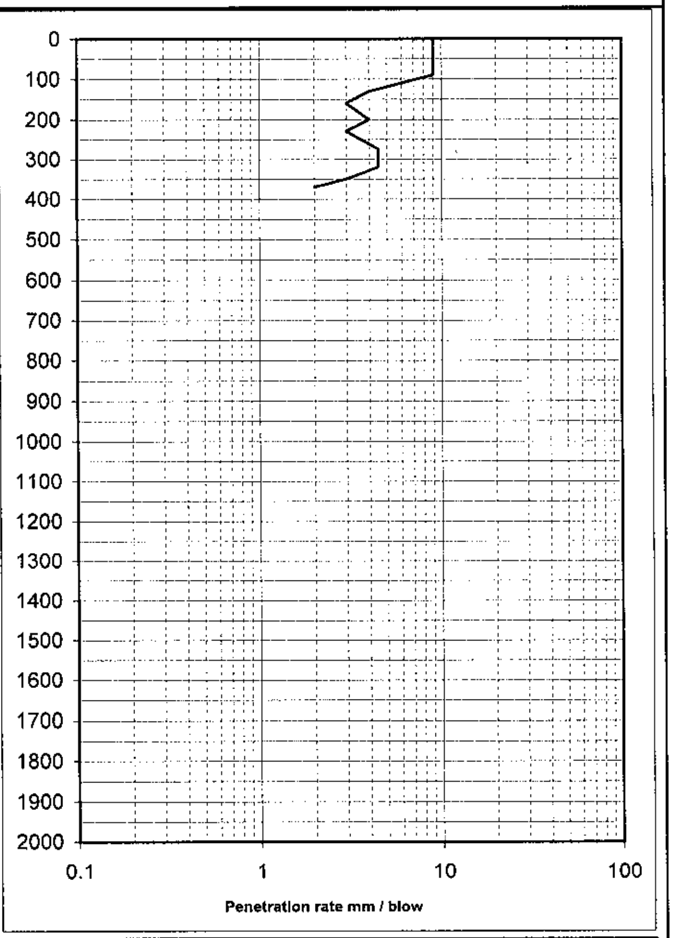
PROJECT: Ngqamakhwe RWSS:
Phase 5
REF: MT32019
DATE: 2017-04-26

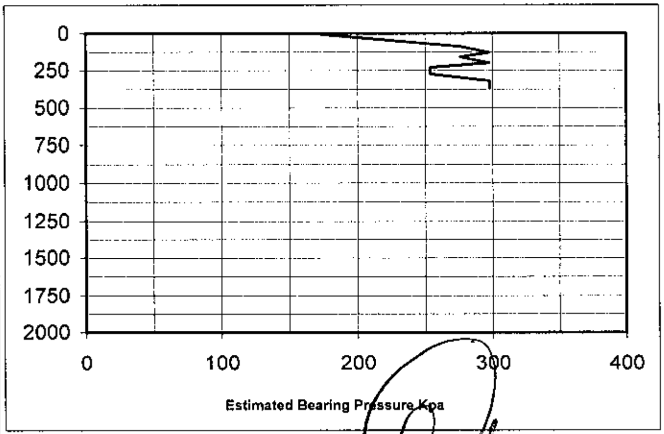
DYNAMIC CONE PENETROMETER DATA

POSITION: TP 11 MAIN PIPELINE
S 32°02'40.3" E 27°51'22.5"

REMARKS: Refusal @ 370mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
90	10	9	25				
130	20	4	75				
160	30	3	110				
200	40	4	75				
230	50	3	110				
275	60	4.5	65				
320	70	4.5	65				
350	80	3	110				
370	90	2	>110				





Technical Signatory: D Louw

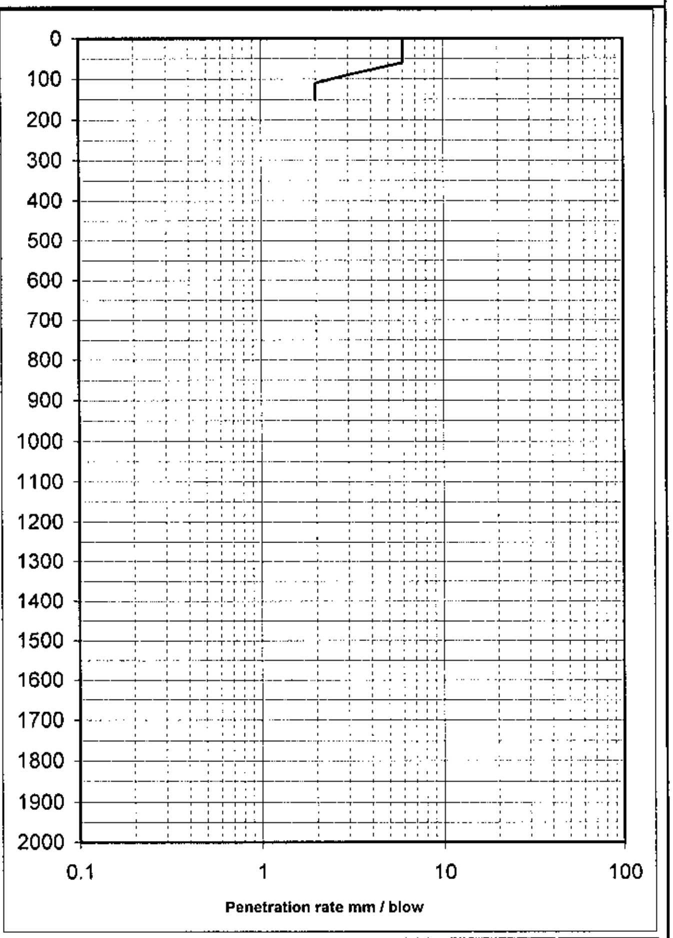
CLIENT:	Aurecon SA (Pty) Ltd PO Box 19553 TECOMA 5214	**PROJECT:**	Ngqamakhwe RWSS: Phase 5
		REF:	MT32019
ATT:	Mr D Luhring	**DATE:**	2017-04-26

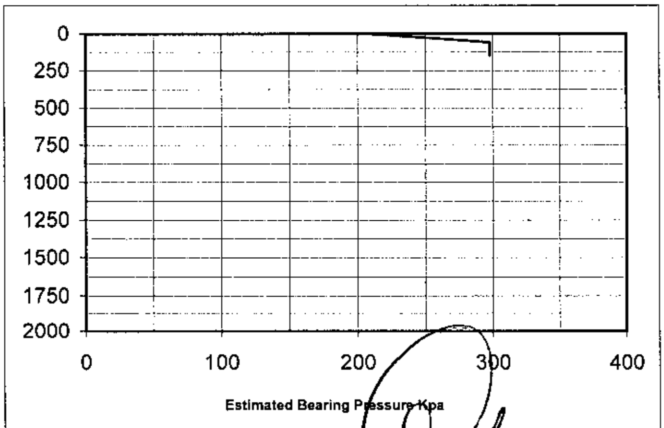
DYNAMIC CONE PENETROMETER DATA

POSITION: TP 12 MAIN PIPELINE
S 32°02'44.0" E 27°51'31.3"

REMARKS: Refusal @ 150mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
60	10	6	45				
90	20	3	110				
110	30	2	>110				
130	40	2	>110				
150	50	2	>110				





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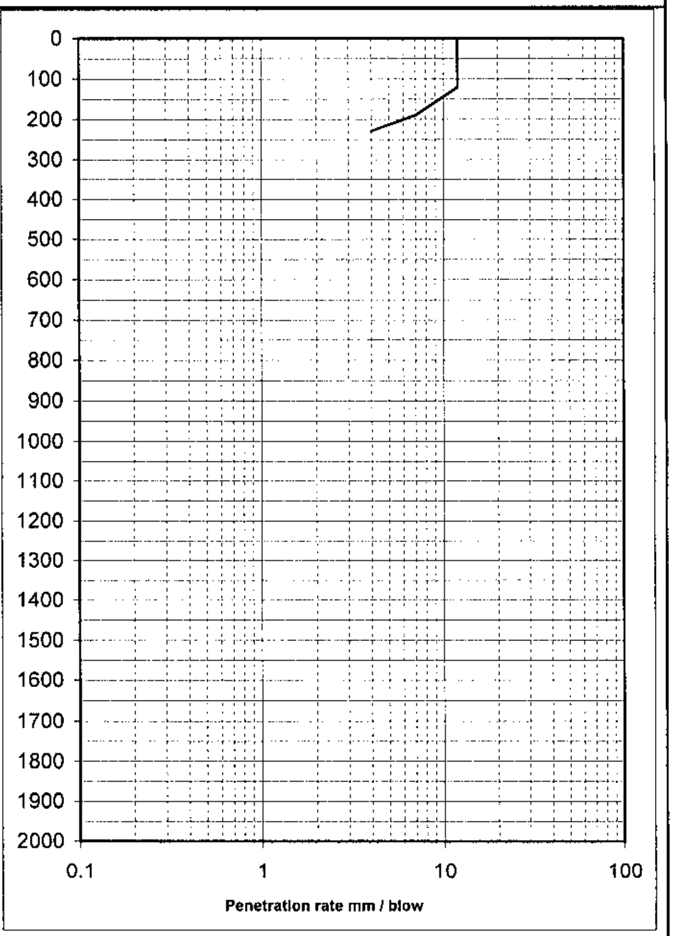
CLIENT:	Aurecon SA (Pty) Ltd PO Box 19553 TECOMA 5214	**PROJECT:**	Ngqamakhwe RWSS: Phase 5
		REF:	MT32019
ATT:	Mr D Luhring	**DATE:**	2017-04-26

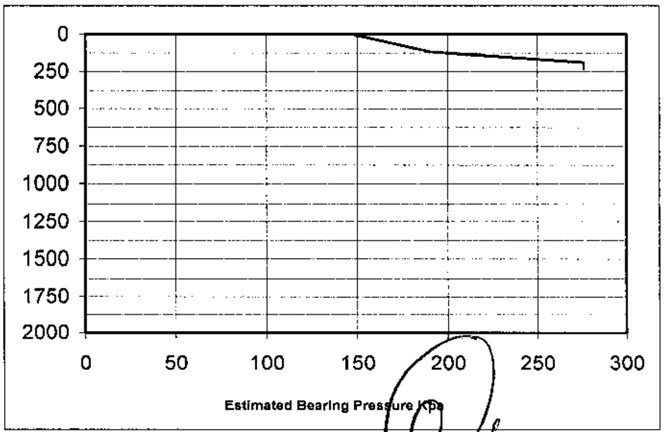
DYNAMIC CONE PENETROMETER DATA

POSITION: TP 15 MAIN PIPELINE
S 32°03'07.5" E 27°51'49.9"

REMARKS: Refusal @ 230mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
120	10	12	18				
190	20	7	35				
230	30	4	75				





Technical Signatory:______________ D Louw

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

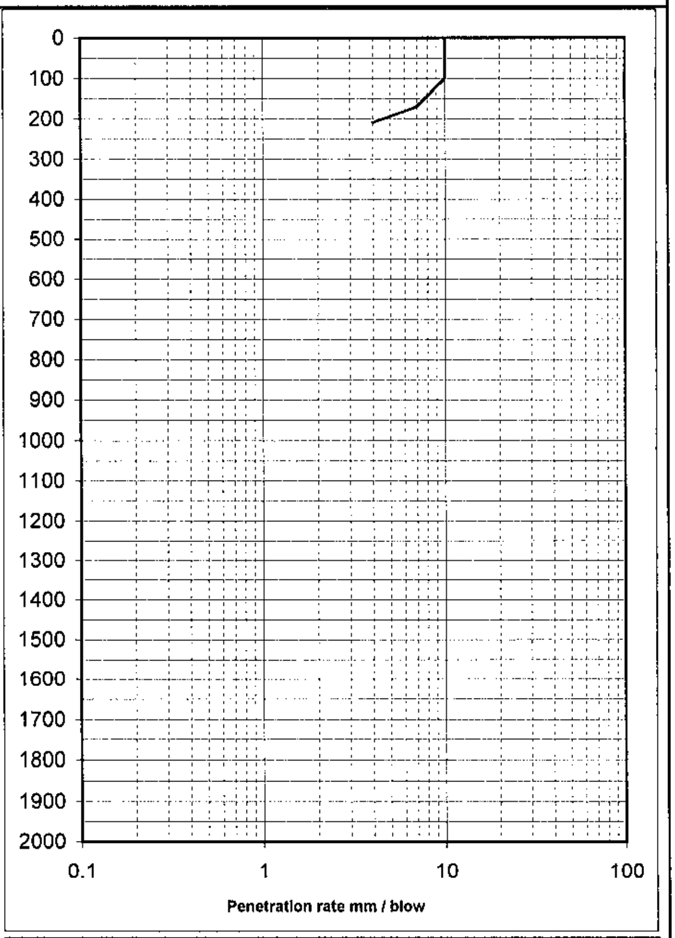
PROJECT: Ngqamakhwe RWSS: Phase 5
REF: MT32019
DATE: 2017-04-26

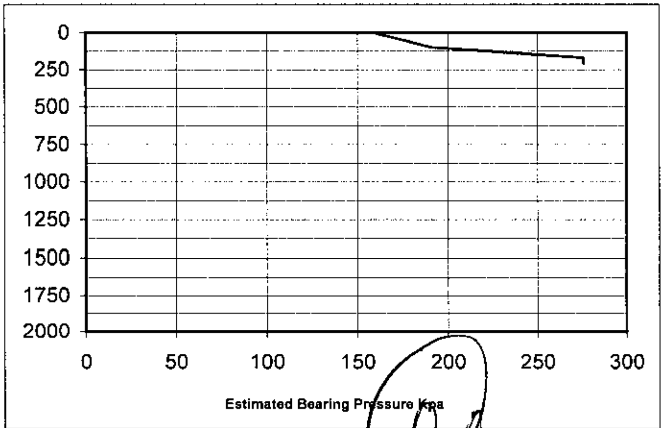
DYNAMIC CONE PENETROMETER DATA

POSITION: TP 16 MAIN PIPELINE
S 32°03'15.2" E 27°51'59.4"

REMARKS: Refusal @ 210mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
100	10	10	22				
170	20	7	35				
210	30	4	75				





Technical Signatory: D Louw

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CLIENT : Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-26
DATE REPORTED: 2017-05-30
TEST REPORT NO.: MT32019

MATERIALS TEST REPORT

SAMPLE NO:	3400	3402	3404			
POSITION / CHAINAGE	PS1 / TP 1	PS1 / TP 2	PS1 / TP 3			
	PUMP STATION 1					
DEPTH	600 - 2900	1200 - 2700	950 - 2900			
DESCRIPTION	lt R	lt R	lt R			
	sdy st	sdy st	sdy st			

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING 75 mm						
63 mm						
53 mm						
37.5 mm						
26.5 mm						
19 mm						
13.2 mm	100	100				
4.75 mm	99	98				
2.00 mm	99	98	100			
0.425 mm	98	97	98			
0.075 mm	51.0	48.5	52.9			

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	1	1	2			
FINE SAND (%)	47	49	45			
SILT / CLAY (%)	52	49	53			
GRADING MODULUS	0.52	0.57	0.49			

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	20	20	21			
PLASTICITY INDEX (%)	6	5	8			
LINEAR SHRINKAGE (%)	3.5	2.0	4.5			

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

Maximum Dry Density (kg/m^3)	1934	1920	1924			
Optimum Moisture Content (%)	11.1	10.7	12.2			
C.B.R. @ 100% COMPACTION	63	55	61			
C.B.R. @ 98 % COMPACTION	50	40	43			
C.B.R. @ 95 % COMPACTION	38	26	25			
C.B.R. @ 93 % COMPACTION	29	18	12			
C.B.R. @ 90 % COMPACTION	20	12	10			
SWELL @ 100% COMP. (%)	0.40	0.60	0.60			
T R H 14 CLASSIFICATION	G8	G8	G8			

The above test results are pertinent to the samples tested only. While the tests are carried out according to recognized standards, Controlab shall not be liable for erroneous testing or reporting thereof. This report may not be reproduced except in full withour prior consent of Controlab.

Technical Signatory: J Atterbury

Remarks:
Sample Delivered by Customer ☐
Sampled by Controlab ☒

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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
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5214
ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-29
DATE REPORTED: 2017-05-30
TEST REPORT NO.: MT 32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	3406	3407	3408			
POSITION	PS1 / TP 4	PS1 / TP 5	PS1 / TP 6			
	PUMP STATION 1					
DEPTH	400 - 900	500 - 2900	1200 - 3900			
DESCRIPTION	lt R	lt R	lt R			
	sdy st	sdy st	high weath			
			Ss + sdy st			

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm						
37.5 mm	100					
19 mm	96					
9.5 mm	95		100			
4.75 mm	95	100	99			
2.36 mm	94	99	98			
1.18 mm	93	99	98			
0.600 mm	92	99	98			
0.425 mm	91	98	97			
0.300 mm	88	95	93			
0.150 mm	67	70	69			
0.075 mm	38.3	39.1	39.1			
GRADING MODULUS	0.8	0.6	0.7			

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	33	34	35			
0.02 mm	18	21	23			
0.006 mm	12	16	15			
0.002 mm	10	14	12			

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	22	23	22			
PLASTICITY INDEX	7	8	8			
LINEAR SHRINKAGE	3.0	3.5	3.5			

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

PI WHOLE SAMPLE	6.0	8.0	8.0			
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW			

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

Maximum Dry Density (kg/m^3)	1947	1951	1917			
Optimum Moisture Content (%)	11.6	10.9	11.0			
C.B.R. @ 100% COMPACTION	50	60	68			
C.B.R. @ 98 % COMPACTION	43	44	50			
C.B.R. @ 95 % COMPACTION	31	28	32			
C.B.R. @ 93 % COMPACTION	24	21	23			
C.B.R. @ 90 % COMPACTION	18	13	15			
SWELL @ 100% COMP. (%)	0.70	0.40	0.40			
T R H 14 CLASSIFICATION	G8	G8	G8			

Technical Signatory:
J Atterbury

Remarks:
Samples Delivered by Customer
Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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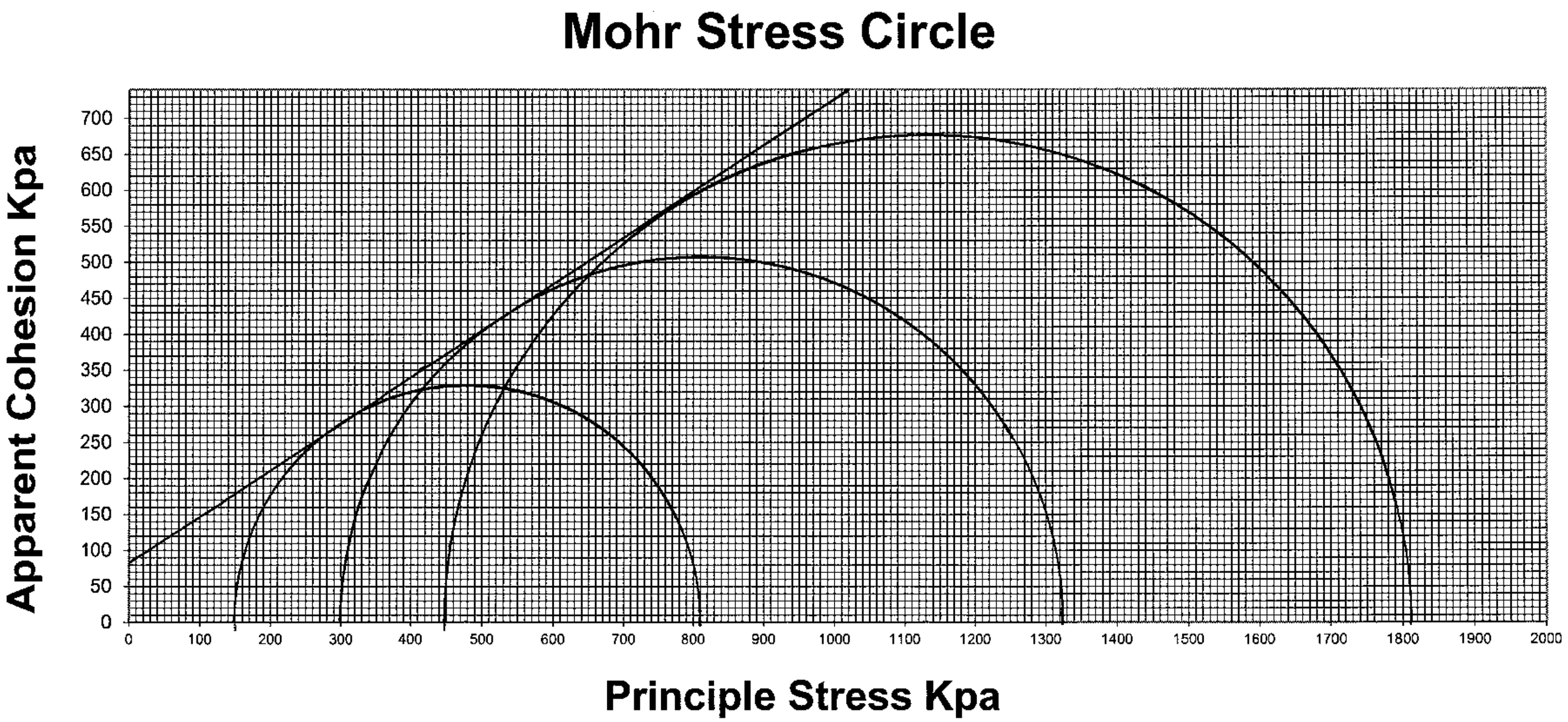
Date :	May 2017	**Position :**	PUMPSTATION 1 - TP3 @ 950 - 2900mm - S/No.: 3218
Client :	Aurecon	**Description :**	dk Y O sdy st
Project :	NGQAMAKHWE RWSS	**Test Type :**	Unconsolidated Undrained - Total Stress Analysis
Test Conditions:	Undisturbed	**In-Situ Dry Density : Kg/m3**	1584
		In-Situ MC: %	9.1

Apparent Cohesion (C) = 85Kpa **Angle of Internal Friction (Ø) = 33°**



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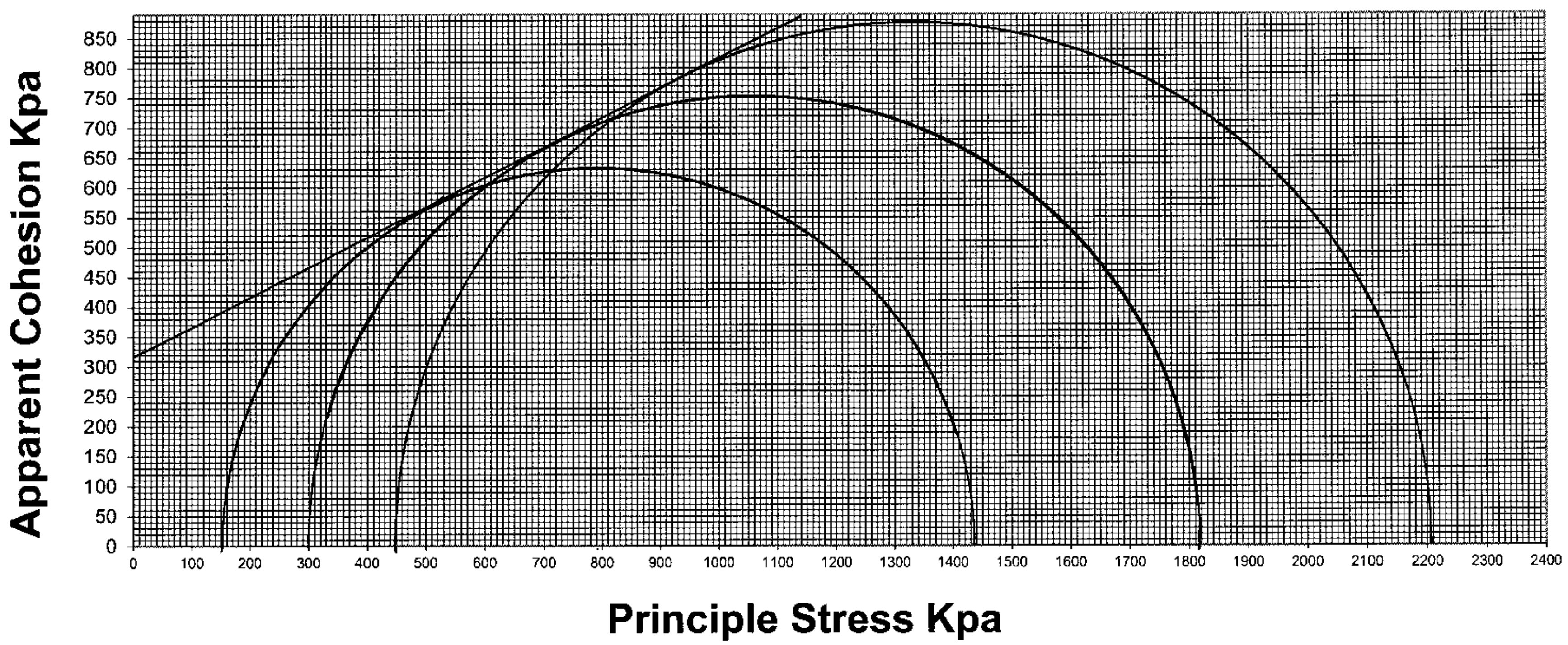
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

Date :	May 2017	**Position :**	PUMPSTATION 1 - TP2 @ 2700 - 3900mm - S/No.: 3219
Client :	Aurecon	**Description :**	dk Y O sdy st
Project :	NGQAMAKHWE RWSS	**Test Type :**	Unconsolidated Undrained - Total Stress Analysis
Test Conditions:	Undisturbed	**In-Situ Dry Density : Kg/m3**	1769
		In-Situ MC: %	7.9

Apparent Cohesion (C) = 320Kpa **Angle of Internal Friction (Ø) = 26°**

Mohr Stress Circle



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CONSOLIDATION TEST SUMMARY OF READINGS

CLIENT: Aurecon SA (Pty) Ltd
PROJECT : NGQAMAKHWE RWSS - PHASE 5
PROJECT NO : MT32019
SAMPLE NO : 3218
POSITION: PS1-TH3
DEPTH: 950-2900mm

INITIAL DIAL READING = 55.947 mm
RING DIAMETER = 75 mm

H1 = 19 mm
H_S = 11.1872 mm
Dial Gauge Div = 1

OEDOMETER NO : 3
BEAM RATIO : 11

BEAM LOAD	COMMENTS	PRESSURE	DIAL READING	UNCORRECTED DEFLECTION	MACHINE CORRECTION	CORRECTED DEFLECTION	HEIGHT CHANGE	VOID RATIO
(kg)		(Kpa)	(mm)	(mm)	(mm)	(mm)	(mm)	
0.1		2.44	55.947	0.000	0.000	0	19.000	0.6984
1.1		26.87	55.911	0.036	0.000	-0.036	18.964	0.6952
3.1		75.72	55.635	0.312	0.000	-0.312	18.688	0.6705
7.1		173.42	55.163	0.784	0.000	-0.784	18.216	0.6283
7.1	SAT	173.42	53.317	2.630	0.000	-2.630	16.370	0.4633
15.1		368.83	52.745	3.202	0.000	-3.202	15.798	0.4122
31.1		759.64	52.140	3.807	0.000	-3.807	15.193	0.3581
15.1		368.83	52.190	3.757	0.000	-3.757	15.243	0.3625
7.1		173.42	52.240	3.707	0.000	-3.707	15.293	0.3670
3.1		75.72	52.297	3.650	0.000	-3.650	15.350	0.3721
1.1		26.87	52.389	3.558	0.000	-3.558	15.442	0.3803
0.1		2.44	52.700	3.247	0.000	-3.247	15.753	0.4081

% COLLAPSE 9.7

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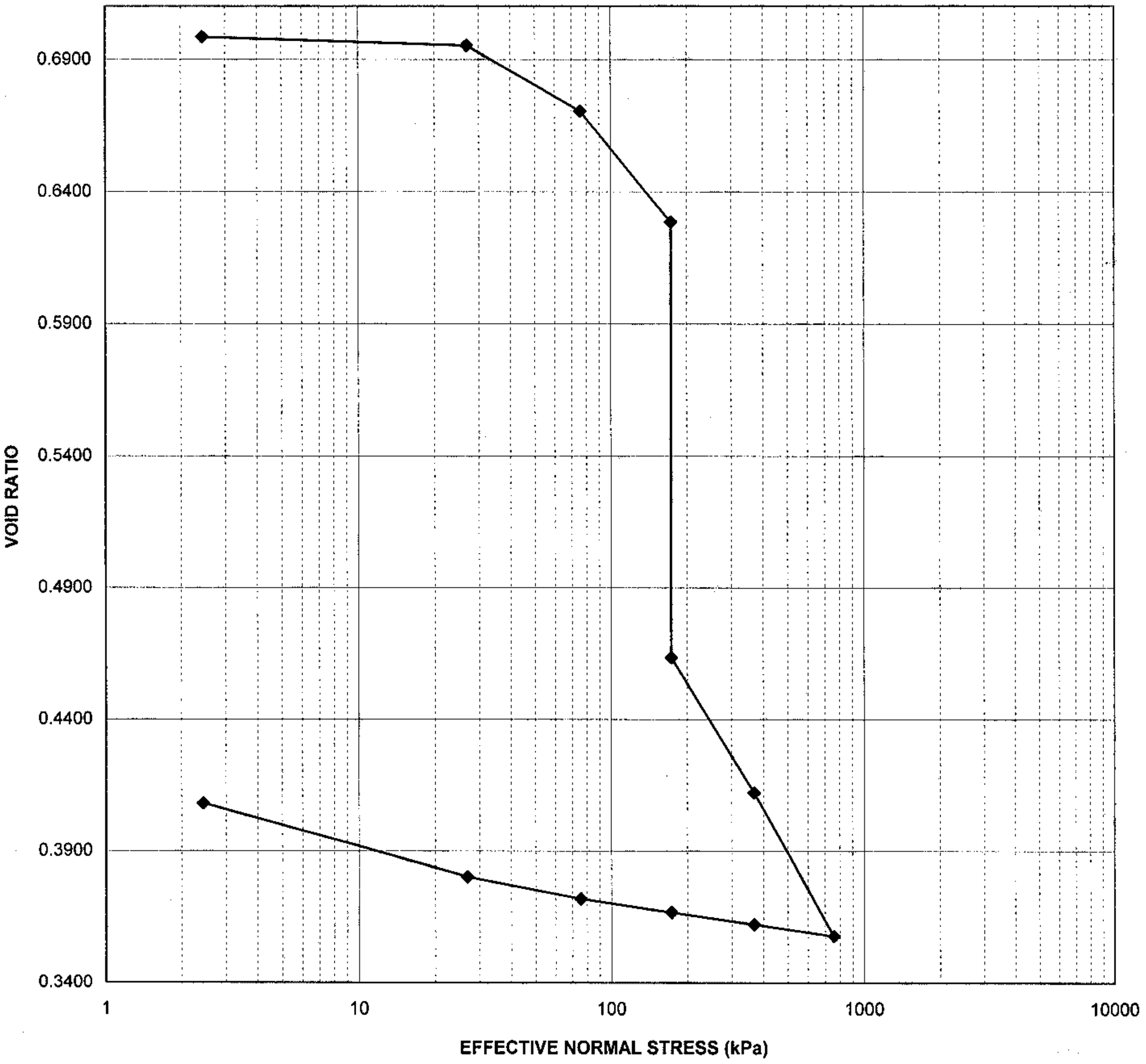
CONSOLIDATION TEST

CLIENT: Aurecon SA (Pty) Ltd
PROJECT : NGQAMAKHWE RWSS - PHASE 5

PROJECT NO : MT32019
SAMPLE NO : 3218
POSITION : PS1-TH3
DEPTH : 950-2900mm

SAMPLE DESCRIPTION : dk Y O sdy st
STATE OF SAMPLE : Remoulded
BULK DENSITY = 1728
DRY DENSITY = 1584 Kg/m3
INITIAL SATURATION = 0.35
INITIAL MOISTURE CONTENT = 9.10 %
INITIAL VOID RATIO = 0.6984
% COLLAPSE 9.7

SPECIFIC GRAVITY est. = 2.69
VOL VOIDS = 0.4112
VOL SOILDS = 0.5888
FINAL SATURATION = 0.72
FINAL MOISTURE CONTENT = 18.6 %
FINAL VOID RATIO = 0.4081



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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Queenstown, Lusaka - Zambia

CONSOLIDATION TEST

SUMMARY OF READINGS

CLIENT: Aurecon SA (Pty) Ltd
PROJECT : NGQAMAKHWE RWSS - PHASE 5

PROJECT NO : MT32019
SAMPLE NO : 3219
POSITION: PS1-TH2
DEPTH: 2700-3900mm

INITIAL DIAL READING = 18.667 mm
RING DIAMETER = 75 mm

H1 = 19 mm
H_S = 12.4964 mm
Dial Gauge Div = 1

OEDOMETER NO : 3
BEAM RATIO : 11

BEAM LOAD	COMMENTS	PRESSURE	DIAL READING	UNCORRECTED DEFLECTION	MACHINE CORRECTION	CORRECTED DEFLECTION	HEIGHT CHANGE	VOID RATIO
(kg)		(Kpa)	(mm)	(mm)	(mm)	(mm)	(mm)	
0.1		2.44	18.667	0.000	0.000	0	19.000	0.5204
1.1		26.87	18.583	0.084	0.000	-0.084	18.916	0.5137
3.1		75.72	18.544	0.123	0.000	-0.123	18.877	0.5106
7.1		173.42	18.464	0.203	0.000	-0.203	18.797	0.5042
7.1	SAT	173.42	17.833	0.834	0.000	-0.834	18.166	0.4537
15.1		368.83	17.194	1.473	0.000	-1.473	17.527	0.4026
31.1		759.64	16.542	2.125	0.000	-2.125	16.875	0.3504
15.1		368.83	16.592	2.075	0.000	-2.075	16.925	0.3544
7.1		173.42	16.629	2.038	0.000	-2.038	16.962	0.3573
3.1		75.72	16.680	1.987	0.000	-1.987	17.013	0.3614
1.1		26.87	16.754	1.913	0.000	-1.913	17.087	0.3674
0.1		2.44	16.954	1.713	0.000	-1.713	17.287	0.3834

% COLLAPSE 3.3

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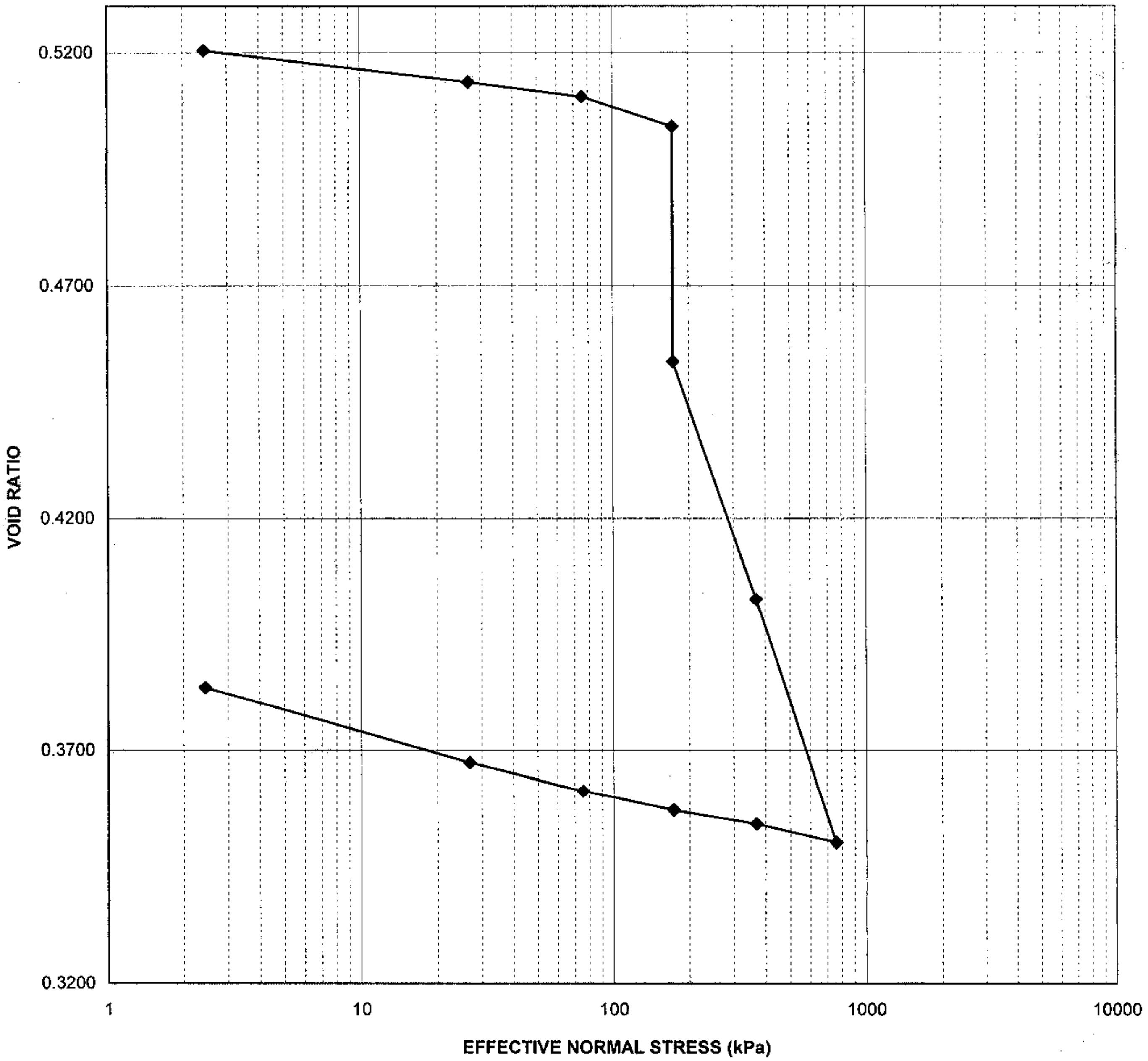
CONSOLIDATION TEST

CLIENT: Aurecon SA (Pty) Ltd
PROJECT : NGQAMAKHWE RWSS - PHASE 5

PROJECT NO : MT32019
SAMPLE NO : 3219
POSITION : PS1-TH2
DEPTH : 2700-3900mm

SAMPLE DESCRIPTION : dk Y O sdy st
STATE OF SAMPLE : Remoulded
BULK DENSITY = 1909
DRY DENSITY = 1769 Kg/m3
INITIAL SATURATION = 0.41
INITIAL MOISTURE CONTENT = 7.90 %
INITIAL VOID RATIO = 0.5204
% COLLAPSE 3.3

SPECIFIC GRAVITY est. = 2.69
VOL VOIDS = 0.34229
VOL SOILDS = 0.65771
FINAL SATURATION = 0.82
FINAL MOISTURE CONTENT = 15.8 %
FINAL VOID RATIO = 0.3834



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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Queenstown, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
P O Box 19553
TECOMA
5214

ATT: Mr D Luhring

PROJECT: NGQAMAKHWE RWSS - PHASE 5

DATE TESTED: 2017-05-16

DATE REPORTED:

TEST REPORT NO.: MT32019

PINHOLE TEST - ASTM D4221-90 METHOD

SAMPLE NO: 3217

SOURCE: RESEVOIR - TP5 @ 300 - 100mm

TEST CONDITIONS: Remoulded at In-Situ Density

DRY DENSITY (Kg/m3): 1462

MC %: 30.8

DESCRIPTION: dk G cl

TIME	HEAD	FLOW PARAMETERS		FLOW RATE ml/s	FINAL FLOWRATE ml/s	TURBIDITY FROM SIDE	HOLE SIZE AFTER TEST
		ml.	sec.				
0	55mm	0	60	0.000			
		5	120	0.042			
		10	180	0.056			
		20	240	0.083			
5min		28	300	0.093			
10min		30	600	0.050	0.050		
AVERAGE FLOWRATE		30	600	0.046		COMPLETELY CLEAR	COLLAPSE
0	180mm	0	60	0.000			
		0	120	0.000			
		0	180	0.000			
		0	240	0.000			
5min		0	300	0.000			
10min		0	600	0.000	0.000		
AVERAGE FLOWRATE		0	600	0.000		COMPLETELY CLEAR	COLLAPSE
0	385	0	60	0.000			
		0	120	0.000			
		0	180	0.000			
		0	240	0.000			
5min		0	300	0.000			
10min		0	600	0.000	0.000		
AVERAGE FLOWRATE		0	600	0.000		COMPLETELY CLEAR	COLLAPSE
						DISPERSIVE GRADE CLASSIFICATION	**ND1**

Technical Signatory:

J Atterbury

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CLIENT: Aurecon SA (Pty) Ltd
P O Box 19553
TECOMA
5214
ATT: Mr D Luhring

PROJECT: NGQAMAKHWE RWSS - PHASE 5

DATE TESTED: 2017-05-16

DATE REPORTED:

TEST REPORT NO.: MT32019

PINHOLE TEST - ASTM D4221-90 METHOD

SAMPLE NO:	3218	**DRY DENSITY (Kg/m3):**	1584
SOURCE:	PUMPSTATION 1 - TP3 @ 900 - 2900mm	**MC %:**	9.1
TEST CONDITIONS:	Remoulded at In-Situ Density	**DESCRIPTION:**	dk Y O sdy st

TIME	HEAD	FLOW PARAMETERS		FLOW RATE ml/s	FINAL FLOWRATE ml/s	TURBIDITY FROM SIDE	HOLE SIZE AFTER TEST
		ml.	sec.				
0	55mm	0	60	0.000			
		0	120	0.000			
		0	180	0.000			
		0	240	0.000			
5min		0	300	0.000			
10min		0	600	0.000	0.000		
AVERAGE FLOWRATE		0	600	0.000		COMPLETELY CLEAR	COLLAPSE
0	180mm	0	60	0.000			
		0	120	0.000			
		0	180	0.000			
		0	240	0.000			
5min		0	300	0.000			
10min		0	600	0.000	0.000		
AVERAGE FLOWRATE		0	600	0.000		COMPLETELY CLEAR	COLLAPSE
0	385	0	60	0.000			
		0	120	0.000			
		0	180	0.000			
		0	240	0.000			
5min		0	300	0.000			
10min		0	600	0.000	0.000		
AVERAGE FLOWRATE		0	600	0.000		DARK	COLLAPSE
DISPERSIVE GRADE CLASSIFICATION							D2

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CLIENT: Aurecon SA (Pty) Ltd
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TECOMA
5214
ATT: Mr D Luhring

PROJECT: NGQAMAKHWE RWSS - PHASE 5
DATE TESTED: 2017-05-16
DATE REPORTED:
TEST REPORT NO.: MT32019

PINHOLE TEST - ASTM D4221-90 METHOD

SAMPLE NO: 3219
SOURCE: PUMPSTATION 1 - TP2 @ 2700 - 3900mm
TEST CONDITIONS: Remoulded at In-Situ Density
DRY DENSITY (Kg/m3): 1769
MC %: 7.9
DESCRIPTION: dk Y O sdy st

TIME	HEAD	FLOW PARAMETERS		FLOW RATE ml/s	FINAL FLOWRATE ml/s	TURBIDITY FROM SIDE	HOLE SIZE AFTER TEST
		ml.	sec.				
0	55mm	0	60	0.000			
		0	120	0.000			
		0	180	0.000			
		0	240	0.000			
5min		0	300	0.000			
10min		0	600	0.000	0.000		
AVERAGE FLOWRATE		0	600	0.000		COMPLETELY CLEAR	COLLAPSE
0	180mm	0	60	0.000			
		0	120	0.000			
		0	180	0.000			
		0	240	0.000			
5min		0	300	0.000			
10min		0	600	0.000	0.000		
AVERAGE FLOWRATE		0	600	0.000		COMPLETELY CLEAR	COLLAPSE
0	385	0	60	0.000			
		0	120	0.000			
		0	180	0.000			
		0	240	0.000			
5min		0	300	0.000			
10min		5	600	0.008	0.008		
AVERAGE FLOWRATE		5	600	0.001		VERY DARK	COLLAPSE
DISPERSIVE GRADE CLASSIFICATION							D1/D2

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CLIENT: Aurecon SA (Pty) Ltd
P O Box 19553
TECOMA
5214

ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS - PHASE 5

DATE.: 2017-05-18

REF NO.: MT32019

Determination of Crumb Test

SAMPLE NO.	POSITION	SOLUTION	CRUMB CONDITION	TIME	CLASSIFICATION
3217	RESEVOIR TP5 @ 300 - 1100mm	0.001N NaOH	AIR DRIED	10 min	1
				2 hrs	1
				>16 hrs	1
3218	PUMPSTATION 1 TP3 @ 950 - 2900mm	0.001N NaOH	AIR DRIED	10 min	1
				2 hrs	1
				>16 hrs	1
3219	PUMPSTATION 1 TP2 @ 2700 - 3900mm	0.001N NaOH	AIR DRIED	10 min	1
				2 hrs	1
				>16 hrs	1

GRADE CLASSIFICATION FOR A CRUMB TEST (WALKER, 1997)

GRADE	REACTION	DESCRIPTION
1	No Reaction	Crumbs may slake, but no sign of cloudiness by colloids in suspension.
2	Slight Reaction	Bare hint of cloudiness in water at surface of crumb.
3	Moderate Reaction	Easily recognisable cloud of colloids in suspension, usually spreading out in thin streaks on bottom of beaker.
4	Strong Reaction	Colloid cloud covers nearly the whole bottom of the beaker, usually as a thick skin.

