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REPUBLIC OF SOUTH AFRICA

Geotechnical Report: Lower Coerney Dam Site: Supplementary Investigations

Support of the Water Reconciliation Strategy for the Algoa Water Supply System

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water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF WATER AND SANITATION

Directorates: National Water Resource Planning and Options Analysis

Support of the Water Reconciliation Strategy for the Algoa Water Supply System

Geotechnical Report: Lower Coerney Dam Site: Supplementary Investigations

September 2019

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Department of Water and Sanitation
Directorates: National Water Resource Planning and Options Analysis

SUPPORT OF THE WATER RECONCILIATION STRATEGY FOR THE ALGOA WATER SUPPLY SYSTEM

APPROVAL

Title : Geotechnical Report: Lower Coerney Dam Site: Supplementary Investigations.

Consultant : Aurecon South Africa (Pty) Ltd

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Bold type indicates this Report.

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Executive Summary

Introduction

Aurecon South Africa (Pty) Ltd was appointed by the Department of Water and Sanitation (DWS) to investigate various options for augmenting water supply to Port Elizabeth. As part of the wider study, geotechnical investigations have been conducted at the two most favourable dam sites, namely a site immediately upstream of the existing Scheepersvlakte Dam, called Upper Scheepersvlakte, and a site located in the adjacent catchment, designated the Lower Coerney Dam site.

The Lower Coerney site was subsequently chosen as the preferred option amongst the two sites to be investigated at feasibility level. This decision was supported by the various role players at the Study Management Meeting 12, held on 25 February 2018. The current investigations were recommended to further obtain additional information required for the feasibility design of the Coerney Dam.

This report collates the findings of the supplementary investigations together with the earlier findings into this comprehensive geotechnical report for feasibility design purposes.

These geotechnical investigations (inclusive of the earlier investigations)) included the following elements;

- Geophysical (resistivity) surveys;
- Test pitting including the additional test pitting for the supplementary investigation;
- Rotary core drilling;
- Field testing including SPT's and packer (Lugeon) testing;
- Laboratory testing; and
- Interpretation, analysis and reporting.

Geology of the site

The underlying geology comprises alluvium, colluvium, reworked terrace gravels (mixed origin), thin grey sandstones, siltstones and mudrocks of the Sundays River Formation of the Uitenhage Group; part of a collection of sedimentary strata within the structurally controlled Algoa Basin.

The seismic hazard of the area is considered to be very low and the Peak Ground Acceleration (PGA) values are less than 0.02g, with a 10% probability of being exceeded in a 50-year period.

The dam site is characterised by gentle, almost flat slopes; as is the greater basin. For the most part, the site is covered by very dense bush.

The geological profile is characterised by soil strata with thickness up to 7 m to 8 m on the left flank, but 3 m to 4 m on the right flank and river section. Various horizons are recognised, including topsoil, colluvium as well as colluvium with evidence of pedocrete development, and a horizon of gravel-sands, considered to represent reworked terrace gravels, that blankets the bedrock across the entire dam footprint, as well as within the basin.

Bedrock comprises an alternating succession of sandstones and mudrocks, including silty sandstones. The lateral continuity of these strata is uncertain. The bedrock is characterised by extensive, pervasive weathering, and these rocks are generally considered weak rocks.

The transported soils essentially comprise mixtures of sand, clay and silt; either clayey silt, sandy silt or silty sand. The recent investigation indicates a clay content of 4% to 35%, with the highest content indicated on the mudrocks. A coarser fraction is present within the 'reworked terrace gravels' but is not uniformly distributed. In places a concentrated coarse fraction occurs that might represent former drainage channels, and in other areas the coarse fraction is a minor component.

The permeability of the respective soil strata varies between 1.84 x 10^{-5} cm/s and 7.08 x 10^{-7} cm/s. The suite of dispersivity tests indicates that the soils are at least non-dispersive to intermediate dispersivity.

Dam type, founding conditions and materials

The geological profile, as well as other factors such as the topography, indicates that only an embankment dam is possible at this site. There are no suitable sources of rock in the immediate vicinity, and an earthfill embankment is the only viable option. A cut-off (under the embankment) would generally have to extend to the base of the gravel soils in order to ensure the potential seepage is effectively cut off. The side channel spillway on the left flank would be underlain by soils and bedrock; full concrete lining of the chute will be required and provision for energy dissipation must be included at the downstream end. Bedrock was encountered between 3.4 m and 4.9 m in test pits TP126 and TP125 respectively, at the end of the spillway.

Packer tests within the bedrock yielded variable results, and included some significant losses ascribed to wash-out of weathered, soft rock interbeds.

In assessing various material types within the basin, no clear distinction can be made on the suitability of the various material types for either impervious core material or for semi-pervious shell material. In other words, the properties of the various material groupings do not permit clear definition of their suitability, and therefore clear delineation into different borrow areas for the respective material uses cannot sensibly be made. In view of this, and also considering the almost total compliance of these basin materials with typical homogeneous embankment specifications, it is recommended that the Coerney Dam be constructed as a homogeneous earthfill embankment rather than a zoned embankment.

Involvement of a geotechnical specialist during construction is essential. Activities would include regular inspection of all excavated faces and cut slopes from a stability point of view, oversight of any further geotechnical exploration and quality assurance testing, confirmation of bedrock depth at the spillway end, engineering geological mapping of the cut-off trench and recording of the as-built details, etc.

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Abbreviations

DWS	Department of Water and Sanitation
FSL	Full Supply Level
GPS	Global Positioning System
GWS	Government Water Scheme
mamsl	Metres above mean sea level
NOCL	Non-Overspill Crest Level
ORP	Orange River Project
PGA	Peak Ground Acceleration
SPT	Standard Penetration Test

1 Introduction

Aurecon South Africa (Pty) Ltd was appointed by the Department of Water & Sanitation (DWS) to investigate various options for improving the assurance of supply that is provided by the Scheepersvlakte Dam to the Nooitgedagt WTW, recommend a preferred storage site, and undertake feasibility design. After considering the various options identified, two possible alternate new dam sites were recognised as the most favourable, namely a site immediately upstream of the existing Scheepersvlakte Dam, called Upper Scheepersvlakte, and a site located in the adjacent catchment, designated the Lower Coerney site. The locations of these sites are illustrated below in **Figure 1.1.**

In order to support selection of a preferred site, geotechnical investigations were initiated at both these options. The following geotechnical reports were submitted as part of the evaluation process:

- Department of Water and Sanitation, South Africa 2019, Geotechnical Report: Lower Coerney Dam Site. Report Number P WMA 07/N40/00/2619/2. Prepared by Aurecon South Africa (Pty) Ltd as part of the Support of the Water Reconciliation Strategy for the Algoa Water Supply System.
- Department of Water and Sanitation, South Africa 2019, Geotechnical Report: Upper Scheepersvlakte Report Number P WMA 07/N40/00/2619/1. Prepared by Aurecon South Africa (Pty) Ltd as part of the Support of the Water Reconciliation Strategy for the Algoa Water Supply System.

The Lower Coerney Dam site was subsequently chosen as the preferred option amongst the two sites for further investigation at feasibility level. This decision was supported by the various role players at Study Management Meeting 12, held on 25 February 2018.

Access within the general basin area during earlier investigation was very restricted due to the very dense bush, with only few test pits excavated in the basin. To obtain additional information required for the feasibility design of the Coerney Dam and to manoeuvre the bush, an excavator was proposed for excavation of the additional test pits. This was conducted with the aim of getting deeper profiles for better understanding of the basin ground conditions.

A motivation letter was subsequently sent to DWS for approval to proceed with the additional geotechnical investigation on the 22nd March 2019. This letter was in reference to the need to also confirm materials availability within the basin and to confirm compliance with the required specifications by means of complimentary laboratory testing. The additional geotechnical work was then approved by the DWS and supplementary investigations were conducted during the week of 10-14 June 2019.

This report presents the findings of the supplementary investigations. For ease of reference, however, findings from the previous investigations are incorporated into this report.

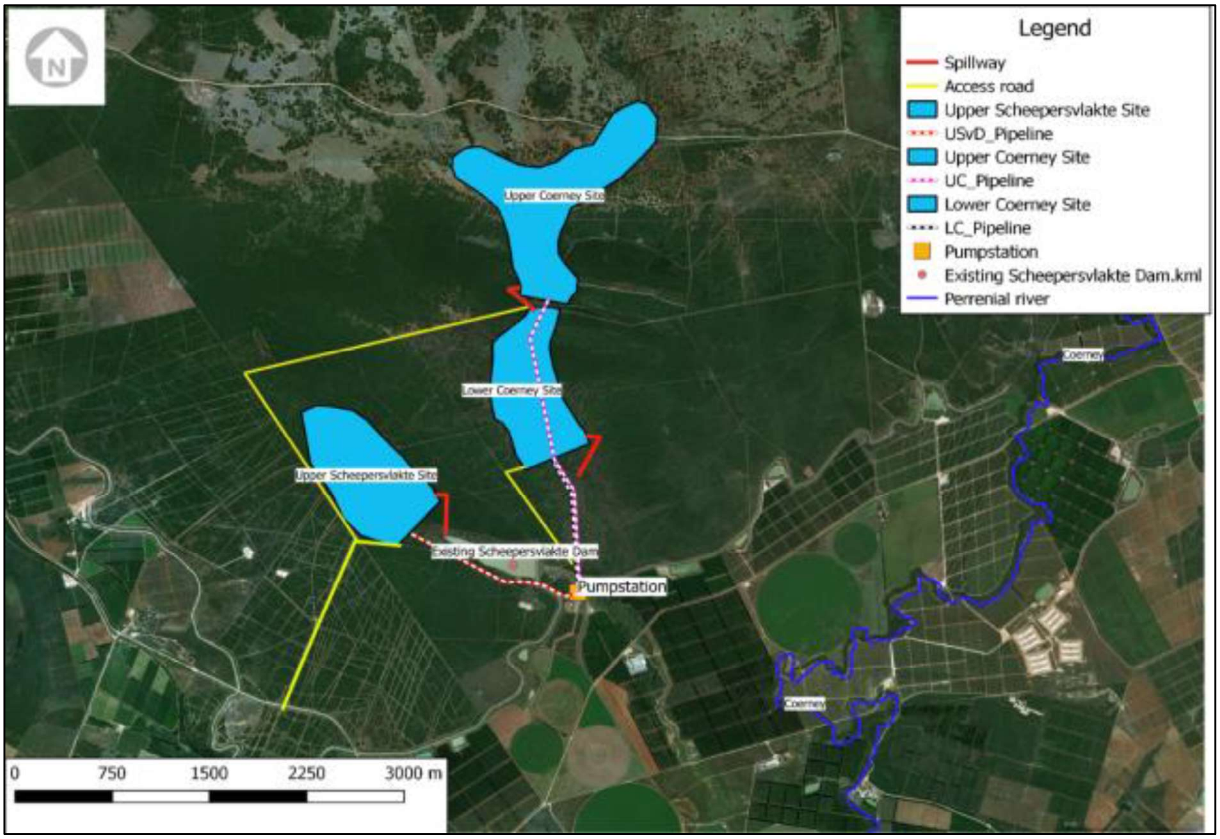

Figure 1.1: General locality plan of the respective alternate dam sites investigated

The preliminary dam details are summarised below in **Table 1-1.**

Table 1-1: Dam design details for Lower Coerney site

Dam feature	Lower Coerney Dam
Type of dam	Zoned Earthfill Embankment
NOC (amsl)	103.8
FSL (amsl)	98.8
Freeboard (m)	5.0
Crest width (m)	5.0
DS slope (1V:H)	2.0
US slope (1V:H)	3.0
Embankment fill volume (m^3)	355,993

Dam feature	Lower Coerney Dam
Core trench volume (m^3)	46,798
Crest length (m)	623
Total gross dam capacity (m^3)	4,600,000
Surface area at FSL (ha)	597,317
Maximum wall height (m)	19.0
Catchment area (km^2)	34
Unrouted SEF Inflow (m^3/s)	890
Spillway configuration description	Concrete-lined, 36 m wide, side channel spillway located on the left abutment. (Note: spillway position dependant on geotechnical conditions) with downstream concrete outlet chamber, 4x4x3m, with 2 valves for the two pipes.
Outlet works description	Dry well tower (19 m high) with inside dimensions of 4x4m. Three offtake levels controlled by valves.
Access road length (km)	1.0

2 Available information

The following available information was used for this investigation:

- Geological map Sheet 3324 Port Elizabeth. Council for Geoscience.
- Geological Survey February 1987. Scheepersvlakte Dam – Side Valley Site; 1st Engineering Geological Feasibility / Design Report – Founding Conditions. Report to Department of Water Affairs.
- Department of Water Affairs (DWA). October 1988. O.R.D.P. Lower Sundays River G.W.S.; Scheepersvlakte Dam. Design Report.
- Department of Water Affairs and Forestry (DWAF). July 1992. O.R.D.P. Lower Sundays River G.W.S.; Scheepersvlakte Dam. Completion Report. (in Afrikaans) Report No N400/10/ED07.
- Outeniqua Lab EC cc. 2016. Geotechnical Report. Geotechnical Site Investigation for the Proposed Scheepersvlakte Irrigation Scheme Dam near Port Elizabeth in the Eastern Cape. Report to Inconsult Engineers, dated 22 July 2016.

3 Previous investigations

Several investigations have been conducted over the years, specifically for the original Scheepersvlakte Dam.

The proximity of the Lower Coerney site to Scheepersvlakte dam site indicates some relevance to general ground conditions as encountered at the Lower Coerney site, but these earlier investigations are not unpacked in this report. One useful reference report was the Completion Report for Scheepersvlakte Dam (DWAF, 1992).

In the reporting on the Scheepersvlakte investigations[1] it was mentioned, however, that earlier investigations were conducted in 1978/79 at what is presumably the current Lower Coerney site, before investigations shifted to the Scheepersvlakte "side-valley" site that proceeded to be constructed. At the time these investigations were also called "Scheepersvlakte" but might be referred to as "Coerney". These original investigations at the Coerney option considered three centre-lines. It is mentioned that 20 boreholes (total length 340.97 m) were drilled; concentrated mostly at an "upper" site. There is also mention of trenching only having been carried out at a "middle" site, while a "lower" site was also investigated.

The Scheepersvlakte "side valley" report (Geological Survey, 1987) mentioned that a separate report would be prepared for these "Coerney" investigations, but it remains doubtful whether this was done. No records of such a report could be located.

A geotechnical investigation of the Coerney site was further carried out in 2016 by Outeniqua Lab EC who were appointed by Inconsult Engineers[2]. The work primarily comprised excavation and profiling of test pits (17 No), accompanied by laboratory testing.

Option analysis, to distinguish between the Upper Scheepersvlakte and Lower Coerney dam sites was conducted in 2018. These investigations were conducted to improve geotechnical information, and update design parameters and costs, to be able to make a final recommendation on the preferred dam site. These investigations included geophysical surveys, test pitting, sampling and laboratory testing, and rotary core drilling.

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[1] Scheepersvlakte Dam – Side Valley Site; *1st Engineering Geological Feasibility / Design Report – Founding Conditions*. February 1987. Geological Survey Report.

[2] Outeniqua Lab EC cc. 2016. Geotechnical Report. *Geotechnical Site Investigation for the Proposed Scheepersvlakte Irrigation Scheme Dam near Port Elizabeth in the Eastern Cape*. Report to Inconsult Engineers, dated 22 July 2016.

4 Investigation methodology

Additional test pit investigation was conducted on the Lower Coerney site (preferred option) using a tracked excavator, with the aim of supplementary investigation of the basin area, spillway chute, particularly at the end, and some in-fill test pitting, especially on the upper right flank. The geophysical survey and rotary core drilling methodologies from the previous investigation are kept in this section for ease of reference.

4.1 Geophysical surveys

Resistivity surveys were conducted by specialist geophysicists, Engineering & Exploration Geophysical Surveys cc (EEGS).

The purpose of commencing these geotechnical investigations with the geophysical surveys was primarily to identify sub-surface anomalies that might potentially impact on the envisaged layout, and thus provide potential targets for the boreholes, which would aim to validate these anomalies.

It might be noted that vegetation proved too dense to allow working access, and environmental constraints placed strict limits on the extent of permissible bush clearing. It was therefore necessary to appoint a service provider, B K Bush Clearing, to manually clear cut-lines along these geophysical traverses. It is worth noting that these “cut-lines” had a width intended for pedestrian traffic, not vehicular access, even though in places it was possible to use these cut-lines for access by the TLB. The larger trees were however not cut, and access was still limited.

Three traverses were set out; one longitudinal traverse along the centre-line, one traverse essentially perpendicular to the centre-line, roughly aligned along the intake **–** outlet conduit, and the third traverse aligned along the spillway. The positions of these traverses are shown in Drawing 112546-GEO-DRG-CC-001-B.

Detailed description of the methodologies, and the equipment used, as well as the results, are presented in the Appendices. The findings are incorporated into the discussion on the geological profiles encountered.

4.2 Test pitting

Test pits were excavated at the dam footprint, spillway, and on the basin as the potential construction material source. A test pit summary is presented below in **Table 4-1**. This table includes test pits excavated during earlier investigations and the recent supplementary investigations, annotated as “LC” and “TP” respectively. In total, forty-one test pits were excavated, with the majority of test pits excavated within the basin during this supplementary investigation, which included some infill investigation on the dam footprint and the spillway. Test pit positions are indicated on the site plan (Dwg 112546-GEO-DRG-CC-001-B).

Table 4-1: Test pit summary

Test Pit No	Coordinates		Termination depth (m)	Remarks
	Y	X		
LC02	-058111	X3702708	2.75	No refusal, no water
LC03	-058187	X3702632	2.4	No refusal, no seepage
LC04	-058140	X3702665	1.35	Near-refusal, no seepage
LC05	-058115	X3702619	2.25	No refusal, no seepage
LC06	-058320	X3702486	1.65	No refusal but slow excavation, no seepage
LC07	-058175	X3702718	2.25	Near-refusal, no seepage
LC08	-058402	X3702424	1.5	No refusal but slow at 1.5 m, no seepage
LC09	-058262	X3702543	2.4	No refusal, no seepage
LC10	-058447	X3702411	1.6	No refusal but slow at 1.6 m, no seepage
LC11	-058381	X3702592	1.95	No refusal but slow at 1.95 m, no seepage
LC12	-058355	X3702759	2.35	Refusal on boulders, no seepage
LC20	-058164	X3702165	1.95	No refusal but slow at 1.95 m, no seepage
LC22	-057865	X3702228	2.4	Refusal on hardpan calcrete, no seepage
LC23	-057735	X3702243	2.25	No refusal, no seepage
TP101	-058062	X3702708	4.2	No refusal, no seepage
TP102	-058165	X3702624	2.8	Refusal on boulders at 2.8m, no seepage
TP103	-058338	X3702744	2.9	No refusal, no seepage
TP104	-058252	X3702577	2.4	No refusal but slow at 2.4, no seepage
TP105	-057929	X3702599	3.6	No refusal but slow at 3.6, no seepage
TP106	-058045	X3702532	3.1	No refusal, no seepage
TP107	-058129	X3702468	2.9	Refusal on sandstone, no seepage
TP108	-058195	X3702391	3.9	Refusal on sandstone, no seepage
TP109	-057867	X3702499	4.1	No refusal but slow at 4.1, no seepage
TP110	-057988	X3702433	3.4	No refusal but slow at 3.4, no seepage
TP111	-058103	X3702367	3.9	No refusal, no seepage
TP112	-058209	X3702277	4.0	No refusal but slow at 4.0, no seepage
TP113	-057805	X3702363	4.5	No refusal, no seepage
TP114	-057907	X3702336	3.7	Refusal on mudstone, no seepage
TP115	-058024	X3702289	4.2	No refusal but slow at 4.2, no seepage
TP116	-057691	X3702130	4.8	No refusal, no seepage
TP117	-057832	X3702102	3.3	Refusal on mudstone, no seepage
TP118	-058004	X3702086	3.3	Refusal on sandstone, no seepage
TP119	-057671	X3701972	2.2	Refusal on hardpan ferricrete, no seepage
TP120	-057836	X3701938	3.7	Refusal on sandstone, no seepage

Test Pit No	Coordinates		Termination depth (m)	Remarks
	Y	X		
TP121	-058020	X3701894	2.9	No refusal but slow at 2.9, no seepage
TP122	-057728	X3701805	2.0	Refusal on hardpan ferricrete, no seepage
TP123	-057767	X3701695	2.7	Near refusal, no seepage
TP124	-057899	X3701616	3.6	Refusal on sandstone, no seepage
TP125	-058386	X3702712	4.9	Refusal on sandstone, no seepage
TP126	-058409	X3702695	3.4	Refusal on sandstone, no seepage
TP127	-058029	X3702727	3.7	Refusal on sandstone, no seepage

The “LC” test pits were excavated using a light JCB 3DX tractor-loader backhoe (TLB), sub-contracted from Renaissance Construction by Tosca Lab (Pty) Ltd, and the “TP” test pits were excavated using a JCB JS290LC Excavator (30-ton) sourced by appointed geotechnical testing laboratory Controlab SA (Pty) Ltd. Note that the excavator was hired from a co-owner of the Scheepersvlakte farm, Mr Boet Muller.

