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

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Report to Naidu Consulting (Pty) Ltd on the Results of a Geotechnical Investigation for the Proposed Thandokuhle Reservoir, eThekwini Municipality, KwaZulu-Natal

Reference: 063-20.R01 Revision 1

Dated: 15 October 2020

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Reference : 063-20.R01 Revision 1

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Report Title	Report to Naidu Consulting (Pty) Ltd on the Results of a Geotechnical Investigation for the Proposed Thandokuhle Reservoir, eThekwini Municipality, KwaZulu-Natal		
Report Reference	063-20.R01	**Responsible Persons**	Mr N. Mpungose
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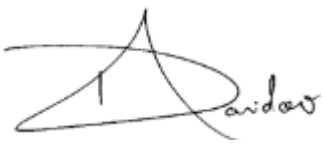
Revision	Date	Revision Details/Status	Author
0	01/10/20	Geotechnical report with recommendations.	Mr A. Ramroop
1	15/10/20	Report revised after Client provided revised invert level of the proposed structure.	Mr A. Ramroop

Current Revision
1

Approval

Author Signature		
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Report to Naidu Consulting (Pty) Ltd on the Results of a Geotechnical Investigation for the Proposed Thandokuhle Reservoir, eThekwini Municipality, KwaZulu-Natal

Reference: 063-20.R01 Revision 1 **Date: 15 October 2020**

TABLE OF CONTENTS

Abbreviations and Expansions

AASHTO	American Association of State Highway and Transportation
CBR	California Bearing Ratio
DCP	Dynamic Cone Penetrometer
E	east
EGL	existing ground level
EXP	exposure
Geosure	Geosure (Pty) Ltd
GM	grading modulus
GPS	Global Positioning System
h	horizontal
IMC	insitu moisture content
IP	inspection pit
km	kilometre(s)
kN/m^2	kilonewtons per metre square
LL	liquid limit
LS	linear shrinkage
m	metre (s)
m/s	metres per second
MDD	maximum dry density
Ml	Mega litre
mm	Millimetre(s)
MPA	MegaPascal
No.	number
NP	non plastic
OMC	Optimum Moisture Content
PI	plasticity index
SANS	South African National Standards
S	south
SM	Silty Sand
TLB	tractor loader backhoe
TMH	Technical Manual for Highways
TRH	Technical Recommendations for Highways (1985)
UCS	unconfined compressive strength
USCS	Unified Soil Classification System
v	vertical
Unified Soil Classification System	
SC	Clayey sand
SM	Silty sand
SP	Poorly graded sands

Report to Naidu Consulting (Pty) Ltd on the Results of a Geotechnical Investigation for the Proposed Thandokuhle Reservoir, eThekwini Municipality, KwaZulu-Natal

Reference: 063-20.R01 Revision 1 **Date: 15 October 2020**

1. TERMS OF REFERENCE

Geosure (Pty) Ltd was requested by Naidu Consulting on 24 February 2020 to submit a proposal and cost estimate for a geotechnical investigation for the proposed Thandokuhle Reservoir, eThekwini Municipality, KwaZulu-Natal. Naidu Consulting issued Geosure with a Request for Quotation (RFQ) detailing the proposed development and the required scope of work for the geotechnical investigation.

Accordingly, Geosure submitted a proposal and cost estimate to Naidu Consulting in a letter referenced p118-20 (Thandokuhle Reservoir Site)/mb and dated 04 March 2020. The RFQ was signed by Geosure and submitted to Naidu Consulting.

Subsequently, Geosure was appointed by Naidu Consulting, hereafter referred to as the Client, to carry out the geotechnical investigation as proposed in an appointment letter referenced D732/34/9033 dated 05 March 2020.

2. SCOPE OF REPORT

This report details the results of a geotechnical investigation for the proposed Thandokuhle Reservoir, eThekwini Municipality, KwaZulu-Natal, hereafter referred to as the site.

The soil and rock conditions underlying the site are described and comment is made on the general stability of the site. Recommendations for earthworks, drainage, materials excavatability, materials usage and foundations are provided.

3. GUIDELINES FOR INVESTIGATION

The fieldwork for the investigation was carried out according to guidelines relevant to geotechnical investigations of this nature.

The formation and weathering of geological materials are discontinuous processes and unexpected variations in soil, rock and groundwater regimes may occur even on sites where the conditions seem to be uniform or consistent. Variations in what is reported here may become evident during construction and it is thus imperative that an appropriately qualified and experienced geotechnical professional inspects all critical stages of development including, but not limited to, excavations to assess the conditions encountered and to assist in the interpretation of observations at variance with the information supplied in this report.

This report was prepared for use by Naidu Consulting (Pty) Ltd and their professional team for the purpose stated and should not be relied upon for any other purpose.

4. INFORMATION SUPPLIED/UTILISED

The following information was referenced to assist with the investigation and subsequent reporting:

i. A digital copy (PDF format) of a survey drawing referenced D732-51-5001 Rev A, titled "*Site Plan Layout, Site B*", dated May 2020 and prepared by Naidu Consulting to a scale of 1:200.

ii. A digital copy (PDF format) of an unreferenced survey drawing of the site and immediate surroundings.

iii. A digital copy (PDF format) of a survey drawing referenced 5002 Rev A, titled "*Reservoir Sections, Concrete Outline and Details*", dated May 2020 and prepared by Naidu Consulting to a scale of 1:200.

iv. A regional geological map titled "*2930 Durban"*, (Council for Geoscience, 1988) to a scale of 1:250 000.

v. Low-resolution satellite imagery (Google Earth, 2020).

5. SITE DESCRIPTION

The site for the proposed development is located in a rural area approximately 22km north of Waterfall, KwaZulu Natal, at the approximate latitude and longitude coordinates 29°40'36.31"S and 30°45'38.84"E, respectively.

Rural dwellings and homesteads border the site in all directions. The site is situated on a hilltop setting with gently sloping terrain immediately adjacent to the site.

Vegetation comprising short grass was observed at the areas investigated.

The regional and local contexts of the site are shown in Plates 1 and 2. The general layout of the site is shown in 063-20.R01-001. A general view across the site is shown in Plate 3.

Plate 1: Regional Context of the Site

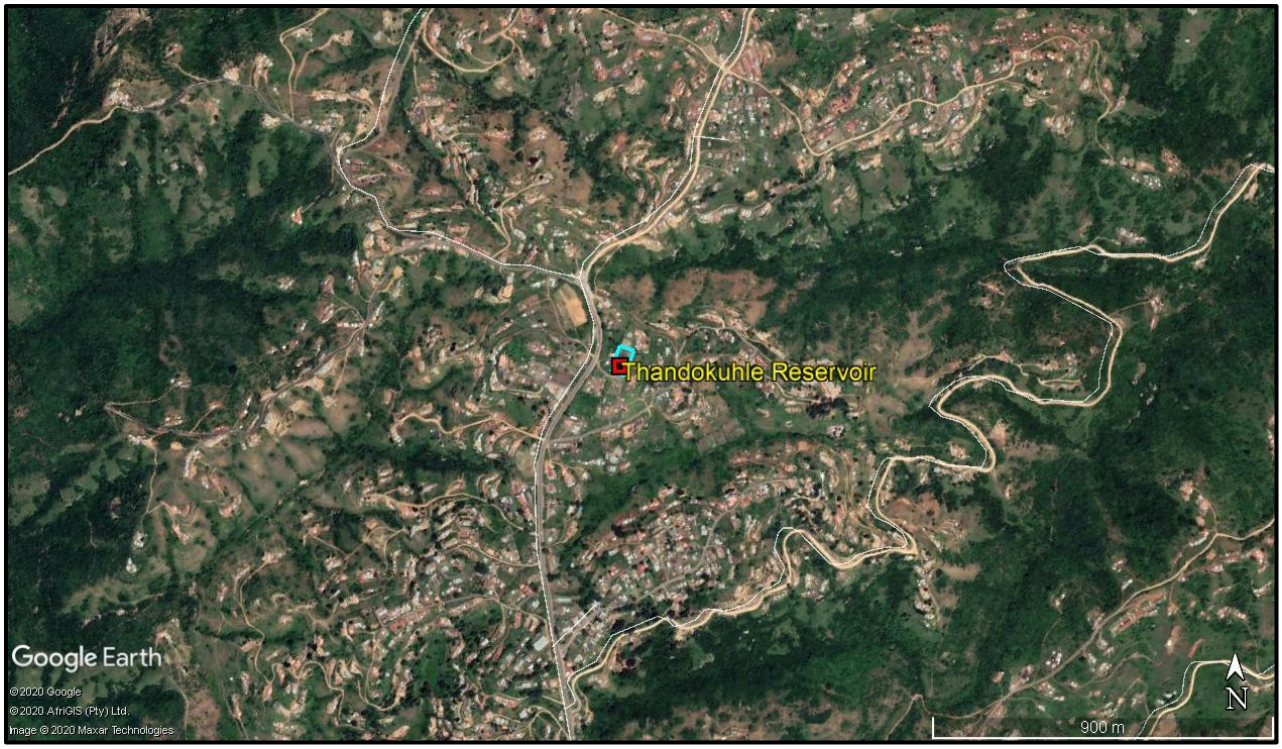

Plate 2: Local Context of the Site

Plate 3: General view across the site

6. FIELDWORK

Fieldwork for the investigation was carried out during the period August 2020 to September 2020, and comprised the following:

i. Geotechnical Boreholes;
ii. Inspection Pits;
iii. Dynamic Cone Penetrometer Light (DPL) Tests.

The positions of the field tests were determined by the Client and provided to Geosure on a marked up aerial image of the site.

6.1 Geotechnical Boreholes

Five (5 No.) boreholes, designated BH1 through BH2, were drilled with Standard Penetration Tests (SPT) and disturbed sampling by Geopractica Contracting (Pty) Ltd at the approximate positions given in 063-20.R01-001.

The positions of the boreholes were provided by the Client on the drawing referenced D732-51-5001.

The boreholes were of NXC and NWD4 diameters cased through soft materials to maintain sidewall stability. Material that was too hard for SPT was drilled and sampled by the NWD4 core barrel.

Material retrieved from the boreholes were profiled in accordance with the South African Geoterminology Guidelines (Brink & Bruin, 2002) and sampled for laboratory testing. The detailed borehole profiles are given in Appendix A.

6.2 Inspection Pits

Nine (9 No.) inspection pits, designated IP1 through IP9, were excavate using hand tools at the approximate positions shown in 063-20.R01-001. The inspection pits were advanced to final / refusal depths in the approximate range 1.17m (IP3 refers) to 2.5m (IP1 and IP2 refer) below EGL.

The inspection pits were profiled in accordance with the South African Geoterminology Guidelines (Brink & Bruin, 2002), sampled for laboratory testing and backfilled on completion.

Detailed inspection pit profiles are given in Appendix B.

6.3 Dynamic Cone Penetrometer (DCP) Tests

Nine (9 No.) DCP tests, designated DC1 through DC9, were carried out at the approximate positions given in 063-20.R01-001.

The DCP tests were advanced to refusal depths in the range 0.9m (DC9 refers) to 3.1m (DC5 and DC10 refer) below EGL.

Detailed DCP test results and graphs of blow count versus depth of penetration are given in Appendix C.

7. GEOLOGY AND INFERRED SUBSURFACE CONDITIONS

Regional map sheet "*2930 Durban*" to scale 1:250 000 by the Council for Geoscience indicates that the site and surrounds are underlain by Megacrystic Biotite Granite and Biotite Gneiss of the Natal Structural and Metamorphic Province. An extract of the geological map showing the regional geology is shown in Plate 3.

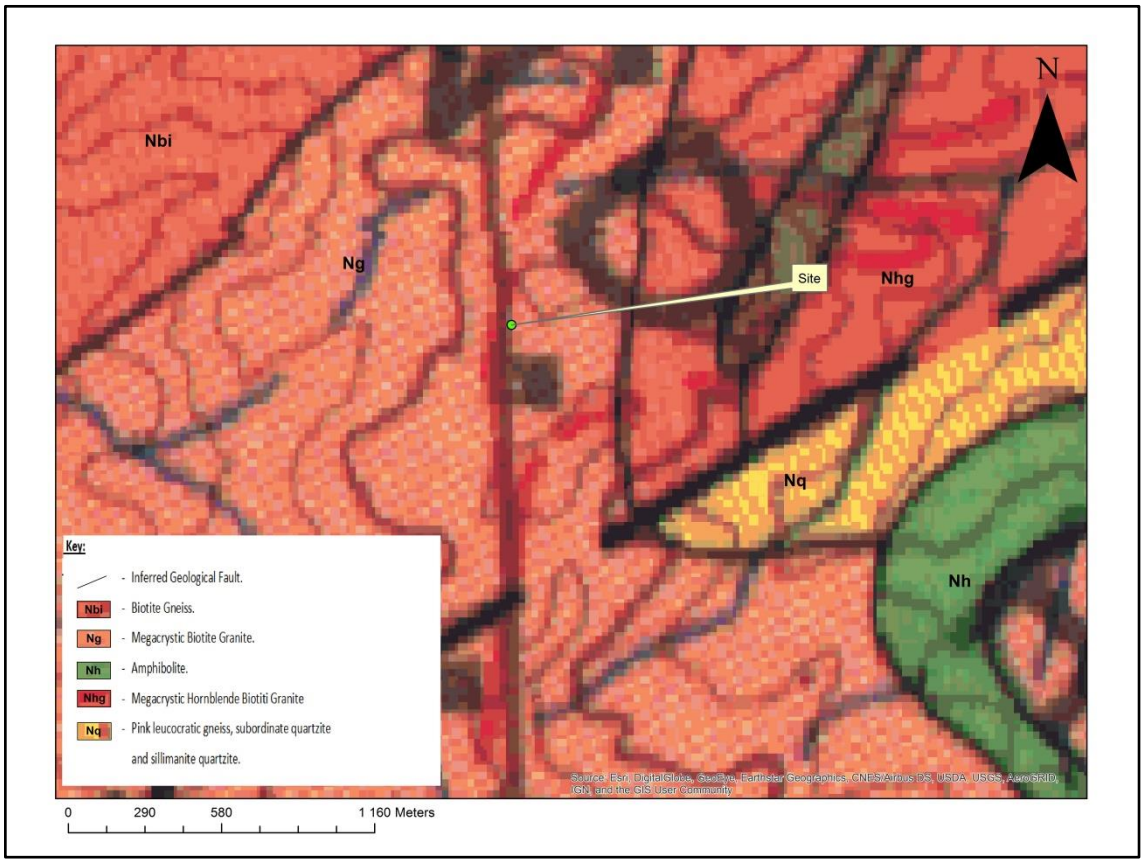

Plate 3: Geological map showing the site and regional geology (excerpt from South African Council of Geoscience's 1:250 000 Geological Series, Sheet 2930, Durban)

The site was observed to be underlain by fill material, colluvium, residuals soils derived from the insitu weathering of the underlying Megacrystic granitic gneiss rock. These geological units are generally described in order of increasing depth.

Fill – The fill can be described as slightly moist, medium brown / light to dark greyish brown, loose to medium dense, fine to medium grained, silty SAND with an abundance of gravel to sandy silty GRAVEL / firm, slightly gravelly sandy CLAY. The fill was encountered in BH1 through BH4 and IP1 through IP9 was observed to extend to an depths in the approximate range 0.15m (IP3 and IP4 refer) to 0.63m (IP8 refers) below EGL.

Colluvium – Colluvium can be described as slightly moist to moist, medium brownish grey / dark grey / dark orange brown medium brownish grey / light greyish brown, firm to stiff, fine to medium grained, slightly gravelly sandy CLAY to sandy silty CLAY with occasional gravel. Colluvium was encountered in BH1, BH3 BH4, BH5 and IP5 through IP8 and was observed to extend to depths in the approximate range 0.35m (BH5 refers) to 1.52m (IP7 refers) below EGL.

Residual Gneiss – These soils can be described as slightly moist to moist, medium brownish orange / dark orange red / dark reddish orange / dark yellowish orange, firm to stiff, intact, slightly sandy clayey SILT / slightly gravelly silty CLAY / gravelly sandy CLAY / sandy silty CLAY / sandy CLAY. The residual soils were encountered in all the boreholes and inspection pits and were observed to extend to depths in the approximate range 0.88m (IP3 refers) to in excess of 9.45m (BH5) below EGL. The residual soils in

BH5 were interbedded with a layer of weathered rock between depths in the approximate range 3.55m to 4.5m below EGL.

Weathered Granitic Gneiss Rock – The weathered gneiss rock can be described as light orange stained dark orange / light orange brown / dark reddish orange, highly weathered, fine to coarse grained, highly fractured, highly friable, micaceous, very soft rock with residual sandy silty CLAY. Poor recovery of rock core was experienced in BH1 and BH4 at depths of 4.42m to11.02m and 5.90m to10.0m, respectively.

Plates 4 and 5 show general ground profiles observed in the inspection pits during the field investigation. Detailed borehole core photographs are given in Appendix D.

Plate 4: View of soil profile in IP1

Plate 5: View of Aeolian deposits in IP5

8. GROUNDWATER

No shallow groundwater seepage was observed in the inspection pits during the course of the investigation.

Standpipe piezometers were installed in the boreholes to facilitate the measurement of groundwater levels.

The depth to the water table encountered in the piezometers, as measured on 31 August 2020, 01 September 2020 and 03 September 2020 are given in Table 1.

Table 1: Depth to Groundwater Occurrence

BH No.	Depth below EGL (m)
BH1	10.0
BH2	9.5
BH3	9.5
BH4	9.0
BH5	8.5

A perched water table may develop both during and after periods of rainfall and/or during the high rainfall season. It is expected that the groundwater condition is depressed during the drier months and elevated during the wetter periods.

The probability of groundwater seepage activity is assessed to increase with depth and/or near any weakly drained slopes.

The necessity for implementation of subsoil drainage measures or suitable foundation controls should be assessed during the construction phase of the project in consultation with the geotechnical professional.

9. LABORATORY TESTS

The following laboratory tests were carried out on soil samples retrieved during the investigation.

i. Grading Analysis to 0.075mm sieve with Atterberg Limit Determinations;
ii. Hydrometer Analysis;
iii. Modified AASHTO; and
iv. California Bearing Ratio (CBR) tests.

The results of the laboratory tests are summarised in Table 2 and given in Appendix E.

Table 2: Summary of Results of Particle Size Distribution Analysis, Atterberg Limit Determinations, Insitu Moisture Contents, Modified AASHTO and California Bearing Ratio

IP No.	Depth (m)	Description	Particle Size %				Atterberg Limits %			GM	[OMC] IMC (%)	MDD (kg/m^3)	% Swell	CBR (%)						Material Code & Classification
			Clay	Silt	Sand	Gravel	LL	PI	LS					90	93	95	97	98	100	
RESIDUAL GRANITIC GNEISS																				
IP1	0.44-2.12	Dark yellowish orange, sandy silty CLAY	38		27	35	48	20	12,0	1,54	[12.0]	1934	0.1	5.8	10	15	22	27	40	A-7-6 SM G10
IP5	0.76-1.86	Dark reddish orange, slightly gravelly sandy CLAY	62		21	17	55	22	12,0	0,89	[15.9]	1597	0.1	4.1	6.1	8	11	12	16	A-7-5 (13) MH/OH‡ G10
BH1	1.01-1.5	Dark orange red slightly sandy clayey SILT.	30	18	32	20	59	25	12,0	1,06	-	-	-	-	-	-	-	-	-	A-7-5 (11) MH/OH‡ *Medium
BH1	1.95-2.23	Dark orange red speckled light olive grey slighlty gravelly silty CLAY.	20	18	45	17	50	19	9,5	1,16	-	-	-	-	-	-	-	-	-	A-7-5 (4) SM *Medium
BH1	2.23-2.50	Dark orange red speckled light olive grey slighlty gravelly silty CLAY.	12	22	45	21	45	16	8,5	1,29	-	-	-	-	-	-	-	-	-	A-7-6 (2) SM *Low
BH2	1.00-1.25	Dark orange red speckled light grey slightly gravelly silty CLAY.	29	13	44	14	55	21	11,0	1,06	-	-	-	-	-	-	-	-	-	A-7-5 (6) SM *Medium
BH2	1.25-1.50	Dark orange red speckled light grey slightly gravelly silty CLAY.	18	18	46	18	56	22	10,0	1,15	-	-	-	-	-	-	-	-	-	A-7-5 (4) SM *Medium
BH2	1.95-2.48	Dark orange red speckled light grey slightly gravelly silty CLAY.	17	14	53	16	56	24	10,5	1,24	-	-	-	-	-	-	-	-	-	A-2-7 (3) SM *Medium

IP No.	Depth (m)	Description	Particle Size %				Atterberg Limits %			GM	[OMC] IMC (%)	MDD (kg/m^3)	% Swell	CBR (%)						Material Code & Classification
			Clay	Silt	Sand	Gravel	LL	PI	LS					90	93	95	97	98	100	
BH3	1.06-1.28	Dark orange red mottled light greyish orange slightly gravelly sandy silty CLAY.	29	12	37	22	56	21	11,0	1,25	-	-	-	-	-	-	-	-	-	A-7-5 (6) SM *Medium
BH3	1.28-1.50	Dark orange red speckled mottled light greyish olive slightly gravelly sandy silty CLAY.	25	13	46	16	42	16	8,0	1,26	-	-	-	-	-	-	-	-	-	A-7-6 (2) SM *Low
BH3	1.95-2.40	Dark orange red mottled light greyish orange slightly gravelly sandy silty CLAY.	28	13	41	18	47	21	10,0	1,22	-	-	-	-	-	-	-	-	-	A-7-6 (4) SC *Low
BH4	1.09-1.50	Dark orange red speckled light yellow slightly gravelly sandy silty CLAY.	17	18	43	22	43	16	9,5	1,38	-	-	-	-	-	-	-	-	-	A-7-6 (2) SM *Low
BH4	1.95-2.53	Dark orange red speckled light yellow slightly gravelly sandy silty CLAY.	16	17	47	20	43	19	10,5	1,39	-	-	-	-	-	-	-	-	-	A-7-6 (2) SC *Low
BH5	1.04-1.27	Dark orange red slightly gravelly sandy silty CLAY.	30	15	41	14	41	19	10,5	1,07	-	-	-	-	-	-	-	-	-	A-7-6 (6) SC *Medium
BH5	1.95-2.48	Dark orange red slightly gravelly sandy silty CLAY.	23	13	39	25	57	25	13,5	1,37	-	-	-	-	-	-	-	-	-	A-7-5 (5) SM *Medium
BH5	2.48-3.00	Dark orange red and light olive grey gravelly silty CLAY.	18	15	44	23	54	26	13,0	1,42	-	-	-	-	-	-	-	-	-	A-7-6 (4) SC *Medium
BH5	4.95-6.00	Dark reddish orange and light grey silty sandy CLAY.	54	23	16	7	63	28	15,0	0,44	-	-	-	-	-	-	-	-	-	A-7-5 (25) MH/OH‡ *Low

IP No.	Depth (m)	Description	Particle Size %				Atterberg Limits %			GM	[OMC] IMC (%)	MDD (kg/m^3)	% Swell	CBR (%)						Material Code & Classification
			Clay	Silt	Sand	Gravel	LL	PI	LS					90	93	95	97	98	100	
WEATHERED GRANITIC GNEISS ROCK																				
IP3	0.88-1.17	Dark orange and dark reddish grey highly fractured, very soft rock.	44	31	25		50	22	12,0	1,32	[11.6]	1890	0.6	2.4	6.8	14	27	39	77	A-7-6 (6) SC Poorer than G10

LL - Liquid Limit
IMC - Insitu Moisture Content
A-7-6 - Revised U.S Classification
PI - Plasticity Index
LS - Linear Shrinkage
GM - Grading Modulus
MDD - Maximum Dry Density
IMC - Insitu Moisture Content
SM -Unified Classification
OMC - Optimum Moisture Content
G10 - TRH14 Classification
>G10 - Poorer than G10
*Low - Expansiveness According to van der Merwe (1964)

10. DISCUSSION

10.1 Proposed Development

It is understood that the proposed development will comprise a new 3ML reinforced concrete reservoir and associated inlet and outlet pipes.

The RFQ and the reservoir drawings indicate the following with regards to the proposed development:

i. The top water level (TWL) of the proposed reservoir is 661.51m above MSL.
ii. The level beneath the blinding of the reservoir is 650.73m above MSL.
iii. A bearing capacity of 200kN/m^2 to 250kN/m^2 is required for the proposed reservoir.
iv. Reservoir floor thickness is 200mm underlain by 75mm thick blinding.

10.2 General Stability and Suitability of the Site

The soil cover observed in the inspection pits and boreholes is considered highly susceptible to rapid erosion by uncontrolled stormwater runoff. Open excavations in these soils are considered likely to display rapid sidewall collapse.

Sound earthworks and drainage controls to engineer's design and monitoring of the earthworks and site drainage works by the engineer's representative in consultation with the geotechnical professional, are therefore recommended.

Based on the results of the fieldwork undertaken during this investigation, it is considered that the site is generally stable and suitable for the proposed development, provided that the recommendations given in this report are adhered to. Such precautionary measures amount to no more than sound development practices appropriate to the site conditions anticipated and the nature of the proposed development confirmed with Geosure at the time of preparation of this report.

10.3 Excavation Characteristics

Excavations within the fill, colluvium, residual soils and highly weathered very soft granitic gneiss rock are likely to classify as "SOFT" excavations in terms of SANS 1200 (current version) down to the depths investigated on site. Such material can normally be excavated by plant similar to a TLB of flywheel power approximately 0.10kW per millimetre of tined bucket width.

Although soft and harder varieties of the weathered granitic gneiss rock were not encountered during the investigation, excavations within soft rock and harder varieties are likely to classify as "INTERMEDIATE" to "HARD" excavations in terms of SANS 1200. The presence of corestones within the residual soils and tillite rock is likely to result in "BOULDER Class" excavations in terms of SANS 1200.

It is recommended that a contingency be allowed for "INTERMEDIATE", "HARD" and "BOULDER Class" excavation at shallower depths to cater for potential geological variations.

10.4 General Earthworks

It is recommended that all earthworks be carried out in accordance with SANS 1200 D (current version). All vegetation, topsoil and unsuitable subgrade material should be cleared from areas over which fills are to be built. Under fills of more than three metres in height, further subgrade improvement may be necessary.

Cut and fill heights greater than approximately 1.5m will need to be analysed and approved by a geotechnical professional. All cut slopes must be designed by, or in consultation with, a geotechnical professional.

10.4.1 General Fills

General fills should be placed in layers not exceeding 0.25m when placed in loose condition, and compacted to a minimum of 93% of Modified AASHTO maximum dry density. Boulders larger than 0.2m should not be included in the fill material. Large boulders or construction rubble within the fill could affect compaction and mask voids into which fines could later migrate, resulting in subsidence. Boulders / rubble may also adversely affect foundation excavations including piling.

If natural ground slopes are steeper than 1 vertical to 6 horizontal (6 degrees), the fill must be benched into the slope. The bench widths and depths must be determined by a geotechnical professional during the design of the fill embankments.

Density control of fill material should be undertaken at appropriate intervals during fill construction.

Fill slopes in soils should be formed to batters of up to 1 vertical to 2 horizontal (≤ 26°) and to a height not greater than approximately 1.5m where retaining walls are not provided. Engineered fill slopes should be over constructed and thereafter trimmed back to the required position.

10.4.2 General Cuts

Permanent cut slopes in soils should be formed to batters of up to 1 vertical to 2 horizontal (≤ 26°) and to a height not greater than approximately 2.0m where retaining walls are not provided.

Cut slopes in competent weathered rock should be no steeper than 1 vertical to 0.75 horizontal (≤ 53°) and to a height not greater than 3.0m where lateral support is not provided. Where joints or bedding planes are exposed during excavation it is recommended that a geotechnical specialist be appointed to assess their effects on the stability of the cutting and the global stability of the slope.

Cuts slopes in within the highly friable granitic gneiss rock should be no steeper than 1 vertical to 1 horizontal (≤ 45°) and to a height not greater than 3.0m where lateral support is not provided.
Where excavations intersect or approach the water table, the sidewalls will tend to become unstable and need to be drained and laterally supported or battered back at slopes of the order of 1 vertical in 5 horizontal.

Workers should not enter any excavations deeper than 1.5m that are not shored or battered back as described above. Sidewalls within sandy soils will be prone to collapse. All excavations are to be inspected on a daily basis by a competent person to confirm stability. These inspections should be formally documented. It remains the responsibility of the contractor, however, to ensure compliance with the current Occupational Health and Safety Act and Construction Regulations (South African Department of Labour, 1993 and 2014).

10.5 Classification Area Materials and Recommended Usage

The subgrade materials underlying the site have been classified in terms of their suitability for use in construction based on field observations and laboratory testing. The materials classifications are given in Table 3.

Table 3: Materials Classification and Usage

Material Type	Description	Classification Details	Recommended Use
Fill	Not Tested		The fill soils are poor quality subgrade material and should be used as a general fill where encountered at or below subgrade level.
Colluvium	Not Tested		Due to the organic content of the colluvium, these soils are considered poor subgrade material and should be undercut and replaced with good quality granular material where encountered at or below subgrade level.
Residual Granitic Gneiss	Slightly sandy clayey SILT / slightly gravelly silty CLAY / gravelly sandy CLAY / sandy silty CLAY / sandy CLAY	A-7-5 to A-7-6 PI = 16 to 28 GM = 0.44 to 1.54 CBR@90% = 4.1 to 5.8 CBR@93% = 6.1 to 10 TRH14 : G10	Due to the high clay content and potential for heave when wet, these soils are considered poor subgrade material and should be undercut and replaced with good quality granular material where encountered at or below subgrade level. Can be used as a general fill not supporting foundation loads.
Weathered Granitic Gneiss Rock	Highly weathered, very soft rock	A-7-6 PI = 22 GM = 1.32 CBR@90% = 2.4 CBR@93% = 6.8 TRH14 : Poorer than G10	These soils are considered poor quality subgrade material and should be undercut and replaced with good quality granular material where encountered at or below subgrade level.

If boulders and rubble are encountered, they will need to be selectively removed when found at or near subgrade or formation level. Boulders larger than 63 mm or ⅔ layer thickness should not be included in fills. Large boulders will inhibit compaction of the fills. Density control testing of fill material should be undertaken at regular intervals during fill construction.

The classification of the subgrade materials given in Table 3 are only applicable to the samples tested. Variations throughout the soils encountered on site are considered likely.

10.6 Subgrade Treatment

Where poor subgrade conditions (≥G10) are exposed at or near subgrade or formation level, it is recommended that these materials be boxed out or undercut to the depth specified by the design engineer. This material should then be replaced with a good quality granular soil of at least G6 quality and compacted to at least 93% Modified AASHTO maximum dry density to ±2% Optimum Moisture Content (OMC). Provided the above recommendations are followed, a design CBR of 10 can be adopted.

Where granular soils meeting the subgrade requirements are encountered at subgrade level, it is recommended that these materials be ripped to the specified depth and re-compacted to 93% Modified AASHTO maximum dry density to ±2% Optimum Moisture Content (OMC).

10.7 Inferred Founding Conditions

The inferred founding conditions identified at site are characterised by the following:

i. Presence of fill and colluvium material of variable soil consistencies and variable soil descriptions down to depths in the approximate range 0.63m (IP8 refers) to 1.52m (IP7 refers).

ii. Residual soils of firm consistencies occur in the range 0.15m to 1.52m below EGL. The residual soils were observed to extend to depths in the approximate range 0.88m (IP3 refers) to in excess of 9.45m (BH5) below EGL.

iii. The fill, colluvium and residual soils are considered to have low bearing capacities and are compressible under proposed foundation pressures. These soils are considered poor founding horizons for reservoir foundations.

iv. Weathered rock, suitable for founding, were encountered at depths in the approximate range 0.88m (IP3 refers) to in excess of 9.45m (BH5) below EGL.

v. Suitable rock for founding purposes was not encountered in BH5.

vi. Medium potential expansiveness of the residual soils where heave of up to 75mm can be expected when the moisture contents of the clayey residual soils are increased beyond the insitu moisture content.

vii. Trench / excavation sidewalls excavated into the loosely consolidated fill and sandy Aeolian soils are likely to be unstable and require shoring / battering back to engineer's detail.

10.8 Foundation Recommendations

A summary of the exposed geological horizon at the proposed founding level (650.73m) at each borehole is given in Table 4.

Table 4: Summary of Geological Horizon Exposed at Proposed Reservoir Founding Level

BH No.	Exposed Geology at Founding Level	Comments on Founding Media
BH1	Weathered Granitic Gneiss	Good founding horizon
BH2	Weathered Granitic Gneiss	Good founding horizon
BH3	Residual Gneiss	Poor founding horizon
BH4	Residual Gneiss	Poor founding horizon
BH5	Residual Gneiss	Poor founding horizon

Inferring from Table 4, poor founding horizons are likely to be exposed at the proposed founding level of 650.73m above MSL in some portions of the reservoir footprint.

The bearing capacity of the soils and rock at various elevations above MSL were required as per the RFQ. The fill and colluvial soils have low bearing capacities (<50kN/m^2). Bearing pressures of up to 100kN/m^2 can be considered applicable for foundations placed on residual granitic gneiss. Where foundations are placed on the highly weathered granitic gneiss rock, a net allowable bearing pressure of 200kN/m^2 is considered applicable.

The bearing capacities at the geological horizons likely to be exposed at elevations of 654m, 653m, 652m, 651m and 650m above MSL are given in Table 5.

Table 5: Bearing Capacities of Soils and Rock Encountered in Boreholes

Elevation (m)	Estimated Allowable Bearing Capacity (kN/m^2)					Comments
	BH1	BH2	BH3	BH4	BH5	
654	50	50	*N/A	*N/A	50	-
653	75	100	50	50	100	-
652	100	100	100	100	100	-
651	200	200	100	100	100	-
650	200	200	200	200	100	Below reservoir founding level

As seen in Table 4, the allowable bearing pressures are likely to vary across the reservoir footprint due to the variable ground conditions encountered in each borehole. Suitable bearing for the proposed reservoir foundations are likely to be achieved at an elevation of approximately 650m above MSL. It should be noted however, that competent rock was not encountered in BH5.

Total approximate settlement of reservoir foundations placed on the insitu soils at proposed founding level (650.73m) is likely to be in the range 50mm to 60mm. The thickness of the compressible soil profile was approximately 10m in BH5 and approximate settlements of 150mm to 175mm can be expected for foundations near the position of BH5.