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ATT: Mr D Luhring

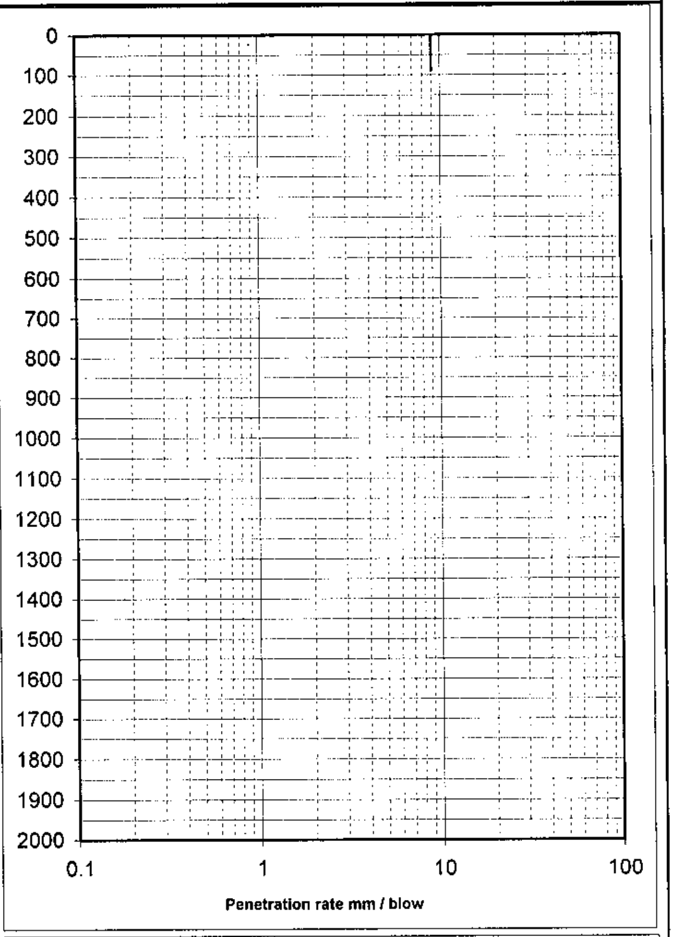
PROJECT: Ngqamakhwe RWSS: Phase 5
REF: MT32019
DATE: 2017-04-26

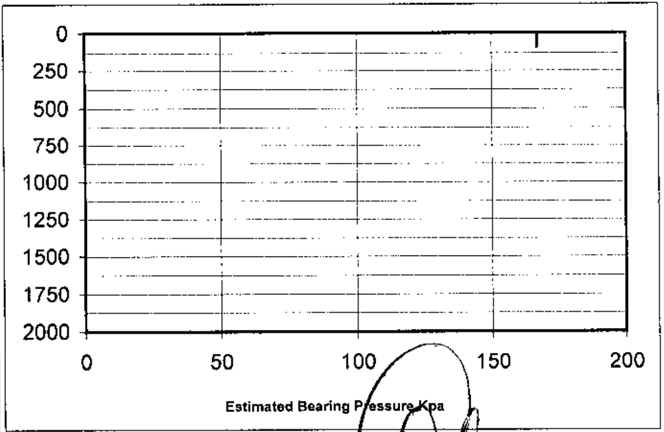
DYNAMIC CONE PENETROMETER DATA

POSITION: PS1 TP 1
S 32°02'07.3" E 27°49'36.3"

REMARKS: Refusal @ 90mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
90	10	9	25				





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ATT: Mr D Luhring

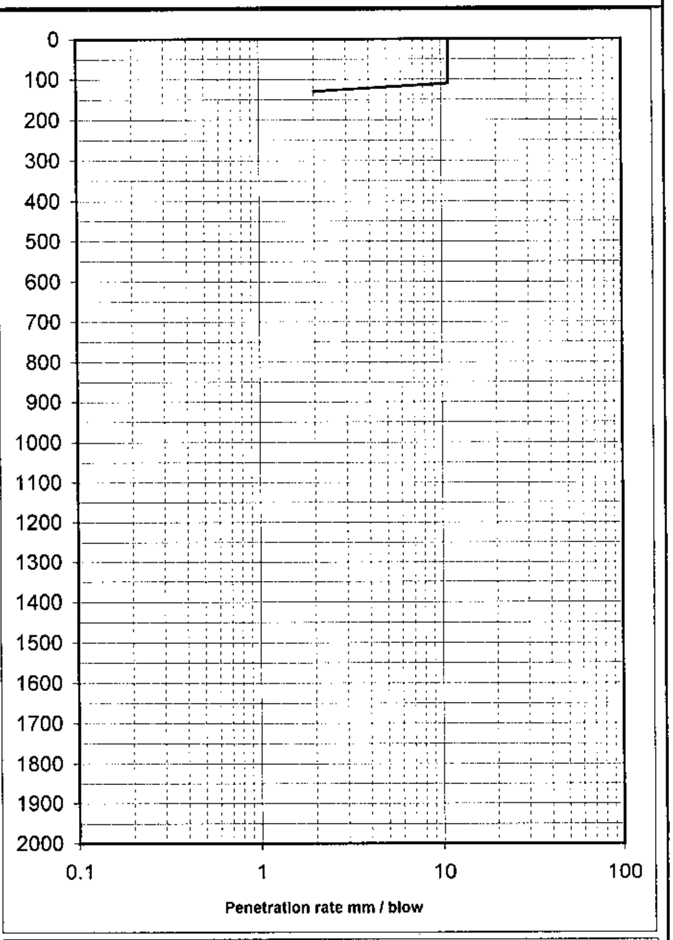
PROJECT: Ngqamakhwe RWSS: Phase 5
REF: MT32019
DATE: 2017-04-26

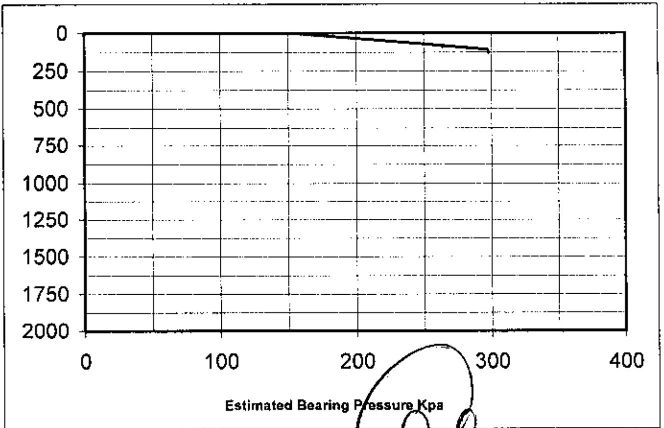
DYNAMIC CONE PENETROMETER DATA

POSITION: PS1 TP 2
S 32°02'07.4" E 27°49'36.8"

REMARKS: Refusal @ 130mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
110	10	11	20				
130	20	2	>110				





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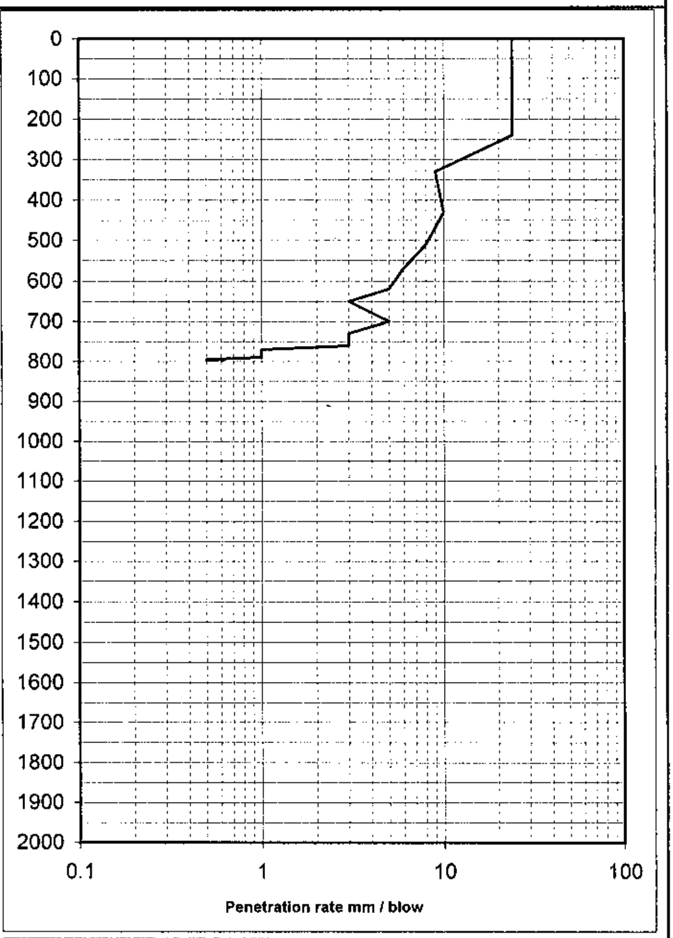
CLIENT:	Aurecon SA (Pty) Ltd PO Box 19553 TECOMA 5214	**PROJECT:**	Ngqamakhwe RWSS: Phase 5
		REF:	MT32019
ATT:	Mr D Luhring	**DATE:**	2017-04-26

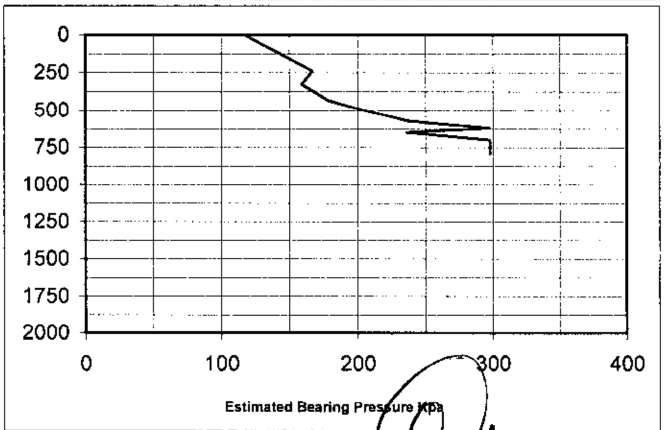
DYNAMIC CONE PENETROMETER DATA

POSITION: PS1 TP 3
S 32°02'07.0" E 27°49'36.6"

REMARKS: Refusal @ 795mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
240	10	24	8				
330	20	9	25				
430	30	10	22				
510	40	8	30				
570	50	6	45				
620	60	5	55				
650	70	3	110				
700	80	5	55				
730	90	3	110				
760	100	3	110				
770	110	1	>110				
780	120	1	>110				
790	130	1	>110				
795	140	0.5	>110				





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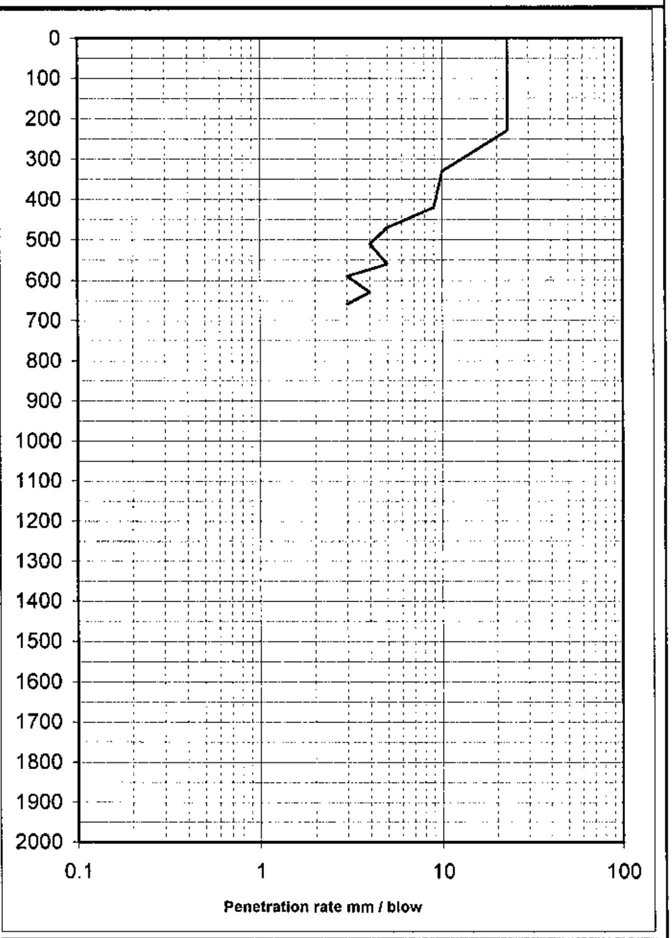
PROJECT: Ngqamakhwe RWSS:
Phase 5
REF: MT32019
DATE: 2017-04-26

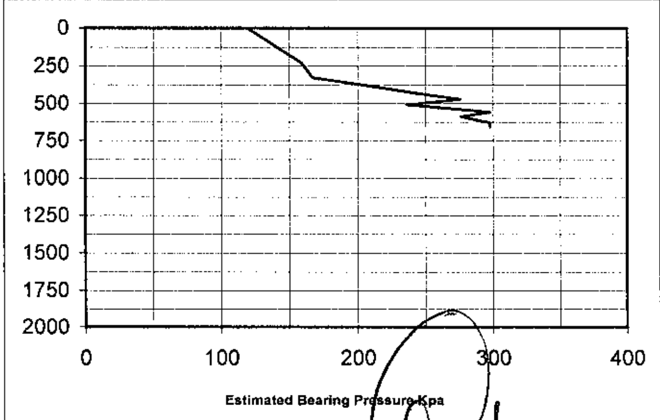
DYNAMIC CONE PENETROMETER DATA

POSITION: PS1 TP 4
S 32°02'07.2" E 27°49'37.1"

REMARKS: Refusal @ 660mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
230	10	23	8				
330	20	10	22				
420	30	9	25				
470	40	5	55				
510	50	4	75				
560	60	5	55				
590	70	3	110				
630	80	4	75				
660	90	3	110				





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CLIENT: Aurecon SA (Pty) Ltd
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ATT: Mr D Luhring

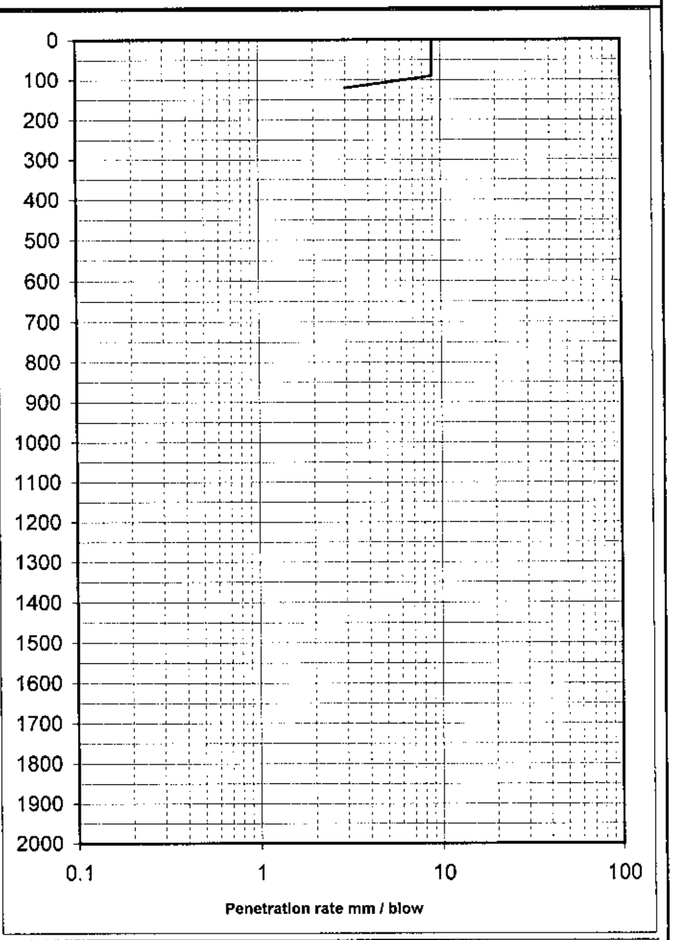
PROJECT: Ngqamakhwe RWSS: Phase 5
REF: MT32019
DATE: 2017-04-26

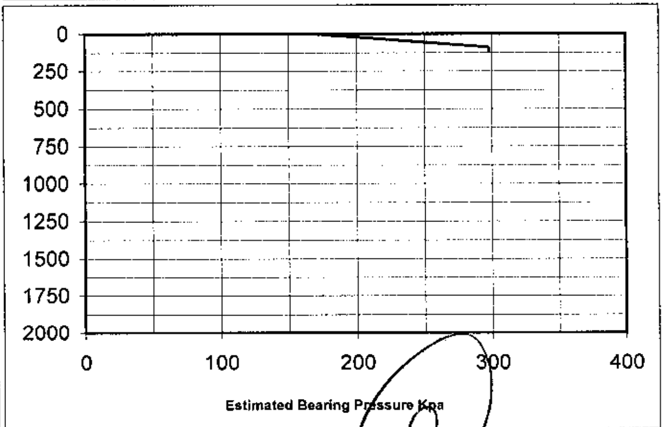
DYNAMIC CONE PENETROMETER DATA

POSITION: PS1 TP 5
S 32°02'07.9" E 27°49'37.3"

REMARKS: Refusal @ 120mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
90	10	9	25				
120	20	3	110				





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ATT: Mr D Luhring

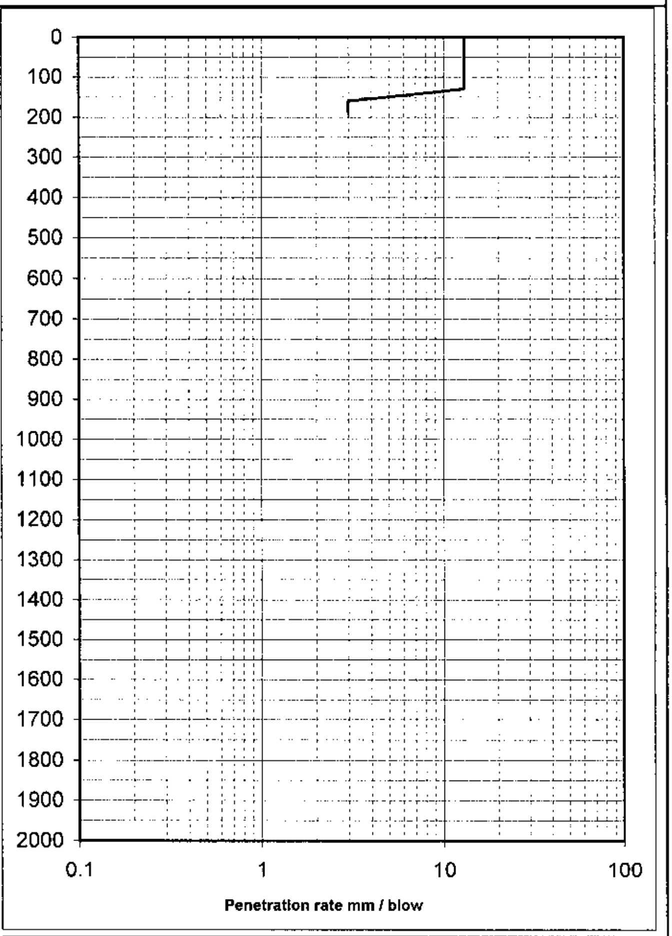
PROJECT: Ngqamakhwe RWSS: Phase 5
REF: MT32019
DATE: 2017-04-26

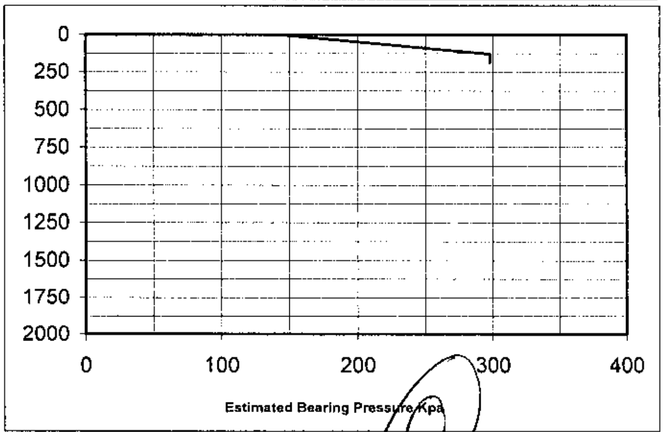
DYNAMIC CONE PENETROMETER DATA

POSITION: PS1 TP 6
S 32°02'08.3" E 27°49'36.3"

REMARKS: Refusal @ 190mm

Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR	Depth (mm)	Cumutalive No. Blows	Penetration Rate (mm)	Estimated Insitu CBR
0							
130	10	13	16				
160	20	3	110				
190	30	3	110				





Technical Signatory: D Louw

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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Queenstown, Lusaka - Zambia

CLIENT : Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT: Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-29
DATE REPORTED: 2017-06-02
TEST REPORT NO.: MT32019

MATERIALS TEST REPORT

SAMPLE NO:	3410	3413				
POSITION / CHAINAGE	PS2 - TP 2	PS2 - TP 6				
	PUMP STATION 2					
DEPTH mm	110 - 350	580 - 1100				
DESCRIPTION	dk R Br	lt R O				
	weath Ss +	Ms +				
	sty s	cly s				

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING 75 mm						
63 mm						
53 mm	100	100				
37.5 mm	95	98				
26.5 mm	81	92				
19 mm	70	84				
13.2 mm	56	66				
4.75 mm	30	30				
2.00 mm	23	16				
0.425 mm	18	9				
0.075 mm	6.8	5.8				

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	22	44				
FINE SAND (%)	49	20				
SILT / CLAY (%)	30	36				
GRADING MODULUS	2.52	2.69				

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	CBD	33				
PLASTICITY INDEX (%)	SP	16				
LINEAR SHRINKAGE (%)	1.5	8.0				

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

Maximum Dry Density (kg/m^3)	2061	2074				
Optimum Moisture Content (%)	9.0	9.7				
C.B.R. @ 100% COMPACTION	76	69				
C.B.R. @ 98 % COMPACTION	56	49				
C.B.R. @ 95 % COMPACTION	36	29				
C.B.R. @ 93 % COMPACTION	27	21				
C.B.R. @ 90 % COMPACTION	17	13				
SWELL @ 100% COMP. (%)	0.10	0.50				
T R H 14 CLASSIFICATION	G6	G6				

Technical Signatory: J Atterbury

Remarks:
Sample Delivered by Customer ☐
Sampled by Controlab ☒

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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Queenstown, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-29
DATE REPORTED: 2017-06-02
TEST REPORT NO.: MT 32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	3409	3412	3414			
POSITION	PS 2 - TP 1	PS 2 - TP 5	PS 2 - TP 6			
	PUMP STATION 2					
DEPTH mm	850 - 1100	600 - 960	1100 - 1230			
DESCRIPTION	dk R Br	lt R O	lt R O			
	Ss +	Ss +	Ms +			
	sty s	cly s	cly s			

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm	100					
37.5 mm	61	100	100			
19 mm	51	95	77			
9.5 mm	41	76	54			
4.75 mm	34	44	38			
2.36 mm	29	25	28			
1.18 mm	26	17	23			
0.600 mm	24	13	22			
0.425 mm	23	12	21			
0.300 mm	22	12	21			
0.150 mm	15	11	18			
0.075 mm	8.6	8.9	12.4			
GRADING MODULUS	2.4	2.5	2.4			

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	8	8	10			
0.02 mm	5	5	5			
0.006 mm	3	3	3			
0.002 mm	3	3	2			

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	23	28	23			
PLASTICITY INDEX	8	15	11			
LINEAR SHRINKAGE	4.5	7.5	5.5			

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

PI WHOLE SAMPLE	2.0	2.0	1.0			
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW			

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

Maximum Dry Density (kg/m^3)	2124	2120				
Optimum Moisture Content (%)	8.3	9.3				
C.B.R. @ 100% COMPACTION	81	93				
C.B.R. @ 98 % COMPACTION	60	66				
C.B.R. @ 95 % COMPACTION	40	40				
C.B.R. @ 93 % COMPACTION	32	29				
C.B.R. @ 90 % COMPACTION	20	17				
SWELL @ 100% COMP. (%)	0.40	0.6				
T R H 14 CLASSIFICATION	G6	G6				

The above test results are pertinent to the samples received and tested only.
While the tests are carried our according to recognized standards Controlab shall not be liable for erroneous testing or reporting thereof. This report may not be reproduced except in full without prior consent of Controlab.

Technical Signatory:
J Atterbury

Remarks:

Samples Delivered by Customer

Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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PROJECT: NGQAMAKHWE RWSS: PHASE 5
DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-29
DATE REPORTED: 2017-06-02
TEST REPORT NO.: MT32019

MATERIALS TEST REPORT

SAMPLE NO:	3415					
POSITION / CHAINAGE	RES - TP 1					
	RESERVOIR					
DEPTH mm	300 - 1600					
DESCRIPTION	dk R Br					
	Sh +					
	sty s					

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING 75 mm	90					
63 mm	90					
53 mm	86					
37.5 mm	82					
26.5 mm	82					
19 mm	63					
13.2 mm	50					
4.75 mm	29					
2.00 mm	20					
0.425 mm	14					
0.075 mm	11.2					

Soil Mortar Analysis - TMH1 - Method A5

COURSE SAND (%)	30					
FINE SAND (%)	14					
SILT / CLAY (%)	56					
GRADING MODULUS	2.55					

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	28					
PLASTICITY INDEX (%)	9					
LINEAR SHRINKAGE (%)	4.5					

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

Maximum Dry Density (kg/m^3)	2020					
Optimum Moisture Content (%)	11.8					
C.B.R. @ 100% COMPACTION	61					
C.B.R. @ 98 % COMPACTION	52					
C.B.R. @ 95 % COMPACTION	41					
C.B.R. @ 93 % COMPACTION	32					
C.B.R. @ 90 % COMPACTION	19					
SWELL @ 100% COMP. (%)	0.40					
T R H 14 CLASSIFICATION	G6					

The above test results are pertinent to the samples tested only. While the tests are carried out according to recognized standards, Controlab shall not be liable for erroneous testing or reporting thereof. This report may not be reproduced except in full withour prior consent of Controlab.

Technical Signatory: J Atterbury

Remarks:
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DATE RECEIVED: 2017-04-30
DATE TESTED: 2017-05-29
DATE REPORTED: 2017-06-02
TEST REPORT NO.: MT 32019

FOUNDATION INDICATOR REPORT

SAMPLE NO	3416	3417	3418	3419	3420	3421
POSITION	RES - TP 1	RES - TP 2	RES - TP 3	RES - TP 4	RES - TP 5	RES - TP 6
	RESERVOIR					
DEPTH mm	2500 - 3000	560- 3000	180 - 3100	800 - 2500	1100 - 2400	1050 - 2400
DESCRIPTION	Pale R	Pale R	Pale R	Pale R	Pale R	Pale R
	Sh +	Sh +	Sh +	Sh +	Ss +	Sh +
	sty s	sty s	cly s	cly s	cly s	cly s

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm		100	100	100	100	
37.5 mm	100	61	62	67	62	100
19 mm	83	48	44	50	50	76
9.5 mm	63	37	29	36	42	56
4.75 mm	46	30	22	28	37	43
2.36 mm	34	25	17	22	33	34
1.18 mm	27	21	13	18	29	28
0.600 mm	21	18	11	14	27	24
0.425 mm	19	17	10	13	26	22
0.300 mm	18	16	10	13	26	22
0.150 mm	16	16	9	12	24	20
0.075 mm	11.8	13.2	7.9	9.5	21.0	17.1
GRADING MODULUS	2.4	2.4	2.7	2.6	2.2	2.3

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	11	11	7	8	19	15
0.02 mm	7	8	5	6	14	10
0.006 mm	4	4	3	4	9	7
0.002 mm	3	3	3	3	7	6

ATTERBERG LIMITS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	30	33	35	33	42	31
PLASTICITY INDEX	8	9	11	14	10	15
LINEAR SHRINKAGE	4.5	4.5	5.5	6.5	5.0	7.0

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

PI WHOLE SAMPLE	2.0	2.0	1.0	2.0	3.0	3.0
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW	LOW	LOW	LOW

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

Maximum Dry Density (kg/m^3)		1905	2031	1997		1980
Optimum Moisture Content (%)		12.9	12.1	13.8		11.4
C.B.R. @ 100% COMPACTION		55	75	62		74
C.B.R. @ 98 % COMPACTION		50	60	52		53
C.B.R. @ 95 % COMPACTION		42	43	41		31
C.B.R. @ 93 % COMPACTION		38	31	34		22
C.B.R. @ 90 % COMPACTION		33	21	27		13
SWELL @ 100% COMP. (%)		0.30	0.60	0.70		0.40
T R H 14 CLASSIFICATION		G6	G6	G6		G6

Technical Signatory:
J Atterbury

Remarks:

Samples Delivered by Customer

Sampled by Controlab: YES

HYDROMETER ANALYSIS - NON-ACCREDITED TESTS

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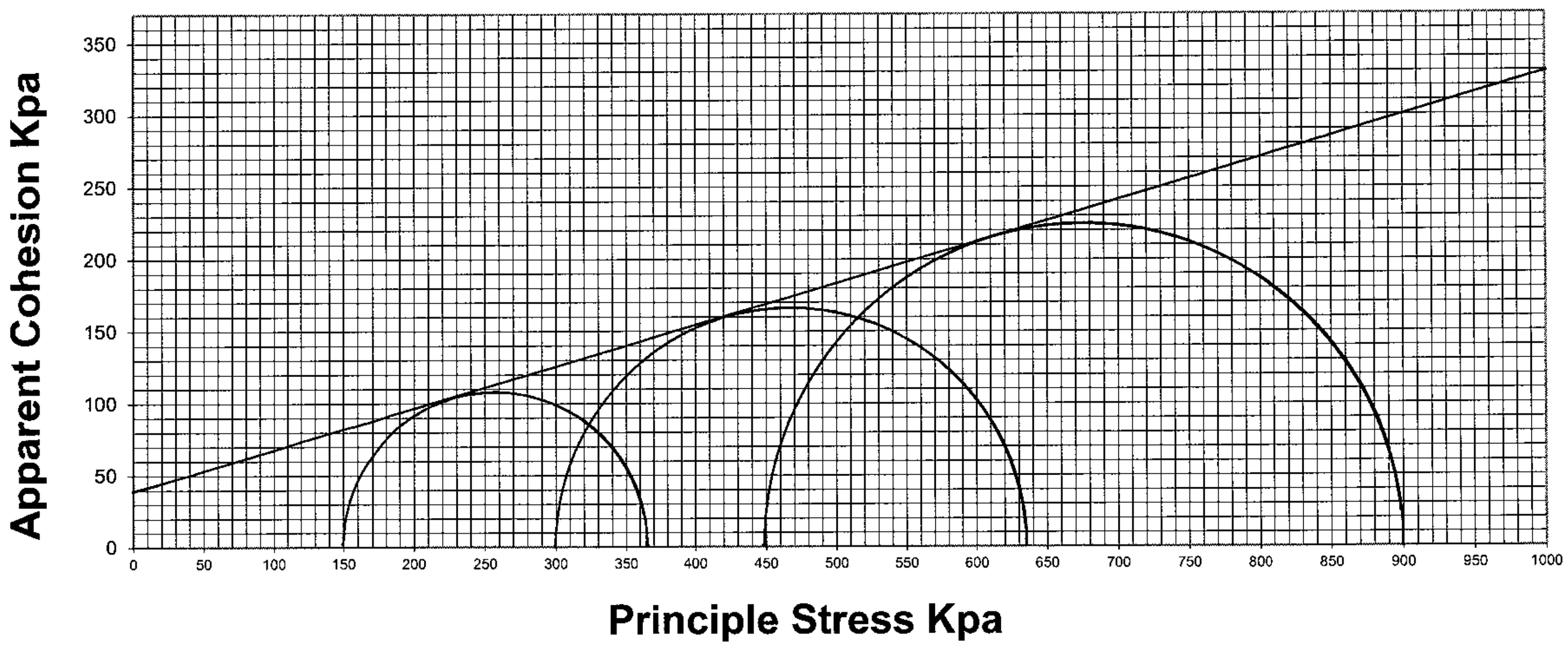
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

Date :	May 2017	**Position :**	RESEVOIR TP5 @ 300 - 1100mm - S/No.: 3217
Client :	Aurecon	**Description :**	dk G cl
Project :	NGQAMAKHWE RWSS	**Test Type :**	Unconsolidated Undrained - Total Stress Analysis
Test Conditions:	Undisturbed	**In-Situ Dry Density : Kg/m3**	1462
		In-Situ MC: %	30.8

Apparent Cohesion (C) = 40Kpa　　**Angle of Internal Friction (Ø) = 16°**

Mohr Stress Circle



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CONSOLIDATION TEST

SUMMARY OF READINGS

CLIENT: Aurecon SA (Pty) Ltd
PROJECT : NGQAMAKHWE RWSS - PHASE 5

PROJECT NO : MT32019
SAMPLE NO : 3217
POSITION: RES-TH5
DEPTH: 300-1100mm

INITIAL DIAL READING = 27.269 mm
RING DIAMETER = 70.7 mm

H1 = 19.3 mm
H_S = 10.6085 mm
Dial Gauge Div = 1

OEDOMETER NO : 1
BEAM RATIO : 11

BEAM LOAD	COMMENTS	PRESSURE	DIAL READING	UNCORRECTED DEFLECTION	MACHINE CORRECTION	CORRECTED DEFLECTION	HEIGHT CHANGE	VOID RATIO
(kg)		(Kpa)	(mm)	(mm)	(mm)	(mm)	(mm)	
0.1		2.75	27.269	0.000	0.000	0	19.300	0.8193
0.1	sat	2.75	28.051	-0.782	0.000	0.782	20.082	0.8930
1.1		30.24	27.752	-0.483	0.000	0.483	19.783	0.8648
3.1		85.21	27.278	-0.009	0.000	0.009	19.309	0.8201
7.1		195.16	26.956	0.313	0.000	-0.313	18.987	0.7898
15.1		415.06	26.436	0.833	0.000	-0.833	18.467	0.7408
31.1		854.86	25.707	1.562	0.000	-1.562	17.738	0.6721
15.1		415.06	25.795	1.474	0.000	-1.474	17.826	0.6804
7.1		195.16	25.945	1.324	0.000	-1.324	17.976	0.6945
3.1		85.21	26.183	1.086	0.000	-1.086	18.214	0.7169
1.1		30.24	26.521	0.748	0.000	-0.748	18.552	0.7488
0.1		2.75	27.082	0.187	0.000	-0.187	19.113	0.8017

% SWELL 4.1

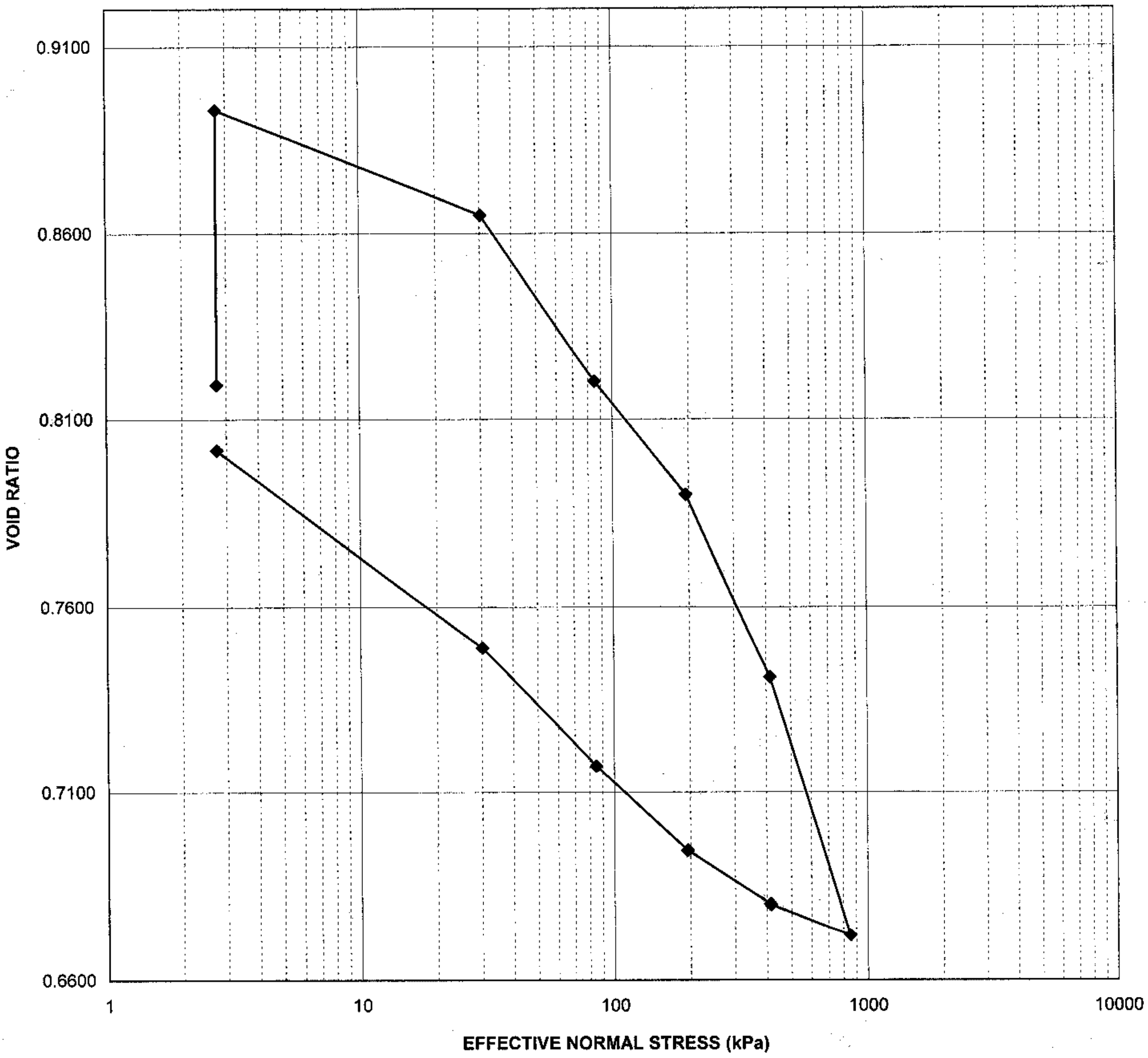
CONSOLIDATION TEST

CLIENT: Aurecon SA (Pty) Ltd
PROJECT : NGQAMAKHWE RWSS - PHASE 5

PROJECT NO : MT32019
SAMPLE NO : 3217
POSITION : RES-TH5
DEPTH : 300-1100mm

SAMPLE DESCRIPTION : dk G cl
STATE OF SAMPLE : Undisturbed
BULK DENSITY = 1934
DRY DENSITY = 1479 Kg/m3
INITIAL SATURATION = 1.01
INITIAL MOISTURE CONTENT = 30.80 %
INITIAL VOID RATIO = 0.8193
% SWELL 4.1

SPECIFIC GRAVITY est. = 2.69
VOL VOIDS = 0.45034
VOL SOILDS = 0.54966
FINAL SATURATION = 1.20
FINAL MOISTURE CONTENT = 36.7 %
FINAL VOID RATIO = 0.8017



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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

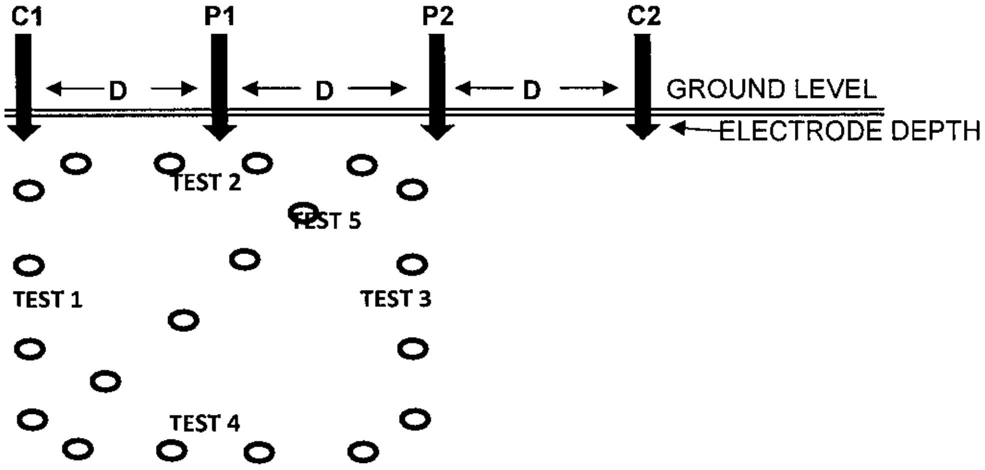
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-04-09
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	AR-SR1	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COLD	
SOIL CONDITION:	VERY MOIST	**GPS CO-ORD:**	S 32°02'40.1"	E 27°50'03.1"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	10.00	10.80	203.6
2	SE	3.0	15.0	10.00		
3	SW	3.0	15.0	12.00		
4	NW	3.0	15.0	12.00		
5	NW	3.0	15.0	10.00		

ADDITIONAL NOTES: ALTERNATIVE ROUTE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
C Becker

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ATT : Mr D Luhring

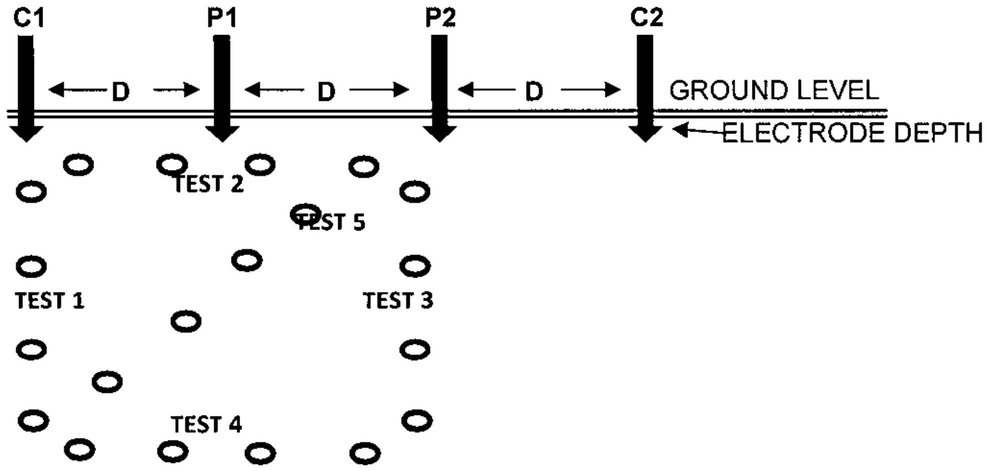
PROJECT: Ngqamakhwe RWSS:
Phase 5
DATE.: 2017-04-09
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	AR-SR6	**TEMPERATURE:**		
DESCRIPTION:	lt Y Br sty s	**WEATHER COND:**	COLD	
SOIL CONDITION:	VERY MOIST	**GPS CO-ORD:**	S 32°02'54.0"	E 27°50'33.5"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0	5.43	6.69	126.0
2	SW	3.0	15.0	7.00		
3	NW	3.0	15.0	8.00		
4	NE	3.0	15.0	7.00		
5	NE	3.0	15.0	6.00		

ADDITIONAL NOTES: ALTERNATIVE ROUTE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Lusaka - Zambia

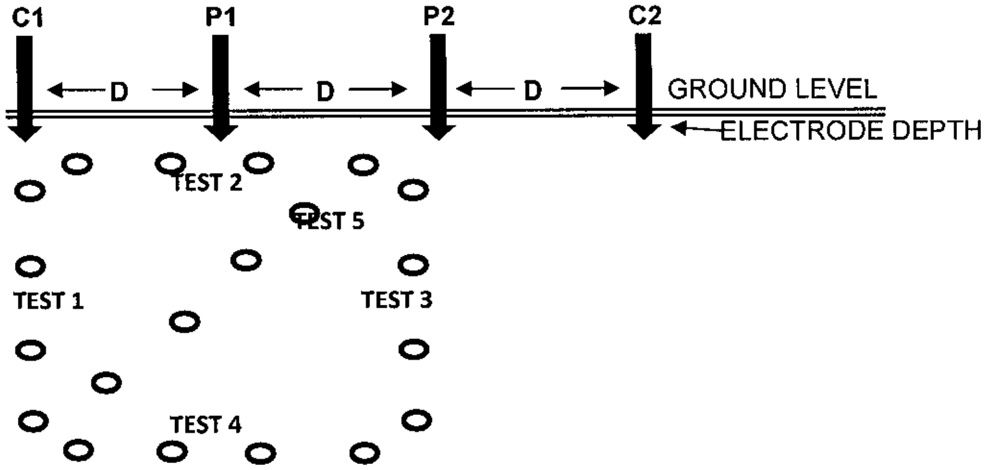
CLIENT:	Aurecon SA (Pty) Ltd PO Box 19553 TECOMA 5214	**PROJECT:**	Ngqamakhwe RWSS: Phase 5
		DATE.:	2017-04-09
		REF NO.:	MT32019
ATT :	Mr D Luhring	**INSTRUMENT S/N:**	DET4TC2

Determination of Soil Resistivity

TEST POSITION	AR-SR7	**TEMPERATURE:**		
DESCRIPTION:	lt Y Br sty s	**WEATHER COND:**	COLD	
SOIL CONDITION:	VERY MOIST	**GPS CO-ORD:**	S 32°02'49.9"	E 27°50'41.3"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0	17.00	14.40	271.4
2	SW	3.0	15.0	17.00		
3	NW	3.0	15.0	12.00		
4	NE	3.0	15.0	14.00		
5	NE	3.0	15.0	12.00		

ADDITIONAL NOTES: ALTERNATIVE ROUTE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:

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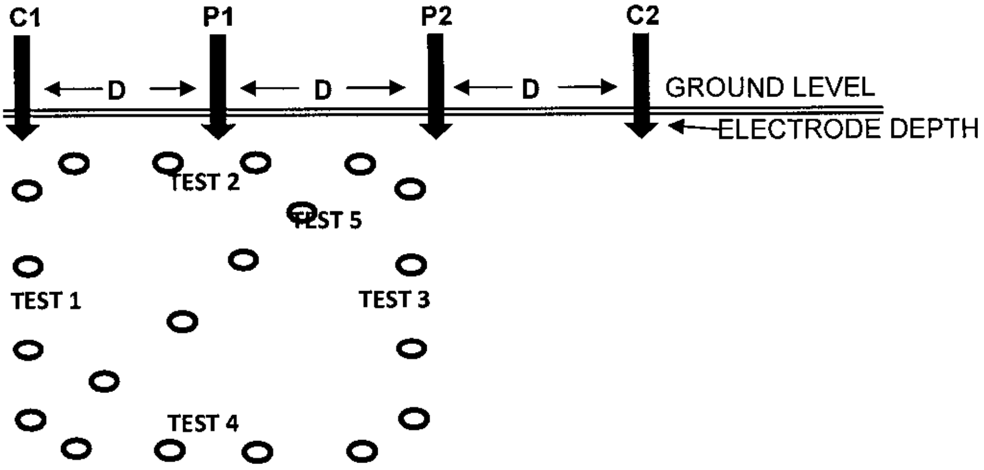
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-04-09
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	AR-SR8	**TEMPERATURE:**		
DESCRIPTION:	lt Y Br sty s	**WEATHER COND:**	COOL	
SOIL CONDITION:	VERY MOIST	**GPS CO-ORD:**	S 32°02'38.5"	E 27°50'50.8"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0	9.00	10.00	188.5
2	SW	3.0	15.0	10.00		
3	NW	3.0	15.0	9.00		
4	NE	3.0	15.0	10.00		
5	NE	3.0	15.0	12.00		

ADDITIONAL NOTES: ALTERNATIVE ROUTE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
C Becker

ControLab South Africa (Pty) Ltd

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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

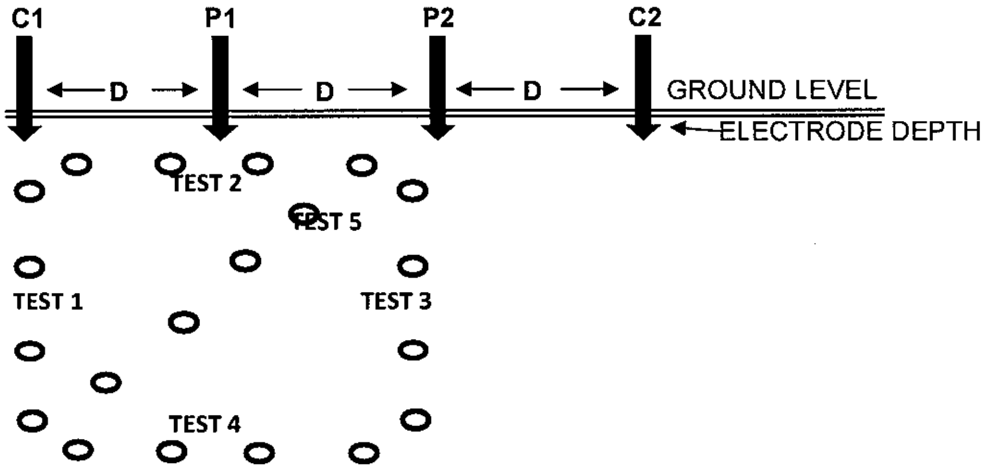
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-04-09
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	AR-SR9	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COOL	
SOIL CONDITION:	VERY MOIST	**GPS CO-ORD:**	S 32°02'47.2"	E27°51'00.2"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	14.00	11.68	220.2
2	SE	3.0	15.0	14.00		
3	SW	3.0	15.0	8.40		
4	NW	3.0	15.0	10.00		
5	N	3.0	15.0	12.00		

ADDITIONAL NOTES: ALTERNATIVE ROUTE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:

C Becker

CLIENT: Aurecon SA (Pty) Ltd
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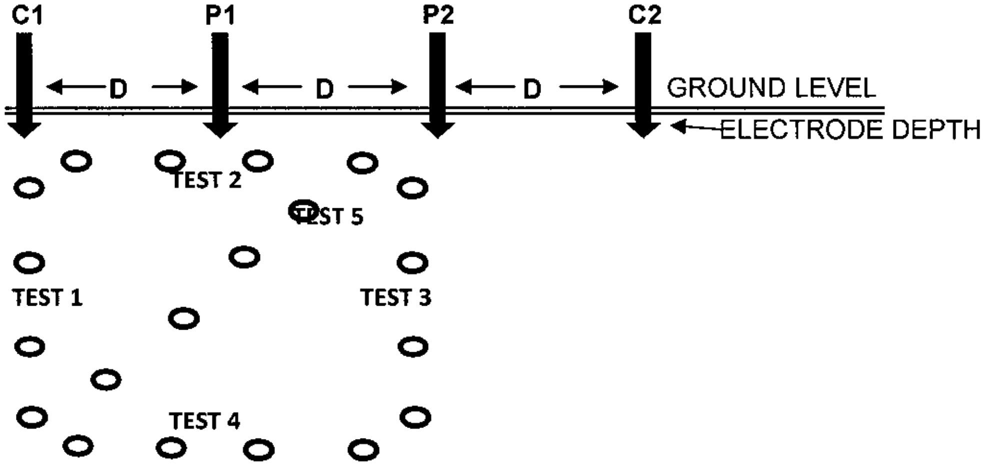
Determination of Soil Resistivity