The supplementary investigations were conducted during the week of 10 to 14 June 2019. The initial investigations were conducted from 17 May 2018 to 4 October 2018.

Test pits were profiled by a graduate civil engineer and engineering geologists in accordance with accepted southern African standards (as per Jennings, Brink, and Williams, 1973).

The two-person team carrying out the test pitting ensured compliance with accepted safety requirements as reflected in the South African Code of Practice (SAICE: 2007). Further observance of good safety practice is exhibited by the following;

- Compilation of a Health & Safety File in compliance with the South African OHS Act, including the necessary legal appointments (Section 8(2)(i)).
- Maintaining good management of the machinery (TLB and excavator, respectively, as well as drilling equipment) and the excavation process, including placement of spoil away from the pit edges, maintaining a safe distance from the machine, conducting a full briefing / induction of the operator, excavation of a sloping ramp at one end for easier entry / egress etc.
- Conducting a risk assessment by the competent person prior to entering the test pit. Such safe practices included limited or non-entry into the deeper excavator pits, and primarily profiling from surface spoil.
- Test pits were closed immediately after profiling and sampling. No pits were left open overnight.

Test pit positions were recorded with a Garmin hand-held GPS. Coordinates in the South African grid, WGS84 datum, are reflected in **Table 4.1**.

4.3 Rotary core drilling

A total of six rotary cored boreholes were drilled on the dam footprint / spillway and positions are shown on Drawing 112546-GEO-DRG-CC-001-B. No boreholes were drilled within the general reservoir area. Borehole details are summarised below in **Table 4-2.** All boreholes were drilled vertically.

Table 4-2: Borehole summary

BH No	Coordinates		Elevation	BH length (m)	Remarks
	Y	X			
LC BH01	-58099.59	3702689.25	83.36	15.01	Mid-right flank
LC BH02	-58215.90	3702532.15	89.15	20.45	Intake, lower left flank
LC BH03	-58252.35	3702625.65	84.30	20.43	Outlet, lower left flank
LC BH04	-58170.99	3702620.43	81.82	15.04	Mid -embankment / lowest point
LC BH05	-58427.33	3702391.34	102.01	10.03	Extreme left flank / spillway crest
LC BH06	-58387.47	3702608.97	89.98	10.1	Spillway

Specialist geotechnical drilling contractor, RWBE Geotechnical Drilling, was appointed for the drilling. Where possible, Standard Penetration Testing (SPTs) was carried out. In practice, the presence of gravels and cobbles within the soil profile severely limited the number of tests that were possible. Water acceptance (also referred to as packer or Lugeon) tests were carried out in selected boreholes, after the methodology described by Houlsby (1976).

Boreholes were located to investigate key elements of the dam – with due cognisance of the geophysics survey results. Borehole cores were logged in accordance with accepted standards. Logs are included in the Appendices, as are photographs of the borehole cores.

Boreholes were set out initially using a hand-held GPS, but the completed boreholes were accurately surveyed by DWS Survey Services.

No further drilling was undertaken during the supplementary investigations.

4.4 Laboratory testing

For initial investigations, representative samples were submitted to Tosca Lab in Port Elizabeth for testing. A list of tests conducted is presented below (**Table 4-3**). Samples comprised both disturbed bulk samples as well as undisturbed samples.

Table 4-3: Summary of laboratory tests conducted from initial investigations

Test	Quantities
Foundation Indicators	19
Moisture content	7
Relative density	4
Standard AASTHO (Proctor) compaction	8
Permeability	7
Shear box	10
Suite of dispersivity tests, comprising i) Pinhole test, ii) crumb test, iii) double hydrometer test, and iv) exchangeable sodium percentage (ESP) test.	4

For the supplementary investigations, the majority of the representative samples were submitted to Controlab (Pty) Ltd in East London for testing, with an approximate 10% portion of duplicate samples submitted to Labco (Pty) Ltd laboratories in Port Elizabeth for quality assurance / quality control (QA/QC) purposes. The tests conducted, and respective quantities are summarised in the following tables (Table 4-4 and Table 4-5).

Table 4-4: Bulk sample quantities for laboratory testing at Controlab

Test	Quantities
Foundation Indicators	22
Moisture content	15
Relative density	9
Standard AASTHO (Proctor) compaction	14
Permeability	9
Shear box	9
Suite of dispersivity tests, comprising i) Pinhole test, ii) crumb test, and iii) double hydrometer test.	5

Table 4-5: Duplicate sample quantities submitted for testing at Labco

Test	Quantities
Foundation Indicators	6
Moisture content	3
Relative density	2
Standard AASTHO (Proctor) compaction	3
Falling Head Permeability	2

Detailed test results are included in the Appendices, and the findings are discussed below (Section 6.3).

5 Regional geology

5.1 Stratigraphy and lithology

Geologically, the area of interest falls within the Algoa Basin which is one of the complex grabens and half-graben structures along the present eastern and southern coast associated accumulations of Jurassic and Cretaceous deposits. These basins formed along the margins of the newly-formed African continent at the time of the break-up of Gondwana (Shone, 2006).

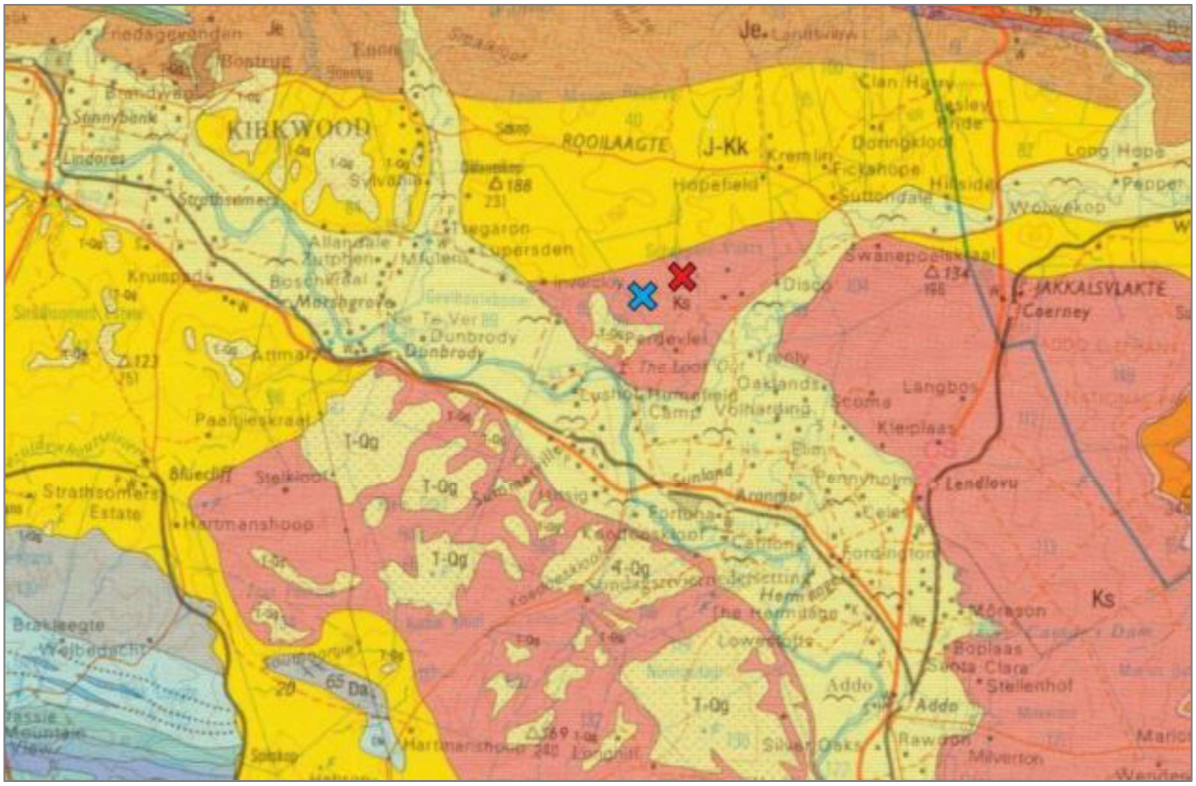
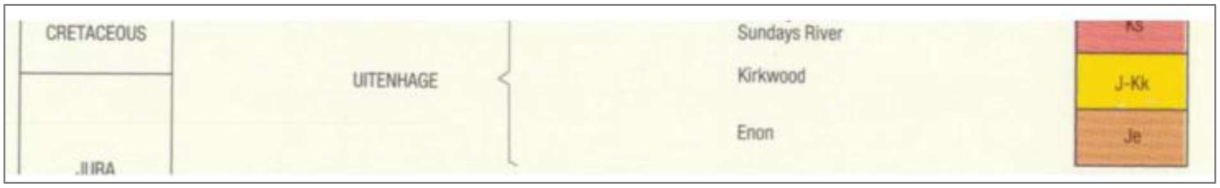


Figure 5.1: Excerpt of geological map (Sheet 3324)

The two site options are marked with crosses (blue = Upper Scheepersvlakte, red = Lower Coerney)



CRETACEOUS	UITENHAGE	Sundays River	Ks
		Kirkwood	J-Kk
JURA		Enon	Je

Figure 5.2: Geological explanation, excerpt from geological map

According to the 1:250 000 geological map (Port Elizabeth Sheet 3324, Council for Geoscience), the dam sites are both underlain by the strata of the Sunday River Formation, although in both instances the upper reaches of the respective basins are underlain by strata of the Kirkwood Formation. All are part of Uitenhage Group (**Figure 5.1**, **Figure 5.2**).

The older Kirkwood Formation consists of porous and permeable, coarse- to medium-grained, buff- and olive coloured lithic sandstone. Sandstone beds may be up to several metres thick and of variable lateral extent, interbedded with thick (often more than 30 m thick), red and greyish green siltstones and mudrocks.

The younger Sundays River Formation overlies and appears to grade laterally into the Kirkwood Formation. This Sundays River Formation consists of thin grey sandstones, siltstones and mudrocks. The sandstones are less porous and permeable than the older Kirkwood strata.

The oldest Enon Formation sediments of the Uitenhage Group are located to the north of the area of interest and do not impact directly on the discussion on the prevailing geological and geotechnical conditions of the respective sites. There is however an indirect impact, and this is dealt with at a later point.

5.2 Structural geology and seismic hazard

It is mentioned above that the Algoa basin is a half-graben structure. Such a basin is defined by faulting, in this case on the northern boundary, and the relative subsidence of the ‘fault-defined’ block (horst) in effect created the basin in which the sediments accumulated. The Algoa basin is known to be more complex than most, with diagonal faults cutting the horst block.

Several other prominent faults are recognised in the general area, including the Coega Fault which extends from west of the Groendal Dam to beyond the mouth of the Coega River. This fault has a vertical displacement in excess of 2000 m. these prominent NW to SE trending faults are as close as 35 - 40 km from the proposed balancing dam sites.

While the sediments within the Algoa Basin are not significantly deformed, and only display a nominal shallow dip towards the present coast, these basins are located within the Cape Fold Belt and the older Table Mountain Group strata are intensely folded. These shallow dips of approximately 10 degrees are seemingly confirmed by detailed mapping of the Scheepersvlakte Dam foundations.

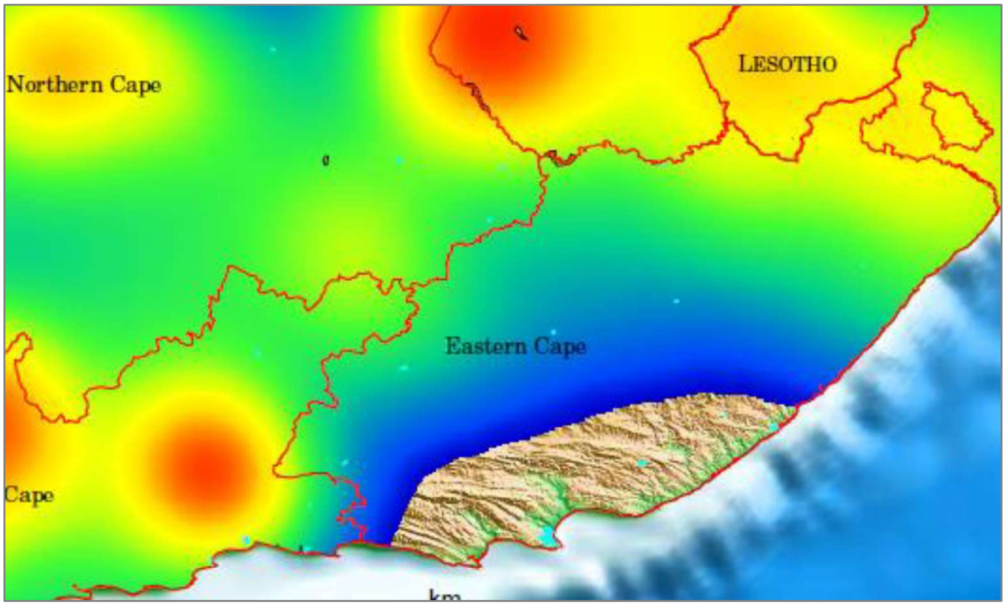


Figure 5.3: Excerpt of the seismic hazard map of South Africa (after Kijko et al, 2003)

Even though the very existence of the Algoa Basin is directly linked to faulting, and other regional-scale faults are also recognised, the seismic hazard of the area is considered to be very low. **Figure 5.3** is an excerpt of the seismic hazard map (after Kijko, et al, 2003) which shows the Peak Ground Acceleration (PGA) values of less than 0.02g, where these are with a 10% probability of being exceeded in a 50-year period.

5.3 Economic geology

There are no known reserves of economically important minerals within the respective dam basins. Within the general area economic activities relating to the geology would revolve around construction materials, including suitable rocks for processing of aggregates, as well as clays for brick-making. There are no such active commercial quarry sites within the Lower Coerney Dam basin.

5.4 Weathering and geomorphology

The area of interest lies to the east of Weinert's N = 5 line and it is estimated that the appropriate value is likely in the order of 3 to 3.5 (Port Elizabeth is at 2.6), as per Weinert, 1980. This indicates that chemical decomposition is the dominant mode of weathering. Typically, this would suggest deep residual soil profiles, but this is not a feature of the profiles encountered.

The higher-lying areas in the general area are also characterised by the formation of pedocretes associated with the African erosion surface; in this instance calcrete and ferricrete. On the respective dam sites, the calcrete formation was recognised, but was not developed to any significant degree. A harder capping of calcrete hardpan or ‘duricrust’ is noted on the higher-lying areas beyond the dam basin. Hardpan ferricrete was generally recognised north of the basin where it was encountered as very dense sometimes with calcrete concretions in patches.

There is no evidence of erosion and depositions being currently-active geological processes.

The evolution of the sedimentary basin, as well as periods of fluctuating sea levels have however complicated the geological sequence observed. The area extending between the current coast and the Zuurberge mountain range to the north of the dam sites representing a relatively level wave cut platform linked to a period of elevated sea level. Such wave erosion in the period roughly between 20 and 2 million years ago would have resulted in erosion of the older Enon Formation conglomerates at the foothills of the Zuurberge – and redistribution of these gravels in a ‘veneer’ across the coastal plain, while also concentrating these gravels in alluvial channels.

6 Investigation findings

6.1 Site description

The dam site is characterised by gentle, almost flat slopes; as is the greater basin. For the most part, the site is covered by very dense bush. As mentioned, this required cutting of traverse lines for the geophysical survey to proceed. Limited jeep tracks along farm boundaries also facilitated vehicle access (**Plate 6.1**), specifically downstream of the dam site, and traversing the left flank, and another traversing the basin area. With the exception of these tracks, the bush is generally impenetrable, although open areas were occasionally present. These open spots were targeted during the additional investigations in view of the ease of access for the excavator, and also considering the lesser impact on the natural bush.

For clarity, the description that follows includes the subdivision into respective flanks and river section. It is noted however that there is no clearly defined water course as such, and the concept of 'river section' refers more to the relatively flat area between the opposite flanks.

Plate 6-1 General panorama of Lower Coerney site, from the access track a short distance downstream of the centre-line (which is to the left)

6.2 Geological profile

6.2.1 Left flank, including spillway

Subsurface conditions on the left flank, inclusive of the spillway (**Plate 6.2**), have been investigated by geophysical traverses, test pits as well as boreholes, as shown on Drawing 112546-GEO-DRG-CC-001-B. The summarised findings are presented below in **Table 6-1** in the case of the test pits and **Table 6-2** for the boreholes. A longitudinal geological section has been compiled (drawings 112546-GEO-DRG-CC-002A-A and 112546-GEO-DRG-CC-002B-B).

It has been mentioned that the dense bush restricted access, and that this was then achieved chiefly via the narrow cleared intersect lines, and the track which traverses the left flank. The positions of the test pits, as well as the boreholes were partly governed by this access. The test pits were excavated across the left flank; extending from lower flank, to mid- and upper flank areas. A test pit was also excavated midway along the spillway alignment. Supplementary test pits were excavated at the end of the spillway in order to investigate likely founding conditions.

Table 6-1: Left flank test pits; summarised geological profile (depths in m)

TP no	Topsoil; silty to clayey sand, loose to medium dense, or dense	Colluvium; silty sand with gravels, medium dense to dense, or very dense	Colluvium, partly pedogenic; silty sand with calcrete / ferricrete nodules / near-hardpan, dense to very dense	Mixed origin; clayey silt, very stiff	Residual sandstone, very dense silty sand with sandstone gravel	Sandstone; moderately weathered, hard rock
LC09	0 – 0.4	0.4 – 0.85	0.85 – 1.2	1.2 – 2.4+		
LC11	0 – 0.3	0.3 – 0.5	0.5 – 1.95+			
LC06	0 – 0.2	0.2 – 0.5	0.5 – 1.65+			
LC08	0 – 0.3		0.3 – 1.5+			
LC10	0 – 0.3	0.3 – 0.7	0.7 – 1.6+			
TP104	0 – 0.4	0.4 - 1.3	1.3 – 2.3+			
TP125	0 – 0.5	0.5 – 2.2	2.2 – 4.9			4.9+
TP126	0 - 0.3	0.3 – 1.2	1.2 - 3.4			3.4+
TP103[1]	0.0 – 0.2	0.2 – 2.1			2.1 – 2.9+	

Notes [1]; *TP103 is technically within the river section but is duplicated in the above table to facilitate the discussions.*

Table 6-2: Left flank boreholes, summarised geological profile (depths in m)

BH no	Colluvium; slightly clayey, silty sand	Alluvium / mixed origin; gravels in sand matrix	Mudstone; highly to completely weathered, soft to very soft rock	Mudstone; unweathered, hard rock	Interbedded mudstone / sandstone; highly to moderately weathered, generally medium hard rock	Sandstone; highly (to completely) weathered, hard (soft / to sand) rock	Sandstone; moderately weathered, hard rock
LC BH02	0 – 2.65	2.65 – 7.7	7.7 – 9.75		9.75 – 14.15	15.15 – 19.33	19.33 – 20.45
LC BH03	0 – 1.28	1.28 – 4.05		15.16 – 20.43	4.05 - 12		12 – 15.16
LC BH05	0 - 4	4 – 7.2	7.2 – 10.03				
LC BH06	0 – 5.45	5.45 – 6.7				6.7 – 10.1	

Plate 6-2: General view of left flank conditions, looking here along the spillway alignment in a downstream direction

Boreholes were drilled at specific elements of the proposed dam layout; specifically, the lower flank areas to cover the intake / conduit outlet (boreholes LC BH02 and LC BH03, respectively), as well as the upper flank / crest coinciding with the spillway crest (borehole LC BH05). A further borehole was drilled roughly midway along the spillway chute (LC BH05)

The geophysics profiles confirm the flank is essentially a ‘conductor’, which would generally be consistent with weathered rock. The left flank, in particular is characterised by a ‘conductor’; a slight increase in resistivity is apparent with depth, but this is in a disjointed, irregular manner and the impression of horizontal layering is not readily apparent. The profile indicates a number of the lateral interruptions, which might indicate faulting. This resistivity profile is consistent for the traverse along the centre-line and also the traverse along the spillway alignment.