Due to the variable ground conditions providing variable allowable bearing capacities and total approximate settlements in excess of 50mm, consideration should be given to carrying out the following foundation solutions:

i) Foundations on engineered fill;
ii) Improving insitu soils with the addition of stone columns; and
iii) High modulus inclusions.

10.8.1 Foundations on Engineered Fill

Consideration can be given to undercutting the fill, colluvium and residual soils to a competent horizon or expose bedrock and backfilling the excavation up to the proposed founding level with an engineered fill comprising at least G5 quality material.

The foundations placed on engineered fill in the area of BH5 are likely to experience larger settlements than the foundations placed on engineered fill elsewhere across the reservoir footprint. In this regard, it is recommended that the foundations and the reservoir structure be designed to accommodate the differential settlement of the foundations.

In order to reduce the settlement of the engineered fill, consideration could be given to backfilling the excavations with mass concrete or mechanically stabilized earth.

The settlement of the engineered earth fill is dependent on the design of the engineered fill and cannot be provided for at this stage. It is recommended that the engineered fill and platform be designed by a geotechnical engineering professional.

10.8.2 Stone Columns

Consideration may be given to driving stone columns down to the weathered bedrock horizon in order to densify the softer residual soils and reduce the anticipated settlements of the insitu soils.

Constructing stone columns is carried out by forming vertical holes of about 0.6m in diameter down to bedrock in a grid pattern across the site. The holes are progressively back-filled with small charges of crushed stone that are vibrated or rammed with a “down the hole” hammer (DTH) between charges as a temporary liner tube, if present, is withdrawn.

The foundations placed on stone columns in the area of BH5 is likely to experience larger settlements than foundations placed on shallow engineered fill or bedrock elsewhere across the reservoir footprint. In this regard, it is recommended that the foundations and the reservoir structure be designed to accommodate the differential settlement of the foundations.

The design of the stone column solution should be carried out by a suitably experienced geotechnical professional person. The approximate settlement of foundations placed on ground with stone columns will depend on the design of the stone column solution.

10.8.3 High Modulus Inclusions

High modulus inclusions comprise unreinforced concrete elements, advanced to the desired founding depth in a manner similar to that of auger piles or Continuous Flight Augured Piles. The inclusions are capped with a reinforced soil mattress that is designed to arch between the individual inclusions.

The purpose of this system is to transfer the foundation loads from the structure through the high modulus inclusion to the soils and rock surrounding the inclusions (friction) and / or at the base of the inclusions (end bearing).

All inclusions should be taken down through the fill, colluvium and residual soils and be socketed into the highly weathered granitic gneiss rock.

A detailed design of the high modulus inclusion must be carried out by a specialist contractor.

It is recommended that low energy Frequency Response dynamic pile integrity tests be carried out on all high modulus inclusions before they are covered by the soil mattress. Axial load tests should also be carried out to determine the load bearing capacities of the inclusions.

10.9 Drainage

A critically important factor in the stable development of the site is the control and removal of both surface and groundwater from the site.

Earthworks and drainage measures should be designed in such a way as to prevent ponding or high concentrations of stormwater or groundwater anywhere on the site, both during and after the development.

Virtually all of the soils encountered on site are considered susceptible to rapid erosion due to uncontrolled and/or surplus surface water runoff. As such, it is imperative that earthworks and drainage measures be designed in such a way as to prevent ponding of or high concentrations of stormwater and/or groundwater anywhere on the site and to address the high risk of erosion, both during and after completion of construction.

Terraces should be shaped to a gradient to prevent water ponding on the surface and should be graded to direct water away from the foundations and excavations.

11. SUMMARY OF FINDINGS AND RECOMMENDATIONS

i) This report details the results of a geotechnical investigation carried out for the proposed Thandokuhle Reservoir, eThekwini Municipality, KwaZulu-Natal.

ii) The site was observed to be underlain by fill, colluvium and residual soils derived from the insitu weathering of the underlying granitic gneiss rock.

iii) Groundwater seepage was not encountered in the inspection pits excavated on site.

iv) Standpipe piezometers installed in the boreholes indicate that the depth to the groundwater surface is in the approximate range 8.5m to 10.0m below EGL.

v) The soils observed on site are considered susceptible to rapid erosion by uncontrolled stormwater runoff. Furthermore, open excavations, even to shallow depths, are considered likely to display rapid sidewall collapse.

vi) It is considered that the site is generally stable and suitable for the proposed development, provided that the recommendations given in this report are adhered to. Measures amount to no more than sound development controls appropriate to the site conditions expected and the development proposals known to Geosure at the time of preparation of this report.

vii) All earthworks should be carried out in a manner to promote stable development of the site. It is recommended that earthworks be carried out along the guidelines given in SANS 1200 (current version).

viii) The proposed development is to comprise a new 3 ML reservoir. Information supplied indicates that proposed foundation pressures are likely 200kN/m^2 to 250kN/m^2.

ix) Information supplied to Geosure indicates that the proposed founding level is 650.73m above MSL. At this proposed founding level, poor founding horizons are exposed across some portions of the reservoir.

x) Large foundation settlements can be expected at the proposed founding level for the foundation pressures provided by the Client. It is therefore recommended that consideration be given to either the use of an engineered fill platform, soil improvement using stone columns or a high modulus inclusion system to reduce total and differential settlement of the proposed foundations.

xi) It is imperative that earthworks and drainage measures be designed in such a way as to prevent ponding of, or high concentrations of, stormwater or groundwater anywhere on the site and include effective erosion and anti-siltation controls, both during and after the development, to engineer's detail. Stormwater from roofed and surface areas may be reticulated on site, allowing for attenuation and siltation controls. An engineering analysis is recommended to determine confirmed development catchment volumes and required evapotranspiration areas downslope of the soakaway position(s).

xii) The ground conditions given in this report refer specifically to the field tests carried out on site. It is, therefore, quite possible that conditions at variance with those given in this report could be encountered elsewhere on site during construction.

xiii) It is also important that Geosure be appointed to carry out periodic inspections during construction. Any change from the anticipated ground conditions could then be taken into account to avoid unnecessary expense.

12. REFERENCES

Brink, A. B. & Bruin, R. M., 2002. *Guidelines for Soil and Rock Logging in South Africa.* s.l., Association of Engineering Geologists, South African Institute Civil Engineering - Geotechnical Division, and South Africa Institue for Engineering and Environemntakl Geologists, p. 47.

Commitee of State Road Authorities, 1985. *TRH14: Technical Recommendations for Highways - Guidelines for Road Construction Materials.* Pretoria: Department of Transport.

Council for Geoscience, 1988. *2930 Durban*: South African Council for Geoscience.

G.Byrne & A.D.Berry, 2008. *A Guide to Pratical Geotechnical Engineering in South Africa.* s.l.:Franki.

Google Earth, 2020. *AfriGIS (Pty) Ltd.* [Online] Available at: www.googlearth.com [Accessed 29 January 2020].

SABS, 1990. SANS 10400: South African Standard Code of Practice for the Application of National Building Regulations. In: s.l.:s.n.

South African Department of Labour, 1991. *Occupational Health and Safety Amendment Act, No. 181 of 1993.* s.l.:Department of Labour - South Africa.

South African National Standards, 1990. *SANS 1200 DA - Standardised Specification for Civil Engineering Construction - Earthworks (Small Works).* s.l.:South African National Standards.

APPENDIX A

BOREHOLE PROFILES

GEOSURE (Pty) Ltd
P O Box 1461, Westville, 3630, South Africa
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Geotechnical, Environmental & Groundwater Engineering
Pile Integrity Testing & Civil Engineering Laboratory

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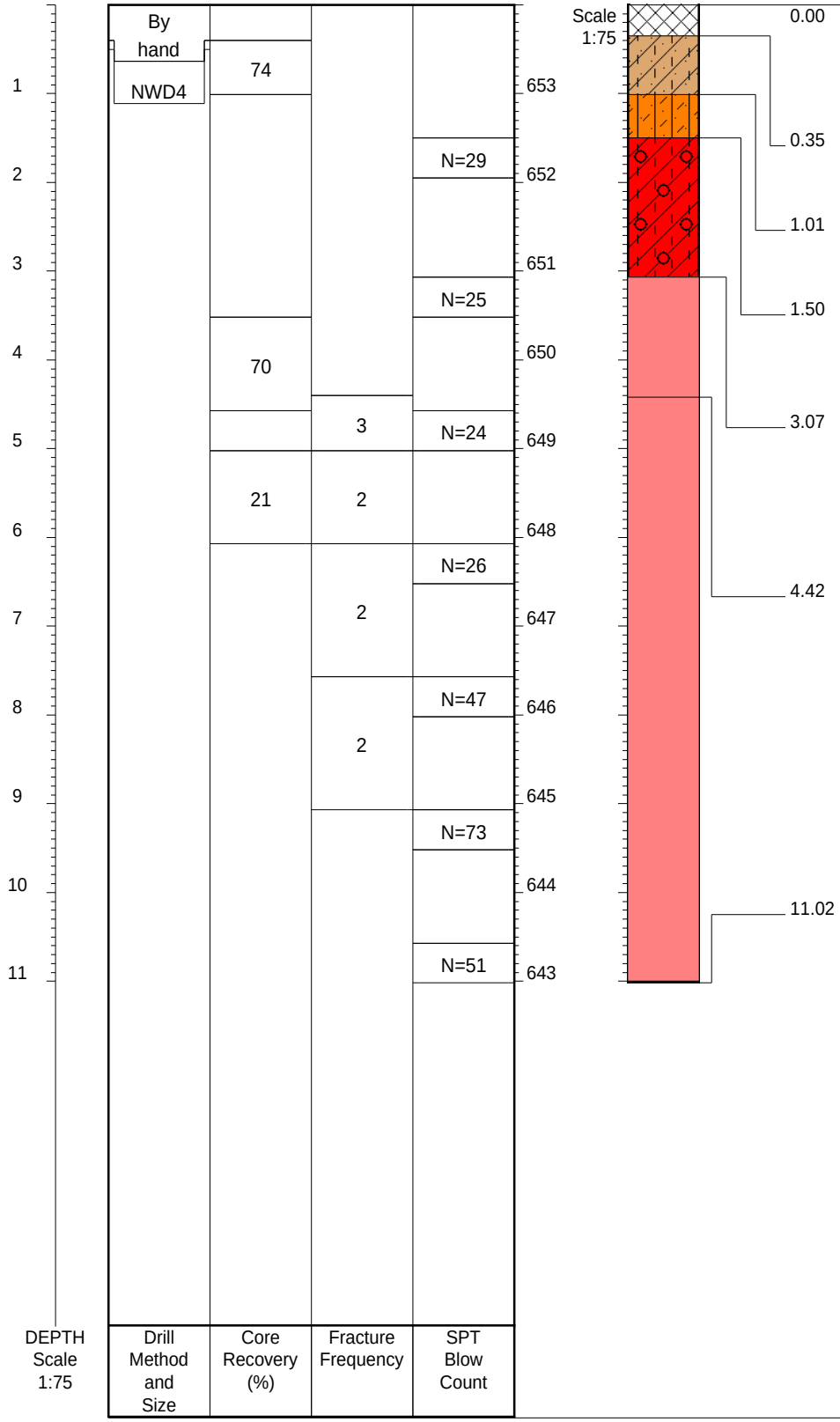
www.geosure.co.za

Naidu Consulting
Proposed Thandokuhle Reservoir
KwaZulu Natal

HOLE No: BH1
Sheet 1 of 1

JOB NUMBER: 063-20



Medium brown, loose to medium dense, fine to medium grained, silty sandy GRAVEL with an abundance of angular medium to coarse grained gravel. FILL.

Medium brownish grey, sandy silty CLAY. Colluvium.

Dark orange red, slightly sandy clayey SILT. Residual Gneiss.

Dark orange red speckled light olive grey, stiff, micaceous, slightly gravelly silty CLAY. Residual Gneiss.

Light orange stained dark orange and light grey, highly weathered, fine to coarse grained, highly fractured, micaceous, very soft rock with residual sandy silty clay. Granitic Gneiss.

Medium brown and light orange brown and light grey, highly weathered, fine to coarse grained, highly fractured, very soft highly friable rock with poor recovery and residual fine sandy silty clay. Granitic Gneiss.

NOTES

1) Borehole terminated at 11,02m below EGL.

2) Prelimnary standpipe type piezometer installed to 11,02m.

3) Water level recorded at 9,40m on 26.08.2020.

4) Water level recorded at 10,0m on 31.08.2020.

CONTRACTOR : Geopractica
MACHINE : D45
DRILLED BY :
PROFILED BY : E.Dada Mia

TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARG.SET

INCLINATION : -
DIAM :
DATE : 24 August 2020
DATE : 25 August 2020

DATE : 05/10/20 16:13
TEXT : ..C:\LOGS\BH1.TXT

ELEVATION : 654m
X-COORD : 30 45' 38.6"E
Y-COORD : 29 40' 36.0"S

HOLE No: BH1
-

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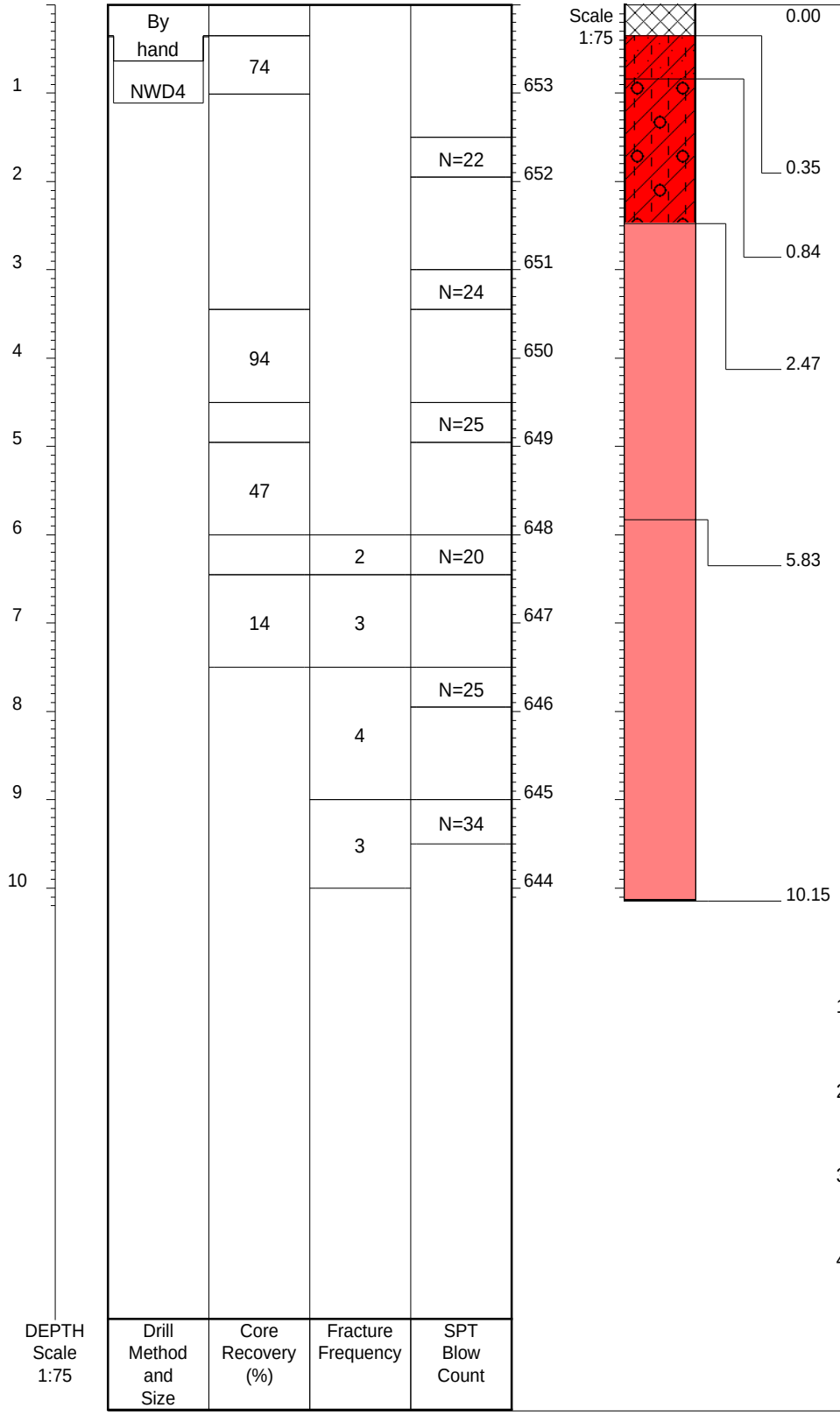
KwaZulu Natal

HOLE No: BH2
Sheet 1 of 1

JOB NUMBER: 063-20



Medium brownish grey, loose to medium dense, fine to medium grained, silty sandy GRAVEL with and abundance of angular medium to coarse grained gravel. FILL.

Medium brownish grey, sandy silty CLAY. Residual.

Dark orange red speckled light grey, stiff, micaceous, slightly gravelly silty CLAY. Residual Gneiss.

Light orange stained dark orange and light grey, highly weathered, fine to coarse grained, slightly to highly fractured, micaceous, very soft highly friable rock with residual fine sandy silty clay. Granitic GNEISS.

Light orange brown and light grey, highly weathered, fine to coarse grained, slightly to highly fractured, very soft highly friable rock. Granitic GNEISS.

NOTES

1) Borehole terminated at 10,15m below EGL.

2) Standpipe type piezometer installed to 10,15m.

3) Water level recorded at 9,50m on 31/08/2020.

4) Water level recorded at 9,50m on 01/09/2020.

CONTRACTOR : Geopractica
MACHINE : D45
DRILLED BY :
PROFILED BY : E.Dada Mia

TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARG.SET

INCLINATION : -
DIAM :
DATE : 26 August 2020
DATE : 26 August 2020

DATE : 05/10/20 16:14
TEXT : ..C:\LOGS\BH2.TXT

ELEVATION : 654m
X-COORD : 30 45' 39.3"E
Y-COORD : 29 40' 36.1"S

HOLE No: BH2
-

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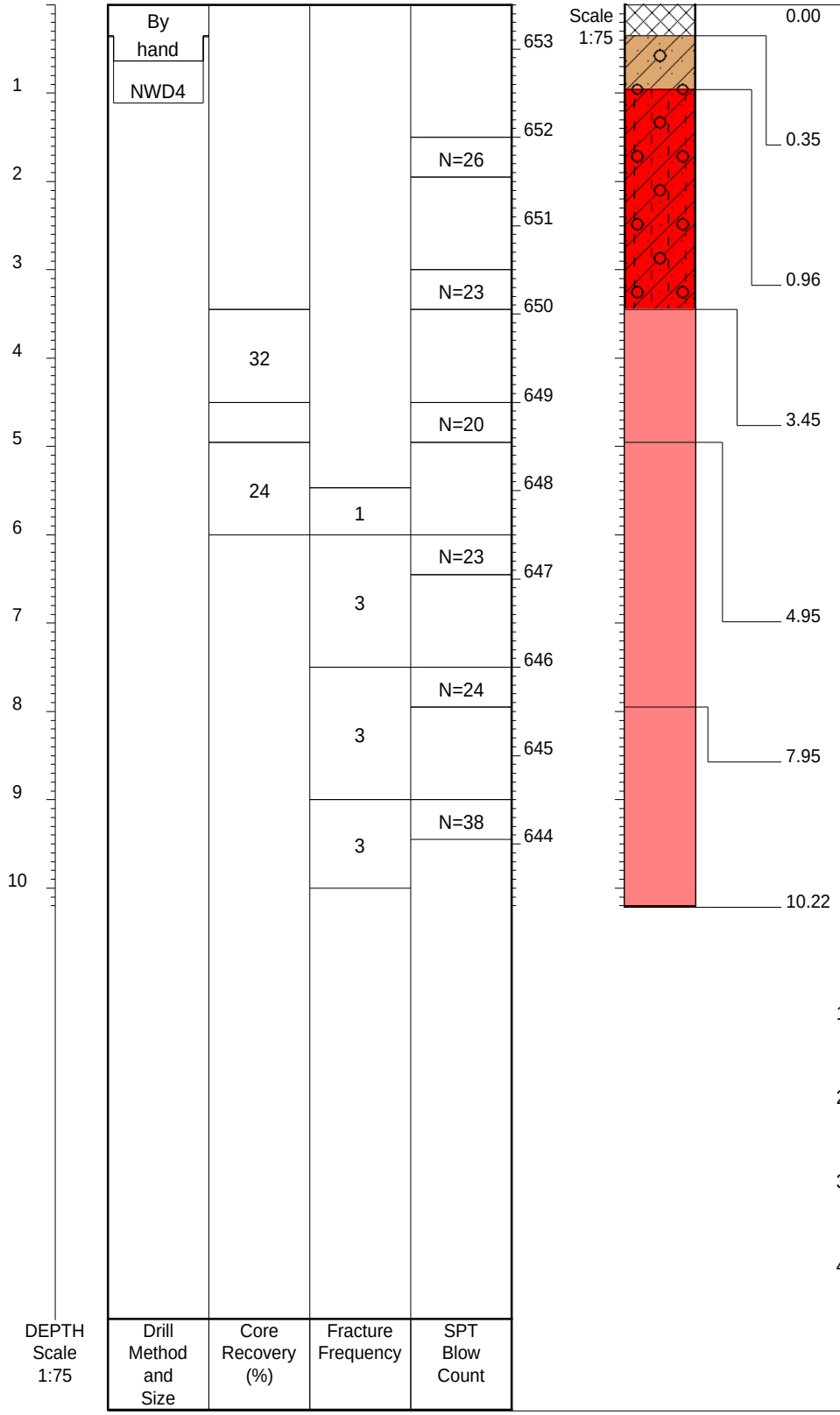
HOLE No: BH3
Sheet 1 of 1

JOB NUMBER: 063-20



Medium brown, loose to medium dense, fine to medium grained, silty sandy GRAVEL with an abundance of angular medium to coarse grained gravel. FILL.

Dark orange brown medium brownish grey, slightly gravelly sandy CLAY containing occasional fine gravel. Colluvium.

Dark orange red mottled light greyish orange, stiff, slightly gravelly sandy silty CLAY containing occasional granite gravel. Residual Gneiss.

Light orange brown dark orange and light grey, highly weathered, fine to coarse grained, slightly fractured, micaceous, very soft rock containing residual silty sandy clay. Granitic GNEISS.

Light orange brown and light grey, highly weathered, fine to coarse grained, slightly to highly fractured, very soft rock. Megacrystic Granitic GNEISS.

Light orange brown, highly weathered, fine to coarse grained, slightly to highly fractured, highly micacous, highly friable very soft rock. Granitic GNEISS.

NOTES

1) Borehole terminated at 10,22m below EGL.

2) Standpipe type piezometer installed to 10,22m.

3) Water level recorded at 9,00m on 31/08/2020.

4) Water level recorded at 9,50m on 01/09/2020.

CONTRACTOR : Geopractica
MACHINE : D45
DRILLED BY :
PROFILED BY : E.Dada Mia

TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARG.SET

INCLINATION : -
DIAM :
DATE : 27 August 2020
DATE : 29 August 2020

DATE : 05/10/20 16:14
TEXT : ..C:\LOGS\BH3.TXT

ELEVATION : 653.5m
X-COORD : 30 45' 38.6"E
Y-COORD : 29 40' 36.7"S

HOLE No: BH3
-

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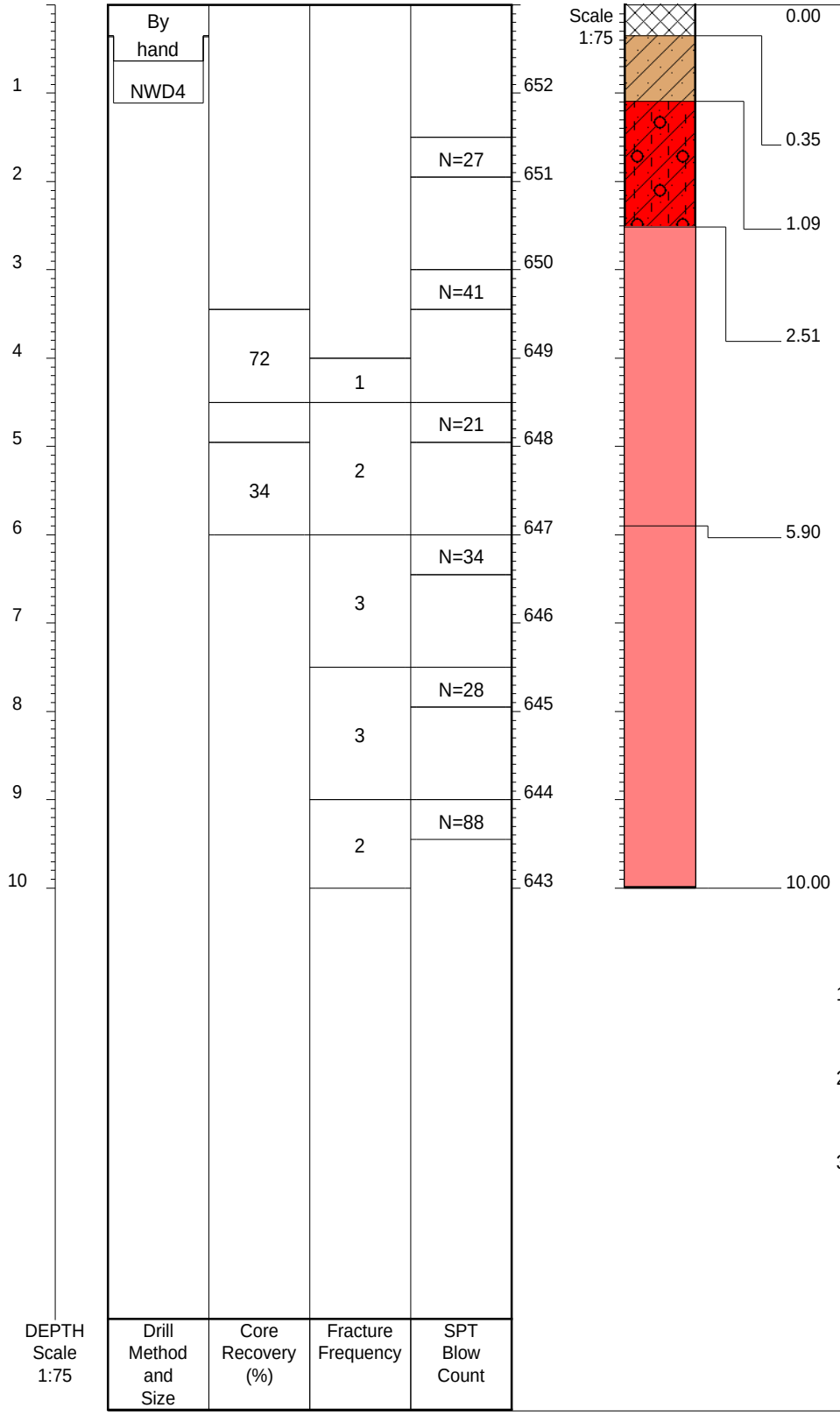
KwaZulu Natal

HOLE No: BH4
Sheet 1 of 1

JOB NUMBER: 063-20



Medium brown, loose to medium dense, fine to medium grained, silty sandy GRAVEL with an abundance of angular medium to coarse grained gravel. FILL.

Dark brownish grey, sandy CLAY. Colluvium.

Dark orange red specked light yellow, stiff, slightly gravelly sandy silty CLAY. Residual Gneiss.

Light orange stained dark orange and light grey, highly weathered, fine to coarse grained, slightly to highly fractured, micaceous, very soft rock with residual sandy silty clay. Megacrystic Granitic GNEISS.

Light and medium dark brown and orange brown, highly weathered, fine to coarse grained, slightly to highly fractured, highly friable very soft rock with poor recovery. Granitic GNEISS.

NOTES

1) Borehole terminated at 10,0m below EGL.

2) Standpipe type piezometer installed to 10,0m.

3) Water level recorded at 9,00m on 03/09/2020.

CONTRACTOR : Geopractica
MACHINE : D45
DRILLED BY :
PROFILED BY : E.Dada Mia

TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARG.SET

INCLINATION : -
DIAM :
DATE : 31 August 2020
DATE : 31 August 2020

DATE : 05/10/20 16:14
TEXT : ..C:\LOGS\BH4.TXT

ELEVATION : 653m
X-COORD : 30 45' 38.1"E
Y-COORD : 29 40' 37.1"S

HOLE No: BH4
-

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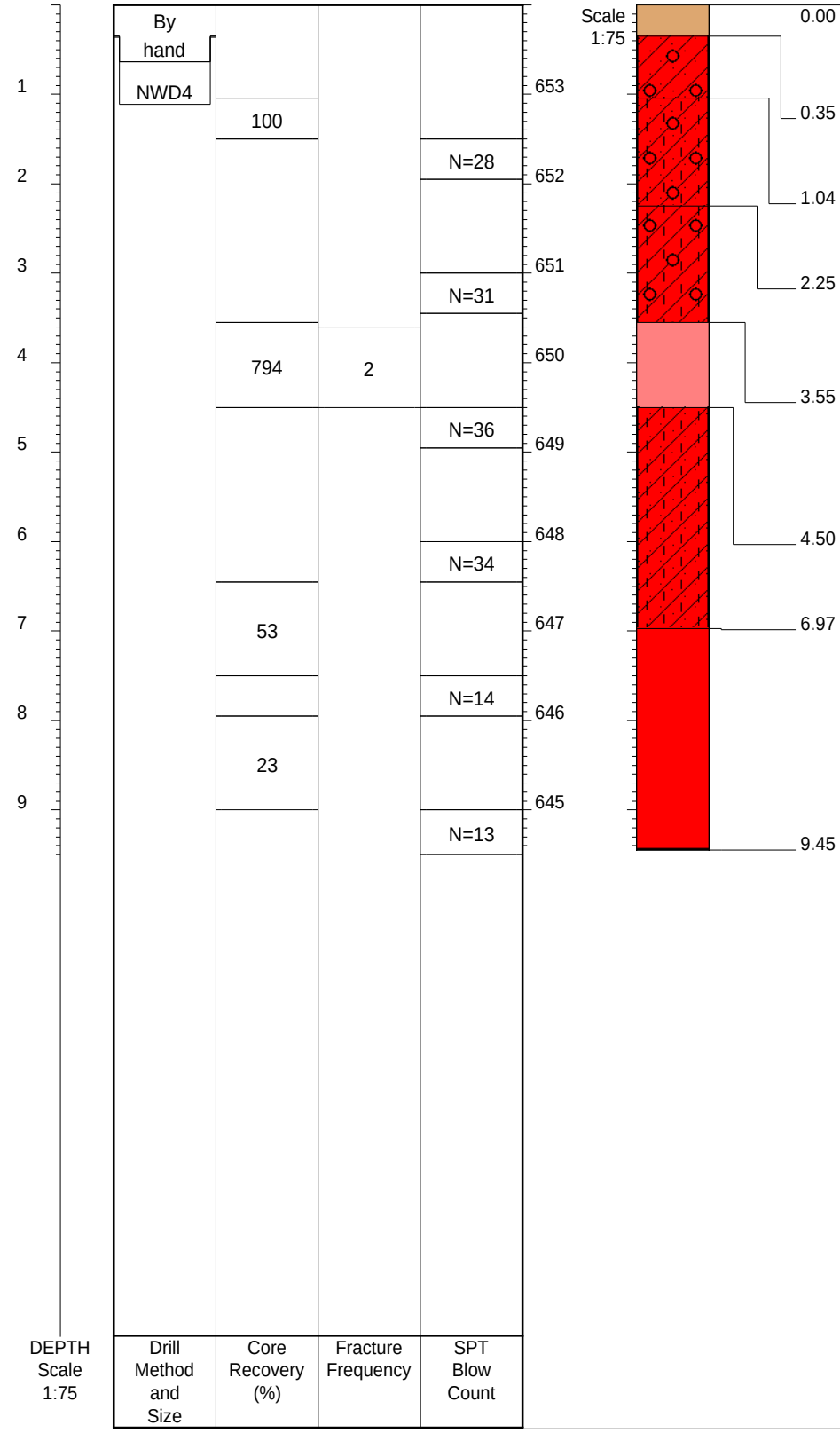
HOLE No: BH5
Sheet 1 of 1

JOB NUMBER: 063-20



0.00 – 0.35	Dark brownish grey, fine to medium grained, slightly gravelly clayey SAND. Colluvium.
0.35 – 1.04	Medium brownish orange, slightly gravelly sandy CLAY. Residual Gneiss.
1.04 – 2.25	Dark orange red, stiff, slightly gravelly sandy silty CLAY. Residual Gneiss.
2.25 – 3.55	Dark orange red anf light olive grey, very stiff, gravelly silty CLAY. Residual Gneiss.
3.55 – 4.50	Dark reddish orange and light grey, highly weathered, fine to coarse grained, slightly to highly fractured, very soft rock. Megacrystic Granitic GNEISS.
4.50 – 6.97	Dark reddish orange and light grey, very stiff, silty sandy CLAY. Residual Gneiss.
6.97 – 9.45	Dark reddish orange and light grey, firm, sandy silty CLAY. Residual Gneiss.

NOTES

1) Borehole terminated at 9,45m below EGL.

2) Standpipe type piezometer installed to 9,50m.

3) Water level recorded at 8,50m on 03/09/2020.

CONTRACTOR : Geopractica
MACHINE : D45
DRILLED BY :
PROFILED BY : E.Dada Mia

TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARG.SET

INCLINATION : -
DIAM :
DATE : 02 September 2020
DATE : 02 September 2020

DATE : 05/10/20 16:14
TEXT : ..C:\LOGS\BH5.TXT

ELEVATION : 654m
X-COORD : 30 45' 38.7"E
Y-COORD : 29 40' 37.6"S

HOLE No: BH5
-

APPENDIX B

INSPECTION PIT PROFILES

GEOSURE (Pty) Ltd
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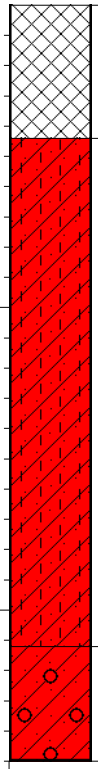
Proposed Thandokuhle Reservoir
KwaZulu Natal

HOLE No: IP1
Sheet 1 of 1

JOB NUMBER: 063-20

Scale 1:25



0.00 — Slightly moist, dark greyish brown, firm, fine to medium grained, slightly gravelly sandy CLAY. FILL.