TEST POSITION	AR-SR10	**TEMPERATURE:**	
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	WARM
SOIL CONDITION:	VERY MOIST	**GPS CO-ORD:**	S 32°02'48.2" E 27°51'08.2"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	S	3.0	15.0	6.49	6.01	113.3
2	SW	3.0	15.0	3.82		
3	NE	3.0	15.0	8.00		
4	SE	3.0	15.0	5.75		
5	SE	3.0	15.0	6.00		

ADDITIONAL NOTES: ALTERNATIVE ROUTE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:

C Becker

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201000682907
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
www.controlab.co.za

HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7859, Fax: 043 726 7426
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Phase 5
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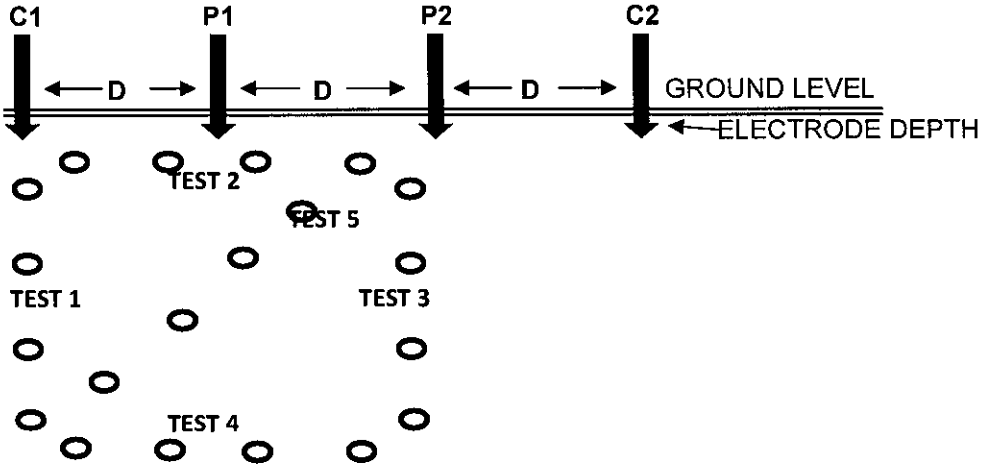
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	AR-SR12	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	WARM	
SOIL CONDITION:	MOIST	**GPS CO-ORD:**	S 32°02'56.6"	E 27°51'19.2"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	5.87	6.24	117.6
2	SE	3.0	15.0	8.00		
3	SW	3.0	15.0	6.57		
4	NW	3.0	15.0	4.75		
5	NW	3.0	15.0	6.00		

ADDITIONAL NOTES: ALTERNATIVE ROUTE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

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Phase 5
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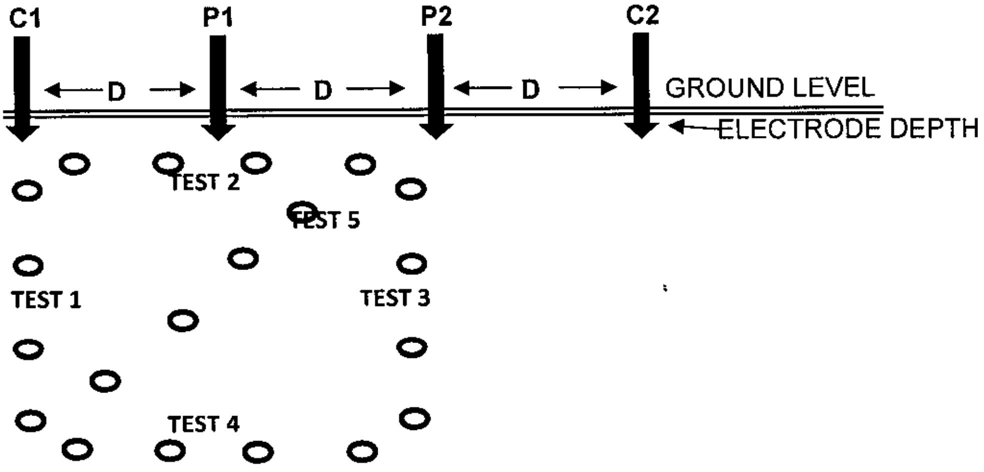
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	AR-SR13	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	WARM	
SOIL CONDITION:	MOIST	**GPS CO-ORD:**	S 32°03'04.4"	E 27°51'20.1"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SW	3.0	15.0	16.00	13.60	256.4
2	SE	3.0	15.0	16.00		
3	SW	3.0	15.0	12.00		
4	NW	3.0	15.0	10.00		
5	NW	3.0	15.0	14.00		

ADDITIONAL NOTES: ALTERNATIVE ROUTE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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TECOMA
5214
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Phase 5
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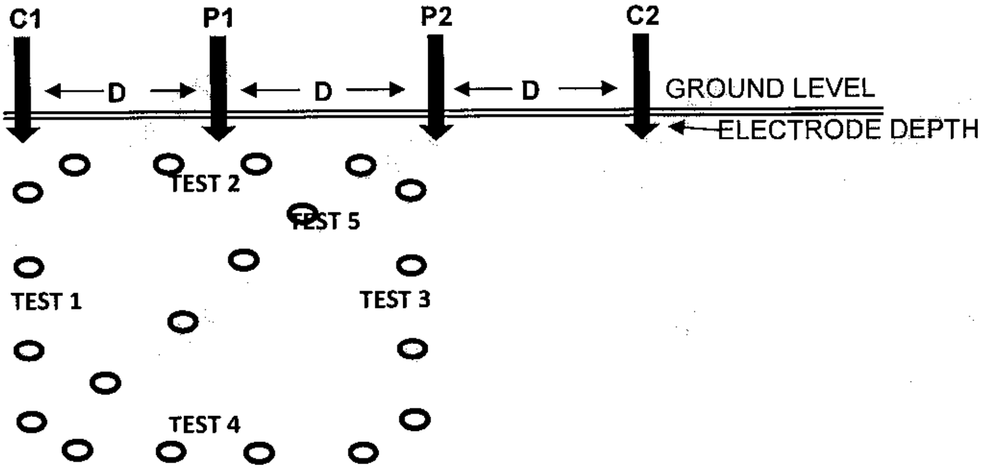
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	AR - SR14	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COLD	
SOIL CONDITION:	MOIST	**GPS CO-ORD:**	S32° 03' 08.6"	E27° 51' 25.5"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SW	3.0	15.0	9.00	8.00	150.8
2	NW	3.0	15.0	9.00		
3	NE	3.0	15.0	7.00		
4	SE	3.0	15.0	7.00		
5	SW	3.0	15.0	8.00		

ADDITIONAL NOTES: ALTERNATIVE ROUTE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
J Atterbury

201000682907

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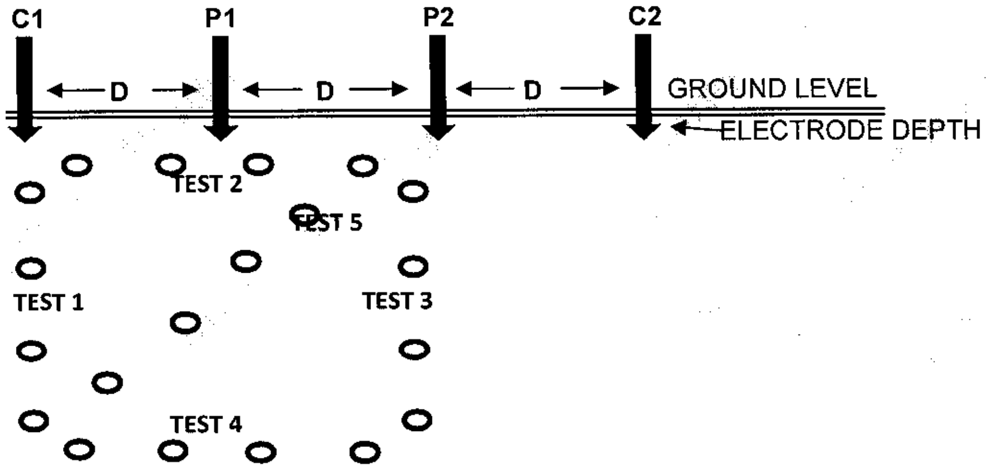
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	AR - SR15	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 03' 09.8"	E27° 51' 35.0"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0	2.00	1.91	36.1
2	SW	3.0	15.0	1.57		
3	NW	3.0	15.0	2.00		
4	NE	3.0	15.0	2.00		
5	SW	3.0	15.0	2.00		

ADDITIONAL NOTES: ALTERNATIVE ROUTE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

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TECOMA
5214
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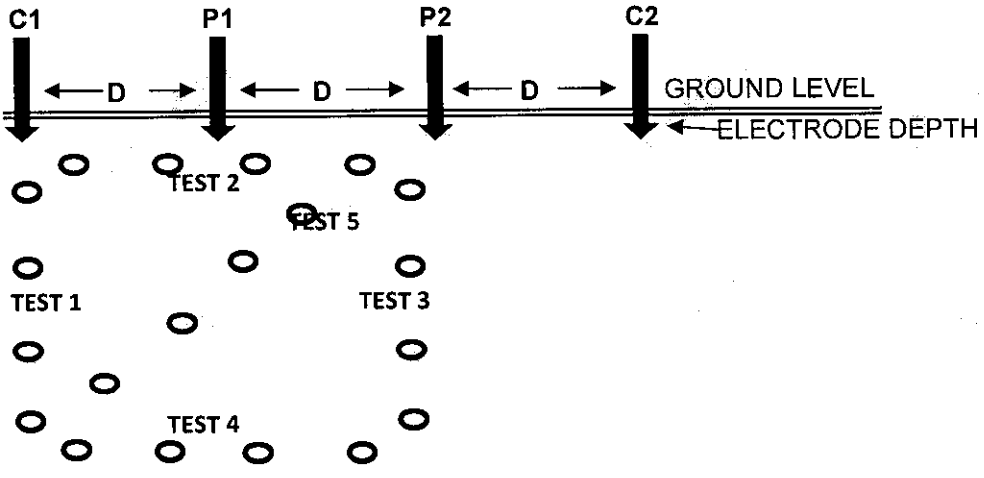
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	AR - SR16	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 03' 13.2"	E27° 51' 43.6"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	1.00	1.20	22.6
2	SE	3.0	15.0	1.00		
3	SW	3.0	15.0	2.00		
4	NE	3.0	15.0	1.00		
5	NW	3.0	15.0	1.00		

ADDITIONAL NOTES: ALTERNATIVE ROUTE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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GEOTECHNICAL AND ENVIRONMENTAL SERVICES
201000682907
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HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7859, Fax: 043 726 7426
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TECOMA
5214
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Phase 5
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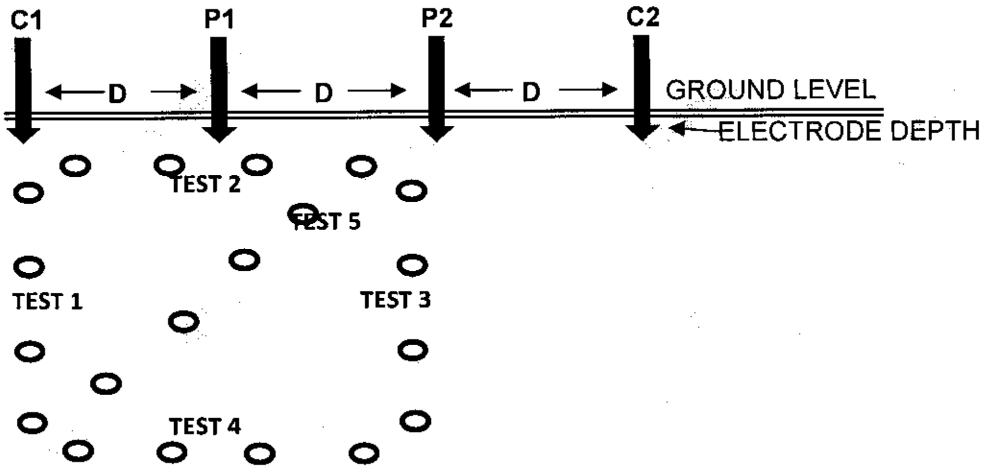
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	AR-SR17	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 03' 17.1"	E27° 51' 52.1"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0	11.12	11.88	223.9
2	SW	3.0	15.0	11.27		
3	NE	3.0	15.0	12.00		
4	NW	3.0	15.0	13.00		
5	SE	3.0	15.0	12.00		

ADDITIONAL NOTES: ALTERNATIVE ROUTE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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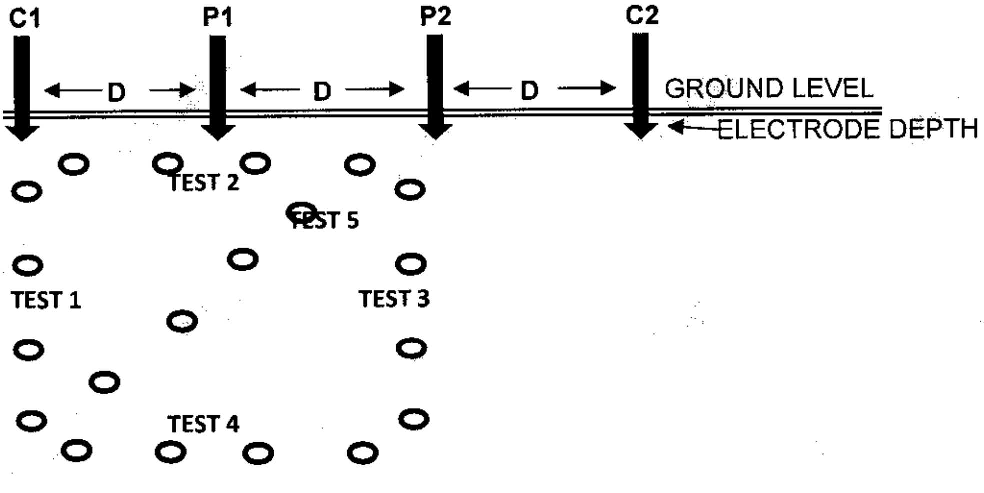
Determination of Soil Resistivity

TEST POSITION	AR-SR18	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 03' 18.6"	E27° 52' 01.4"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SW	3.0	15.0	9.00	10.40	196.0
2	NW	3.0	15.0	10.00		
3	SE	3.0	15.0	10.00		
4	NE	3.0	15.0	12.00		
5	SW	3.0	15.0	11.00		

ADDITIONAL NOTES: ALTERNATIVE ROUTE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

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TECOMA
5214
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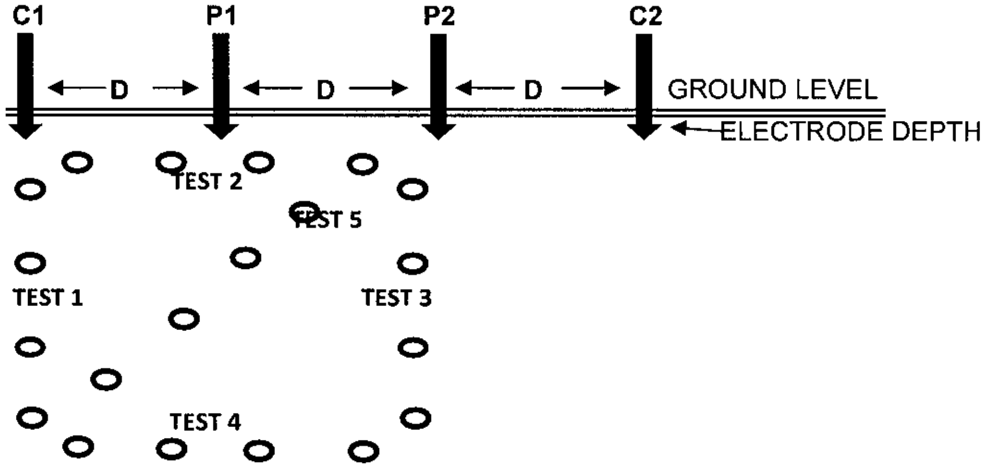
Determination of Soil Resistivity

TEST POSITION	SR1	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COOL, SUNNY	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S 32°02'07.7"	E 27°49'36.7"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NW	3.0	15.0	3.62	3.29	62.0
2	NE	3.0	15.0	2.73		
3	SE	3.0	15.0	2.63		
4	SW	3.0	15.0	4.00		
5	SE	3.0	15.0	3.47		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
C Becker

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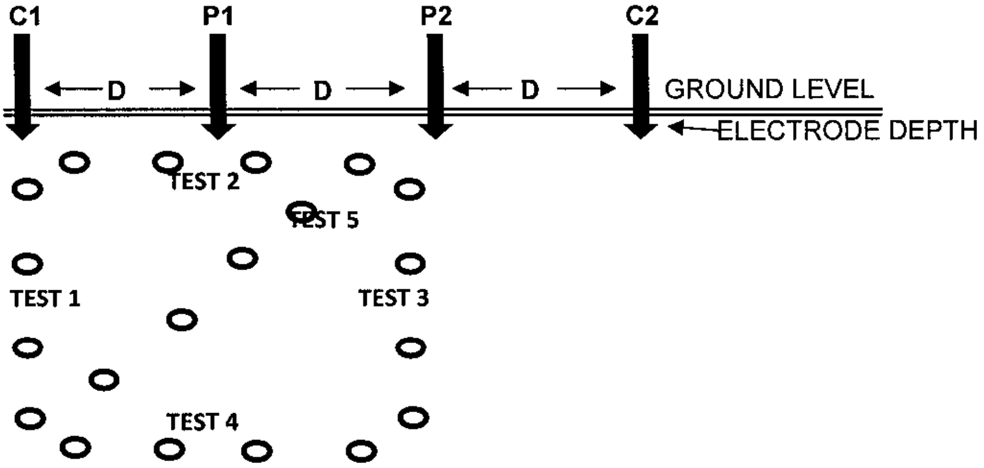
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR2	**TEMPERATURE:**	
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	HOT
SOIL CONDITION:	DRY	**GPS CO-ORD:**	S 32°02'11.5" E 27°49'44.7"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0	9.09	7.62	143.6
2	SW	3.0	15.0	9.00		
3	NW	3.0	15.0	6.00		
4	NE	3.0	15.0	6.00		
5	NE	3.0	15.0	8.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:

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DATE.: 2017-04-04
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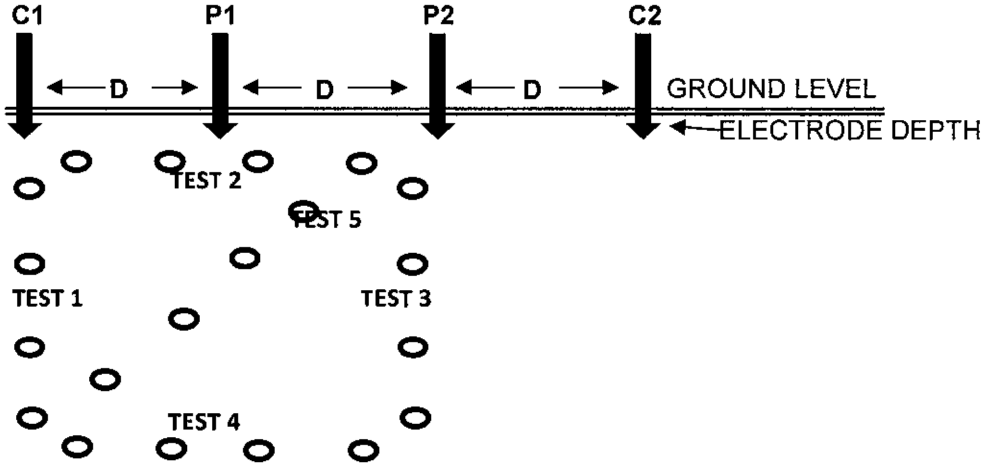
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR3			**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s			**WEATHER COND:**	HOT	
SOIL CONDITION:	DRY			**GPS CO-ORD:**	S 32°02'18.5"	E 27°49'49.6"
TEST NO.:	**DIRECTION:**	**DISTANCE BETWEEN ELECTRODES (m)**	**ELECTRODE DEPTH (cm)**	**RESISTANCE READING (Ω)**	**AVERAGE RESISTANCE READING (Ω)**	**APPARENT SOIL RESISTIVITY (Ω/m)**
1	NE	3.0	15.0	6.38	7.86	148.2
2	NW	3.0	15.0	8.00		
3	SW	3.0	15.0	8.00		
4	SE	3.0	15.0	7.92		
5	SW	3.0	15.0	9.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
C Becker

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201000682907
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HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7859, Fax: 043 726 7426
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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

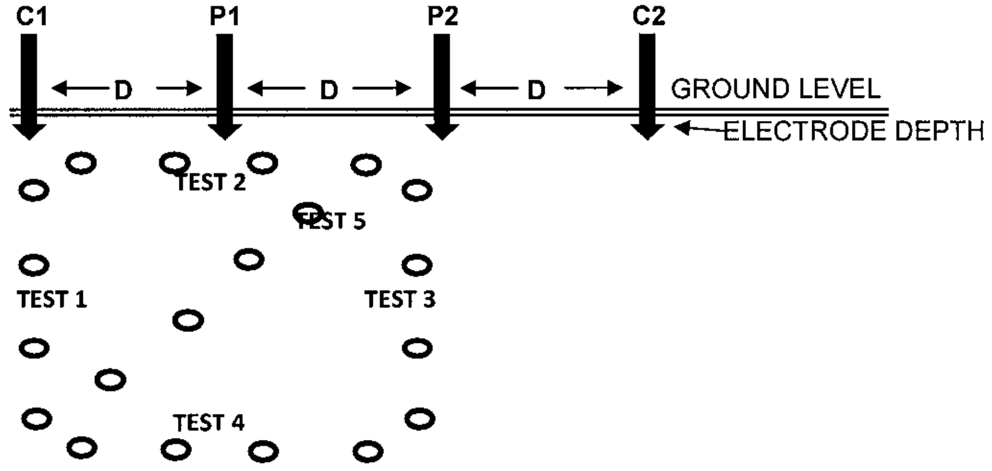
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-04-04
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR5	**TEMPERATURE:**		
DESCRIPTION:	It Br sty s	**WEATHER COND:**	VERY HOT	
SOIL CONDITION:	DRY	**GPS CO-ORD:**	S 32°02'29.2"	E 27°50'00.9"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0	4.00	4.80	90.5
2	NE	3.0	15.0	5.00		
3	NW	3.0	15.0	4.00		
4	SW	3.0	15.0	5.00		
5	W	3.0	15.0	6.00		

ADDITIONAL NOTES: ______________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

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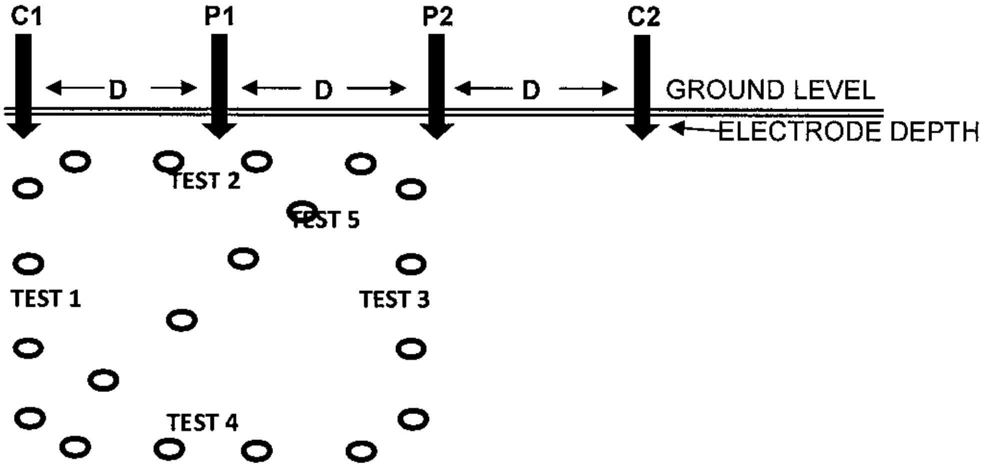
Determination of Soil Resistivity

TEST POSITION	SR6	**TEMPERATURE:**	
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY HOT
SOIL CONDITION:	DRY	**GPS CO-ORD:**	S 32°02'34.8" E 27°50'07.5"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SW	3.0	15.0	15.00	15.96	300.8
2	NE	3.0	15.0	16.00		
3	NW	3.0	15.0	17.00		
4	SW	3.0	15.0	16.00		
5	NW	3.0	15.0	15.80		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

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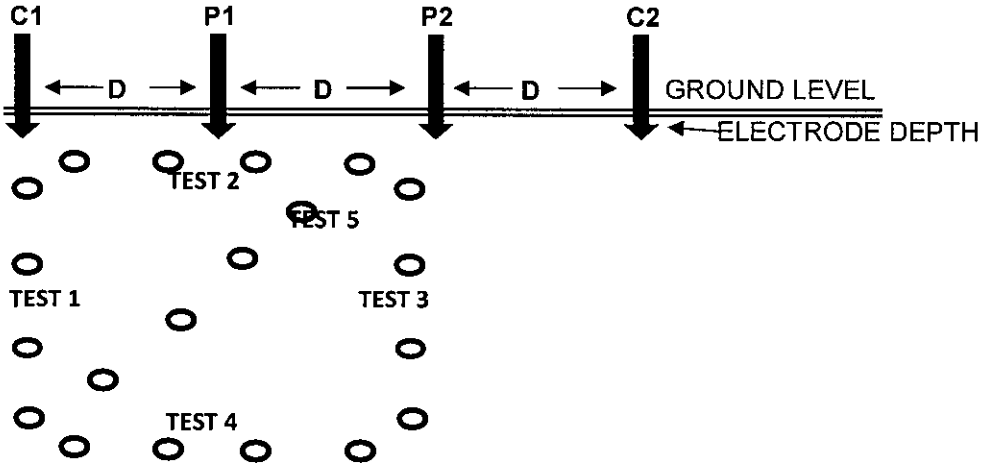
Determination of Soil Resistivity

TEST POSITION	SR7	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S 32°02'40.3"	E 27°50'14.8"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SW	3.0	15.0	12.00	13.80	260.1
2	NE	3.0	15.0	15.00		
3	NW	3.0	15.0	12.00		
4	SW	3.0	15.0	16.00		
5	SW	3.0	15.0	14.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

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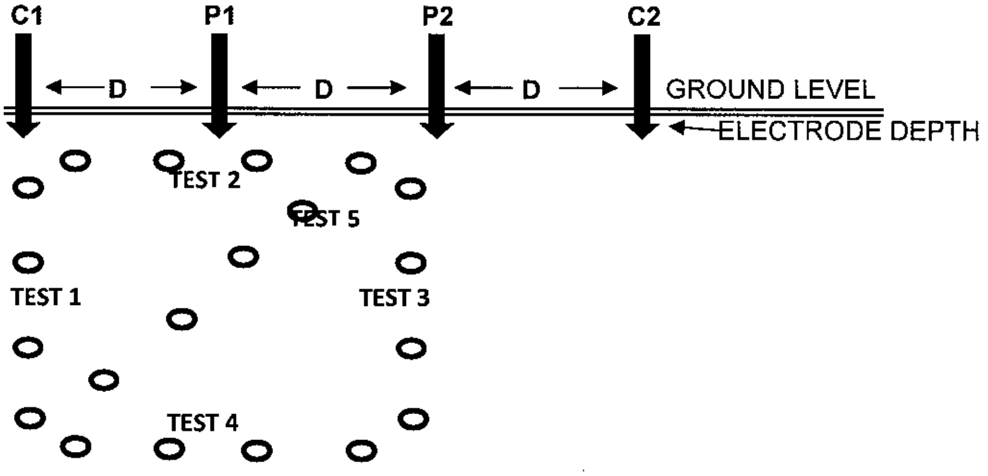
Determination of Soil Resistivity

TEST POSITION	SR9	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S 32°02'39.4"	E 27°50'33.0"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0	14.00	13.00	245.0
2	NE	3.0	15.0	12.00		
3	NW	3.0	15.0	11.00		
4	SW	3.0	15.0	15.00		
5	SW	3.0	15.0	13.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

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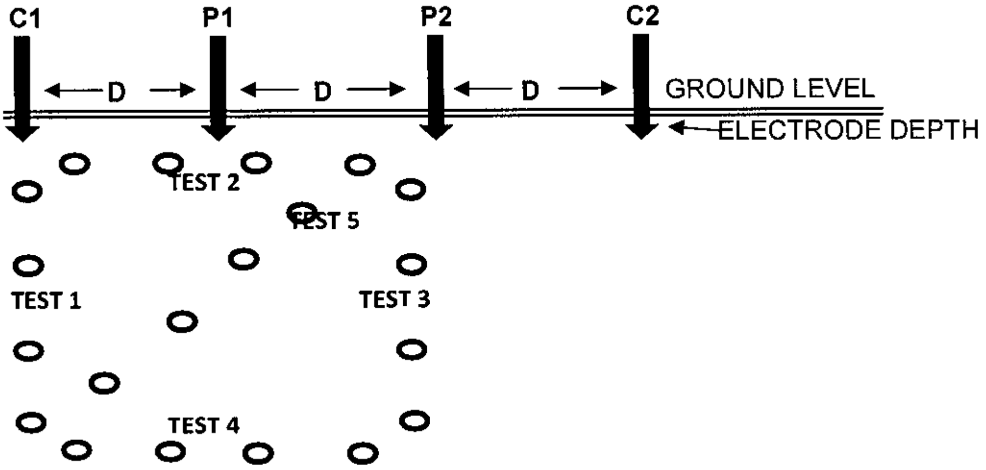
Determination of Soil Resistivity

TEST POSITION	SR10	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S 32°02'38.7"	E 27°50'42.4"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0	4.00	4.20	79.2
2	NE	3.0	15.0	4.00		
3	NW	3.0	15.0	4.00		
4	SW	3.0	15.0	5.00		
5	SW	3.0	15.0	4.00		

ADDITIONAL NOTES: PROPERTY OWNER COMPLAINED



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

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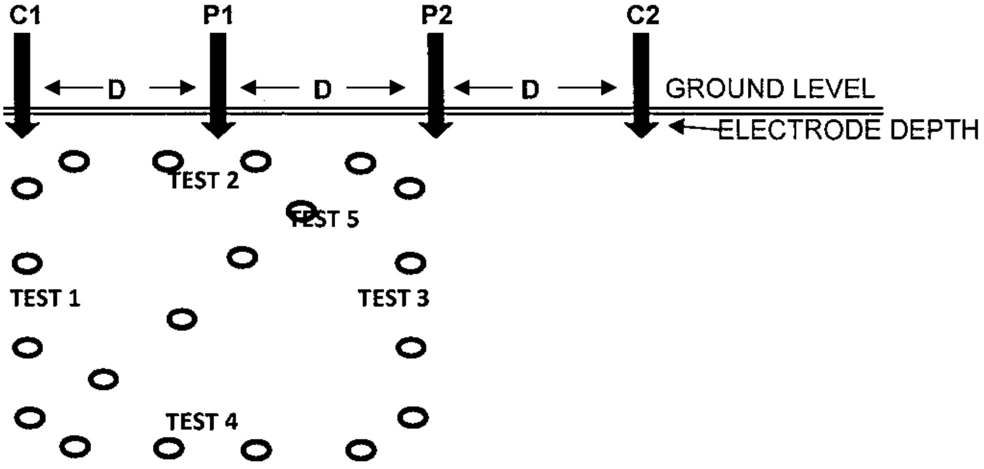
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR11	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COOL	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S 32°02'38.1"	E 27°50'52.0"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	19.00	17.60	331.8
2	SE	3.0	15.0	18.00		
3	SW	3.0	15.0	19.00		
4	NW	3.0	15.0	15.00		
5	NW	3.0	15.0	17.00		

ADDITIONAL NOTES: ______________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: ______________

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5214
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PROJECT: Ngqamakhwe RWSS:
Phase 5
DATE.: 2017-04-05
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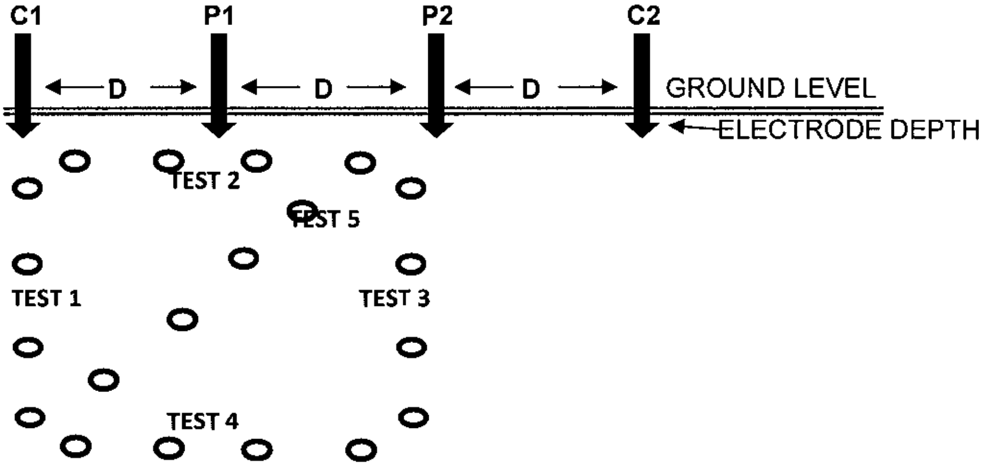
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR12	**TEMPERATURE:**	
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COOL
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S 32°02'36.0" E 27°50'59.4"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	6.00	7.60	143.3
2	SE	3.0	15.0	8.00		
3	SW	3.0	15.0	10.00		
4	NW	3.0	15.0	6.00		
5	NW	3.0	15.0	8.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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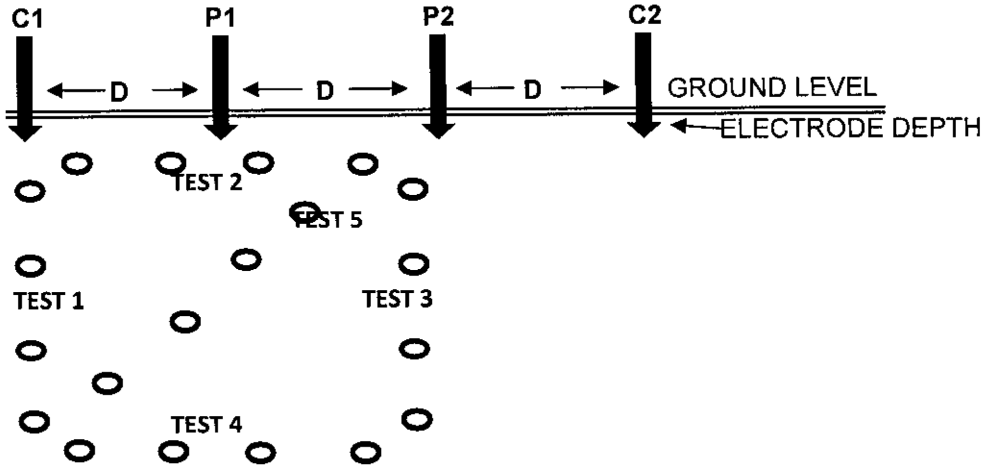
Determination of Soil Resistivity

TEST POSITION	SR13	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	WARM	
SOIL CONDITION:	DRY	**GPS CO-ORD:**	S 32°02'35.8"	E 27°51'08.9"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	13.00	11.60	218.7
2	SE	3.0	15.0	8.00		
3	SW	3.0	15.0	12.00		
4	NW	3.0	15.0	14.00		
5	NW	3.0	15.0	11.00		

ADDITIONAL NOTES: ______________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: ______

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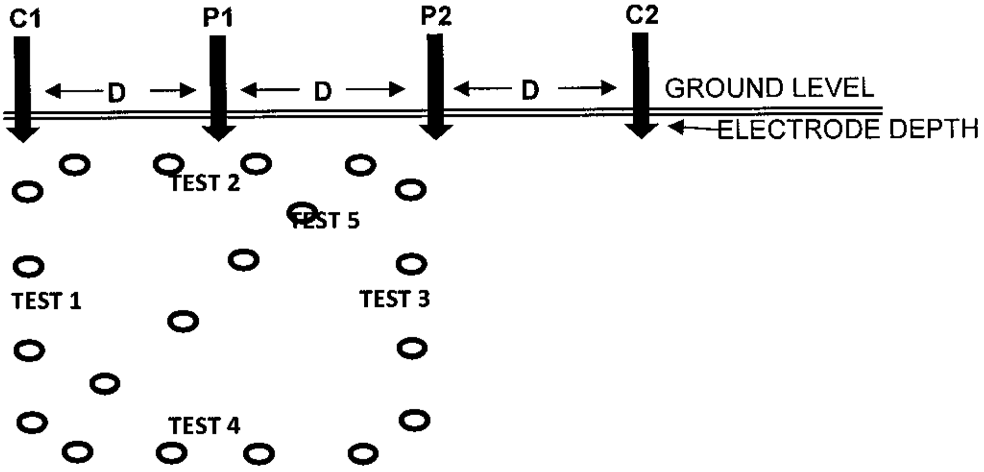
Determination of Soil Resistivity

TEST POSITION	SR14	**TEMPERATURE:**	
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	HOT
SOIL CONDITION:	DRY	**GPS CO-ORD:**	S 32°02'36.0" E 27°51'18.2"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	11.00	11.40	214.9
2	SE	3.0	15.0	11.00		
3	SW	3.0	15.0	11.00		
4	NW	3.0	15.0	12.00		
5	NW	3.0	15.0	12.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

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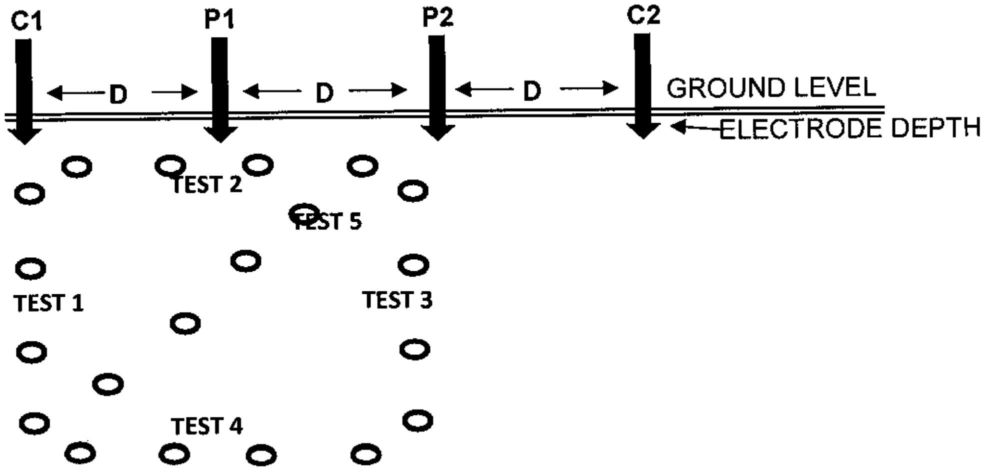
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR18	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	HOT	
SOIL CONDITION:	DRY	**GPS CO-ORD:**	S 32°02'55.3"	E 27°51'32.9"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NW	3.0	15.0	11.00	12.40	233.7
2	NE	3.0	15.0	12.00		
3	SE	3.0	15.0	14.00		
4	SW	3.0	15.0	13.00		
5	NE	3.0	15.0	12.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:

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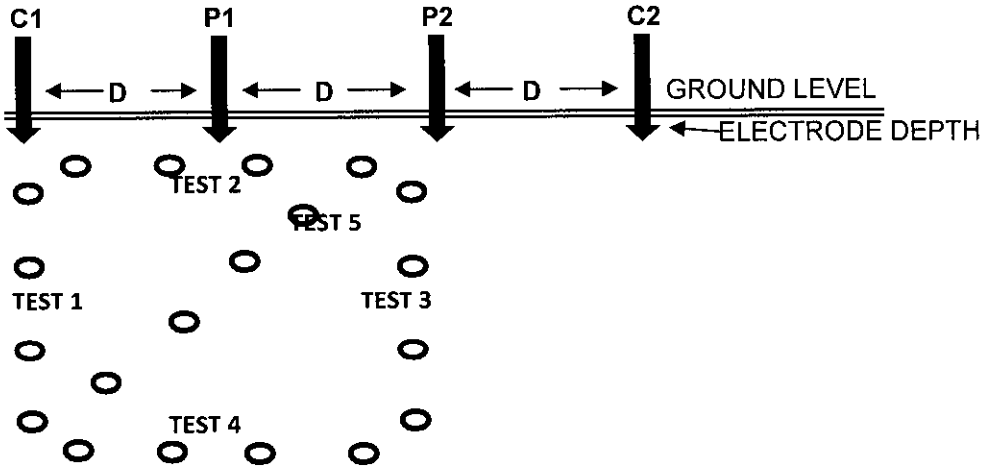
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR19	**TEMPERATURE:**	
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY HOT
SOIL CONDITION:	DRY	**GPS CO-ORD:**	S 32°03'00.2" E 27°51'37.5"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	27.00	19.20	361.9
2	SE	3.0	15.0	16.00		
3	SW	3.0	15.0	18.00		
4	NW	3.0	15.0	15.00		
5	NW	3.0	15.0	20.00		

ADDITIONAL NOTES: ____________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

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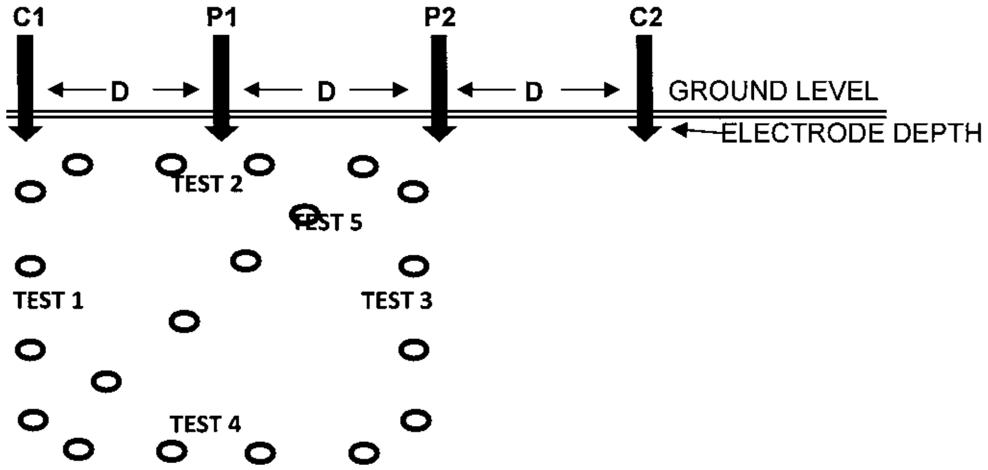
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR20	**TEMPERATURE:**	
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY HOT
SOIL CONDITION:	DRY	**GPS CO-ORD:**	S 32°03'04.8" E 27°51'45.1"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	9.00	8.20	154.6
2	SE	3.0	15.0	9.00		
3	SW	3.0	15.0	8.00		
4	NW	3.0	15.0	7.00		
5	NW	3.0	15.0	8.00		

ADDITIONAL NOTES: ____________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
C Becker

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201000682907
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
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HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7859, Fax: 043 726 7426
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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

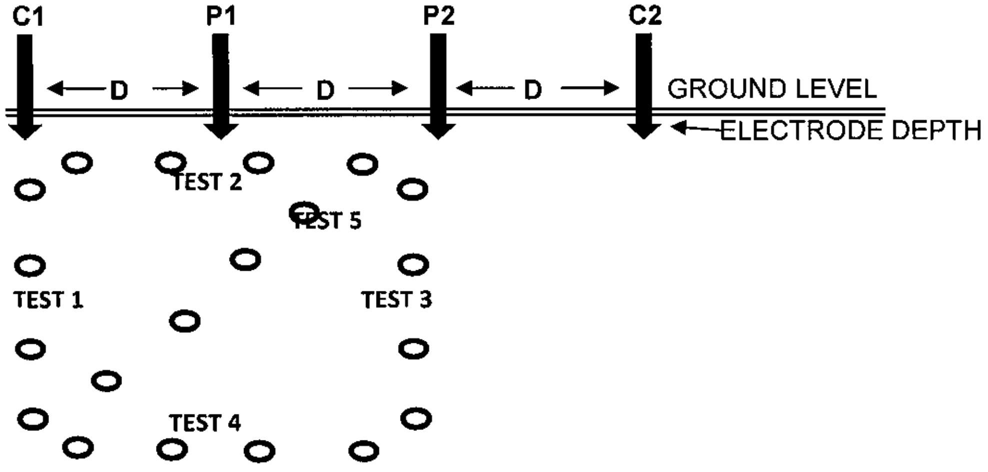
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-04-05
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR21	TEMPERATURE:		
DESCRIPTION:	lt Y Br sty s	WEATHER COND:	VERY HOT	
SOIL CONDITION:	DRY	GPS CO-ORD:	S 32°03'09.5"	E 27°51'53.0"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NW	3.0	15.0	3.33	4.57	86.1
2	NE	3.0	15.0	4.00		
3	SE	3.0	15.0	6.00		
4	SW	3.0	15.0	4.50		
5	SW	3.0	15.0	5.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

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PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

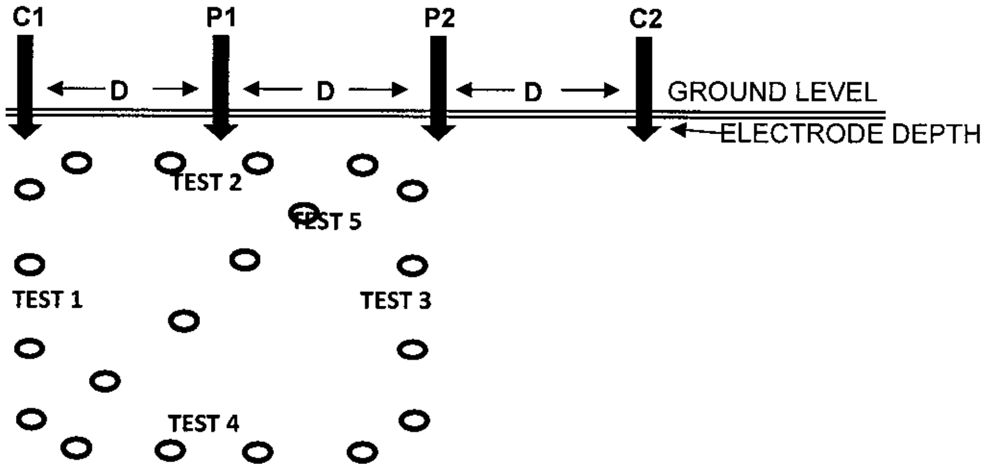
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-04-07
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR22	TEMPERATURE:		
DESCRIPTION:	lt Br sty s	WEATHER COND:	COLD	
SOIL CONDITION:	MOIST	GPS CO-ORD:	S 32°03'15.2"	E 27°51'59.4"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SW	3.0	15.0	14.00	12.60	237.5
2	NW	3.0	15.0	11.00		
3	NE	3.0	15.0	15.00		
4	SE	3.0	15.0	11.00		
5	SW	3.0	15.0	12.00		

ADDITIONAL NOTES: FREQUENCY USED 50V / 128hz



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:

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PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