The various strata identified within the geological profile on the left flank are described in more detail below. For detailed description of the shallow soil strata, reliance is placed on the test pits, while for the deeper soil horizons and the underlying bedrock, the information is derived from the boreholes. The geological profile comprises;

- Topsoil,
- Colluvium,
- Colluvium that has been altered by pedogenic action,
- Alluvium or reworked terrace gravels,
- Bedrock, comprising variable combinations of mudstone, siltstone and sandstone.

The upmost **topsoil** horizon is described as dry, brown, medium dense occasionally loose or even dense, blocky or micro-blocky structure or even shattered occasionally, with occasional burrows or pinholes, otherwise intact silty sand. Roots are typically found. The thickness varies between 0.2 m and 0.5 m.

The general **colluvial material** is described as dry, reddish to orange brown, medium dense to dense, occasionally very dense, intact, slightly clayey, silty sand. In places this horizon might contain minor fine calcrete nodules as well as roots. Minor pinholes are recorded on occasion. In places a minor fraction of fine or medium, angular to sub-rounded gravels is recognised. Only if the presence of the pedogenic nodules is particularly minor is this material considered as 'colluvium'; should the pedocrete development be significant then these soils would be considered to be a 'pedocrete', as referred to below. Thickness varies between 0.2 m and 0.9 m but may be thicker, as encountered in TP125t where a thickness of 1.7 m was recorded.

A colluvial soil stratum with significant **pedocrete** development is identified. These materials comprise dry to slightly moist, dark to reddish brown or orange brown / orange, mottled whitish, intact, slightly clayey silty sand (i.e. as per the above colluvium), with scattered calcrete accretions that vary between powder calcrete to honeycomb calcrete, and calcrete nodules. In limited instances, the stratum contained both calcrete as well as ferricrete nodules. In test pit LC11 the ferruginised sand horizon approaches hardpan ferricrete and comprises very dense silty to sandy (gravel-sized) nodules. The overall consistency varies between dense and very dense. In places distinction can be made between an upper horizon of medium dense to dense consistency, with minor or macro pinholes, and a lower horizon described as dense to very dense. In one instance this stratum was noted to contain sub-rounded, medium gravels of hard rock quartzite. Horizon thickness varies between 0.9 m and 2.7 m.

Test pit LC10 on the extreme upper left flank and TP126 located by the end of the spillway chute terminated in calcrete-cemented and sandstone bedrock respectively, clayey, silty sand with loosely-packed, medium and coarse, sub-rounded quartzite gravels are encountered in these two locations. The boreholes, however, confirm this horizon to extend to all parts of the left flank. Although described as alluvium it is considered more likely to see this deposit as representing reworked terrace gravels. In places these gravels / cobbles appear more concentrated, i.e. comprising a higher proportion of coarse clasts and a relatively minor component of the finer matrix material. These concentrated coarser deposits might represent earlier river / stream channels. This gravel stratum is encountered at depths between 1.28 m and 5.45 m. The stratum thickness varies between 1.25 m and 5.05 m. Broadly this gravel layer is most well developed on the lower flank areas but is intersected at depth across the entire flank. This transported gravel horizon is directly underlain by bedrock.

A single occurrence (test pit LC09) was recorded where a lower soil horizon of **uncertain origin** (i.e. mixed origin) was noted at a depth between 1.2 m and 2.4 m, i.e. a minimum thickness of 1.2 m. This material comprises slightly moist, reddish brown, very stiff, intact clayey silt.

Test pits excavated at the end of the spillway on the lower left flank (TP125 and TP126) indicate the depth to bedrock, i.e. the rockhead, to be between 4.9 m and 3.4m, respectively. The boreholes indicated rockhead to be at depths varying between 4 m and 7.7 m. In essence, bedrock on the left flank can be expected between depths of 3.4 m and 7.7 m

Bedrock comprises a succession of sandstones and mudstones in varying proportions. Horizons of mudstone, or sandstone are recognised, as well as strata where the mudstones / sandstones are interbedded. The boundaries of these lithological changes have not been confirmed with absolute certainty; partly because the boreholes do not intersect all changes, but also due to the often-gradational nature of these variations. It is further expected that significant lateral variation will characterise the strata, and that the horizons are not necessarily laterally continuous. From the limited borehole intersections of traceable contacts, it would appear that the strata dip into the flank at shallow angles of 4° to 5°.

The bedrock is characterised by pervasive weathering, and as a rule the rock mass is weathered throughout.

Two boreholes (only one on the left flank) did however reveal unweathered rock at the base of the borehole. Borehole LC03 intersected unweathered mudstone at a depth of 15.16 m (approximate elevation 69 masl). The uppermost bedrock horizon either comprises mudstone or sandstone; characterised by a 'highly to completely' degree of weathering, to the extent that the rock is soft to very soft and in places is weathered to clay, or sand, depending on whether the rock is mudstone or sandstone. Generally, the profile is characterised by improving weathering with increasing depth; with a progressive change from highly / completely weathered rock at surface to moderately or even slightly weathered rock at the borehole termination depths. At these depths the rock is described as 'hard rock'.

It is worth noting that while the unweathered mudstones classify as hard rock, these rocks are known to be susceptible to slaking, and will therefore rapidly deteriorate upon exposure to the atmosphere. Such propensity to slake will also be experienced within predominantly sandstone horizons, but where interbedded mudstone strata are present.

The generally expected shallow dip of the strata is further borne out by the discontinuities, which reflect the common occurrence of shallow joints dipping at 0° to 10°. This discontinuity set is considered to represent the bedding. Other prominent joints include very steeply dipping / sub-vertical joints (80° to 90°), and less commonly, joints dipping at angles between 40° and 60°. At shallower depths within the bedrock, the rock mass is typically characterised by the interbeds, which have weathered to clay, or sand. Commonly, the drilling within these weak rocks is characterised by notable material losses; which are assumed linked to these weathered interbeds of clay / sand. Even if not lost ('washed'), the weathered interbeds are characteristically weaker than the surrounding material.

6.2.2 River section

The summarised geological profile within the river section, as revealed by test pits and boreholes, is presented in **Table 6-3** and **Table 6-4**, respectively. A measure of overlap is considered in these summary tables, hence the seeming repetition.

Table 6-3: River section, summarised test pit profiles (depths in metres)

TP no	Topsoil; loose to medium dense or dense, silty to medium sand	Colluvium; medium dense or dense, silty sand	Colluvium / partly pedogenic; loose to medium dense / dense	Gravels / cobbles in sand matrix, overall loose to medium dense / very dense; Mixed origin	Alluvium; very dense, silty clayey sand	Residual sandstone, very dense silty sand with sandstone gravel
LC02	0 – 0.3	0.3 – 1	1 – 1.95	1.95 – 2.75+		
LC03	0 – 0.3	0.3 – 1.15	2.05 – 2.4+	1.15 – 2.05		
LC04	0 – 0.3			0.3 – 0.9	0.9 – 1.35+	
LC05	0 – 0.3			0.3 – 2.25+		
LC12	0 – 0.2			0.2 – 2.35+		
TP102	0 – 0.4	0.4 – 1.8		1.8 – 2.8+		
TP103	0 – 0.2	0.2 – 2.1				2.1 – 2.9+

Table 6-4: River section, summarised borehole profiles (depths in metres)

BH no	Colluvium; slightly clayey, silty sand	Alluvium / mixed origin; gravels in sand matrix	Mudstone; highly to completely weathered, soft to very soft rock	Mudstone' slightly to moderately weathered, soft to medium hard rock	Mudstone; unweathered, hard rock	Interbedded mudstone / sandstone; highly to moderately weathered, generally medium hard rock	Sandstone; highly (to completely) weathered, hard (soft / to sand) rock	Sandstone; moderately weathered, hard rock
LC BH02	0 – 2.65	2.65 – 7.7	7.7 – 9.75			9.75 – 14.15	15.15 – 19.33	19.33 – 20.45
LC BH03	0 – 1.28	1.28 – 4.05			15.16 – 20.43	4.05 - 12		12 – 15.16
LC BH04	0 - 2	2 – 3.25		10.95 – 13.3	13.3 – 15.04+		3.25 – 7.5	7.5 – 10.95
LC BH01	0 – 0.8	0.8 – 2.7	4.55 – 10.94	13.1 – 15.01+			2.7 – 4.55 10.94 – 13.1	

The resistivity profile within the central section is characterised by a prominent resistant layer at surface, extending to an estimated depth of 5 m – 10 m. This horizon was considered to represent a measure of cementation within the upper soil horizon. Beneath this surface ‘resistor’ the profile is characterised by ‘conductors’. Further layering in this regard is not readily apparent, and these conductor values are consistent with weathered rock.

The geological profile within the central portion is characterised by the following strata;

- Topsoil,
- Colluvium,
- Colluvium that is altered by pedogenesis,
- Gravel soils, considered to be of mixed origin (reworked terrace gravels),
- Occasional / rare alluvial stratum,
- Residual soil derived from sandstone, and
- Bedrock

Plate 6-3: River section view, looking towards right flank (test pit LC03 in foreground)

The upper **topsoil** horizon covers the entire central section. The thickness varies between 0.2 m and 0.4 m. The topsoil comprises silty sand and at the time of the test pitting was typically described as dry, with consistency varying between very loose and medium dense. Occasionally the material is dense to very dense. Roots are generally present.

The underlying horizon of **colluvium** was intersected in test pits LC02, LC03 TP102 and TP103. The colluvial material comprises silty sand, or slightly clayey silty sand. The moisture content at the time was described as slightly moist, and the consistency as medium dense, dense and very dense. Pinholes were recognised in the structure. Roots are present. This colluvium is not present across the entire footprint in the river section and is likely patchy. Where present, the thickness varies between 0.7 m and 1.9 m.

Distinction is made between the colluvial material described above, and colluvium which is exhibits evidence of some **pedogenic** alteration. This material is also only evident in test pits LC02 and LC03 and is therefore not developed across the entire footprint. The material is described as slightly moist, reddish brown to light brown, loose to medium dense or dense, silty sand with ferricrete nodules or honeycomb calcrete with calcrete nodules. The thickness of this patchy horizon varies up to 0.9 m.

The stratum of **reworked terrace gravels** is recognised across the entire footprint except in TP103. These materials comprise a coarse fraction of gravels or cobbles of very hard rock quartzite with a matrix of silty to fine sand. The gravels are generally medium to coarse in size, and typically rounded or sub-rounded. The relative abundance of the coarse and fine fractions varies; in places the coarse fraction is tightly packed, i.e. clast-supported but in other strata the matrix dominates, i.e. matrix-supported, and characterised by occasional cobbles / gravels. The overall consistency varies between loose and medium dense or dense or very dense. Occasionally pinholes are recognised within the stratum. Horizon thickness typically varies between 0.6 m and 1.0 m but may be thicker; in the case of test pit LC12 the total thickness of this stratum is greater than 2 m. The boreholes confirm total thickness of this gravel stratum to vary between 1.25 m and 5 m. In the case of test pit LC12, two horizons are recognised; an upper horizon that is predominantly sand with occasional coarser fraction, and a lower horizon where the coarser fraction is dominant.

Sandy **alluvium** was recognised in only one place. Test pit LC04 intersected alluvial silty, clayey sand between depths between 0.9 m and 1.35 m. This sandy stratum was described as very dense.

The very dense silty sand with sandstone gravel material of **residual** origin, derived from the in-situ weathering of the sandstone bedrock, was only encountered in TP103 located at the end of the spillway chute. This material was encountered underlying the colluvium horizon. This stratum was encountered at 2.1 m depth with a minimum thickness of 0.8m to the end of hole at a depth of 2.9 m.

The deeper **bedrock** profile within the river section is mainly confirmed by borehole LC BH04, but other boreholes which confirm the lateral continuity of these horizons include LC BH01. Rockhead is intersected at depths between 2.7 m and 3.25 m (elevations of 80.66 and 78.57 masl, for boreholes LC BH01 and LC BH04, respectively). Test pit TP102 excavated as part of additional confirmatory investigations within the river section indicated bedrock at 2.8 m, which is between the depths of 2.7 m and 3.25 m as identified in the boreholes.

Plate 6-4: Bedrock encountered in TP102, at 2.8m depth

Bedrock comprises interbedded sandstone and mudstone horizons. In borehole LC BH01, drilled on the lower right flank, bedrock predominantly comprises mudstone strata with subordinate interbedded sandstone horizons. In LC BH04 the uppermost horizons, extending from the rockhead at a depth of 3.25 m (roughly 3 m as encountered in TP102) to a depth of 10,95 m, i.e. with a thickness of 7.7 m, the bedrock predominantly comprises sandstone with minor mudstone interbeds, while below 10.95 m depth the rock is predominantly mudstone but with minor sandstone interbeds.

The rock mass is characteristically highly weathered, improving with increasing depth, and unweathered mudstone is intersected at a depth of 13.3 m (LC BH04). Borehole LC BH01, in contrast, shows no improvement in weathering and the rock mass is highly weathered throughout – to a depth of at least 15 m. These weathered rocks generally comprise soft to medium hard rock. The uppermost strata may be very soft rock in places. In addition, certain strata tend to hard rock; typically, the sandstone horizons at depth where highly weathered. Where unweathered mudstone is intersected this also tends to hard rock in places.

It must be noted that the mudstones in particular are susceptible to slaking, i.e. will rapidly disintegrate upon exposure to the elements. This phenomenon will also affect the sandstone beds where interbedded mudstone lenses of laminations occur. Even rock that appears as hard rock will therefore disintegrate on exposure. This characteristic holds implications for foundation excavations and treatment and is discussed in more detail in Section 7.3.

Up to four discontinuity sets are recognised within the rock strata, although some horizons only see one or two sets. Shallow dipping (10°) discontinuities are ubiquitous and represent the bedding planes. Other common joint orientations include moderately steep joints (dipping 50° to 60°) and sub-vertical joints (80° to 90°). Joint surfaces are commonly smooth. Joint infill material is rarely recorded, and generally only staining of the surfaces might be noted. In terms of joint infill, however, it is pertinent to note the occurrence of horizons that are occasionally weathered to clay, particularly within the mudstone horizons. Also relevant are the material losses, particularly within the upper horizons, where these are ascribed to wash-out of very soft rock interbeds.

6.2.3 Right flank

During the initial investigations, the right flank investigations were limited due to dense bush. This meant most investigative points were on the lower right flank with an information gap on the upper flank. The addition of test pits TP101 and TP127 during the supplementary investigations was specifically to better understand the ground conditions of the upper right flank area. The geological profiles are summarised below in **Table 6-5** Error! Reference source not found. and **Table 6-6**. Nearby borehole and test pit profile summaries are included in these tables for greater clarity. The geological longitudinal section is presented in Drawing 112546-GEO-DRG-CC-002A-B.

Results from borehole LC BH01 have been incorporated into the above section on the geological profile in the river section (Section 6.2.2) but is also discussed here in the context of the right flank.

Table 6-5: Right flank, summarised test pit profiles (depths in metres)

TP no	Topsoil; loose to medium dense or dense, silty to medium sand	Colluvium; medium dense or very dense, silty sand	Colluvium / partly pedogenic; loose to medium dense / dense	Gravels / cobbles in sand matrix, overall loose to medium dense / very dense. Mixed origin	Alluvium; very dense, silty clayey sand	Residual sandstone, very dense silty sand with sandstone gravel	Sandstone; highly (to completely) weathered, hard (soft / to sand) rock
LC02	0 – 0.3	0.3 - 1	1 – 1.95	1.95 – 2.75+			
LC04	0 – 0.3			0.3 – 0.9	0.9 - 1.35+		
LC05	0 – 0.3			0.3 – 2.25+			
TP101	0 – 0.4	0.4 – 3.3		3.3 - 3.7		3.7 – 4.2+	
TP127				0 – 3.3			3.3 – 3.7+

Table 6-6: Right flank, summarised borehole profiles (depths in m)

BH no	Colluvium; slightly clayey, silty sand	Alluvium / mixed origin; gravels in sand matrix	Mudstone; highly to completely weathered, soft to very soft rock	Mudstone' slightly to moderately weathered, soft to medium hard rock	Mudstone; unweathered, hard rock	Interbedded mudstone / sandstone; highly to moderately weathered, generally medium hard rock	Sandstone; highly (to completely) weathered, hard (soft / to sand) rock	Sandstone; moderately weathered, hard rock
LC BH04	0 - 2	2 – 3.25		10.95 – 13.3	13.3 – 15.04+		3.25 – 7.5	7.5 – 10.95
LC BH01	0 – 0.8	0.8 – 2.7	4.55 – 10.94	13.1 – 15.01+			2.7 – 4.55 10.94 – 13.1	

The geological profile is characterised by the following horizons;

- Topsoil
- Colluvium
- Colluvium partly altered by pedogenesis
- Reworked terrace gravels,
- Residual sandstone, and
- Bedrock.

The upper **topsoil** horizon is generally expected to cover the entire flank with the exception of the upper right flank where it was not encountered in TP127. On the lower flank area this horizon is 0.3 m thick, gets to 0.4 m and absent towards the upper flank. The topsoil comprises dry, loose to medium dense and occasional very dense silty sand with minor rounded gravel. Roots are generally present.

The underlying horizon of **colluvial material** comprises silty sand. The moisture content at the time was described as slightly moist, and the consistency as medium dense to very dense. Pinholes were recognised in the structure. This horizon was only encountered in LC02 and TP101 test pits. Roots are present. Thickness varies between 0.7 m to 2.9 m.

An underlying **horizon of colluvium displaying some pedogenic** alteration occurs at depths between 1.0 m and 1.95 m. The material comprises slightly moist, reddish brown to light brown, loose to medium dense, silty sand with ferricrete nodules.

The stratum of **reworked terrace gravels** was intersected in all excavated test pits on the right flank, with depth varying between 1.95 m to 3.7 m at the base of test pit TP101. These gravel and cobbles are encountered as tightly packed in a silty sand matrix with the overall consistency ranging between dense to very dense. The borehole (LC BH01) indicates a thickness of 1.9 m.

Residual soil from sandstone was only encountered in TP101. This stratum was encountered on the upper flank as very dense, slightly ferruginised silty sand. This material was encountered beneath the colluvium horizon. This stratum was encountered at 3.7 m depth with minimum thickness of 0.5 m to the end of the hole.

Bedrock is intersected by borehole LC BH01 at a depth of 2.7 m (elevations 80.66 masl) and on test pit TP127 at a depth of 3.3 m. Bedrock comprises interbedded sandstone and mudstone horizons; predominantly mudstone strata with subordinate interbedded sandstone horizons.

The rock mass is characteristically completely to highly weathered, and shows no improvement in weathering**–** to a depth of at least 15 m. These weathered rocks generally comprise soft to medium hard rock. The uppermost strata may be very soft rock in places. In addition, certain strata tend to hard rock; typically, the sandstone horizons at depth where highly weathered.

It re-iterated that the mudstones in particular are susceptible to slaking, i.e. will rapidly disintegrate upon exposure to the elements. This phenomenon will also affect the sandstone beds where interbedded mudstone lenses of laminations occur. Even rock that appears as hard rock will therefore disintegrate on exposure. This characteristic holds implications for foundation excavations and treatment and is discussed in more detail in Section 7.3.