0.44 — Slightly moist to moist, dark yellowish orange, firm to stiff, intact, sandy silty CLAY. Residual Gneiss.

2.12 — Moist, dark yellowish orange and dark red, slightly gravelly sandy CLAY. Residual Gneiss.

2.50

NOTES

1) No groundwater seepage observed.

2) Inspection pit extended using hand auger from 1,50m.

3) Samples taken at:
S1 0,44--2,12 (2 x Bulk)
S2 2,12--2,50 (1 x Ind)

4) Final depth at 2,50m.

CONTRACTOR :
MACHINE : By hand
DRILLED BY :
PROFILED BY : E. Dada Mia

TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 01 September 2020
DATE : 01 September 2020

DATE : 05/10/20 15:54
TEXT : ..C:\LOGS\PITS.TXT

ELEVATION : -
X-COORD : 30 45'38.4"E
Y-COORD : 29 40'37.2"S

HOLE No: IP1

GEOSURE (Pty) Ltd
P O Box 1461, Westville, 3630, South Africa
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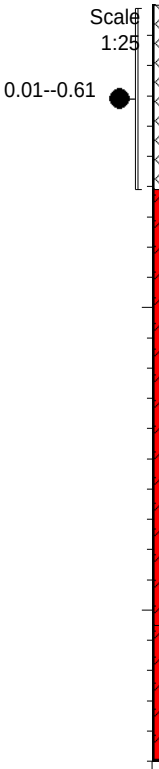
Naidu Consulting (Pty) Ltd
Proposed Thandokuhle Reservoir
KwaZulu Natal

HOLE No: IP2
Sheet 1 of 1

JOB NUMBER: 063-20

Scale 1:25



0.00 Slightly moist, dark greyish brown, firm, fine to medium grained, slightly gravelly sandy CLAY. FILL.

0.61 Slightly moist to moist, dark yellowish orange, firm to stiff, intact, sandy silty CLAY. Residual Gneiss.

2.05 Moist, dark yellowish orange and dark red, slightly gravelly sandy CLAY. Residual Gneiss.

2.50

NOTES

1) No groundwater seepage observed.

2) Inspection pit extended using hand auger from 1,50m.

3) Sample taken at:
S1 0,01--0,61 (2 x Bulk)

4) Final depth at 2,50m.

CONTRACTOR :
MACHINE : By hand
DRILLED BY :
PROFILED BY : E. Dada Mia
TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 01 September 2020
DATE : 01 September 2020
DATE : 05/10/20 15:54
TEXT : ..C:\LOGS\PITS.TXT

ELEVATION : -
X-COORD : 30 45'37.9"E
Y-COORD : 29 40'37.1"S

HOLE No: IP2

GEOSURE (Pty) Ltd
P O Box 1461, Westville, 3630, South Africa
Tel: (031) 266-0458
email: geosure@ iafrica.com

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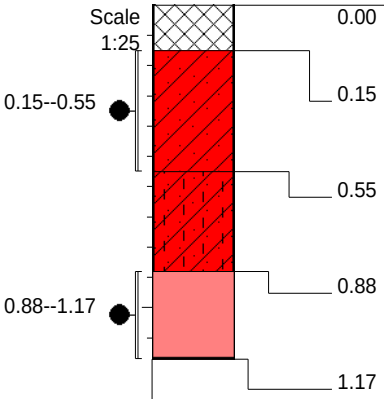
www.geosure.co.za

Naidu Consulting (Pty) Ltd
Proposed Thandokuhle Reservoir
KwaZulu Natal

HOLE No: IP3
Sheet 1 of 1

JOB NUMBER: 063-20



Slightly moist, dark greyish brown, firm, fine to medium grained, slightly gravelly sandy CLAY with abundance of 19mm stone. FILL.

Slightly moist, medium brownish grey, firm, fine to medium grained, sandy CLAY. Residual Gneiss.

Slightly moist to moist, dark yellowish orange, firm to stiff, intact, sandy silty CLAY. Residual Gneiss.

Dark orange and dark reddish grey, highly weathered, fine to coarse grained, highly fractured, very soft rock. Megacrystic Granitic GNEISS.

NOTES

1) No groundwater seepage observed.

2) Samples taken at:
S1 0,15--0,55 (1 x Ind)
S2 0,88--1,17 (2 x Bulk)

3) Refusal depth at 1,17m.

CONTRACTOR :
MACHINE : By hand
DRILLED BY :
PROFILED BY : E. Dada Mia

TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 01 September 2020
DATE : 01 September 2020

DATE : 05/10/20 15:54
TEXT : ..C:\LOGS\PITS.TXT

ELEVATION : -
X-COORD : 30 45'38.9"E
Y-COORD : 29 40'36.9"S

HOLE No: IP3

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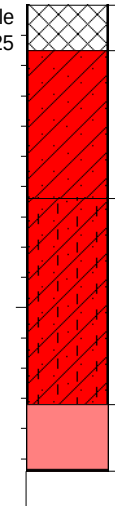
Naidu Consulting (Pty) Ltd
Proposed Thandokuhle Reservoir
KwaZulu Natal

HOLE No: IP4
Sheet 1 of 1

JOB NUMBER: 063-20

Scale 1:25



0.00	Slightly moist, dark greyish brown, firm, fine to medium grained, slightly gravelly sandy CLAY. FILL.
0.15	Slightly moist, medium brownish grey, firm, fine to medium grained, sandy CLAY. Residual Gneiss.
0.64	Slightly moist to moist, dark yellowish orange, firm to stiff, intact, sandy silty CLAY. Residual Gneiss.
1.32	Dark orange and dark reddish grey, highly weathered, fine to coarse grained, highly fractured, very soft rock. GNEISS.
1.54	

NOTES

1) No groundwater seepage observed.

2) Refusal depth at 1,54m.

CONTRACTOR :
MACHINE : By hand
DRILLED BY :
PROFILED BY : E. Dada Mia

TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 01 September 2020
DATE : 01 September 2020

DATE : 05/10/20 15:54
TEXT : ..C:\LOGS\PITS.TXT

ELEVATION : -
X-COORD : 30 45'39.1"E
Y-COORD : 29 40'36.4"S

HOLE No: IP4

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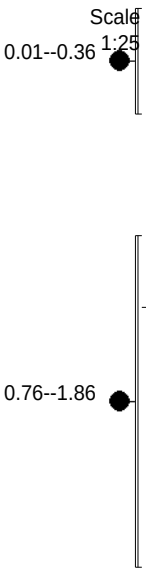
Naidu Consulting (Pty) Ltd
Proposed Thandokuhle Reservoir
KwaZulu Natal

HOLE No: IP5
Sheet 1 of 1

JOB NUMBER: 063-20



0.00 — Slightly moist, light greyish brown, medium dense, fine to medium grained, slightly gravelly clayey SAND with traces of 19mm concrete stone. FILL.

0.36 — Slightly moist, dark greyish brown, firm, fine to medium grained, sandy CLAY. Colluvium.

0.76 — Moist, dark reddish orange, firm to stiff, intact, slightly gravelly sandy CLAY. Residual Gneiss.

1.86

NOTES

1) No groundwater seepage observed.

2) Inspection pit extended using hand auger from 1,50m.

3) Samples taken at:
S1 0,01--0,36 (1 x Ind)
S2 0,76--1,86 (2 x Bulk) (1 x Ind)

4) Refusal depth at 1,86m.

CONTRACTOR :
MACHINE : By hand
DRILLED BY :
PROFILED BY : E. Dada Mia

TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 01 September 2020
DATE : 01 September 2020

DATE : 05/10/20 15:54
TEXT : ..C:\LOGS\PITS.TXT

ELEVATION : -
X-COORD : 30 45'38.9"E
Y-COORD : 29 40'36.1"S

HOLE No: IP5

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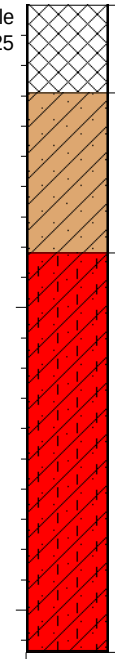
Naidu Consulting (Pty) Ltd
Proposed Thandokuhle Reservoir
KwaZulu Natal

HOLE No: IP6
Sheet 1 of 1

JOB NUMBER: 063-20

Scale 1:25



0.00 Slightly moist, light greyish brown, medium dense, fine to medium grained, slightly gravelly clayey SAND with traces of 19mm concrete stone. FILL.

0.29 Slightly moist, dark greyish brown, firm, fine to medium grained, sandy CLAY. Colluvium.

0.82 Moist, dark reddish orange, sandy silty CLAY. Residual Gneiss.

2.14

NOTES

1) No groundwater seepage observed.

2) Inspection pit extended using hand auger from 1,50m.

3) Refusal depth at 2,14m.

CONTRACTOR :
MACHINE : By hand
DRILLED BY :
PROFILED BY : E. Dada Mia

TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 01 September 2020
DATE : 01 September 2020

DATE : 05/10/20 15:54
TEXT : ..C:\LOGS\PITS.TXT

ELEVATION : -
X-COORD : 30 45'38.8"E
Y-COORD : 29 40'36.5"S

HOLE No: IP6

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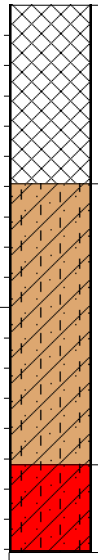
Naidu Consulting (Pty) Ltd
Proposed Thandokuhle Reservoir
KwaZulu Natal

HOLE No: IP7
Sheet 1 of 1

JOB NUMBER: 063-20

Scale 1:25



0.59--1.52

0.00 Slightly moist, light greyish brown, loose to medium dense, fine to medium grained, gravelly clayey SAND. FILL.

0.59 Slightly moist to moist, dark grey, firm to stiff, intact, sandy silty CLAY. Colluvium.

1.52 Moist, dark reddish orange, sandy silty CLAY. Residual Gneiss.

1.81

NOTES

1) No groundwater seepage observed.

2) Inspection pit extended using hand auger from 1,40m.

3) Sample taken at:
S1 0,59--1,52 (2 x Bulk)

4) Refusal depth at 1,81m.

CONTRACTOR :
MACHINE : By hand
DRILLED BY :
PROFILED BY : E. Dada Mia

TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 01 September 2020
DATE : 01 September 2020

DATE : 05/10/20 15:54
TEXT : ..C:\LOGS\PITS.TXT

ELEVATION : -
X-COORD : 30 45'38.5"E
Y-COORD : 29 40'36.2"S

HOLE No: IP7

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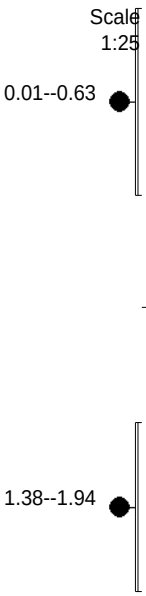
Naidu Consulting (Pty) Ltd
Proposed Thandokuhle Reservoir
KwaZulu Natal

HOLE No: IP8
Sheet 1 of 1

JOB NUMBER: 063-20



0.00 — Slightly moist, light greyish brown, loose to medium dense, fine to medium grained, gravelly clayey SAND. FILL.

0.63 — Slightly moist to moist, dark grey, firm to stiff, intact, sandy silty CLAY. Colluvium.

1.38 — Moist, dark reddish orange, sandy silty CLAY. Residual Gneiss.

1.94

NOTES

1) No groundwater seepage observed.

2) Inspection pit extended using hand auger from 1,50m.

3) Samples taken at:
S1 0,01--0,63 (1 x Ind)
S2 1,38--1,94 (1 x Ind)

4) Refusal depth at 1,94m.

CONTRACTOR :
MACHINE : By hand
DRILLED BY :
PROFILED BY : E. Dada Mia

TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 01 September 2020
DATE : 01 September 2020

DATE : 05/10/20 15:54
TEXT : ..C:\LOGS\PITS.TXT

ELEVATION : -
X-COORD : 30 45'38.2"E
Y-COORD : 29 40'36.8"S

HOLE No: IP8

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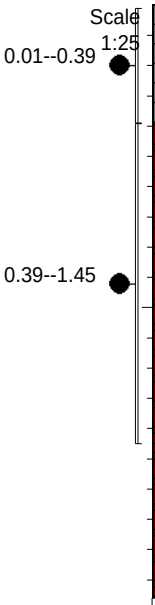
Naidu Consulting (Pty) Ltd
Proposed Thandokuhle Reservoir
KwaZulu Natal

HOLE No: IP9
Sheet 1 of 1

JOB NUMBER: 063-20



0.00	Slightly moist, light greyish brown, medium dense, fine to medium grained, slightly gravelly clayey SAND with traces of 19mm concrete stone. FILL.
0.39	Slightly moist to moist, dark yellowish orange, firm to stiff, intact, sandy silty CLAY. Residual Gneiss.
1.45	Moist, dark yellowish orange and dark red, slightly gravelly sandy CLAY. Residual Gneiss.
1.96	

NOTES

1) No groundwater seepage observed.

2) Inspection pit extended using hand auger from 1,50m.

3) Samples taken at:
S1 0,01--0,39 (1 x Ind)
S2 0,39--1,45 (1 x Ind)

4) Refusal depth at 1,96m.

CONTRACTOR :
MACHINE : By hand
DRILLED BY :
PROFILED BY : E. Dada Mia
TYPE SET BY : K.Kistasamy
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE : 01 September 2020
DATE : 01 September 2020
DATE : 05/10/20 15:54
TEXT : ..C:\LOGS\PITS.TXT

ELEVATION : -
X-COORD : 30 45'38.6"E
Y-COORD : 29 40'36.8"S

HOLE No: IP9

APPENDIX C

DYNAMIC CONE PENETROMETER TEST RESULTS

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

GEOSURE (Pty) Ltd

Client: Naidu Consulting (Pty) Ltd **Ref.No.** 063-20

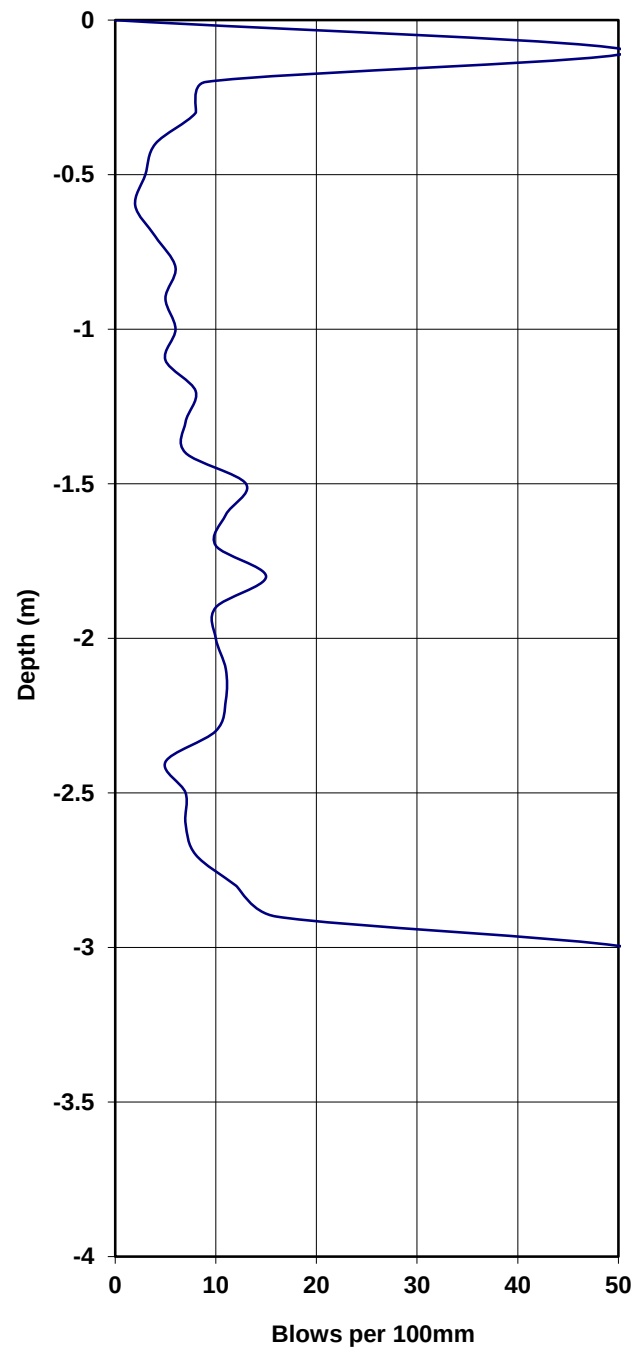
Project: Proposed Thandokuhle Reservoir **Date:** 01.09.2020

Section: KwaZulu Natal **Operator:** E.Dada-Mia

CBR Penetrometer Probe ---------- Test No. DC 1

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0				
0.1	51	Very Stiff	>150 kPa	>55
0.2	9	Stiff	75 kPa	15
0.3	8	Firm	65 kPa	14
0.4	4	Soft	35 kPa	7
0.5	3	Soft	25 kPa	5
0.6	2	Soft	20 kPa	3
0.7	4	Soft	35 kPa	7
0.8	6	Firm	50 kPa	10
0.9	5	Firm	40 kPa	8
1	6	Firm	50 kPa	10
1.1	5	Firm	40 kPa	8
1.2	8	Firm	65 kPa	14
1.3	7	Firm	60 kPa	12
1.4	7	Firm	60 kPa	12
1.5	13	Stiff	110 kPa	23
1.6	11	Stiff	90 kPa	19
1.7	10	Stiff	85 kPa	17
1.8	15	Stiff	125 kPa	27
1.9	10	Stiff	85 kPa	17
2	10	Stiff	85 kPa	17
2.1	11	Stiff	90 kPa	19
2.2	11	Stiff	90 kPa	19
2.3	10	Stiff	85 kPa	17
2.4	5	Firm	40 kPa	8
2.5	7	Firm	60 kPa	12
2.6	7	Firm	60 kPa	12
2.7	8	Firm	65 kPa	14
2.8	12	Stiff	100 kPa	21
2.9	16	Stiff	130 kPa	29
	Refusal			



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GEOSURE (Pty) Ltd

Client: Naidu Consulting (Pty) Ltd **Ref.No.** 063-20

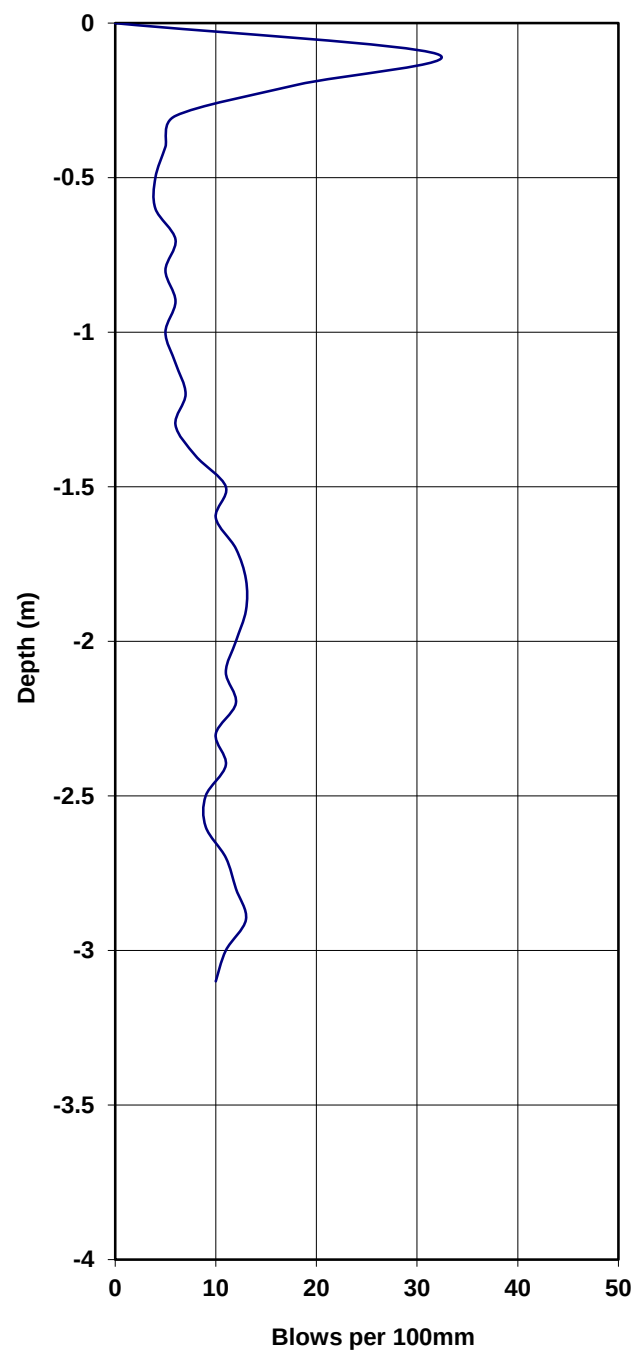
Project: Proposed Thandokuhle Reservoir **Date:** 01.09.2020

Section: KwaZulu Natal **Operator:** E.Dada-Mia

CBR Penetrometer Probe ---------- Test No. DC 2

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0				
0.1	32	Very Stiff	>150 kPa	>55
0.2	18	Stiff	150 kPa	33
0.3	6	Firm	50 kPa	10
0.4	5	Firm	40 kPa	8
0.5	4	Soft	35 kPa	7
0.6	4	Soft	35 kPa	7
0.7	6	Firm	50 kPa	10
0.8	5	Firm	40 kPa	8
0.9	6	Firm	50 kPa	10
1	5	Firm	40 kPa	8
1.1	6	Firm	50 kPa	10
1.2	7	Firm	60 kPa	12
1.3	6	Firm	50 kPa	10
1.4	8	Firm	65 kPa	14
1.5	11	Stiff	90 kPa	19
1.6	10	Stiff	85 kPa	17
1.7	12	Stiff	100 kPa	21
1.8	13	Stiff	110 kPa	23
1.9	13	Stiff	110 kPa	23
2	12	Stiff	100 kPa	21
2.1	11	Stiff	90 kPa	19
2.2	12	Stiff	100 kPa	21
2.3	10	Stiff	85 kPa	17
2.4	11	Stiff	90 kPa	19
2.5	9	Stiff	75 kPa	15
2.6	9	Stiff	75 kPa	15
2.7	11	Stiff	90 kPa	19
2.8	12	Stiff	100 kPa	21
2.9	13	Stiff	110 kPa	23
3	11	Stiff	90 kPa	19
3.1	10	Stiff	85 kPa	17
	End			



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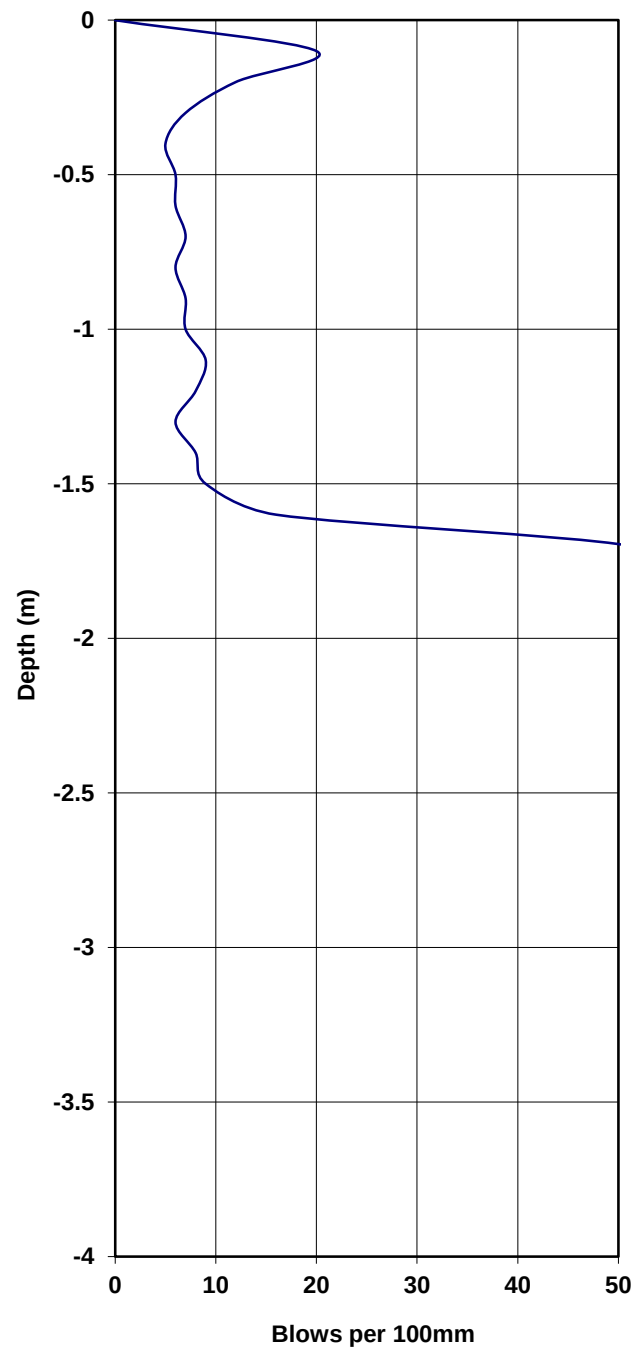
Project: Proposed Thandokuhle Reservoir **Date:** 01.09.2020

Section: KwaZulu Natal **Operator:** E.Dada-Mia

CBR Penetrometer Probe ---------- Test No. DC 3

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0				
0.1	20	Very Stiff	>150 kPa	37
0.2	12	Stiff	100 kPa	21
0.3	7	Firm	60 kPa	12
0.4	5	Firm	40 kPa	8
0.5	6	Firm	50 kPa	10
0.6	6	Firm	50 kPa	10
0.7	7	Firm	60 kPa	12
0.8	6	Firm	50 kPa	10
0.9	7	Firm	60 kPa	12
1	7	Firm	60 kPa	12
1.1	9	Stiff	75 kPa	15
1.2	8	Firm	65 kPa	14
1.3	6	Firm	50 kPa	10
1.4	8	Firm	65 kPa	14
1.5	9	Stiff	75 kPa	15
1.6	16	Stiff	130 kPa	29
	Refusal			



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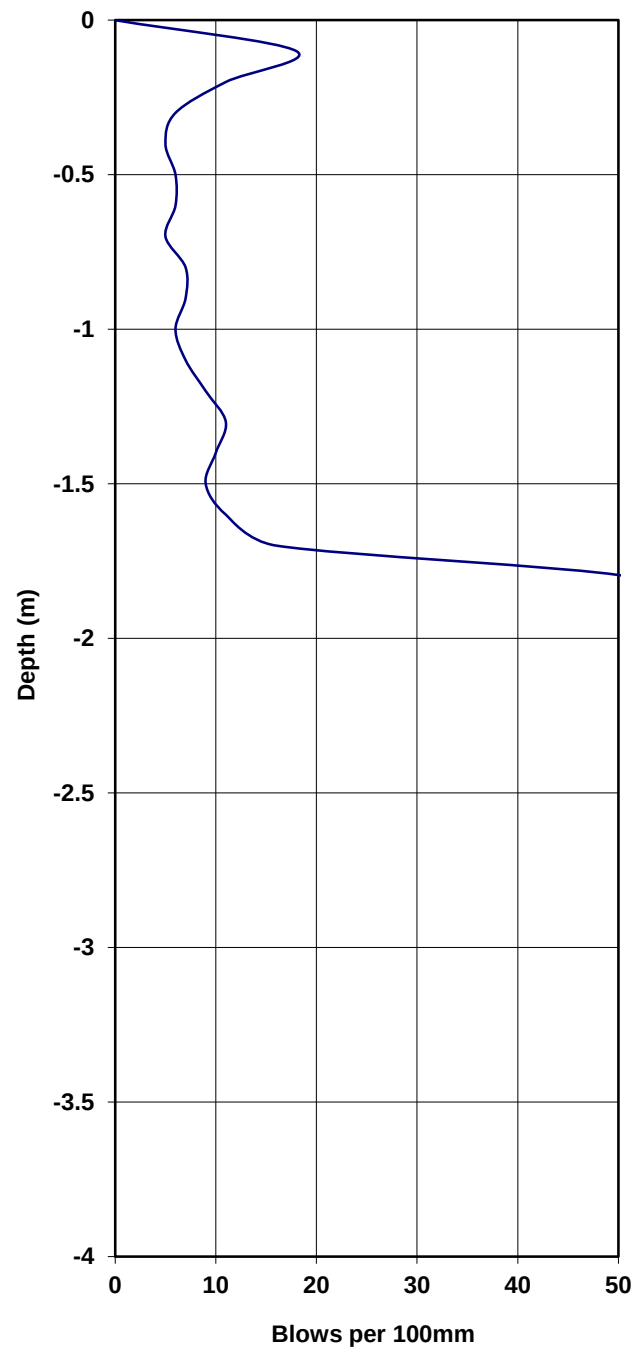
Project: Proposed Thandokuhle Reservoir **Date:** 01.09.2020

Section: KwaZulu Natal **Operator:** E.Dada-Mia

CBR Penetrometer Probe ---------- Test No. DC 4

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0				
0.1	18	Stiff	150 kPa	33
0.2	11	Stiff	90 kPa	19
0.3	6	Firm	50 kPa	10
0.4	5	Firm	40 kPa	8
0.5	6	Firm	50 kPa	10
0.6	6	Firm	50 kPa	10
0.7	5	Firm	40 kPa	8
0.8	7	Firm	60 kPa	12
0.9	7	Firm	60 kPa	12
1	6	Firm	50 kPa	10
1.1	7	Firm	60 kPa	12
1.2	9	Stiff	75 kPa	15
1.3	11	Stiff	90 kPa	19
1.4	10	Stiff	85 kPa	17
1.5	9	Stiff	75 kPa	15
1.6	11	Stiff	90 kPa	19
1.7	16	Stiff	130 kPa	29
	Refusal			



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GEOSURE (Pty) Ltd

Client: Naidu Consulting (Pty) Ltd **Ref.No.** 063-20

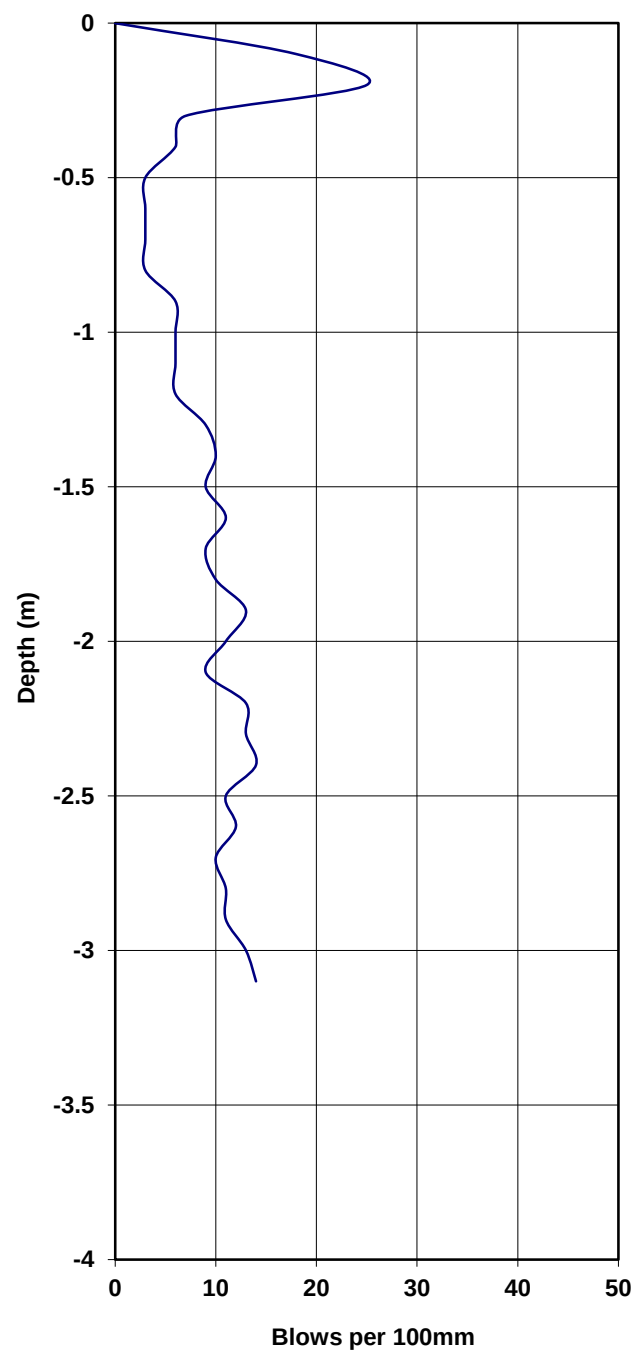
Project: Proposed Thandokuhle Reservoir **Date:** 01.09.2020

Section: KwaZulu Natal **Operator:** E.Dada-Mia

CBR Penetrometer Probe ---------- Test No. DC 5

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0				
0.1	18	Stiff	150 kPa	33
0.2	25	Very Stiff	>150 kPa	49
0.3	7	Firm	60 kPa	12
0.4	6	Firm	50 kPa	10
0.5	3	Soft	25 kPa	5
0.6	3	Soft	25 kPa	5
0.7	3	Soft	25 kPa	5
0.8	3	Soft	25 kPa	5
0.9	6	Firm	50 kPa	10
1	6	Firm	50 kPa	10
1.1	6	Firm	50 kPa	10
1.2	6	Firm	50 kPa	10
1.3	9	Stiff	75 kPa	15
1.4	10	Stiff	85 kPa	17
1.5	9	Stiff	75 kPa	15
1.6	11	Stiff	90 kPa	19
1.7	9	Stiff	75 kPa	15
1.8	10	Stiff	85 kPa	17
1.9	13	Stiff	110 kPa	23
2	11	Stiff	90 kPa	19
2.1	9	Stiff	75 kPa	15
2.2	13	Stiff	110 kPa	23
2.3	13	Stiff	110 kPa	23
2.4	14	Stiff	115 kPa	25
2.5	11	Stiff	90 kPa	19
2.6	12	Stiff	100 kPa	21
2.7	10	Stiff	85 kPa	17
2.8	11	Stiff	90 kPa	19
2.9	11	Stiff	90 kPa	19
3	13	Stiff	110 kPa	23
3.1	14	Stiff	115 kPa	25
	End			



GEOSURE (PTY) LTD.