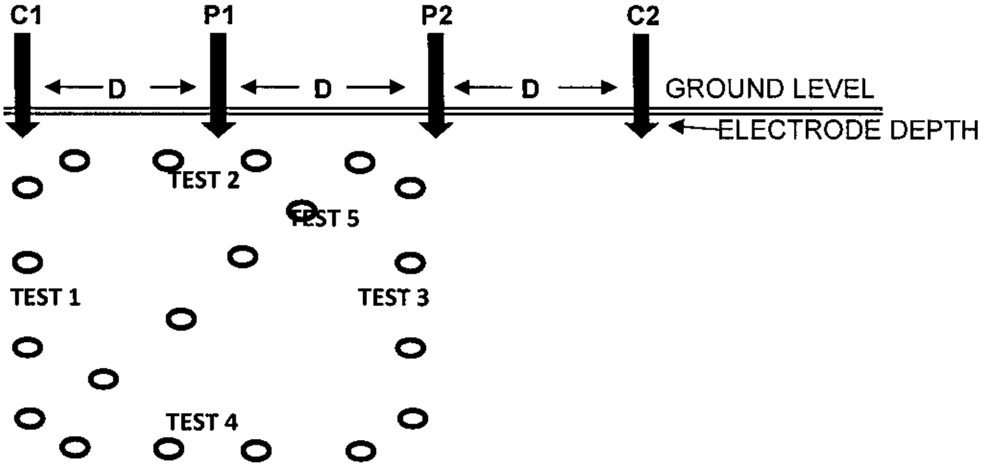
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-04-07
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR23	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COLD	
SOIL CONDITION:	MOIST	**GPS CO-ORD:**	S 32°03'18.6"	E 27°52'07.0"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	6.00	4.40	82.9
2	SE	3.0	15.0	4.00		
3	S	3.0	15.0	3.00		
4	NW	3.0	15.0	4.00		
5	NW	3.0	15.0	5.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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CLIENT: Aurecon SA (Pty) Ltd
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TECOMA
5214
ATT : Mr D Luhring

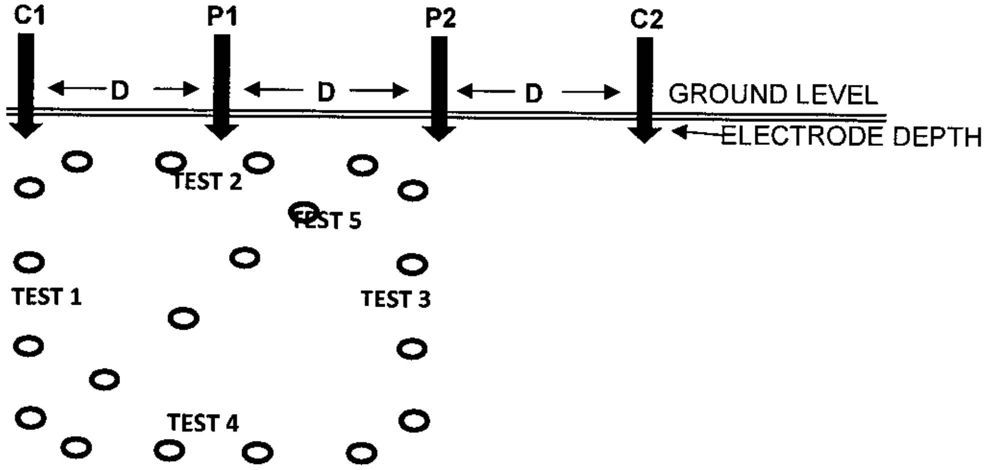
PROJECT: Ngqamakhwe RWSS:
Phase 5
DATE.: 2017-04-07
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR24	TEMPERATURE:		
DESCRIPTION:	lt Br sty s	WEATHER COND:	COOL	
SOIL CONDITION:	MOIST	GPS CO-ORD:	S 32°03'19.1"	E 27°52'16.4"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	21.00	16.00	301.6
2	SE	3.0	15.0	14.00		
3	SW	3.0	15.0	16.00		
4	NW	3.0	15.0	13.00		
5	NW	3.0	15.0	16.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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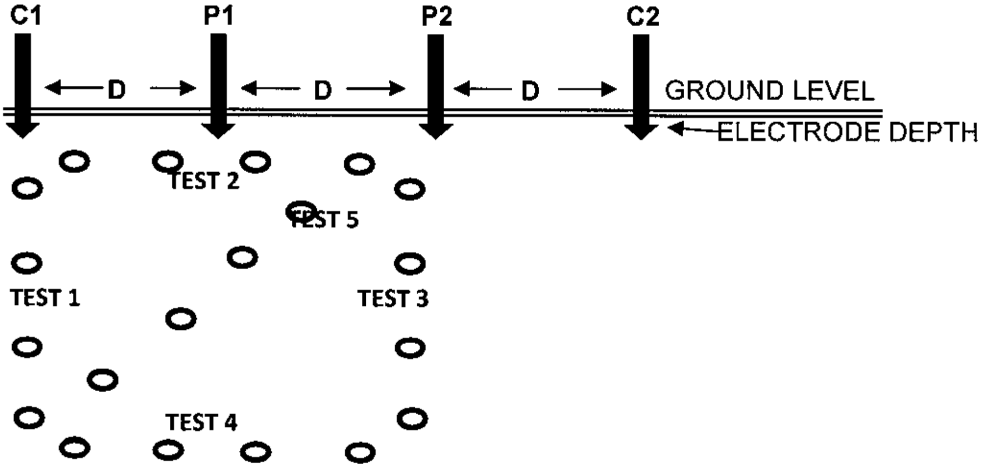
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-04-07
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR25	TEMPERATURE:		
DESCRIPTION:	lt Y Br sty s	WEATHER COND:	COOL	
SOIL CONDITION:	MOIST	GPS CO-ORD:	S 32°03'21.1"	E 27°52'25.7"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	8.00	9.60	181.0
2	SE	3.0	15.0	10.00		
3	SW	3.0	15.0	10.00		
4	NW	3.0	15.0	12.00		
5	NW	3.0	15.0	8.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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PROJECT: Ngqamakhwe RWSS: Phase 5
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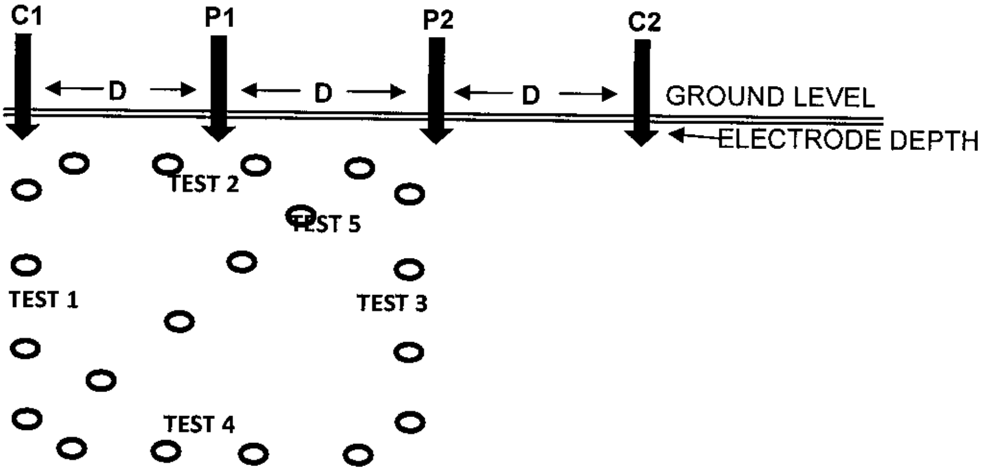
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR26	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COOL	
SOIL CONDITION:	MOIST	**GPS CO-ORD:**	S 32°03'22.6"	E 27°52'35.1"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0	4.00	3.80	71.6
2	SW	3.0	15.0	3.00		
3	NW	3.0	15.0	4.00		
4	NE	3.0	15.0	5.00		
5	NE	3.0	15.0	3.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

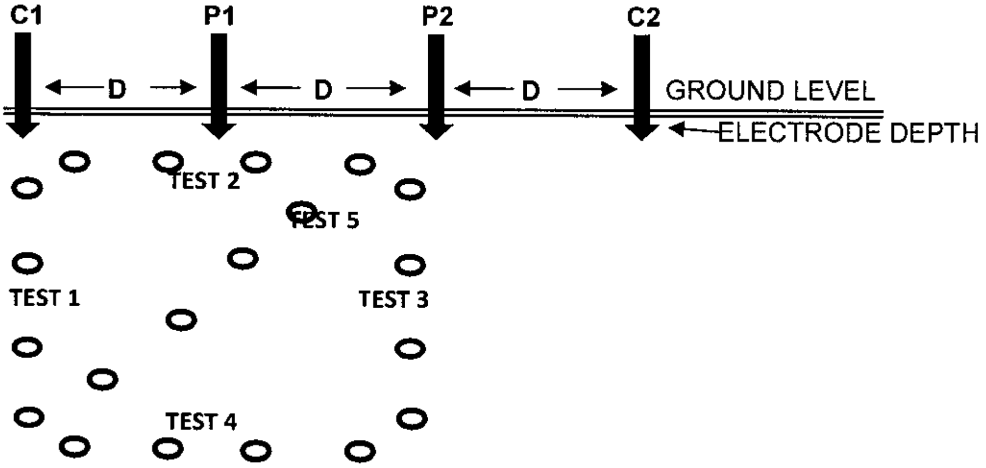
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-04-07
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR28	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COOL	
SOIL CONDITION:	MOIST	**GPS CO-ORD:**	S 32°03'25.8"	E 27°52'54.0"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	3.32	3.86	72.8
2	SE	3.0	15.0	4.00		
3	SW	3.0	15.0	3.00		
4	W	3.0	15.0	5.00		
5	NW	3.0	15.0	4.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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PO Box 19553
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DATE.: 2017-04-07
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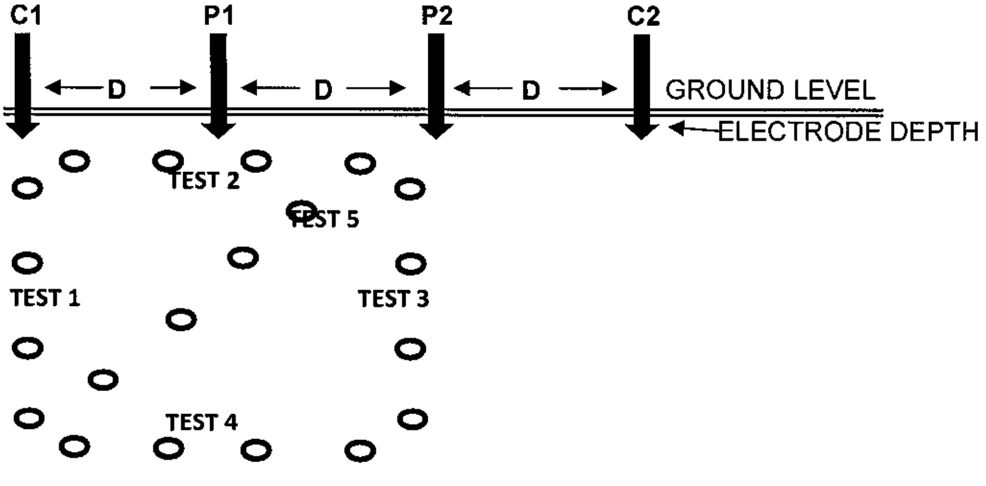
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR29	TEMPERATURE:		
DESCRIPTION:	lt Br sty s	WEATHER COND:	COOL	
SOIL CONDITION:	MOIST	GPS CO-ORD:	S 32°03'27.6"	E 27°53'03.3"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	4.00	3.80	71.6
2	SE	3.0	15.0	3.00		
3	SW	3.0	15.0	4.00		
4	NW	3.0	15.0	5.00		
5	NW	3.0	15.0	3.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:

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TECOMA
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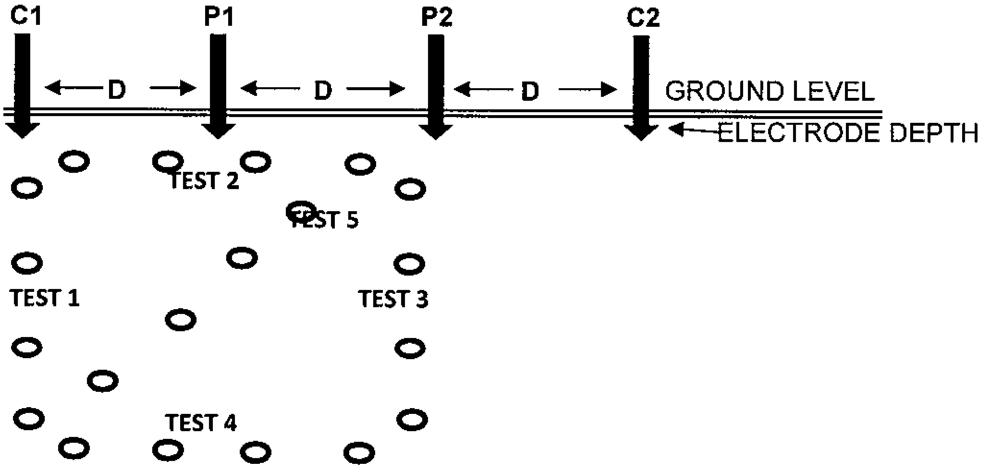
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-04-07
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR30	**TEMPERATURE:**	
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COOL
SOIL CONDITION:	MOIST	**GPS CO-ORD:**	S 32°03'30.3" E 27°53'12.7"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	10.00	10.60	199.8
2	SE	3.0	15.0	11.00		
3	SW	3.0	15.0	9.00		
4	NW	3.0	15.0	12.00		
5	NW	3.0	15.0	11.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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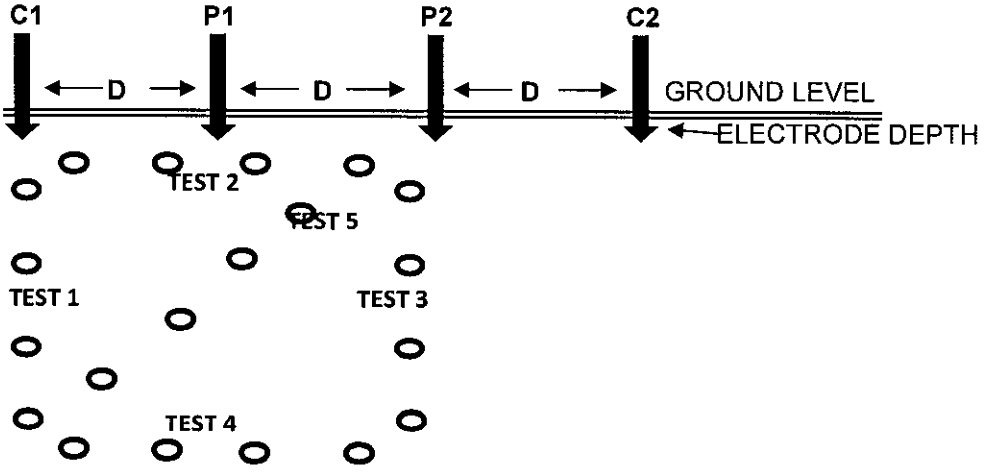
DATE.: 2017-04-07
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR31	TEMPERATURE:		
DESCRIPTION:	lt Br sty s	WEATHER COND:	COLD	
SOIL CONDITION:	MOIST	GPS CO-ORD:	S 32°03'32.7"	E 27°53'21.5"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	6.97	7.39	139.4
2	SE	3.0	15.0	8.80		
3	SW	3.0	15.0	8.00		
4	NW	3.0	15.0	6.20		
5	NW	3.0	15.0	7.00		

ADDITIONAL NOTES: ______________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: ______
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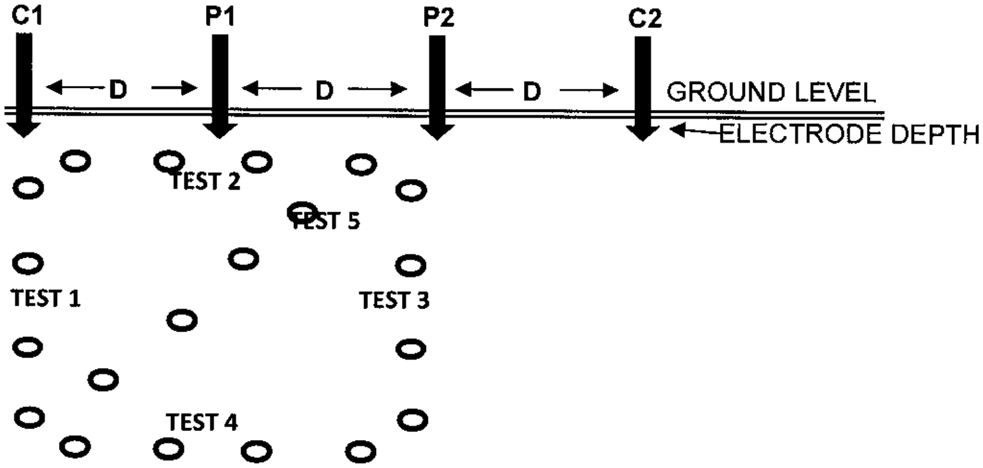
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR32	TEMPERATURE:	
DESCRIPTION:	lt Br sty s	WEATHER COND:	COLD
SOIL CONDITION:	SLIGHTLY MOIST	GPS CO-ORD:	S 32°03'35.4" E 27°53'31.0"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	3.00	3.80	71.6
2	SE	3.0	15.0	4.00		
3	SW	3.0	15.0	3.00		
4	NW	3.0	15.0	4.00		
5	NW	3.0	15.0	5.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
C Becker

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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

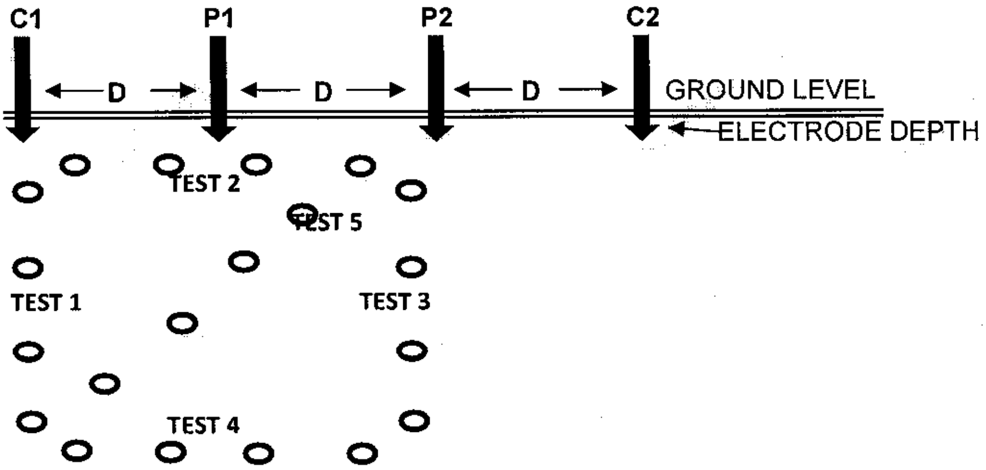
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-19
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR35	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s + decDol	**WEATHER COND:**	COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 03' 44.2"	E27° 53' 56.6"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SW	3.0	15.0	11.26	11.25	212.0
2	SE	3.0	15.0	10.92		
3	SW	3.0	15.0	11.44		
4	NW	3.0	15.0	11.50		
5	W	3.0	15.0	11.12		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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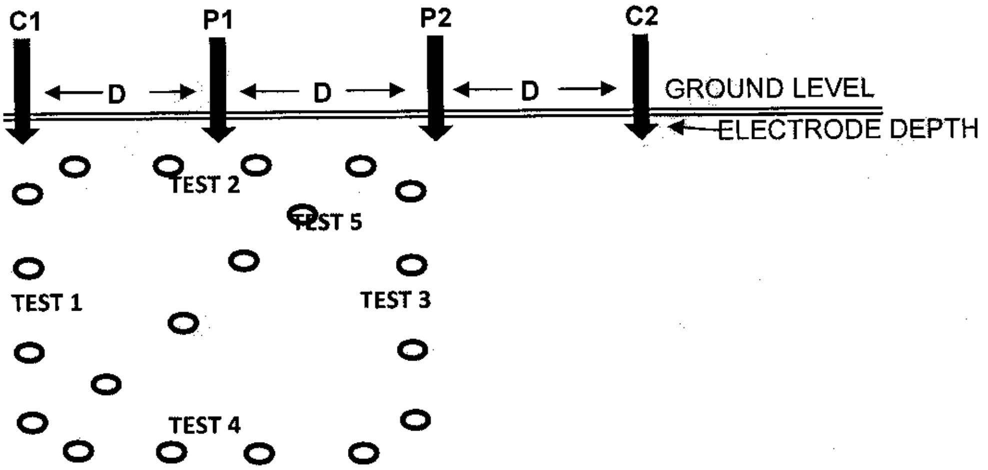
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-19
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR36	TEMPERATURE:		
DESCRIPTION:	lt Br sty s + dec Dol	WEATHER COND:	COLD/WINDY	
SOIL CONDITION:	SLIGHTLY MOIST	GPS CO-ORD:	S32° 03' 47.2"	E27° 54' 05.4"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SW	3.0	15.0	9.32	8.57	161.5
2	SE	3.0	15.0	8.90		
3	SW	3.0	15.0	8.50		
4	NW	3.0	15.0	7.99		
5	W	3.0	15.0	8,13		

ADDITIONAL NOTES: ____________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: ____________
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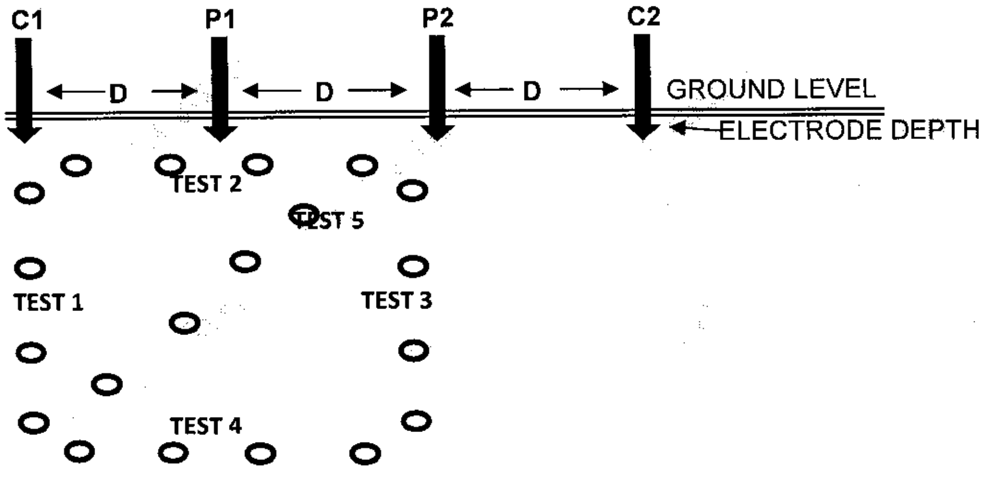
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR34	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s + decDol	**WEATHER COND:**	COLD	
SOIL CONDITION:	DRY	**GPS CO-ORD:**	S32° 03' 41.0"	E27° 53' 47.6"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0		0.00	0.0
2	SW	3.0	15.0			
3	NE	3.0	15.0			
4	NW	3.0	15.0			
5	SE	3.0	15.0			

ADDITIONAL NOTES: (UTD) - PROBES UNABLE TO PENETRATE SURFACE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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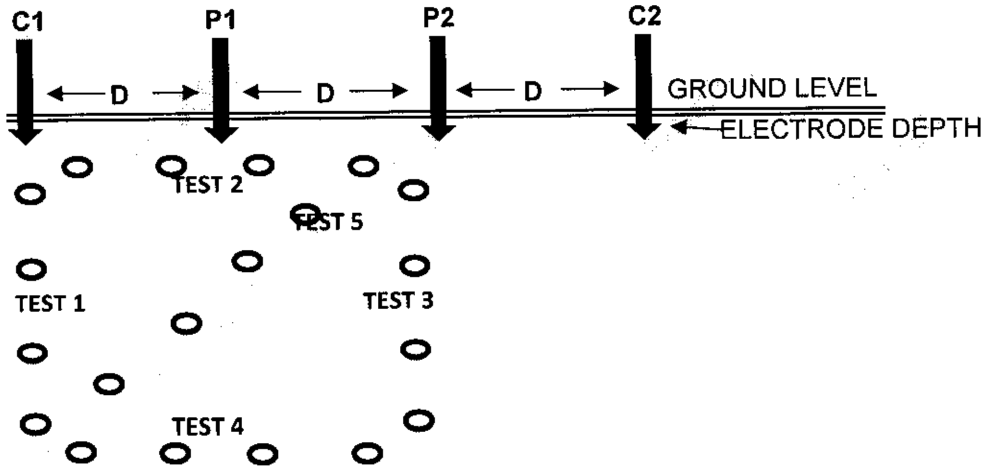
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR37	**TEMPERATURE:**		
DESCRIPTION:	It Br dec Dol	**WEATHER COND:**	VERY COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 03' 50.3"	E27° 54' 14.3"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	8.25	6.91	130.3
2	SE	3.0	15.0	6.79		
3	SW	3.0	15.0	6.29		
4	NW	3.0	15.0	6.89		
5	NE	3.0	15.0	6.35		

ADDITIONAL NOTES: ______________________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: ____________
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PROJECT: Ngqamakhwe RWSS: Phase 5
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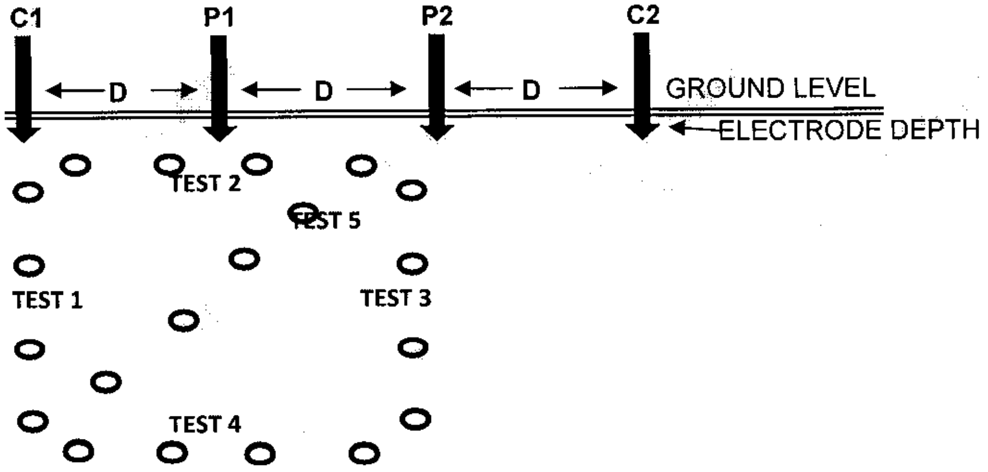
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR38	**TEMPERATURE:**		
DESCRIPTION:	lt Br dec Dol	**WEATHER COND:**	VERY COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 03' 53.9"	E27° 54' 22.7"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	15.84	13.69	258.1
2	SE	3.0	15.0	12.67		
3	SW	3.0	15.0	10.70		
4	NW	3.0	15.0	15.74		
5	NE	3.0	15.0	13.50		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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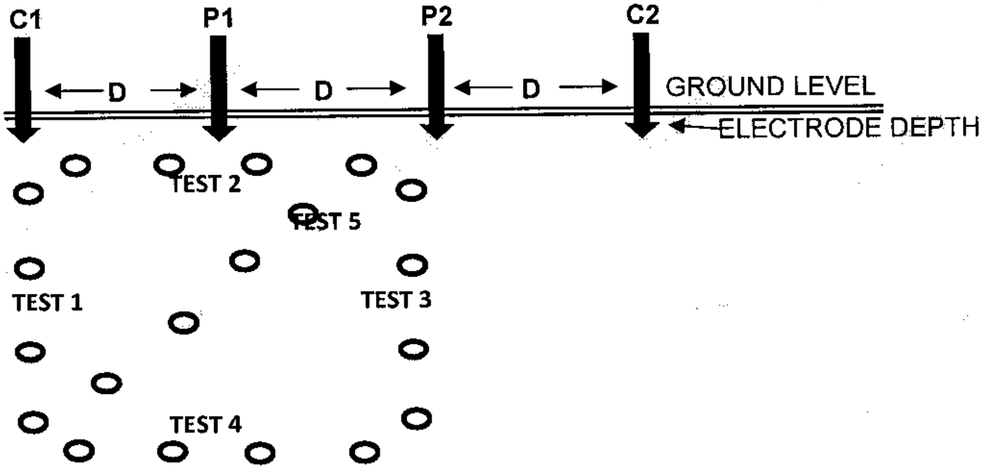
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR39	TEMPERATURE:		
DESCRIPTION:	lt Br dec Dol	WEATHER COND:	VERY COLD	
SOIL CONDITION:	SLIGHTLY MOIST	GPS CO-ORD:	S32° 04' 00.6"	E27° 54' 28.4"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	13.37	14.32	269.9
2	SE	3.0	15.0	15.17		
3	SW	3.0	15.0	13.12		
4	NW	3.0	15.0	14.68		
5	NE	3.0	15.0	15.25		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

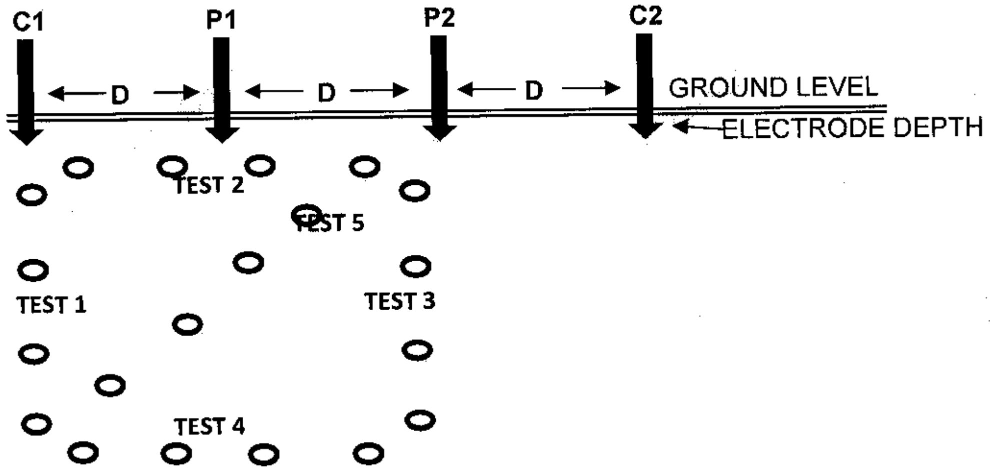
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-20
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR40	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 04' 07.0"	E27° 54' 33.9"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SW	3.0	15.0	9.37	10.02	188.9
2	NW	3.0	15.0	9.73		
3	NE	3.0	15.0	11.00		
4	SE	3.0	15.0	12.00		
5	SW	3.0	15.0	8.00		

ADDITIONAL NOTES: ______________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: ______
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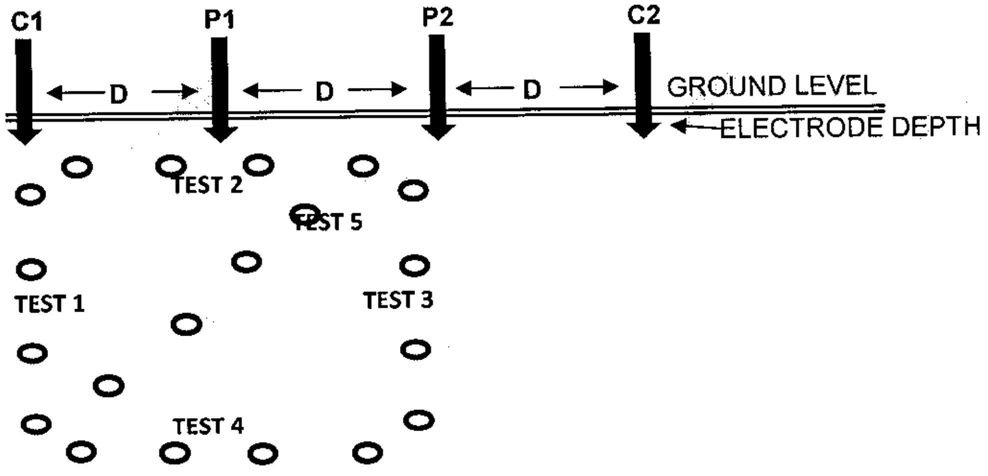
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR41	TEMPERATURE:		
DESCRIPTION:	lt Br dec Dol	WEATHER COND:	VERY COLD	
SOIL CONDITION:	SLIGHTLY MOIST	GPS CO-ORD:	S32° 04' 14.2"	E27° 54' 40.2"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0		0.00	0.0
2	SE	3.0	15.0			
3	SW	3.0	15.0			
4	NW	3.0	15.0			
5	NE	3.0	15.0			

ADDITIONAL NOTES: (UTD) - PROBES UNABLE TO PENETRATE SURFACE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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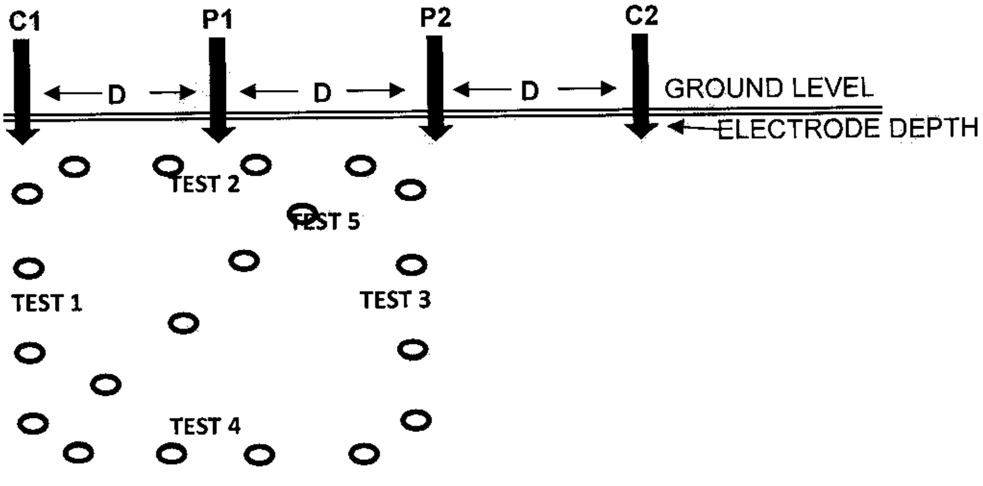
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR42	**TEMPERATURE:**		
DESCRIPTION:	lt Y Br dec Dol	**WEATHER COND:**	COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 04' 20.7"	E27° 54' 45.9"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	11.25	11.12	209.5
2	SE	3.0	15.0	10.36		
3	SW	3.0	15.0	11.47		
4	NW	3.0	15.0	10.17		
5	SE	3.0	15.0	12.33		

ADDITIONAL NOTES: ______________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: ______
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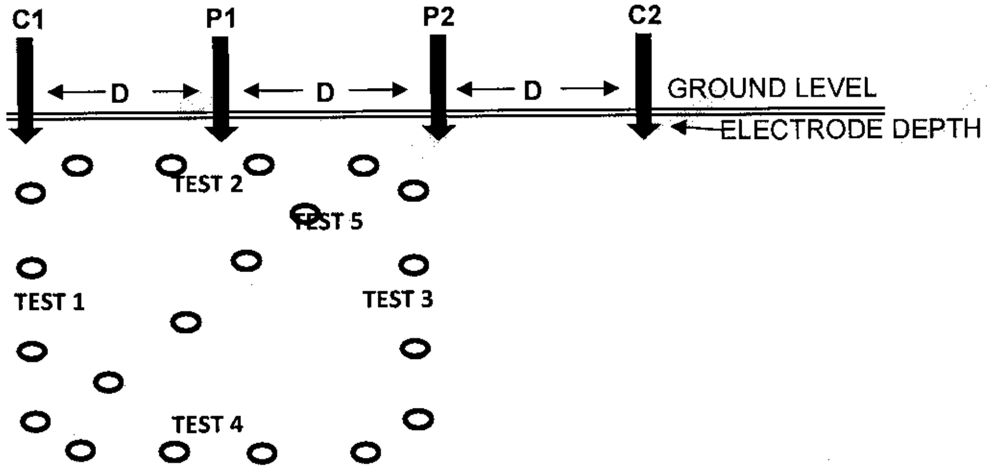
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR43	**TEMPERATURE:**		
DESCRIPTION:	lt Y Br dec Dol	**WEATHER COND:**	COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 04' 27.0"	E27° 54' 51.3"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	0.73	0.68	12.9
2	SE	3.0	15.0	0.55		
3	SW	3.0	15.0	0.65		
4	NW	3.0	15.0	0.77		
5	NE	3.0	15.0	0.71		

ADDITIONAL NOTES: ____________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: J Atterbury

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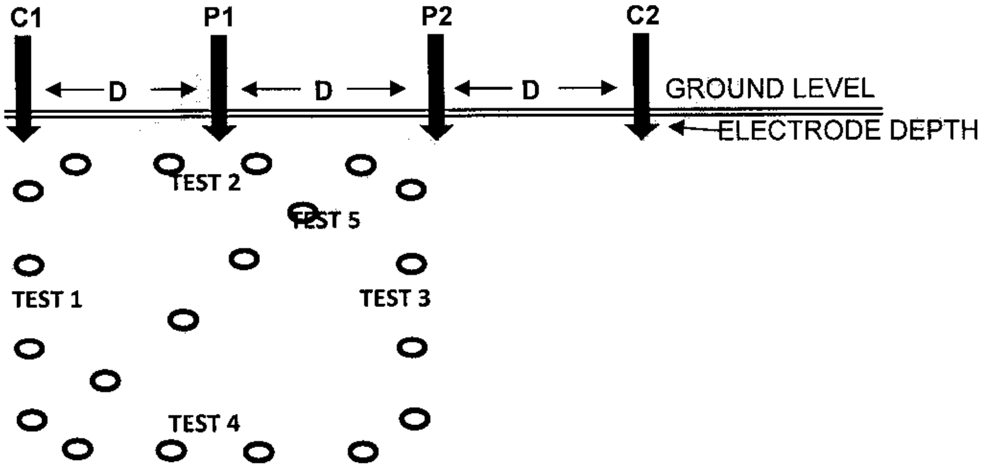
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR44	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 04' 33.5"	E27° 54' 56.8"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	5.58	6.61	124.6
2	SE	3.0	15.0	6.52		
3	SW	3.0	15.0	7.56		
4	NW	3.0	15.0	6.76		
5	NE	3.0	15.0	6.62		

ADDITIONAL NOTES: ______________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory
J Atterbury

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201000682907
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www.controlab.co.za

HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7859, Fax: 043 726 7426
CENTRAL LABORATORY : 10 St Pauls Road, East London, 5201, Tel: 043 722 5420 / 722 8565, Fax: 043 743 9942, P O Box 346, East London, 5200
OTHER BRANCH OFFICES: Cape Town, Kokstad, Johannesburg, Mthatha, Queenstown, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

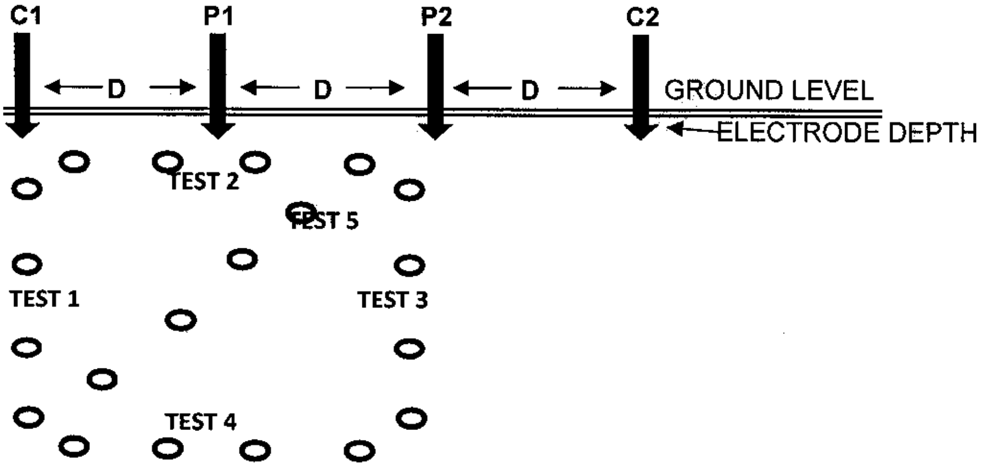
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-21
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR45	**TEMPERATURE:**	
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY COLD
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 04' 39.9" E27° 55' 02.7"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	4.77	5.33	100.4
2	SE	3.0	15.0	6.49		
3	SW	3.0	15.0	5.38		
4	NW	3.0	15.0	4.80		
5	NE	3.0	15.0	5.20		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
J Atterbury

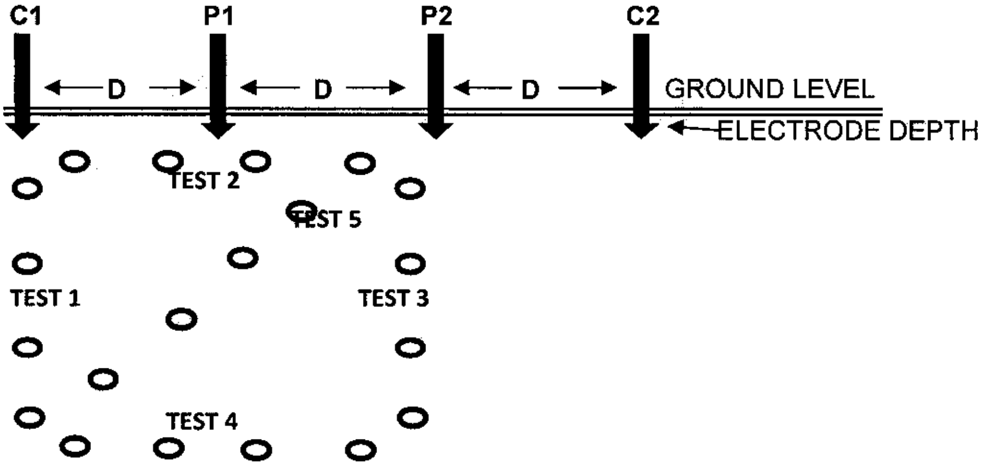
CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-21
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR46			TEMPERATURE:		
DESCRIPTION:	lt Br sty s			WEATHER COND:	VERY COLD	
SOIL CONDITION:	SLIGHTLY MOIST			GPS CO-ORD:	S32° 04' 46.2"	E27° 55' 08.5"
TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	1.00	1.00	18.9
2	SE	3.0	15.0	1.01		
3	SW	3.0	15.0	1.03		
4	NW	3.0	15.0	0.96		
5	NE	3.0	15.0	1.01		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
J Atterbury

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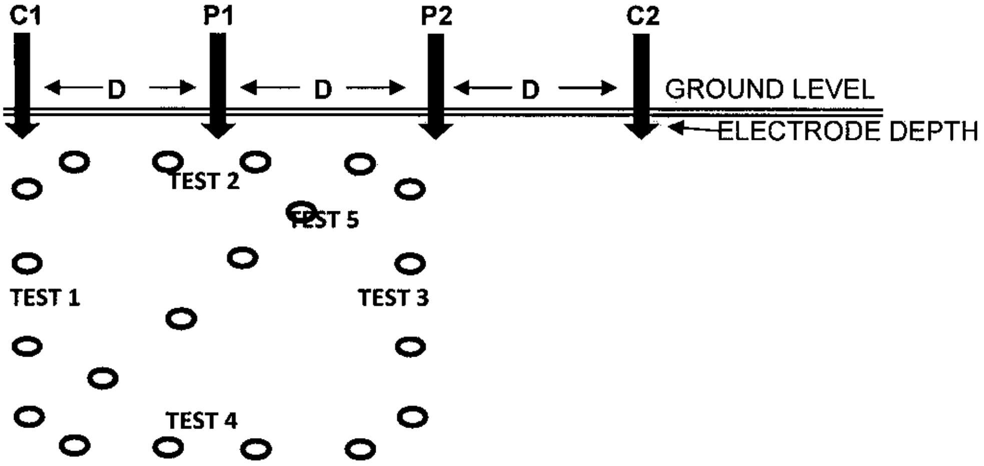
PROJECT: Ngqamakhwe RWSS:
Phase 5
DATE.: 2017-06-21
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR47	TEMPERATURE:		
DESCRIPTION:	lt Br dec Dol	WEATHER COND:	VERY COLD	
SOIL CONDITION:	SLIGHTLY MOIST	GPS CO-ORD:	S32° 04' 52.9"	E27° 55' 12.9"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	12.04	10.27	193.6
2	SE	3.0	15.0	10.00		
3	SW	3.0	15.0	9.00		
4	NW	3.0	15.0	11.06		
5	NE	3.0	15.0	9.26		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

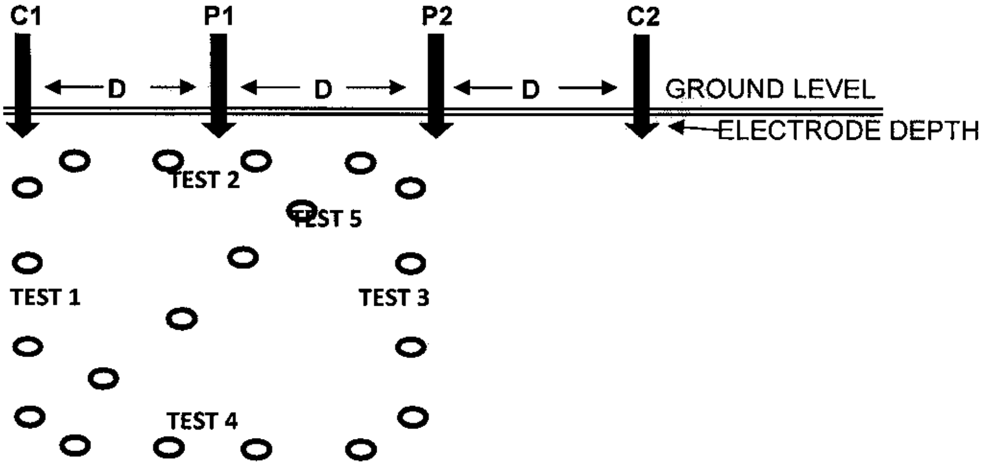
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-21
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR48	**TEMPERATURE:**		
DESCRIPTION:	lt Br dec Dol	**WEATHER COND:**	VERY COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 00.5"	E27° 55' 16.4"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	2.09	1.84	34.6
2	SE	3.0	15.0	1.88		
3	SW	3.0	15.0	1.77		
4	NW	3.0	15.0	2.01		
5	NE	3.0	15.0	1.44		

ADDITIONAL NOTES: ____________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: ____________
J Atterbury

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

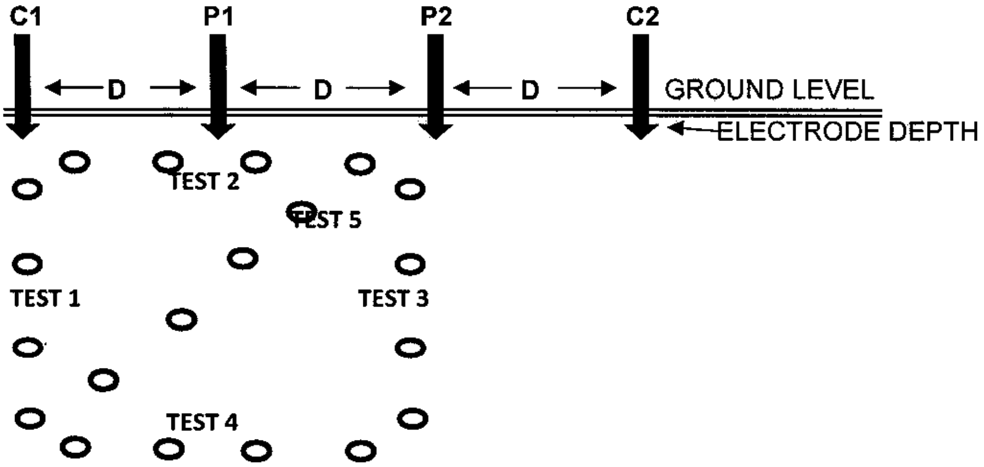
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-21
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR49	**TEMPERATURE:**	
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY COLD
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 08.0" E27° 55' 19.8"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	0.79	0.73	13.8
2	SE	3.0	15.0	0.79		
3	SW	3.0	15.0	0.68		
4	NW	3.0	15.0	0.61		
5	NE	3.0	15.0	0.78		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
J Atterbury

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PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