Generally, two or three discontinuity sets are recognised within the respective rock strata. Shallow dipping (0° - 10°) discontinuities are ubiquitous and represent the bedding planes. Other common joint orientations include moderately steep joints (dipping at 70°) and sub-vertical joints (80° to 90°). Joint surfaces are commonly smooth. Joint infill material is rarely recorded, and generally only staining of the surfaces might be noted. Horizons are recognised where the rock is weathered to clayey sand, or very soft rock in the case of the uppermost sandstone horizon.

6.2.4 Reservoir basin

Test pits were excavated within the reservoir area, primarily to confirm potential for sourcing suitable materials for embankment construction. During the initial investigations access was severely restricted and only three test pits were excavated (numbered LC20, LC22 and LC23), along a track that traverses the basin. The need for further investigations to expand on the knowledge base was however recognised, and to this end a 30-ton tracked excavator was procured for further investigation. The benefits of using an excavator included the ability to excavate deeper profiles as well as greater ease of access. A further important consideration is that this plant replicates the plant to be used during actual construction.

For these additional investigations, twenty further test pits were excavated within the basin, bringing the total to 23. These are numbered TP105 to TP124 as shown in Drawing 112546-GEO-DRG-CC-001-B.

Geological profiles within these test pits are summarised below (**Table 6-7**). The test pits excavated on the dam footprint are also relevant to the description of the soils to be encountered within the general reservoir, but reference is made to the descriptions in the sections above (Sections 6.2.1 to Section 6.2.3).

Table 6-7: Reservoir area, summarised geological test pit profiles (depths in m)

TP no	Topsoil; medium dense to dense, silty sand	Colluvium; dense to very dense, silty sand	Colluvium / partly pedogenic; dense / very dense silty sand, ferruginised, plus ferricrete and calcrete nodules to hardpan	Gravels / cobbles in sand matrix, Overall very dense to medium dense. Reworked terrace gravels	Mudstone; highly to completely weathered, soft to very soft rock	Sandstone; highly (to completely) weathered, hard (soft / to sand) rock
LC20	0 – 0.3		0.3 – 1.95	1.95+		
LC22	0 – 0.25	0.25 – 0.55		0.55 – 2.4+		
LC23	0 – 0.25			0.25 – 2.25+		
TP105	0 – 0.5	0.5 – 3.6				
TP106				0 – 1.6	1.6 – 3.1+	
TP107	0 – 0.3	0.3 – 1.6		1.6 – 2.3		2.3 – 2.9+
TP108	0 - 0.2	0.2 – 0.6	0.6 – 2.2	2.2 – 2.9		2.9 – 3.9+
TP109		0 - 0.7	0.7 – 4.1			
TP110		0 – 0.9		0.9 – 2.1	2.1 – 3.4+	
TP111		0 – 0.6	0.6 – 2.2	2.2 – 3.9+		
TP112	0 – 0.2		0.2 – 4.0+			
TP113	0 – 0.4		0.4 – 4.5+			
TP114	0 – 0.4	0.4 – 1.1		1.1 – 3.2	3.2 – 3.7+	
TP115	0 – 0.4		0.4 – 2.4	2.4 - 4.2+		
TP116	0 – 0.4		0.4 – 4.8+			
TP117	0 - 0.4	0.4 – 1.3		1.3 – 2.6	2.6 – 3.3+	
TP118	0 -0.2	0.2 – 1.2		1.2 – 3.1		3.1 -3.3+
TP119	0 – 0.2		0.2 – 2.2+			
TP120	0 - 0.4	0.4 – 0.8	0.8 – 2.6	2.6 – 3.4		3.4 – 3.7+
TP121	0 – 0.4	0.4 – 2.8		2.8 – 2.9+		
TP122	0 – 0.3	0.3 – 1.3	1.3 – 2.0+			
TP123	0 – 0.3		0.3 – 2.0	2.0 – 2.7+		
TP124	0 – 0.4			0.4 – 3.5		3.5 - 3.6+

The typical soil profile within the reservoir area comprises;

- Topsoil,

- Colluvium,
- Colluvium that is partly pedogenic,
- Reworked terrace gravels / gravelly soils of mixed origin, and
- Bedrock

The upper **topsoil** stratum varies in thickness between 0.2 m and 0.5 m. These soils are described as dry, brown, medium dense sometimes tending to dense, intact to blocky, silty sand. Roots, i.e. organic material, are typically present. Occasionally these soils are pinholed.

Colluvium is encountered on the flanks and in the river section within the reservoir footprint. It is encountered as dry to slightly moist, dense to very dense, silty sand with occasional gravel, sometimes slightly ferruginised and calcritised. Distinction is made between this colluvial material, and mixed colluvium and pedogenic material described below. Where encountered, this material varies in thickness between 0.3 m and at least 3.1 m within the basin.

Material of **mixed colluvial and pedogenic origin** is largely recognised on the left and right flanks within the basin, occasionally encountered within the river section. The northern section of the reservoir largely comprises of ferricrete nodules and hardpan where pedocretes are encountered, and the southern section largely encountering calcrete concretion and nodules. The material comprises slightly moist, dense to very dense, ferruginised or calcritised silty sand. In the northern section (i.e. test pit TP119 and TP122) the material was encountered as very dense to very soft rock, highly cemented into almost hardpan with pockets of grey gravel. Where present, refusal on the hardpan ferricrete was recorded at 2.2 m and 2.0 m respectively. This mixed colluvial / pedogenic material typically varies in thickness between 0.7 m and at least 3.4 m within the basin.

The horizon considered to represent **reworked terrace gravels** is developed across the basin except where the mixed colluvial and pedogenic material is well developed. Thickness varies between 0.7 m and at least 3.1 m. Essentially, this material comprises slightly clayey, silty sand (matrix) with a coarser fraction comprising sub-rounded to sub-angular gravels and cobbles (sandstone and mudstone gravel) and occasional boulders. The gravels and cobbles of this horizon are generally encountered as tightly packed and occasionally calcritised. The overall consistency is dense to very dense, and medium dense in horizons where the sandy matrix predominates.

Bedrock is intersected in some of the test pit pits excavated along the “river section” within the reservoir footprint i.e. TP106, TP107, TP110, TP114, TP117, TP120 and TP124. These strata comprise highly to completed weathered, very soft mudstone and sandstone. These strata are typically interbedded. Bedrock is encountered at variable depths between 1.6 m and 3.5 m.

6.3 Material properties

The annotation "LC" indicates test pits and hence laboratory test results from the initial investigations, with the "TP" indicating test pits and results from the recent supplementary investigations.

In terms of collating the results from both phases of investigation, the usual approach would simply be to consider all results together in a single sample pool. Interrogation of the laboratory data revealed some concerns regarding some test results and pooling the results would have led to skewing of the data. In the light of these apparent anomalies it was therefore decided to separate the results of the respective investigation phases. It is further worth noting that the supplementary investigations prescribed to a principle of testing of duplicate samples (approximately 10%) at an independent laboratory, specifically for quality assurance (QA) purposes. For sake of completeness, all results are included below but greater reliance should be placed on the results emanating from the supplementary investigations.

6.3.1 Foundation Indicator results

Foundation Indicator results, i.e. combined grading analyses including sieve and hydrometer analyses, as well as Atterberg constants, are summarised below in **Table 6-8** (for the initial investigation phase) and **Table 6-9** (for the supplementary investigations)

Table 6-8: Summarised Foundation Indicator results (initial investigations)

Test pit no	Depth (m)	Material type	Soil composition				GM	Atterberg limits			LS (%)	Activity	Unified Class.	AASHTO class.
			Clay (%)	Silt (%)	Sand (%)	Gravel (%)		LL (%)	PI (%)	WPI (%)				
Colluvium														
LC03	0.3 – 1.15	Colluvium	1	35	62	2	0.61	15	4	4	2.0	4.0	SC-SM	A – 4
LC03	0.3 – 2.05	Colluvium	0	41	58	1	0.56	15	3	3	1.5	-	SM	A – 4
Alluvium														
LC04	0.3 – 1.15	Alluvium	1	32	57	10	0.77	17	7	6	3.5	7.0	SC-SM	A – 2 – 4
LC05	1.3 - 2.75	Alluvium	0	8	39	53	2.11	49	20	6	10.0	-	GM	A – 2 – 7
LC07	0.9 – 2.0	Alluvium	0	51	49	0	0.38	25	11	11	5.5	-	CL	A – 6
Colluvium, partly pedogenic														
LC02	1.0 – 1.95	Colluvium + part pedogenic	0	63	36	1	0.3	21	7	7	3.5	-	CL	A – 4
LC06	0.5 – 1.65	Colluvium + part pedogenic	0	53	45	2	0.31	32	18	17	9.0	-	CL	A – 6

Test pit no	Depth (m)	Material type	Soil composition				GM	Atterberg limits			LS (%)	Activity	Unified Class.	AASHTO class.
			Clay (%)	Silt (%)	Sand (%)	Gravel (%)		LL (%)	PI (%)	WPI (%)				
LC08	0.5 – 1.5	Colluvium + part pedogenic	0	58	39	3	0.76	26	12	12	6.0	-	CL	A – 6
LC09	0.4 – 0.85	Colluvium + part pedogenic	0	57	43	0	0.21	37	19	19	9.5	-	CL	A – 6
LC09	0.85 – 1.2	Colluvium + part pedogenic	0	18	34	48	1.78	30	18	8	9.0	-	SC	A – 2 – 6
LC10	1.0 – 1.6	Colluvium + part pedogenic	0	62	36	2	0.31	29	15	14	7.5	-	CL	A – 6
LC11	0.5 – 1.5	Pedogenic	1	22	37	40	1.68	31	10	4	5.0	10.0	SC	A – 2 – 4
LC20	0.9 – 1.95	Pedogenic	0	64	32	4	0.33	39	20	18	10.0	-	CL	A – 6
Mixed origin (reworked terrace gravels)														
LC04	0.3 – 1.35	Terrace gravels	1	32	57	10	0.77	17	7	6	3.5	7.0	SC-SM	A – 2 – 4
LC05	0.3 – 1.3	Mixed Origin	0	30	67	3	0.77	15	5	4	2.5	-	SC-SM	A – 2 – 4
LC05	1.3 – 2.75	Terrace gravels	0	8	39	53	2.11	49	20	6	10.0	-	GM	A – 2 – 7
LC07	0.9 – 2.0	Terrace gravels	0	51	49	0	0.38	25	11	11	5.5	-	CL	A – 6
LC09	1.2 – 2.4	Mixed Origin	4	62	28	6	0.38	39	18	16	9.0	4.5	CL	A – 6
LC23	0.5 – 2.0	Terrace gravels	1	34	61	4	0.59	19	7	4	3.5	7.0	SC-SM	A – 2 – 4

Legend
GM = Grading modulus
LL = Liquid Limit
PI = Plasticity Index
WPI = Weighted Plasticity Index
LS = Linear Shrinkage
Activity = Activity of the soil according to Van der Merwe's 1964 method

Considering the above results from the initial investigations;

No samples of the **topsoil** were tested, as it was considered that the topsoil would be stripped from the footprint due to the organic content (i.e. presence of roots) and would not be a key element in construction.

Alluvial soils largely comprise variable soil types, i.e. silty sand, clayey sand, clayey silt and silty gravel. The sand fractions are approximately between 39% and 57%, silt fraction between 8% and 51%, with clay content almost negligible at 1% and the gravel content varying from zero to 53%. The liquid limit ranges from 17% to 49% which is low to moderate, weighted plasticity index low between 6% and 11% and linear shrinkage low between 3.5% and 10%.

The **colluvial** soils were primarily encountered as silty sand; with the sand fraction of approximately 60% and the silt fraction between 35% and 40%. Clay and gravel fractions are negligible; up to 1% and 2%, respectively. Due to the negligible clay fraction, the Liquid Limits

(LL) as well as the Plasticity Index (PI) values are very low (15%, and 3% to 4%, respectively). The very low PI values further result in identical Weighted PI[3] values on account of the high fraction passing 0.425 mm. These colluvial materials might therefore be considered to exhibit very low plasticity (almost non-plastic).

Where the **colluvial soils also are associated with evidence of pedogenic action**, these soils predominantly comprise sandy silt, where the dominant silt fraction is typically approximately 60% and the lesser sand fraction varies between 35% to 45%. The clay fraction is typically zero, and the gravel fraction is also negligible (only up to 3%). While generally consistent, these materials also exhibit some wide variability which is likely ascribed to variable pedocrete development. Some of these soils are gravelly (40% to 50%), with sand and silt fractions at 35 – 40%, and approximately 20%, respectively. The clay fraction is constant at zero. The Plasticity Indices (PI's) vary between 10% and 20%, i.e. may be considered moderate. Occasional lower values are recorded. Because of the variable gradings, the Weighted PI values show a wider spread; between 4% and 20%. The Liquid Limit values generally vary between 20% and 40% (indicating soils with low to intermediate plasticity), while the Linear Shrinkage values vary between 3.5% and 10%, i.e. low to moderate values.

The gravel soils are considered under the umbrella of '**reworked terrace gravels'** but these materials are not entirely uniform and significant variability is evident. Importantly only the finer fraction was submitted for testing, i.e. the coarse fraction comprising cobbles and boulders, as well as the gravels was not included in the test samples. The finer fraction of these soils generally comprises silty sand, where the sand fraction is between 50% and 70%, and the silt fraction is typically approximately 30% but occasionally as much as 50%. The clay fraction is commonly zero but might be up to 4%. In the context of the selective sampling the gravel fraction is not representative of the bulk sample but was recorded up to 40 – 50%. It has been stated previously that this stratum is, in any event, not uniform. Considering the Atterberg constants, the Liquid Limit varies between 15% and 50% illustrating low to intermediate plasticity, the Plasticity Index ranges between 5% and 20%, i.e. low to moderate values, and the Linear Shrinkage varies between 2.5% and 10%, also considered low to moderate.

It is worth noting that the earlier investigations were mainly focused around the dam footprint area and the spillway chute with little attention given to the general basin for reasons indicated in earlier chapters.

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[3] *A short note regarding PI versus Weighted PI; The Weighted Plasticity Index (WPI) is defined as the value of the plasticity index (PI) times the % passing the 425-micron sieve (0.425 mm sieve), i.e. the Weighted PI is representative of the PI for the whole sample.*

The recent supplementary investigation laboratory results indicate a slightly different picture to the earlier results, most notable are the clay contents which vary from 4 to 35%. These are summarised below in **Table 6-9**.

Table 6-9: Summarised Foundation Indicator results (supplementary investigation)

Test pit no	Depth (m)	Material type	Soil composition				GM	Atterberg limits			LS (%)	Activity	Unified Class.	AASHTO class.
			Clay (%)	Silt (%)	Sand (%)	Gravel (%)		LL (%)	PI (%)	WPI (%)				
Colluvium														
TP105	1.0 - 3.6	Colluvium	25	59	15	1	0.19	29	14	14	7.0	0.6	CL	A – 6
TP121	0.4 - 2.8	Colluvium	21	41	31	7	0.61	29	14	12	6.5	0.7	CL	A – 6
TP102	0.4 - 1.8	Colluvium	16	39	45	0	0.51	17	6	6	3.0	0.4	CL	A – 4
TP110	0.0 – 0.9	Colluvium	13	38	40	9	0.77	0	SP	0	1.5	0	CL	A – 6
TP118	0.2 – 1.2	Colluvium	6	65	29	0	0.35	22	9	8	4.0	1.5	CL	A – 4
TP122	0.3 – 1.3	Colluvium	17	60	23	0	0.24	19	7	7	3.5	0.4	CL	A – 4
Colluvium, partly pedogenic														
TP113	0.4 - 4.5	Colluvium + part pedogenic	16	55	24	5	0.40	32	16	15	8.5	1.0	CL	A – 6
TP120	0.8 - 2.6	Colluvium + part pedogenic	11	50	37	2	0.47	25	8	8	4.0	0.7	CL	A – 4
TP104	0.4 – 1.3	Colluvium + part pedogenic	26	44	21	9	0.54	42	17	14	8.0	0.7	CL	A - 7 - 6
TP104	1.3-2.3	Colluvium + part pedogenic	34	47	17	2	0.27	42	19	18	9.0	0.6	CL	A - 7 - 6
TP108	0.6 – 2.2	Pedogenic	4	44	27	25	1.19	34	13	8	6.5	3.3	SC	A – 6
TP109	0.7 – 4.1	Colluvium + part pedogenic	27	56	14	3	0.25	35	18	17	9.0	0.7	CL	A – 6
TP115	0.4 – 2.4	Colluvium + part pedogenic	14	66	17	3	0.3	33	17	16	8.0	1.2	CL	A – 6
TP116	0.4 – 4.8	Colluvium + part pedogenic	27	47	26	0	0.27	27	13	13	6.0	0.5	CL	A – 6
TP119	0.8 – 2.2	Pedogenic	16	59	24	1	0.28	26	10	10	5.0	0.6	CL	A – 4
Mixed origin (reworked terrace gravels)														
TP111	2.2 - 3.9	Terrace gravels	12	24	36	28	1.30	27	11	7	5.5	0.9	SC	A – 6
TP101	3.3 - 3.7	Terrace gravels	7	65	27	1	0.33	24	7	7	4.0	1.0	CL	A – 4
TP115	2.4 - 4.2	Terrace gravels	7	65	26	2	0.36	25	8	8	4.0	1.1	CL	A – 4
TP123	2.0 – 2.7	Terrace gravels	11	45	35	9	0.79	34	15	11	7.0	1.4	CL	A – 6
Weathered mudstone bedrock														
TP106	1.6 – 3.1	Mudstone	35	35	18	12	0.56	32	10	9	5.0	0.3	CL	A – 4
TP110	2.1 – 3.4	Mudstone	23	53	21	3	0.36	39	13	12	6.0	0.6	ML	A – 6
TP117	2.6 – 3.3	Mudstone	27	43	4	26	0.84	32	15	11	7.0	0.6	CL	A – 6

<u>Legend</u> GM = Grading modulus

LL = Liquid Limit
PI = Plasticity Index
WPI = Weighted Plasticity Index
LS = Linear Shrinkage
Activity = Activity of the soil according to Van der Merwe's 1964 method

Considering the above data from the supplementary investigation,

The **colluvial** soils were largely encountered as silty sand, clayey silt and sandy silt materials; the sand fraction is encountered between 15% and 45%, silt fraction between 38% and 65%, clay fraction between 6 and 25%, and the gravel content from negligible up to 9%. It is always worth noting that the coarser (gravel) fraction is not necessarily representative. Obviously larger pieces are removed from the samples when collected. The Liquid Limits (LL) range from zero to 29% and the Plasticity Index (PI) values ranging between slight plastic up to 14%. The Weighted Plasticity Index (WPI) values are from negligible up to 14%, with the Linear Shrinkage values very low between 1.5% and 7.0%. These colluvial materials are considered to exhibit low activity.

The **colluvial soils associated with pedocretes**, are predominately encountered as sandy silt and occasional clayey silt and gravelly silt, where the dominant silt fraction is typically between 44% and 63%, sand fraction varies between 14% and 37%, with clay ranging between 11% and 34% but occasionally as low as 4%, and the gravel content varies from negligible to 9% occasionally up to 25% where pedocrete development has been dominant. The Plasticity Indices (PI's) vary between 8% and 19%, i.e. may be considered moderate. The Weighted PI values show a similar spread to the PI values, encountered as moderate between 8 and 17%. The Liquid Limit values generally vary between 25% and 42% (indicating soils with low to intermediate plasticity), while the Linear Shrinkage values vary between 4% and 9%, i.e. low to moderate values.

The gravel soils representing '**reworked terrace gravels of mixed origin**' were not encountered to be entirely uniform. The testing was largely focused on the finer fraction, with gravel and cobbles not included in the samples. This finer fraction generally comprises silty sand and sandy silt, with the dominant silt fraction varying between 24% and 65%, sand fraction between 26% and 36%. The clay fraction varies from 7% up to 12%, and the gravel content between 1% and 28%. It should again be noted that the gravel fraction is not necessarily representative of the bulk sample for reasons stated above. The Liquid Limit varies between 24% and 34% illustrating intermediate plasticity, the Plasticity Index ranges between 7% and 15%, i.e. low to moderate values, and the Linear Shrinkage considered low with values varying between 4.0% and 7%.