Geotechnical Engineering Consultants

Tel: (031) 266 0458 Fax: 086 689 5506 Email: info@geosure.co.za

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

GEOSURE (Pty) Ltd

Client: Naidu Consulting (Pty) Ltd **Ref.No.** 063-20

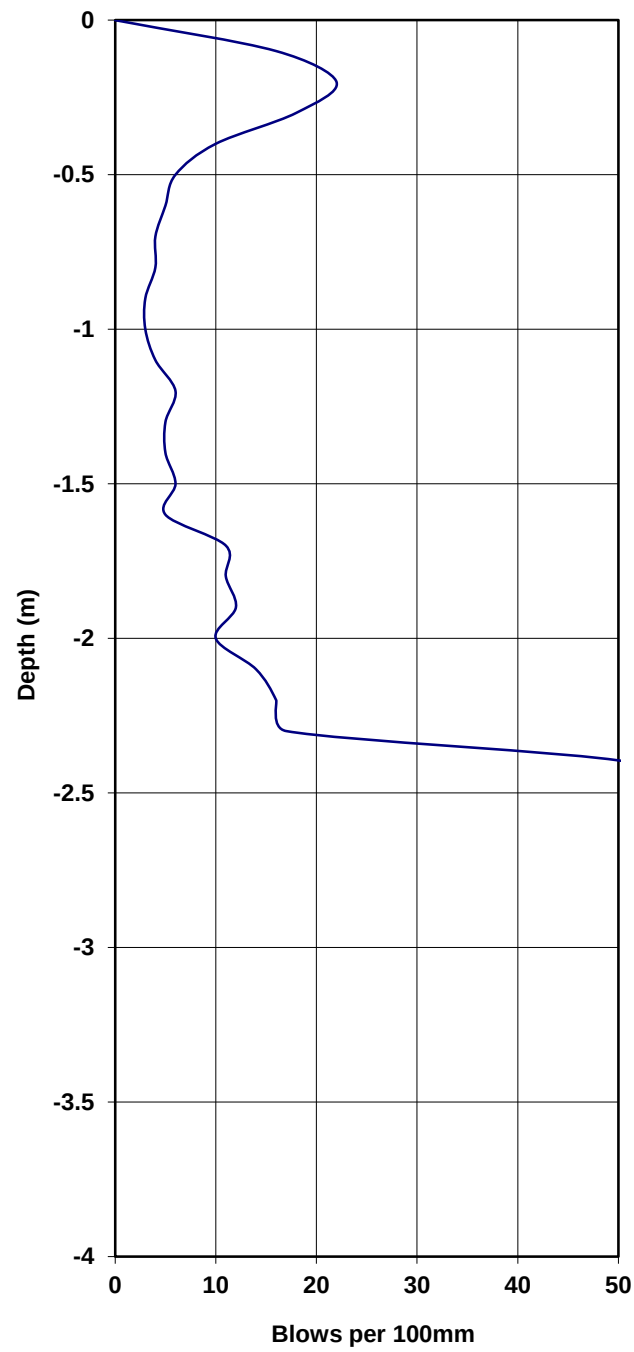
Project: Proposed Thandokuhle Reservoir **Date:** 01.09.2020

Section: KwaZulu Natal **Operator:** E.Dada-Mia

CBR Penetrometer Probe ---------- Test No. DC 6

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0				
0.1	16	Stiff	130 kPa	29
0.2	22	Very Stiff	>150 kPa	42
0.3	18	Stiff	150 kPa	33
0.4	10	Stiff	85 kPa	17
0.5	6	Firm	50 kPa	10
0.6	5	Firm	40 kPa	8
0.7	4	Soft	35 kPa	7
0.8	4	Soft	35 kPa	7
0.9	3	Soft	25 kPa	5
1	3	Soft	25 kPa	5
1.1	4	Soft	35 kPa	7
1.2	6	Firm	50 kPa	10
1.3	5	Firm	40 kPa	8
1.4	5	Firm	40 kPa	8
1.5	6	Firm	50 kPa	10
1.6	5	Firm	40 kPa	8
1.7	11	Stiff	90 kPa	19
1.8	11	Stiff	90 kPa	19
1.9	12	Stiff	100 kPa	21
2	10	Stiff	85 kPa	17
2.1	14	Stiff	115 kPa	25
2.2	16	Stiff	130 kPa	29
2.3	17	Stiff	140 kPa	31
	Refusal			



GEOSURE (PTY) LTD.

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

GEOSURE (Pty) Ltd

Client: Naidu Consulting (Pty) Ltd **Ref.No.** 063-20

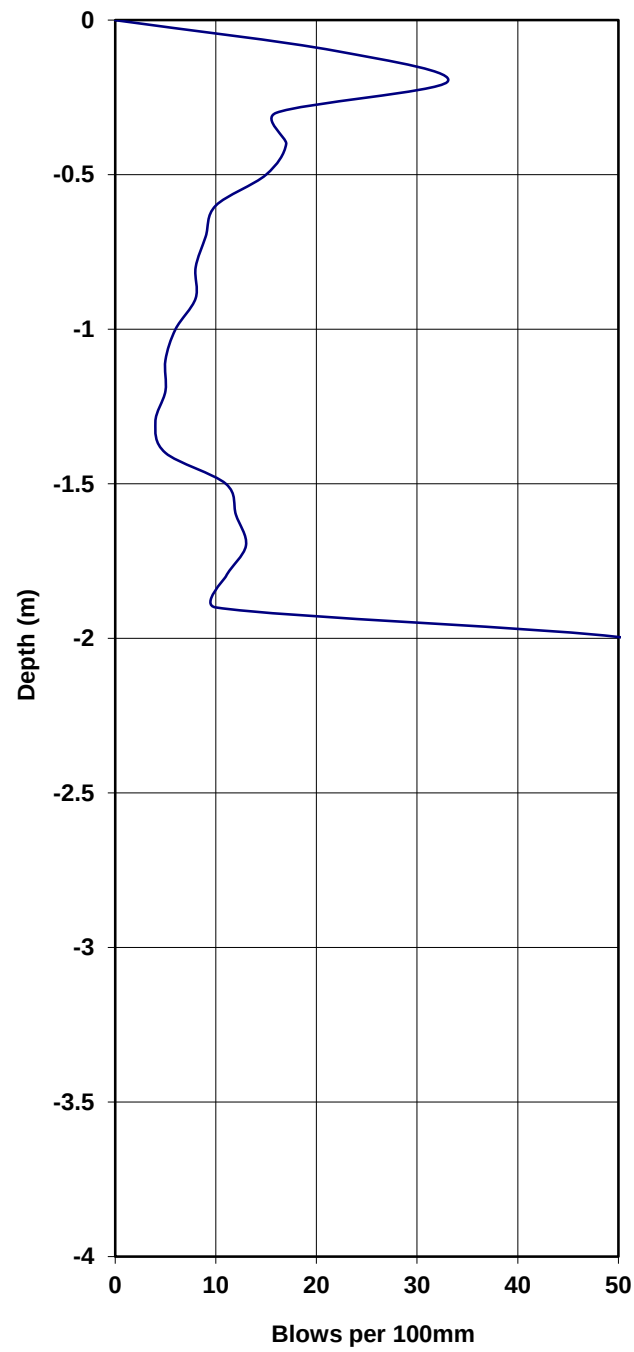
Project: Proposed Thandokuhle Reservoir **Date:** 01.09.2020

Section: KwaZulu Natal **Operator:** E.Dada-Mia

CBR Penetrometer Probe ---------- Test No. DC 7

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0				
0.1	22	Very Stiff	>150 kPa	42
0.2	33	Very Stiff	>150 kPa	>55
0.3	16	Stiff	130 kPa	29
0.4	17	Stiff	140 kPa	31
0.5	15	Stiff	125 kPa	27
0.6	10	Stiff	85 kPa	17
0.7	9	Stiff	75 kPa	15
0.8	8	Firm	65 kPa	14
0.9	8	Firm	65 kPa	14
1	6	Firm	50 kPa	10
1.1	5	Firm	40 kPa	8
1.2	5	Firm	40 kPa	8
1.3	4	Soft	35 kPa	7
1.4	5	Firm	40 kPa	8
1.5	11	Stiff	90 kPa	19
1.6	12	Stiff	100 kPa	21
1.7	13	Stiff	110 kPa	23
1.8	11	Stiff	90 kPa	19
1.9	10	Stiff	85 kPa	17
	Refusal			



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

GEOSURE (Pty) Ltd

Client: Naidu Consulting (Pty) Ltd **Ref.No.** 063-20

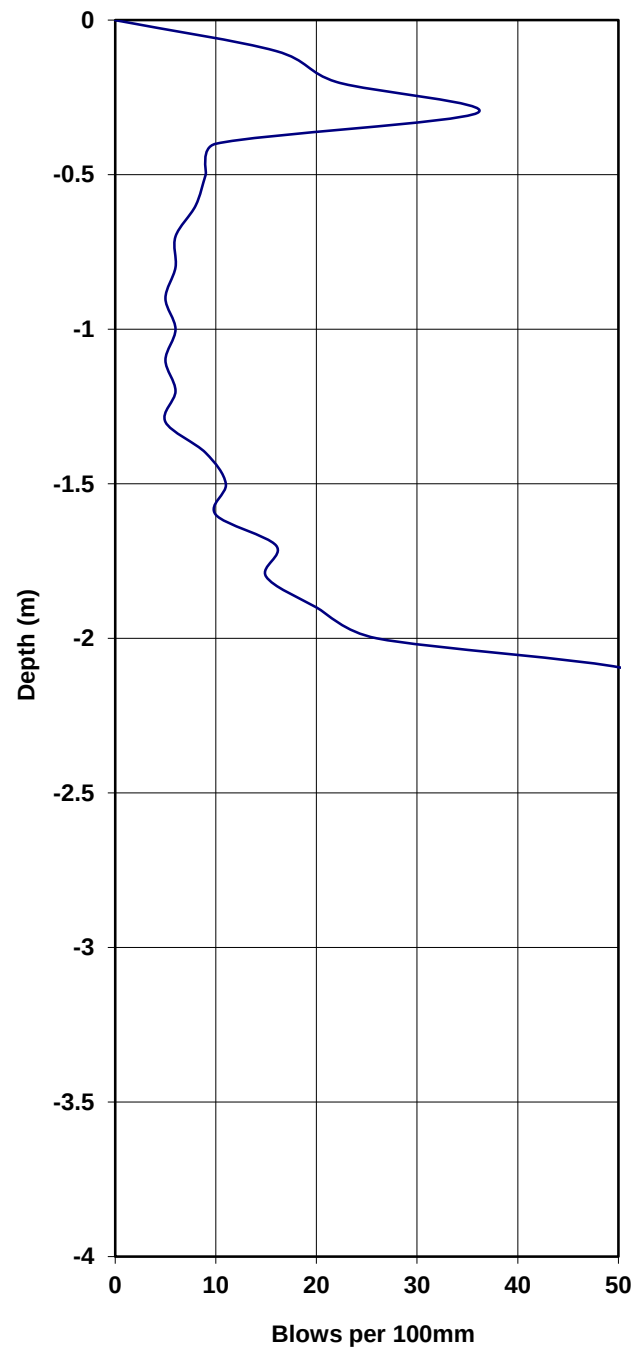
Project: Proposed Thandokuhle Reservoir **Date:** 01.09.2020

Section: KwaZulu Natal **Operator:** E.Dada-Mia

CBR Penetrometer Probe ---------- Test No. DC 8

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0				
0.1	16	Stiff	130 kPa	29
0.2	22	Very Stiff	>150 kPa	42
0.3	36	Very Stiff	>150 kPa	>55
0.4	10	Stiff	85 kPa	17
0.5	9	Stiff	75 kPa	15
0.6	8	Firm	65 kPa	14
0.7	6	Firm	50 kPa	10
0.8	6	Firm	50 kPa	10
0.9	5	Firm	40 kPa	8
1	6	Firm	50 kPa	10
1.1	5	Firm	40 kPa	8
1.2	6	Firm	50 kPa	10
1.3	5	Firm	40 kPa	8
1.4	9	Stiff	75 kPa	15
1.5	11	Stiff	90 kPa	19
1.6	10	Stiff	85 kPa	17
1.7	16	Stiff	130 kPa	29
1.8	15	Stiff	125 kPa	27
1.9	20	Very Stiff	>150 kPa	37
2	26	Very Stiff	>150 kPa	51
	Refusal			



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

GEOSURE (Pty) Ltd

Client: Naidu Consulting (Pty) Ltd **Ref.No.** 063-20

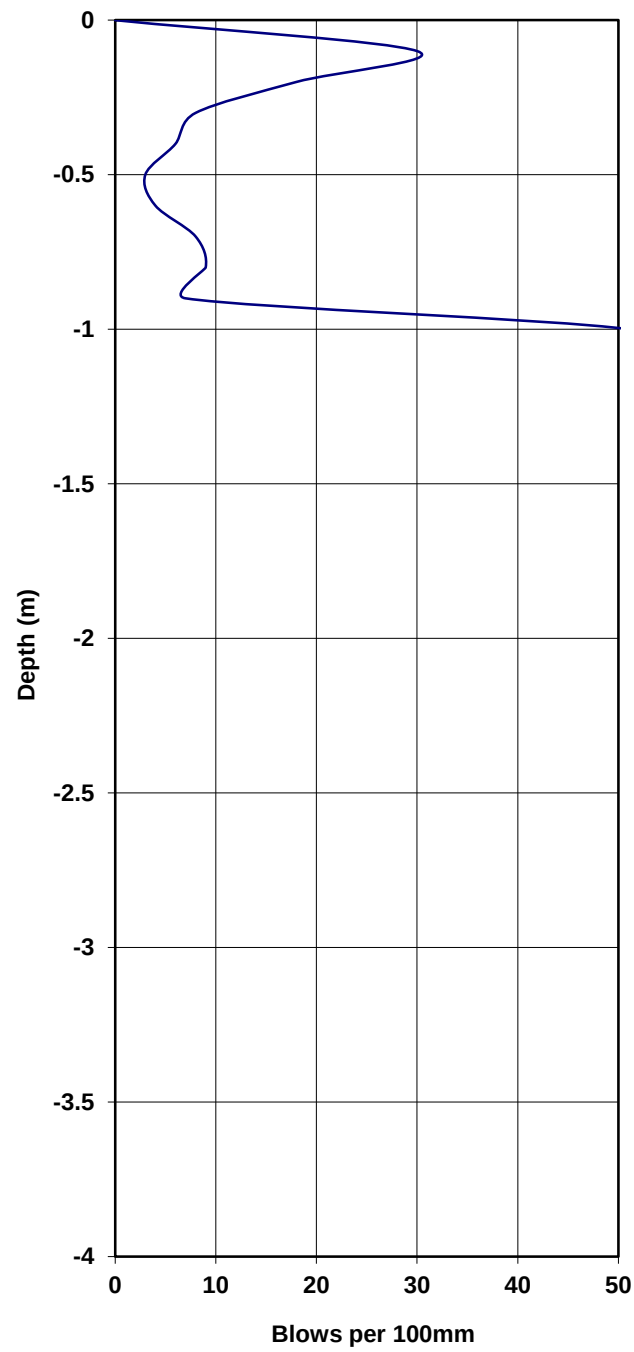
Project: Proposed Thandokuhle Reservoir **Date:** 01.09.2020

Section: KwaZulu Natal **Operator:** E.Dada-Mia

CBR Penetrometer Probe ---------- Test No. DC 9

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0				
0.1	30	Very Stiff	>150 kPa	>55
0.2	18	Stiff	150 kPa	33
0.3	8	Firm	65 kPa	14
0.4	6	Firm	50 kPa	10
0.5	3	Soft	25 kPa	5
0.6	4	Soft	35 kPa	7
0.7	8	Firm	65 kPa	14
0.8	9	Stiff	75 kPa	15
0.9	7	Firm	60 kPa	12
	Refusal			



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

GEOSURE (Pty) Ltd

Client: Naidu Consulting (Pty) Ltd **Ref.No.** 063-20

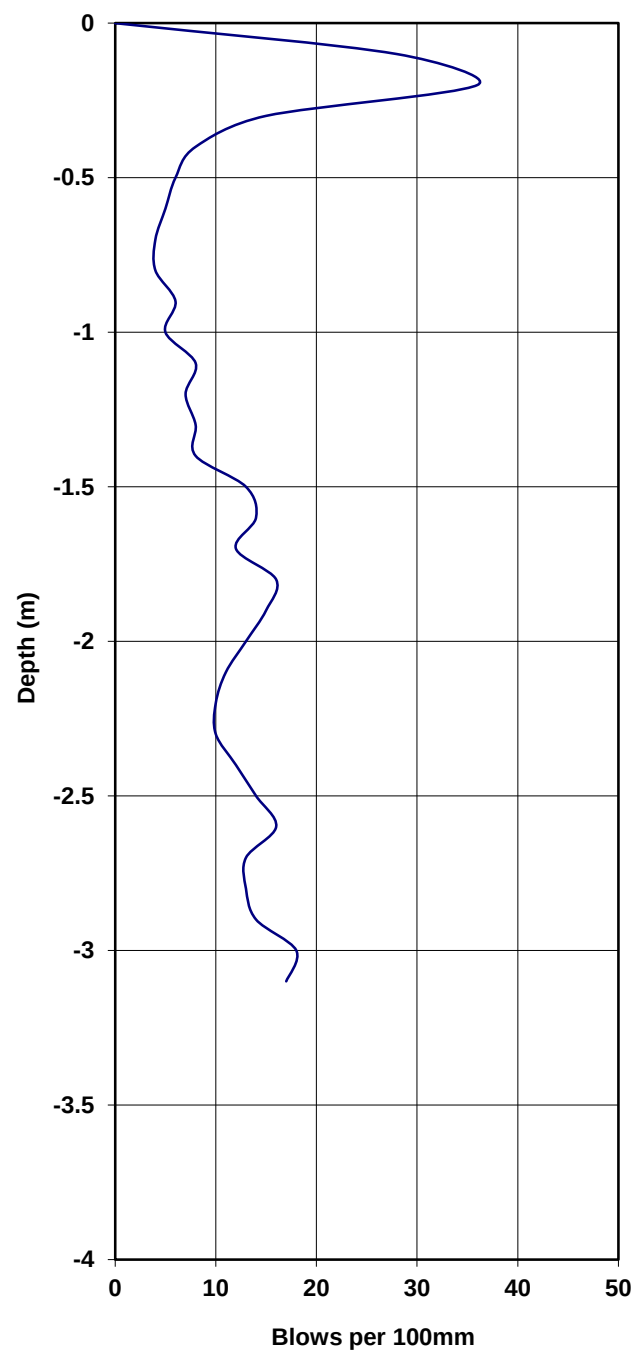
Project: Proposed Thandokuhle Reservoir **Date:** 01.09.2020

Section: KwaZulu Natal **Operator:** E.Dada-Mia

CBR Penetrometer Probe ---------- Test No. DC 10

THE STRENGTH AND CBR VALUES ARE EMPIRICAL AND DEPEND ON FACTORS SUCH AS MOISTURE CONTENT WHICH HAVE NOT BEEN DETERMINED. THEY ARE THEREFORE INDICATIVE ONLY AND SHOULD BE VERIFIED BY TEST OR OBSERVATION

Depth (m)	Blows/ 100mm	Inferred Consistency	Shear Strength	CBR %
0				
0.1	28	Very Stiff	>150 kPa	>55
0.2	36	Very Stiff	>150 kPa	>55
0.3	15	Stiff	125 kPa	27
0.4	8	Firm	65 kPa	14
0.5	6	Firm	50 kPa	10
0.6	5	Firm	40 kPa	8
0.7	4	Soft	35 kPa	7
0.8	4	Soft	35 kPa	7
0.9	6	Firm	50 kPa	10
1	5	Firm	40 kPa	8
1.1	8	Firm	65 kPa	14
1.2	7	Firm	60 kPa	12
1.3	8	Firm	65 kPa	14
1.4	8	Firm	65 kPa	14
1.5	13	Stiff	110 kPa	23
1.6	14	Stiff	115 kPa	25
1.7	12	Stiff	100 kPa	21
1.8	16	Stiff	130 kPa	29
1.9	15	Stiff	125 kPa	27
2	13	Stiff	110 kPa	23
2.1	11	Stiff	90 kPa	19
2.2	10	Stiff	85 kPa	17
2.3	10	Stiff	85 kPa	17
2.4	12	Stiff	100 kPa	21
2.5	14	Stiff	115 kPa	25
2.6	16	Stiff	130 kPa	29
2.7	13	Stiff	110 kPa	23
2.8	13	Stiff	110 kPa	23
2.9	14	Stiff	115 kPa	25
3	18	Stiff	150 kPa	33
3.1	17	Stiff	140 kPa	31
	End			



APPENDIX D

BOREHOLE CORE PHOTOGRAPHS

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

GEOSURE (Pty) Ltd

Client:	Naidu Consulting (Pty) Ltd
Project:	Proposed Thandokuhle Reservoir
Reference No.:	063-20
Borehole No:	BH1
Depth:	0,00m to 11,02m
Box No:	1 and 2

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

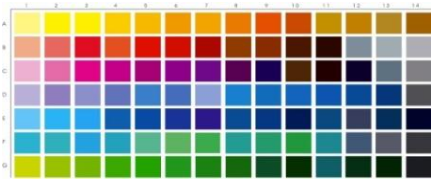
GEOSURE (Pty) Ltd

Client:	Naidu Consulting (Pty) Ltd
Project:	Proposed Thandokuhle Reservoir
Reference No.:	063-20
Borehole No:	BH2
Depth:	0,00m to 10,15m
Box No:	1 of 1

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

GEOSURE (Pty) Ltd

Client:	Naidu Consulting (Pty) Ltd
Project:	Proposed Thandokuhle Reservoir
Reference No.:	063-20
Borehole No:	BH3
Depth:	0,00m to 10,22m
Box No:	1 of 1



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

GEOSURE (Pty) Ltd

Client:	Naidu Consulting (Pty) Ltd
Project:	Proposed Thandokuhle Reservoir
Reference No.:	063-20
Borehole No:	BH4
Depth:	0,00m to 10,0m
Box No:	1 of 1

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

GEOSURE (Pty) Ltd

Client:	Naidu Consulting (Pty) Ltd
Project:	Proposed Thandokuhle Reservoir
Reference No.:	063-20
Borehole No:	BH5
Depth:	0,00m to 9,45m
Box No:	1 and 2

APPENDIX E

LABORATORY TEST RESULTS

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

GEOSURE (Pty) Ltd

sanas Testing Laboratory T0483

CLIENT : Geosure (Pty) Ltd
PHYSICAL ADDRESS : 122 Intersite Avenue, Springfield Park,
Umgeni
Durban, 4001
ATTENTION : Mr D. Naidoo
PROJECT : Thandokuhle Reservoir

TEST REPORT REFERENCE NUMBER: 50332

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

Date Received	**08.09.2020**
Date Tested	10.09.2020 to 18.09.2020
Sample Location	Refer to Report
Sampling Method	N/A
Sample Condition	Moist
Sampling Environmental Condition	N/A
Sampler(s) Name	Client
Total Number of Pages	26

Test Carried Out			
SANS3001 GR1	✓	TMH1 Method C3	
SANS3001 GR10, GR12	✓	TMH1 Method C4a	
SANS3001 GR30	✓	TMH1 Method B6	
SANS3001 GR40	✓	Hydrometer Analysis - ASTM D422	
TMH1 Method A10(b)		SABS1200 (Compactibility Factor)#	✓
TMH1 Method A13T + A14app		SANS 5862-1	
TMH1 Method A15d		SANS 5860, 5861-1, 5861-2, 5861-3	
TMH1 Method A13T + A16T		TMH1 Method B9	

✓ - Tick denotes tests that were carried out. #Denotes non accredited tests

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

Yours faithfully

Technical Signatory,
Bradley Hariram for Geosure (Pty) Ltd.

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122 Intersite Avenue, Umgeni Business Park, Durban 4091, South Africa
PO Box 1461, Westville, 3630, South Africa
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Mobile: +27 (0)82 784 0544
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Civil Engineering Laboratory
122 Intersite Avenue, Umgeni Business Park, Durban, 4091, South Africa
PO Box 1461, Westville, 3630, South Africa
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Gauteng Branch
P. O. Box 32381, Kyalami 1684
Tel.: 0861 GEOSURE / 0861 436 7873
Fax: 086 689 8327
Mobile: 083 377 6559
Email: gauteng@geosure.co.za

Consulting Engineering Geologists, Geotechnical Engineers, Geotechnicians & Geotechnical Quality Assurance Specialists
GEOSURE (Pty) Ltd
sanas T0483

Reg.No.: 92/03145/07
LABORATORY AND HEAD OFFICE ADDRESS: 122 Intersite Avenue, Umgeni Business Park, Durban, 4091
LABORATORY CONTACT INFO.: Tel.: +27(0) 31 701 9732 Fax: 086 684 9785
Mobile: +27(0) 72 870 2621 e-mail: lab@geosure.co.za
HEAD OFFICE CONTACT INFO.: Tel.: +27(0) 31 266 0458 Fax: 086 689 5506
Mobile: +27(0) 82 784 0544 e-mail:geosure@iafrica.com
WEBSITE: www.geosure.co.za

Client : **Geosure (Pty) Ltd** **Our Ref.** : **50332**

Project : **Thandokuhle Reservoir** **Your Ref.** : **063-20**

Date Tested : **10.09.2020 to 22.09.2020**

Attention : **Mr D. Naidoo** **Date Reported** : **23.09.2020**

Sample No.			T27492	T27493	T27494	T27495	T27496
Field No.			BH1	BH1	BH1	BH2	BH2
Position in Field			Layer 3	Layer 4	Layer 4	Layer 3	Layer 3
Depth (m)			1.01-1.5	1.95-2.23	2.23-2.50	1.00-1.25	1.25-1.50
Material Description			Dark orange red slightly sandy clayey SILT. Residual Gneiss	Dark orange red speckled light olive grey slighlty gravelly silty CLAY. Residual Gneiss	Dark orange red speckled light olive grey slighlty gravelly silty CLAY. Residual Gneiss	Dark orange red speckled light grey slightly gravelly silty CLAY. Residual Gneiss	Dark orange red speckled light grey slightly gravelly silty CLAY. Residual Gneiss
Sieve Analysis (Wet Preparation) - SANS3001 GR 1 - Percent Passing Sieve Size							
% Passing	**100.0**	**mm**	100	100	100	100	100
	75.0	**mm**	100	100	100	100	100
	63.0	**mm**	100	100	100	100	100
	50.0	**mm**	100	100	100	100	100
	37.5	**mm**	100	100	100	100	100
	28.0	**mm**	100	100	100	100	100
	20.0	**mm**	100	100	100	100	100
	14.0	**mm**	100	100	100	100	100
	5.00	**mm**	98	97	96	97	97
	2.00	**mm**	81	83	78	85	82
	0.425	**mm**	60	60	55	66	63
	0.250	**mm**	57	52	48	56	54
	0.150	**mm**	55	46	42	49	46
	0.075	**mm**	52	41	38	44	40
Hydrometer Analysis - ASTM - D422 - Percent Passing Particle Diameter (<0.425mm)							
% Passing	**0.060**	**mm**	50	39	35	42	38
	0.050	**mm**	49	38	34	41	36
	0.040	**mm**	47	36	32	40	34
	0.026	**mm**	45	34	30	39	32
	0.015	**mm**	41	31	25	37	26
	0.010	**mm**	39	29	22	34	26
	0.0074	**mm**	37	26	19	33	23
	0.0036	**mm**	32	22	15	30	20
	0.0020	**mm**	30	20	12	29	18
	0.0015	**mm**	28	18	11	27	17
Mechanical analysis - SANS3001 GR1 - Percent of Soil Mortar (<2 mm) for Grain Size range							
Coarse Sand		**%**	25	27	30	23	23
Coarse Fine Sand		**%**	4	9	9	12	11
Medium Fine Sand		**%**	3	7	7	8	9
Fine Fine Sand		**%**	3	6	6	6	7
Silt & Clay		**%**	65	50	48	51	49
Grading Modulus			1.06	1.16	1.29	1.06	1.15
Atterberg Limits - SANS3001 GR10, GR12 (<0.425mm)							
Liquid Limit		**%**	59	50	45	55	56
Plasticity Index		**%**	25	19	16	21	22
Linear Shrinkage		**%**	12.0	9.5	8.5	11.0	10.0
AASHTO Classification (Group Index)*			A-7-5 (11)	A-7-5 (4)	A-7-6 (2)	A-7-5 (6)	A-7-5 (4)
Unified Classification*			MH/OH‡	SM	SM	SM	SM
Moisture Content		**%**					

Remarks: Date Received: 09.09.2020

Sampled by Client.

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

Consulting Engineering Geologists, Geotechnical Engineers, Geotechnicians & Geotechnical Quality Assurance Specialists
GEOSURE (Pty) Ltd

sanas T6483

Reg.No.: 92/03145/07

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Mobile: +27(0) 82 784 0544 e-mail:geosure@iafrica.com

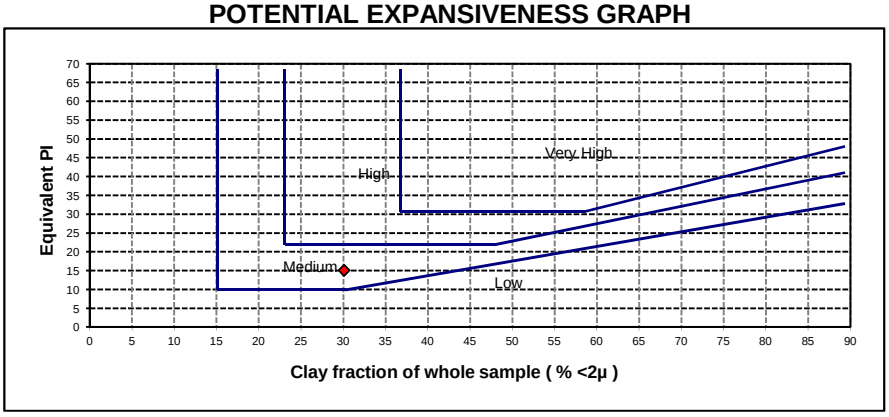
WEBSITE: www.geosure.co.za

Client : Geosure (Pty) Ltd
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

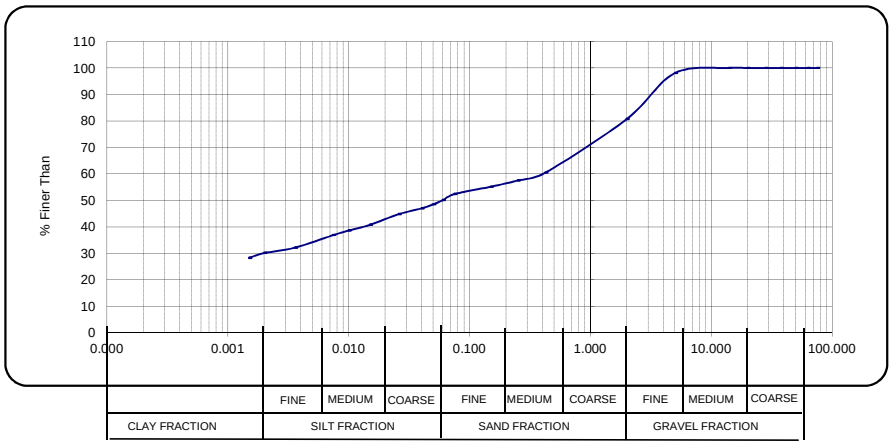
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27492
Field No. : BH1
Sample Description : Dark orange red slightly sandy clayey SILT. Residual Gneiss
Equivalent PI : 15 **Clay fraction of whole sample (% <2μ)** : 30

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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GEOSURE (Pty) Ltd

sanas Testing Laboratory T0483

Reg.No.: 92/03145/07

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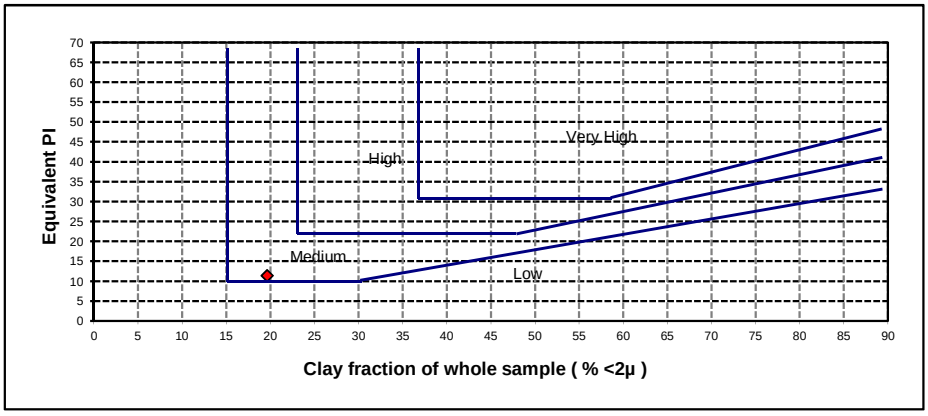
WEBSITE: www.geosure.co.za

Client : Geosure (Pty) Ltd
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

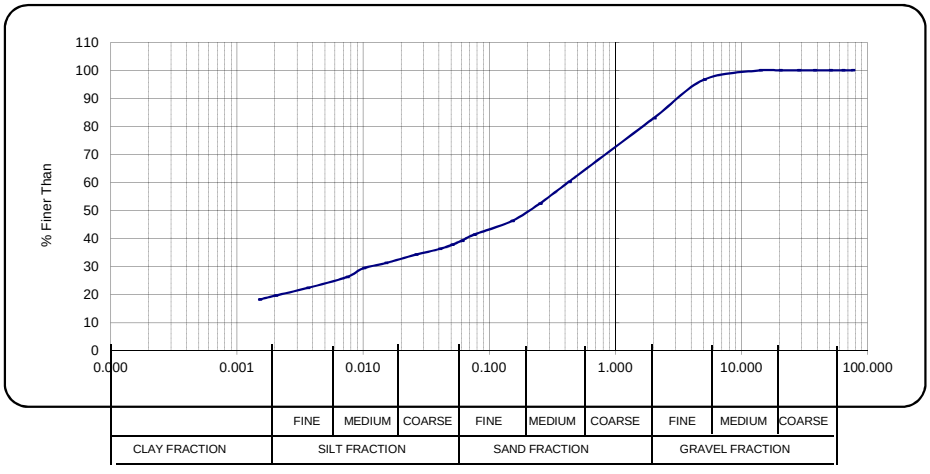
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27493
Field No. : BH1
Sample Description : Dark orange red speckled light olive grey slighlty gravelly silty CLAY. Residual Gneiss
Equivalent PI : 11 **Clay fraction of whole sample (% <2μ)** : 20