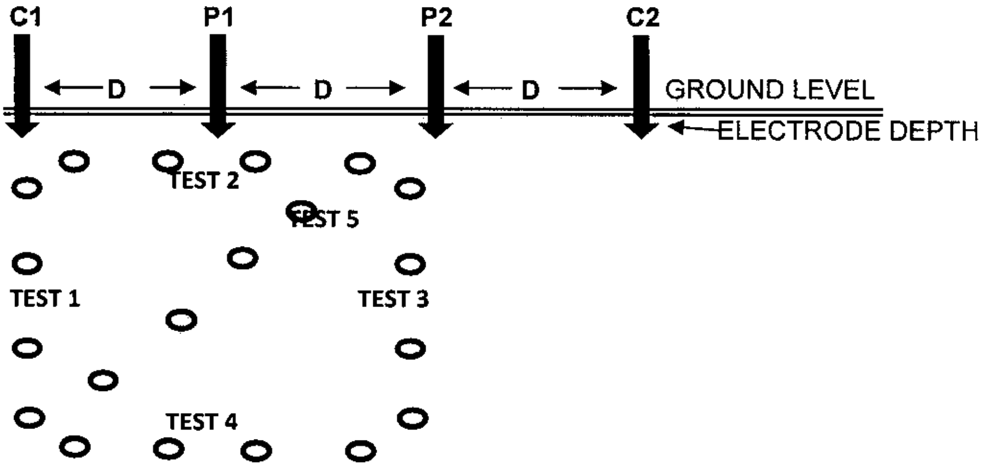
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-21
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR50	TEMPERATURE:	
DESCRIPTION:	lt Br sty s	WEATHER COND:	VERY COLD
SOIL CONDITION:	SLIGHTLY MOIST	GPS CO-ORD:	S32° 05' 15.4" E27° 55' 23.2"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	7.79	6.71	126.4
2	SE	3.0	15.0	6.44		
3	SW	3.0	15.0	5.84		
4	NW	3.0	15.0	6.12		
5	NE	3.0	15.0	7.35		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
J Attenbury

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CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

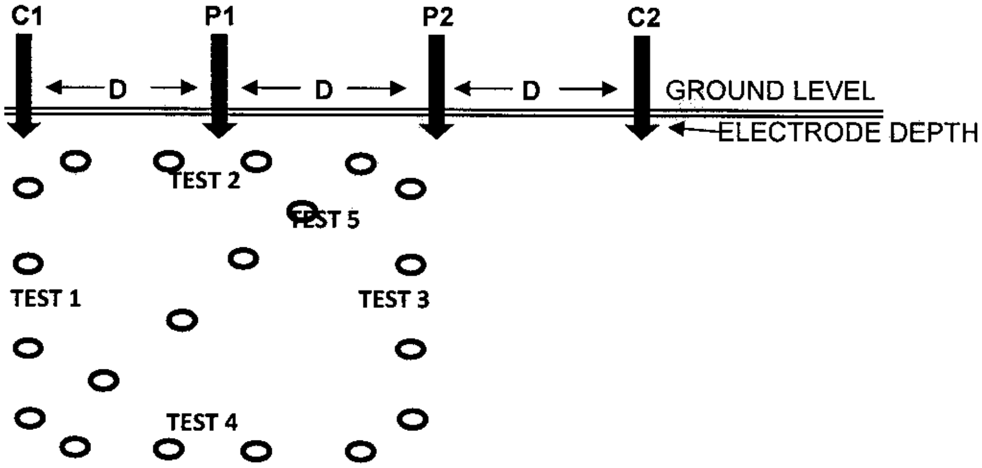
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-21
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR51	**TEMPERATURE:**		
DESCRIPTION:	P Ms	**WEATHER COND:**	VERY COLD	
SOIL CONDITION:	DRY	**GPS CO-ORD:**	S32° 05' 21.9"	E27° 55' 27.2"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0			
2	SE	3.0	15.0			
3	SW	3.0	15.0			
4	NW	3.0	15.0			
5	NE	3.0	15.0			

ADDITIONAL NOTES: (UTD) - PROBES UNABLE TO PENETRATE SURFACE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
J Atterbury

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OTHER BRANCH OFFICES: Cape Town, Kokstad, Johannesburg, Mthatha, Queenstown, Lusaka - Zambia

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PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

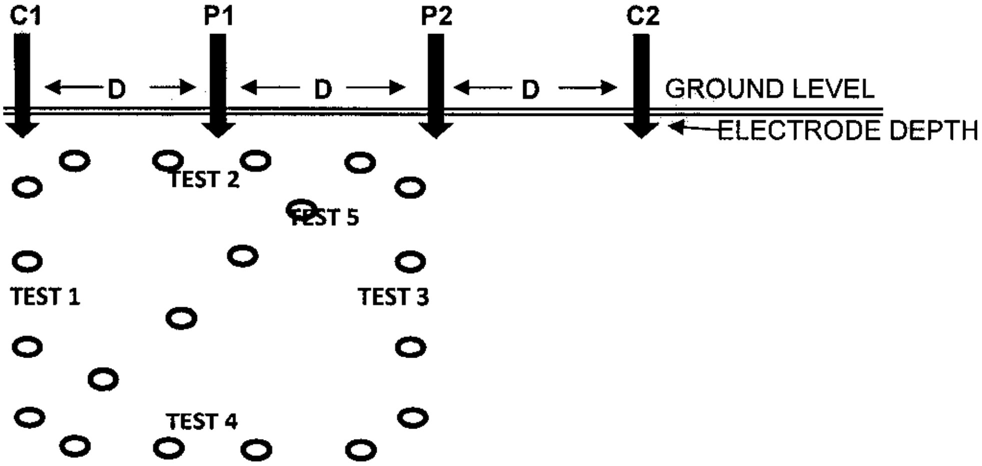
PROJECT: Ngqamakhwe RWSS:
Phase 5
DATE.: 21/06/2017
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR52	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 29.3"	E27° 55' 30.7"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	6.20	4.76	89.7
2	SE	3.0	15.0	4.30		
3	SW	3.0	15.0	3.44		
4	NW	3.0	15.0	4.10		
5	NE	3.0	15.0	5.76		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: ____________
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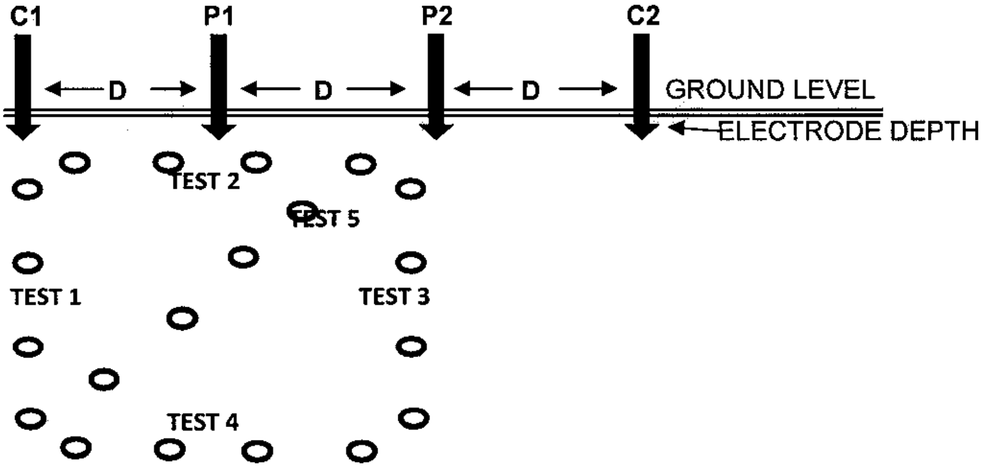
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-22
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR53	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 36.9"	E27° 55' 35.2"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	1.51	2.30	43.4
2	SE	3.0	15.0	2.00		
3	SW	3.0	15.0	2.00		
4	NW	3.0	15.0	3.00		
5	NE	3.0	15.0	3.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

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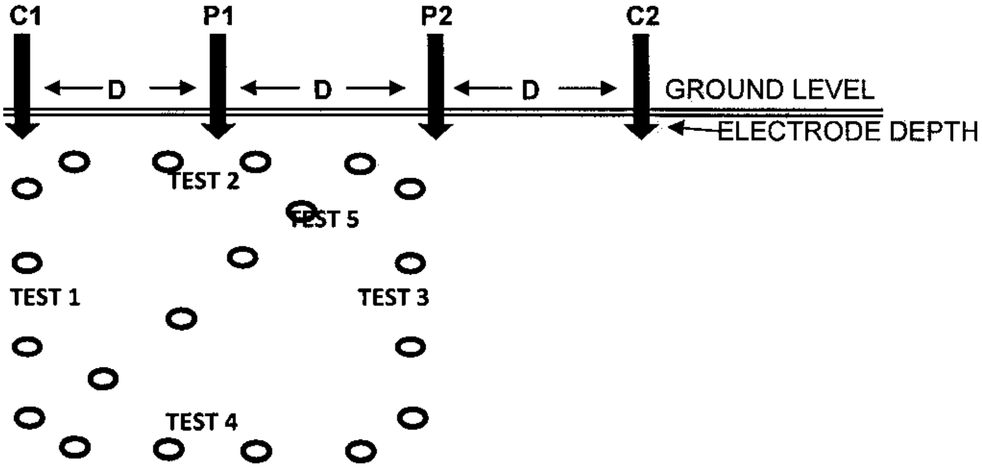
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR54	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY COLD	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 36.1"	E27° 55' 44.3"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	2.31	2.52	47.5
2	SE	3.0	15.0	2.69		
3	SW	3.0	15.0	2.43		
4	NW	3.0	15.0	2.65		
5	NE	3.0	15.0	2.51		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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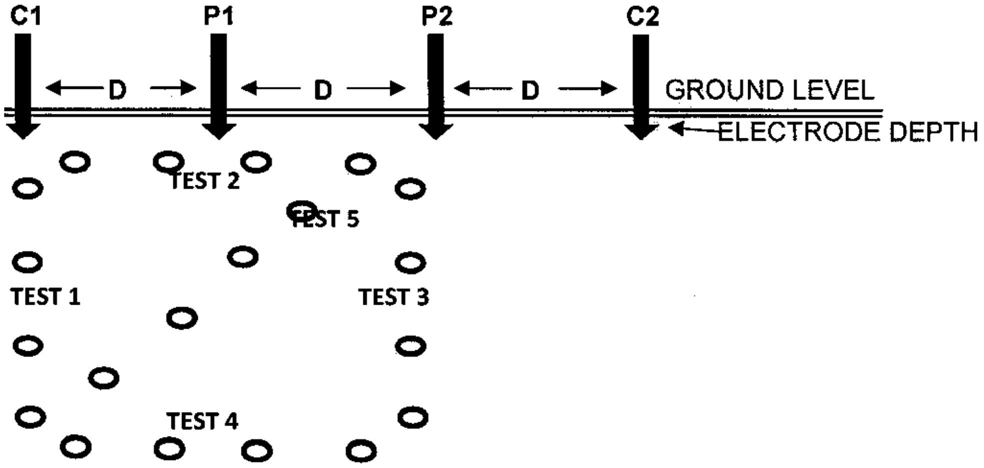
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR55	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY COLD/WINDY	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 34.7"	E27° 55' 54.0"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	3.73	3.83	72.1
2	SE	3.0	15.0	3.90		
3	SW	3.0	15.0	3.65		
4	NW	3.0	15.0	4.00		
5	NE	3.0	15.0	3.85		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010

SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
J Atterbury

ControLab South Africa (Pty) Ltd
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OTHER BRANCH OFFICES: Cape Town, Kokstad, Johannesburg, Mthatha, Queenstown, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

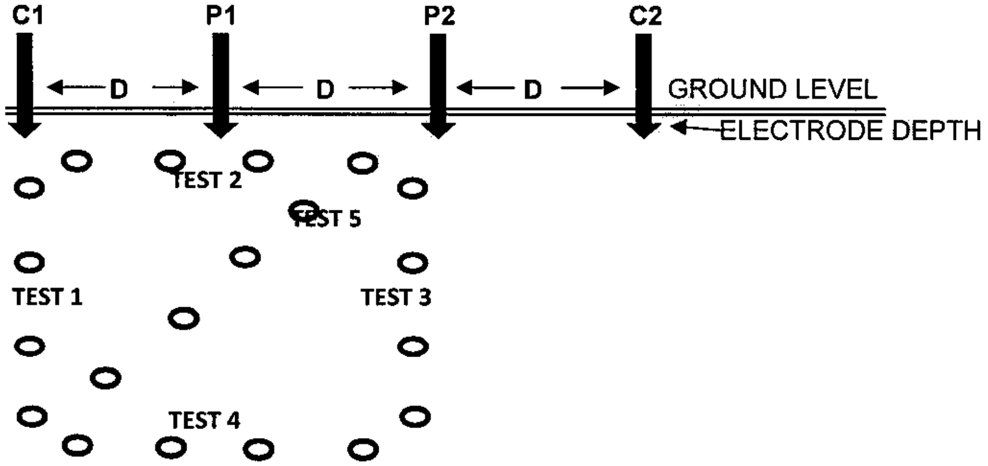
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 22/06/2017
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR56	**TEMPERATURE:**		
DESCRIPTION:	weath Ms	**WEATHER COND:**	VERY COLD/WINDY	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 31.7"	E27° 56' 02.4"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0			
2	SE	3.0	15.0			
3	SW	3.0	15.0			
4	NW	3.0	15.0			
5	NE	3.0	15.0			

ADDITIONAL NOTES: (UTD) - PROBES UNABLE TO PENETRATE THE SURFACE



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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5214
ATT : Mr D Luhring

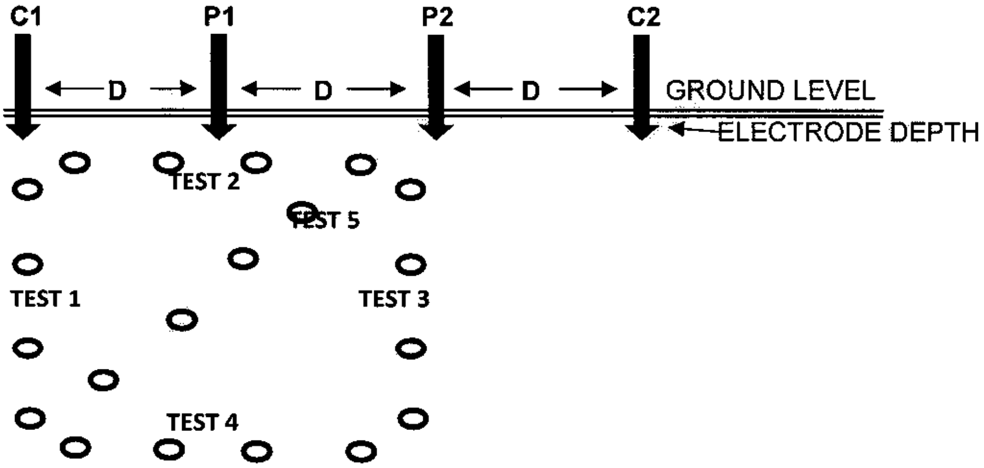
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-22
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR57	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY COLD/WINDY	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 26.9"	E27° 56' 09.6"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0	2.56	2.30	43.4
2	SW	3.0	15.0	2.16		
3	NE	3.0	15.0	2.10		
4	NW	3.0	15.0	1.90		
5	SE	3.0	15.0	2.78		

ADDITIONAL NOTES: ____________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: ____________
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OTHER BRANCH OFFICES: Cape Town, Kokstad, Johannesburg, Mthatha, Queenstown, Lusaka - Zambia

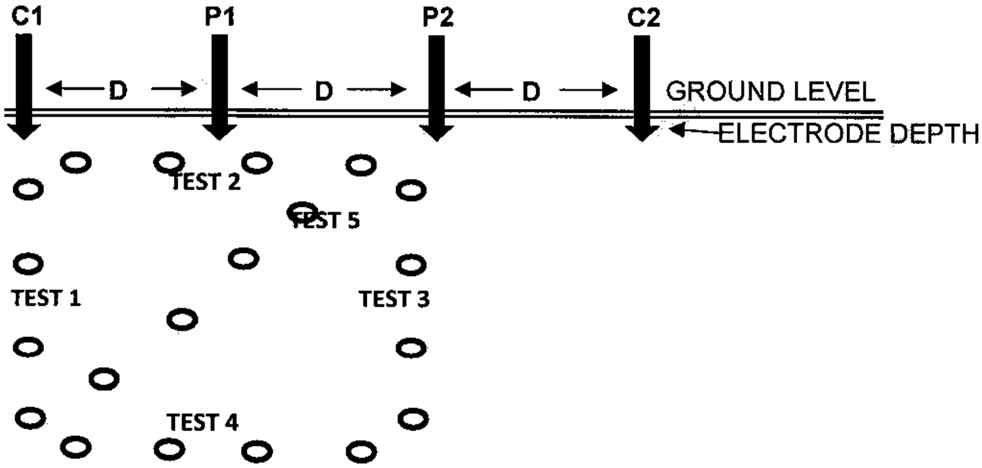
CLIENT:	Aurecon SA (Pty) Ltd PO Box 19553 TECOMA 5214	**PROJECT:**	Ngqamakhwe RWSS: Phase 5
		DATE.:	22/06/2017
		REF NO.:	MT32019
ATT :	Mr D Luhring	**INSTRUMENT S/N:**	DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR58	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s + Ms	**WEATHER COND:**	VERY COLD/WINDY	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 22.3"	E27° 56' 17.7"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0	34.00	32.20	607.0
2	SW	3.0	15.0	32.00		
3	NE	3.0	15.0	34.00		
4	NW	3.0	15.0	31.00		
5	SE	3.0	15.0	30.00		

ADDITIONAL NOTES: ______________________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: ____________
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ATT : Mr D Luhring

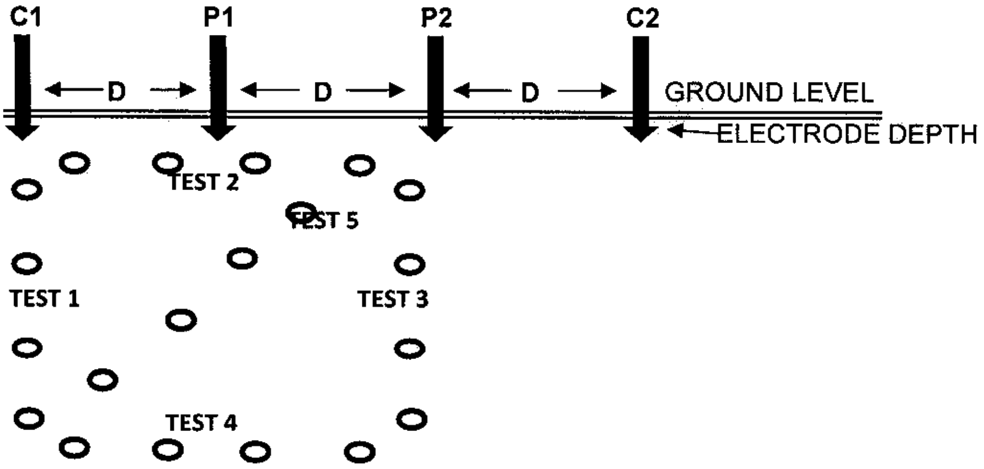
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-22
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR59	TEMPERATURE:	
DESCRIPTION:	lt Br sty s	WEATHER COND:	VERY COLD/WINDY
SOIL CONDITION:	SLIGHTLY MOIST	GPS CO-ORD:	S32° 05' 22.0" E27° 56' 27.0"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0	9.00	8.00	150.8
2	SW	3.0	15.0	7.00		
3	NE	3.0	15.0	9.00		
4	NW	3.0	15.0	8.00		
5	SE	3.0	15.0	7.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory
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PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

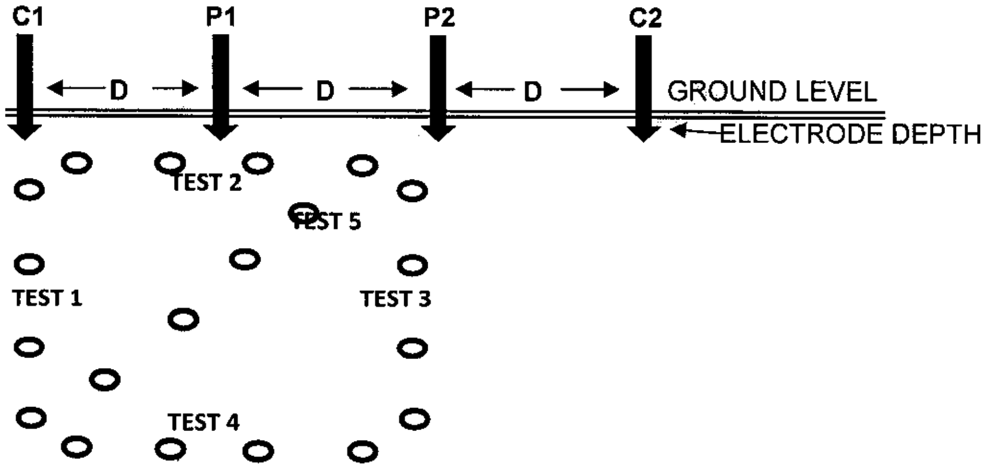
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-22
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR60	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY COLD/WINDY	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 21.9"	E27° 56' 36.9"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SE	3.0	15.0	7.00	6.40	120.6
2	SW	3.0	15.0	6.00		
3	NE	3.0	15.0	8.00		
4	NW	3.0	15.0	5.00		
5	SE	3.0	15.0	6.00		

ADDITIONAL NOTES: ____________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010

SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: ____________
J Atterbury

CLIENT: Aurecon SA (Pty) Ltd
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TECOMA
5214
ATT : Mr D Luhring

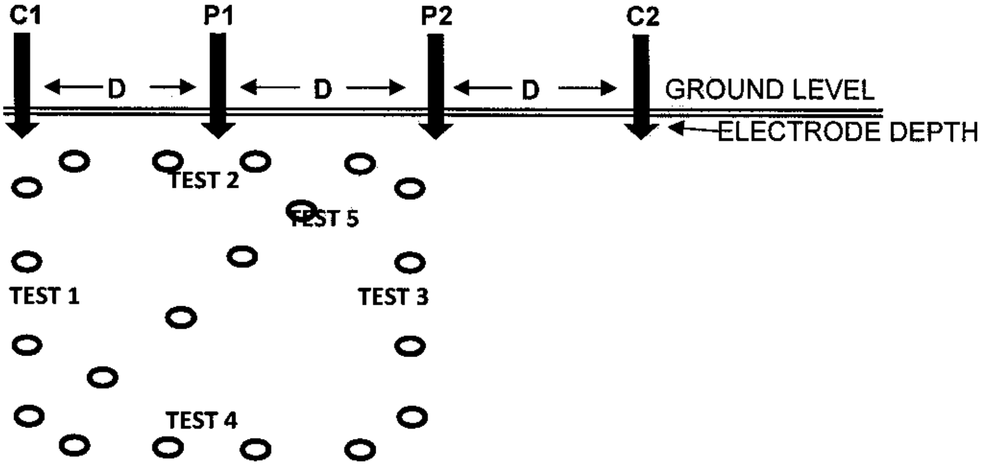
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-22
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR61	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY COLD/WINDY	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 17.5"	E27° 56' 43.1"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	3.05	3.02	56.9
2	SE	3.0	15.0	3.00		
3	SW	3.0	15.0	3.20		
4	NW	3.0	15.0	3.10		
5	NE	3.0	15.0	2.75		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
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GEOTECHNICAL AND ENVIRONMENTAL SERVICES
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CENTRAL LABORATORY : 10 St Pauls Road, East London, 5201, Tel: 043 722 5420 / 722 8565, Fax: 043 743 9942, P O Box 346, East London, 5200
OTHER BRANCH OFFICES: Cape Town, Kokstad, Johannesburg, Mthatha, Queenstown, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

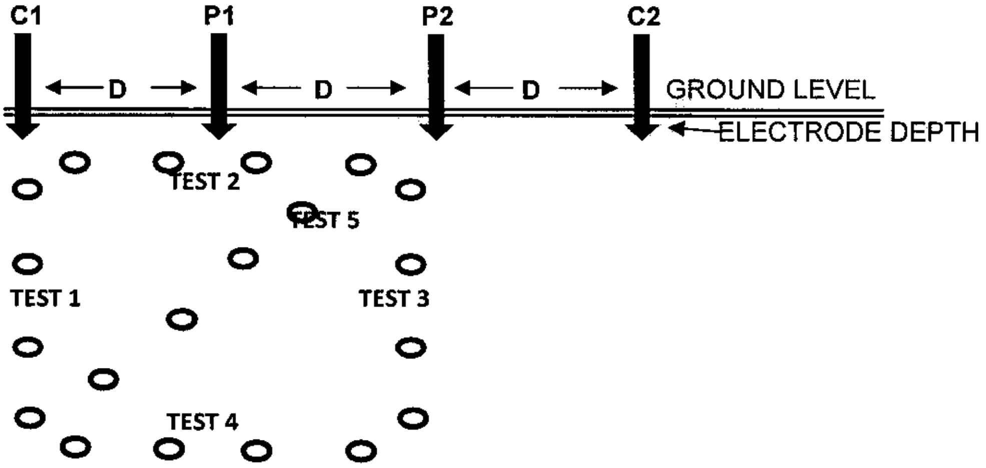
PROJECT: Ngqamakhwe RWSS:
Phase 5
DATE.: 2017-06-22
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR62	**TEMPERATURE:**	
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY COLD/WINDY
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 10.7" E27° 56' 47.8"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	7.00	6.80	128.2
2	SE	3.0	15.0	6.00		
3	SW	3.0	15.0	9.00		
4	NW	3.0	15.0	5.00		
5	NE	3.0	15.0	7.00		

ADDITIONAL NOTES: ____________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
J Atterbury

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OTHER BRANCH OFFICES: Cape Town, Kokstad, Johannesburg, Mthatha, Queenstown, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
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TECOMA
5214
ATT : Mr D Luhring

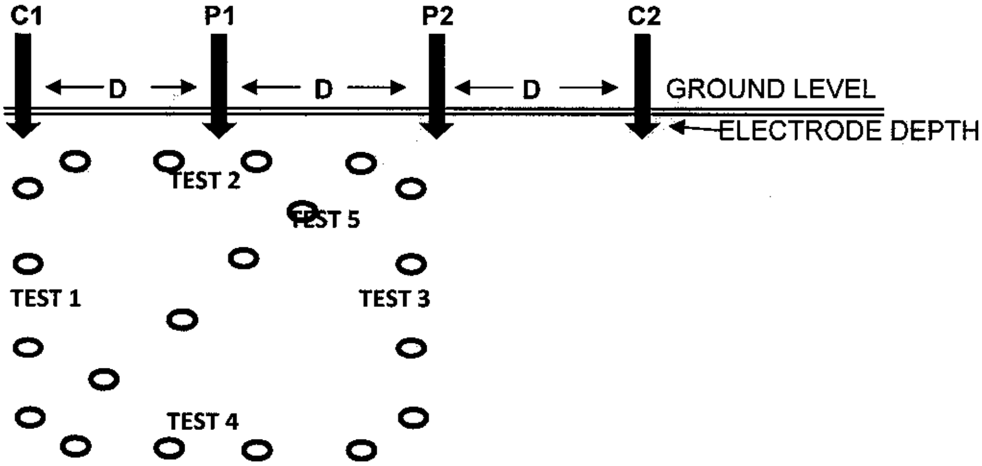
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-22
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR63	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY COLD/WINDY	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 03.6"	E27° 56' 52.4"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	10.00	10.80	203.6
2	SE	3.0	15.0	11.00		
3	SW	3.0	15.0	10.00		
4	NW	3.0	15.0	12.00		
5	NE	3.0	15.0	11.00		

ADDITIONAL NOTES: ______________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: ____________
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ATT : Mr D Luhring

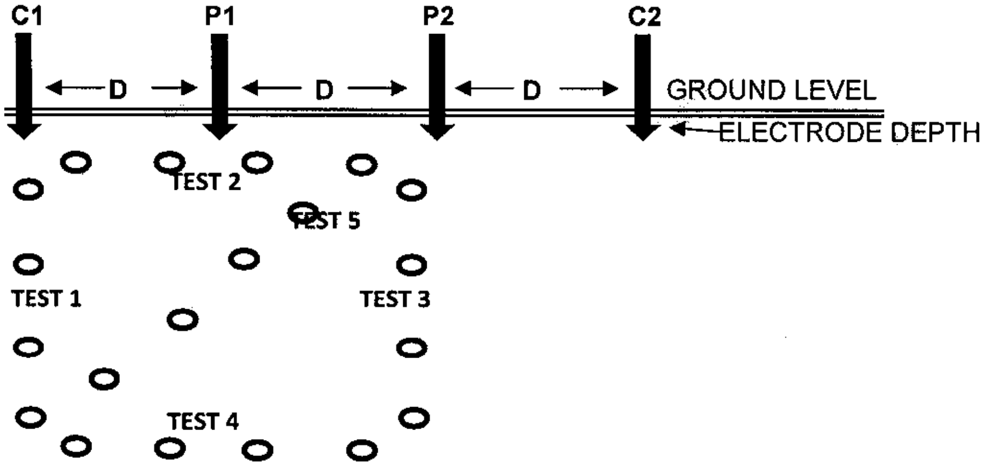
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-22
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR64	TEMPERATURE:		
DESCRIPTION:	lt Br sty s	WEATHER COND:	VERY COLD/WINDY	
SOIL CONDITION:	SLIGHTLY MOIST	GPS CO-ORD:	S32° 04' 57.8"	E27° 56' 56.3"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	NE	3.0	15.0	9.00	8.40	158.3
2	SE	3.0	15.0	9.00		
3	SW	3.0	15.0	7.00		
4	NW	3.0	15.0	8.00		
5	NE	3.0	15.0	9.00		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

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5214
ATT : Mr D Luhring

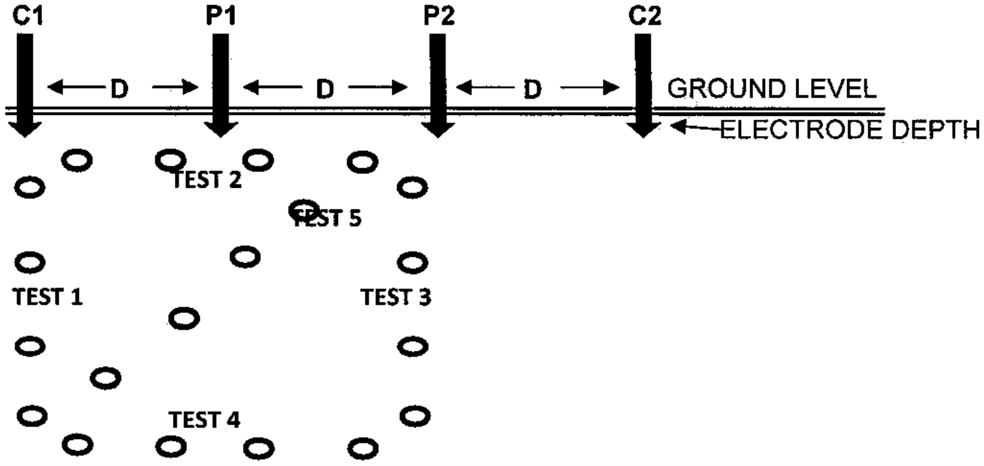
PROJECT: Ngqamakhwe RWSS:
Phase 5
DATE.: 2017-06-22
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR65	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY COLD/WINDY	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 37.2"	E27° 56' 03.4"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SW	3.0	15.0	5.76	4.63	87.3
2	NW	3.0	15.0	4.00		
3	NE	3.0	15.0	3.65		
4	SE	3.0	15.0	5.00		
5	SW	3.0	15.0	4.75		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

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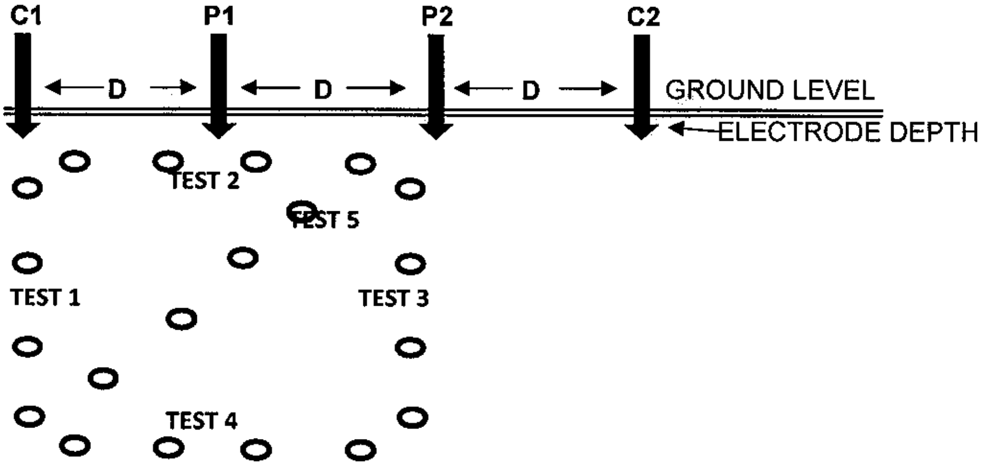
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR66	TEMPERATURE:		
DESCRIPTION:	lt Br sty s	WEATHER COND:	VERY COLD/WINDY	
SOIL CONDITION:	SLIGHTLY MOIST	GPS CO-ORD:	S32° 05' 44.8"	E27° 56' 03.6"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SW	3.0	15.0	2.79	2.87	54.1
2	NW	3.0	15.0	3.10		
3	NE	3.0	15.0	2.98		
4	SE	3.0	15.0	2.00		
5	SW	3.0	15.0	3.47		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
J Atterbury

ControLab South Africa (Pty) Ltd
CIVIL ENGINEERING MATERIAL AND GEOTECHNICAL LABORATORY,
GEOTECHNICAL AND ENVIRONMENTAL SERVICES
201000682907
www.controlab.co.za

HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7859, Fax: 043 726 7426
CENTRAL LABORATORY : 10 St Pauls Road, East London, 5201, Tel: 043 722 5420 / 722 8565, Fax: 043 743 9942, P O Box 346, East London, 5200
OTHER BRANCH OFFICES: Cape Town, Kokstad, Johannesburg, Mthatha, Queenstown, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

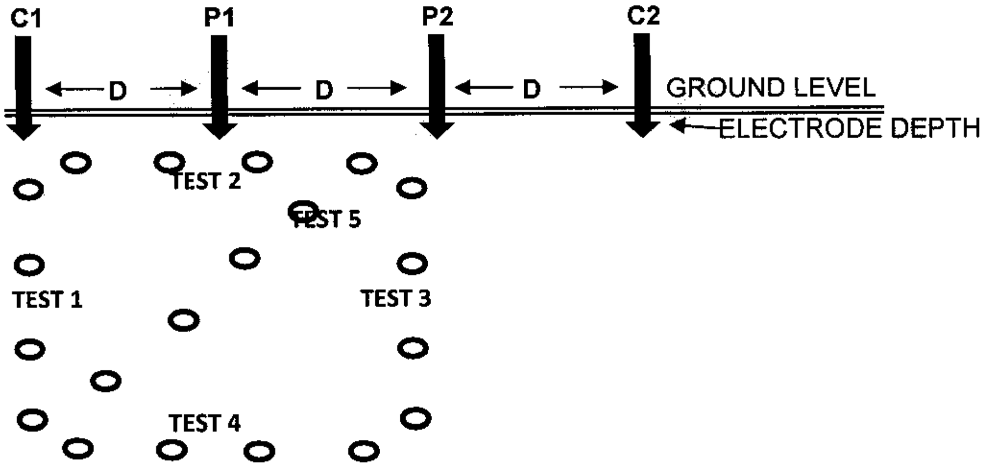
PROJECT: Ngqamakhwe RWSS: Phase 5
DATE.: 2017-06-22
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR67	**TEMPERATURE:**		
DESCRIPTION:	lt Br sty s	**WEATHER COND:**	VERY COLD/WINDY	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 52.7"	E27° 56' 03.8"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SW	3.0	15.0	4.26	3.85	72.6
2	NW	3.0	15.0	3.78		
3	NE	3.0	15.0	3.95		
4	SE	3.0	15.0	4.00		
5	SW	3.0	15.0	3,26		

ADDITIONAL NOTES: ______________________



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010

SOIL RESISTIVITY (Ω/m)	CORROSIVENESS
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory: ______
J Atterbury

CLIENT: Aurecon SA (Pty) Ltd
PO Box 19553
TECOMA
5214
ATT : Mr D Luhring

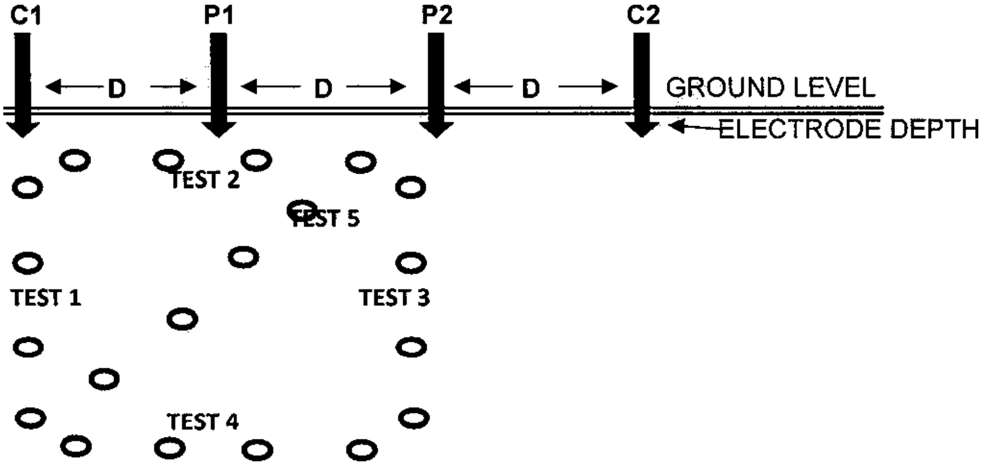
PROJECT: Ngqamakhwe RWSS:
Phase 5
DATE.: 2017-06-22
REF NO.: MT32019
INSTRUMENT S/N: DET4TC2

Determination of Soil Resistivity

TEST POSITION	SR68	**TEMPERATURE:**		
DESCRIPTION:	It Br sty s	**WEATHER COND:**	VERY COLD/WINDY	
SOIL CONDITION:	SLIGHTLY MOIST	**GPS CO-ORD:**	S32° 05' 32.2"	E27° 56' 12.9"

TEST NO.:	DIRECTION:	DISTANCE BETWEEN ELECTRODES (m)	ELECTRODE DEPTH (cm)	RESISTANCE READING (Ω)	AVERAGE RESISTANCE READING (Ω)	APPARENT SOIL RESISTIVITY (Ω/m)
1	SW	3.0	15.0	5.00	4.11	77.4
2	NW	3.0	15.0	3.62		
3	NE	3.0	15.0	3.82		
4	SE	3.0	15.0	5.00		
5	SW	3.0	15.0	3.10		

ADDITIONAL NOTES:



RELATIONSHIP BETWEEN SOIL RESISTIVITY AND CORROSIVENESS: AS PER SANS 10199:2010	
SOIL RESISTIVITY (Ω/m)	**CORROSIVENESS**
0 - 10	VERY SEVERE
10 - 100	MODERATE TO SEVERE
100 - 1000	MILD (IF AERATED)
> 1000	PROBABLY NOT CORROSIVE

Technical Signatory:
J Atterbury

PART C4.2: HERITAGE INVESTIGATION REPORT

Phase 1 Archaeological & Cultural Heritage Impact Assessment –

Ngqamakwe Phase 5 Water Supply Project, near Tsomo, Chris Hani and Amathole District Municipalities, Eastern Cape

- 23 May 2017 -

Report to:

Sello Mokhanya (Eastern Cape Provincial Heritage Resources Agency – EC PHRA, APM Unit)
E-mail: smokhanya@ecphra.org.za; Tel: 043 745 0888; Postal Address: N/A

Brendon Steytler (Indwe Environmental Consulting)
E-mail: brendon@indwecon.co.za; Tel: 043 721 2344; Postal Address: P.O. Box 19829, Tecoma, East London, 5214

Prepared by:

Karen van Ryneveld (ArchaeoMaps)
E-mail: karen@archaeomaps.co.za; Tel: 084 871 1064; Postal Address: Postnet Suite 239, Private Bag X3, Beacon Bay, 5205

Specialist Declaration of Interest

I, Karen van Ryneveld (Company – ArchaeoMaps; Qualification – MSc Archaeology), declare that:

- I am suitably qualified and accredited to act as independent specialist in this application;
- I do not have any financial or personal interest in the application, its' proponent or subsidiaries, aside from fair remuneration for specialist services rendered; and
- That work conducted have been done in an objective manner – and that any circumstances that may have compromised objectivity have been reported on transparently.

Signature – **- 23 May 2017 -**

Ngqamakwe Phase 5 Water Supply Project, near Tsomo, Chris Hani and Amathole District Municipalities, Eastern Cape

Executive Summary

Project Description –

Indwe Environmental have been appointed as independent Environmental Assessment Practitioner (EAP) by the project proponent to apply for Environmental Authorization (EA), including a Basic Assessment Report (BAR) and Environmental Management Plan (EMPr) to the Eastern Cape Department of Economic Development, Environmental Affairs and Tourism (DEDEAT) for the proposed *Ngqamakwe Phase 5 Water Supply Project*, near Tsomo, Eastern Cape. The proposed development is situated at general development co-ordinate S32°02'43.7"; E27°51'04.3 (Nxaybisa Village) and comprises an approximate 20km water pipeline development.

The Phase 1 Archaeological & Cultural Heritage Impact Assessment –

Project Name & Locality: *Ngqamakwe Phase 5 Water Supply Project*, near Tsomo, Chris Hani and Amathole District Municipalities, Eastern Cape [1:50,000 Map Ref – 3227BB].

Summary of Findings:

Seventeen (17) newly identified and one (1) known heritage site, totalling eighteen (18) heritage sites are situated within the approximate 50-100m survey corridor of the proposed *Ngqamakwe Phase 5 Water Supply Project*. Identified heritage sites comprise primarily Later Iron Age (LIA) grave and informal cemetery sites. Realignment of the line route is not recommended; realignment may well simply result in a new set of heritage sites to me managed during development in the heritage rich area. Recommended temporary conservation measures are based on temporary fencing and signage during the construction phase. All temporary conservation measures should be removed upon completion of construction. Development in the vicinity of unfenced, informal graves or cemeteries should not encroach within 10m from the burial places.

- The proposed development poses no 'fatal flaws' with reference to archaeological and cultural heritage resources.
- The development will have a limited negative visual and cumulative impact on the cultural landscape during the construction phase and no negative visual and cumulative impact during the operational phase.
- It is recommended that a heritage specialist / ECO report on heritage compliance to the EC PHRA during the construction phase of the development.
- [In the event of any incidental archaeological and cultural heritage resources, as defined and protected by the NHRA 1999, being identified during the course of development the process described in '*Appendix B: Heritage Protocol for Incidental Finds during the Construction Phase*' should be followed.]

Heritage Compliance Summary –
Ngqamakwe Phase 5 Water Supply Project, near Tsomo,
Chris Hani and Amathole District Municipalities, Eastern Cape

Map Code	Site	Co-ordinates	Recommendations
Ngqamakwe Phase 5 Water Supply Project			
Site NGQ27	Later Iron Age – Grave	S32°02'38.7"; E27°50'09.3"	Temporary heritage conservation fencing and signage
Site NGQ28	Later Iron Age – Livestock enclosure	S32°02'53.3"; E27°50'34.6"	Temporary heritage conservation fencing and signage
Site NGQ29	Later Iron Age – Cemetery	S32°02'47.8"; E27°50'41.6"	Temporary heritage conservation fencing and signage
Site NGQ30	Later Iron Age – Grave	S32°02'45.7"; E27°50'57.5"	Temporary heritage conservation fencing and signage
Site NGQ31	Later Iron Age – Grave	S32°02'46.8"; E27°51'07.6"	Temporary heritage signage
Site NGQ32	Later Iron Age – Cemetery	S32°02'51.9"; E27°51'12.2"	Temporary heritage conservation fencing and signage
Site NGQ33	Later Iron Age – Graves	S32°02'56.3"; E27°51'18.4"	Temporary heritage conservation fencing and signage
Site NGQ34	Later Iron Age – Homestead remains	S32°02'54.0"; E27°51'18.7"	Temporary heritage signage
Site NGQ35	Later Iron Age – Grave	S32°03'02.1"; E27°51'19.2"	Temporary heritage signage
Site NGQ36	Later Iron Age – Graves	S32°02'40.8"; E27°50'44.2"	Temporary heritage conservation fencing and signage
Site NGQ37	Colonial Period – Residence	S32°02'38.5"; E27°50'52.8"	Temporary heritage conservation fencing and signage
Site NGQ38	Later Iron Age – Cemetery	S32°02'41.2"; E27°51'29.8"	Temporary heritage signage
Site NGQ39	Later Iron Age – Cemetery	S32°02'40.2"; E27°51'30.3"	Temporary heritage conservation fencing and signage
Site NGQ40	Later Iron Age – Homestead remains	S32°02'42.1"; E27°51'33.0"	Temporary heritage signage
Site NGQ41	Later Iron Age – Homestead remains	S32°03'42.7"; E27°53'58.2"	Temporary heritage signage
Site NGQ42	Later Iron Age – Grave	S32°03'55.4"; E27°54'26.2"	Temporary heritage signage
Site NGQ43	Later Iron Age – Grave	S32°03'55.4"; E27°54'26.8"	Temporary heritage signage
Site NGQ04	Later Iron Age – Grave	S32°04'01.1"; E27°54'26.3"	Temporary heritage conservation fencing and signage

Recommendations –

With reference to archaeological and cultural heritage compliance, as per the requirements of the NHRA 1999, it is recommended that the proposed *Ngqamakwe Phase 5 Water Supply Project*, near Tsomo, Chris Hani and Amathole District Municipalities, Eastern Cape, proceed as applied for, provided the developer comply with the above listed heritage recommendations.

The EC PHRA-APM Unit HIA Comment will state legal requirements for development to proceed, or reasons why, from a heritage perspective, development may not be further considered.