The weathered **mudstone** bedrock was encountered along the "river section" within the basin during the latest supplementary investigations. When excavated, this material largely comprises clayey silt, with the dominant silt fraction encountered between 35% and 55%, clay fraction between 20% and 35%, sand content between 4% and 21%, and the gravel fraction between 3% and 26%. Note again the larger pieces were excluded and therefore this coarser fraction is not necessarily representative. The Liquid Limit values generally vary between 30% and 40% indicating soils with intermediate plasticity, with the Plasticity Index intermediate between 10% and 15%, while the Linear Shrinkage values vary between 5% and 7%.

6.3.2 Physical properties

Relative densities for selected samples are summarised below in **Table 6-10**. Moisture contents are summarised in **Table 6-11**.

Table 6-10: Summarised relative density values

Test pit	Material type	Depth (m)	Origin	Relative density
LC03	Silty sand	0.3 – 2.05	Colluvium	2.600
LC09	Sandy silt	0.4 – 0.85	Colluvium, part pedogenic	2.580
LC06	Sandy silt	0.5 – 1.65	Colluvium, part pedogenic	2.560
LC04	Silty sand with gravel	0.3 – 1.35	Terrace gravel	2.570
TP108	Sandy silt	0.6 – 2.2	Colluvium, part pedogenic	2.601
TP109	Clayey silt	0.7 – 4.1	Colluvium, part pedogenic	2.640
TP111	Silty sand	2.2 – 3.9	Terrace gravels	2.633
TP102	Sandy silt	0.4 – 1.8	Colluvium	2.632
TP105	Clayey silt	1.0 – 3.6	Colluvium	2.611
TP106	Clayey silt	1.6 – 3.1	Mudstone	2.669
TP116	Clayey silt	0.4 – 4.8	Colluvium, part pedogenic	2.652
TP117	Clayey silt	2.6 -3.3	Mudstone	2.679
TP119	Silty sand with gravel	0.8 – 2.2	Pedogenic	2.619
TP115	Sandy silt	0.4-2.4	Colluvium, part pedogenic	2.674
TP122	Sandy silt	0.3-1.3	Colluvium	2.682

Table 6-11: Summarised moisture content results

Test pit no	Material type	Depth (m)	Origin	Moisture Content
TP110	Silty sand	0.0 – 0.9	Colluvium	9.4
TP118	Sandy silt	0.2 – 1.2	Colluvium	7.6
TP105	Clayey silt	1.0 – 3.6	Colluvium	11.4
LC06	Sandy silt	0.5 – 1.65	Colluvium, part pedogenic	12.4

Test pit no	Material type	Depth (m)	Origin	Moisture Content
LC08	Sandy silt	0.5 – 1.5	Colluvium, part pedogenic	8.3
TP104	Sandy silt	0.4 – 1.3	Colluvium, part pedogenic	3.9
TP104	Sandy silt	1.3 – 2.3	Colluvium, part pedogenic	9.2
LC20	Sandy silt	0.9 – 1.95	Pedogenic	10.9
LC04	Silty sand with gravel	0.3 – 1.35	Terrace gravel	6.1
LC23	Silty sand	0.5 – 2.0	Terrace gravel	5.1
LC09	Sandy silt	1.2 – 2.4	Mixed Origin	17.3
TP101	Sandy silt	3.3 – 3.7	Terrace gravel	6.6
TP115	Sandy silt	2.4 – 4.2	Terrace gravel	9.0
TP123	Sandy silt	2.0 – 2.7	Terrace gravel	11.9
TP110	Clayey silt	2.1 – 3.4	Mudstone	13.6
TP111	Silty sand	2.2 – 3.9	Terrace gravels	6.1
TP113	Sandy silt	0.4 – 4.5	Colluvium, part pedogenic	8.7
TP120	Sandy silt	0.8 – 2.6	Colluvium, part pedogenic	6.8
TP121	Sandy silt	0.4 – 2.8	Colluvium	7.6
TP102	Sandy silt	0.4 – 1.8	Colluvium	4.6
TP106	Clayey silt	1.6 - 3.1	Mudstone	7.0
TP108	Sandy silt	0.6 – 2.2	Colluvium, part pedogenic	11.3
TP109	Clayey silt	0.7 – 4.1	Colluvium, part pedogenic	17
TP115	Sandy silt	0.4 – 2.4	Colluvium, part pedogenic	17.6
TP116	Clayey silt	0.4 -4.8	Colluvium, part pedogenic	8.9
TP117	Clayey silt	2.6 – 3.3	Mudstone	7.8
TP119	Silty sand with gravel	0.8 – 2.2	Pedogenic	8.2
TP122	Sandy silt	0.3 – 1.3	Colluvium	7.2

6.3.3 Compaction

Summarised Standard Proctor compaction results are presented in **Table 6-12**.

Table 6-12: Summarised Standard Proctor compaction results

Test pit no	Material	Depth (m)	Origin	Proctor density (kg/m^3)	o m c (%)
LC03	Silty sand	0.3 – 2.05	Colluvium	1857	11.1
TP102	Sandy silt	0.4 – 1.8	Colluvium	1990	10.6

Test pit no	Material	Depth (m)	Origin	Proctor density (kg/m^3)	o m c (%)
TP105	Clayey silt	1.0 – 3.6	Colluvium	1776	15.7
TP121	Sandy silt	0.4 – 2.8	Colluvium	1874	14.4
LC06	Sandy silt	0.5 – 1.65	Colluvium, part pedogenic	1676	18.9
LC08	Sandy silt	0.5 – 1.5	Colluvium, part pedogenic	1759	17.8
LC11	Silty sandy gravel	0.5 – 1.5	Pedogenic	1522	21.7
LC20	Sandy silt	0.9 – 1.95	Pedogenic	1739	22.6
TP108	Sandy silt	0.6 – 2.2	Colluvium, part pedogenic	1773	9.3
TP109	Clayey silt	0.7 – 4.1	Colluvium, part pedogenic	1786	16.3
TP113	Sandy silt	0.4 – 4.5	Colluvium, part pedogenic	1803	14.9
TP115	Sandy silt	0.4 – 2.4	Colluvium, part pedogenic	1870	13.2
TP116	Clayey silt	0.4 – 4.8	Colluvium, part pedogenic	1914	11.1
TP120	Sandy silt	0.8 – 2.6	Colluvium, part pedogenic	1872	14.3
LC09	Sandy silt	1.2 – 2.4	Terrace gravels	1617	23.8
LC23	Silty sand	0.5 – 2.0	Terrace gravels	1826	11.7
LC04	Silty sand with gravel	0.3 – 1.35	Terrace gravels	1868	12.7
TP111	Silty sand	2.2 – 3.9	Terrace gravels	1962	10.6
TP106	Clayey silt	1.6 – 3.1	Mudstone	1966	11.4
TP101	Sandy silt	3.3 - 3.7	Terrace gravels	1990	10.6
TP117	Clayey silt	2.6 - 3.3	Mudstone	1954	12.5
TP119	Silty sand with gravel	0.8 – 2.2	Pedogenic	1812	14.1
TP122	Sandy silt	0.3 – 1.3	Colluvium	1918	10.6

The **colluvium** horizon is characterised by a maximum dry density values (Standard Proctor compaction) in the range of 1776 to 1990 kg/m^3 with an optimum moisture content (omc) values between 10% and 16%.

Typically, the sandy silt and clayey silt of **colluvial / part pedogenic** origin exhibits maximum dry density (Standard Proctor compaction) values in the range of 1676 to 1914 kg/m^3, with optimum moisture contents (omc) between 9.3% and 18.9%. Where the **pedogenic material** is more variable and comprises silty, sandy gravel, the maximum dry density varies between 1522 and 1812 kg/m^3 with an optimum moisture content (omc) of 14% to 23%.

The fine fraction of the **reworked terrace gravels** possesses maximum dry density values in the range of 1617 to 1990 kg/m^3, with optimum moisture contents (omc) between 11% and 24%.

The fines of the excavated **mudstone bedrock** possess maximum dry density values in the range of 1954 to 1966 kg/m^3, with optimum moisture contents (omc) between 11% and 24%.

6.3.4 Shear strengths

Remoulded samples were subjected to slow drained, saturated shear box testing. The results are of significance for the stability of excavation faces and are summarised below in **Table 6-13**.

Table 6-13: Summarised drained slow shear box test results

Test pit no	Material type	Depth (m)	Origin	Maximum effective shear stress kPa	Apparent cohesion given by regression (kPa)	Apparent Friction Angle (°)	Moulded density (kg/m^3)
LC3	Silty sand	03 – 2.05	Colluvium	36.5		18.3	1676
LC3	Silty sand	0.3 – 1.15	Colluvium	38.1		19.2	1693
LC3	Silty sand	0.3 – 2.05	Colluvium	35.4		20.2	1704
LC4	Silty sand with gravels	0.3 – 1.35	Terrace gravels	43.2		26.4	1722
LC6	Sandy silt	0.5 – 1.65	Colluvium, part pedogenic	41.6		21.4	1570
LC8	Sandy silt	0.5 – 1.5	Colluvium, part pedogenic	40.9		24.7	1634
LC9	Sandy silt	1.2 – 2.4	Mixed origin	32.8		23.3	1509
LC11	Silty sandy gravel	0.5 – 1.5	Pedogenic	33.9		20.2	1434
LC20	Sandy silt	0.9 – 1.95	Pedogenic	35.7		24.8	1596
LC23	Silty sand	0.5 – 2.0	Terrace gravel	33.4		19.2	1682
TP102	Sandy silt	0.4 – 1.8	Colluvium		4.9	34	1891
TP106	Clayey silt	1.6 – 3.1	Mudstone		16.1	19.9	1868
TP109	Clayey silt	0.7 – 4.1	Colluvium, part pedogenic		16.9	24.4	1695
TP108	Sandy silt	0.6 - 2.2	Colluvium, part pedogenic		5.9	31.1	1684
TP115	Sandy silt	0.4 – 2.4	Colluvium, part pedogenic		20.1	30.3	1777
TP116	Clayey silt	0.4 – 4.8	Colluvium, part pedogenic		31.5	0.5	1817
TP117	Clayey silt	2.6 – 3.3	Mudstone		26.2	16.8	1856
TP119	Silty sand with gravel	0.8 – 2.2	Pedogenic		9.4	28.1	1721
TP122	Sandy silt	0.3 – 1.3	Colluvium		9.4	28.1	1821

The results indicate that the silty sand and sandy silt material of **colluvial origin** exhibit the values of cohesion of 4.9 kPa to 9.4 kPa, maximum effective shear stress of between 35 kPa to 38.1 kPa, and the angle of shearing resistance between 18 and 34 degrees.

The sandy silt, clayey silt and sandy gravel materials of the **colluvial / partly pedogenic** origin exhibit cohesion values between 5 kPa and 32 kPa, maximum effective shear stress between 33 kPa and 42 kPa, and the angle of shearing resistance between 0.5° and 31°.

The finer fraction of the **reworked terrace gravel or mixed origin gravel** comprises silty sand or sandy gravel material which exhibits maximum effective shear stress of between 32 kPa and 44 kPa, and the angle of shearing resistance between 19° and 27°.

The clayey silt excavated from the **mudstone** bedrock exhibits cohesion values of 16 kPa to 26 kPa, and angle of shearing resistance of 17° to 20°.

6.3.5 Permeability

The results of permeability tests on the remoulded soil samples are summarised below (**Table** 6-14). Results of water acceptance (Lugeon) tests conducted in the boreholes are presented elsewhere (Section 7.3).

Table 6-14: Summarised permeability test results

Test pit No	Material	Depth (m)	Material origin	Permeability (cm/s)
LC04	Clayey, silty sand	0.4 – 1.35	Alluvium	3.16 x 10^{-6}
LC03	Silty sand	0.3 – 2.05	Colluvium	1.84 x 10^{-5}
LC03	Silty sand	0.3 – 1.15	Colluvium	2.31 x 10^{-5}
LC06	Sandy silt	0.5 – 1.65	Colluvium, part pedogenic	4.11 x 10^{-7}
LC08	Sandy silt	0.5 – 1.5	Colluvium, part pedogenic	3.72 x 10^{-6}
LC11	Silty, sandy gravel	0.5 – 1.5	Pedogenic	1.88 x 10^{-6}
LC20	Sandy silt	0.9 – 1.95	Pedogenic	2.62 x 10^{-7}
TP102	Sandy silt	0.4 – 1.8	Colluvium	3.71 x 10^{-6}
TP106	Clayey silt	1.6 – 3.1	Mudstone	2.88 x 10^{-7}
TP108	Sandy silt	0.6 – 2.2	Colluvium, part pedogenic	3.48 x 10^{-6}
TP109	Clayey silt	0.7 – 4.1	Colluvium, part pedogenic	7.08 x 10^{-7}
TP115	Sandy silt	0.4 – 2.4	Colluvium, part pedogenic	6.40 x 10^{-7}
TP116	Clayey silt	0.4 – 4.8	Colluvium, part pedogenic	1.44 x 10^{-7}
TP117	Clayey silt	2.6 – 3.3	Mudstone	2.59 x 10^{-7}
TP119	Silty sand with	0.8 – 2.2	Pedogenic	6.07 x 10^{-7}

Test pit No	Material	Depth (m)	Material origin	Permeability (cm/s)
	gravel			
TP122	Sandy silt	0.3 – 1.3	Colluvium	5.75 x 10^{-7}

The clayey, silty sand of **alluvium origin** exhibits a permeability of 3.16 x 10^{-6} cm/s.

The silty sand and sandy silt of **colluvium** yielded permeabilities between 1.84 x 10^{-5} and 5.75 x 10^{-7} cm/s.

The **colluvium / part pedogenic** material is variable as encountered on site, and this is reflected in the permeability results. The materials are classified as clayey silt and sandy silt, with permeability measured between 7.08 x 10^{-7} and 1.88 x 10^{-6} cm/s.

The **mudstone**, which is of clayey silt material, exhibits a permeability of between 2.59 x 10^{-7} and 2.88 x 10^{-7} cm/s.

6.3.6 Dispersivity

Selected samples were subjected to a suite of tests to assess the dispersivity, including the Double Hydrometer, as well as the Pinhole Test and the Crumb Test. No single test is deemed entirely reliable in confirming the dispersivity of a soil, and for this reason a suite of tests is usually conducted.

For the supplementary investigations, the laboratory indicated challenges in outsourcing testing for the exchangeable sodium percentage (ESP) test. As such these are not presented in this report.

Results are summarised below in **Table 6-15**.

Table 6-15: Summarised dispersivity test results

Hole no	Material type	Depth (m)	Material origin	Double hydro-meter (%)	Pinhole test	Crumb test	Sodium Adsorption Ratio (SAR)	Extract-able Sodium Percentage (ESP)
LC03	Silty sand	0.3 – 2.05	Colluvium	40.13	ND3	Grade 2	7.22	9.63
LC03	Silty sand	0.3 – 1.15	Colluvium	35.97	ND3	Grade 2	6.71	9.01
LC06	Sandy silt	0.5 – 1.65	Colluvium, part pedogenic	43.26	ND2	Grade 3	6.92	9.26
LC04	Silty sand	0.3 – 1.35	Terrace gravels	48.3	ND2	Grade 2	5.92	8.03

Hole no	Material type	Depth (m)	Material origin	Double hydro-meter (%)	Pinhole test	Crumb test	Sodium Adsorption Ratio (SAR)	Extract-able Sodium Percentage (ESP)
TP105	Clayey silt	1.0 – 3.6	Colluvium	28.6	ND3 or ND4	Grade 1	-	-
TP111	Silty sand	2.2 – 3.9	Terrace gravels	18.5	ND3 or ND4	Grade 2	-	-
TP113	Sandy silt	0.4 – 4.5	Colluvium, part pedogenic	34.2	ND4	Grade 2	-	-
TP120	Sandy silt	0.8 – 2.6	Colluvium, part pedogenic	4.8	ND3 or ND4	Grade 1	-	-
TP121	Sandy silt	0.4 – 2.8	Colluvium	20.2	ND3 or ND4	Grade 2	-	-

For the double hydrometer, the percentage dispersion results for all materials vary between 5% and 50% which is considered non-dispersive to intermediate degree of dispersion (ASTM D4221, 2006).

The Pinhole Test results vary between ND2 to ND4 i.e. between slight dispersive and intermediate dispersivity (after Sherard, 1976).

The Crumb Test results alternated between Grade 1 and Grade 3, i.e. non-reaction and moderate reactions (after Emerson, 1964).

From the initial chemical test results, both the SAR (Sodium Adsorption Ration) as well as the ESP (Exchangeable Sodium Percentage) values indicate an ‘intermediate’ degree of dispersion, after Harmse (1980).

6.3.7 Rock material strengths

Opportunities for obtaining rock samples suitable for Uniaxial Compressive Strength (UCS) testing were extremely limited. Apart from the sample length requirements, which were at odds with the generally broken nature of the cores, the low strengths of these weak rocks were considered a major hurdle in sample preparation and the chances of the cores surviving the machining process were unlikely. As an alternative, selected core pieces were subjected to Point Load Strength (PLS) Testing. Furthermore, as a way around the limited number of samples, tests from both Lower Coerney as well as Upper Scheepersvlakte boreholes are considered jointly here. These results are presented below (**Table 6-16**).

The difficulties of obtaining accurate rock material strengths for very weak material are acknowledged, but from the above it is evident that the rocks are very weak. Assuming a typical conversion factor of 24 implies that these rocks have the equivalent uniaxial compressive strength values up to 1 MPa, and commonly less than 1 MPa.

Table 6-16: Summarised Point Load strengths

BH No	Depth (m)	Material description	Test type	$I_{s(50)}$ MPa
LC1	5.90	Sandstone, highly weathered, fine-grained	axial	0.01
LC2	10.04	Sandstone, highly weathered, coarse-grained	axial	0.05
LC4	6.38	Sandstone, highly weathered, coarse-grained	axial	0.01
US1	10.85	Sandstone, highly weathered, medium to fine-grained	diametral	0.06
US1	10.85	Sandstone, highly weathered, medium to fine grained	diametral	0.09
US5	2.83	Sandstone, highly weathered	axial	0.03
US4	8.74	Siltstone, highly weathered	diametral	0.03
US4	8.74	Siltstone, highly weathered	axial	0.07
LC2	12.92	Mudstone, unweathered	diametral	0.1
LC3	19.80	Mudstone, unweathered, carbonaceous	diametral	0.03
LC3	15.36	Mudstone, unweathered	diametral	0.03
LC3	19.80	Mudstone, unweathered, carbonaceous	axial	0.11
LC4	14.85	Mudstone, unweathered, carbonaceous	axial	0.09

6.4 Material properties for verification purposes

The results below are from the samples submitted to Labco laboratories as duplicate (10%) samples submitted to an independent laboratory primarily for QA purposes. As such it makes little sense to present this data together with the majority data as this would bias the mean values. The data is included below for record purposes but presented separately.

6.4.1 Foundation Indicator results

Foundation Indicator results are summarised below in **Table 6-17.**

Table 6-17: Summarised Foundation Indicator results (QA)

Test pit no	Depth (m)	Material type	Soil composition				GM	Atterberg limits			LS (%)	Activity	Unified Class.	AASHTO class.
			Clay (%)	Silt (%)	Sand (%)	Gravel (%)		LL (%)	PI (%)	WPI (%)				
Colluvium														
TP105	1.0 - 3.6	Colluvium	28	50	21	1	0.25	27	12	12	5.0	0.4	CL	A - 6
Colluvium, partly pedogenic														
TP108	0.6 - 2.2	Colluvium + part pedogenic	8	28	40	24	1.32	35	13	7	6.0	1.6	SC	A – 6

Test pit no	Depth (m)	Material type	Soil composition				GM	Atterberg limits			LS (%)	Activity	Unified Class.	AASHTO class.
			Clay (%)	Silt (%)	Sand (%)	Gravel (%)		LL (%)	PI (%)	WPI (%)				
TP109	0.7 – 4.1	Colluvium + part pedogenic	27	42	28	3	0.40	29	13	11	5.0	0.5	CL	A – 6
TP113	0.4 – 4.5	Colluvium + part pedogenic	20	48	29	3	0.39	26	11	11	5.0	0.6	CL	A – 6
TP119	0.8 – 2.2	Colluvium + part pedogenic	16	57	27	0	0.29	29	11	11	5.0	0.7	CL	A – 6
Mixed origin (reworked terrace gravels)														
TP115	2.4 – 4.2	Terrace gravels	7	15	31	47	1.85	20	8	3	3.5	1.1	SC	A – 2 – 4

Legend
GM = Grading modulus
LL = Liquid Limit
PI = Plasticity Index
WPI = Weighted Plasticity Index
LS = Linear Shrinkage
Activity = Activity of the soil according to Van der Merwe's 1964 method

The single sample of **colluvial** soil was encountered as sandy silt/ silty clay; with the clay fraction at 28%, silt fraction at 50%, sand fraction around 21% with the gravel content almost negligible at 1%. Due to the clay content, the Liquid Limit (LL) is moderate at 27%, Weighted Plasticity Index moderate at 12% and Linear Shrinkage low at 5.0%. These colluvial materials may be of low potential activity.