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



Consulting Engineering Geologists, Geotechnical Engineers, Geotechnicians & Geotechnical Quality Assurance Specialists
GEOSURE (Pty) Ltd
sanas T0483

Reg.No.: 92/03145/07
LABORATORY AND HEAD OFFICE ADDRESS: 122 Intersite Avenue, Umgeni Business Park, Durban, 4091
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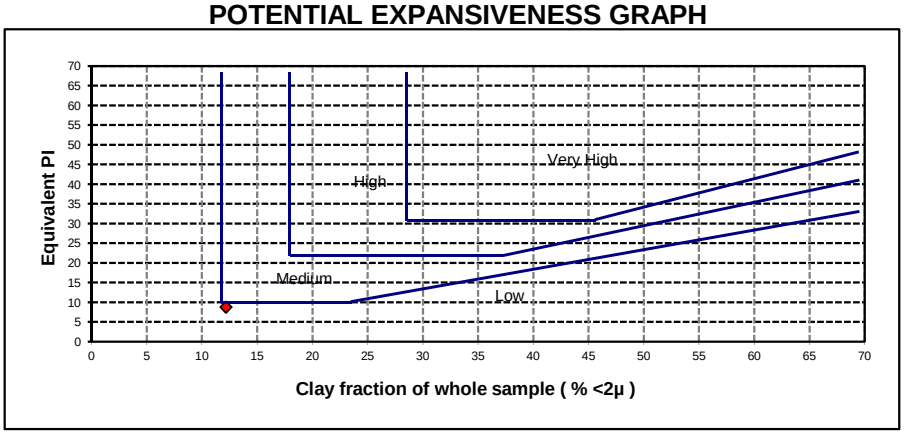
HEAD OFFICE CONTACT INFO.: Tel.: +27(0) 31 266 0458 Fax: 086 689 5506
Mobile: +27(0) 82 784 0544 e-mail:geosure@iafrica.com
WEBSITE: www.geosure.co.za

Client : Geosure (Pty) Ltd
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

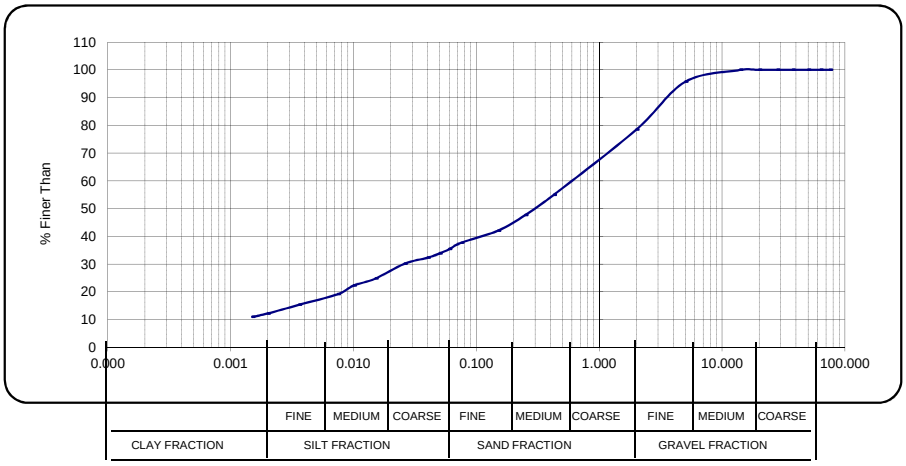
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27494
Field No. : BH1
Sample Description : Dark orange red speckled light olive grey slighlty gravelly silty CLAY. Residual Gneiss
Equivalent PI : 9 **Clay fraction of whole sample (% <2μ)** : 12

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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Reg.No.: 92/03145/07

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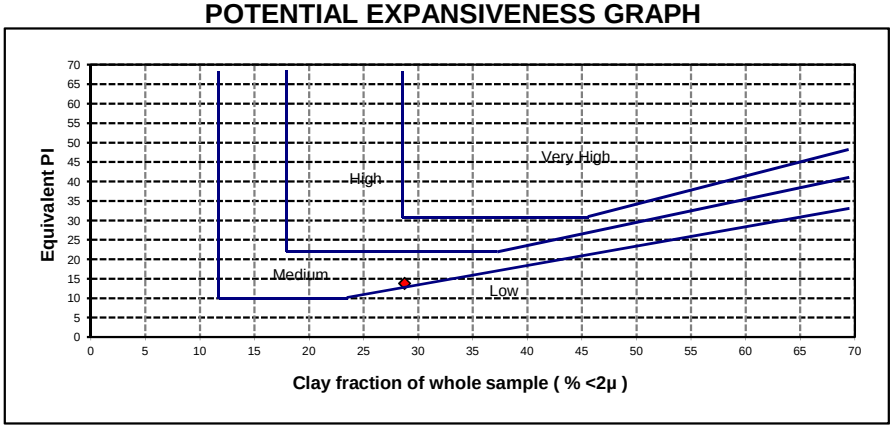
WEBSITE: www.geosure.co.za

Client : Geosure (Pty) Ltd
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

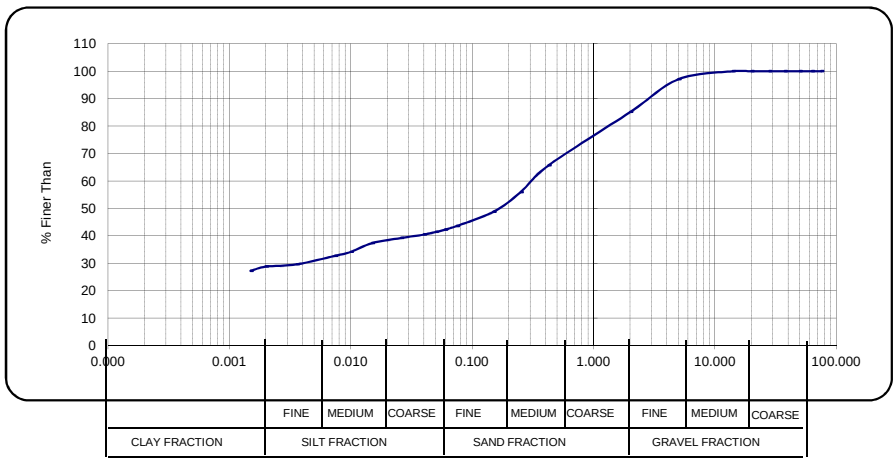
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27495
Field No. : BH2
Sample Description : Dark orange red speckled light grey slightly gravelly silty CLAY. Residual Gneiss
Equivalent PI : 14 **Clay fraction of whole sample (% <2μ)** : 29

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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Reg.No.: 92/03145/07

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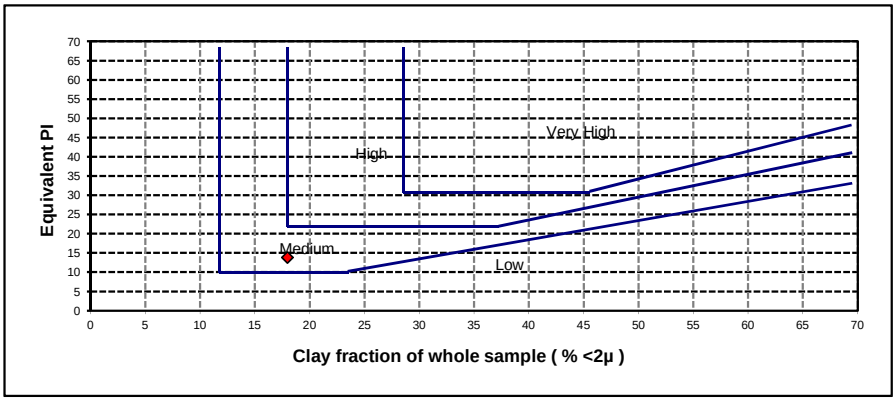
WEBSITE: www.geosure.co.za

Client : Geosure (Pty) Ltd
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

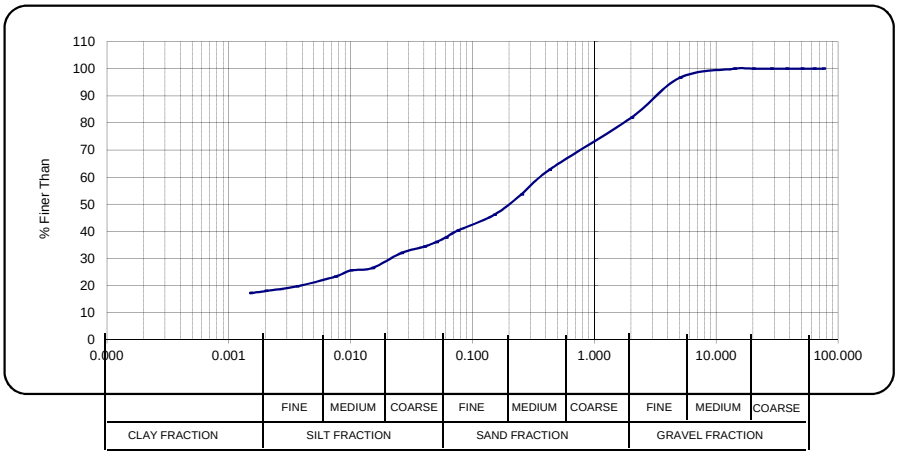
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27496
Field No. : BH2
Sample Description : Dark orange red speckled light grey slightly gravelly silty CLAY. Residual Gneiss
Equivalent PI : 14 **Clay fraction of whole sample (% <2μ)** : 18

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



Consulting Engineering Geologists, Geotechnical Engineers, Geotechnicians & Geotechnical Quality Assurance Specialists
GEOSURE (Pty) Ltd

sanas Testing Laboratory T0483

Reg.No.: 92/03145/07

LABORATORY AND HEAD OFFICE ADDRESS: 122 Intersite Avenue, Umgeni Business Park, Durban, 4091

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WEBSITE: www.geosure.co.za

Client : **Geosure (Pty) Ltd** **Our Ref.** : **50332**

Project : **Thandokuhle Reservoir** **Your Ref.** : **063-20**

Date Tested : **10.09.2020 to 22.09.2020**

Attention : **Mr D. Naidoo** **Date Reported** : **23.09.2020**

Sample No.			T27497	T27498	T27499	T27500	T27501
Field No.			BH2	BH3	BH3	BH3	BH4
Position in Field			Layer 3	Layer 3	Layer 3	Layer 3	Layer 3
Depth (m)			1.95-2.48	1.06-1.28	1.28-1.50	1.95-2.40	1.09-1.50
Material Description			Dark orange red speckled light grey slightly gravelly silty CLAY. Residual Gneiss	Dark orange red mottled light greyish orange slightly gravelly sandy silty CLAY. Residual Gneiss	Dark orange red speckled mottled light greyish olive slightly gravelly sandy silty CLAY. Residual Gneiss	Dark orange red mottled light greyish orange slightly gravelly sandy silty CLAY. Residual Gneiss	Dark orange red speckled light yellow slightly gravelly sandy silty CLAY. Residual Gneiss
Sieve Analysis (Wet Preparation) - SANS3001 GR 1 - Percent Passing Sieve Size							
% Passing	**100.0**	**mm**	100	100	100	100	100
	75.0	**mm**	100	100	100	100	100
	63.0	**mm**	100	100	100	100	100
	50.0	**mm**	100	100	100	100	100
	37.5	**mm**	100	100	100	100	100
	28.0	**mm**	100	100	100	100	100
	20.0	**mm**	100	100	100	100	100
	14.0	**mm**	100	100	98	100	100
	5.00	**mm**	98	95	97	98	98
	2.00	**mm**	84	78	84	82	77
	0.425	**mm**	58	53	50	55	48
	0.250	**mm**	48	50	46	50	45
	0.150	**mm**	40	47	43	45	41
	0.075	**mm**	34	44	39	42	38
Hydrometer Analysis - ASTM - D422 - Percent Passing Particle Diameter (<0.425mm)							
% Passing	**0.060**	**mm**	32	42	38	41	36
	0.050	**mm**	31	41	37	41	34
	0.040	**mm**	30	39	37	41	33
	0.026	**mm**	28	37	36	40	30
	0.015	**mm**	25	35	33	37	26
	0.010	**mm**	22	34	31	35	23
	0.0074	**mm**	21	33	29	33	21
	0.0036	**mm**	18	29	25	29	18
	0.0020	**mm**	17	29	25	28	17
	0.0015	**mm**	16	28	23	27	16
Mechanical analysis - SANS3001 GR1 - Percent of Soil Mortar (<2 mm) for Grain Size range							
Coarse Sand		**%**	31	32	40	33	38
Coarse Fine Sand		**%**	12	4	5	6	4
Medium Fine Sand		**%**	10	4	4	5	4
Fine Fine Sand		**%**	7	3	4	5	4
Silt & Clay		**%**	40	57	47	51	50
Grading Modulus			1.24	1.25	1.26	1.22	1.38
Atterberg Limits - SANS3001 GR10, GR12 (<0.425mm)							
Liquid Limit		**%**	56	56	42	47	43
Plasticity Index		**%**	24	21	16	21	16
Linear Shrinkage		**%**	10.5	11.0	8.0	10.0	9.5
AASHTO Classification (Group Index)*			A-2-7 (3)	A-7-5 (6)	A-7-6 (2)	A-7-6 (4)	A-7-6 (2)
Unified Classification*			SM	SM	SM	SC	SM
Moisture Content		**%**					

Remarks: Date Received: 09.09.2020

Sampled by Client.

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

Consulting Engineering Geologists, Geotechnical Engineers, Geotechnicians & Geotechnical Quality Assurance Specialists
GEOSURE (Pty) Ltd

sanas T6483

Reg.No.: 92/03145/07

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HEAD OFFICE CONTACT INFO.: Tel.: +27(0) 31 266 0458 Fax: 086 689 5506
Mobile: +27(0) 82 784 0544 e-mail:geosure@iafrica.com

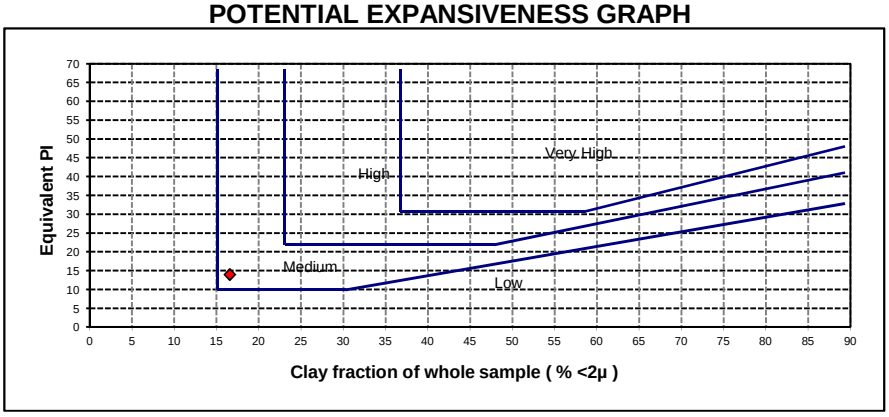
WEBSITE: www.geosure.co.za

Client : Geosure (Pty) Ltd
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

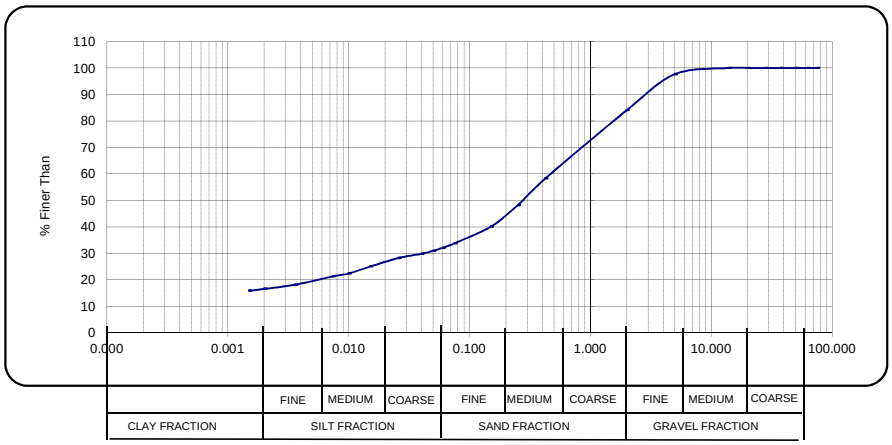
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27497
Field No. : BH2
Sample Description : Dark orange red speckled light grey slightly gravelly silty CLAY. Residual Gneiss
Equivalent PI : 14 **Clay fraction of whole sample (% <2μ)** : 17

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



Consulting Engineering Geologists, Geotechnical Engineers, Geotechnicians & Geotechnical Quality Assurance Specialists
GEOSURE (Pty) Ltd

sanas Testing Laboratory T0483

Reg.No.: 92/03145/07

LABORATORY AND HEAD OFFICE ADDRESS: 122 Intersite Avenue, Umgeni Business Park, Durban, 4091

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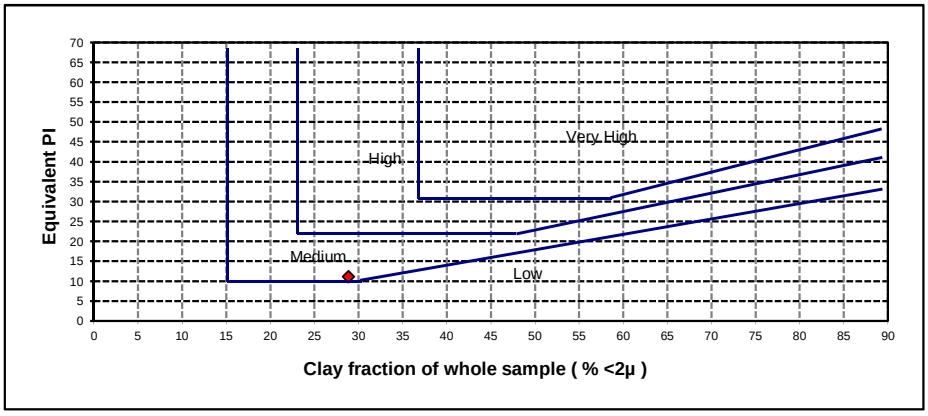
Client : Geosure (Pty) Ltd
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

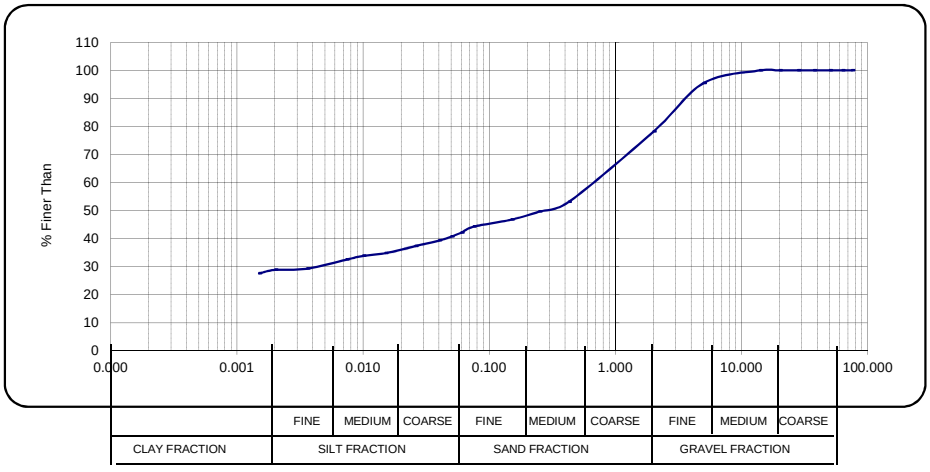
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27498
Field No. : BH3
Sample Description : Dark orange red mottled light greyish orange slightly gravelly sandy silty CLAY. Residual Gneiss
Equivalent PI : 11 **Clay fraction of whole sample (% <2μ)** : 29

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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GEOSURE (Pty) Ltd

Reg.No.: 92/03145/07

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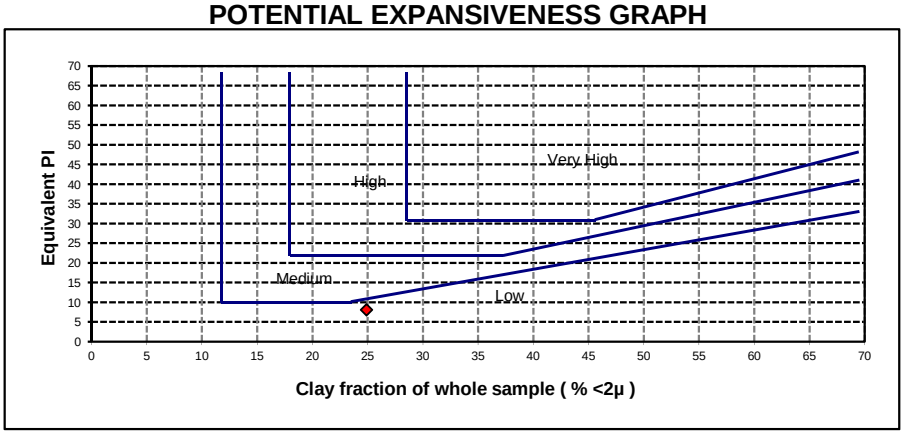
WEBSITE: www.geosure.co.za

Client : Geosure (Pty) Ltd
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

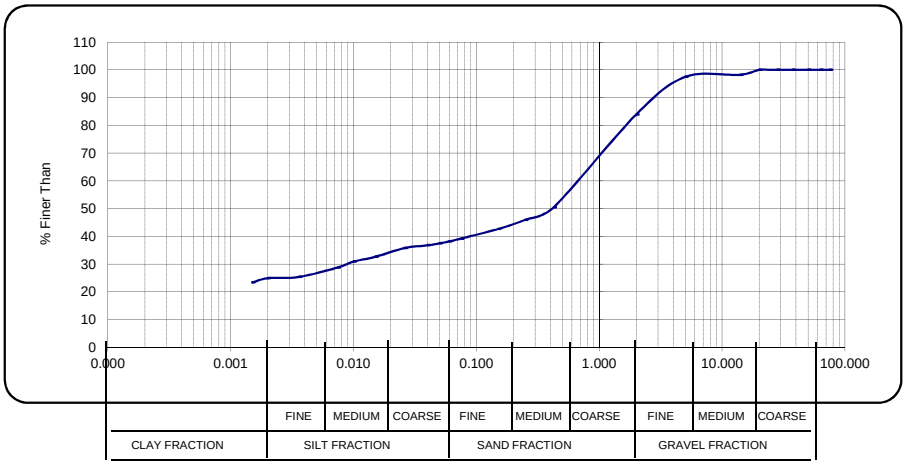
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27499
Field No. : BH3
Sample Description : Dark orange red speckled mottled light greyish olive slightly gravelly sandy silty CLAY. Residual G
Equivalent PI : 8 **Clay fraction of whole sample (% <2μ)** : 25

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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GEOSURE (Pty) Ltd

Reg.No.: 92/03145/07

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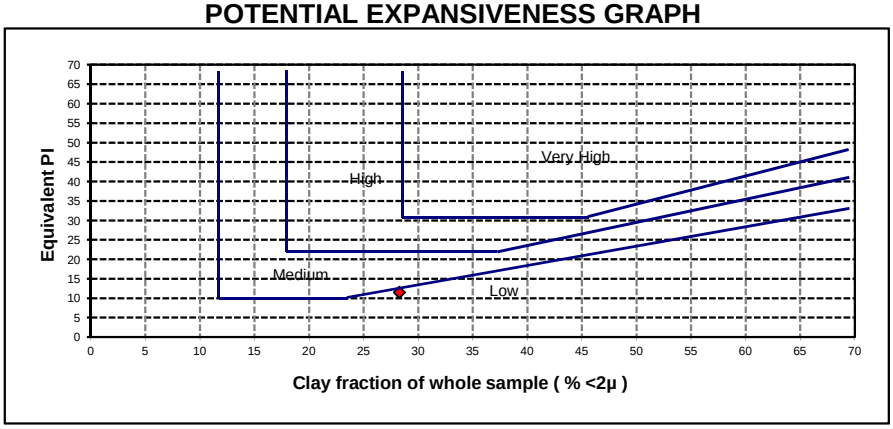
WEBSITE: www.geosure.co.za

Client : Geosure (Pty) Ltd
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

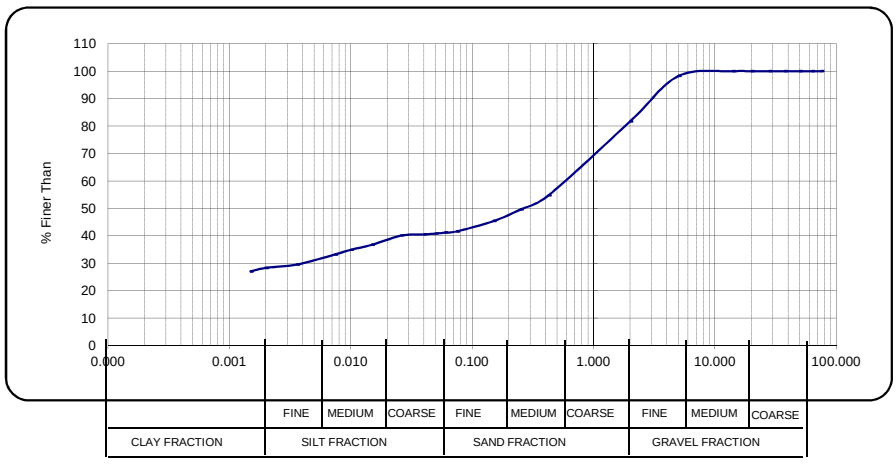
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27500
Field No. : BH3
Sample Description : Dark orange red mottled light greyish orange slightly gravelly sandy silty CLAY. Residual Gneiss
Equivalent PI : 11 **Clay fraction of whole sample (% <2μ)** : 28

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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GEOSURE (Pty) Ltd

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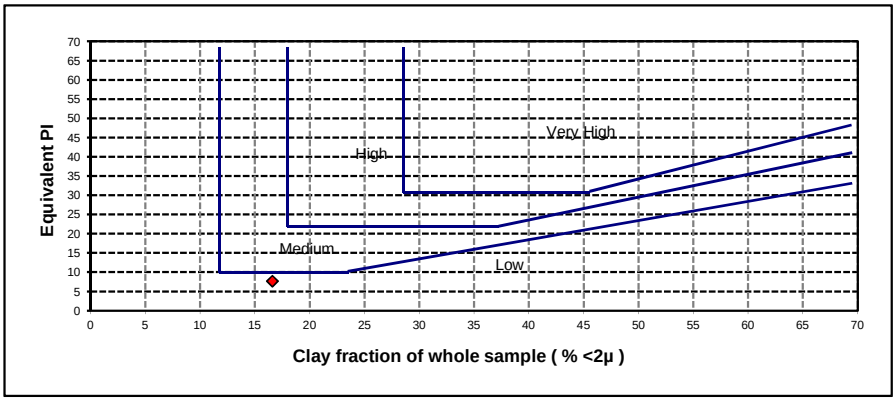
Client : Geosure (Pty) Ltd
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

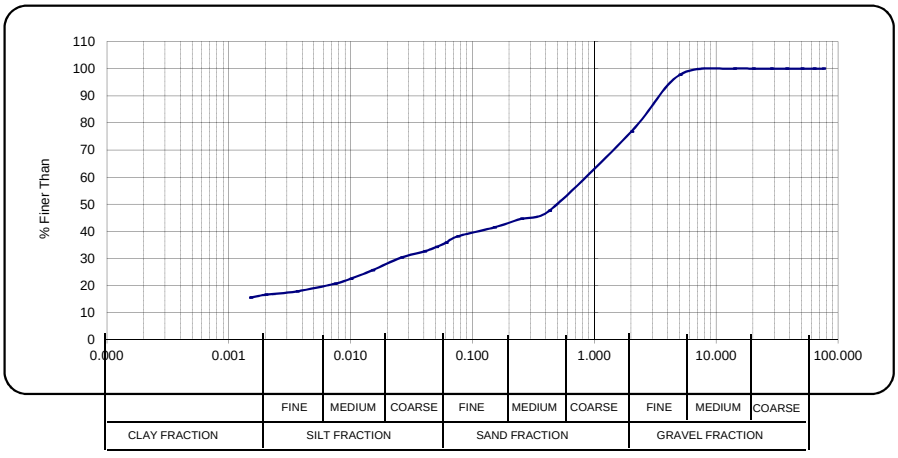
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27501
Field No. : BH4
Sample Description : Dark orange red speckled light yellow slightly gravelly sandy silty CLAY. Residual Gneiss
Equivalent PI : 8 **Clay fraction of whole sample (% <2μ)** : 17

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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GEOSURE (Pty) Ltd

sanas Testing Laboratory T0483

Reg.No.: 92/03145/07

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Mobile: +27(0) 82 784 0544 e-mail:geosure@iafrica.com

WEBSITE: www.geosure.co.za

Client : **Geosure (Pty) Ltd** **Our Ref.** : **50332**

Project : **Thandokuhle Reservoir** **Your Ref.** : **063-20**

Date Tested : **10.09.2020 to 22.09.2020**

Attention : **Mr D. Naidoo** **Date Reported** : **23.09.2020**

Sample No.			T27502	T27503	T27504	T27505	T27506
Field No.			BH4	BH5	BH5	BH5	BH5
Position in Field			Layer 3	Layer 3	Layer 3	Layer 4	Layer 5
Depth (m)			1.95-2.53	1.04-1.27	1.95-2.48	2.48-3.00	4.95-6.00
Material Description			Dark orange red speckled light yellow slightly gravelly sandy silty CLAY. Residual Gneiss	Dark orange red slightly gravelly sandy silty CLAY. Residual Gneiss	Dark orange red slightly gravelly sandy silty CLAY. Residual Gneiss	Dark orange red and light olive grey gravelly silty CLAY. Residual Gneiss	Dark reddish orange and light grey silty sandy CLAY. Residual Gneiss
Sieve Analysis (Wet Preparation) - SANS3001 GR 1 - Percent Passing Sieve Size							
% Passing	**100.0**	**mm**	100	100	100	100	100
	75.0	**mm**	100	100	100	100	100
	63.0	**mm**	100	100	100	100	100
	50.0	**mm**	100	100	100	100	100
	37.5	**mm**	100	100	100	100	100
	28.0	**mm**	100	100	100	100	100
	20.0	**mm**	100	100	100	100	100
	14.0	**mm**	100	100	100	100	100
	5.00	**mm**	99	100	99	99	100
	2.00	**mm**	79	86	76	76	93
	0.425	**mm**	45	59	47	44	84
	0.250	**mm**	41	55	44	41	83
	0.150	**mm**	39	51	42	39	81
	0.075	**mm**	37	48	40	37	79
Hydrometer Analysis - ASTM - D422 - Percent Passing Particle Diameter (<0.425mm)							
% Passing	**0.060**	**mm**	34	47	38	34	78
	0.050	**mm**	32	46	37	33	77
	0.040	**mm**	31	45	35	31	76
	0.026	**mm**	28	44	33	28	75
	0.015	**mm**	25	41	30	25	71
	0.010	**mm**	22	38	29	24	66
	0.0074	**mm**	20	36	27	22	64
	0.0036	**mm**	18	32	24	19	56
	0.0020	**mm**	16	30	23	18	54
	0.0015	**mm**	15	28	22	16	47
Mechanical analysis - SANS3001 GR1 - Percent of Soil Mortar (<2 mm) for Grain Size range							
Coarse Sand		**%**	44	32	38	42	9
Coarse Fine Sand		**%**	4	5	3	5	2
Medium Fine Sand		**%**	3	4	3	3	2
Fine Fine Sand		**%**	3	4	3	3	2
Silt & Clay		**%**	46	55	53	48	85
Grading Modulus			1.39	1.07	1.37	1.42	0.44
Atterberg Limits - SANS3001 GR10, GR12 (<0.425mm)							
Liquid Limit		**%**	43	41	57	54	63
Plasticity Index		**%**	19	19	25	26	28
Linear Shrinkage		**%**	10.5	10.5	13.5	13.0	15.0
AASHTO Classification (Group Index)*			A-7-6 (2)	A-7-6 (6)	A-7-5 (5)	A-7-6 (4)	A-7-5 (25)
Unified Classification*			SC	SC	SM	SC	MH/OH‡
Moisture Content		**%**					

Remarks: Date Received: 09.09.2020

Sampled by Client.