CONTENTS

Appendix A:
Schematic Outline of the Pre-colonial and Colonial Periods in South Arica

Appendix B:
Heritage Protocol for Incidental Finds during the Construction Phase

Appendix C:
Resumé: Karen van Ryneveld

List of Maps

List of Plates

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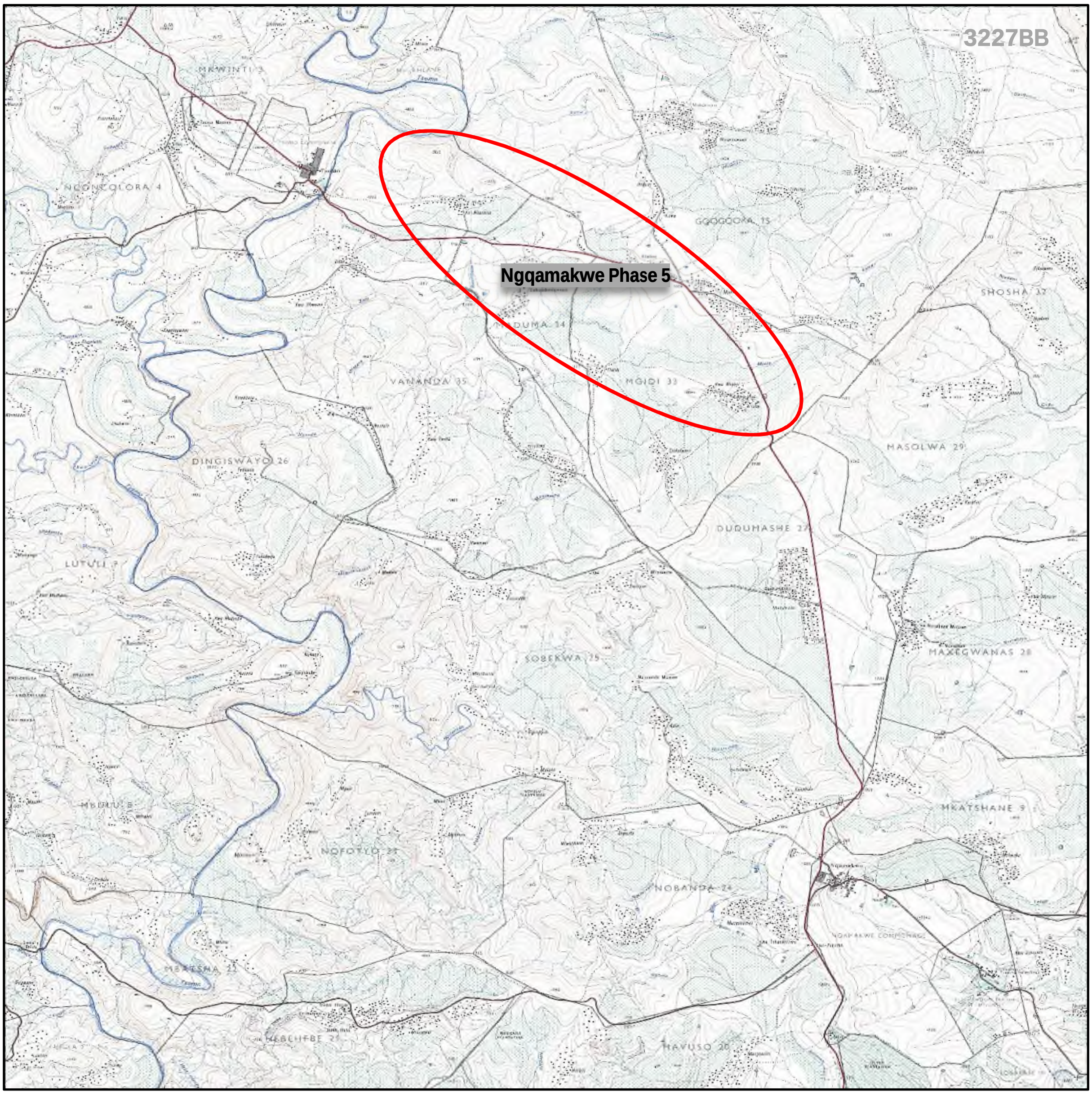
1 – Project Description & Terms of Reference

Indwe Environmental have been appointed as independent Environmental Assessment Practitioner (EAP) by the project proponent to apply for Environmental Authorization (EA), including a Basic Assessment Report (BAR) and Environmental Management Plan (EMPr) to the Eastern Cape Department of Economic Development, Environmental Affairs and Tourism (DEDEAT) for the proposed *Ngqamakwe Phase 5 Water Supply Project*, near Tsomo, Eastern Cape. The proposed development is situated at general development co-ordinate S32°02'43.7"; E27°51'04.3 (Nxaybisa Village) and comprises an approximate 20km water pipeline development.

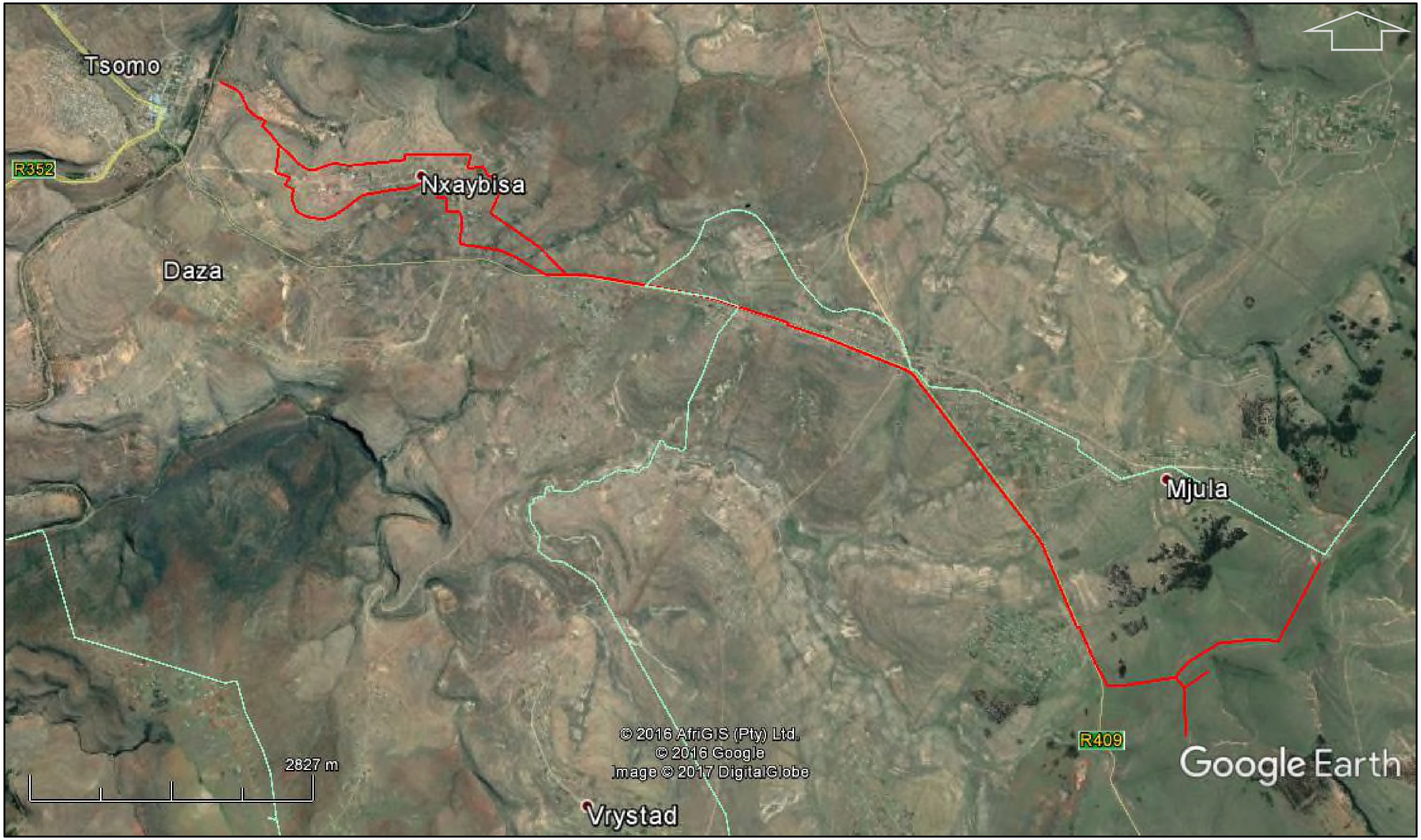
ArchaeoMaps have been appointed by Indwe Environmental to compile the Phase 1 Archaeological & Cultural Heritage Impact Assessment (AIA) for the development, as specialist component to the application's Heritage Impact Assessment (HIA), and with findings and recommendations thereof to be included in the BAR and EMPr. Terms of Reference (ToR) for the Phase 1 AIA are summarized as:

- Describe the existing area to be directly affected by the proposal in terms of its archaeological and cultural heritage characteristics as formally protected by the National Heritage Resources Act, No 25 of 1999 (NHRA 1999) and the general sensitivity of these components to change;
- Describe the likely scope, scale and significance of impacts (positive and negative) on the archaeological and cultural heritage resources of the area associated with the 1) construction and 2) operation or use phases of the proposal;
- Make recommendations on the scope of any mitigation measures that may be applied during the 1) construction and 2) operation or use phases to reduce / avoid the significance of identified related impacts. Mitigation measures could be design recommendations as well as operational controls, monitoring programmes, Phase 2 mitigation, management procedures and the like;
- Broadly describe the implication of a 'No-Go' option;
- Broadly comment on the cumulative impact (positive or negative) on archaeological or cultural heritage resources associated with the 1) construction and 2) operation or use phases of the proposal; and
- Confirm if there are any outright 'fatal flaws' to the proposal at its current location from an archaeological and cultural heritage perspective.

Map 1: General locality of the *Ngqamakwe Phase 5 Water Supply Project*, near Tsomo, Chris Hani and Amathole District Municipalities (Base Map – MapStudio, 2008)



Map 2: Locality of the *Ngqamakwe Phase 5 Water Supply Project,* near Tsomo, Chris Hani and Amathole District Municipalities, Eastern Cape [1: 50,000 Map Ref – 3227BB]



Map 3: The *Ngqamakwe Phase 5 Water Supply Project* (red line), near Tsomo, Chris Hani and Amahole District Municipalities, Eastern Cape

2.1.1) Archaeological & Cultural Heritage Legislative Compliance

The Phase 1 Archaeological & Cultural Heritage Impact Assessment (AIA) for the *Ngqamakwe Phase 5 Water Supply Project,* near Tsomo, Chris Hani and Amathole District Municipalities, Eastern Cape, was requested to meet the Eastern Cape Provincial Heritage Resources Authority's (EC PHRA) requirements with reference to archaeological and basic cultural heritage resources in terms of the National Heritage Resources Act, No 25 of 1999 (NHRA 1999), with specific reference to Section 38(1)(a). This report is submitted in (partial) fulfilment of the NHRA 1999, Section 38(3) requirements, for purposes of a NHRA 1999, Section 38(4) / Section 38(8) Heritage Impact Assessment (HIA) Comment by the EC PHRA.

NHRA 1999, Section 38

1) Subject to the provisions of subsections 7), 8) and 9), any person who intends to undertake a development categorized as –
    - **a) The construction of a road, wall, powerline, pipeline, canal or other similar form of linear development or barrier exceeding 300m in length;**
    - b) The construction of a bridge or similar structure exceeding 50m in length;
    - c) Any development or other activity which will change the character of a site –
        - i. Exceeding 5,000m^2 in extent; or
        - ii. Involving three or more existing erven or subdivisions thereof; or
        - iii. Involving three or more erven or subdivisions thereof which have been consolidated within the past five years; or
        - iv. The costs which will exceed a sum set in terms of regulations by SAHRA or a provincial heritage resources authority;
    - d) The rezoning of a site exceeding 10,000m^2 in extent;
    - e) Any other category of development provided for in regulations by SAHRA or a provincial heritage resources authority,

    Must at the very earliest stages of initiating such a development, notify the responsible heritage resources authority and furnish it with details regarding the location, nature and extent of the proposed development.

Table 1: Extract from the NHRA 1999, Section 38

The Phase 1 AIA aimed to locate, identify and assess the significance of archaeological and cultural heritage resources, inclusive of archaeological deposits / sites (Stone Age, Iron Age and Colonial Period), rock art and shipwreck sites, built structures older than 60 years, sites of military history older than 75 years, certain categories of burial grounds and graves, graves of victims of conflict, basic living heritage and cultural landscapes and viewscapes as defined and protected by the NHRA 1999, Section 2, that may be affected by the development.

This report comprises a Phase 1 AIA, including a basic pre-feasibility study and field assessment only. The report was prepared in accordance with the 'Minimum Standards' specifications for Phase 1 AIA reports, as stipulated by SAHRA (2007).

Additional relevant legislation pertaining to the Phase 1 AIA is listed as:

- National Environmental Management Act, No 107 of 1998 (NEMA 1998) and associated Regulations (2014).

2.1.2) Methodology & Gap Analysis

The Phase 1 AIA includes a basic pre-feasibility study and field assessment:

- The pre-feasibility assessment is based on the Appendix A schematic outline of South Africa's Pre-colonial and Colonial past, associated with introductory archaeological as well as general and scientific literature available and relevant to the study site. Databases consulted include the SAHRA 2009 Mapping Project Database (MPD), the South African Heritage Resources Information System (SAHRIS) and SAHRA database(s) on declared Provincial Heritage Sites (PHS) pertaining to the study site. The study excludes consultation of museum and university databases.

- The field assessment was done over a 1 day period (2017-05-17) with fieldwork conducted by the author. The assessment was done by vehicle and foot and limited to a Phase 1 surface survey. GPS co-ordinates were taken with Garmin Montana 650 (Datum: WGS84) Photographic documentation was done with a Canon EOS 1300D camera. A combination of Garmap (Base Camp) and Google Earth software was used in the display of spatial information.

The Phase 1 AIA was done according to the system and 'Minimum Standards' prescribed for the 3-tiered Phase 1-3 Heritage Impact Assessment (HIA) process (SAHRA 2007):

- Phase 1 HIA – A Phase 1 HIA is compulsory for development types as stipulated in the NHRA 1999, Section 38(1) and Section 38(8), including any other development type or study site as required by the South African Heritage Resources Agency (SAHRA) or relevant Provincial Heritage Resources Authority (PHRA). A Phase 1 HIA comprises at minimum of an archaeological (AIA) and palaeontological (PIA) study, but aims to address all heritage types protected by the NHRA 1999 and to alert developers to additional heritage specialist study requirements, if and where relevant to a development. Phase 1 HIA studies focusses on pre-feasibility and desktop studies, routinely coined with field assessments in order to locate, describe and assign heritage site significance ratings to identified resources that may be impacted by development. The aim of a Phase 1 AIA is to make site specific and general development recommendations regarding identified heritage resources for development planning and implementation purposes and may include recommendations for conservation, heritage site declaration, monitoring, Phase 2 mitigation (excavation), or destruction.

- Phase 2 HIA – Phase 2 HIAs are as a norm required where heritage resources of such significance have been identified during the Phase 1 HIA that mitigation (excavation) thereof is necessary for development purposes. Aside from large scale Phase 2 mitigation (routinely to precede development impact), lower keyed Phase 2 requirements may well include sampling, testing and monitoring during the construction or implementation phase of a development. Phase 2 HIA work is as a norm done under a compulsory heritage permit.

- Phase 3 HIA – As an extension to Phase 2 HIA work or cases where recommendations for heritage declaration formed part of a development's heritage compliance requirements, heritage resources of such scientific or heritage tourism significance, that their long-term conservation and continued research would be necessary within a development framework is proposed as a Phase 3 HIA.

Archaeological and cultural heritage site significance assessment and associated mitigation recommendations are done according to the combined NHRA 1999, Section 7(1) and SAHRA (2007) system.

SAHRA Archaeological & Cultural Heritage Site Significance System			
Site Significance	**Field Rating**	**Grade**	**Recommended Mitigation**
High Significance	National Significance	Grade I	Heritage site conservation / Heritage site development
High Significance	Provincial Significance	Grade II	Heritage site conservation / Heritage site development
High Significance	Local Significance	Grade III-A	Heritage site conservation or extensive mitigation prior to development / destruction
High Significance	Local Significance	Grade III-B	Heritage site conservation or extensive mitigation prior to development / destruction
High / Medium Significance	Generally Protected A	Grade IV-A	Heritage site conservation or mitigation prior to development / destruction
Medium Significance	Generally Protected B	Grade IV-B	Heritage site conservation or mitigation / test excavation / systematic sampling / monitoring prior to or during development / destruction
Low Significance	Generally Protected C	Grade IV-C	On-site sampling, monitoring or no heritage mitigation required prior to or during development / destruction

Table 2: SAHRA archaeological and cultural heritage site significance assessment ratings and associated mitigation recommendations

2.2.1) Pre-feasibility Summary

Based on the Appendix A schematic outline of the Pre-colonial and Colonial Periods in South Africa and background literature and database information, the probability of archaeological and cultural heritage resources situated on, or in proximity to the *Ngqamakwe Phase 5 Water Supply Project*, near Tsomo, Chris Hani and Amathole District Municipalities, Eastern Cape, can briefly be described as:

Archaeological and Basic Cultural Heritage Probability Assessment –
Ngqamakwe Phase 5 Water Supply Project, near Tsomo,
Chris Hani and Amathole District Municipalities, Eastern Cape

Primary Type / Period	Sub-period	Sub-period type site	Probability
EARLY HOMININ / HOMINID	-	-	None
	Graves / human remains: High scientific significance		
STONE AGE	Earlier Stone Age (ESA)		Low
	Middle Stone Age (MSA)		Low
	Later Stone Age (LSA)		Low
		Rock Art	None
		Shel Middens	None
	Graves / human remains: ESA & MSA - High scientific significance; LSA – High scientific & social significance		
IRON AGE	Early Iron Age (EIA)		None-Low
	Middle Iron Age (MIA)		None
	Later Iron Age (LIA)		High
	Graves / human remains: EIA – High scientific significance; MIA & LIA – High scientific & social significance		
COLONIAL PERIOD	Colonial Period		None
		LSA – Colonial Period Contact	None-Low
		LIA – Colonial Period Contact	Medium
		Industrial Revolution	Low
		Apartheid & Struggle	High
	Graves / human remains: Medium-high scientific & high social significance		

Table 3: Archaeological and basic cultural heritage probability assessment

2.2.2) The SAHRA 2009 MPD & SAHRIS

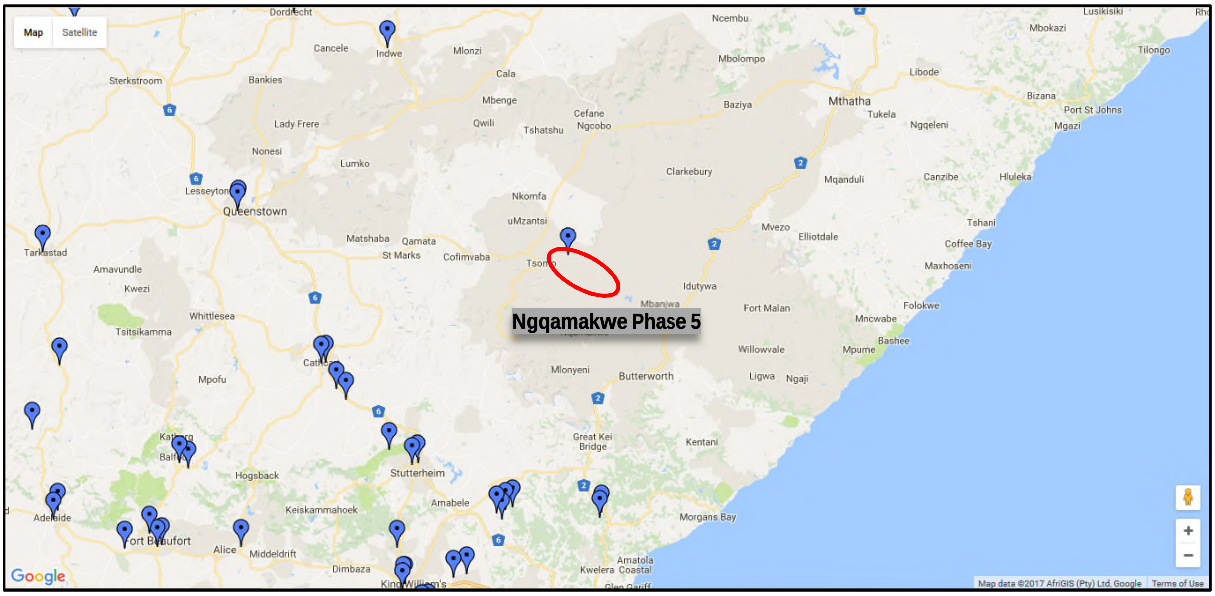
No archaeological Cultural Resources Management (CRM) reports are recorded in the SAHRA 2009 Mapping Project Database (MPD) situated within an approximate 5km radius from the *Ngqamakwe Phase 5 Water Supply Project* study site, while a number of SAHRIS cases are recorded with study sites situated within the 5km radius, but with the majority of the SAHRIS cases referring to a greater Amathole District borrow pit assessment, but including the initial CRM assessment for the Ngqamakwe water reticulation project. Relevant CRM reports are listed as:

- Anderson, G. 2009. (Umlando) *Heritage Survey for the Ngqamakwe Water Reticulation, Eastern Cape*.
- Van Ryneveld, K. 2012. (ArchaeoMaps). Phase 1 Archaeological Impact Assessment – Utilization of Borrow Pits, Amathole District Municipality, Eastern Cape, South Africa.

2.2.3) SAHRA Provincial Heritage Site Database – Eastern Cape

No declared geo-referenced Provincial Heritage Sites (PHS) are recorded in the SAHRA – Eastern Cape database (https://en.wikipedia.org/wiki/List_of_heritage_sites_in_Eastern_Cape) and situated within an approximate 5km radius from the *Ngqamakwe Phase 5 Water Supply Project* study site. The waypoint indicated on the SAHRIS map, in close proximity to Tsomo, is erroneously located and recorded as:

- SAHRA Identifier 9/2/026/0013: Cuthbert's Building, 110 Oxford Street, East London.



Map 4: Spatial distribution of geo-referenced PHSs in the SAHRA – Eastern Cape database in relation to the *Ngqamakwe Phase 5 water Supply Project* study site (https://en.wikipedia.org/wiki/List_of_heritage_sites_in _Eastern_Cape).

2.2.4) General Discussion

While the general area does yield Stone Age artefacts, these are more than often low density scatters of little archaeological significance, with types representing both the Earlier (ESA) and Middle Stone Ages (MSA). No Later Stone Age (LSA) site or scatter of artefacts have to date been recorded, aside from cases where artefacts were found in lag deposits associated with the MSA (Van Ryneveld 2012).

Iron Age sites, and exclusively Later Iron Age (LIA) are most frequently recorded (Anderson 2009, Van Ryneveld 2012), with type sites ranging from homestead and stone walled livestock enclosures to grave and cemetery sites, many of which are still in use and by implication of living heritage significance.

Infrequent Colonial Period sites have been recorded by Anderson (2009) and Van Ryneveld (2012).

The report by Anderson (2009) is of direct relevance to the *Ngqamakwe Phase 5 Water Supply Project*, having been the initial study for the greater Ngqamakwe water reticulation project. The study site assessed by Anderson comprise a much larger area, with the Ngqamakwe Phase 5 Water Supply Project study site being situated along the northern boundary of Anderson's assessment area. Anderson identified 26 heritage sites during is survey, with the majority of the sites being of LIA cultural tradition, dating to Colonial Period times and recorded as Historical / Colonial Period sites, listed as:

Site NGQ01	- Stone Age	- S32°02'40.6"; E27°49'21.8";
Site NGQ02	- Historical Period (incl. graves)	- S32°03'11.2"; E27°50'12.1";
Site NGQ03	- Historical Period (incl. graves)	- S32°03'15.5"; E27°51'42.5";
Site NGQ04	- Historical Period (graves)	- S32°04'01.1"; E27°54'14.2";
Site NGQ05	- Stone Age	- S32°06'54.2"; E27°49'13.0";
Site NGQ06	- Historical Period	- S32°08'53.1"; E27°51'24.5";
Site NGQ07	- Historical Period (Colonial building)	- S32°07'46.5"; E27°54'06.4";
Site NGQ08	- Historical Period (incl. graves)	- S32°12'53.8"; E28°01'12.7";
Site NGQ29	- Historical Period (incl. graves?)	- S32°13'50.11"; E27°55'25.8";
Site NGQ10	- Stone Age	- S32°13'42.8"; E27°48'43.8";
Site NGQ11	- Stone Age	- S32°13'25.6"; E27°46'25.2";
Site NGQ12	- Historical Period (Colonial Mission Church)	- S32°14'09.6"; E27°49'30.5";
Site NGQ13	- Stone Age	- S32°16'30.1"; E27°49'35.9";
Site NGQ14	- Stone Age	- S32°18'46.8"; E27°51'49.9";
Site NGQ15	- Historical Period (Colonial Trade Post)	- S32°20'46.6"; E27°51'38.9";
Site NGQ16	- Historical Period	- S32°03'47.5"; E27°57'33.1";
Site NGQ17	- Historical Period	- S32°06'14.2"; E27°55'46.2";
Site NGQ18	- Historical Period	- S32°06'58.9"; E27°57'06.6";

Site NGQ19	- Historical Period	- S32°07’31.7”; E27°57’47.0”;
Site NGQ20	- Historical Period	- S32°07’40.9”; E27°52’33.1”;
Site NGQ21	- Historical Period	- S32°11’09.4”; E27°53’05.4”;
Site NGQ22	- Historical Period (Colonial buildings)	- S32°12’09.2”; E27°56’27.6”;
Site NGQ23	- Historical Period	- S32°12’38.7”; E28°00’02.9”;
Site NGQ24	- Historical Period	- S32°18’19.5”; E27°48’28.2”;
Site NGQ25	- Historical Period	- S32°10’18.8”; E28°01’38.8”; and
Site NGQ26	- Historical Period	- S32°13’44.6”; E27°52’35.4”.

2.2.1) Introduction

Anderson (2009) identified 26 heritage sites during the initial survey for the Ngqamakwe Water Project, with Sites NGQ01, NGQ02, NGQ03, NGQ04, NGQ16 and NGQ49 situated along the northern perimeter of the 2009 study site. Of the sites initially identified by Anderson (2009), only Site NGQ04 is of direct relevance and situated within the approximate 50-100m survey corridor of the *Ngqamakwe Phase 5 Water Supply Project* study site.

An additional 17 heritage sites were identified during the field assessment for the *Ngqamakwe Phase 5 Water Supply Project*, for consistency labelled Site NGQ27 – NGQ43. In totality 18 heritage sites are of relevance for development, including Sites NGQ27 – NGQ43 and Site NGQ04. Of the heritage sites, all comprise Later Iron Age tradition sites, aside from Site NGQ37, being the only Colonial Period site. By far the majority of Iron Age sites constitute grave or cemetery sites, clustered primarily in the village of Nxaybisa.

Despite proximity of many of the sites to the development alignment realignment of the line route is not proposed. The area is noticeably rich in Later Iron Age type sites, many of which are of living heritage significance. By inference realignment of the line route will simply result in a new set of resources being identified in proximity to a new proposed route. Recommendations of this report centre on the conservation of heritage sites situated within a rough 50-100m from the proposed development alignment, many of which within 10-20m from the line route. Recommendations for conservation is based on light weight temporary conservation measures during the course of construction, comprising of temporary heritage fencing (construction netting or a similar visually clear demarcation), and temporary heritage signage to indicate identified sensitive areas as ‘NO ENTRY – HERITAGE SITE’ zones. Proposed development will not result in the destruction of any identified heritage site and no mitigation prior to impact is recommended. It is not recommended that sites be permanently conserved (permanently fenced) without prior community consultation. All temporary conservation measures should be removed upon completion of construction.

Based on light weight temporary conservation recommended in this report it is imperative that heritage compliance reports on temporary conservation be submitted either by the ECO or an accredited heritage practitioner during the construction phase.

Map 5: Heritage sites identified by Anderson (2009) in relation to the *Ngqamakwe Phase 5 Water Supply Project* study site (red line)

2.2.2) Site Descriptions

2.2.2.1) Site NGQ27: Later Iron Age - Grave (S32°02'38.7"; E27°50'09.3")

Site NGQ27 comprise a LIA stone cairn grave. The grave is unfenced and situated approximately 50m from the proposed line route.

- ***Site Significance and Recommendations:*** Site NGQ27 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *High / Medium Significance* and a *Generally Protected IV-A Field Rating*. It is recommended that temporary site conservation measures, including a temporary fence and signage be instated for the duration of construction.

2.2.2.2) Site NGQ28: Later Iron Age – Livestock Enclosure (S32°02'53.3"; E27°50'34.6")

Site NGQ28 comprise the foundation remains of a LIA livestock enclosure. The site is situated approximately 15m from the proposed line routes. At present, no conservation measures are in place.

- ***Site Significance and Recommendations:*** Site NGQ28 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *Low Significance* and a *Generally Protected IV-C Field Rating*. It is recommended that temporary site conservation measures, including a temporary fence and signage be instated for the duration of construction, with a minimum approximate 10m conservation buffer zone between the site and the line route alignment.

2.2.2.3) Site NGQ29: Later Iron Age - Cemetery (S32°02'47.8"; E27°50'41.6")

Site NGQ29 comprise a LIA cemetery, containing modern style, stone cairn and stone outlined graves. The cemetery is situated within 50m from the proposed line route

- ***Site Significance and Recommendations:*** Site NGQ29 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *High / Medium Significance* and a *Generally Protected IV-A Field Rating*. It is recommended that temporary site conservation measures, including a temporary fence and signage be instated for the duration of construction. The temporary conservation fence should allow for a minimum 10m conservation buffer between the conservation fence and the development alignment.

2.2.2.4) Site NGQ30: Later Iron Age - Grave (S32°02'45.7"; E27°50'57.5")

Site NGQ30 comprise a LIA grave. The site is situated in a privately fenced area, where direct access to the line route was not possible. The presence of the rave warns against similar type sites that may be present in non-accessible areas. On-site conservation measures, similar to that described for Site NGQ30 should be instated in cases where the line route pass through privately fenced areas containing graves.

- ***Site Significance and Recommendations:*** Site NGQ30 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *High / Medium Significance* and a *Generally Protected IV-A Field Rating*. It is recommended that temporary site conservation measures, including a temporary fence and signage be instated for the duration of construction. Preferably an approximate 10m conservation buffer should be maintained between graves and the development alignment.

2.2.2.5) Site NGQ31: Later Iron Age - Grave (S32°02'46.8"; E27°51'07.6")

Site NGQ27 comprise a LIA stone grave. The grave is situated within 10m from the proposed line route, but within an existing fenced area, with current conservation measures including a conservation fence complying with SAHRA / EC PHRA minimum standards for heritage site conservation.

- ***Site Significance and Recommendations:*** Site NGQ31 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *High / Medium Significance* and a *Generally Protected IV-A Field Rating*. The rave is situated within a formally fenced area. It is recommended that temporary site conservation signage be attached to the existing fence as cautionary measure during construction.

2.2.2.6) Site NGQ32: Later Iron Age - Cemetery (S32°02'51.9"; E27°51'12.2")

Site NGQ32 comprise a LIA cemetery, containing modern style, stone cairn and stone outlined graves. The cemetery is situated directly along the proposed development alignment and slight realignment of the line route may be necessary.

- ***Site Significance and Recommendations:*** Site NGQ32 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *High / Medium Significance* and a *Generally Protected IV-A Field Rating*. It is recommended that temporary site conservation measures, including a temporary fence and signage be instated for the duration of construction. The temporary conservation fence should allow for a minimum 10m conservation buffer between the conservation fence and the development alignment. Slight realignment of the proposed line route may well be necessary to ensure prescribed conservation measures.

2.2.2.7) Site NGQ33: Later Iron Age - Graves (S32°02'56.3"; E27°51'18.4")

Site NGQ33 comprise 2 LIA graves. The graves are not fenced and situated within 10m from the proposed development corridor.

- ***Site Significance and Recommendations:*** Site NGQ33 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *High / Medium Significance* and a *Generally Protected IV-A Field Rating*. It is recommended that temporary site conservation measures, including a temporary fence and signage be instated for the duration of construction. A minimum 10m heritage conservation buffer should be maintained between the conservation fence and the development alignment, which may require slight realignment to the line route.

2.2.2.8) Site NGQ34: Later Iron Age – Homestead (S32°02'54.0"; E27°51'18.7")

Site NGQ34 comprise a LIA homestead site, including amongst others the remains of 2 huts and a livestock enclosure. Smaller feature remains are visible on site, although artefacts remain extremely scares comprising only a few metal remains. The site is situated approximately 70m from the proposed development alignment.

- ***Site Significance and Recommendations:*** Site NGQ34 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *Medium Significance* and a *Generally Protected IV-B Field Rating*. Based on proximity from the proposed development alignment it is recommended that temporary signage be instated at the site during the construction phase to avoid accidental impact on the site.

2.2.2.9) Site NGQ35: Later Iron Age - Grave (S32°03'02.1"; E27°51'19.2")

Site NGQ35 comprise an already fenced grave. The site is situated approximately 30m from the development corridor.

- ***Site Significance and Recommendations:*** Site NGQ35 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *High / Medium Significance* and a *Generally Protected IV-A Field Rating*. It is recommended that temporary heritage signage be attached to the existing fence at the rave to ensure no accidental impact during the course of construction.

2.2.2.10) Site NGQ36: Later Iron Age - Graves (S32°02'40.8"; E27°50'44.2")

Site NGQ36 comprise of 2 LIA stone outlined graves. The unfenced graves are situated approximately 60m from the proposed development alignment.

- ***Site Significance and Recommendations:*** Site NGQ36 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *High / Medium Significance* and a *Generally Protected IV-A Field Rating*. It is recommended that temporary site conservation measures, including a temporary fence and signage be instated for the duration of construction.

2.2.2.11) Site NGQ37: Colonial Period – Residence (S32°02'38.5"; E27°50'52.8")

Site NGQ37 constitute the only Colonial Period site identified during the field assessment. The site comprise the stone built wall remains of a residence. Site NGQ37 is situated more or less 20m from the proposed development alignment. A number of monolithic stones are found across the study site, these are interpreted as directly associated with Site NGQ37 and are farm, or farm camp fence post markers. Although of equal Colonial Period temporal significance, individual post markers are of such low heritage significance that individual recording and recommendations are not included in this report.

- ***Site Significance and Recommendations:*** Site NGQ37 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *Medium Significance* and a *Generally Protected IV-B Field Rating*. Based on proximity from the proposed development alignment it is recommended that temporary fencing and signage be instated at the site during the construction phase, allowing for a minimum 10m conservation buffer around the structure.

2.2.2.12) Site NGQ38: Later Iron Age - Cemetery (S32°02'41.2"; E27°51'29.8")

Site NGQ38 comprise a LIA cemetery, situated within a privately fenced homestead yard, with current conservation measures (permanent fence) complying with SAHRA / EC PHRA minimum standards for heritage site conservation. Site NGQ38 is situated within 15m from the proposed line route.

- ***Site Significance and Recommendations:*** Site NGQ38 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *High / Medium Significance* and a *Generally Protected IV-A Field Rating*. It is recommended that temporary heritage signage be attached to the existing conservation fence as cautionary measure during the course of construction.

2.2.2.13) Site NGQ39: Later Iron Age - Cemetery (S32°02'40.2"; E27°51'30.3")

Site NGQ39 comprise a LIA cemetery, including a few permanently fenced moderns style graves, as well as a number of stone cairn and stone outlined graves. The site is situated more or less 40m from the proposed line route.

- ***Site Significance and Recommendations:*** Site NGQ39 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *High / Medium Significance* and a *Generally Protected IV-A Field Rating*. It is recommended that temporary site conservation measures, including a temporary fence and signage be instated for the duration of construction.

2.2.2.14) Site NGQ40: Later Iron Age – Homestead (S32°02'42.1"; E27°51'33.0")

Site NGQ40 comprise a LIA homestead site, situated approximately 60m from the proposed development alignment. Site features include livestock enclosure remains as well as at least 2 hut foundation remains, while evidence of smaller associated built features is present on site. No associated artefacts or middens were identified

- ***Site Significance and Recommendations:*** Site NGQ40 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *Medium Significance* and a *Generally Protected IV-B Field Rating*. Based on proximity from the proposed development alignment it is recommended that temporary signage be instated at the site during the construction phase to avoid accidental impact on the site.

2.2.2.15) Site NGQ41: Later Iron Age – Homestead (S32°03'42.7"; E27°53'58.2")

Site NGQ41 comprise a LIA homestead site, situated approximately 60m from the proposed development alignment and on the opposite site of the R409. Site features include livestock enclosure remains as well as residential hut remains. The site is permanently fenced.

- ***Site Significance and Recommendations:*** Site NGQ41 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *Medium Significance* and a *Generally Protected IV-B Field Rating*. Based on proximity from the proposed development alignment it is recommended that temporary signage be attached to the existing fence during the construction phase to avoid accidental impact on the site.

2.2.2.16) Site NGQ42: Later Iron Age - Grave (S32°03'55.4"; E27°54'26.2")

Site NGQ42 comprise a single, formally fenced grave. The grave is situated approximately 50m from the proposed development alignment.

- ***Site Significance and Recommendations:*** Site NGQ42 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *High / Medium Significance* and a *Generally Protected IV-A Field Rating.* It is recommended that temporary heritage signage be attached at the existing fence to ensure no accidental impact on the site during the construction phase.

2.2.2.17) Site NGQ43: Later Iron Age - Grave (S32°03'55.4"; E27°54'26.8")

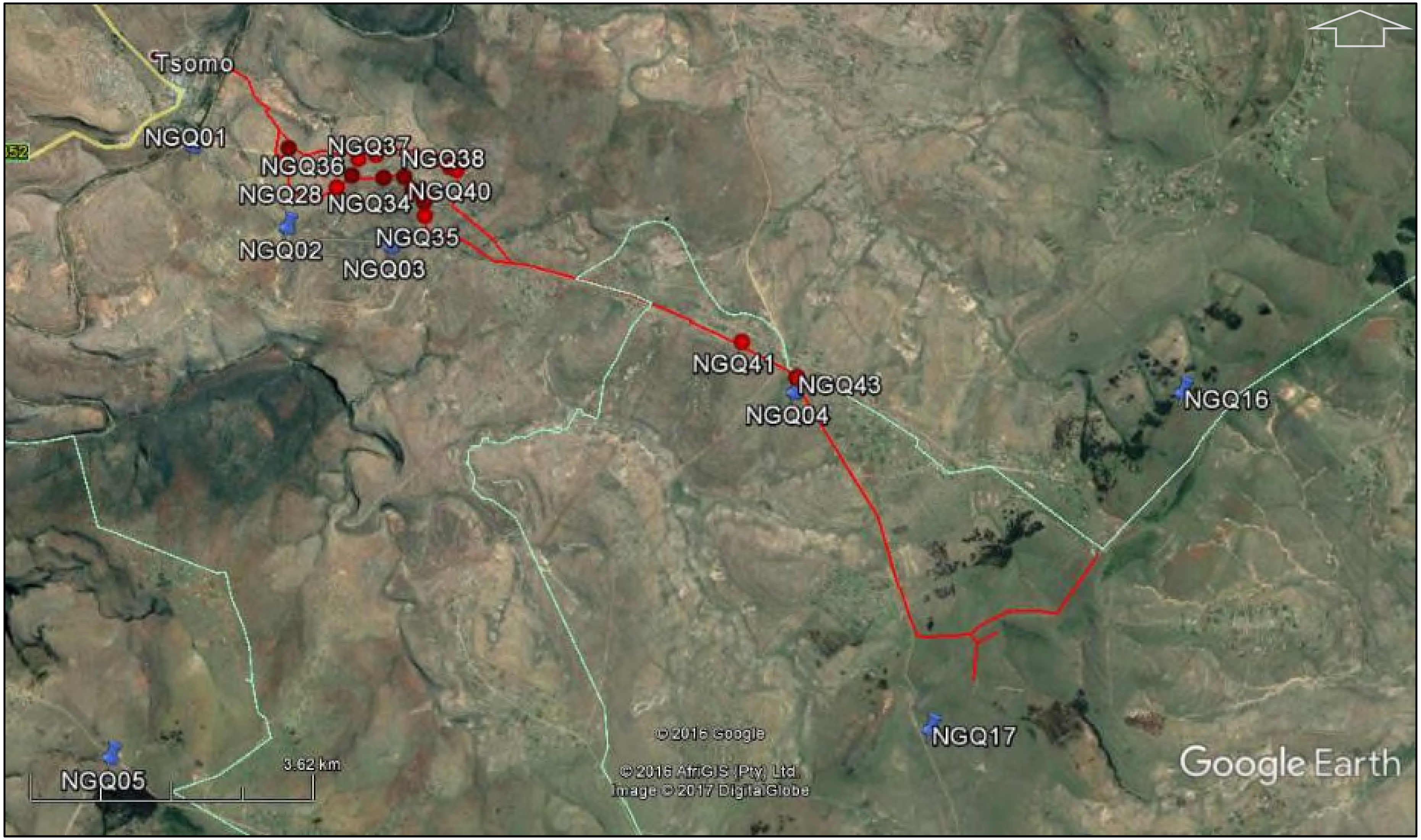
Site NGQ43 comprise a single, modern style grave. The grave is situated within a privately fenced homestead yard.

- ***Site Significance and Recommendations:*** Site NGQ43 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *High / Medium Significance* and a *Generally Protected IV-A Field Rating*. It is recommended that temporary heritage signage be attached at the existing fence as cautionary measure, ensuring no accidental impact on the site during the course of construction.

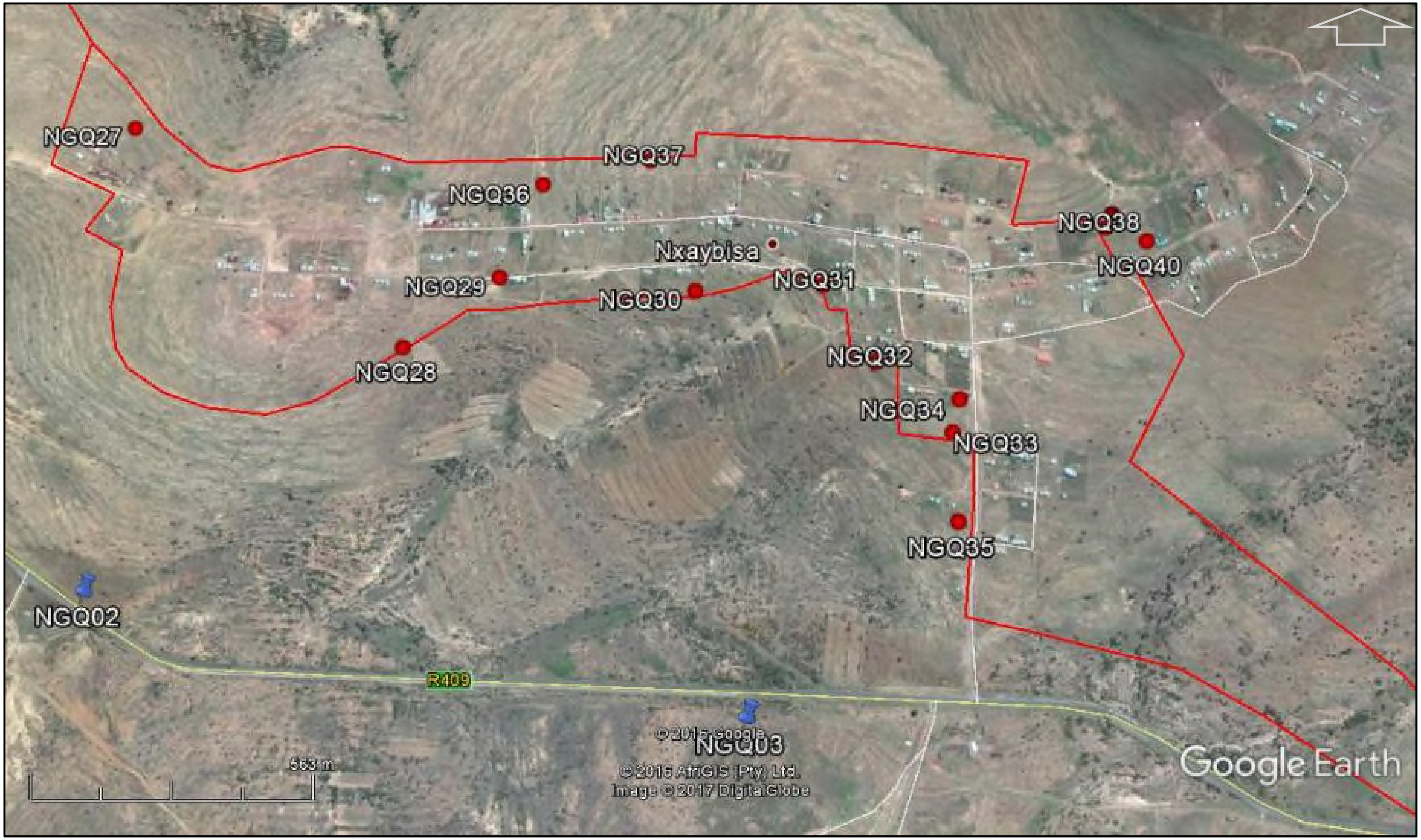
2.2.2.18) Site NGQ04: Later Iron Age - Grave (S32°04'01.1"; E27°54'26.3")

Site NGQ04 was first recorded by Anderson (2009) and described as a single grave of High Significance, situated approximately 50m from the R409 and the proposed line route.

- ***Site Significance and Recommendations:*** Site NGQ04 comprise a heritage site formally protected by the NHRA 1999. The site is ascribed a SAHRA / EC PHRA *High / Medium Significance* and a *Generally Protected IV-A Field Rating*. It is recommended that temporary site conservation measures, including a temporary fence and signage be instated for the duration of construction.



Map 6: Results of the field assessment



Map 7: Results of the field assessment (Close-up of Nxaybisa village)

Map 8: Results of the field assessment (Close-up of Mjula village)

Plate 1: Site NGQ27

Plate 3: Site NGQ29 [1]

Plate 2: Site NGQ28

Plate 4: Site NGQ29 [2]

Plate 5: NGQ29 [3]

Plate 6: Site NGQ30

Plate 7: Site NGQ31

Plate 8: Site NGQ32 [1]

Plate 9: Site NGQ32 [2]

Plate 10: Site NGQ32 [3]

Plate 11: Site NGQ33

Plate 12: Site NGQ34

Plate 13: Site NGQ35

Plate 15: Site NGQ37

Plate 14: Site NGQ36

Plate 16: Typical monolithic farm, or farm camp fence post markers, associated with Site NGQ37

Plate 17: Site NGQ38

Plate 19: Site NGQ40 [1]

Plate 18: Site NGQ39

Plate 20: Site NGQ40 [2]

Plate 21: Site NGQ41

Plate 23: Site NGQ43

Plate 22: Site NGQ42

Plate 24: Site NGQ4 (Anderson 2009)

3 – Environmental Impact Assessment Rating

Identified archaeological and cultural heritage resources are ascribed an Environmental Impact Assessment (EIA) rating, based on the outline presented below to provide a significance rating of development impact on resources, both during the 1) construction and 2) operation and use phases of development (in accordance with NEMA 1998, Regulations 2014):

Overall Nature:	1) **Negative** (negative impact on affected biophysical or human environment), or 2) **Positive** (benefit to the affected biophysical or human environment).
Type:	1) **Direct** (caused by the action and occur at the same time and place), 2) **Indirect or secondary** (caused by the action and are later in time or father removed in distance but reasonably foreseeable), or 3) **Cumulative** (impact which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions; can result from individually minor, but collectively significant actions taking place over a period of time).
Spatial Extent:	1) **Site** (immediate area of activity, incorporating a 5m zone from the edge of the affected area), 2) **Local** (area up to and/or within 10km from the 'site' as defined above), 3) **Regional** (entire community, basin or landscape), or 4) **National** (South Africa).
Duration:	1) **Short-term** (impact would last for the duration of activities; quickly reversible), 2) **Medium-term** (impact would affect project activity; reversible over time), 3) **Long-term** (impact would continue beyond project activity), or 4) **Permanent** (impact would continue beyond decommissioning).
Severity:	1) **Low**, 2) **Medium**, or 3) **High**, being +) **Positive**, or -) **Negative** (based on separately described categories examining whether the impact is destructive or benign, whether it destroys the impacted environment, alters its functionality or slightly alters he environment itself).
Reversibility:	1) **Completely reversible** (completely reversible impact with implementation of correct mitigation measures), 2) **Partly reversible** (partly reversible impact with implementation of correct mitigation measures), or 3) **Irreversible** (impact cannot be reversed, regardless of mitigation or rehabilitation measures).
Irreplaceable loss:	1) **Resource will not be lost** (resource will not be lost provided mitigation measures are implemented), 2) **Resource will be partly lost** (partial loss or destruction of the resource will occur even though management and mitigation measures are implemented), or 3) **Resource cannot be replaced** (resource is irreplaceable no matter which management or mitigation measures are implemented).
Probability:	1) **Unlikely** (<40% probability), 2) **Possible** (40% probability), 3) **Probable** (>70% probability), or 4) **Definite** (>90% probability).
Mitigation potential:	1) **High or completely mitigatable** (relatively easy and cost effective to manage. Specialist expertize and equipment generally not required. Nature of impact easily understood and may be mitigated through implementation of a management plan or 'good housekeeping', including regular monitoring and reporting regimes. Significance of the impact after mitigation is likely to be low or negligible), 2) **Moderate or partially mitigatable** (management requires higher level of expertise and resources to maintain impacts with acceptable levels. Mitigation can be tied up in the design of the project. Significance of the impacts after mitigation is likely to be low to moderate. It may not be possible to mitigate the impact entirely, with residual impacts resulting), or 3) **Low or un-mitigatable** (will not be possible to mitigate the impact entirely, regardless of expertise and resources. Potential to manage the impacts may be beyond the scope of the project. Management of the impact is not likely to result in a measurable change in the level of significance).
Impact significance:	1) **Negligible**, 2) **Low** (largely of HIGH mitigation potential, after consideration of other criteria), 3) **Moderate** (largely of MODERATE or partial mitigation potential, after consideration of other criteria), or 4) **Substantial** (largely of LOW mitigation potential, after consideration of other criteria).