The **colluvial / pedogenic soils** comprise sandy silts and silty sand material, with the sand fraction between 27% and 40%, silt fraction ranging between 28% and 57%, clay fraction between 8% and 27% and the gravel content ranging from zero to 24%. The gravel content is quite variable, due to changes in ferricrete nodules content as ascribed to pedocrete development. The Liquid Limit (LL) is considered moderate and varies between 26% and 35%, Weighted Plasticity Index values low to moderate between 7% and 11%, and Linear Shrinkage varying between 5% and 6%. These soils may be considered as being of low potential activity.

Only a single sample of the gravel soils of '**reworked terrace gravels of mixed origin'** was submitted for QA testing. These soils generally comprise a coarse fraction i.e. gravel and cobbles, with silty sand fines as a matrix. The finer fraction comprises sand at 31%, gravel content at 47%, silt fraction at 15% and the clay fraction at 7%. The Liquid Limit (LL) is low at 20%, Weighted Plasticity Index low at 3%, and Linear Shrinkage low at 3.5%. These soils may be considered as of low potential activity.

The above QA results are essentially in agreement with and therefore validate the other majority results tested from Controlab.

6.4.2 Physical properties

Relative densities for selected samples are summarised below in **Table 6-18**. Moisture contents are summarised in **Table 6-19.**

Table 6-18: Summarised relative density values (QA)

Test pit	Material type	Depth (m)	Origin	Relative density
TP105	Silty sand	1.0 - 3.6	Colluvium	2.593
TP115	Silty sand	0.4 – 2.4	Colluvium, part pedogenic	2.552

Table 6-19: Summarised moisture content results (QA)

Test pit no	Material type	Depth (m)	Origin	Moisture Content
TP105	Silty sand	1.0 - 3.6	Colluvium	11.1
TP108	Silty sand	0.6 – 2.2	Colluvium, part pedogenic	13.2
TP115	Silty sand	0.4 – 2.4	Colluvium, part pedogenic	14.2

6.4.3 Compaction

Summarised Standard Proctor compaction results are presented in **Table 6-20.**

Table 6-20: Summarised Proctor compaction results (QA)

Test pit no	Material	Depth (m)	Origin	Proctor density (kg/m^3)	o m c (%)
TP105	Silty sand	1.0 - 3.6	Colluvium	1616	15.0
TP108	Silty sand	0.6 – 2.2	Colluvium, part pedogenic	1542	14.4
TP115	Silty sand	0.4 – 2.4	Colluvium, part pedogenic	1551	17.5

The **colluvium** horizon is characterised by a maximum dry density (Standard Proctor compaction) of 1616 kg/m^3 with an optimum moisture content (omc) of 15%.

The **colluvial / part pedogenic** origin soils exhibit maximum dry density values in the range of 1542 to 1551 kg/m^3, with optimum moisture contents (omc) between 14.4% and 17.5%.

6.4.4 Permeability

The results of permeability tests on the remoulded soil samples are summarised below (**Table** 6-21).

Table 6-21: Summarised permeability test results (QA)

Hole no	Material	Depth (m)	Material origin	Permeability (cm/s)
TP105	Silty sand	1.0 - 3.6	Colluvium	2.58×10^{-7}
TP115	Silty sand	0.4 – 2.4	Colluvium, part pedogenic	2.40×10^{-6}

The silty sand **colluvium** yielded a permeability of 2.58×10^{-7} cm/s and the **colluvium / part pedogenic** material yielded a permeability of 2.40×10^{-6} cm/s.

7 Geotechnical considerations

The nearby Scheepersvlakte Dam, completed in 1990, provides a view of the typical structure layout being considered for the Lower Coerney Dam. In addition, the conditions experienced and recorded in some detail, permit some parallels to be drawn for this Lower Coerney Dam site.

7.1 Site suitability and founding conditions

The site is characterised by gently sloping flanks and a relatively wide river section. Ignoring for a moment the founding conditions, this topography places certain limitations on the favoured structure. The biggest influence on the favoured structure type would however be the founding geology.

The key characteristics of these geological conditions that impact on the selection of the favoured dam type may be summarised as follows;

- Variable soil cover,
- In particular, the presence of mixed gravels in sandy matrix horizon at depth, across the entire footprint, as well as the reservoir area, and
- Weak bedrock comprising sandstones and mudstones, characterised by pervasive weathering.

The availability of suitable construction materials is a further important consideration; this is discussed in more detail below (Section 7.5 Construction materials), but is briefly referred to in this section. These topics are individually addressed below.

7.1.1 Topography

In terms of the topography, the ratio of crest length to the maximum height of the dam is a common consideration in dam type selection. For this Lower Coerney Dam site the ratio is roughly 30, which already points to an embankment dam.

7.1.2 Soil horizons

The cumulative thickness of the various soil strata varies between just less than 3 m to almost 8 m. Soil cover appears shallowest on the right flank, extending into the river section, while on the left flank soil thicknesses are generally between 7 m and 8 m. The soil thickness solely is therefore not reason alone to translate into selection of a specific structure. Of significance in terms of the soil strata, however, is the presence of a gravel horizon at depth. This horizon blankets the entire site, including dam and spillway footprint as well as the basin area, and has implications for the dam type and founding depths. Depths and thicknesses of this horizon beneath the dam footprint are summarised below (**Table 7-1**). The test pits are indicated with no elevation information as these points were not surveyed. A view of in situ conditions as exposed with a test pit is shown below in **Plate 7-1**.

Table 7-1: Gravel horizon beneath dam footprint, summarised depths and thickness (all metres)

BH no	Depth; upper boundary	Elevation (masl)	Depth; lower boundary	Elevation (masl)	Horizon thickness (m)	Comment
LC BH01	0.8	82.56	2.7	80.66	1.9	Lower right flank Coarser fraction comprises 20-40%; finer matrix not recovered
TP101	3.3	-	3.7	-	0.4	Upper right flank Mainly coarse fraction with silty sand matrix
TP127	0	-	3.3	-	3.3	Upper right flank Mainly coarse fraction with silty sand matrix
LC BH02	2.65	86.50	7.7	81.45	5.05	Lower left flank. Matrix typically lost, material recovery 40-90% therefore coarse fraction abundant
LC BH03	1.28	83.02	4.05	80.25	2.77	Lower left flank Matrix mostly lost, recoveries 20 – 100%; conclude variable coarse fraction
LC BH04	2	79.82	3.25	78.57	1.25	River section Matrix lost, recovery 30 – 50%
LC BH05	4	98.01	7.2	94.81	3.2	Upper left flank / spillway crest Coarse fraction a relatively minor component
LC BH06	5.45	84.53	6.7	83.28	1.25	Left flank, mid spillway chute Coarse fraction generally minor component but concentrated at base of horizon.

When initially encountered in some test pits this gravel horizon was considered to represent an alluvial palaeo-channel, i.e. representative of an earlier river course, subsequently buried by younger sediments. On later reflection, with due consideration of the geological history and landscape evolution, and following completion of all the boreholes, this gravel horizon is considered more likely to represent reworked terrace gravels, rather than purely a palaeo-channel. The horizon is however not uniform. In general, the gravels and occasional cobble fraction are relatively minor, typically loosely packed components, and the silty sand matrix is dominant. In some instances, however, this gravel horizon is more 'concentrated' with the coarser fraction, predominantly comprising gravels but also occasional cobbles and even rare boulders, is tightly packed, i.e. clast-supported. It is possible that within these lower elevations this concentration of the coarser fraction might be representative of palaeo-alluvial activity, i.e. at least partly represent palaeo-channels.

The significance of this stratum for the dam design is that these materials are potentially highly pervious, and in such cases would represent potential preferred seepage paths. This aspect, including the implications for excavation depths, as well as foundation treatment is discussed in more detail below.

Plate 7-1: The gravelly layer as exposed within a test pit (this view test pit LC22); the boundary indicated by the dotted line

Plate 7-2: Spoil from the same test pit, better illustrating the nature of the gravelly material.

7.1.3 Bedrock

As alluded to above, the soil horizons viewed in isolation do not represent the most decisive factor in determining the dam type. Considering the soil depths jointly with the bedrock conditions is however key in assessing the optimal dam type.

The gravelly horizon described above overlies the bedrock or in some instances the residual sandstone (bedrock) material. As described above, the bedrock comprises a sequence of interbedded sandstones and mudstones, including fine grained silty sandstones. The degree of interbedding is variable throughout the sequence; certain strata would be either entirely sandstone or mudstone, but other horizons are recognised that they are either predominantly sandstone, with relatively minor mudstone interbeds, or vice versa. Aside from the lithological differences, the degree of weathering, together with the nature of the jointing are key influences on the overall bedrock conditions and therefore suitability as founding horizon.

Generally, the bedrock is characterised by pervasive weathering. For the most part the strata are highly weathered, i.e. the effects of the weathering are evident throughout the rock mass.

Typically, where the uppermost rock strata mainly comprise mudstones these are classified as highly to completely weathered, and where the uppermost bedrock horizon comprises sandstone these strata are generally highly weathered, although a thin layer of highly to completely weathered material is also recognised. The significance of the 'completely weathered' horizons is that these are approaching a soil in terms of appearance and behaviour. As a result, these upper sandstone strata comprise medium hard to very soft rock where completely weathered; even to sand in some instances. The upper mudstone horizons would generally comprise soft rock to very soft rock. More importantly, in places, the weathering has produced clay layers that vary in thickness from as little as 40 mm to as much as 300 mm[4]. Where an improvement in degree of weathering was noted at depth it is possible to define the thickness of the highly weathered strata; varying between 4.25 m and 11.6 m. With the shallow boreholes on the left flank the base of the highly weathered horizon was not intersected, and even in borehole LC BH01 on the right flank the base was not recorded with the minimum thickness therefore 13.3 m. With only two exceptions where boreholes intersected unweathered rock at the base (boreholes LC BH03 and LC BH04, respectively), any observed improvement in the degree of weathering was only gradational – generally to 'moderate' weathering, or occasionally moderately to slightly weathered. In both the above cases, this unweathered rock comprised mudstone / carbonaceous mudstone, albeit with minor interbedded sandstone strata in LC BH04.

7.1.4 Suitable dam types

The impact of the above discussion on most suitable dam type may be summarised as follows;

- The flat topography favours an embankment dam.
- The soil cover on its own is not a limiting factor, but the underlying bedrock comprises weak rocks. No suitable founding for a mass concrete gravity structure would be defined within shallow depths. It follows that an embankment structure would be optimal in terms of the prevailing founding conditions.
- Although not discussed above (but elaborated on in Section 7.5), the availability of potential construction materials in proximity to the site dictates that an earthfill embankment is favoured, rather than a rockfill structure.

7.2 Excavation depths

The various elements of the envisaged embankment structure have different founding requirements, and these are discussed below. The key elements are listed as follows;

- The embankment, with the impervious core and the outer shell zones considered separately,
- The conduit, including intake and outlet,
- The spillway.

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[4] *Note these thicknesses are as recorded on the cores. These weak materials are however susceptible to being washed, i.e. lost, in the drilling process and the horizons thicknesses are not necessarily an accurate representation of actual in situ conditions.*

Typical foundation requirements for an earthfill embankment may be summarised as follows;

- For embankment outer shell zones,
  - A minimum required foundation Deformation Modulus of 0.2 GPa
- For the cut-off trench,
  - A minimum required foundation Deformation Modulus of 2 GPa
  - In addition, the cut-off would be founded on material that would be deemed groutable.

7.2.1 Embankment shell zones

For the embankment shell zones, it is reasonable to assume that foundation excavations will comprise removal of a nominal 300 mm to 500 mm, primarily to ensure the upper, potentially organic-rich, potentially compressible topsoil stratum is removed.

7.2.2 Embankment cut-off

For the cut-off trench, focusing entirely on the geotechnical profile and not considering the hydraulic requirements, the interpreted minimum excavation depths for the respective boreholes are summarised below (**Table 7-2**). The presence of the gravel-sand horizon within the soil profile is worth mentioning in terms of the decisions regarding depth of cut-off trench excavations. It is recognised that this horizon represents a potential pervious layer, albeit likely variably and that some areas might not be as pervious as others. This gravel-sand layer at its deepest is almost 8 m below surface, but in places only extends to depths of 3 m or 4 m. Such depths are not considered excessive, and special treatment is not considered necessary. Considering the potential seepage, and that the depths are not limiting, it is recommended that the cut-off extend, as a minimum, to the base of this gravel-sand layer.

Table 7-2: Summarised excavation depths for impervious cut-off trench

BH No	Excavation depth (m)	Elevation (masl)	Rockhead depth	Comments
Left flank				
LC BH05	7.2	94.81	7.2	The principle of founding beneath the gravel layer implies an excavation depth of 7.2 m. However, this borehole is located on extreme upper flank area and cut-off depths of 7+ m is perhaps excessive. A shallower cut-off (say 3.5 – 4 m) may be considered, but this would terminate the cut-off within this potentially pervious gravel stratum.
LC BH06	6.7	83.28	6.7	Borehole was drilled on spillway chute alignment but is considered here to be indicative of mid-left flank conditions. Founding beneath gravelly stratum would imply depths of almost 7 m.
LC BH02	7.8	81.35	7.7	Found at 7.8 m i.e. below gravel -sand stratum of reworked terrace gravels.
LC BH03	4.6	79.70	4.05	Found below gravel horizon. Remove uppermost bedrock horizon (thickness 0.55 m) to get beneath very soft rock horizon. Might consider founding immediately beneath gravel soils, but rather remove uppermost horizon of very soft / soft rock / occasionally weathered to sand.
River section				
LC BH04	5.5	76.32	3.25	Possible to found at a minimum depth of 3.5 m but sandstone comprises very soft / soft rock and minor core losses recorded. Preferably found at a depth of 5.5 m.
Right flank				
LC BH01	3.5	83.32	2,7	Found within the upper, highly weathered sandstone stratum, but notably beneath the uppermost highly to completely weathered, very soft rock.
TP101	3.7	-	-	Found below the gravel horizon. Remove all material to 3.7m depth and found on the very dense silty sand of residual sandstone origin
TP127	3.3	-	3.3	Found on the completely to highly weathered, fine grained, soft to medium hard rock. sandstone

Note that the geological conditions are evaluated in all boreholes on the assumption that the respective boreholes are representative of conditions for the embankment – even though the individual borehole might have been drilled for a different purpose or is offset from the centre-line. The two test pits excavated on the upper right flank are added and are in agreement with the borehole drilled on the lower right flank.

7.2.3 Intake and outlet works

In general, the outlet works would comprise an intake structure, outlet pipes within a concrete encasement, and an outlet structure. Boreholes LC BH02 and LC BH03 were drilled at the intake and outlet positions respectively, while the conditions in the central portion of the conduit may be extrapolated from borehole LC BH04. The geological profiles are described above (Sections 6.2.2 and 6.2.1). Implications for the founding of these structures are summarised below (**Table 7-3**).

Table 7-3: Summarised excavation depths for outlet works

BH No	Excavation depth (m)	Elevation (masl)	Thickness of gravel sand stratum (m)	Rockhead depth	Comments
LC BH02 (intake)	2.7	86.45	5.0	7.7	Founding on gravel -sand stratum of reworked terrace gravels. SPT N-value = 43 at depth 2.64 m
LC BH03 (outlet)	1.3	83.00	2.7	4.05	Found on gravel-sand horizon. No SPT test.
LC BH04	2.0	79.82	1.25	3.25	Found at 2 m depth on gravel sand stratum. SPT N-value 66 at depth 1.95 m.

A Standard Penetration Test (SPT) was conducted in borehole LC BH02, at a depth of 2.64 m, i.e. within the horizon of reworked terrace gravels. On the face of it the (single) result of N = 43 suggest dense soils, with an associated allowable bearing capacity of approximately 200 kPa. Another SPT test in borehole LC BH04 yielded an N-value of 66 at a depth of 1.95 m, similarly suggesting allowable bearing capacities in excess of 350 kPa. Some caution must be attached to blindly accepting these values, due to the presence of medium to coarse gravels within the tested horizon and the uncertainty whether the test results are truly representative or might reflect skewed data from interception of these boulders / gravels.

- A key element of founding of the outlet works (intake structure, conduit as well as outlet structure) would be the occurrence of highly variable conditions that might have implications in terms of foundation characteristics, notably the possibility of differential settlement. The reworked gravel-sand stratum is present over the entire footprint and in that sense the founding conditions might be considered relatively uniform, which would mitigate against the possibility of differential settlement. Note that the excavation depths (and founding levels) reflected above in

Table **7-3** do not consider inlet and outlet design levels or conduit design gradient. Such optimisation will be carried out in the design phase and will have implications for final excavation depths within this gravel-sand stratum.

7.2.4 Spillway

Only two boreholes (LC BH05 and LC BH06) provided confirmation of the deeper geological profile along the spillway alignment. Borehole LC BH05 is located at a position corresponding roughly with the spillway ogee, while borehole LC BH06 is located roughly midway along the chute. No borehole is located at the end of the spillway, but test pit LC12 was initially placed at the end and it exposed the upper soil profile. However, to fully understand the founding conditions at the end of the spillway, test pit TP103, TP125 and TP126 were excavated using the tracked excavator for greater depth ability, as indicated in drawing 112546-GEO-DRG-CC-001-B for the supplementary investigations.

It is assumed that the spillway ogee section will comprise a mass concrete, gravity structure. The spillway chute will have to be concrete-lined, as discussed below (Section 7.4).

The mass concrete gravity ogee spillway structure cannot be founded at depths shallower that 7.2 m, i.e. the structure cannot be founded on the soil horizons but must be founded on the underlying bedrock as a minimum. Bedrock was intersected at a depth of 7.2 m, and comprises very soft to soft rock, predominantly mudstone with subordinate sandstone. The borehole was terminated at 10 m, and the extent to which the bedrock condition improves with depth is uncertain. The uppermost bedrock horizon should also be removed prior to concrete placement, in order to remove the weakest material. It should be noted that the mudstone will be susceptible to slaking; Excavation and foundation preparation cycles will have to allow for near-immediate protection of the exposed rock surfaces, typically by casting of a blinding layer immediately following cleaning of the rock surface.

For the remainder of the chute, the same principle will be followed for determination of the founding depths; i.e. that the soil strata must be removed and that the concrete-lining be founded on the underlying bedrock. In places this bedrock will comprise mudstone, and in other areas the rock will be sandstone.

Founding conditions at the end of the spillway chute are of particular importance, as it is at this point where the concrete lining terminates, and the chute transitions to an unlined channel. Appropriate allowance is therefore required for energy dissipation, with the requirement for suitable founding as well as consideration of erodibility and the risk of undercutting of the lined section. Bedrock was encountered between 3.4 m and 4.9 m in test pits TP126 and TP125 respectively, at the end of the spillway. The bedrock was encountered as slightly weathered, hard rock sandstone. The test pit at the further end of the spillway (TP103) indicated residual sandstone to 2.9 m. It is assumed that at this position the bedrock might therefore be present at depths between 3 m and 5 m. The end of the spillway should be founded on the bedrock at depths of 3.5 - 5 m. It is assumed that the usual energy dissipation measures will be incorporated, and that the end of the chute will also include a cut-off to prevent headwards erosion.