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

Consulting Engineering Geologists, Geotechnical Engineers, Geotechnicians & Geotechnical Quality Assurance Specialists
GEOSURE (Pty) Ltd

sanas T6483

Reg.No.: 92/03145/07

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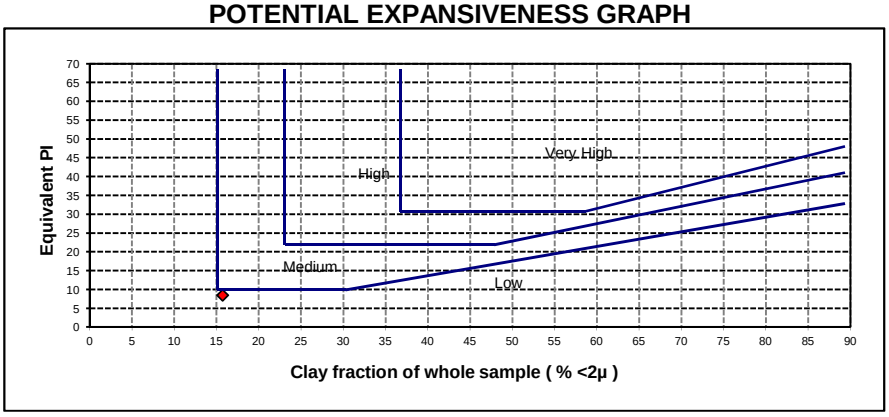
WEBSITE: www.geosure.co.za

Client : Geosure (Pty) Ltd
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

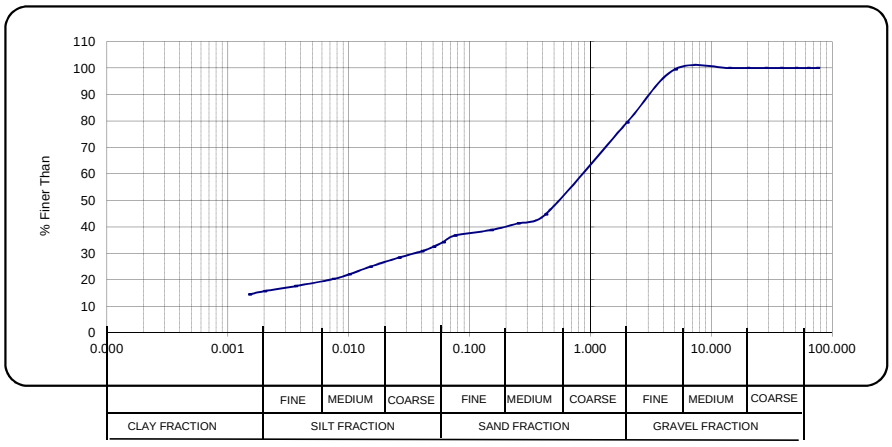
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27502
Field No. : BH4
Sample Description : Dark orange red speckled light yellow slightly gravelly sandy silty CLAY. Residual Gneiss
Equivalent PI : 8 **Clay fraction of whole sample (% <2µ)** : 16

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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sanas Testing Laboratory T0483

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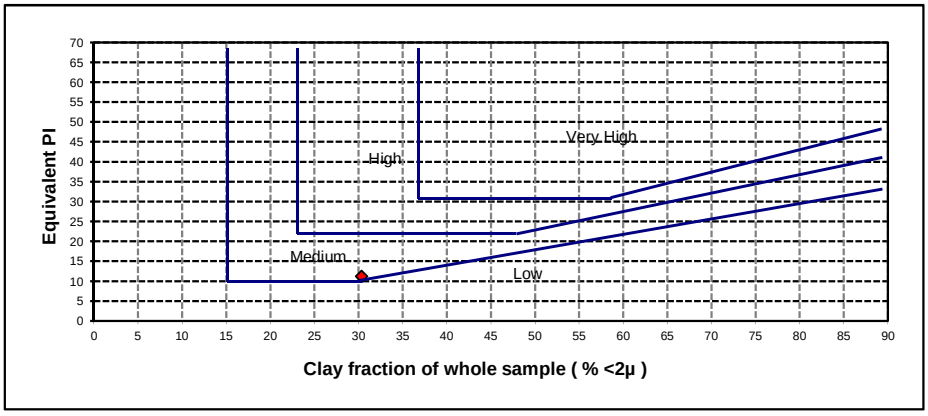
Client : Geosure (Pty) Ltd
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

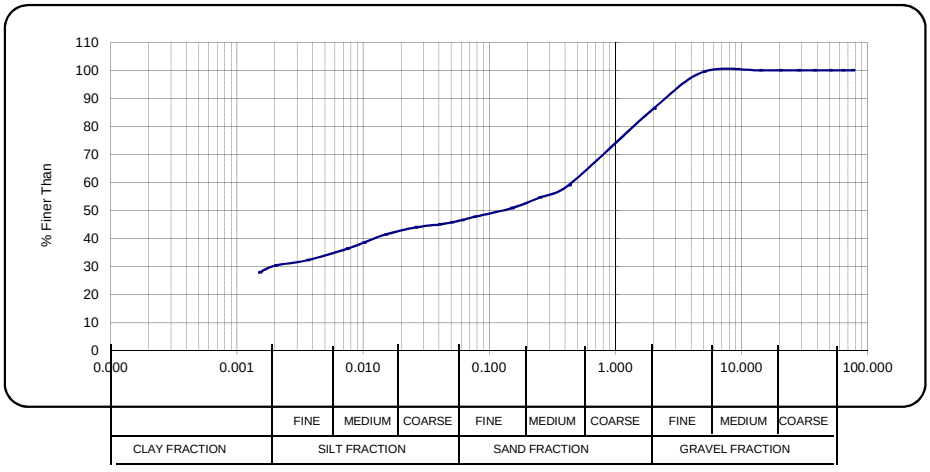
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27503
Field No. : BH5
Sample Description : Dark orange red slightly gravelly sandy silty CLAY. Residual Gneiss
Equivalent PI : 11 **Clay fraction of whole sample (% <2μ)** : 30

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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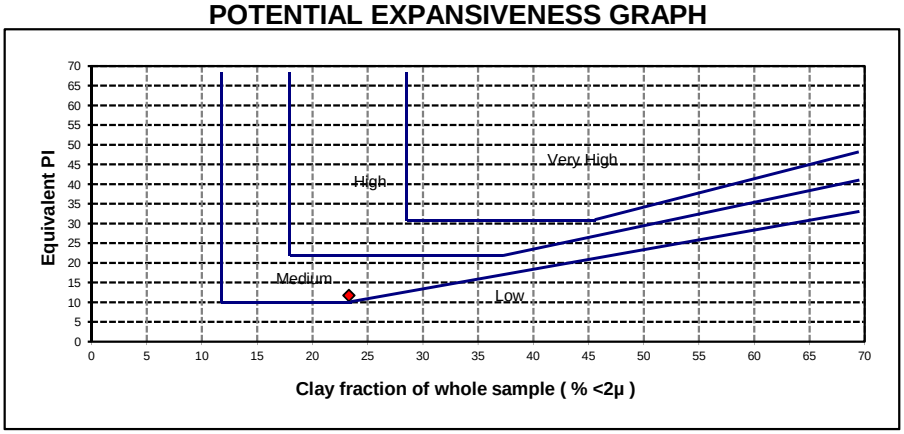
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

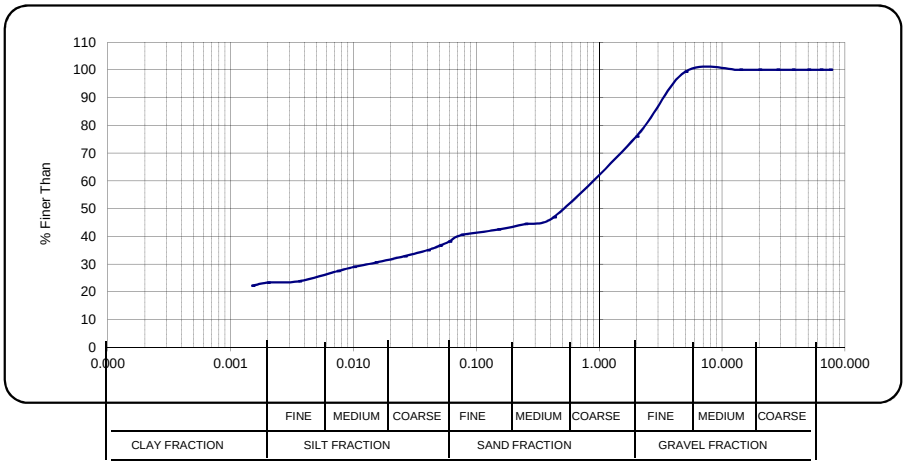
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27504
Field No. : BH5
Sample Description : Dark orange red slightly gravelly sandy silty CLAY. Residual Gneiss
Equivalent PI : 12 **Clay fraction of whole sample (% <2μ)** : 23

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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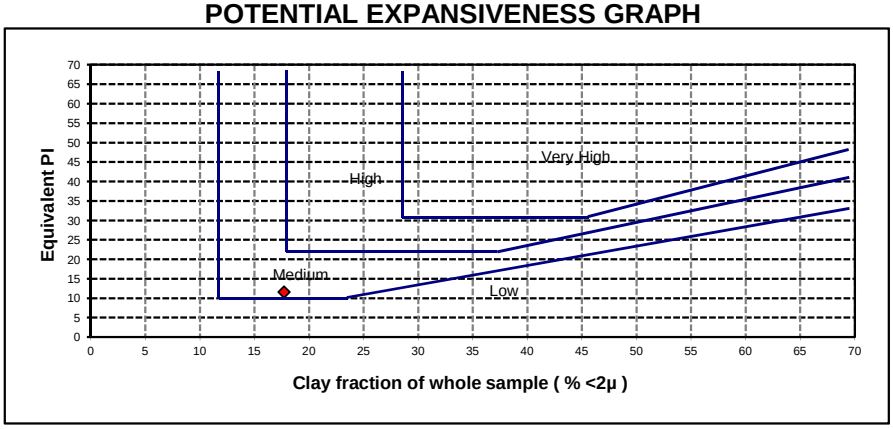
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

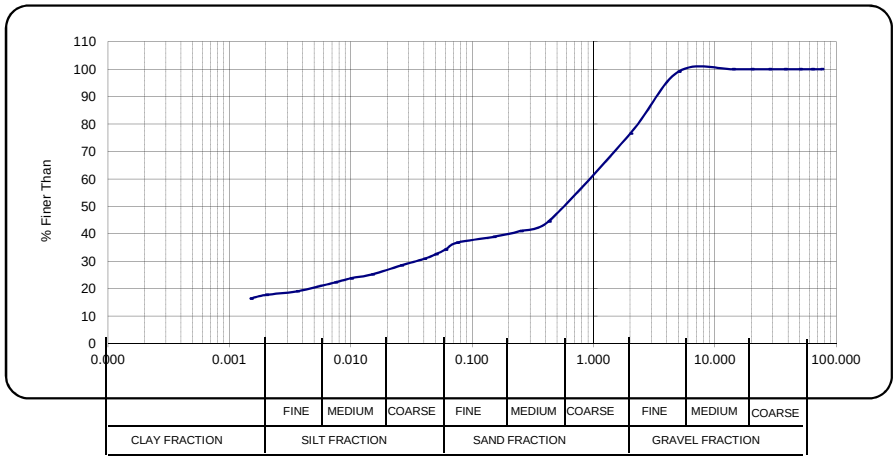
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27505
Field No. : BH5
Sample Description : Dark orange red and light olive grey gravelly silty CLAY. Residual Gneiss
Equivalent PI : 12 **Clay fraction of whole sample (% <2μ)** : 18

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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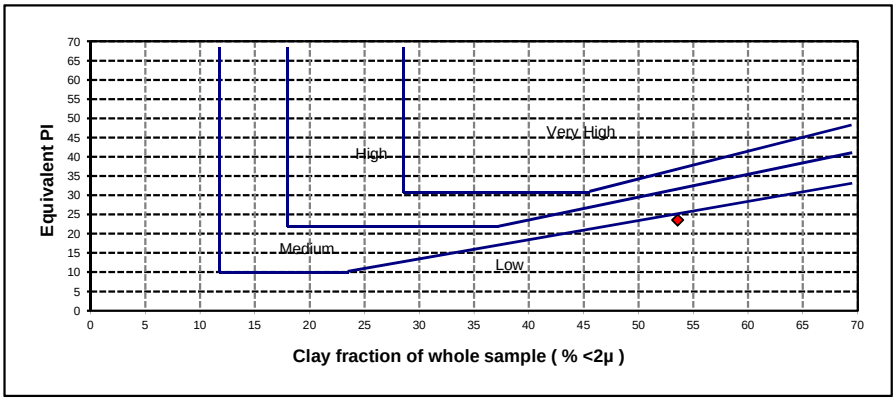
Project : Thandokuhle Reservoir
Attention : Mr D. Naidoo

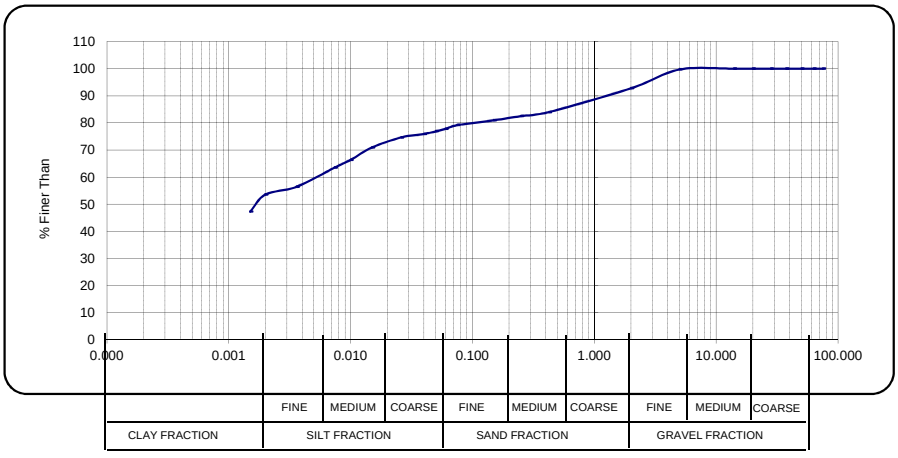
Job No. : 50332
Your Ref.No. : 063-20
Date Tested : 10.09.2020 to 22.09.2020
Date Reported : 23.09.2020

Sample Number : T27506
Field No. : BH5
Sample Description : Dark reddish orange and light grey silty sandy CLAY. Residual Gneiss
Equivalent PI : 24 **Clay fraction of whole sample (% <2μ)** : 54

POTENTIAL EXPANSIVENESS GRAPH



PARTICLE SIZE DISTRIBUTION CHART



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Client : **Geosure (Pty) Ltd** — **Your Ref No. : -**
Project : **Thandokuhle Reservoir** — **Our Ref No. : 50332**
Attention : **Mr D. Naidoo** — **Date Reported : 30/09/2020**

Test Report - SANS 3001

Sample No.	T27489	T27490	T27491		
Field No.	IP1	IP3	IP5		
Position	Layer 2	Layer 4	Layer 3		
Depth (m)	0.44-2.12	0.88-1.17	0.76-1.86		
Method of Preparation	N/A	N/A	N/A		
Material Description	Dark yellowish orange sandy silty CLAY. Residual Gneiss	Dark orange and dark reddish grey highly weathered very soft rock. Megacrystic Granitic Geniss	Dark reddish orange slightly gravelly sandy CLAY. Residual Gneiss		

Sieve Analysis - Percent Passing Sieve Size						
Sieve Aperture (mm)	**100.00**					
	75.00					
	63.00					
	53.00					
	50.00					
	37.50					
	28.00					
	26.50					
	20.00					
	19.00	100	100			
	14.00	97	98			
	13.20	97	98	100		
	5.00	95	97	98		
	4.750	95	97	98		
	2.000	65	75	83		
	0.425	42	49	67		
	0.075	38	44	62		
Grading Modulus		1.54	1.32	0.89		
Mechanical analysis - Percent of Soil Mortar (<2 mm) for Grain Size range						
Coarse Sand	**2.000 - 0.425**	36	35	19		
Coarse-Fine Sand	**0.425 - 0.250**	3	3	2		
Medium-Fine Sand	**0.250 - 0.150**	2	2	2		
Fine-Fine Sand	**0.150 - 0.075**	2	3	2		
Silt and Clay	**< 0.075**	58	58	75		
Atterberg Limits SANS 3001 on <0.425 mm fraction						
Liquid Limit	% or symbol	48	50	55		
Plasticity Index	% or symbol	20	22	22		
Linear Shrinkage	%	12.0	12.0	12.0		
Maximum Dry Density and Optimum Moisture Content						
Maximum Dry Density (kg/m³)		1934	1890	1597		
Optimum moisture content (%)		12.0	11.6	15.9		
California Bearing Ratio						
CBR @100% Compaction	%	40	77	16		
CBR @ 98% Compaction	%	27	39	12		
CBR @ 97% Compaction	%	22	27	11		
CBR @ 95% Compaction	%	15	14	8.0		
CBR @ 93% Compaction	%	10	6.8	6.1		
CBR @ 90% Compaction	%	5.8	2.4	4.1		
Swell @100% Compaction	%	0.1	0.6	0.1		
COLTO Classification (1998)†**		Cannot be Determined	Cannot be Determined	Cannot be Determined		
TRH 14 Classification (1985)**		G10	Poorer than G10	G10		
AASHTO Classification (Group Index)**		A-7-6 (3)	A-7-6 (6)	A-7-5 (13)		
Unified Classification **		SM	SC	MH/OH‡		
‡ If $LL_{(oven\ dried)}$ / $LL_{(not\ dried)}$ < 0.75 then use O-symbol (Organic Material).						

Remarks: ***Subject to further testing as required by TRH14.**

† Subject to further testing as required by COLTO. COLTO above uses only: Atterberg Limits (<0.425 mm fraction; not arithmetic mean), Nominal Max Size, Grading Curve, Coarse Sand Ratio, Grading Modulus, Strength (CBR), and Swell.

Check that Max Size <= 2/3 of compacted layer thickness.

** Opinions and interpretations expressed herein are outside the scope of SANAS accreditation

Version 5.05 - 14 February 2018

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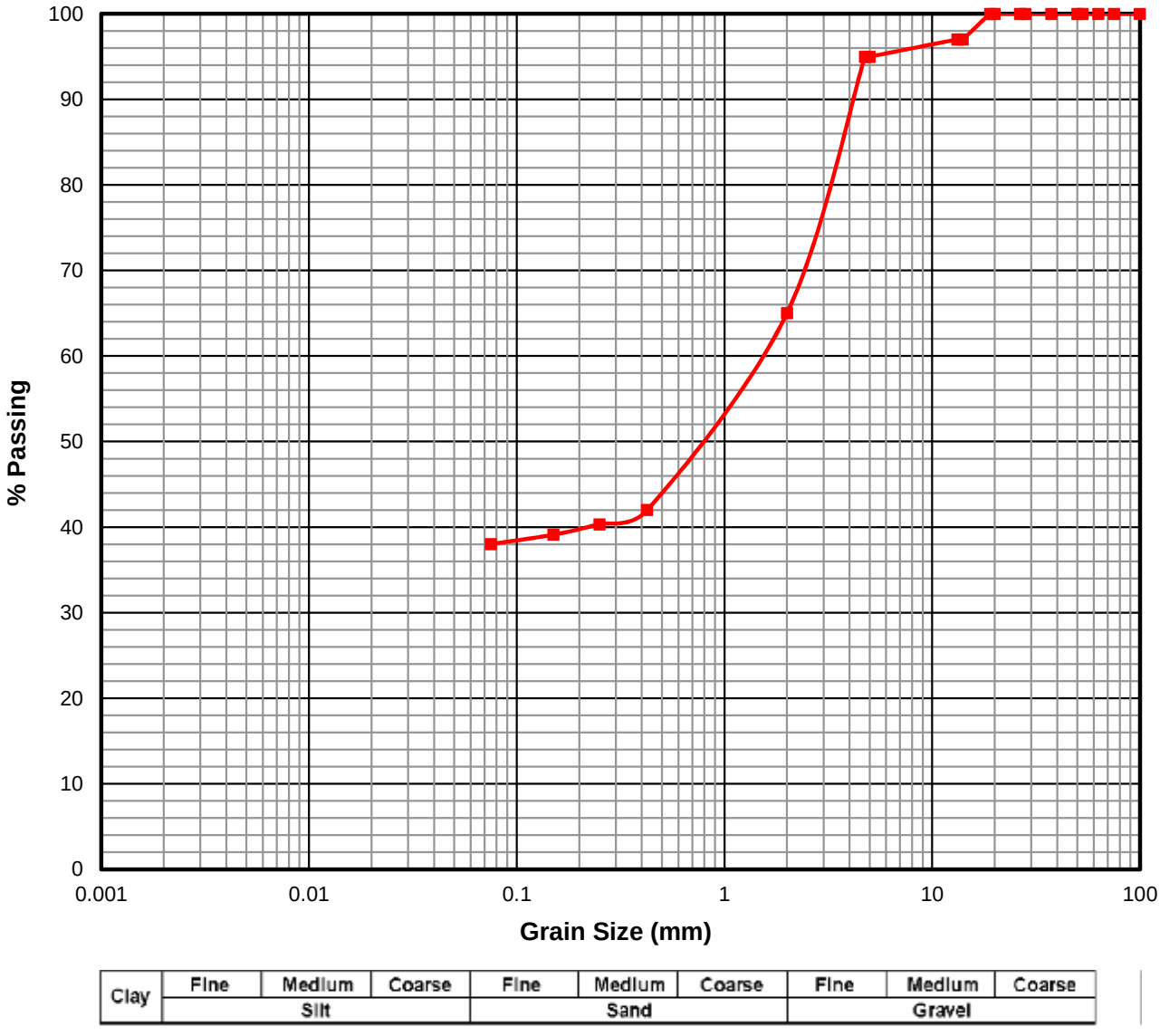
Client : **Geosure (Pty) Ltd**
Project : **Thandokuhle Reservoir**
Attention : **Mr D. Naidoo**

Your Ref No.: -
Our Ref No. : 50332
Date Reported : 30/09/2020

Grading Curve for Sample T27489 – SANS 3001



Thick Red Line is the Grading Curve (COLTO Classification = Cannot be Determined) (TRH 14 Classification = G10)

Sieve Aperture Size	0.075	0.150	0.250	0.425	2.00	4.75	5.00	13.20	14.00	19.00	20.00	26.50	28.0	37.5	50.0	53.0	63	75	100
Percentage Passing	38%	39%	40%	42%	65%	95%	95%	97%	97%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

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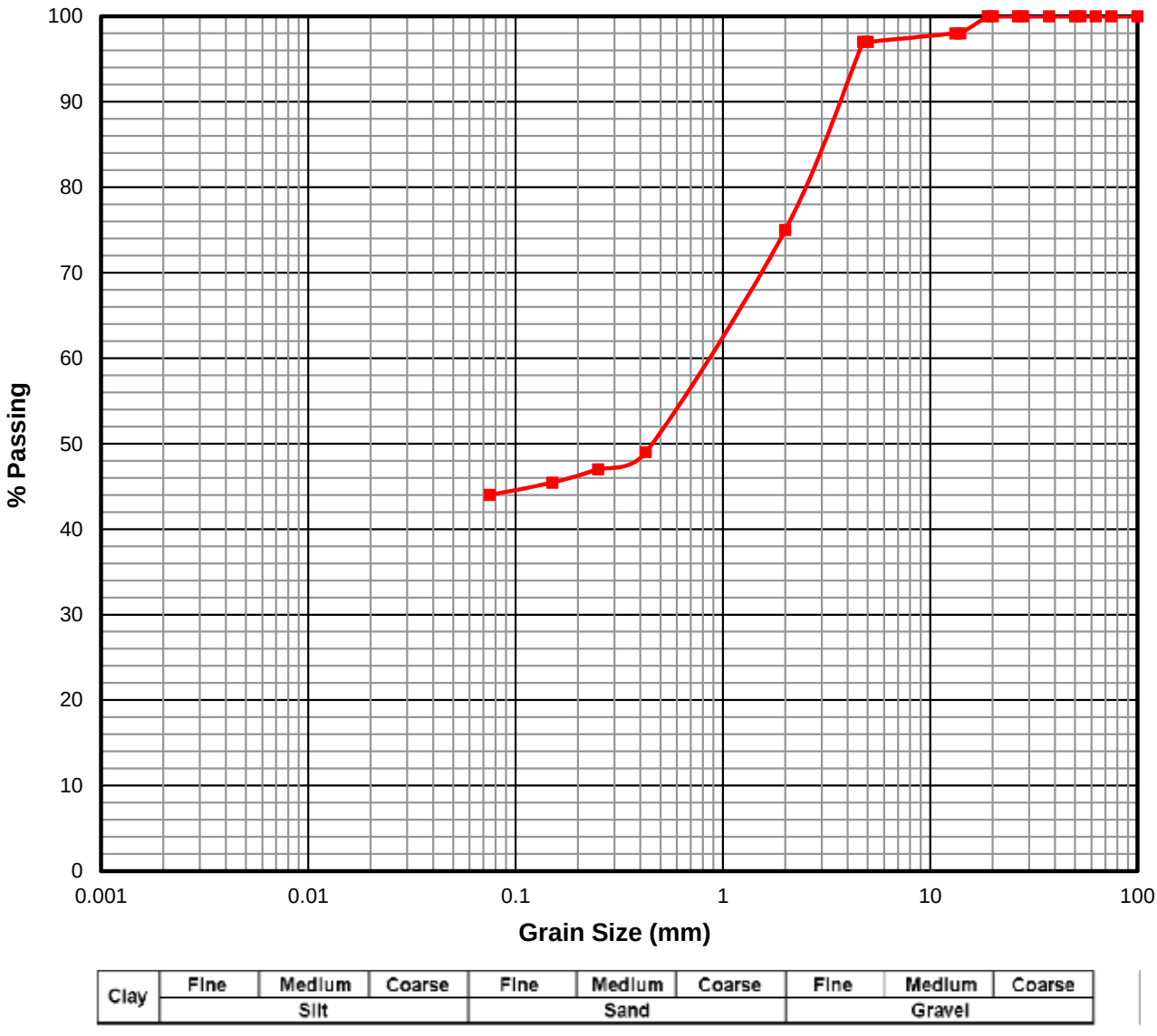
Your Ref No.: **-**
Our Ref No. : **50332**
Date Reported : **30/09/2020**

Grading Curve for Sample T27490 – SANS 3001



ick Red Line is the Grading Curve (COLTO Classification = Cannot be Determined) (TRH 14 Classification = Poorer than G

Sieve Aperture Size	0.075	0.150	0.015	0.026	0.05	0.06	5.00	13.20	14.00	19.00	20.00	26.50	28.0	37.5	50.0	53.0	63	75	100
Percentage Passing	44%	45%	47%	49%	75%	97%	97%	98%	98%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

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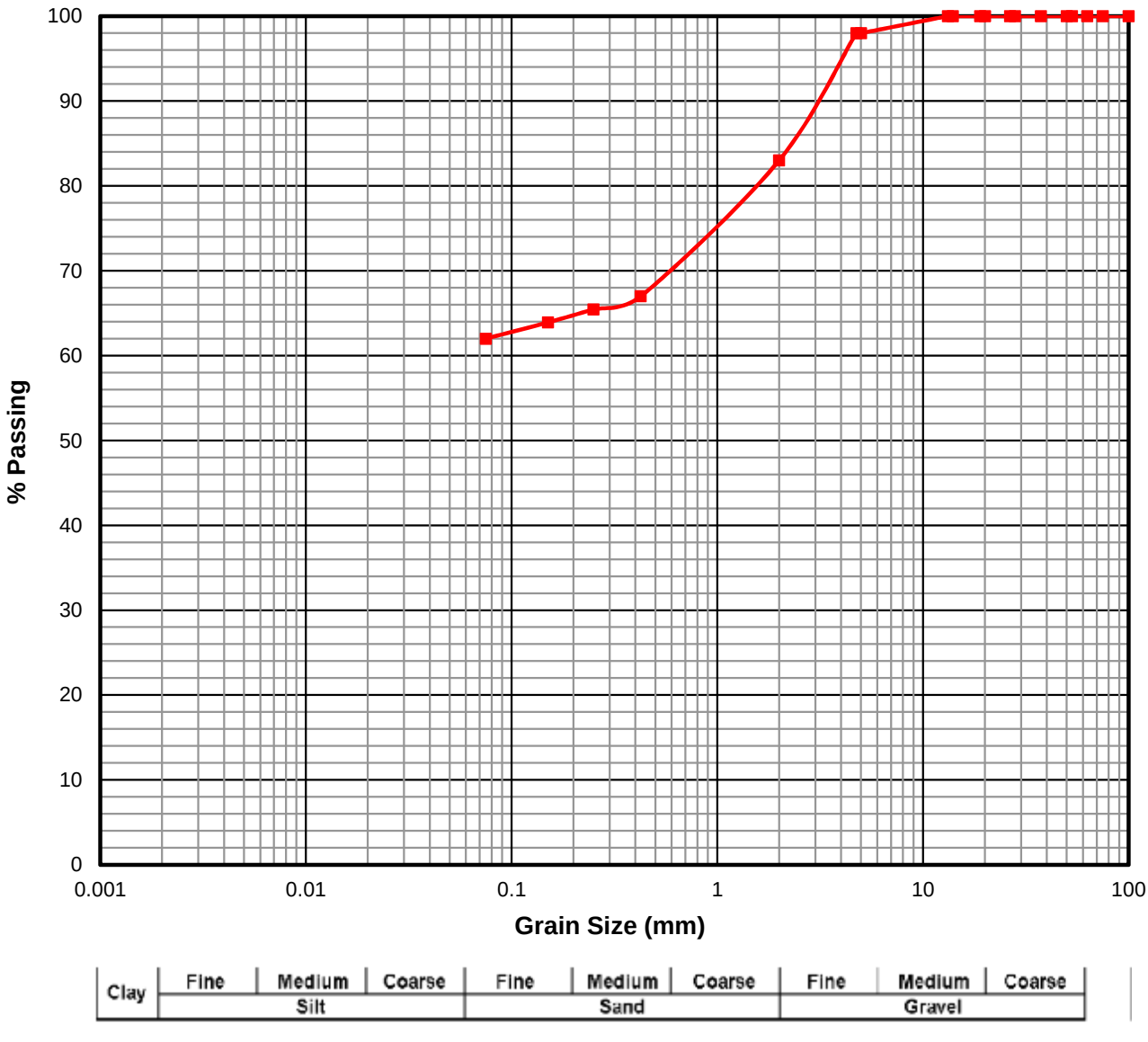
Attention : **Mr D. Naidoo**

Your Ref No.: **-**
Our Ref No. : **50332**
Date Reported : **30/09/2020**

Grading Curve for Sample T27491 – SANS 3001



Thick Red Line is the Grading Curve (COLTO Classification = Cannot be Determined) (TRH 14 Classification = G10)

Sieve Aperture Size	0.075	0.150	0.250	0.425	2.00	4.75	5.00	13.20	14.00	19.00	20.00	26.50	28.0	37.5	50.0	53.0	63	75	100
Percentage Passing	62%	64%	65%	67%	83%	98%	98%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

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Client : **Geosure (Pty) Ltd** | **Your Ref No.** : **063-20**
Project : **Thandokuhle Reservoir** | **Our Ref No.** : **50332**
Attention : **Mr D. Naidoo** | **Date Reported** : **23.09.2020**

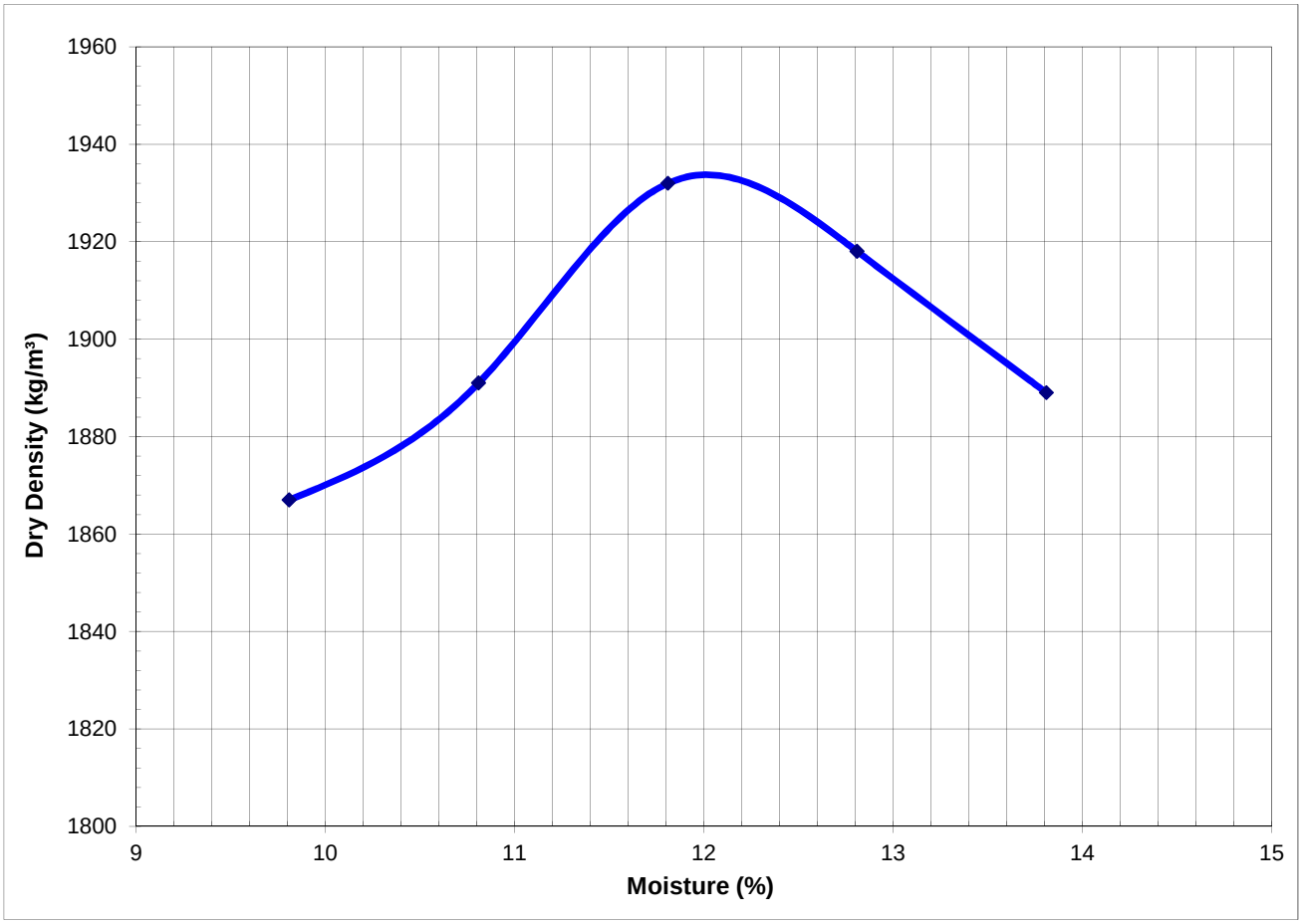
SANS 3001 Moisture/Density Relationship

Sample No.	: T27489	Field No.	: IP1
Method of preparation	: N/A	Depth (m)	: 0.44-2.12
Natural/Stabilised	: Natural	Origin	: Layer 2
Material Description	: Dk.Yell.Or.sandy silty CLAY. Res. Gneiss	Compaction Effort	: Mod AASHTO

Maximum Dry Density (kg/m³) **1934** **Optimum Moisture Content (%)** **12.0**

Plotted Values:

Moisture (%)	9.8	10.8	11.8	12.8	13.8
Dry Density (kg/m³)	1867	1891	1932	1918	1889



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Client	**: Geosure (Pty) Ltd**	**Your Ref No.**	**: 063-20**
Project	**: Thandokuhle Reservoir**	**Our Ref No.**	**: 50332**
Attention	**: Mr D. Naidoo**	**Date Reported**	**: 23.09.2020**