<table>
<tr><th colspan="13">Environmental Impact Assessment Rating:
Ngqamakwe Phase 5 Water Supply Project, near Tsomo, Chris Hani and Amathole District Municipalities, Eastern Cape</th></tr>
<tr><th rowspan="2">Potential Impacts</th><th rowspan="2">Overall nature</th><th rowspan="2">Type</th><th rowspan="2">Spatial extent</th><th rowspan="2">Duration</th><th rowspan="2">Severity</th><th rowspan="2">Reversibility</th><th rowspan="2">Irreplaceable loss</th><th rowspan="2">Probability</th><th rowspan="2">MITIGATION POTENTIAL</th><th colspan="2">IMPACT SIGNIFICANCE</th><th rowspan="2">MITIGATION MEASURES</th></tr>
<tr><th>Without mitigation</th><th>With mitigation</th></tr>
<tr><td colspan="13">SITES: NGQ27, NGQ28, NGQ29, NGQ30, NGQ31, NGQ32, NGQ33, NGQ34, NGQ35, NGQ36, NGQ37, NGQ38, NGQ39, NGQ40, NGQ41, NGQ42, NGQ43 and NGQ04</td></tr>
<tr><td>Construction phase</td><td>Negative</td><td>Direct</td><td>Site</td><td>Permanent</td><td>High Negative</td><td>Irreversible</td><td>Resource cannot be replaced</td><td>Definite</td><td>Low / Unmitigatable</td><td>Moderate</td><td>Negligible</td><td>Heritage Site Conservation (Temporary heritage conservation measures during the course of construction)</td></tr>
<tr><td>Operational phase</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="13">Mitigation details: Temporary heritage conservation measures (fence & signage) during the construction phase. All temporary conservation measures should be removed upon completion of construction</td></tr>
</table>

Table 4: Environmental Impact Assessment Rating

With reference to archaeological and cultural heritage compliance, as per the requirements of the NHRA 1999, it is recommended that the proposed *Ngqamakwe Phase 5 Water Supply Project*, near Tsomo, Chris Hani and Amathole District Municipalities, Eastern Cape, proceed as applied for, provided the developer comply with the below listed heritage recommendations.

Seventeen (17) newly identified and one (1) known heritage site, totalling eighteen (18) heritage sites are situated within the approximate 50-100m survey corridor of the proposed *Ngqamakwe Phase 5 Water Supply Project*. Identified heritage sites comprise primarily Later Iron Age (LIA) grave and informal cemetery sites. Realignment of the line route is not recommended; realignment may well simply result in a new set of heritage sites to me managed during development in the heritage rich area. Recommended temporary conservation measures are based on temporary fencing and signage during the construction phase. All temporary conservation measures should be removed upon completion of construction. Development in the vicinity of unfenced, informal graves or cemeteries should not encroach within 10m from the burial places.

- The proposed development poses no 'fatal flaws' with reference to archaeological and cultural heritage resources.
- The development will have a limited negative visual and cumulative impact on the cultural landscape during the construction phase and no negative visual and cumulative impact during the operational phase.
- It is recommended that a heritage specialist / ECO report on heritage compliance to the EC PHRA during the construction phase of the development.
- [In the event of any incidental archaeological and cultural heritage resources, as defined and protected by the NHRA 1999, being identified during the course of development the process described in '*Appendix B: Heritage Protocol for Incidental Finds during the Construction Phase*' should be followed.]

Heritage Compliance Summary –
Ngqamakwe Phase 5 Water Supply Project, near Tsomo,
Chris Hani and Amathole District Municipalities, Eastern Cape

Map Code	Site	Co-ordinates	Recommendations
Ngqamakwe Phase 5 Water Supply Project			
Site NGQ27	Later Iron Age – Grave	S32°02'38.7"; E27°50'09.3"	Temporary heritage conservation fencing and signage
Site NGQ28	Later Iron Age – Livestock enclosure	S32°02'53.3"; E27°50'34.6"	Temporary heritage conservation fencing and signage
Site NGQ29	Later Iron Age – Cemetery	S32°02'47.8"; E27°50'41.6"	Temporary heritage conservation fencing and signage
Site NGQ30	Later Iron Age – Grave	S32°02'45.7"; E27°50'57.5"	Temporary heritage conservation fencing and signage
Site NGQ31	Later Iron Age – Grave	S32°02'46.8"; E27°51'07.6"	Temporary heritage signage
Site NGQ32	Later Iron Age – Cemetery	S32°02'51.9"; E27°51'12.2"	Temporary heritage conservation fencing and signage
Site NGQ33	Later Iron Age – Graves	S32°02'56.3"; E27°51'18.4"	Temporary heritage conservation fencing and signage
Site NGQ34	Later Iron Age – Homestead remains	S32°02'54.0"; E27°51'18.7"	Temporary heritage signage
Site NGQ35	Later Iron Age – Grave	S32°03'02.1"; E27°51'19.2"	Temporary heritage signage
Site NGQ36	Later Iron Age – Graves	S32°02'40.8"; E27°50'44.2"	Temporary heritage conservation fencing and signage
Site NGQ37	Colonial Period – Residence	S32°02'38.5"; E27°50'52.8"	Temporary heritage conservation fencing and signage
Site NGQ38	Later Iron Age – Cemetery	S32°02'41.2"; E27°51'29.8"	Temporary heritage signage
Site NGQ39	Later Iron Age – Cemetery	S32°02'40.2"; E27°51'30.3"	Temporary heritage conservation fencing and signage
Site NGQ40	Later Iron Age – Homestead remains	S32°02'42.1"; E27°51'33.0"	Temporary heritage signage
Site NGQ41	Later Iron Age – Homestead remains	S32°03'42.7"; E27°53'58.2"	Temporary heritage signage
Site NGQ42	Later Iron Age – Grave	S32°03'55.4"; E27°54'26.2"	Temporary heritage signage
Site NGQ43	Later Iron Age – Grave	S32°03'55.4"; E27°54'26.8"	Temporary heritage signage
Site NGQ04	Later Iron Age – Grave	S32°04'01.1"; E27°54'26.3"	Temporary heritage conservation fencing and signage

Table 5: Heritage compliance summary

The EC PHRA-APM Unit HIA Comment will state legal requirements for development to proceed, or reasons why, from a heritage perspective, development may not be further considered.

Notes:

Should any registered Interested & Affected Party (I&AP) wish to be consulted in terms of Section 38(3)(e) of the NHRA 1999 (socio-cultural consultation / SAHRA SIA) it is recommended that the developer / EAP ensures that the consultation be prioritized within the timeframe of the environmental assessment process.

Simplified Guide to the Identification of Archaeological Sites:

- **Stone Age** – Knapped stone display flakes and flake scars that appear unnatural and may result in similar type 'shaped' stones often concentrated in clusters or forming a distinct layer in the geological stratigraphy. ESA shapes may represent 'pear' or oval shaped stones, often in the region of 10cm or larger. Typical MSA types include blade-like or rough triangular shaped artefacts, often associated with randomly shaped lithics or flakes that display use- or edge-wear around the rim of the artefact. LSA types are similar to MSA types, but generally smaller (≤3cm in size), often informally shaped, and are frequently found in association with bone, pieces of charcoal, ceramic shards and food remains.
  - **Rock Art** – Includes both painted and engraved images.
  - **Shell Middens** – Include compact shell lenses that may be quite extensive in size or small ephemeral scatters of shell food remains, often associated with LSA artefact remains, but may also be of MSA and Iron Age cultural association.
- **Iron Age** – Iron Age sites are often characterized by stone features, i.e. the remains of former livestock enclosures or typical household remains; huts are identified by either mound or depression hollows. Typical artefacts include ceramic remains, farming equipment, beads and trade goods, metal artefacts (including jewellery) etc. Remains of the 'Struggle' – events, histories and landmarks associated therewith are often, based on cultural association, classed as part of the Iron Age heritage of South Africa.
- **Colonial Period** – Built environment remains, either urban or rural, are of a Western cultural affiliation with typical artefacts representing early Western culture, including typical household remains, trade and manufactured goods, such as old bottle, porcelain and metal artefacts. War memorial remains, including the vast array of associated graves and the history of the Industrial Revolution form important parts of South Africa's Colonial Period heritage.

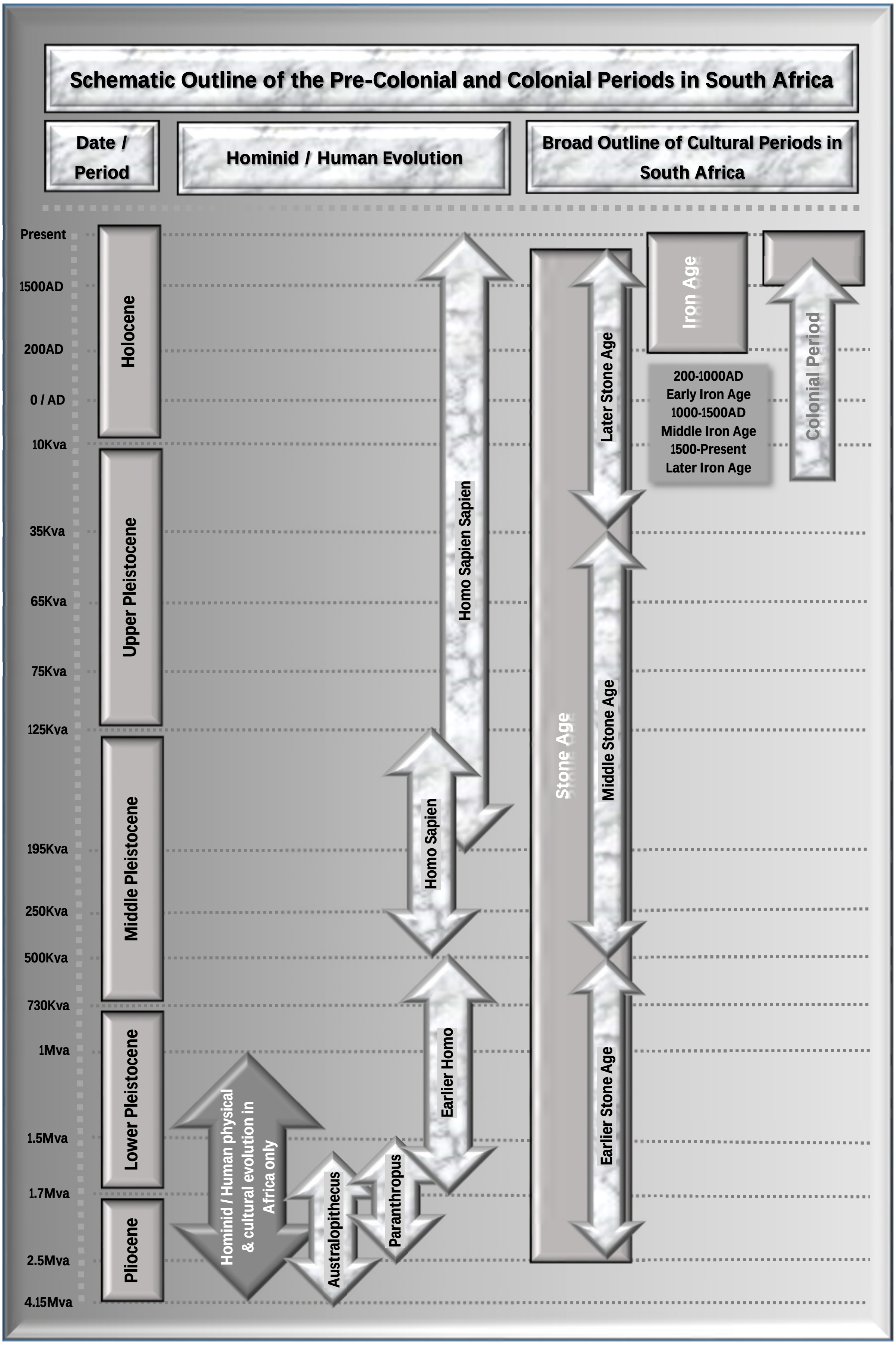
5 – Acronyms & Abbreviations

AD	: Anno Domini (the year 0)
AIA	: Archaeological Impact Assessment
AMAFA	: Amafa aKwaZulu-Natali (Natal PHRA)
ASAPA	: Association of Southern African Professional Archaeologists
BAR	: Basic Assessment Report
BC	: Before the Birth of Christ (the year 0)
BCE	: Before the Common Era (the year 0)
BID	: Background Information Document
BP	: Before the Present (the year 0)
cm	: Centimetre
CMP	: Conservation Management Plan
CRM	: Cultural Resources Management
DAC	: Department of Arts and Culture
DEAT	: Department of Environmental Affairs and Tourism
DME	: Department of Minerals and Energy
EAP	: Environmental Assessment Practitioner
ECO	: Environmental Control Officer
ELO	: Environmental Liaison Officer
EC PHRA	: Eastern Cape Provincial Heritage Resources Authority
EIA_1	: Environmental Impact Assessment
EIA_2	: Early Iron Age
EMPr	: Environmental Management Plan / Programme Report
ESA	: Earlier Stone Age
ha	: Hectare
HIA	: Heritage Impact Assessment
HWC	: heritage Western Cape
ICOMOS	: International Council on Monuments and Sites
IEM	: Integrated Environmental Management
km	: kilometre
Kya	: Thousands of years ago
LIA	: Later Iron Age
LSA	: Later Stone Age
m	: metre
m^2	: Square meter
MIA	: Middle Iron Age
Mm	: millimetre
MPRDA 2002	: Mineral and Petroleum Resources Development Act, No 28 of 2002
MSA	: Middle Stone Age
Mya	: Millions of years ago
NEMA 1998	: National Environmental Management Act, No 107 of 1998
NHRA 1999	: National Heritage Resources Act, No 25 of 1999
PIA	: Palaeontological Impact Assessment
PHRA	: Provincial Heritage Resources Authority
PSSA	: Palaeontological Society of South Africa
PPP	: Public Participation Process
SAHRA	: South African Heritage Resources Agency
SAHRIS	: South African Heritage Resources Information System
SIA	: Social Impact Assessment

6 – References

1. Anderson, G. 2009. (Umlando) *Heritage Survey for the Ngqamakwe Water Reticulation, Eastern Cape*.
2. South African Government. (No 25 of) 1999. *National Heritage Resources Act*.
3. Van Ryneveld, K. 2012. (ArchaeoMaps). Phase 1 Archaeological Impact Assessment – Utilization of Borrow Pits, Amathole District Municipality, Eastern Cape, South Africa.

Appendix A:


Schematic Outline of the Pre-Colonial and Colonial Periods in South Africa
Date / Period
Hominid / Human Evolution
Broad Outline of Cultural Periods in South Africa
Present
1500AD
200AD
0 / AD
10Kva
35Kva
65Kva
75Kva
125Kva
195Kva
250Kva
500Kva
730Kva
1Mva
1.5Mva
1.7Mva
2.5Mva
4.15Mva
Holocene
Upper Pleistocene
Middle Pleistocene
Lower Pleistocene
Pliocene
Homo Sapien Sapien
Homo Sapien
Earlier Homo
Paranthropus
Australopithecus
Hominid / Human physical & cultural evolution in Africa only
Stone Age
Later Stone Age
Middle Stone Age
Earlier Stone Age
Iron Age
200-1000AD
Early Iron Age
1000-1500AD
Middle Iron Age
1500-Present
Later Iron Age
Colonial Period

Appendix B:

Heritage Impact Assessment (HIA) – Ngqamakwe Phase 5 Water Supply Project, near Tsomo, Chris Hani and Amathole District Municipalities, Eastern Cape

Heritage Protocol for Incidental Finds during the Construction Phase

Should any palaeontological, archaeological or cultural heritage resources, including human remains / graves, as defined and protected by the NHRA 1999, be identified during the construction phase of development (including as a norm during vegetation clearing, surface scraping, trenching and excavation phases), it is recommended that the process described below be followed.

➢ On-site Reporting Process:

1. The identifier should immediately notify his / her supervisor of the find.
2. The identifier's supervisor should immediately (and within 24 hours after reporting by the identifier) report the incident to the on-site SHE / SHEQ officer.
3. The on-site SHE / SHEQ officer should immediately (and within 24 hours after reporting by the relevant supervisor) report the incident to the appointed ECO / ELO officer. [Should the find relate to human remains the SHE / SHEQ officer should immediately notify the nearest SAPS station informing them of the find].
4. The ECO / ELO officer should ensure that the find is within 72 hours after the SHE / SHEQ officers report reported on SAHRIS and that a relevant heritage specialist is contacted to make arrangements for a heritage site inspection. [Should the find relate to human remains the ECO / ELO officer should ensure that the archaeological site inspection coincides with a SAPS site inspection, to verify if the find is of forensic, authentic (informal / older than 60 years), or archaeological (older than 100 years) origin].
5. The appointed heritage specialist should compile a 'heritage site inspection' report based on the site specific findings. The site inspection report should make recommendations for the destruction, conservation or mitigation of the find and prescribe a recommended way forward for development. The 'heritage site inspection' report should be submitted to the ECO / ELO, who should ensure submission thereof on SAHRIS.
6. SAHRA / the relevant PHRA will state legal requirements for development to proceed in the SAHRA / PHRA Comment on the 'heritage site inspection' report.
7. The developer should proceed with implementation of the SAHRA / PHRA Comment requirements. SAHRA / PHRA Comment requirements may well stipulate permit specifications for development to proceed.
    - Should permit specifications stipulate further Phase 2 archaeological investigation (including grave mitigation) a suitably accredited heritage specialist should be appointed to conduct the work according to the applicable SAHRA / PHRA process. The heritage specialist should apply for the permit. Upon issue of the SAHRA / PHRA permit the Phase 2 heritage mitigation program may commence.
    - Should permit specifications stipulate destruction of the find under a SAHRA / PHRA permit the developer should immediately proceed with the permit application. Upon the issue of the SAHRA / PHRA permit the developer may legally proceed with destruction of the palaeontological, archaeological or cultural heritage resource.
    - Upon completion of the Phase 2 heritage mitigation program the heritage specialist will submit a Phase 2 report to the ECO / ELO, who should in turn ensure submission thereof on SAHRIS. Report recommendations may include that the remainder of a heritage site be destroyed under a SAHRA / PHRA permit.
    - Should the find relate to human remains of forensic origin the matter will be directly addressed by the SAPS: A SAHRA / PHRA permit will not be applicable.

<u>NOTE:</u> Note that SAHRA / PHRA permit and process requirements relating to the mitigation of human remains requires suitable advertising of the find, a consultation, mitigation and re-internment / deposition process.

Duties of the Supervisor:

1. The supervisor should immediately upon reporting by the identifier ensure that all work in the vicinity of the find is ceased.
2. The supervisor should ensure that the location of the find is immediately secured (and within 12 hours of reporting by the identifier), by means of a temporary conservation fence (construction netting) allowing for a 5-10m heritage conservation buffer zone around the find. The temporary conserved area should be sign-posted as a '*No Entry – Heritage Site*' zone.
3. Where development has impacted on the resource, no attempt should be made to remove artefacts / objects / remains further from their context, and artefacts / objects / remains that have been removed should be collected and placed within the conservation area or kept for safekeeping with the SHE / SHEQ officer. It is imperative that where development has impacted on palaeontological, archaeological and cultural heritage resources the context of the find be preserved as good as possible for interpretive and sample testing purposes.
4. The supervisor should record the name, company and capacity of the identifier and compile a brief report describing the events surrounding the find. The report should be submitted to the SHE / SHEQ officer at the time of the incident report.

Duties of the SHE / SHEQ Officer:

1. The SHE / SHEQ officer should ensure that the location of the find is recorded with a GPS. A photographic record of the find (including implementation of temporary conservation measures) should be compiled. Where relevant a scale bar or object that can indicate scale should be inserted in photographs for interpretive purposes.
2. The SHE / SHEQ officer should ensure that the supervisors report, GPS co-ordinate and photographic record of the find be submitted to the ECO / ELO officer. [Should the find relate to human remains the SHE / SHEQ officer should ensure that the mentioned reporting be made available to the SAPS at the time of the incident report].
3. Any retrieved artefacts / objects / remains should, in consultation with the ECO / ELO officer, be deposited in a safe place (preferably on-site) for safekeeping.

Duties of the ECO / ELO officer:

1. The ECO / ELO officer should ensure that the incident is reported on SAHRIS. (The ECO / ELO officer should ensure that he / she is registered on the relevant SAHRIS case with SAHRIS authorship to the case at the time of appointment to enable heritage reporting].
2. The ECO / ELO officer should ensure that the incident report is forwarded to the heritage specialist for interpretive purposes at his / her soonest opportunity and prior to the heritage site inspection.
3. The ECO / ELO officer should facilitate appointment of the heritage specialist by the developer / construction consultant for the heritage site inspection.
4. The ECO / ELO officer should facilitate access by the heritage specialist to any retrieved artefacts / objects / remains that have been kept in safekeeping.
5. The ECO / ELO officer should facilitate coordination of the heritage site inspection and the SAPS site inspection in the event of a human remains incident report.
6. The ECO / ELO officer should facilitate heritage reporting and heritage compliance requirements by SAHRA / the relevant PHRA, between the developer / construction consultant, the heritage specialist, the SHE / SHEQ officer (where relevant) and the SAPS (where relevant).

Duties of the Developer / Construction Consultant:

The developer / construction consultant should ensure that an adequate heritage contingency budget is accommodated within the project budget to facilitate and streamline the heritage compliance process in the event of identification of incidental palaeontological, archaeological and cultural heritage resources during the course of development, including as a norm during vegetation clearing, surface scraping, trenching and excavation phases, when resources not visible at the time of the surface assessment may well be exposed.

Appendix C:

Resumé
Karen van Ryneveld
2017

Name: Karen van Ryneveld

Contact Details:
1) Mobile – 084 871 1064
2) E-mail – karen@archaeomaps.co.za
3) Website – www.archaeomaps.co.za
4) Postal address – Postnet Suite 239, Private Bag X3, Beacon Bay, 5205

Company: ArchaeoMaps cc

Occupation: Archaeologist

Qualification: MSc Archaeology (WITS University – 2003)

Accreditation:
1) Association of Southern African Professional Archaeologists (ASAPA) accredited Cultural Resources Management CRM practitioner [member nr – 163]
    - 2010 – ASAPA CRM Section: Principle Investigator – Stone Age
    - 2005 – ASAPA CRM Section: Field Director – Iron Age & Colonial Period

2) SAHRA, AMAFA, EC PHRA and HWC listed ASAPA accredited CRM archaeologist

Tertiary Education

2015 – Present	**University of Fort Hare (UFH), East London** (MPhil Environmental Studies)
2010	**University of South Africa (UNISA), Pretoria** (Project Management 501)
2006 – 2007	**Nelson Mandela Metropolitan University (NMMU), Port Elizabeth** (Undergraduate Certificate in Geographical Information Systems – GIS)
2001 – 2003	**University of the Witwatersrand (WITS), Johannesburg** (MSc Archaeology)
1999 – 2000	**University of Pretoria (UP), Pretoria** (BA Hons. Archaeology)
1991 – 1993	**University of Pretoria (UP), Pretoria** (BA Archaeology & History of Art)

Courses

2016/01	SPA (Safety Passport Alliance) – Petrol Retail [SA Safety Management Training Services – SMST]

Employment – Professional Archaeology

2007/04 – Present	ArchaeoMaps [Self-employed] (Archaeologist – CRM)
2006/06 – 2007/03	National Museum, Bloemfontein (Archaeologist – CRM, Dept. of Archaeology)
2005/04 – 2006/05	McGregor Museum, Kimberley (Archaeologist – CRM / Research, Dept. of Archaeology)
2004/04 – 2005/01	Amafa aKwaZulu-Natali (HoD: Archaeology, Palaeontology & Meteorites Unit – APM Unit)
2002/09 – 2004/03	McGregor Museum, Kimberley (Archaeologist – CRM / Research, Dept. of Archaeology)

Employment – Freelance: Ground Penetrating Radar

2015/10 – Present	Terra Scan assistant (BCM area, EC) – GPR & underground utilities focussing on petrol retail (oil & gas) industry

Archaeology – Summary

Karen has been involved in CRM archaeology since 2003 and has been the author (including selected co-authored reports) of approximately 500 Phase 1 AIA studies. Phase 1 AIA work is centred in South Africa, focussing on the Northern and Eastern Cape provinces and the Free State. She has also conducted Phase 1 work in Botswana (2006 / 2007). In 2007 she started ArchaeoMaps, an independent archaeological and heritage consultancy. In 2010 she was awarded ASAPA CRM Principle Investigator (PI) status based on large scale Phase 2 Stone Age mitigation work (De Beers Consolidated Mines – Rooipoort, Northern Cape, 2008 / 2009) and has also been involved in a number of other Phase 2 projects including Stone Age, Shell Middens, Grave / Cemetery projects and Iron Age sites.

In addition to CRM archaeology she has been involved in research, including the international collaborations at Maloney's Kloof and Grootkloof, Ghaap Plateau, Northern Cape (2005 / 2006). Archaeological compliance experience includes her position as Head of the Archaeology, palaeontology and Meteorites (APM) Unit at AMAFA aKwaZulu-Natali (2004).

Company Profile

Company Name : ArchaeoMaps cc
Registration Number : 2005/180719/23
VAT Number : Not VAT Registered
Accountant : AZIMA Financial Services
Members / Shareholders : Karen van Ryneveld (100%)
BBBEE Status : Exempted Micro Enterprise (EME)

PART C4.3: AQUATIC INVESTIGATION REPORT

BUTTERWORTH DROUGHT RELIEF PROJECT:

CONSTRUCTION OF A NEW 7ML RESERVOIR AND A PIPELINE FROM THE TSOMO RIVER TO RELEASE WATER INTO UPPER TRIBUTARIES OF THE XILINKA RIVER FLOWING INTO THE XILINKA DAM

AQUATIC HABITAT AND BIOTA STUDY

Report prepared for

INDWE ENVIRONMENTAL CONSULTING CC

MAY 2017

by

Anton Bok Aquatic Consultants cc
5 Young Lane, Mill Park,
Port Elizabeth 6001
Tel.: 041 3733464

email: antonbok@aquabok.co.za

ANTON BOK AQUATIC CONSULTANTS

Trading as ANTON BOK & ASSOCIATES

EXECUTIVE SUMMARY

Project Proposal

The Butterworth Drought Relief Project proposals include:

a) The construction of a water supply pipeline from the Tsomo River to the upper Xilinka River, which flows into the Xilinka Dam;

b) The construction of a 7ML Reservoir on a high ridge upslope of the Xilinka River catchment;

c) The proposed release of between 130 l/s and 300 l/s of raw water pumped from the Tsomo River into the upper tributaries of the Xilinka River.

Purpose of the Study and Methods used

This specialist aquatic study was undertaken to provide the relevant aquatic impact assessment report contributing to the environmental impact assessment in terms of EIA Regulations of December 2014, pertaining to the National Environmental Management Act, 1998 for the above project. In addition, the environmental data presented will feed into the Water Use Licence Application (WULA) for this project in terms of Section 21(c) and (i) of the National Water Act, 1998. Data from previous ecological studies undertaken in the area were obtained from available databases and published reports. In addition, a field inspection was undertaken on 9th May 2017 of the proposed pipeline route and receiving tributaries, with particularly attention given to the watercourses potentially impacted by this activity.

Characteristics of the Sites

Conservation Planning Studies

The National Freshwater Ecosystem Priority Areas (NFEPA) study (Driver et al. 2011), classified the catchments of two watercourses along the water pipeline route and the receiving tributaries of the Xilinka Rver as being insignificant in terms of freshwater ecosystem conservation. The DWS (2014) review study on South African rivers gave the **PES** designation for both river reaches in the sub-quaternary catchment along the pipeline route (S50J - 7068 and S50J -7104), as being in a **C-category** (i.e. moderately modified with the ecosystem functions predominantly unchanged). The **ecological importance (EI)** and the **ecological sensitivity (ES**) of the both river reaches at the pipeline crossings were designated in the DWS (2014) study as **moderate**. The field investigation showed both these sites to be highly degraded and largely modified, with both sites thus considered to have a **D** category **PES**. The receiving tributary in the upper Xilinka River (sub-quaternary S70C – 7065) consisted of a badly eroded gulley or donga, with a **PES** in a **D** category with **moderate** ecological importance (**EI**) and ecological sensitively (**ES**) values (DWS 2014).

Aquatic Biota

The highly degraded ecological state of the aquatic habitats, as well as the absence of permanent surface water throughout the year, indicates that the affected watercourses are unable to support important aquatic biota of conservation value.

Assessment of Potential Impacts and Proposed Mitigation

Potential Impacts

Impacts potentially associated with the proposed project include:

1. Increased sedimentation and elevated turbidity associated with disturbance of the stream banks and bed and removal of riparian vegetation during pipeline construction and channel erosion due to release of water into upper tributaries of the Xilinka River;
2. Water pollution due to spillages of harmful chemicals used during construction entering the watercourses.

Proposed Mitigation

The two potential impacts mentioned above could be reduced to low significance by a) implementing appropriate ant-erosion measures at the various structures to be built; b) by ensuring that construction activities are carefully managed to prevent any pollution, and c) extending the pipeline further downstream in the upper Xilinka River to discharge into a relatively stable section of the receiving tributary.

To ensure that no environmental impacts arise during the operational phase in the project, the construction sites should be regularly inspected for flood damage or erosion and any required repairs should be undertaken without delay.

Conclusion

If the mitigation measures as recommended in this report are carefully implemented, the construction and operation of the proposed Butterworth drought relief project proposals should have an insignificant impact on the current functioning and present ecological state (PES) of the various watercourses impacted. The project is therefore considered to present a **low risk** to the ecological integrity of the affected aquatic habitats. It is therefore recommended that the proposed activity should be authorised, subject to the incorporation of the mitigation measured recommended in this report.

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1. INTRODUCTION

1.1 PROJECT OVERVIEW

The Drought Relief Project proposals for Butterworth include:

d) The construction of a water supply pipeline over a distance of approximately 13.6 km from the existing Tsomo River pump-station near Tsomo Town to two potential release points in upper tributaries of the Xilinka River, located about 16.4 km upstream (by river) of the Xilinka Dam,

e) The construction of a 7ML Reservoir on a high ridge upslope of the Xilinka River catchment, about 2 km north-west of the pipeline branch-off to the proposed water release points.

f) The proposed release of between 130 l/s and 300 l/s of raw water pumped from the Tsomo River into the upper tributaries of the Xilinka River.

The infrastructure associated with the project and the topographical features are shown in Figure 1 below.

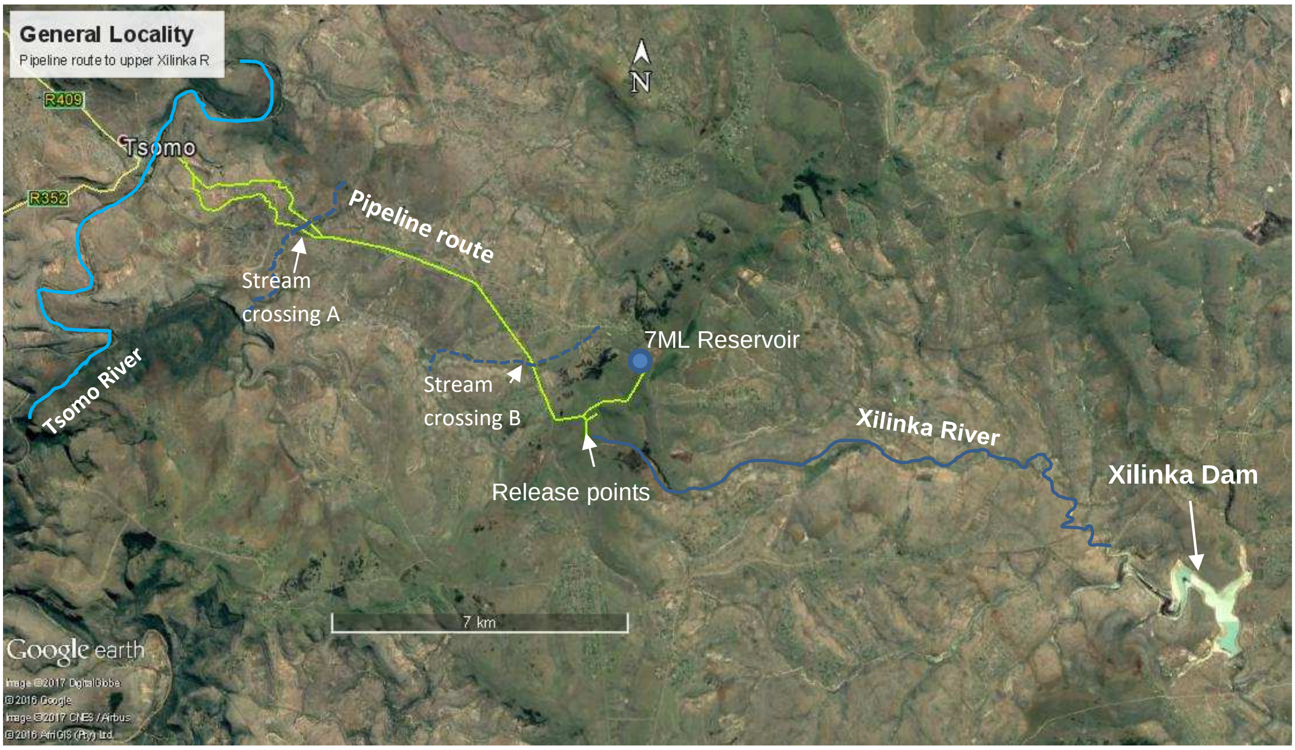

Figure 1. General locality map of the proposed pipeline from the Tsomo River to the upper reaches of the Xilinka River.

1.2 Terms of Reference

The main aim of this investigation is to provide the relevant specialist aquatic report forming part of the environmental impact assessment in terms of EIA Regulations of December 2014, pertaining to the National Environmental Management Act, 1998 for the above project. In addition, the study was designed to contribute relevant environmental information to support the Water Use Licence Application (WULA) in terms of Section 21(c) & (i) of the National Water Act, 1998. This investigation thus involved the following:

1. Assessment of the potential impacts on the aquatic habitats (and aquatic biota, if any) along the pipeline route and receiving tributaries associated with the proposals for the Butterworth Drought Relief Project. Aspects of importance included:

a) The present ecological status (PES) and presence of ecologically important and sensitive habitats associated with the two watercourses or small streams along the pipeline route, namely Stream Crossing A and Stream Crossing B (Mjula Stream), as well as the receiving tributary and upper Xilinka River, as shown in Figure 1 above;

b) The potential impact of the pipeline crossings on the two watercourses and the impact on the receiving watercourses of water released from the pipeline.

2. Production of a report giving the result of the above investigations, including recommendations regarding reasonable mitigation measures to eliminate or reduce any identified impacts to acceptable levels during both the construction and operational phases.

1.3 Methods

The following methods were employed during this study:

- Available data from previous studies on the present ecological status and the ecological importance and sensitivity of the aquatic environments potentially impacted, were reviewed.
- A field visit was undertaken on 9th May 2017 to inspect the instream and riparian zones and assess the present ecological status and sensitivity of the affected watercourses impacted by the proposed construction activities and water releases.
- The findings were incorporated into a report which included an assessment of potential impacts and recommended mitigation measures.

1.4 Assumptions and Limitations

The scope of work was limited to a desktop review of available information and to a single walk-over inspection of the study area, in particular the aquatic habitats potentially impacted. During the site visit a visual assessment of riparian and instream habitats was carried out which was supplemented by studying Google Earth images of the sites. The field inspection was undertaken during a relatively dry period, when there was no streamflow or very little flow in the affected watercourses.

1.5 Details of Author

Dr Anton Bok (PhD Ichthyology, Rhodes University) has over 35 years of experience in the field of conservation, research and management of rivers in southern and central Africa, with emphasis on fish fauna. Dr Bok worked for Cape Nature Conservation as an aquatic scientist involved in fish research and conservation of aquatic biota and habitats for over 20 years. In 1997 he formed the environmental consultancy *Anton Bok Aquatic Consultants cc,* specializing in environmental impact assessments (EIAs) of developments, mainly those associated with aquatic ecosystems and specifically freshwater fish. Projects undertaken in this field include baseline fish biodiversity surveys for EIAs and studies involving ecological “Reserve” determinations in various rivers in SA, with specialist input on the requirements of fish fauna. Dr Bok has undertaken specialist freshwater fish studies as part of EIA investigations throughout South Africa, the Democratic Republic of the Congo, Zambia, Madagascar, Mozambique and Lesotho. He is a registered professional natural scientist (Pr. Sci. Nat.) in the field of Aquatic Science (Reg. No. 400406/11) and an honorary research associate of the South African Institute for Aquatic Biodiversity, Rhodes University in Grahamstown.

2. DESCRIPTION OF NATURAL ENVIRONMENT AT THE PROJECT SITES

2.1 Description of Sites

2.1.1 Water course A Crossing

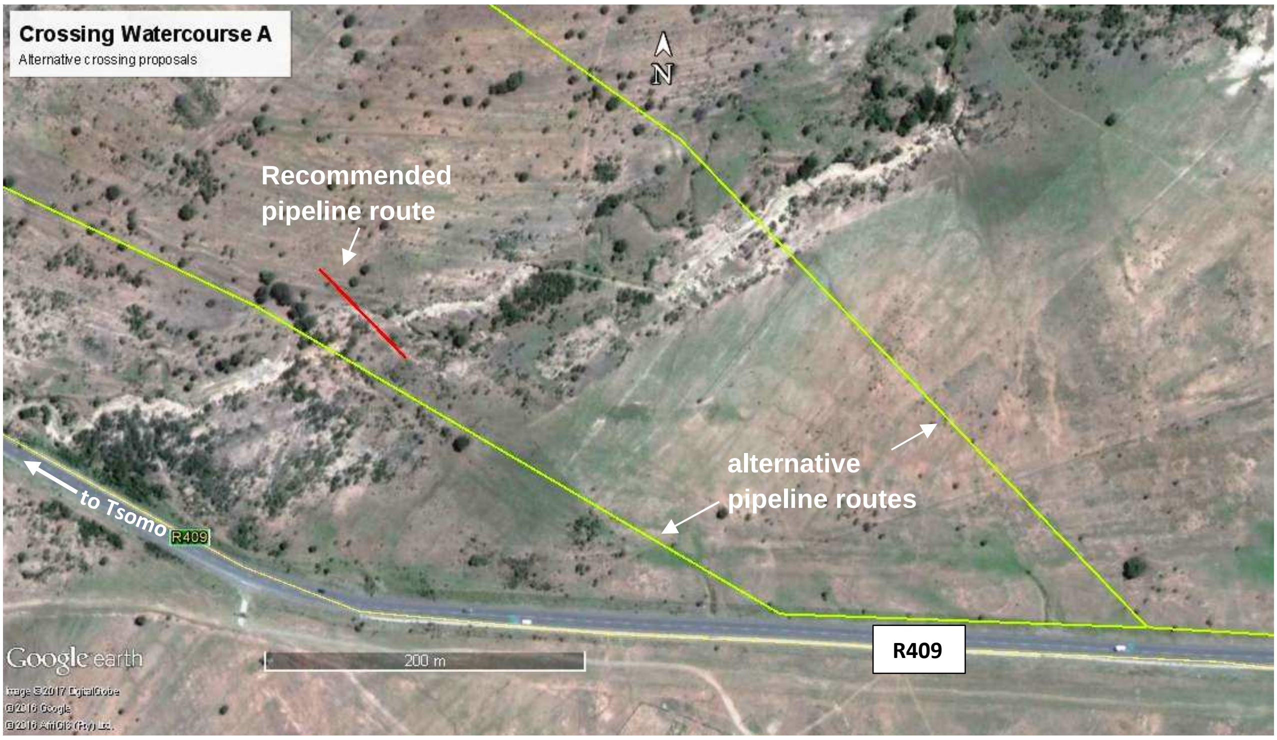

Figure 2. Google Earth overlay of proposed pipeline crossing locations over Watercourse A. The red line marks the preferred crossing site (pers. comm. Dr B van der Waal).

Plate 1. Proposed pipeline route (dotted white line) at preferred crossing location of Watercourse A, as seen from the right bank of the watercourse (dry donga).

As can be seen in Figure 1 and Plate 1, Watercourse A is a highly disturbed ephemeral stream consisting of badly eroded channels with banks from 1m to 3.5m high. The main existing impacts are associated with serious overgrazing and trampling by domestic stock (goats and cattle) and removal of riparian vegetation.

2.1.2 Watercourse B Crossing (Mjula Stream)

Figure 3. Google Earth image of pipeline crossing of Watercours B (Mjula Stream) parallel to the R409.

Plate 2. Pipeline crossing of Watercourse B (Mjula Stream) next to (west of) the R409.

As can be seen in Figure 3 and Plate 2, Watercourse B (Mjula Stream) is highly degraded with virtually all riparian vegetation removed by both local villagers and grazed by domestic stock. The pipeline crossing parallel to the R409 is at an old flood-damaged low-level causeway, with broken sections of the old causeway pipes lying in the channel.

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2.1.3 Release Tributaries

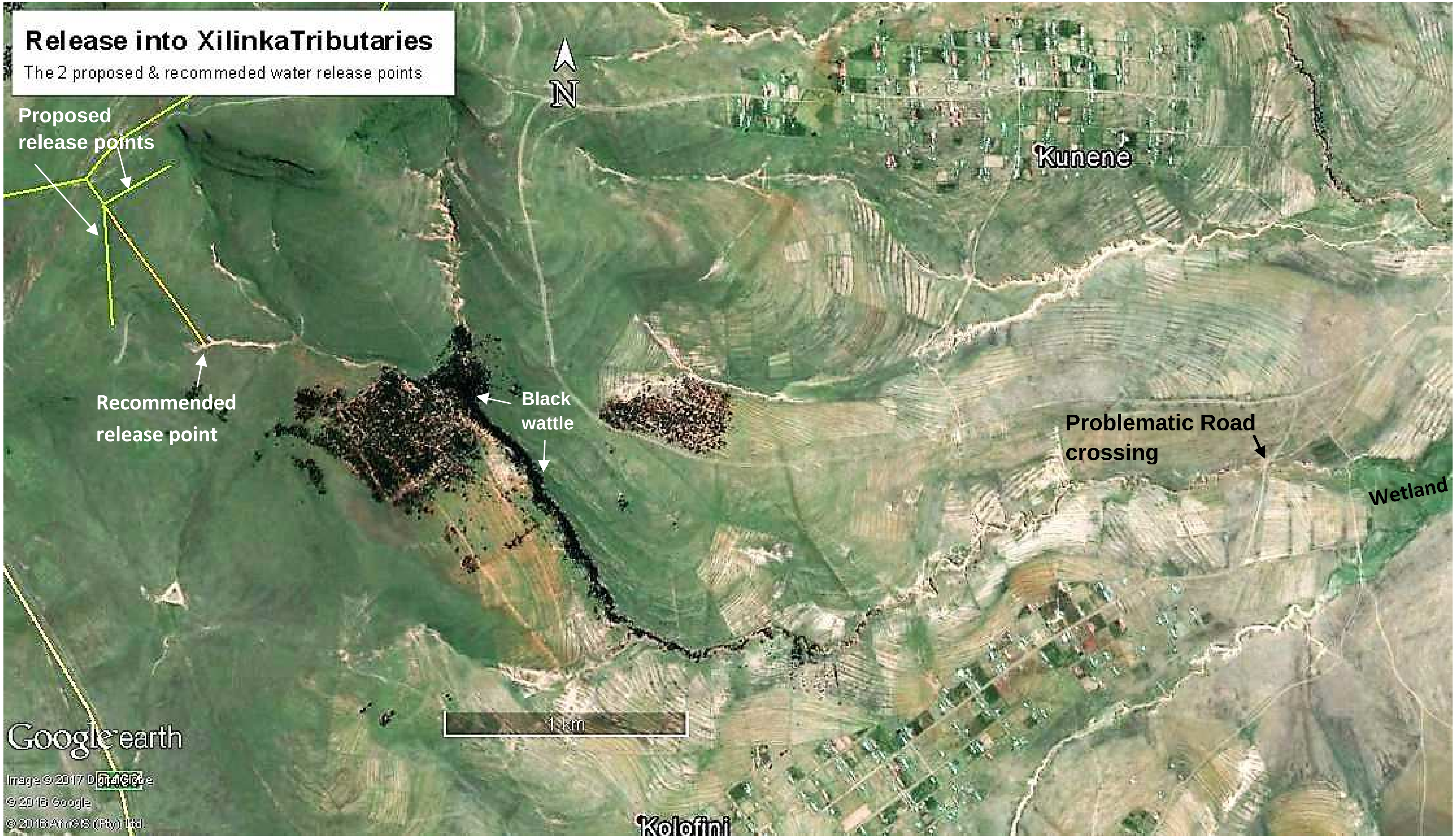

Figure 4. Upper Xillinka River showing proposed (yellow lines) and recommended (white line) water release points, as well as a road crossing about 5 km downstream (by river) of the release point, upstream of the large wetland. Note black wattle invading the watercourse.

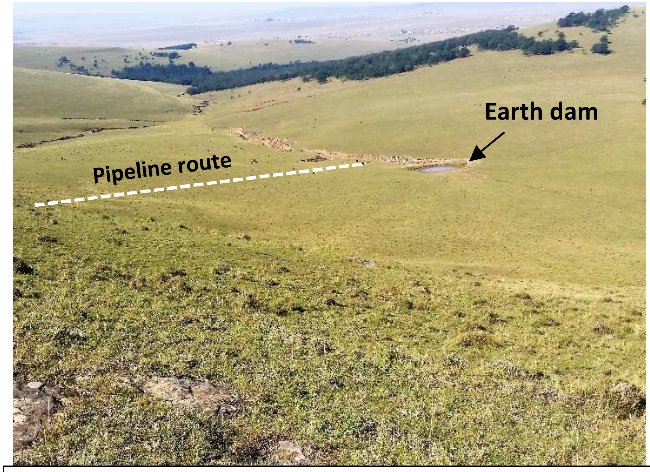

Plate 3. Recommended release location in an eroded gulley below an existing earth dam.

Plate 4. Eroded donga downstream of earth dam at proposed release point.

Plate 5. Eroded dam wall upstream of proposed water release point, looking upstream.

Plate 6. Problematic road crossing some 5 km downstream of release point (looking upstream).

As seen in Figure 3 and Plates 3 to 5, the recommended release point is into an eroded gully about 10m downstream of an existing earth stock-watering dam. As pointed out by Dr B. van der Waal (pers. comm. 9 May 2017), this gulley has already eroded down to bedrock and is considered wide enough to carry the released water without significant bank erosion.

It should be noted that there is a problematic road crossing some 5 km downstream of the proposed release point which according to local villagers, is often impassable after rains. The proposed water releases could exacerbate this problem.

The receiving tributary flows into a large (approximately 250m x 800m) wetland some 5.5km downstream of the release point. As there is no defined stream channel in this wetland, it should act as a sediment sink. Any eroded sediment from upstream should be deposited in this area and not reach the Xilinka Dam itself.

2.2 Existing Spatial Biodiversity and Conservation Planning Data

Information from previous studies of the biodiversity and ecological status of aquatic habitats and biota in the affected sections of the study area was obtained from published scientific literature. In addition, biodiversity and ecological data were obtained from a number of systematic spatial conservation planning studies that have recently been undertaken on rivers in South Africa, including this area, as discussed below.

2.2.1 *National Freshwater Ecosystems Priority Areas project* **(**Driver *et al.* 2011).

The National Freshwater Ecosystems Priority Areas (NFEPA) project **(**Driver *et al.* 2011) identified important freshwater areas in South Africa that require management actions in order to conserve these ecosystems and ensure sustainable use of water resources. These strategic spatial priorities are termed Freshwater Ecosystem Priority Areas or FEPAs. The NFEPA project produced FEPA maps which show different categories with different management implications for freshwater systems. The FEPA map for the study area is given below in Figure 5.