7.3 Foundation permeability and foundation treatment

The chief concern regarding foundation permeability is linked to the presence of the gravel–sand horizon, which is known to be present across the entire dam footprint. If left ‘untreated’ there would be a risk of this stratum functioning as a ‘buried channel’ or preferential seepage path beneath the embankment. The consequences could then potentially be manifested in the form of uncontrolled seepage and the inability of the reservoir to fill and, in the worst case, internal erosion and failure.

Consideration of likely scenarios relating to seepage within the horizon of reworked terrace gravels has been addressed at a high level by GWA Consulting Hydrogeologists cc (see Appendices). This evaluation was also in the context of the potential for sub-surface seepage occurring in a northerly direction, that might be cut-off by the dam, and create future problems in terms of shallow water tables downstream of the dam. The key points of this evaluation can be summarised as follows;

- Groundwater hydraulic gradients are steep, with low permeability.
- The hydraulic gradients show sub-surface seepage in a southerly direction (downstream).
- With the filling of the reservoir it is expected that these gravels will become saturated over time. Actual flow rates are unconfirmed, but with the knowledge that these reworked terrace gravels are variable, it can be assumed that general seepage rates will be low, but zones of higher seepage flows cannot be excluded.
- With the dam cut-off extending through this gravel layer into the underlying bedrock, it can be assumed that the reservoir will not impact on the geo-hydrological regime downstream of the dam.

The indicated excavation depths for the cut-off (**Table 7-2**) have been defined on the basis of ensuring that this potential seepage path, represented by the gravel–sand stratum, is cut off.

Limited water pressure (packer) tests were carried out within the underlying bedrock to assess the rock permeability. These results are presented on the detailed borehole logs (Appendix B) and are summarised below (**Table 7-4**).

The results of the water acceptances tests in some boreholes indicate some significant losses. These instances are presumed to be associated with weathered zones within the rock mass that are typically associated with material losses. The occurrence of such losses is indicative of very weak material that is ground by the drilling action, and subsequently lost to the circulating drilling fluid. This assumed mechanism is supported by interpretation of the water acceptance test data; specifically, the relationship between the applied pressures and the measured water losses (after Houlsby, 1976). The significance of these losses lies in the possibility that they reflect the potential for erosion damage to the founding rock mass under conditions of seepage and high hydraulic gradients.

If the jointed founding rock mass was characterised by open joints with hard wall rock, for example, the foundation would be considered 'groutable', and foundation treatment comprising foundation grouting (compaction and/or curtain grouting) could be readily specified. In the case of these weathered, weak rocks, which evidently are susceptible to wash out, and are further characterised by interbedded mudstones, which in places are weathered to clays, the 'groutability' of the rock mass is more questionable.

Table 7-4: Summarised Water Acceptance (Packer) Test results

BH No	Test section (depths in m)	Lugeon (UL) value	Comment
LC BH02	7.5 – 10.97	64	Wash out. Weathered zones in mudrock likely origin
	11 – 13.97	12	Wash out. Ascribed to weathered zones which are associated with material losses
	14 – 16.97	0	Tight
	17 – 20.45	35	Turbulent flow. Prominent weathered zone in the sandstone that is associated with prominent staining, and therefore assumed to represent a seepage path.
LC BH03	4.5 – 7.65	0	Tight
	7.5 – 10.58	15	Wash out. No obvious link identified in the core logging.
	10.5 – 12.59	1	Dilation / tight
	12.5 – 13.36	0	Tight
	15.5 – 18.59	0	Tight
	18.5 – 20.43	0	Tight
LC BH04	4 – 7.78	0	Tight
	7.5 – 10.94	13	Wash out. Ascribed to local highly weathered zones, associated with significant material losses.
	11 – 13.94	0	Tight
	13.5 – 15.04	0	Tight

7.4 Erodibility

The question of erodibility of these weak rocks has specific bearing on the spillway chute. Two shallow boreholes were initially drilled to investigate the ground profile in this area on the left flank, namely boreholes LC BH05 and LC BH06. Three test pits have subsequently been excavated at the end of the spillway chute. i.e. TP103, TP125 and TP126. These were added to further investigate ground conditions at the end of the chute.

While steps for a detailed appraisal of the erodibility can be followed, some points of logic are pertinent;

- The soil horizons would offer no resistance to erosion and would clearly be washed away in the case of an earth channel. The silty to clayey sands extend to respective depths of 6.7 m and 7.2 m in the two boreholes and to 3.4 m and 4.9 m in test pit TP126 and TP125 respectively, with residual sandstone encountered between 2.1 m and 2.9 m in test pit TP103 located further into the 'river'. The basal soil stratum comprises the gravel-sand reworked terrace deposits and even this material is considered to be erodible.
- Within these boreholes the rockhead was intersected at these respective depths of 6.7 m and 7.2 m, between the ogee and approximately midway along the chute, and at depths of 3.4 m and 4.9 m in test pits at the end of the spillway chute.
- The upper bedrock horizon either comprises completely weathered, becoming highly weathered sandstone or interbedded sandstone / mudstone, or highly and occasionally completely weathered mudstone with subordinate sandstone. Irrespective of the lithology, the bedrock comprises weak rock. The mudstones in particular are considered susceptible to slaking.
- A rock mass exposed to the elements would therefore deteriorate over time as the mudstones, or mudstone interbeds, disintegrate (slake). Repetitive cycles of exposed rock disintegrating, and the resulting fine fraction being eroded means that any resistance to erosion is only temporary. The process would even affect a strong rock mass, and in the case of these already weak rocks, the slaking process would simply impact further on rock which is considered to be erodible.

From the above points, it is evident that an unlined spillway chute is not practical or feasible. A concrete lining of the entire length of the spillway chute is necessary in order to prevent erosion; as constructed for the Scheepersvlakte Dam.

Consideration will have to be given to enough energy-damping at the end of the concrete chute, at the point where the water will be released into the river channel.

7.5 Construction materials

It has been stated above (Section 7.1) that the availability of suitable construction materials in proximity to the dam site is a major factor in considering the most suitable structure. Considering that the prevailing conditions favour an embankment dam, the following materials would be required;

- Embankment fill materials, including general fill and impervious core materials,
- Rip-rap for upstream slope protection,
- Concrete aggregates, including coarse aggregate, as well as sand (fine aggregate), for the concrete elements, including the concrete spillway chute, spillway ogee, intake, conduit as well as outlet works.
- Sand for use in filters.
- Other materials that would be required would include materials for roads construction. This aspect is not addressed.

7.5.1 Embankment fill materials

The existing Scheepersvlakte Dam comprises a homogeneous earthfill structure, with various filters, as recorded in the Completion Report (DWA, 1988). The structure includes a cut-off trench, but there is no impervious core. The initial design envisaged a conventional zoned embankment with an impervious core, and shell zones of semi-pervious material. The shortage of semi-pervious material within the basin, however, led to a change in design to a homogeneous embankment.

The following earthfill specifications (**Table 7-5**) were stated in the design report for Scheepersvlakte Dam (DWA, 1988).

Table 7-5: Scheepersvlakte Dam, homogeneous earthfill specifications (DWA, 1988)

Grading analyses			
Sieve size	% passing		
	Maximum	**Minimum**	**Mean**
4.75	100	45.7	89.8
2.00	100	37.0	86.7
0.425	99.2	29.2	80.9
0.150	93.9	220	71.0
0.050	70.0	10.8	46.3
0.005	48.6	00	19.3
0.002	40.7	0.0	16.9
Atterberg limits			
	Maximum	**Minimum**	**Mean**
Liquid limit (%)	43.0	20.0	34.2
Plastic limit (%)	29.1	11.9	18.4
Plasticity Index	25.0	4.0	15.8
Linear shrinkage (%)	10.7	1.3	7.6
Compaction (Std Proctor)			
	Maximum	**Minimum**	**Mean**
Maximum dry density (kg/m^3)	1884	1542	1736

Optimum moisture content (%)	24.2	10.8	16.3
Direct shear			
	Maximum	**Minimum**	**Mean**
Angle of internal friction (°)	45.0	19.4	35.4
Cohesion (kPa)	153.3	9.29	18.8
Triaxial shear			
	Maximum	**Minimum**	**Mean**
Angle of internal friction (°)	44.8	23.6	31.7
Cohesion (kPa)	40.0	0.0	15.5
Coefficient of permeability (cm/sec)			
	Maximum	**Minimum**	**Mean**
	4.1 x 10^{-5}	1.6 x 10^{-8}	1.1 x 10^{-6}
Relative density			
	Maximum	**Minimum**	**Mean**
	2.75	2.50	2.65

The proximity of the Scheepersvlakte Dam to this proposed Lower Coerney site means that certain lessons learnt would be of value to construction of the Lower Coerney dam.

The material properties confirmed in these investigations are tabulated below and compared to typical requirements for the main elements of a zoned earthfill structure, i.e. the impervious core (**Table 7-6**) and the outer shell zones (**Table 7-7**), respectively.

It is worth noting that the material properties results (specifically Foundation Indicator results) used for this evaluation are mainly from the recent supplementary investigations. This has been done for two main reasons; firstly, because the initial results are not entirely compatible with the later supplementary results, and secondly in view of the later investigation focussing mainly on the basin as a possible materials source, and therefore more relevant.

Table 7-6: Summarised material properties and comparison against typical requirements (impervious core), after Badenhorst, 1988

Parameter	**Criteria**	**Material types**				
		Colluvium	**Colluvium / partly pedogenic**	**Pedogenic**	**Mixed origin (reworked terrace gravels)**	**Mudstone**
Grading	>60% passing 0.425 mm sieve	81 – 98% ((6))	85 – 99% ((7))	58 – 98% (2) ((1))	62 – 96% ((4))	72 – 91% ((3))
Clay %	10<%<30	6 to 25% (6) ((5))	11 to 34% ((7))	4 to 16% (2) ((1))	7 – 12 (4) ((2))	23 - 35% (3) ((2))
Liquid Limit %	30<LL<60	0 to 29% (6)	25 to 42% (7) ((5))	26 to 34% (2) ((1))	24 – 34 (4) ((1))	32 – 39% ((3))
Plasticity Index %	12<PI<35	SP to 14% (6) ((2))	8 to 19% (7) ((6))	10 to 13% (2) ((1))	7 – 15 (4) ((1))	10 – 15% (3) ((2))

Parameter	Criteria	Material types				
		Colluvium	Colluvium / partly pedogenic	Pedogenic	Mixed origin (reworked terrace gravels)	Mudstone
Linear Shrinkage %	4<LS<10	1.5 to 7.0% (6) ((4))	4 to 9.0% ((7))	5 to 6.5% ((2))	4 – 7% ((4))	5.0 – 7.0% ((3))
Maximum Dry Density kg/m^3	1450<MDD<1880	1776 – 1990 (5) ((3))	1676 – 1914 (8) ((7))	1522 – 1812 ((3))	1617 – 1990 (5) ((3))	1954 – 1966 (2)
Optimum moisture content omc %	14<omc<25	10.6 – 15.7 (5) ((2))	9.3 – 18.9 (8) ((6))	14.1 – 22.6 ((3))	10.6 – 23.8 (5) ((1))	11.4 – 12.4% (2)
Shear Strength kPa	12<kPa<24	35.4 to 38.1 (4)	40.9 to 41.6 (2)	33.9 to 35.7 (2)	33.4 – 43.2 (3)	
Friction angle	$18<\Phi^\circ<30$	18.3 to 34 (5) ((4))	0.5 to 31.1 (7) ((5))	20.2 to 24.8 ((2))	19.2 – 26.4 ((3))	19.9 to 26.2 ((2))
Permeability *k* cm/s	$<1 \times 10^{-4}$	1.84×10^{-5} to 5.75×10^{-7} ((2))	7.08×10^{-7} to 3.48×10^{-6} ((6))	6.07×10^{-7} to 1.88×10^{-6} ((3))		2.88×10^{-7} to 2.59×10^{-7} ((2))

Where numbers of total sample quantities are shown in single brackets, while double brackets in turn indicating a number of samples in compliance. Note also the stated maximum PI by Badenhorst (1988) is considered too high.

To facilitate easy comparison where material properties fall outside the broadly-stated objectives, the relevant cells in the above table (**Table 7-6**) have been shaded, with unshaded cells indicating compliant results and the shaded cells indicating results that falls outside compliance boundaries to a variable degree; pale shading indicates a minor discrepancy while darker shading indicates a greater non-compliance.

The values in double brackets within the cells indicate a number of sample results in compliance with the Badenhorst (1988) criteria; against the total number of samples tested (in single brackets).

The following comments summarise broad observations in respect of the suitability of the local materials for use in the impervious core;

- In terms of the material grading, the clay content largely complies with the above criteria with only a few scattered values falling either side of the target range between 10% and 30%. This applies across the spectrum of material types encountered. The percentages passing the 0.425 mm sieves are routinely greater than 60%, and therefore show general compliance. Only a few discrepancies were noted.
- Considering the Atterberg limits i.e. Liquid Limits, Plasticity Index, and Linear Shrinkage, the results again show scatter, reflecting some results falling outside the requirements,

specifically on the low side. The Liquid Limits and the Plasticity Indices (PI's) in particular are sometimes too low, i.e. lower than the stated minima of 30% and 12%, respectively. It must be noted, however, that there remain a large number of values that meet the stated criteria, and that occasional low values should not detract from the general compliance.

- The standard Proctor compaction results show general compliance. The reworked terrace gravel horizon does, however, record some anomalous values, where occasional samples yielded occasional dry density values that were too high, while the optimum moisture contents were too low.
- The shear strength data shows the materials all exhibit greater shear strengths than required, while the friction angles largely comply with the requirements (between 18° and 30°).
- The measured permeabilities all show relatively impervious materials, well within the range required (less than 10^{-4} cm/sec).

Special mention needs to be made of the 'mudstone'. Although bedrock, as opposed to the overlying transported soils, the mudrock in reality comprises soft rock to very soft rock and during excavation using the tracked excavator this material is generally recovered as clayey silt / silty clay with variable sand fraction as well as an occasional coarse fraction. The horizon therefore does not exhibit true rock material properties, and the laboratory testing was in effect conducted on the fine-grained soils. A further point here is that these materials are susceptible to slaking, and once exposed to the elements / excavated it is to be expected that further deterioration will occur – with the mudrock becoming ever-finer; eventually becoming a clay.

It is also pertinent to note lessons from construction of Scheepersvlakte Dam, notably in terms of the required moisture content (DWAF, 1992). As a result of the relatively high moisture requirements (for the homogeneous fill), coupled with the high clay content, construction difficulties were experienced. The high required optimum moisture contents also resulted in compaction problems.

Table 7-7: Summarised material properties and comparison against typical requirements for outer shell zones, i.e. semi-pervious zones (after Badenhorst, 1988)

Parameter	Criteria	Material types				
		Colluvium	Colluvium / partly pedogenic	Pedogenic	Mixed origin (reworked terrace gravels)	Mudstone
Grading	>40% passing 0.425 mm sieve	81 – 98% ((6))	85 – 99% ((7))	58 – 98% ((2))	62 – 96% ((4))	72 – 91% ((3))
Clay %	<10%	6 to 25% (6) ((1))	11 to 34% (7)	4 to 16% (2) ((1))	7 – 12 (4) ((2))	23 - 35% (3)

Parameter	Criteria	Material types				
		Colluvium	**Colluvium / partly pedogenic**	**Pedogenic**	**Mixed origin (reworked terrace gravels)**	**Mudstone**
Liquid Limit %	LL <30	0 to 29% ((6))	25 to 42% (7) ((3))	26 to 34% (2) ((1))	24 – 34 (4) ((3))	32 – 39% (3)
Plasticity Index %	4< PI<12.5	SP to 14% (6) ((3))	8 to 19% (7) ((4))	10 to 13% ((2))	7 – 15 (4) ((3))	10 – 15% (3) ((2))
Linear Shrinkage %	0<LS<7	1.5 to 7.0% ((6))	4 to 9.0% (7) ((2))	5 to 6.5% ((2))	4 – 7% ((4))	5.0 – 7.0% ((3))
Maximum Dry Density kg/m^3	1750<MDD<2100	1776 – 1990 ((5))	1676 – 1914 (8) ((7))	1522 – 1812 (3) ((1))	1617 – 1990 (5) ((4))	1954 – 1966 ((2))
Optimum moisture content omc %	6<omc<16	10.6 – 15.7 ((5))	9.3 – 18.9 (8) ((6))	14.1 – 22.6 (3) ((1))	10.6 – 23.8 (5) ((4))	11.4 – 12.4% ((2))
Shear Strength kPa	kPa<12	35.4 to 38.1 (4)	40.9 to 41.6 (2)	33.9 to 35.7 (2)	33.4 – 43.2 (3)	
Friction angle	28<Φ°<38	18.3 to 34 (5) ((2))	0.5 to 31.1 (7) ((5))	20.2 to 24.8 (2)	19.2 – 26.4 (3)	19.9 to 26.2 (2)
Permeability *k* cm/s	>1 x 10^{-4}	1.84 x 10^{-5} to 5.75 x 10^{-7} (2)	7.08 x 10^{-7} to 3.48 x 10^{-6} (6)	6.07 x 10^{-7} to 1.88 x 10^{-6} (3)		2.88 x 10^{-7} to 2.59 x 10^{-7} (2)

Where numbers of samples are shown in single brackets and double brackets indicating a number of samples in compliance with the criteria

As per the above table, the shading of the cells has been applied to highlight where the material properties are not fully compliant with the requirements for a typical outer shell zone with unshaded cells indicating compliant results and the shaded cells indicating results that fall outside the criteria, to variable degrees; with pale shading indicating a minor discrepancy while darker shading indicates a greater non-compliance. The values in double brackets indicate the number of compliant results, while the number in single brackets reflects the total number of samples tested for the particular horizon.

A broad summary of the general material suitability for use in the outer semi-pervious / shell zones can be presented as follows;

- The grading is all in complaint in that the fraction passing the 0.425 mm sieve is greater than 40%. The clay contents, however, are generally non-compliant across all materials encountered in the basin; being too high, i.e. generally above the maximum of 10%. At times these clay fractions are as much as 35%.
- The Atterberg limits results yielded scattered values, with a limited number of results falling outside the desired criteria. Some Liquid Limit values are as high as approximately 40%

which is significantly higher than the required 30% maximum. Several Plasticity Index values and some Linear Shrinkages are also encountered to be outside the acceptable range. The results from the clay / silt soils excavated from the mudstone bedrock can be excluded from this discussion.

- In terms of the compaction characteristics, the materials generally fall within the acceptable range for the maximum dry density, i.e. between 1750 and 2100 kg/m^3., however some fall on the low side of the acceptable range, particularly for the pedogenic and terrace gravel materials. Similarly, the optimum moisture contents (omc) show some scatter, and at time the values are too high (up to 24%) against the desired maximum of 16%.
- Shear strengths are generally very high, i.e. significantly greater than required, generally varying between 33kPa and more than 40kPa, against the required maximum of 12kPa. Friction angles are generally low, but there is some scatter and some values fall within the target range between 28° and 38°.
- Very low permeabilities were recorded, where no measured permeabilities satisfied the criteria for semi-pervious material, i.e. a permeability greater than 10^{-4} cm/sec. Recorded values varied between 10^{-5} and 10^{-7} cm/sec which speaks to the clay contents for the various materials which typically varied between 10% and 25%, although some anomalous values were also recorded.

In assessing the various material types available in the basin in terms of suitability for use as either impervious core material or semi-pervious shell material it is evident that the materials show wide scatter in their properties. No clear distinction can therefore be made between the various materials types in terms of their suitability for either impervious core material, or for semi-impervious shell material. In other words, the properties of the various material groupings do not permit clear definition of their suitability – and therefore clear delineation into different borrow areas for the respective material uses cannot sensibly be made.

On the other hand, if the properties of the various material types are evaluated in terms of the specifications for the homogeneous embankment constructed for Scheepersvlakte Dam (see Table 7-5) then the general compliance of the soils within this Lower Coerney basin is evident. Only limited values fall outside these specifications, specifically some Atterberg limits in the form of an occasional Liquid Limit, or some Plasticity Index values which are less than 12% and therefore slightly on the low side.