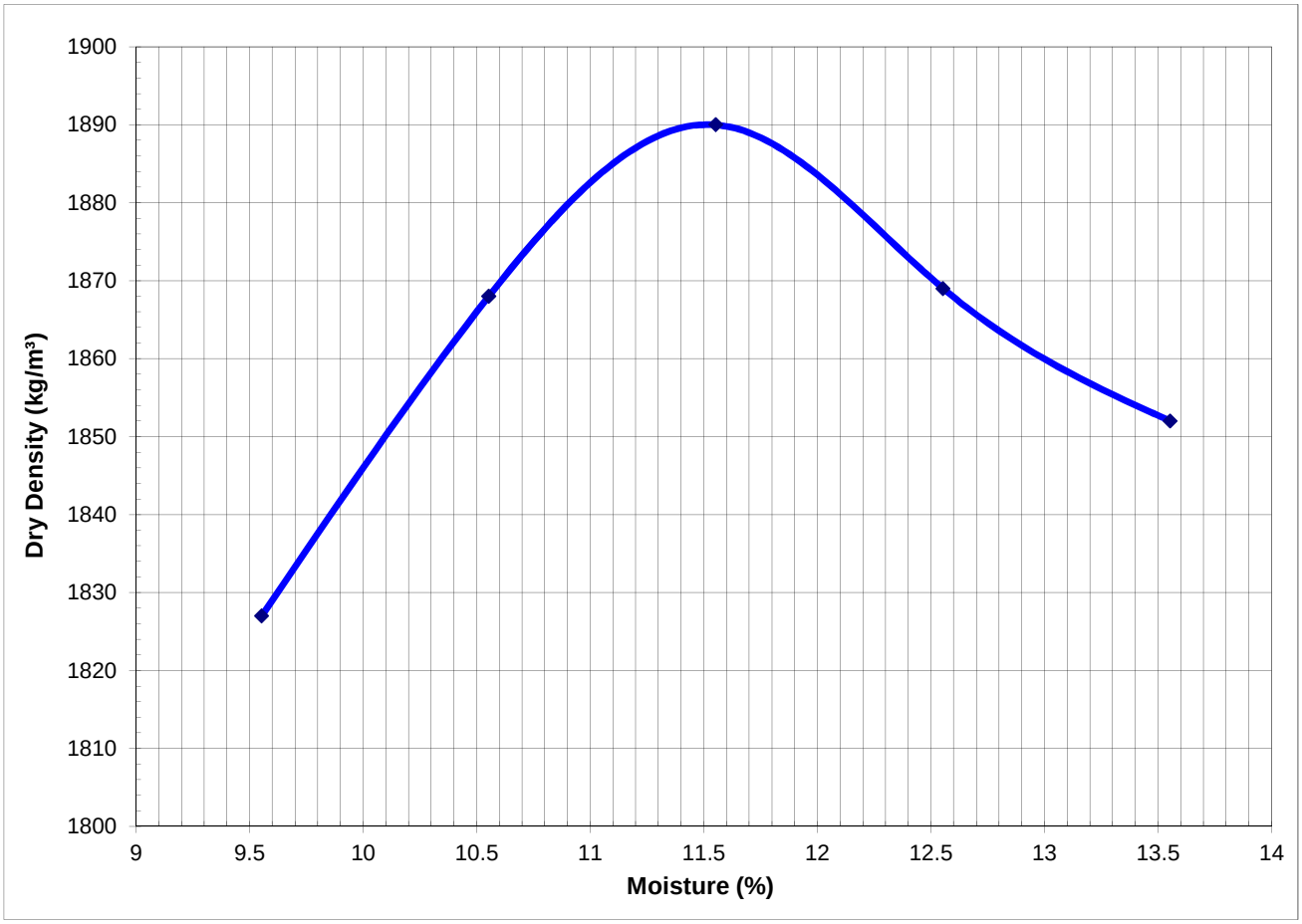
SANS 3001 Moisture/Density Relationship

Sample No.	: T27490	Field No.	: IP3
Method of preparation	: N/A	Depth (m)	: 0.88-1.17
Natural/Stabilised	: Natural	Origin	: Layer 4
Material Description	: Dk.Or.Dk.Rd.Gr.Hi.Wth.very soft rock. Megacrystic	Compaction Effort	: Mod AASHTO

Maximum Dry Density (kg/m³) 1890 **Optimum Moisture Content (%) 11.6**

Plotted Values:

Moisture (%)	9.6	10.6	11.6	12.6	13.6
Dry Density (kg/m³)	1827	1868	1890	1869	1852



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Client : **Geosure (Pty) Ltd** | **Your Ref No.** : **063-20**
Project : **Thandokuhle Reservoir** | **Our Ref No.** : **50332**
Attention : **Mr D. Naidoo** | **Date Reported** : **23.09.2020**

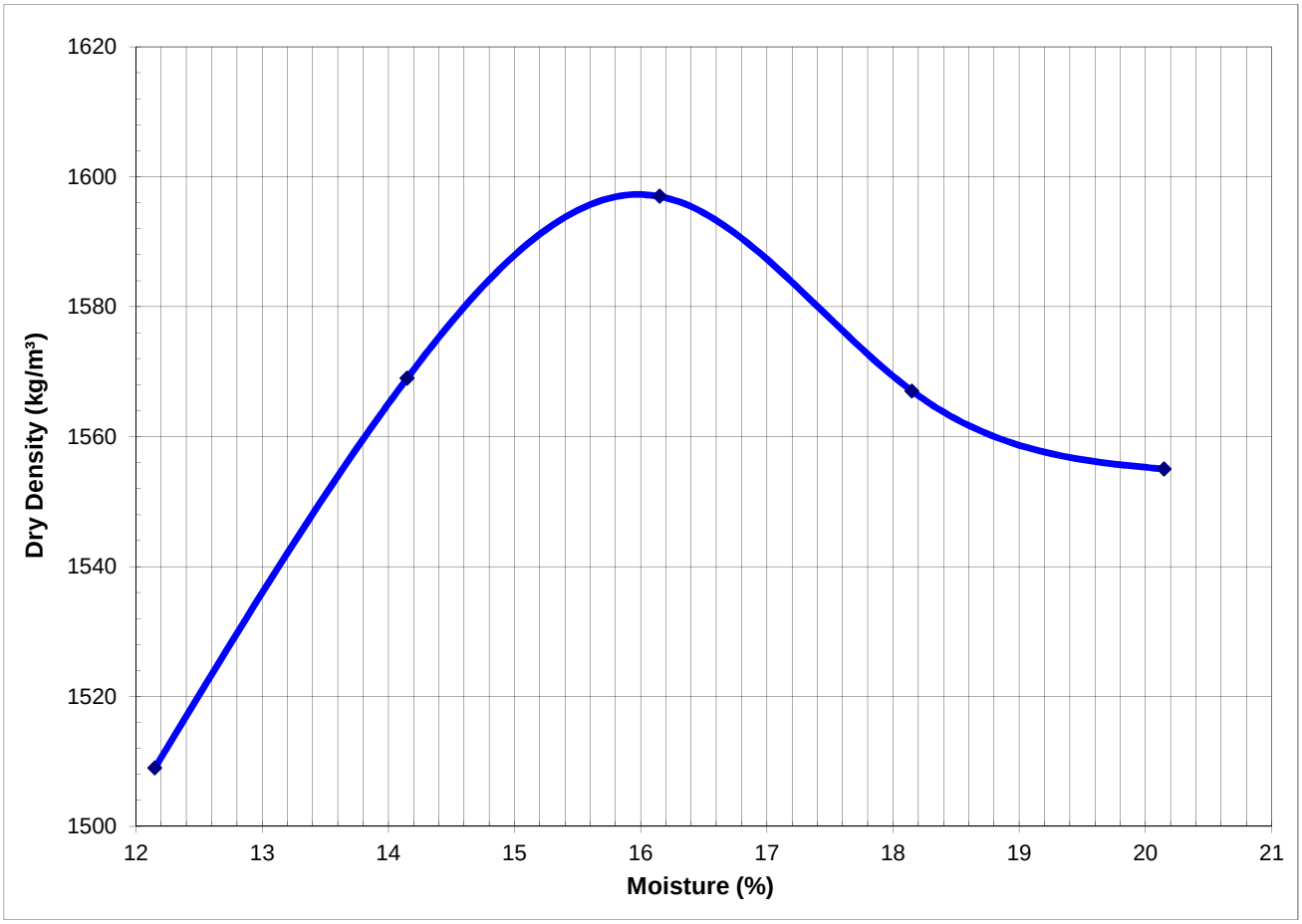
SANS 3001 Moisture/Density Relationship

Sample No.	: T27491	Field No.	: IP5
Method of preparation	: N/A	Depth (m)	: 0.76-1.86
Natural/Stabilised	: Natural	Origin	: Layer 3
Material Description	: Dk.Red.Or.Sl.gravelly sandy CLAY. Res. Gneiss	Compaction Effort	: Mod AASHTO

Maximum Dry Density (kg/m³) **1597** **Optimum Moisture Content (%)** **15.9**

Plotted Values:

Moisture (%)	12.1	14.1	16.1	18.1	20.1
Dry Density (kg/m³)	1509	1569	1597	1567	1555



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063-20.R01-001

SITE PLAN

KEY:

BH1 ⊗ — Approximate position of Borehole.

IP1 ☒ (>2.5) >2.5 — Approximate position of Inspection Pit showing depth to rock () and depth to refusal in metres below existing ground level.

DC1 ▼ 2.9 — Approximate position of CBR Dynamic Cone Penetrometer Test showing depth to refusal in metres below existing ground level.

Site plan showing approximate positions of:

Boreholes;
Inspection Pits; and
CBR Dynamic Cone Penetrometer (DCP) Tests.

SCALE 1:250

0 2,5 5
Metres

Naidu Consulting (Pty) Ltd

Proposed Thandokuhle Reservoir
Geotechnical Investigation

GEOSURE (PTY) LTD
Consulting Engineering Geologists, Geotechnical Engineers, Geotechnidans and Geotechnical Quality Assurance Specialists
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E-Mail : info@geosure.co.za, Website: www.geosure.co.za

DATE: 01-10-2020
DRAWN BY: V.G
CHECKED BY: A.R
REFERENCE NO. 063-20

063-20.R01-001

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

GEOSURE (Pty) Ltd

- *Geotechnical Engineering Services*
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- *Road Pavement Materials and Design*
- *Project Management*

Report to Naidu Consulting (Pty) Ltd on the Design of the Ground Improvement for the Proposed Thandokuhle Reservoir, eThekwini Municipality, KwaZulu-Natal

Reference: 063-20.R02 Revision 1

Dated: 22 January 2021

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Report to Naidu Consulting (Pty) Ltd on the Design of the Ground Improvement for the Proposed Thandokuhle Reservoir, eThekwini Municipality, KwaZulu-Natal

Reference : 063-20.R02 Revision 1

Dated : 22 January 2021

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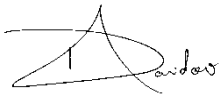
Report Title		Report to Naidu Consulting (Pty) Ltd on the Design of the Ground Improvement for the Proposed Thandokuhle Reservoir, eThekwini Municipality, KwaZulu-Natal		
Report Reference		063-20.R02	**Responsible Person**	Mr D. Ramghulam
Client Name		Naidu Consulting (Pty) Ltd	**Client Contact Details**	Devesh.Ramghulam@naiduconsulting.com Tel: +27 31 265 6007
Revision	**Date**	**Revision Details/Status**		**Authors**
0	11/01/21	Design Report		Mr A. Ramroop Mr S. Hiralal
1	22/01/21	Design report with typical costs for construction.		Mr A. Ramroop Mr S. Hiralal
Current Revision				
1				

Approval			
Author Signature			
Name	S. Hiralal	A. Ramroop Pr.Eng	D. Naidoo Pr.Sci.Nat
Title	Geotechnical Engineer	Geotechnical Engineering Manager	Managing Director

Report to Naidu Consulting (Pty) Ltd on the Design of the Ground Improvement for the Proposed Thandokuhle Reservoir, eThekwini Municipality, KwaZulu-Natal

Reference: 063-20.R02 Revision 1 **Date: 22 January 2021**

TABLE OF CONTENTS

Abbreviations and Expansions

Abbreviation	Definition
DPL	Dynamic Cone Penetrometer Light
E	East
EGL	existing ground level
FOS	Factor of Safety
IP	Inspection pit
kml	keyhole markup language
kN	Kilonewton
m	metre (s)
ML	Mega litre
mm	millimetre (s)
MSL	Mean sea level
No.	number
pdf	Portable document format
S	South
SABS	South African Bureau of Standards
SANS	South African National Standards
TRH	Technical Recommendations for Highways

Report to Naidu Consulting (Pty) Ltd on the Design of the Ground Improvement for the Proposed 5ML Zinkwazi Reservoir at Nkwazi, KwaZulu-Natal

Reference: 063-20.R02 Revision 0 **Date: 11 January 2021**

1. TERMS OF REFERENCE

Geosure (Pty) Ltd was requested by Naidu Consulting on 24 February 2020 to submit a proposal and cost estimate to carry out a geotechnical investigation for the proposed Thandokuhle Reservoir, eThekwini Municipality, KwaZulu-Natal. Naidu Consulting issued Geosure with a Request for Quotation (RFQ) detailing the proposed development and the required scope of work for the geotechnical investigation.

Accordingly, Geosure submitted a proposal and cost estimate to Naidu Consulting in a letter referenced p118-20 (Thandokuhle Reservoir Site)/mb and dated 04 March 2020. The RFQ was signed by Geosure and submitted to Naidu Consulting.

Subsequently, Geosure was appointed by Naidu Consulting, hereafter referred to as the Client, to carry out the geotechnical investigation as proposed in an appointment letter referenced D732/34/9033 dated 05 March 2020.

In Geosure's geotechnical report for the proposed Thandokuhle Reservoir, referenced 063-20.R01 Revision 0 and dated 01 October 2020, Geosure recommended that ground improvement be carried out due to the poor insitu ground conditions. The Client thereafter requested that Geosure provide a proposal and cost estimate for the design of the ground improvement solution for the proposed Thandokuhle Reservoir.

Geosure submitted a proposal and cost estimate for the design of the ground improvement for Thandokuhle Reservoir in a letter referenced 063-20.003 (Design Fee Prop)/mb and dated 22 October 2020. Subsequently, the Client authorised Geosure to carry out the design for the ground improvement for Thandokuhle Reservoir in correspondence dated 26 November 2020, referenced D732/34/9807.

2. SCOPE OF REPORT

This report details the design of the ground improvement solution for the proposed Thandokuhle Reservoir, eThekwini Municipality, KwaZulu-Natal, hereafter referred to as the site.

This report was prepared for use by the Client and their professional team for the purpose stated and should not be relied upon for any other purpose.

3. INFORMATION UTILISED

The following information was referenced to assist with the investigation and subsequent reporting:

i. A digital copy (PDF format) of a survey drawing referenced D732-51-5001 Rev A, titled "*Site Plan Layout, Site B*", dated May 2020 and prepared by Naidu Consulting to a scale of 1:200.

ii. A digital copy (PDF format) of an unreferenced survey drawing of the site and immediate surroundings.

iii. A digital copy (PDF format) of a survey drawing referenced 5002 Rev A, titled "*Reservoir Sections, Concrete Outline and Details*", dated May 2020 and prepared by Naidu Consulting to a scale of 1:200.

iv. A regional geological map titled "*2930 Durban"*, (Council for Geoscience, 1988) to a scale of 1:250 000.

v. Low-resolution satellite imagery (Google Earth, 2020).

4. SITE DESCRIPTION

The site for the proposed development is located in a rural area approximately 22km north of Waterfall, KwaZulu Natal, at the approximate latitude and longitude coordinates 29°40'36.31"S and 30°45'38.84"E, respectively.

Rural dwellings and homesteads border the site in all directions. The site is situated on a hilltop setting with gently sloping terrain immediately adjacent to the site.

Vegetation comprising short grass was observed at the areas investigated.

The regional and local contexts of the site are shown in Plates 1 and 2. The general layout of the site is shown in 063-20.R01-001. A general view across the site is shown in Plate 3.

Plate 1: Regional context of the site demarcated in yellow (South African Department of Labour, 1993 and 2014)

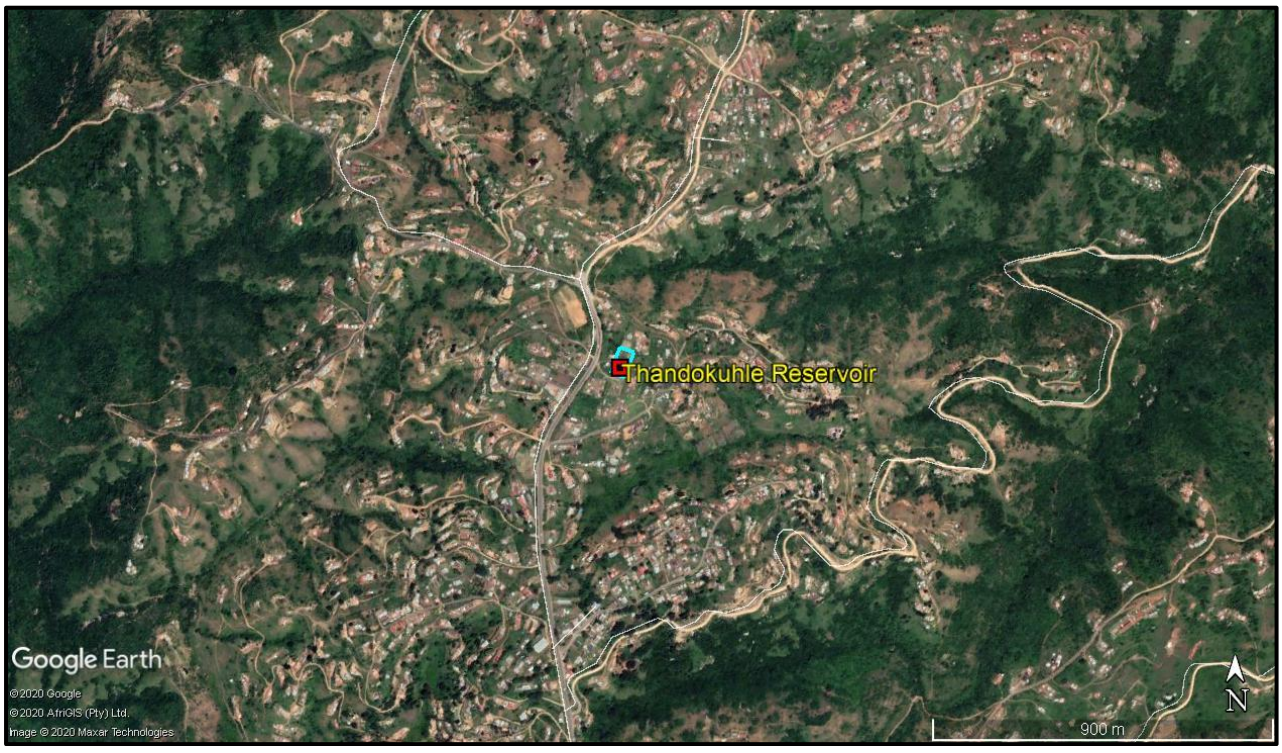


Plate 2: Local context of the site (Google earth, 2017)

Plate 3: General view across the site

5. GEOLOGY AND ANTICIPATED SUBSURFACE CONDITIONS

The site, at the positions profiled during the geotechnical investigation, was observed to be underlain by fill material, colluvium and residuals soils derived from the insitu weathering of the underlying Megacrystic granitic gneiss rock.

The following soil units observed during the field investigation are described in Table 1 below:

Table 1: Soil Units Observed in Geotechnical Investigation

Unit	Depth Range (below EGL)	Description
Fill	0.15m to 0.63m	Slightly moist, medium brown / light to dark greyish brown, loose to medium dense, fine to medium grained, silty SAND with an abundance of gravel to sandy silty GRAVEL / firm, slightly gravelly sandy CLAY
Colluvium	0.35m to 1.52m	Slightly moist to moist, medium brownish grey / dark grey / dark orange brown medium brownish grey / light greyish brown, firm to stiff, fine to medium grained, slightly gravelly sandy CLAY to sandy silty CLAY with occasional gravel.
Residual Gneiss	0.88m to 9.45m	Slightly moist to moist, medium brownish orange / dark orange red / dark reddish orange / dark yellowish orange, firm to stiff, intact, slightly sandy clayey SILT / slightly gravelly silty CLAY / gravelly sandy CLAY / sandy silty CLAY / sandy CLAY.
Weathered Granitic Gneiss Rock	2.47m and 3.45m	Light orange stained dark orange / light orange brown / dark reddish orange, highly weathered, fine to coarse grained, highly fractured, highly friable, micaceous, very soft rock with residual sandy silty CLAY.

Photographs showing the general soil profiles observed on site are given in Plates 4 through 7.

Plate 4: View of soil profile in IP1

Plate 5: View of soil profile in IP3

Plate 6: View of soil profile in IP7

Plate 7: View of soil profile in IP9

Inspection pit (IP) profiles are detailed in the geotechnical report referenced 063-20.R01 Revision 0.

The soils observed on site are susceptible to rapid erosion due to uncontrolled surface water action.

Results of the DCP tests confirmed the presence of firm to very stiff soils below soils extend to approximately 0.5m below EGL. Below the firm to very stiff soil horizon, occasional layers of soft soil consistencies occur to an approximate depth of 1.3m below EGL.

The results of the SPT tests confirmed the presence of stiff to very stiff soils from approximate depths in the range of 1.95m to 11.02m below EGL. Due to the highly fractured and friable nature of the weathered gneiss rock, the SPT was able to penetrate through the rock horizon and achieve blow counts similar to that of stiff clay soils.

The graphical plot of blow count versus depth of the Standard Penetration Tests (SPTs) is given in Plate 8. Some of the soil parameters used in the design were derived from the results of the SPT data.

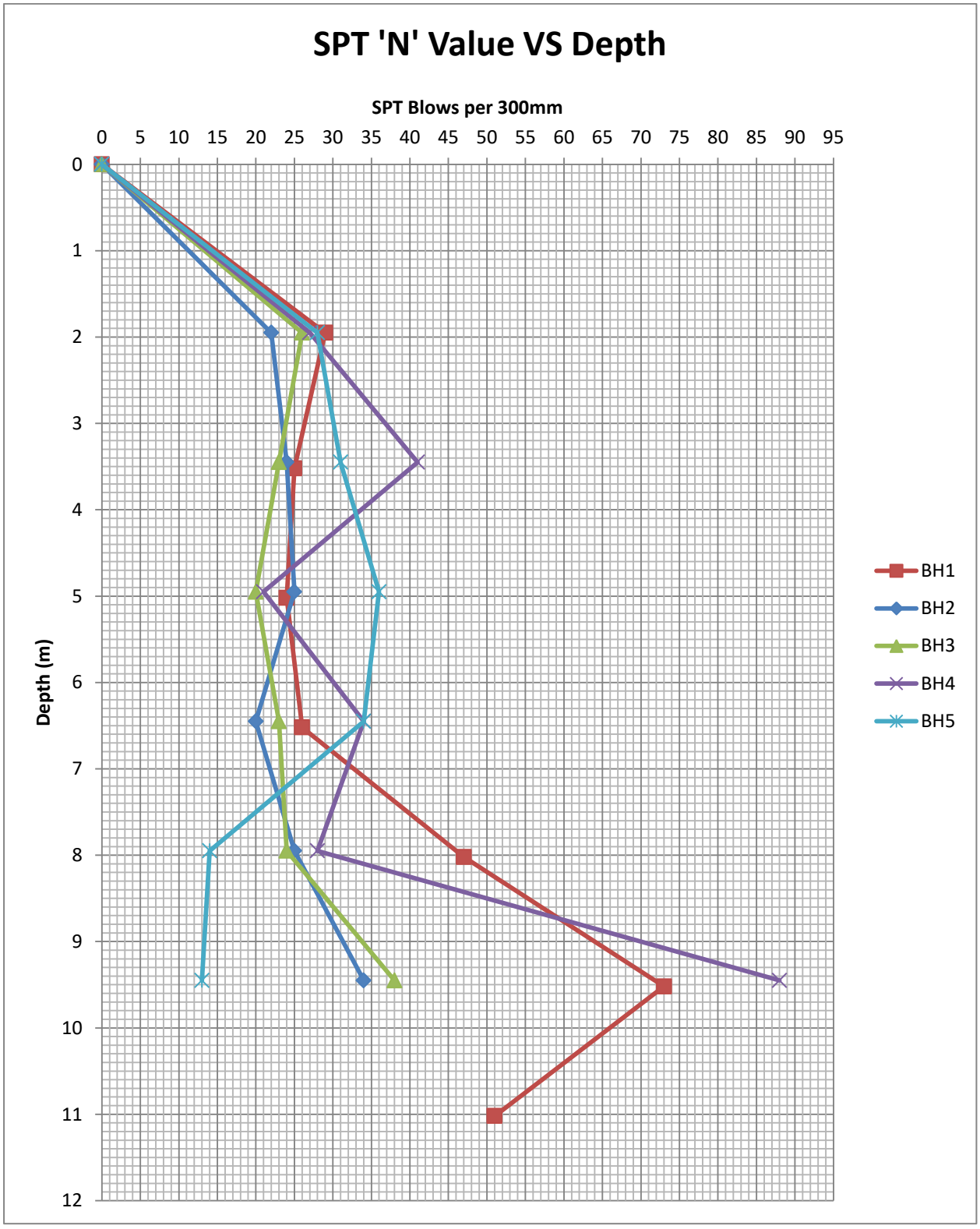


Plate 8: Summary of SPT Blows versus Depth

6. GROUNDWATER

No shallow groundwater seepage was observed in the inspection pits during the course of the investigation.

Standpipe piezometers were installed in the boreholes to facilitate the measurement of groundwater levels.

The depth to the water table encountered in the piezometers, as measured on 31 August 2020, 01 September 2020 and 03 September 2020 are given in Table 2.

Table 2: Depth to Groundwater Occurrence

BH No.	Depth below EGL (m)
BH1	10.0
BH2	9.5
BH3	9.5
BH4	9.0
BH5	8.5

A perched water table may develop both during and after periods of rainfall and/or during the high rainfall season. It is expected that the groundwater condition is depressed during the drier months and elevated during the wetter periods.

7. PROPOSED DESIGN

7.1 Summary of Proposed Design

The proposed design comprises the following:

i) Excavate the in-situ clayey soils to a depth of 1.0m below underside of the reservoir foundation level (650.73msl) or to expose weathered gneiss rock, whichever is shallower.

ii) The bottom of the excavation is then ripped to a depth of 150mm and re-compacted to 95% MOD AASHTO Dry Density.

iii) The excavation must be backfilled with G5 quality material (TRH14 classification) in 250mm thick layers compacted to 95% MOD AASHTO dry density. Each layer of G5 material is to be lined with two layers of ParaGrid CMD150/05 geogrid at right angles to each layer.

iv) The proposed reservoir foundation footprint at design level is assumed to straddle rock and soil. Therefore, the ground improvement may only be required for a portion of the reservoir footprint. A geotechnical professional will be required to assess founding conditions on site during the construction process.

The proposed ground improvement layerworks is illustrated in Plate 9. The detailed drawing showing the ground improvement is given in Drawing No. 063-20.R02-001 Rev 0. Although the footprint of the design solution is dependent on the depth and quality of rock encountered

below the foundation, the ground improvement shown in Drawing No. 063-20.R02-001 Rev 0 extends across the full footprint of the reservoir foundation.

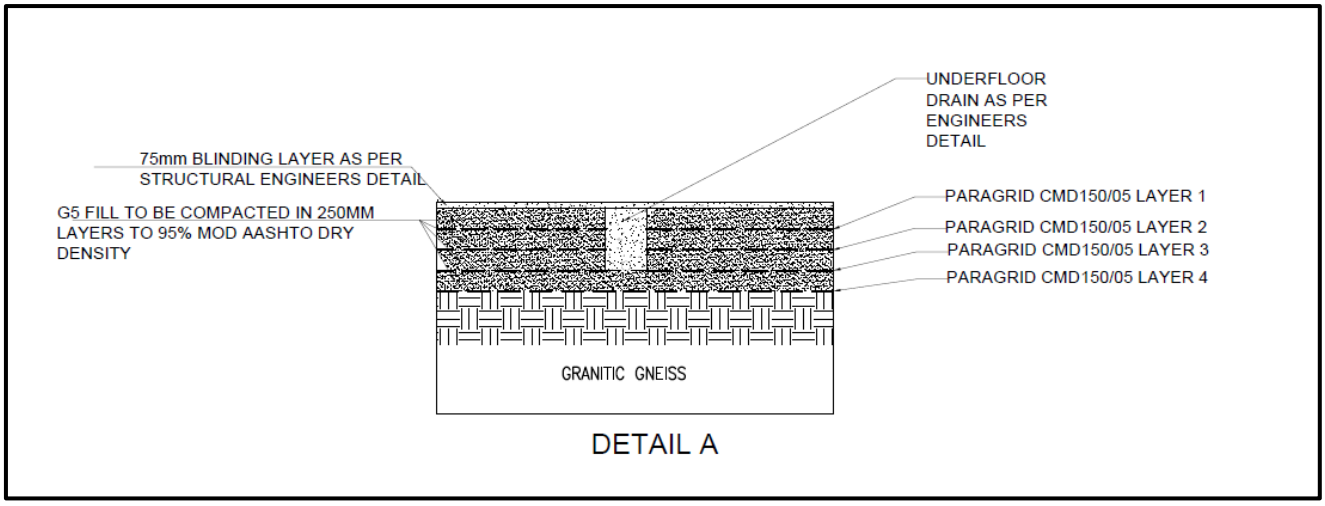


Plate 9: Ground improvement Details

7.2 Soil and Rock Properties used in Design

The soil and rock parameters utilised for the design are summarised in Table 3 and Table 4 below.

Table 3: Mohr Coulomb Soil Parameters used in Design

Depth (m)	Material	Density (kN/m^3)	Angle of Friction Φ' (°)	Drained Cohesion c' (kN/m^2)	Young's Modulus E' (kN/m^2)	Poisson's Ratio
0.00 to 4.50	Residual Gneiss	18.0	0	40	20000	0.3
0.00 to 4.50	G5 Fill	24	34	0	40000	0.3

Table 4: Generalised Hoek-Brown Rock Parameters used in Design

Depth (m)	Material	Density (kN/m^3)	Intact Compressive Strength (kPa)	Geological Strength Index (GSI)	Intact Rock Constant (mi)
0.00 to 4.50	Granitic Gneiss	27.0	1000	19	28

7.3 Geogrid Properties

The material properties of the ParaGrid CMD150/05 used in the design are given in Table 5.

Table 5: Summary of ParaGrid Material Properties

Item	Material Direction	Tensile Strength at Peak (kN/m)	Tensile Modulus (kN/m)
Paragrid CMD 150/05	Longitudinal	80	727

7.4 Finite Element Analysis Model

Rocscience 2D Finite Element Geotechnical Analysis Software, hereafter referred to as 'RS2', was utilised to analyse the proposed ground improvement solution for the proposed reservoir.

The model comprised a compacted G5 backfill with four intermediate geogrid layers for soil reinforcement.

The model was analysed to determine the global behaviour of the structure and to determine the minimum Factor of Safety (FOS) against bearing capacity failure.

A screenshot of the model showing the insitu soil layers and ground improvement layers are given in Plate 10.

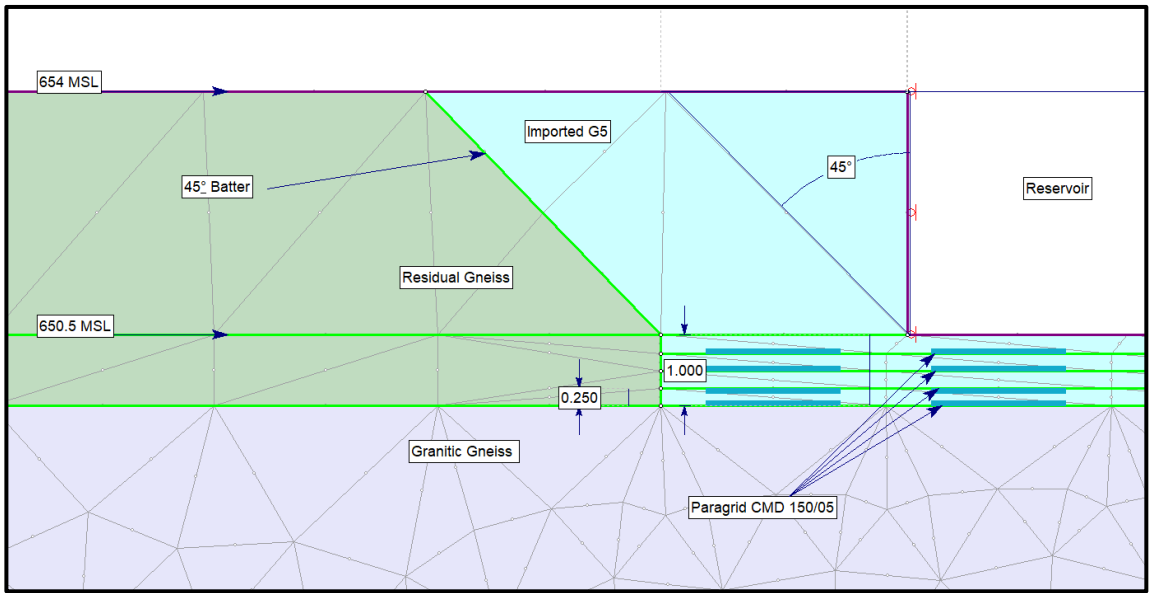


Plate 10: RS2 Model showing soil profile used in analysis

7.4.1 Design Assumptions

The following assumptions were made in order to model the proposed ground improvement solution on *RS2*:

i) The effects of groundwater were not considered in the analysis as groundwater was encountered deep within the weathered gneiss rock.

ii) The soil stratum was assumed to be horizontal with depth.

iii) The soil parameters used for the design solution were considered after analysis of the geotechnical report data in conjunction with empirical data from literature.

iv) The reinforced concrete slab and retaining wall were modelled in *RS2* as reinforced concrete liners with nominal reinforcement (Assumed $E_{concrete}$ = 3GPa).

v) A conservative maximum strain of 11% was assumed for the PARAGRID CMD150/05 geogrid material. This results in an allowable tensile modulus 727kN/m in the longitudinal direction. A FOS of 2.0 was applied to the ultimate tensile moduli.

vi) A plain strain model was adopted and the reservoir loading was applied along the longitudinal direction.

vii) It must be noted that *RS2* is limited to two dimensional analyses and due to the symmetry of the reservoir and loading conditions provided by Naidu Consulting, a single cross section only was required to conduct the finite element analysis on *RS2*.