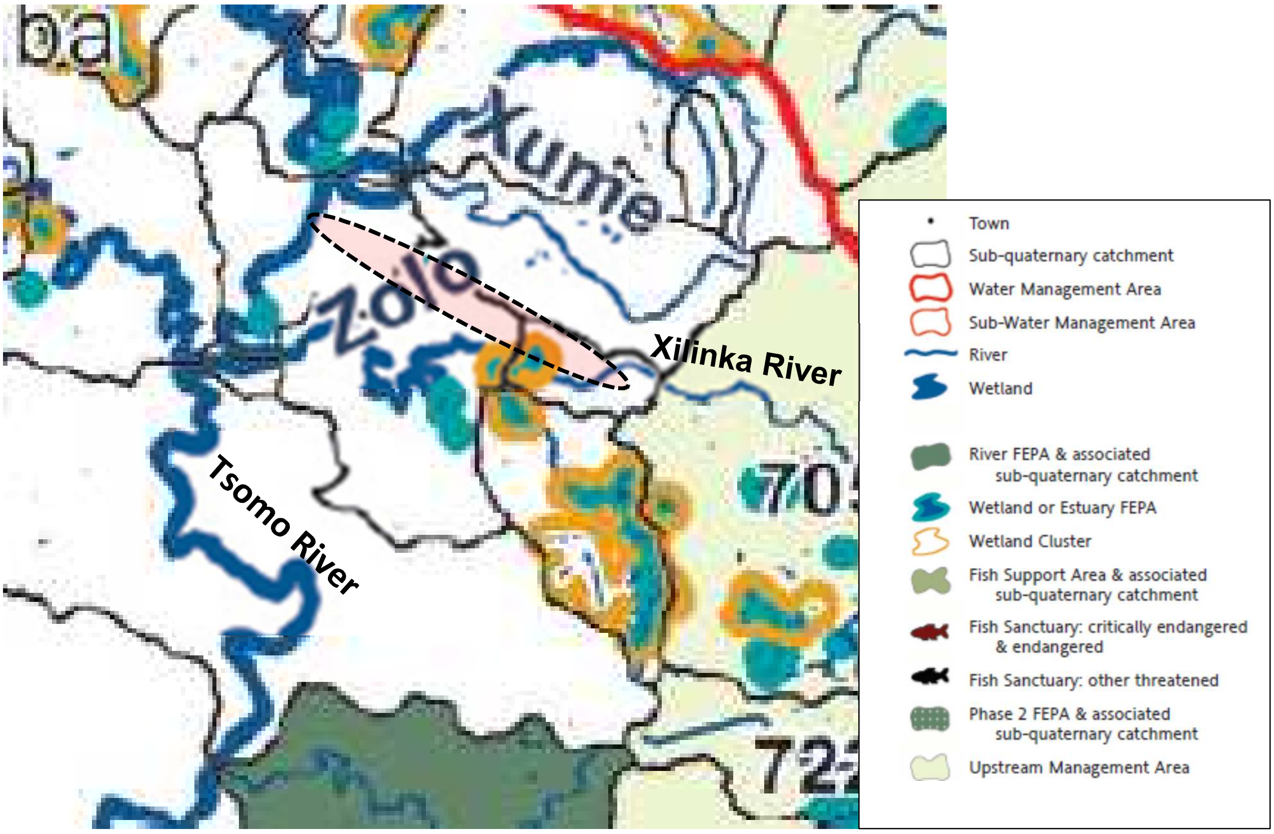

Figure 5. The NFEPA map covering the study area (light red oval) (from Driver *et al*. 2011).

As indicated in Figure 5, the impacted watercourses in the study area are located in the upper Zolo River and Xilinka River catchments which are not considered to fall within a priority area in terms of conservation of the biodiversity of freshwater ecosystems. These areas do not even fall within an Upstream Management Area and are thus considered to have limited conservation value in terms of conserving aquatic biodiversity or ecological functioning of downstream aquatic ecosystems.

2.2.2. Present Ecological Status (PES), Ecological Importance (EI) and Ecological Sensitivity (ES) of South African Rivers (DWS 2014).

The project undertaken by the Department of Water and Sanitation (DWS 2014) to review the DWAF 1999 database on the present ecological status (PES), ecological importance (EI) and ecological sensitivity (ES) data) for South African rivers, took into account all existing biophysical information available on the river reaches within the various sub-quaternary catchments in the country.

The section of pipeline from the Tsomo River to the ridge forming the catchment divide with the Xilinka River, crosses two watercourses, namely an unnamed tributary of the Zolo River (Crossing A) and the Mjula River tributary of the Zolo River (Crossing B). The proposed water release point is located in the upper Xilinka River catchment. The PES, EI and ES values given for these river reaches, taken from the above study (DWS 2014), are given in Table 1 below.

Table 1. The PES, EI and ES of the river reaches within the sub-quaternary catchments in which the proposed infrastructure and potential impacts associated with the Butterworth Drought Relief Project are located (taken from DWS (2014).

SITE	SUB-QUATERNARY (NFEPA CODE)	PES	EI	ES
Crossing A (tributary of Zolo R.) along pipeline from Tsomo River to ridge forming. catchment divide	S50J (7068))	C	Moderate	Moderate
Crossing B (Mjula River) along pipeline from Tsomo River to ridge forming. catchment divide	S50J (7104)	C	Moderate	Moderate
Upper Xilinka River downstream of water release point	S70C (7065)	D	Moderate	Moderate

As shown in Table 1, the **PES** designation for both sub-quaternary catchments for the two watercourse pipeline crossings (S50J - 7068 and S59J - 7104), was given as a **C-category** (DWS 2014). The definition of a C Category is given as: *"Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged",* after Kleynhans (1996).

However, observations during the field inspection on the 9th May 2017 indicated that the two watercourses involved have in recent years been seriously transformed and degraded by man-induced impacts. These impacts include serious destruction of the riparian habitat due to cattle trampling and overgrazing, removal of indigenous riparian vegetation by local villagers, as well as significant catchment erosion due to overgrazing and poor agricultural practices.

The pipeline crossing point at the Mjula River has been further degraded by the construction of the R409 road bridge, as well as by residual impacts from an old flood-damaged low-level causeway at the crossing site (see Plate 2). These impacts have destabilised the stream banks, resulting in bank-slumping and massive erosion. The **PES** values of the two watercourses crossed by the pipeline are thus considered to be in a **D-category,** defined as "*being largely modified, where a large loss of natural habitat, biota and ecosystem functions have occurred*", after Kleynhans (1996).

The recommended receiving watercourse in the Xilinka River catchment consists of a badly eroded gulley or donga originating below a small earth dam (see Plates 3, 4 & 5). Downstream the river channel and riparian zone has been invaded by alien black wattle, further destabilising the banks. Observations during the site investigation of the upper Xilinka River tributaries on 9 May 2017 concur with the previously-mentioned DWS (2014) study that found the receiving watercourse to be largely modified and degraded, and thus to be in a **D** present ecological state (**PES**), as indicated in Table 1 above.

2.3 Aquatic Biota

The absence of permanent surface water in the watercourses at the pipeline crossing points, as well as the serious degradation clearly evident, means that these habitats are unable to support any valuable aquatic life dependent of permanent surface water. In terms of aquatic conservation, these two watercourses are considered to have limited value in terms of supporting aquatic biodiversity.

A visual inspection of the clear shallow pools and runs in the receiving tributary in the upper Xilinka River some 5 to 7 km downstream of the water release point, showed these habitats support common aquatic life such as crabs and tadpoles, but no fish were seen. Any elevated flow in the upper Xilinka River tributary should be of benefit to the large wetland located some 5.5 km downstream and should stimulate growth of existing wetland vegetation presently impacted by overgrazing and periodic dry spells.

It important to note that as both the Tsomo River and Xilinka River are tributaries of the Great Kei River, this project is not considered an inter-basin transfer. In the highly unlikely event of any fish surviving being pumped up into the upper Xilinka River catchment, fish alien to this river system would not be translocated.

3 ASSESSMENT OF POTENTIAL IMPACTS

3.1 Overview

The main potential environmental impacts presented by the proposed Butterworth drought relief projects considered in this study appear to be associated with the following:

1. Elevated erosion and sediment mobilization due to destabilization of the banks of the watercourses crossed by the pipeline and elevated erosion of the channel in the release tributary.
2. Possible changes in quality water (chemical pollution) in the two watercourses crossed by the pipeline associated with the proposed construction activities.

3.2 Assessment of Potential Impacts and Proposed Mitigation

3.2.1 Increased Sedimentation and Elevated Turbidity

Cause and Comment

Disturbance of the stream banks and riparian vegetation during the construction of the pipeline at the two watercourse crossings, as well as elevated flow in the release tributary in the upper Xilinka River, could result in increased erosion and sediment input into the watercourses. Elevated sediment input and raised turbidity levels in the river could have serious negative impacts on aquatic habitats and biota downstream. Reduced water quality due to increased sediment input, together with water pollution due to a variety of factors, is considered one of the biggest threats facing rivers and associated aquatic biota in southern Africa (Skelton 2001).

The negative impacts of elevated turbidity on fish and other aquatic biota, include:

- The whole food web can be disrupted due to reduced light penetration and photosynthesis, resulting in reduced primary production and a reduction in submerged plant life, including phytoplankton.
- Reduced number of benthic organisms (e.g. benthic algae, crabs, small aquatic invertebrates) due to altered substrate composition and smothering.
- Clogging, abrading and damage to fish gills, leading to reduced oxygen absorption, damage to gill filaments, resulting in increased stress, disease and even death.
- Smothering of newly fertilized fish eggs and larval fish.
- Reduced feeding efficiency and slower growth rates, even starvation of fish – this can have a major impact on visual predators as they are unable to see and find enough food in the turbid water and filter feeders are unable to cope with a high proportion of non-food items.
- Deep pools could be filled with sediment, reducing their ability to provide refuge habitat for fish (and other aquatic life) during low flow periods.

Preconstruction

Clearing of top-soil and vegetation cover in preparation for construction of infrastructure near the watercourses, particularly in the riparian zone, could increase soil erosion and sediment input into the adjacent stream channel.

Construction

Run-off from newly-cleared areas and earth-moving activities near the watercourses during construction may increase soil erosion and sediment levels present in stormwater run-off to the adjacent channel, elevating the turbidity, particularly during heavy rains.

Operation

- Elevated flows due to the release of between 130 l/s to 300 l/sec in the receiving tributary, could cause bank erosion and slumping, resulting in elevated sediment input and also turbidity within the watercourse.
- Unless all disturbed areas on the banks and riparian zones of various watercourses are adequately stabilized with vegetation and/or well-designed erosion-protection works which are adequately maintained, flood damage and bank erosion and slumping could occur during heavy rains and/or at high stream flows, resulting in elevated sediment input into the adjacent watercourse.
- Unless the pipeline is buried below the natural ground level at the watercourse crossings and placed in bedrock or protected by appropriate gabion structures, the altered flow patterns during high flows could erode the stream banks.

Significance Statement

Both watercourses to be crossed by the proposed pipeline already have moderately to largely modified present ecological status (**PES of a C and D Category**) due to existing man-induced impacts. The significance of the possible impact of elevated erosion and turbidity due to this project is thus considered to be **moderate**. With appropriate mitigation this should be reduced to a **low** or insignificant impact.

The tributary or gulley recommended to receive the released water (see Figure 4 and Plates 3, 4 & 5) already has a largely modified PES and is eroded down to bedrock in most areas. As this eroded gulley already has a relatively wide channel, the elevated flow should not cause further significant erosion. In addition, any sediment produced should be trapped by the large wetland about 5.5 km downstream.

Impact	**Effect**			**Risk or Likelihood**	**Significance**
	Temporal Scale	Spatial Scale	Severity of Impact		
Preconstruction and Construction Phase					
Without Mitigation	Short term	Study Area	Moderate	May occur	Moderate
With Mitigation	Short term	Study Area	Slight	Unlikely	Low
Operational Phase					
Without Mitigation	Medium term	Study Area	Moderate	May occur	Moderate
With Mitigation	Medium term	Study Area	Slight	Unlikely	Low

Mitigation

- To prevent scouring and erosion at the river crossings during heavy rains via surface run-off as well as during high river flows, appropriate (best practice) gabion protection works and rehabilitation of all disturbed areas on the river banks and riparian zone with appropriate indigenous vegetation will be necessary.
- The pipeline should be buried below the natural ground level at the watercourse crossings and placed in bedrock (if present) and/or protected by appropriate gabion structures or cement casing.
- The recommended pipeline crossing point over Watercourse A shown in Figure 2 and Plate1 (at S 32^0 03’ 12.4”, E 27^0 51’ 44.34”) is at a point where the stream is confined to single channel with a sandstone floor. A pipeline crossing at this site will reduce the risk of future erosion problems.
- Water should be released continually, rather than in short bursts, to prevent the collapse of saturated banks resulting in elevated erosion.

- Details of mitigation measures to prevent destabilization of the river bank and damage to the riparian zones, as well rehabilitation measures using indigenous riparian vegetation, should be set out in the construction environmental management plan (CEMP).

3.2.2 Water Quality: Chemical Pollutants

Cause and comment

Careless and inappropriate construction activities and problematic equipment and machinery (e.g. oil leaks) could result in pollutants such as hydrocarbons, uncured cement, shuttering oils, etc., entering the watercourse during the construction phase. These toxic chemicals associated with the construction activities and machinery used during construction can be very harmful to aquatic biota. During rainfall events or after accidental spillages, these chemical could be washed into the adjacent watercourse and then downstream, posing a risk to downstream aquatic biota, as well as domestic stock and villagers using the water for drinking purposes.

Preconstruction & Construction

- Chemical pollutants (hydrocarbons, drilling and cleaning fluids) associated with site-clearing and earth-moving machinery could wash into the watercourse.
- Hazardous materials & chemical pollutants stored on site and used in construction could accidently spill or be washed into the watercourse channel.
- Uncured concrete and dry cement powder could contaminate the watercourse – e.g. due to heavy rains during construction. It is important to note that uncured cement is highly alkaline and could significantly raise the pH of any water in contact with it to levels lethal to aquatic life.

Operation

The above impacts are associated with the construction phase and pollution risks should be minimal during operation provided appropriate maintenance and repairs are carried out with due diligence.

Mitigation

- Strict use and management of all hazardous materials used on site.
- Strict management of potential sources of pollution (hydrocarbons from vehicles & machinery, cement during construction, etc.).
- Containment of all contaminated water before it can enter the adjacent watercourse.

Significance Statement

During construction there will be a short-term risk of chemical pollution, which could potentially result in impacts of **moderate** significance in the adjacent watercourse and downstream. However, with appropriate mitigation this potential impact could readily be reduced to **low** significance.

Impact	**Effect**			**Risk or Likelihood**	**Significance**
	Temporal Scale	Spatial Scale	Severity of Impact		
Construction Phase					
Without Mitigation	Short term	Study Area	Moderate	May occur	Moderate
With Mitigation	Short term	Study Area	Slight	Unlikely	Low

3.2.3 Monitoring Requirements

All newly-built structures at the two watercourse crossings and the channel of the water release tributary, as well as all riparian areas disturbed during construction, should be regularly inspected for flood damage and any necessary erosion protection and required repairs undertaken without delay.

3.3. Concluding Statement

The potential impacts associated with the proposed Butterworth drought relief project are considered to be of low to moderate significance without any mitigation. However, all **potential impacts** should readily be reduced to **low significance** provided the construction work is carried out with due diligence and appropriate mitigation measures, as recommended in this report, are carried out.

The proposed activity should thus not affect the current functioning or reduce the present ecological state (PES) of the downstream aquatic habitats and biota in the affected reaches of the watercourses impacted. The project is therefore considered to present a **low risk** to the ecological integrity of the affected aquatic habitats. It is therefore recommended that the proposed project should be authorised subject to the mitigation measures set out this report.

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PART C4.4: GEOMORPHOLOGICAL INVESTIGATION

The instream impact and erosion mitigation of flow release down tributaries feeding Xilinxa Dam, Butterworth, Eastern Cape Province.

Geomorphic consequences and preventative options

May 2017

Prepared by Dr BW van der Waal
7 Landsdowne Road
Grahamstown
6140
084 740 7671
bvdwaal@gmail.com

Prepared for: Brendon Steytler
Indwe Environmental Consulting CC
12 Preston Avenue
Vincent
East London
5247
Tel: 043 726 6860
Fax: 086 513 9734
Email: brendon@indwecon.co.za
www.indwecon.co.za

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Glossary

Channel – the outline of a flow pathway where water is concentrated.

Floodout – flat sediment depositional area downstream of a defined channel where water is spread out across the surface.

Flow path – route that runoff will take due to gravity and local topography.

Incision – downward erosion along a drainage line or river resulting in the drainage line floor or river bed being much deeper than the surrounding landscape.

Wetland – area where soils are permanently or periodically inundated or saturated by water.

Specialist statement

This statement has been prepared with the requirements of the Environmental Impact Assessment Regulations and the National Environmental Management Act (107 of 1998), any subsequent amendments and any relevant other National and/or Provincial Policies related to ecological or biodiversity assessments in mind, such as the National Environmental Management: Biodiversity Act (10 of 2004) and National Water Act (36 of 1998).

Prepared by:

Dr BW van der Waal

Qualifications: BSc. (Botany and Geography), BSc. Hons. Geography (Environmental Water Management), MSc Geography (Biogeography) and PhD Geography (Geomorphology), Tools for Wetland Assessment short course.

6 years of experience doing specialist geomorphological assessments.

Signature Date: June 2017

Reviewed by:

Prof KM Rowntree

Qualifications: BSc Hons (Geography), MSc Geography (wetland hydrology), PhD Civil Engineering (sediment modelling).

20 years of experience as geomorphology specialist on river condition studies and environmental flow assessments.

K.M Rowntree

Signature Date: June 2017

1. Introduction

The water supply to the town of Butterworth is severely limited with the Xilinxa Dam, one of the main storage facilities for the town, currently at 2%. The proposed solution is to pump water from the Tsomo River over the catchment divide and release water at a single point down a headwater drainage line flowing into the Toboyi River to enter the Xilinxa Dam. A new pipeline and 7ML command reservoir will be part of the infrastructure needed for the water transfer. It is proposed that 15ML/day with peak flow rate of 270L/s will be released into the Toboyi River (Aurecon, 2017). It is envisaged that the release will take place for 16 hours a day due to the large pump capacity (Aurecon, 2017). Aurecon has proposed two possible pipe outlet options for discharging water into the Toboyi River system. The pipe outlet option with the least environmental threat should be used.

The increased discharge down the Toboyi River system is likely to cause some degradation along the release flow path. Geomorphological specialist inputs regarding the impacts of the targeted tributary were requested to recommend best option for flow release that will minimise receiving stream impacts.

The specialist has been approached to provide the following:

- Desktop assessment and selection of the preferred receiving tributaries in terms of minimal geomorphological disturbance
- Identification of areas sensitive to increased/continuous flow
- Field assessment of the selected receiving tributaries and sensitive areas
- Report on likely impacts, preferred tributary options, recommendations as to receiving stream preparation, stream and streambank erosion mitigation and monitoring.

2. Methods

The study was based on desktop and field methods.

The desktop assessment included aerial and satellite image interrogation along possible flow pathways provided by Aurecon (2017). The planned pipeline route (with two release point options) was loaded onto Google Earth and ArcMap GIS software and was used for further mapping of the receiving channels. High resolution (0.5m) colour aerial orthophotos from 2009 were used in ArcMap to digitize geomorphic features. More recent (2017) satellite images were used in Google Earth to verify the current extent of the digitized features.

Characteristics of the various proposed flow-release pathways, such as channels incised to bedrock, channels incised into alluvium and unchanneled sediment floodouts or wetlands (sediment and water buffers) were mapped. Stream crossings were noted and all headcuts in floodouts were digitized. These spatial data were loaded onto a GPS enabled tablet for verification in the field.

General soil erodibility data were sourced from the South African Atlas of Climatology and Agrohydrology by Schulze (2007).

The field assessment was done during autumn low-flow conditions on the 9th of May 2017. Low-flow conditions are important for assessing drainage line floor stability as there is very little water in the channel. The upper reaches of the likely drainage paths from the proposed pipe outlets (Aurecon, 2017) were visually assessed on foot in order to determine the level of incision, drainage line floor material, width of drainage channel, bank material, floodout sediment composition and signs of headcut activity. The desktop mapping was verified in the field and geotagged, ground-based photos were taken of features along the drainage lines. Changes to channel shape and type were recorded on the tablet. The lower sections of the Toboyi and Xilinxa Rivers were assessed where vehicle access allowed.

3. Present channel condition

The Toboyi River drains to the east and is a tributary of the Xilinxa River and the larger Kei River basin. These rivers are indicated on the 1:50 000 topographical maps as perennial rivers. The Toboyi and Xilinxa Rivers are extensively incised into the landscape from the headwaters to the inlet at the Xilinxa Dam (Figure 1 and 2). The upper 500m of the Toboyi River is underlain by resistant dolerite, whereas the rest of the Toboyi and Xilinxa Rivers are underlain by erodible mudstones. Soil erodibility is moderate on the dolerite and high on the mudstones, especially where dispersive duplex soils are present (Schulze, 2007). Stream banks and gully sidewalls are mostly fine grained mudstone subsoils that are possibly dispersive due to high sodium concentration associated with mudstones (Hardie, 2009; Beckedahl and De Villiers, 2000). The incision has cut down to bedrock along most of the river course, with short sections where deposition occurs in the form of floodouts or unchanneled valley bottom wetlands (Figure 2). Fine sand, silt and clay is deposited on these floodouts. These floodouts are unchanneled and act as an important buffer for water and sediment in the landscape (Figure 3). Upstream of the floodouts the incised channel has partly filled with sediment and is indicated as 'incised in alluvium' in Figure 2. These floodouts or depositional zones are the most sensitive to degradation or incision through gullying. Headcuts are present within the depositional zones, cutting a channel or gully into the deposited sediment (Figure 4 and 5). These headcuts are active and will advance during times when water is falling into the base of the headcut, eroding the supporting subsurface layer, leading to the collapse of the upper more stable layer. This upstream headcut propagation is a natural cut-and-fill process that reworks and redistributes sediment (Temme et al., 2008). This process can be accelerated by changes to flow, especially increased flow associated with the proposed activity.

Figure 1: Images of the Toboyi River incised to bedrock along its upper (left) and middle reaches (right).

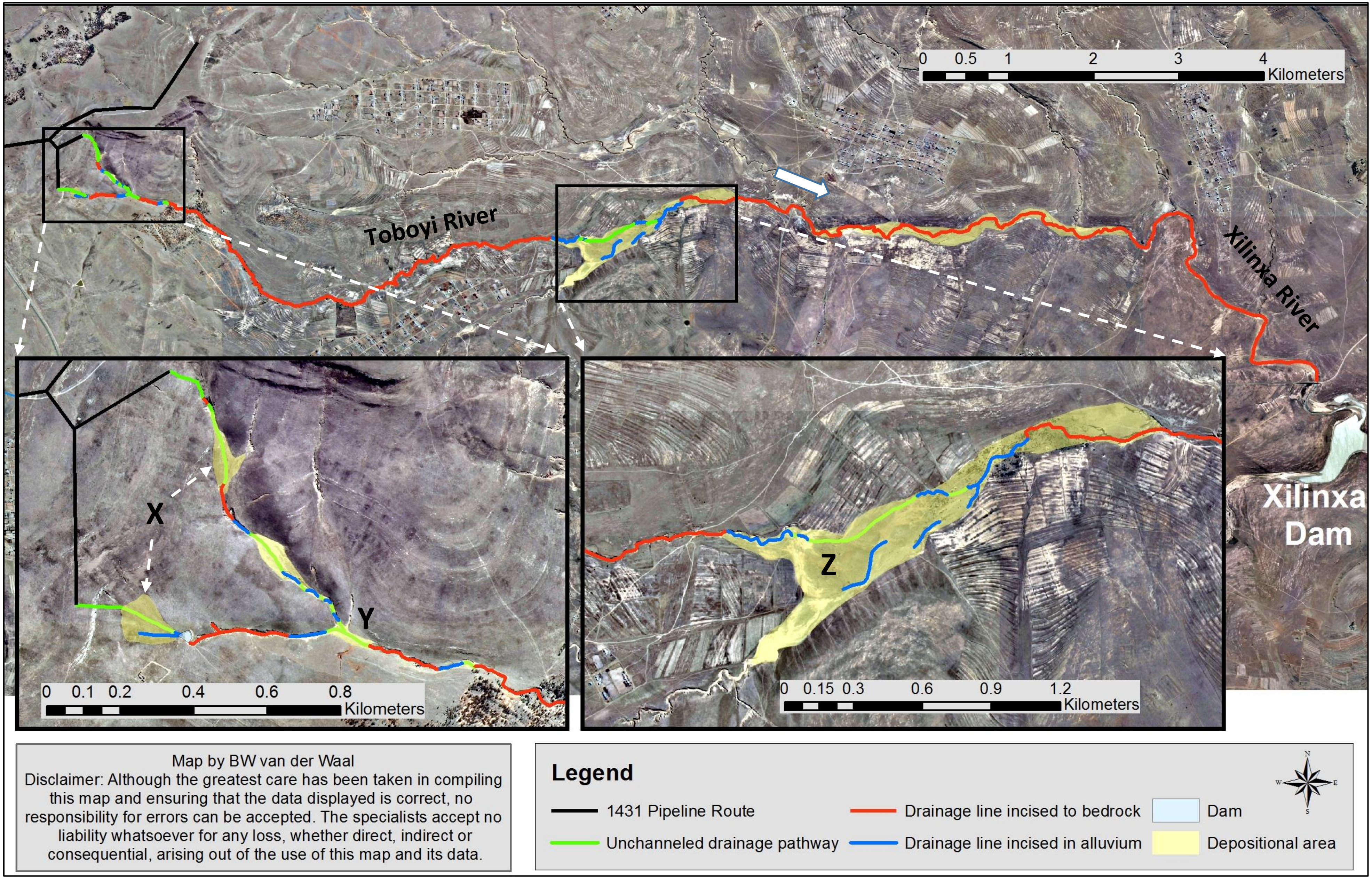

Figure 2: State of the drainage pathway of water released into the Toboyi and Xilinxa Rivers. Flow direction indicated by a white arrow.

Figure 3: Image of a floodout or sediment deposition area (circled in black) in the upper Toboyi River catchment.

Figure 4: Image of an active headcut in the upper Toboyi River catchment. Note the slumping of grassed topsoil where erosion is taking place.

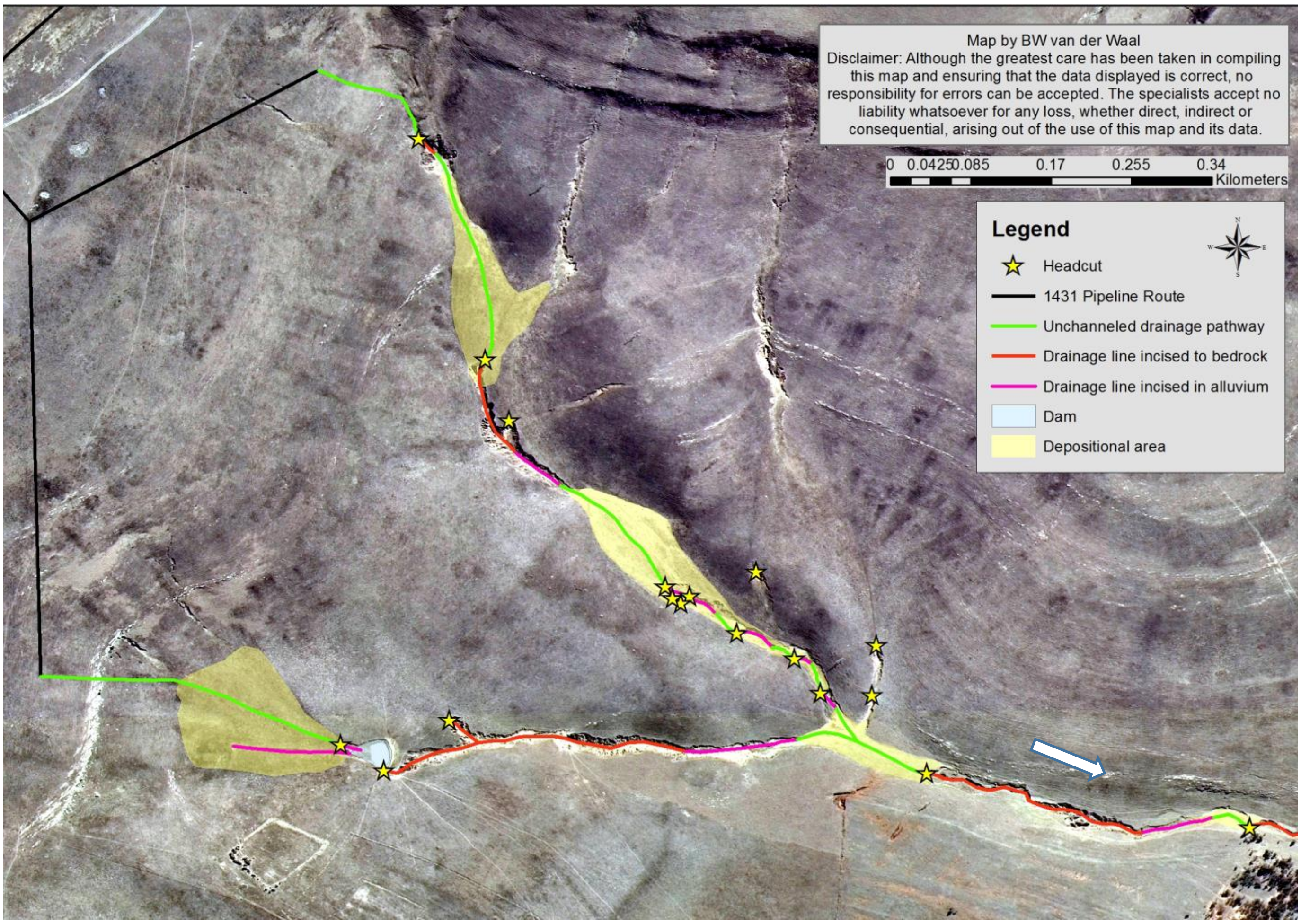

Figure 5: The location of active headcuts along the upper Toboyi River. Flow direction indicated by a white arrow.

4. Likely geomorphic effects of additional flow on channels and depositional areas

The general expected outcome of the addition of water to a drainage line is incision or channel degradation due to increased energy to erode and transport sediment. This is clearly indicated by Lane's balance in Figure 6 where transport capacity will be increased, tipping Lane's balance towards 'degradation'.

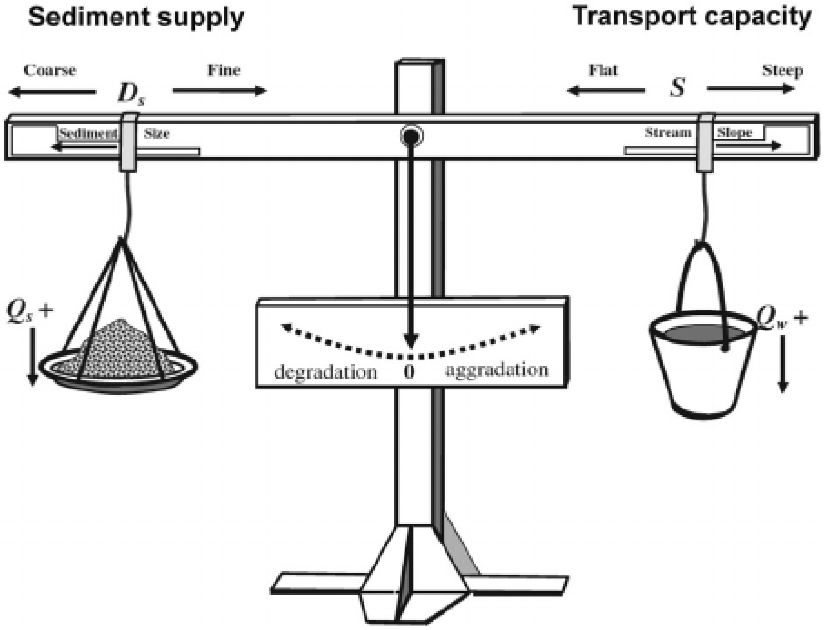

Figure 6: A conceptual diagram by Lane (1955) showing likely channel response due to changes to discharge.

Cases of channel degradation due to increased discharge have been recorded in the literature. Severe channel incision has been described by Du Plessis (2000) where an Inter-basin Transfer (IBT) transferring Orange River Water (Orange-Fish-Sundays River Inter-basin Transfer Scheme) into a first order (small) stream (Skoenmakers River). The hydrology was changed to the extent that the IBT release was much greater than natural flood flows of the Skoenmakers River. This caused severe erosion and channel incision along the upper reaches of the receiving stream. Beckedahl and De Villiers (2000) described severe erosion associated with road culverts concentrating runoff on mudstones in the former Transkei area.

In the case of the Tsomo-Toboyi River transfer, the peak release volume of 0.27m^3.s^{-1} is much less than flood volumes with a two year recurrence interval (Table 1). Peak discharge for an event with a two year recurrence interval was calculated for three of the wetlands (ranging from the smallest wetland catchment to largest wetland along the Toboyi River) to determine the ratio of ITB release to natural peak discharge prediction for the Toboyi River. The cases were:

- the uppermost sediment depositional areas (X in Figure 2; catchment size of ~15 ha)
- the sediment deposition area at the confluence of the two highest tributaries (Y in Figure 2; catchment size of ~100 ha)
- the larger sediment depositional area 7km along the Toboyi River (Z in Figure 2; catchment size of ~1300 ha).

The Rational Method as described by SANRAL (2007) was used to calculate peak discharge. A rainfall event of 45mm with a 2 year return period was used as this is a likely size of event that the flow pathway is adjusted to along the alluvial sections (Wolman and Miller, 1960). It was calculated that the upper most sediment deposition zone's (marked X in Figure 2) peak flows will be increased by 27%, whereas only by 4.2% at the confluence of the two minor drainage lines (marked Y in Figure 2; Table 1). At the downstream sediment depositional area (marked Z in Figure 2) the increase in discharge will be negligible at 0.3%. It is likely that the increase in peak discharge will have some effect on the upper sediment depositional areas as peak discharge is increased by more than a quarter, but no significant effect lower down.

The other consideration is the duration of the release. Although the increase in peak discharge is relatively small, the flow will be more continuous under the proposed release conditions than under present day conditions. This will allow the floodouts to become saturated and erosional processes, such as undercutting, slumping and bank collapse, to occur at the headcuts. This could result in slow, but continuous erosion at headcuts, causing extensive erosion over time. It is likely that the headcuts at X and Y in Figure 2 will advance at an increased but steady rate as a result of the addition of continuous flow. Due to the catchment size of the lower sediment depositional area at Z in Figure 2, the effects of erosion due to the release are expected to be negligible.

Table 1: Peak discharge calculations for various sediment deposition zones along the Toboyi River.

Drainage area (ha)	Peak discharge for event with 2 year recurrence interval ($m^3.s^{-1}$)	Peak release ($m^3.s^{-1}$) (Aurecon 2017)	Ratio of release: 2year event as %
15	1	0.27	27
100	6.5	0.27	4.2
1300	88	0.27	0.3

As most of the Toboyi and Xilinxa Rivers are incised to bedrock and widened to accommodate flood flows larger than 0.27 $m^3.s^{-1}$, these sections will remain stable given the relatively small release flow. These channels have widened to such an extent that the incised channel floor is between 1.5 and 8m wide. Along the narrower sections erosion will occur along the banks, but this will be limited to short sections (20 – 50m) in length where stream banks are likely to steepen as a result of channel widening. This sediment production will slow as soon as the channel has adjusted to the release volume of 0.27 $m^3.s^{-1}$.

The depositional areas are threatened by headward erosion. Several headcuts are present in the vicinity of the sediment depositional areas and as they are active, are likely to advance further upstream during flow releases (Figure 5). The headcuts can be stabilised to reduce the undercutting of the base materials and associated bank collapse and slumping.

The majotity of eroded sediment will be deposited in floodout areas downstream along the Toboyi River. Due to the extensive size of the floodout at Z in Figure 2, it will act as a sink for sediment eroded from upstream channels and sediment depositional areas, thus a minimal volume of sediment will make it to the Xilinxa Dam (provided the sediment sink at Z remains stable). Ongoing deposition of sediment in the floodout Z in Figure 2 will lead to the steepening of the floodout slope and eventually lead to erosion thereof.

5. Recommendations

Below are recommendations regarding the release points, methods to stabilise the incision of headcuts and methods of monitoring erosion along the drainage line. Notes are included on areas where the proposed pipeline crosses streams and where vehicles cross the Toboyi River.

5.1. Release options

Pipe outlets A and B and an additional pipe ending at C are shown in Figure 7. Pipe ending C will minimize the likely erosion along the sediment depositional features and is thus the recommended option. Pipe outlet A will have the highest risk of accelerated channel degradation as there are nine headcuts along the drainage path eating into the ~700m of unchanneled sediment deposit or soil (Table 2). Protecting all nine headcuts will be costly. The first 100m below the pipe outlet is steep grassed hillslope (30% slope) and will be susceptible to erosion due to its gradient. Livestock are likely to trample these wet areas along the flow path, further increasing the risk of soil erosion.

Pipe outlet B is likely to be of lower sediment erosion risk compared to A, as the channel network has four active headcuts and can possibly erode 450m of unchanneled drainage pathway (Table 2; Figure 8). One of these headcuts is approaching a small-dam spillway and might cause community upset if this feature is lost (important drinking point for livestock)(Figure 8). The first 100m below the pipe outlet is steep grassed hillslope (30% slope) and will be susceptible to erosion due to its gradient. Livestock are likely to trample these wet areas along the flow path, further increasing the risk of soil erosion.

Pipe outlet C would pose the lowest threat to erosion of steep grassed hillslopes and unchanneled sections of the drainage pathway as this site has two headcuts along 166m of unchanneled sediment deposit (Table 2; Figure 8).

The additional water will possibly increase vegetation growth along the release pathway, mitigating any erosion risk. Due to the location of the site in communal grazing land the increased vegetation growth will attract livestock. This will result in trampling of vegetation and destabilising of surface soils. This can initiate and promote soil erosion and thus should be avoided. Fencing is an effective option for managing livestock access to these sensitive areas.

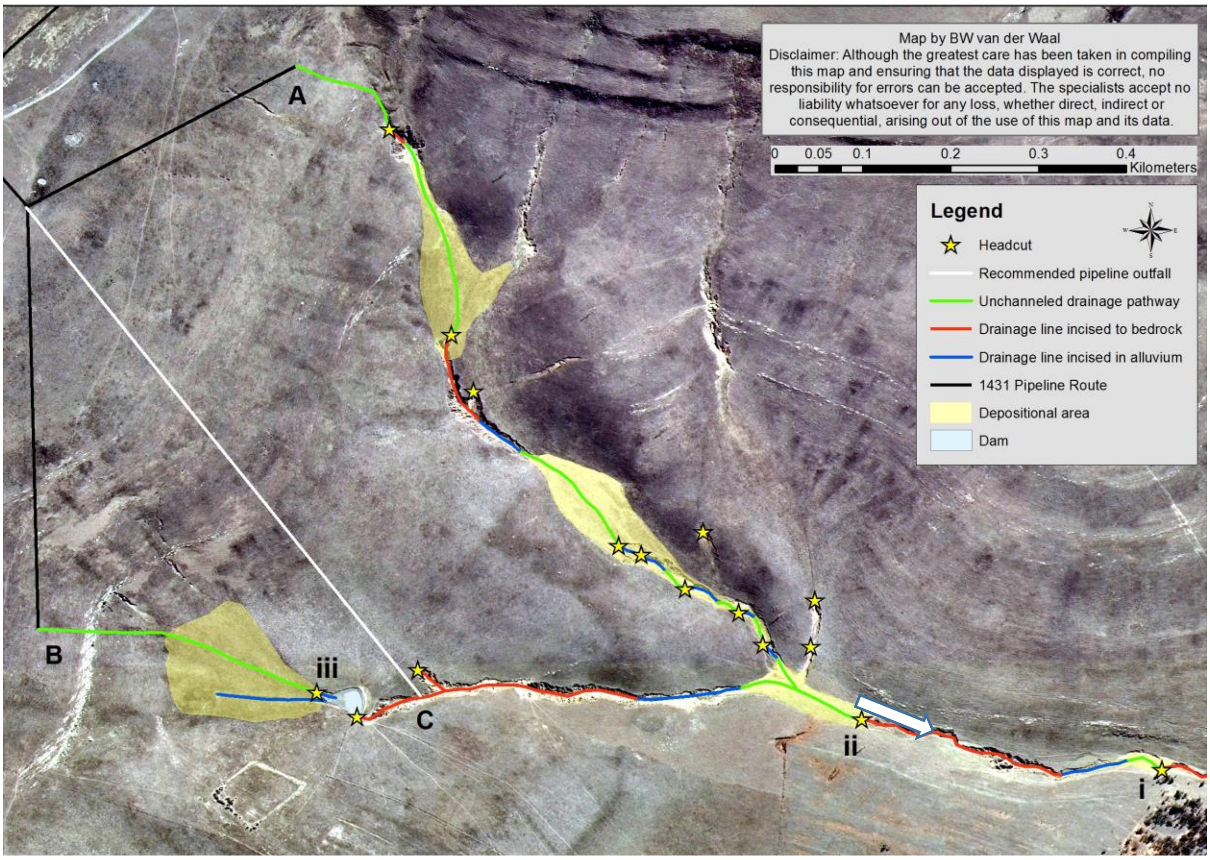

Figure 7: Pipe outlets and headcut stabilisation options. Flow direction indicated by a white arrow.

Table 2: Pipe outlet options giving number of active headcuts, length of unincised flow path.

Pipeline ending	Number of existing headcuts	Length of unchanneled section (m)	Length of channel incised into alluvium (m)
A	9	702	249
B	4 (one at dam outlet)	451	169
C	2	166	169

*Figure 8: Images of a) the headcut (at **i** in Figure 7), b) the headcut (at **ii** in Figure 7), c) the headcut at dam spillway (at **iii** in Figure 7) and d) headcut upstream of the dam.*

5.2. Stabilisation of soils and headcuts

It is recommended that the headcuts along the chosen route are stabilised to prevent further degradation of the sediment depositional areas associated with more permanent flow from the release point. Various options are available to stabilise headcuts:

- construct a weir or gabion to lift the channel height and effectively drown-out the headcut
- construct a chute so water enters the lowest portion of the channel without further erosion of the base sediment
- similar to a chute, a pipe can be installed to concentrate the water in the pipe upstream of the nick point and release it in the lowest part of the incised channel (Figure 9; see Russell et al. (2009) for details on design).

Gabions are not preferred as they are easily vandalised, are prone to rust, need frequent maintenance and are often undermined by tunnel erosion (Pers. Comm. J. Buckle). All of these options are high risk as the soils are relatively unstable and likely to be dispersive along the Toboyi River, thus easily undermined by tunnel erosion. To reduce the risk of structure failure, the structures should be well keyed into the banks and frequently monitored. Soils used for backfilling should be treated with hydrated lime, alum or polyacrylamides and compacted to 9.3kg/cm^2 if the soils are dispersive (Hardie, 2009).

Figure 9: Examples of headcut control structures: a) weir, b) gabion, c) and d) chute (photos by J Buckle).

If water is released from point A or B (Figure 7), then soil erosion on the hillslope will be likely due to steep nature of the slopes (30% slope) and the moderate erodibility of these soils. It is likely that the vegetation cover will increase due to the augmented availability of soil moisture and should limit soil erosion. If the vegetation or soil surface is disturbed along the flow path erosion is likely and an intervention will be needed to prevent erosion. The released water will gain erosive energy over a short distance, thus an erosion resistant lining or energy breaks will be necessary. A lining will create an open canal protecting the soil from eroding. This lining can be temporary and can be removed once the water is no longer released. Energy breaks can be accomplished by installing various pervious barriers that will slow and spread the water. Erosion control fences can be made of geotextiles that are installed vertically along the contour lines (Coetzee, 2016). Due to the steep slope they will need to be installed at 1.5m intervals along the slope (one fence for every 0.5m drop in elevation) and should be wide enough to capture all the flow at each level. Care should be taken to install these correctly so water is not undercutting the fences or concentrated and diverted along the fence, as this will cause further erosion. These erosion fences are best used on low angled slopes and are easily damaged by livestock and fires (Coetzee, 2016).

5.3. Monitoring

The receiving hillslope directly below the discharge point will be the most sensitive to the flow release due to the relatively large flow volume and associated erosional energy and will thus require frequent assessment of erosion. The hillslopes and floodout areas should be monitored to see if the vegetation cover remains dense and if signs of erosion are observed. Fixed point photography will be best along the drainage pathway, having fixed stations 50m apart for the hillslope sections below pipe ending A or B (Figure 7) and unchanneled floodouts. All gully headcuts along the flow path should be included in the monitoring. Photos should be taken on a monthly basis and erosion control fences should be installed immediately should any surface erosion be detected. If the erosion is more severe (more than 20cm deep) then larger structures will be needed to prevent further incision.

The headcut control structures should be monitored on a monthly basis (visual inspection for signs of erosion around the structure), with immediate remediative action should erosion be observed. The headcuts at the larger floodout Z (Figure 2) should also be assessed and photographed on a monthly basis, so action can be taken to prevent further erosion along the flow path in this wetland. A headcut control structure might be needed should erosion be noted along this flow path through the wetland.

The stream banks and gully sidewalls will erode along narrow sections to adjust to the increased flow. Due to the wide nature of most of the incised channel and gully, this erosion should be negligible.

5.4. Notes on river crossings

The proposed pipeline route has two options for crossing the drainage line in Figure 10.

- The western option is the better of the two proposed options as the channel is relatively confined with no floodplain. The channel is incised (>3,5m) with various gullies along the proposed river crossing.
- The eastern option should be avoided as it crosses a small floodplain with three flood channels. The channel is deeply incised (>3,5m) with an unstable bed.
- An alternative option is suggested along the yellow line in Figure 10 (crossing point at -32.053475°; 27.862443°). The pipe will cross the stream where the stream is most confined (no floodplain or secondary channels/gullies) and has banks that are ~2m high. The floor is sandstone and should be resistant to rapid erosion. Best would be to place the pipe below the surface of the bedrock so as not to dam water in the channel (banks could be/are dispersive and can cause tunnelling around the structure). The banks are likely to be dispersive soils, so erosion of backfilled soil will be an ongoing issue unless treated chemically with hydrated lime, alum or polyacrylamides and compacted to 9.3kg/cm^2 (Hardie, 2009).

Figure 10: Proposed drainage line crossings of the pipeline (orange line) along the R409 (Google Earth image). The yellow line indicates the best geomorphic location for crossing the stream.

There are several vehicle crossing points along the Toboyi River channel. These crossing points can only be safely used during low flow as there is no bridge or culvert at any of the crossings. Only one of the crossings was used frequently and serves as the main access route to Kunene Village (Figure 11). This crossing (-32.103200°; 27.984985°) could benefit from bridge infrastructure to allow access to the village during higher flow events. However, the peak release flow of $0.27m^3.s^{-1}$ will result in a flow depth of <10cm deep and should not pose a threat to pedestrians or vehicles. A syphon could be installed with a capacity large enough to convey the released flow below the bed of the crossing point. Care should be taken when using this crossing during times of high runoff, as is currently the case.

Figure 11: Image of the main drift crossing the Toboyi River.

6. Conclusions

The release of $0.27m^3.s^{-1}$ along the incised Toboyi and Xilinxa Rivers will have very little effect on stream morphology and functioning as these streams are in a degraded state and incised to bedrock along most of the river course. Sensitive areas are limited to the upper reaches of the Toboyi River where buffers exist in the form of floodouts or unchanneled valley bottom wetlands. These floodouts all have active headcuts eroding the stored sediment. Due to the proposed constant flow release the headcut erosion can be accelerated. This can be prevented by installing erosion control structures. The lowest and largest wetland is likely to remain stable without erosion control interventions. The wetlands higher up will need headcut control structures to prevent accelerated erosion. It is recommended that the release pipe be extended to the existing gully as indicated in Figure 7 and water be released in the stable gully bottom.

This option will prevent slope erosion and limit erosion along buffer areas. Monitoring of the headcut control structures and headcuts in the largest wetland is advised so remedial action can be taken should erosion be detected. The addition of flow will enhance vegetation growth and attract livestock, which can lead to trampling of the saturated soils. It will thus be necessary to manage livestock along the unchanneled sections of the flow pathway to prevent surface and subsequent gully erosion.

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PART C5: APPENDICES

No appendices