7.4.2 Design Models

The structure was analysed for the following two conditions:

i) Model 1 - 250kN/m^2 applied pressure under the reservoir wall foundations, column foundations and floor on the insitu ground conditions.

ii) Model 2 – 250kN/m^2 applied under the reservoir wall foundations, column foundations and floor on a reinforced G5 ground improvement.

Both cases provided insight on the necessity of the ground improvement through a comparative analysis.

7.4.3 Analyses and Output

Plastic analyses were carried out on two models using *RS2* and the shear strength reduction factor (SRF) of each model was determined.

The SRF analysis reduces the soil shear strengths incrementally until a failure criterion is reached. This provides a critical SRF which is equivalent to the minimum FOS against a bearing capacity failure.

The first model represented the insitu condition i.e. the model did not include any form of ground improvement or adjustments to the insitu ground conditions.

The second model represented the post construction of the ground improvement condition i.e. the model included the ground improvement layerworks.

The SRF for both models are given in Table 6.

Table 6: Summary of Strength Reduction Factor

Model No.	Description	Strength Reduction Factor	Comments
1	Insitu condition	2.79(Refer to Plate 12)	FOS not acceptable
2	Ground improvement	3.54 (Refer to Plate 13)	FOS acceptable

Taking into account the assumed geotechnical parameters, a minimum FOS against bearing capacity failure of at least 3.5 is considered acceptable for the proposed reservoir.

Screenshots of both models showing contours of shear strains are given in Plates 11 and 12.

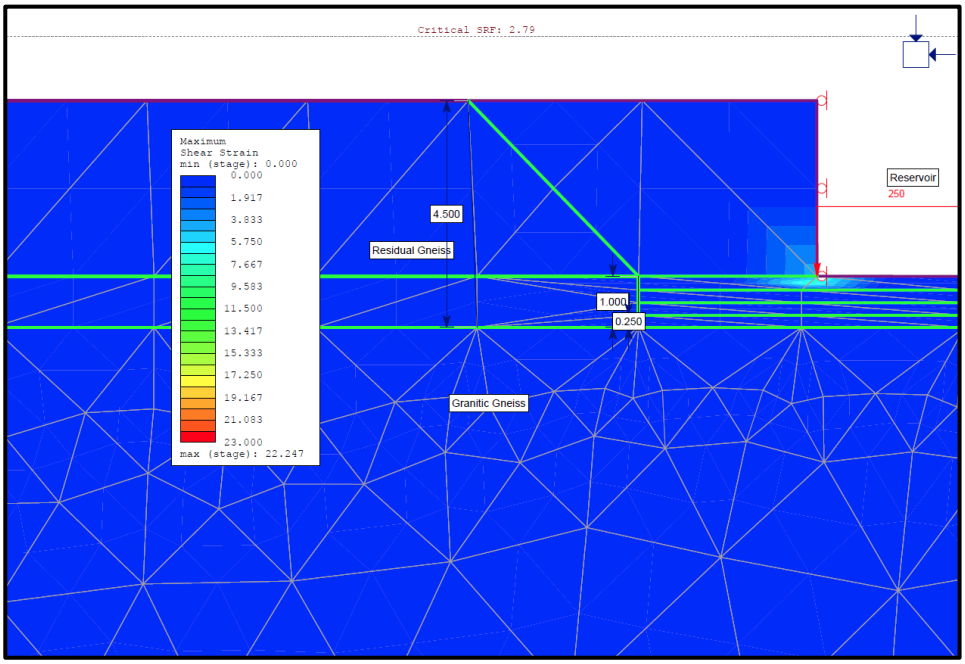


Plate 11: Shear Strain Diagram – Insitu ground conditions (Model 1)

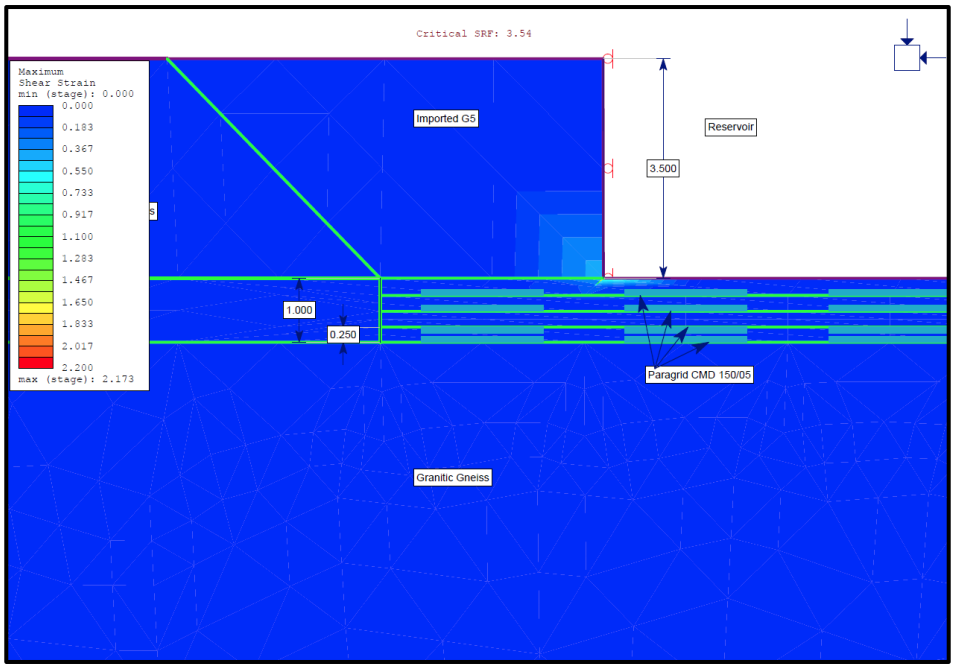


Plate 12: Shear Strain Diagram – Ground Improvement (Model 2)

7.5 Settlement

A settlement analysis was carried out on the Settle 3D v3.0 software package. The service loading condition was modelled together with the soil models described in Table 4.

The service loading conditions used in Settle 3D, provided by Naidu Consulting is summarised in Table 7.

Table 7: Summary of Service Loading Condition

Structural Member	Applied Serviceability Pressure (kN/m^2)
External Walls	250
Internal Columns	250
Floor Slab	250

The maximum settlements for Model 1 and 2 are given in Table 8. The anticipated settlements for the insitu ground condition and the ground improvement model is given in Plates 13 and 14.

Table 8: Maximum Reservoir Settlements

Model No.	Description	Maximum Settlement (mm)
1	Insitu condition	40 - 45
2	Ground improvement	20 - 25

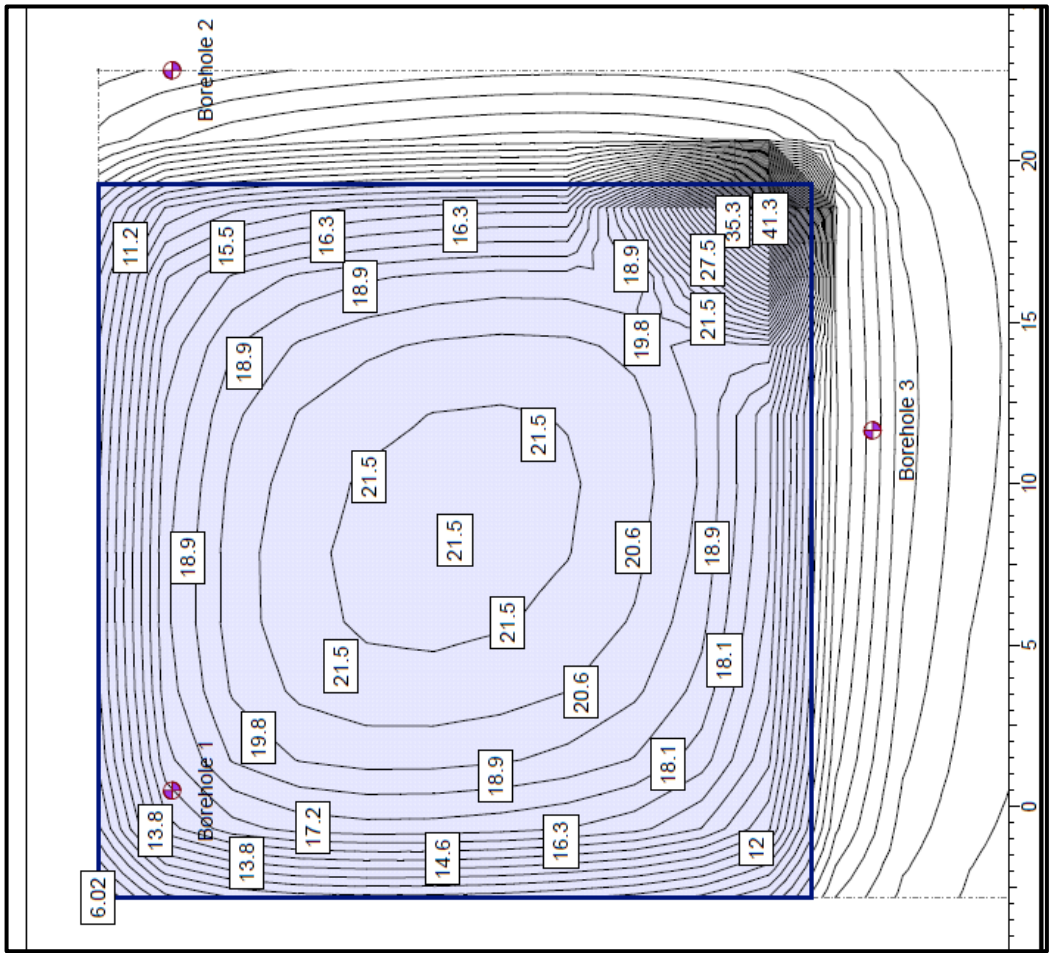


Plate 13: Settlement of Reservoir – Insitu Ground Condition (no ground improvement) Model 1

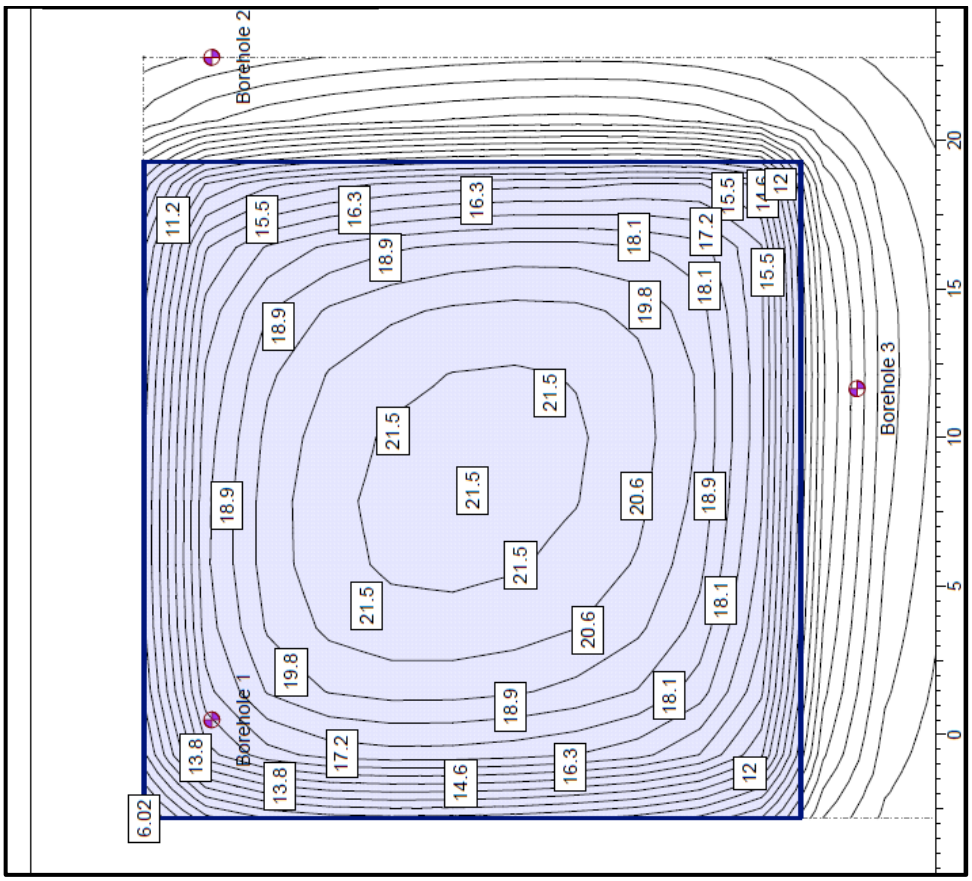


Plate 14: Settlement of Reservoir – Post Ground Improvement Model 2

8. ALTERNATIVE DESIGN SOLUTIONS

The following solutions outlines the alternative design solutions evaluated prior to selection of the most feasible design solution. After assessing cost projections, constructability and time constraints the most feasible design solution was selected.

8.1 Mass Concrete Fill

The proposed design comprises the following:

i) Excavate the in-situ clayey soils to a depth of 1.0m below underside of the reservoir foundation level (650.73msl) or to expose weathered gneiss rock, whichever is shallower.

ii) The bottom of the excavation is then ripped to a depth of 150mm and re-compacted to 95% MOD AASHTO Dry Density.

iii) Mass concrete fill of 30MPa strength to be placed at 500mm lifts. The concrete will be allowed 3 day to 4 day curing period.

iv) The proposed reservoir foundation level is assumed to straddle rock and the mass concrete fill. Therefore, the mass concrete may only be required for a portion of the reservoir footprint. However, the construction cost estimates given in this report comprise the mass concrete fill beneath the full area of the reservoir footprint.

8.2 Dump Rock Fill

The proposed design comprises the following:

i) Excavate the in-situ clayey soils to a depth of 1.0m below underside of the reservoir foundation level (650.73msl) or to expose weathered gneiss rock, whichever is shallower.

ii) The bottom of the excavation is then ripped to a depth of 150mm and re-compacted to 95% MOD AASHTO Dry Density.

iii) Selected dump rock of maximum particle size of 250mm should be imported for use as fill.

iv) The founding rock fill layer is to be compacted into insitu soils until negligible movement is observed.

v) Dump rock is to be placed at 250mm layers and compacted using suitable high energy compaction plant. Sufficient fines are to be filled into all voids within the dump rock fill layers.

vi) The proposed reservoir foundation level is assumed to straddle rock and the dump rock. Therefore, the dump rock fill may only be required for a portion of the reservoir footprint. However, the construction cost estimates given in this report comprise the mass concrete fill beneath the full area of the reservoir footprint.

8.3 Discussion of Alternative Solutions

The settlement of mass concrete fill is considered to be minimal when compared to the settlement of soil fill under loading. There is a risk of cracks forming within the concrete mass due to shrinkage of the concrete where the concrete is not given a sufficient curing period. Concrete material cost and transportation are high therefore, this solution is not cost effective.

The usage of dump rock is a time consuming operation inclusive of sourcing and placement of material to specification. Dump rock is difficult to process and ensure fines fill all voids. It is difficult to compact to the desired level, as a result, blinding is generally required to allow for an even platform for the reservoir foundations.

The alternative design solutions outlined in Section 8.1 and Section 8.2 were considered unfeasible due to cost effectiveness.

8.4 Cost Estimates for Design Solutions

The cost estimates for the design solutions discussed in this report is given in Table 9.

Table 9: Cost Estimates for the Various Design Solutions

Items	Cost of Design Solutions*		
	Concrete	Dump Rock	G5 and Geogrid
Labour	R 445 339,81	R 102 273,26	R 139 675,82
Plant	R 194 319,78	R 373 307,31	R 283 048,93
Materials	R 3 538 080,00	R 1 705 860,00	R 1 529 625,88
Total (Ex VAT)	**R 4 177 739,59**	**R 2 181 440,57**	**R 1 952 350,62**
VAT	R 626 660,94	R 327 216,09	R 292 852,59
Total (incl. VAT)	**R 4 804 400,53**	**R 2 508 656,66**	**R 2 245 203,21**

* The cost estimates exclude costs for contractor's Establishment and Preliminary and General.

9. SUMMARY

i) This report details the design of the ground improvement solution for the proposed Thandokuhle Reservoir, KwaZulu Natal.

ii) The site was observed to be underlain by fill material, colluvium and residuals soils derived from the insitu weathering of the underlying megacrystic granitic gneiss rock.

iii) Although groundwater seepage was encountered during the deeper geotechnical investigation by measurement of standpipe piezometers, the proposed ground improvement solution does not extend to this depth. Subsequently, groundwater was not considered in the design procedure.

iv) The FOS against a bearing capacity failure of the insitu soils is approximately 2.79. A minimum FOS against bearing capacity of 3.5 is considered acceptable for the proposed reservoir.

v) The design of the ground improvement comprises the excavation of the insitu soils beneath the proposed reservoir footprint to a depth of 1.0m below underside of reservoir floor level and replacing the excavation with reinforced earth up to underside of reservoir floor level.

vi) The initial single cell reservoir position had three (3 No.) boreholes situated across its footprint (i.e. BH1, BH2 and BH3), however, the reservoir was subsequently shifted resulting in only one borehole (i.e. BH1) being positioned across the reservoir footprint. This reduces the certainty of the underlying soil layers. Therefore, the ground improvement may not be required across the entire footprint of the reservoir due to the possibility of encountering competent rock. Site supervision during the construction process by Geosure to ensure assessment of founding conditions and quality assurance of the final product will be necessary.

vii) The reinforced earth comprises 8 No. layers of ParaGrid CMD 150/05, spaced at 0.25m intervals, and backfilled with G5 quality material compacted to 95% Modified AASHTO dry density.

viii) By carrying out the ground improvement, the FOS against bearing capacity failure increases to 3.54. This is considered acceptable for the proposed reservoir.

10. REFERENCES

i) Brink, A. B., & Bruin, R. M. (2002). Guidelines for Soil and Rock Logging in South Africa. *Proceedings of the Geoterminology Workshop* (p. 47). Association of Engineering Geologists, South African Institute Civil Engineering - Geotechnical Division, and South Africa Institue for Engineering and Environemntal Geologists.

ii) Committee of State Road Authorities. (1985). *THR14: Guidelines for Road Construction Materials.* South Africa: Department of Transport.

iii) Council for Geoscience. (1988). 2930 Durban. *1:250 000 Geological Series*. South Africa Council for Geoscience.

iv) G.Byrne, & A.D.Berry. (2008). *A Guide to Pratical Geotechnical Engineering in South Africa.* Franki.

v) Google earth. (2017). *AfriGIS (Pty) Ltd*. Retrieved 01 09, 2018, from Google earth: www.googlearth.com

vi) Google Earth. (2020). *AfriGIS (Pty) Ltd*. Retrieved 04 03, 2020, from Google Earth: www.googlearth.com

vii) Look, B. (2007). *Handbook of Geotechnical Investigation and Design Tables.* Taylor and Francis Group.

viii) South African Bereau of Standards. (1990). *Code of Practice for the Application of the National Building Regulations.* South Africa: South African Bereau of Standards.

ix) South African Department of Labour. (1993 and 2014). *Occupational Health and Safety Ammendment Act, No. 181 of 1993 and Construction Regulations, 2014.* Department of Labour - South Africa.

APPENDIX A

PARAGRID CMD 150/05 TECHNICAL DATA SHEET

MACCAFERRI AFRICA

TECHNICAL DATA SHEET

TDS ZA-ParaGrid-Rev02-Feb17

PARAGRID® - CMD 05

STRIP BONDED GEOGRIDS WITH HIGH TENACITY POLYESTER CORE

PARAGRID			30/05	40/05	50/05	65/05	80/05	90/05	100/05	120/05	135/05	150/05	175/05	200/05
Mechanical properties														
UTS - longitudinal *		kN/m	37	47	57	71	86	96	106	130	145	160	185	212
Tolerance *		kN/m	-7	-7	-7	-6	-6	-6	-6	-10	-10	-10	-10	-12
Strip tensile strength - (longitudinal)		kN	2.25	3.00	3.75	4.85	6.00	6.75	7.50	9.00	10.15	11.25	13.10	15.00
UTS - transverse *		kN/m	6	6	6	6	6	6	6	6	6	6	6	6
Tolerance *		kN/m	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Elongation in both directions - (typical value)		%	11	11	11	11	11	11	11	11	11	11	11	11
Phsysical properties														
Strip reinforcement polymer			PET	PET	PET	PET	PET	PET	PET	PET	PET	PET	PET	PET
Strip coating polymer			PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE
Thickness		mm	0.7	0.7	0.8	0.9	1.1	1.1	1.2	1.4	1.4	1.4	1.4	1.7
Strip width (longitudinal)		mm	24	24	24	24	24	24	24	33	33	33	33	33
Mesh size		mm	426x51	426x51	426x51	426x51	426x51	426x51	426x51	426x42	426x42	426x42	426x42	426x42
Roll length		m	100	100	100	80	80	80	80	50	50	50	50	50
Roll width		m	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90
Roll diameter		m	0.41	0.41	0.41	0.40	0.45	0.45	0.45	0.34	0.35	0.36	0.36	0.40
Roll weigth		kg	93	99	105	107	108	134	140	116	123	131	139	147

ParaGrid geogrids are planar structures consisting of a biaxial array of composite geosynthetic strips. The strips comprise of a core of high tenacity polyester tendons encased in a polyethylene sheath.

* Short-term tests in accordance with EN ISO 10319:2008. The values given are mean values of ultimate strength and tolerance values correspond to the 95% confidence level to establish the characteristic short-term tensile strength in accordance with EN 13251:2001

NOTE:
Special products can be manufactured on request for specific projects. The white columns are the standards products mostly available on stock; the coloured columns are special products to be manufactured on request and generally not available on stock.

As part of the ISO 9001 Management Systems, guided research and development programmes, information contained herein is continuously updated. Please confirm with Maccaferri Africa (Pty) Ltd the latest version of the Product's Specification available.

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Engineering a Better Solution

063-20.R01-001

SITE PLAN

KEY:

BH1 ⊗ — Approximate position of Borehole.

IP1 ☒ (>2.5) >2.5 — Approximate position of Inspection Pit showing depth to rock () and depth to refusal in metres below existing ground level.

DC1 ▼ 2.9 — Approximate position of CBR Dynamic Cone Penetrometer Test showing depth to refusal in metres below existing ground level.

Site plan showing approximate positions of:

Boreholes;
Inspection Pits; and
CBR Dynamic Cone Penetrometer (DCP) Tests.

SCALE 1:250

0 2,5 5
Metres

Naidu Consulting (Pty) Ltd

Proposed Thandokuhle Reservoir
Geotechnical Investigation

GEOSURE (PTY) LTD
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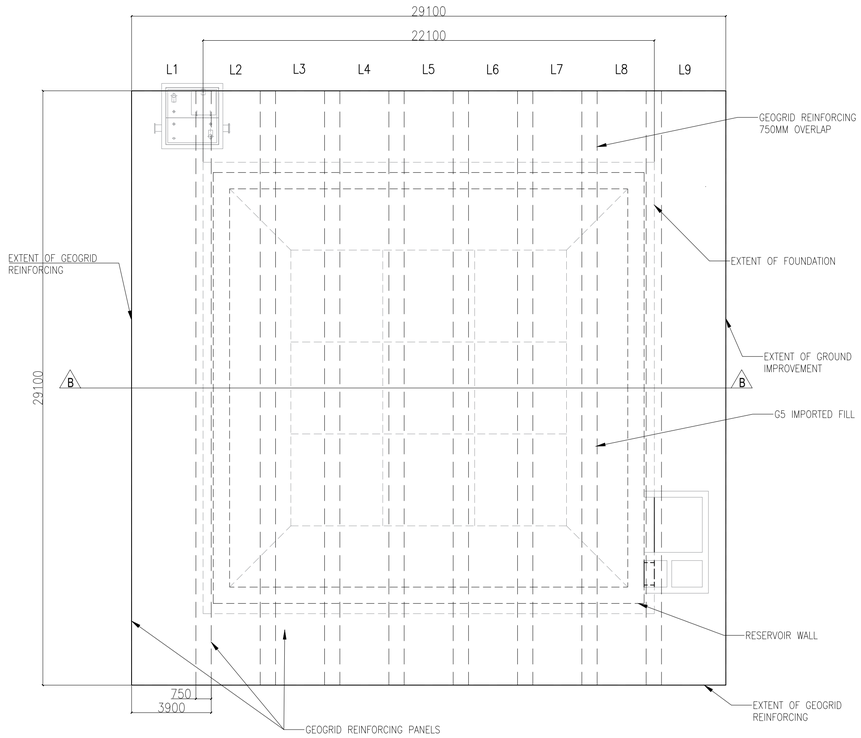
DATE: 01-10-2020
DRAWN BY: V.G
CHECKED BY: A.R
REFERENCE NO. 063-20

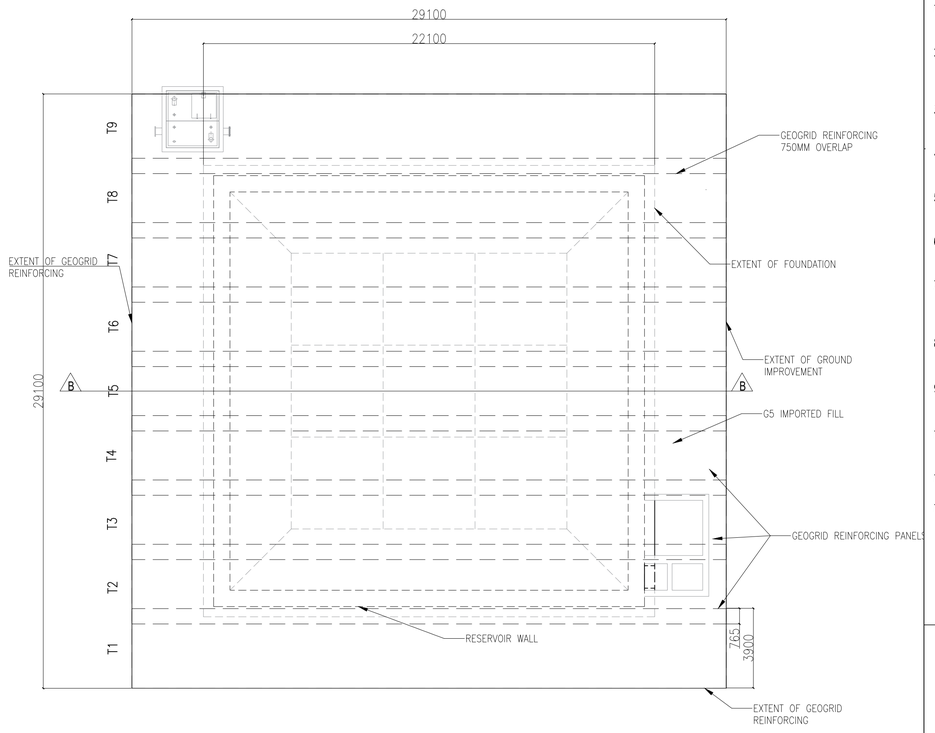
063-20.R01-001

063-20.R02-001

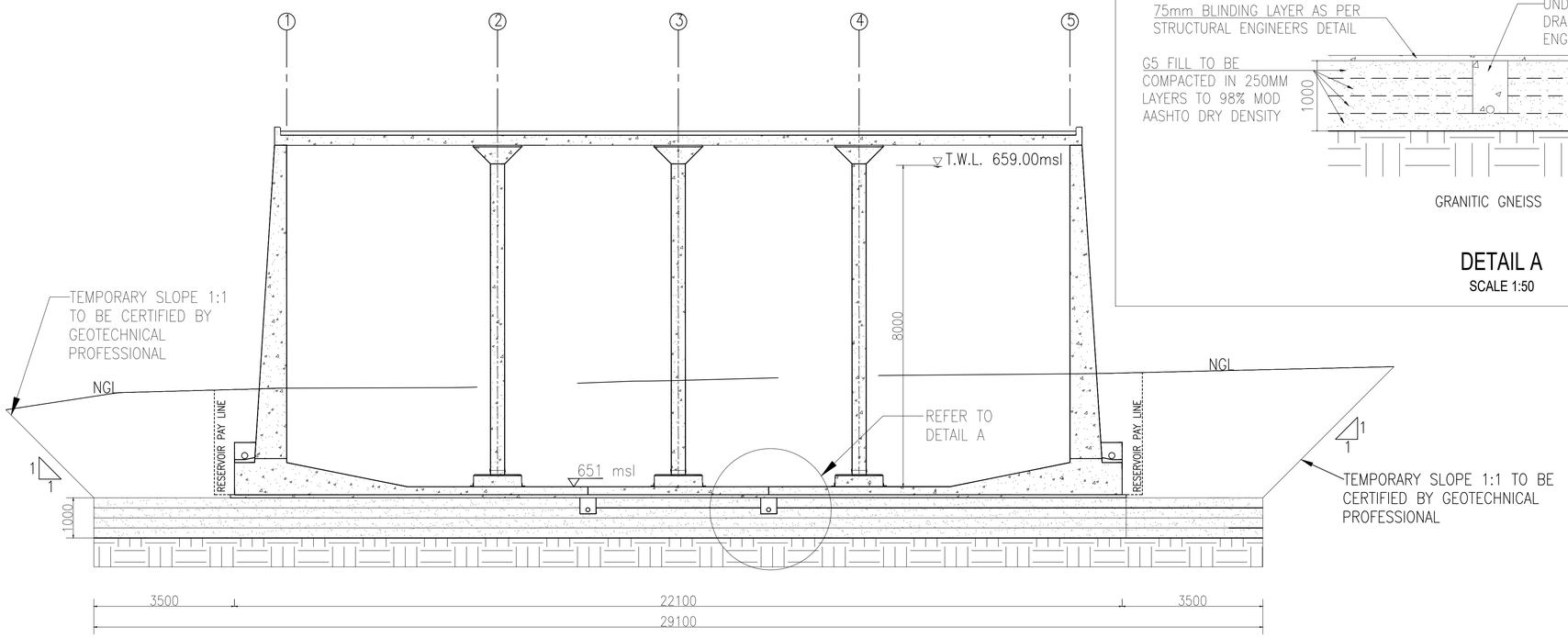
DETAIL OF GROUND IMPROVEMENT LAYERWORKS FOR PROPOSED RESERVOIR



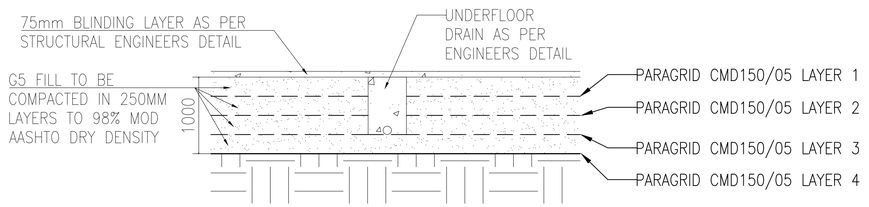
GROUND IMPROVEMENT PLAN - LATERAL GEOGRID LAYOUT
SCALE 1:100



GROUND IMPROVEMENT PLAN - TRANSVERSE GEOGRID LAYOUT
SCALE 1:100



SECTION B-B
SCALE 1:150



DETAIL A
SCALE 1:50

PARAGRID CMD 150/05 – GEOGRID PER 250mm LAYER		
Roll Number	Length (mm)	Width (mm)
L1/T1	29100	3900
L2/T2	29100	3900
L3/T3	29100	3900
L4/T4	29100	3900
L5/T5	29100	3900
L6/T6	29100	3900
L7/T7	29100	3900
L8/T8	29100	3900
L9/T9	29100	3900
TOTAL PER LAYER	523800	X
REQD. ROLLS	11	
LENGTHS INCLUDE OVERLAPS		

DO NOT SCALE

NOTES

1) DO NOT SCALE THIS DRAWING. FOLLOW SCALES AS PER FIGURES.
2) CONTRACTOR SHALL NOTIFY ENGINEER OF ANY DISCREPANCIES IN DRAWING PRIOR TO COMMENCEMENT OF WORKS.
3) ALL ELEVATIONS AND SETTING OUT POINTS AS PROVIDED BY NAIDU CONSULTING.
4) PARAGRID CMD150/05 DIMENSIONS ON DRAWING AS PER MACCAFFERI SOUTH AFRICA SPECIFICATION.
5) INSTALLATION OF GEOGRID TO BE IN ACCORDANCE WITH MANUFACTURERS GUIDELINES.
6) PROPOSED GEOGRID, PARAGRID CMD150/05, ROLL SIZE OF 50mx3.90m.
7) G5 BULK EARTHWORKS FILL TO BE EXTENDED 2m BELOW AND BEYOND FOOTPRINT OF CONCRETE RESERVOIR FOOTING.
8) OVERLAP OF PARAGRID CMD05 TO BE 750mm ALONG THE LONGITUDINAL DIRECTION (LONG EDGE).
9) OVERLAP OF PARAGRID CMD05 TO BE 500mm ALONG THE TRANSVERSE DIRECTION (SHORT EDGE).
10) LENGTHS PROVIDED EXCLUDE TRANSVERSE OVERLAP.
11) G5 FILL TO BE COMPACTED IN 250mm LAYERS.
12) ALL EARTHWORKS TO BE CARRIED OUT ACCORDING TO SANS1200

CURRENT DRAWING ISSUED TO:
NAIDU CONSULTING

REV	DATE	BY	DESCRIPTION	CHK	APD
0	18/01	AR	FOR COMMENT		

DRAWING STATUS:
FOR INFORMATION

Consulting Engineering Geologists, Geotechnical Engineers, Geotechnicians & Geotechnical Quality Assurance Specialists
GEOSURE (Pty) Ltd

PROJECT:
THANDOKUHLE RESERVOIR

TITLE:
DETAIL OF GROUND IMPROVEMENT FOR PROPOSED RESERVOIR

SCALE @ A1:	CHECKED:	APPROVED:
AS SHOWN	AR	AR
DRAWN:	DESIGNED:	DATE:
SH	AR	18/01/20

PROJECT No:	DRAWING No:	REV:
063-20	063-20.R02-001	0