In view of no clear ability to delineate the basin materials into sources suitable for placing into either the impervious core, or the semi-pervious outer shells, and at the same time considering the almost total compliance of these basin materials with typical homogeneous embankment specifications, it is recommended that the Lower Coerney Dam be constructed as an homogeneous earthfill embankment rather than a zoned embankment.

7.5.2 Filter sands

Sands suitable for use in the various filter zones are not readily available in the general area of the proposed Lower Coerney site. This is also borne out by experiences during construction of the Scheepersvlakte embankment. No sources of natural sand for use in the filters could be identified. Initially, the manufactured crusher sand was used, but there were limitations due to the crusher being required to produce coarse aggregate. Subsequently, a number of options were explored whereby various sources of sands were mixed with crusher run from a number of commercial crushers. Such products were hauled from as far afield as Patterson, or the Uitenhage district, some 40 km away.

7.5.3 Coarse aggregate for concrete

The investigations did not actively target the proving of potential hard rock sources that might be crushed to produce coarse aggregate. Certainly, there are no expectations for such potential sources within the Lower Coerney basin. Even in the general area of the Lower Coerney site and the Lower Sundays River valley in general, the chances of identifying a suitable source of coarse aggregate are remote. The general geology comprises weak sandstones and mudstones or siltstones which are not associated with crushed aggregates. The volumes of concrete required would be quite limited, however, and it is most likely that coarse aggregate requirements would be met from commercial sources.

7.5.4 Possible commercial sources

A number of possible commercial sources for sand and coarse aggregates have been identified – but all are located some distances away from Lower Coerney site.

- The sand quarry (Potgieter Quarries) located in the Paterson area is one option. However, attempts to contact the quarry and identify the quantities and the materials they produce has proven to be impossible at this stage.

The closest identified possible commercial sources are located in the Uitenhage and Coega areas, located more than 60 km away from site. The following potential sources details are summarised below:

- Harbron Quarries is located in the Uitenhage area, approximately 50 km from site. This quarry manufactures all types of sand and stone products. The quarry is located at coordinates, i.e. 33°46'1.71"S, 25°21'38.92"E.

- Denver Afrimat Aggreates quarry is located about 70 km from Lower Coerney site, also in the Uitenhage area (coordinates: 34°54’8.15” S, 25°26’56.96” E). This quarry produces both sand and aggregates. Available sand products are plaster sand, crusher sand, super sand and filling sand. Stone products vary from 4.75 mm to 53 mm in size with G1 to G7 base and subbase material.
- The Glendore Sand and Stone produces sand and coarse aggregates from the Sonop sand quarry and Coega Kop quarry respectively. Sonop quarry is located about 75km from site (i.e. coordinates: 33°46’41.47”S, 25°42’29.27”E) and Coega Kop Quarry at about 65 km from site (i.e. coordinates: 33°46'19.64"S, 25°37'21.44"E). Sonop quarry manufactures a range of sand products from dune concrete sand, filling or bedding sand, building sand, sandpit sand etc. The Coega Kop quarry manufactures 13 mm and 19 mm concrete stones with G5 basecourse and subbase materials and gabion stones.

7.6 Stability of cut slopes

Construction activities will result in temporary cut slopes, for instance for the cut-off trench, but also for the intake, conduit and the outlet work, as well as for the spillway ogee and chute excavations. These excavated faces within the soil horizons might be as deep as 8 m.

The gravel–sand stratum of reworked terrace gravels is a concern in terms of the stability of cut slopes. Where the cut slopes intersect this horizon, there is a likelihood that ravelling, and spalling will occur within these gravel soils. This can result in undercutting of the overlying strata, and an associated risk of slope failure. The stability of these horizons will be further compromised when wet. Excavation within these gravels also carries the risk that removal of the coarser fraction can result in further disturbance of the stratum, and due care is called for in these instances.

All slopes must be cut to safe angles, and/or shored as appropriate; particular attention must be paid to the gravel–sand horizons as described above. It is essential that these safe slope angles for these cut faces be verified by a suitably qualified and experienced geotechnical practitioner.

7.7 Reservoir basin slope stability

The slopes defining the reservoir basin are characteristically very gently sloping. There are consequently no concerns regarding the possibility of catastrophic failure of the reservoir slopes to the extent of being a risk to the structure.

8 Conclusions and Recommendations

This report presents the findings of the ground investigations conducted at the Lower Coerney dam site. **Table 8-1** has been revised to include geotechnical considerations from the supplementary investigations:

Table 8-1: Summarised geotechnical factor for Lower Coerney Dam site

Geological factors	Lower Coerney
General geology	Underlain by strata of the Sundays River Formation, Uitenhage Group, comprising thin grey sandstones, siltstones and mudrocks.
Geological profile; dam footprint	***Left flank;*** (upper), soils to 7.2 m (including horizon of gravelly soils 4 m – 7,2 m); very soft rock mudstone, subordinate sandstone from 7.2m. ***Central section*** (conduit – intake and outlet) *Intake*; sandy soil to 2.65 m; gravelly soils to 7.7 m; soft to very soft rock (occasionally to clay) mudstone from 7.7 m; medium hard to hard rock interbedded mudstone / sandstone from 9.8 m. *Outlet*; sandy soil to 1.3m; gravel-sand horizon to 4 m; very soft to soft rock sandstone from 4 m; soft to medium hard rock sandstone interbedded mudstone from 4.6m; hard rock sandstone from 12 m. *Central section*; sandy soils to 2 m; gravelly horizon to 3.25 m; soft to very soft rock sandstone from 3.25 m; medium hard rock sandstone from 5.5 m; hard rock sandstone from 7.5 m; mudstones more prominent from 11 m. ***Right flank***; topsoil to 0.8 m; gravelly horizon to 2.7 m; highly weathered, medium hard to soft rock from 2.7 m. Interbedded sandstones, mudstones. The **upper right flank** comprises upper soils to 3.3 m and 4.2 m where bedrock is encountered
Founding considerations	A gravelly horizon (1.2 m to 5 m thick) is recognised which occurs across the footprint; considered to represent reworked terrace gravels. Note however the horizon is variable. Mostly the matrix was not recovered in the boreholes, but this stratum represents a potential preferred seepage path (a buried channel). Cut-off design is to consider this feature.
Excavation depths	For the **cut-off**, on the extreme / uppermost left flank, the principle of excavating to base of alluvial gravels implies a depth up to 7.2 m, maybe some relaxation allowed on extreme upper flank.; in central section assume minimum depth of 5.5 m but note some variability; on mid right flank consider minimum depth of 3.5 m (below gravel layer).
Foundation treatment	Mudrocks are susceptible to slaking; provision must be made for immediate protection after exposure. As above re presence of potential 'buried channel'; must ensure cut-off intersects this stratum. Permeability of rock mass is generally very low / tight, but instances of wash-out of softer strata are recorded. The 'groutability' of these weathered rocks is however uncertain. At face value the outlet conduit could likely be founded on the gravel-sand stratum, but this does not consider required founding levels.

Geological factors	Lower Coerney
Spillway; geological profile	Upper spillway (near ogee / sill); soils to 4 m; gravelly soil horizon to 7.2 m; very soft / soft rock (mainly mudstone, subordinate sandstone) from 7.2 m. Lower spillway (actually midway); soils to 5.45 m; gravelly soils to 6.7 m; very soft rock sandstone (sand in places) from 6.7 m; interbedded sandstone / mudstone from 8 m. End of spillway: bedrock encountered as slightly weathered hard rock sandstone is encountered between 3.4 m and 4.9 m.
Spillway considerations	Soils underlain by weak bedrock that would be susceptible to erosion. Assume full concrete lining is required. The appropriate energy dissipation must be incorporated at the end of the spillway lining, and measures must be incorporated to prevent undercutting of the concrete. The end of spillway should then be founded on the bedrock which should be encountered beyond 2.9 m depth, with all the upper horizons removed prior to placement of concrete
Reservoir slopes	Natural slopes are essentially flat / gently sloping; no slope stability issues foreseen.
Construction materials	No clear distinction can be made between the various materials types within the basin in terms of their suitability for either impervious core material, or for semi-impervious shell material. Clear delineation into different borrow areas for the respective material uses therefore cannot sensibly be made. However, these materials do exhibit almost total compliance with specifications for use in a homogeneous earthfill embankment, and it is therefore recommended that the Lower Coerney dam be constructed as a homogeneous earthfill embankment rather than a zoned embankment. Other materials like coarse aggregate for concrete and filter sands / fine aggregate will have to be imported.

The following should be borne in mind, together with consideration as stated in the above table:

- Involvement of a geotechnical specialist during construction is essential. Activities would include regular inspection of all excavated faces and cut slopes from a stability point of view, oversight of any further geotechnical exploration and quality assurance testing, confirmation of bedrock depth at the spillway end, engineering geological mapping of the cut-off trench and recording of the as-built details, etc.
- One of the first actions on establishing a contractor would be the controlled backfilling of all geotechnical investigation points (boreholes and test pits that are located on the dam footprint).

9 Report limitations

1. Aurecon Ground Engineering has prepared this report for the use of our Client, Department of Water and Sanitation (DWS). The report has not been prepared for use by parties other than the Client, and the Client's respective consulting advisors.
2. This report has been written with the express intent of providing sufficient information for Preliminary Design purposes. The geotechnical investigation has been conducted in accordance with accepted practice, and the opinions and conclusions expressed are made in good faith, based on the information available to the Ground Engineering team of Aurecon at the time of preparing this report.
3. There are always some variations in subsurface conditions across a site due to geological conditions that cannot be defined fully even by exhaustive investigation. Hence, it is possible that the measurements and values obtained during the investigation may not represent the extremes of conditions which exist within the site. The precision with which subsurface conditions are identified depends on the method of drilling, the frequency and recovery of samples, the method of sampling, and the uniformity of the subsurface conditions. Subsurface conditions may therefore vary from the conditions encountered in the test pit / borehole locations.
4. The borehole logs and test pit profiles represent the subsurface conditions at the specific test location only. Boundaries between zones on the logs are often not distinct, but rather are transitional and have been interpreted. The soil descriptions in this report are based on accepted methods of classification and identification employed in geotechnical practice, as stated in this report. Classification and identification of soil involves judgement, and the Aurecon Ground Engineering infers accuracy in the classification and identification methods to the extent that is common in current geotechnical practice, and within the limitations of the ground investigation that was performed.
5. Furthermore, subsurface conditions, including groundwater levels can change over time. The groundwater conditions described in this report refer only to those observed at the place and time of observation noted in the report. These conditions may vary seasonally or as a consequence of construction activities in the area. This should be borne in mind, particularly if the report is used after a protracted delay or a period of protracted climatic conditions.
6. Should conditions exposed at the site during subsequent investigation or construction works vary significantly from those provided in this report, we request that Aurecon (Tshwane) Ground Engineering be informed and have the opportunity to review any of the

findings or conclusions of this report. It is highly recommended that during construction the site conditions be inspected by a representative of Aurecon Ground Engineering to confirm the geotechnical conditions and interpretations as well as recommendations in this report.

Note: the above list of limitations should be considered a live document, subject to amendment over time. This serves to highlight specific limitations and risks to the Client. These listed limitations are not protection against substandard work.

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Appendix A:
Summary of soil and rock description terminology

STANDARD DESCRIPTIONS USED IN SOIL PROFILING

1. MOISTURE CONDITION

Term	Description
Dry	
Slightly moist	Requires addition of water to reach optimum moisture content for compaction
Moist	Near optimum content
Very Moist	Requires drying to attain optimum content
Wet	Fully saturated and generally below water table

2. COLOUR

The Predominant colours or colour combinations are described including secondary coloration described as banded, streaked, blotched, mottled, speckled or stained.

3. CONSISTENCY

3.1 Non-Cohesive Soils

Term	Description
Very Loose	Crumbles very easily when scraped with geological pick
Loose	Small resistance to penetration by sharp end of geological pick
Medium Dense	Considerable resistance to penetration by sharp end of geological pick
Dense	Very high resistance to penetration to sharp end of geological pick. Requires many blows of hand pick for excavation.
Very Dense	High resistance to repeated blows of geological pick. Requires power tools for excavation

3.2 Cohesive Soils

Term	Description
Very soft	Easily penetrated by thumb. Sharp end of pick can be pushed in 30 - 40mm. Easily moulded by fingers.
Soft	Pick head can easily be pushed into the shaft of handle. Moulded by fingers with some pressure.
Firm	Indented by thumb with effort. Sharp end of pick can be pushed in up to 10mm. Can just be penetrated with an ordinary spade.
Stiff	Penetrated by thumbnail. Slight indentation produced by pushing pick point into soil. Cannot be moulded by fingers. Requires hand pick for excavation.
Very Stiff	Indented by thumbnail. Slight indentation produced by blow of pick point. Requires power tools for excavation.

4. STRUCTURE

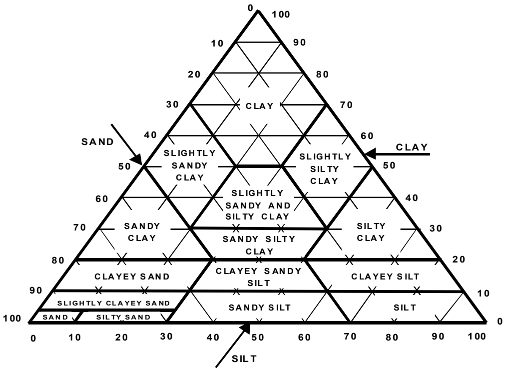
Term	Description
Intact	Absence of fissures or joints
Fissured	Presence of closed joints
Shattered	Presence of closely spaced air filled joints giving cubical fragments
Micro-shattered	Small scale shattering with shattered fragments the size of sand grains
Slickensided	Polished planar surfaces representing shear movement in soil
Bedded Folitated	Many residual soils show structures of parent rock.

5. SOIL TYPE

5.1 Particle Size

Term	Size (mm)
Boulder	>200
Pebbles	60 – 200
Gravel	60 – 2
Sand	2 – 0,06
Silt	0,06 – 0,002
Clay	<0,002

5.2 Soil Classification



6. ORIGIN

6.1 Transported Soils

Term	Agency of Transportation
Colluvium	Gravity deposits
Talus	Scree or coarse colluvium
Hillwash	Fine colluvium
Alluvial	River deposits
Aeolian	Wind deposits
Litoral	Beach deposits
Estuarine	Tidal – river deposits
Lacustine	Lake deposits

6.2 Residual soils

These are products of in-situ weathering of rocks and are described as e.g. Residual Shale

6.3 Pedocretes

Formed in transported and residual soils etc. calcrete, silcrete, manganocrete and ferricrete.

SUMMARY OF DESCRIPTIONS USED IN ROCK CORE LOGGING

1. WEATHERING

Term	Symbol	Diagnostic Features
Residual Soil	W5	Rock is discoloured and completely changed to a soil in which original rock fabric is completely destroyed. There is a large change in volume.
Completely Weathered	W5	Rock is discoloured and changed to a soil but original fabric is mainly preserved. There may be occasional small corestones.
Highly Weathered	W4	Rock is discoloured, discontinuities may be open and have discoloured surfaces, and the original fabric of the rock near the discontinuities may be altered; alternation penetrates deeply inwards, but corestones are still present.
Moderately Weathered	W3	Rock is discoloured, discontinuities may be open and will have discoloured surfaces with alteration starting to penetrate inwards, intact rock is noticeably weaker than the fresh rock.
Slightly Weathered	W2	Rock may be slightly discoloured, particularly adjacent to discontinuities, which may be open and will have slightly discoloured surfaces, the intact rock is not noticeably weaker than the fresh rock.
Unweathered	W1	Parent rock showing no discolouration, loss of strength or any other weathering effects.

2. HARDNESS

Classification	Field Test	Compressive Strength Range MPa
Very Soft Rock	Can be peeled with a knife. Material crumbles under firm blows with the sharp end of a geological pick.	1 to 3
Soft Rock	Can be scraped with a knife, indentation of 2 to 4 mm with firm blows of the pick point.	3 to 10
Medium Hard Rock	Cannot be scraped or peeled with a knife. Hand held specimen breaks with firm blows of the pick.	10 to 25
Hard Rock	Point load tests must be carried out in order to distinguish between these classifications	25 - 70
Very Hard Rock	These results may be verified by uniaxial compressive strength tests on selected samples.	70 - 200
Extremely Hard Rock		>200

3. COLOUR

The predominant colours or colour combination are described including secondary colouration described as banded, streaked, blotched, mottled, speckled or stained.

4. FABRIC

4.1 Grain Size

Term	Size (mm)
Very Coarse	>2,0
Coarse	0,6 – 2,0
Medium	0,2 – 0,6
Fine	0,06 – 0,2
Very Fine	< 0,06

4.2 Discontinuity Spacing

Description for: Bedding, foliation, laminations	Spacing (mm)	Descriptions for joints, faults, etc.
Very Thickly Bedded	> 2000	Very Widely
Thickly Bedded	600 – 2000	Widely
Medium Bedded	200 – 600	Medium
Thinly Bedded	20 – 200	Closely
Laminated	6 – 20	Very closely
Thinly Laminated	<6	

5. ROCK NAME

Classified in terms of origin:

IGNEOUS	Granite, Diorite, Gabbro, Syenite, Diabase, Dolerite, Trachyte, Andesite, Basalt.
METAMORPHIC	Slate, Quartzite, Gneiss, Schist,
SEDIMENTARY	Shale, Mudstone, Siltstone, Sandstone, Dolomite, Conglomerate, Tillite, Quartzite, Limestone.

6. STRATIGRAPHIC HORIZON

Identification of rock type in terms of stratigraphic horizons.

Appendix B:
Borehole logs

ABREVIATIONS
N/A not applicable
N/M not measureable
IT invalid test
NT no test

JOINT INFILL
Cl Clay
Slt Silt
Snd Sand
St Stained
Cn Clean

JOINT SPACING
VCJ very close spacing
CJ close spacing
MJ medium spacing
WJ wide spacing
VWJ very wide spacing

JOINT ROUGHNESS
S smooth
SR slightly rough
R rough

WEATHERING SHADING
BROWN soil
100% completely weathered
75% highly weathered
50% moderately weathered
25% slightly weathered
0% unweathered

aurecon

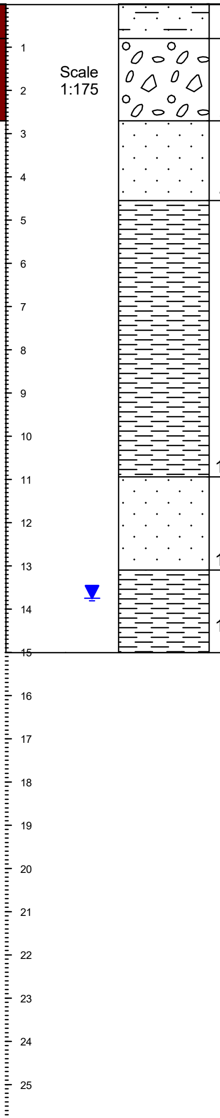
Lower Coerney

HOLE No: LC1
Sheet 1 of 1

Reduced Level	Depth	Joint Inclin. (deg)	Joint Spacing	Joint Rough-ness	Joint Infill	Weathering	Description
83.36	0.00	N/A	N/A	N/A	N/A	🟥	Brown to red-brown, slightly clayey silty sand. Colluvium.
82.56	0.80	N/A	N/A	N/A	N/A	🟥	Round / sub-round, medium to coarse gravel (10-50mm) of very hard rock quartzite. Alluvium. NOTE: 1. Matrix lost
80.66	2.70	10-20 70	CJ -	R/S R/S	weathered film weathered film	🟩	Light brown, highly weathered, closely jointed (60-200mm), medium hard rock sandstone. NOTE: 1. 2.7-3.35m has highly to completely weathered, very soft rock.
78.81	4.55	10-20 70	VCJ -	S S	- -	🟩	Light yellow-brown / grey / brown / purple-brown, highly weathered, very closely to closely jointed (<60-180mm), soft rock to medium hard rock, mainly mudstone also interbedded with fine silty sandstone (5-6.5m, 7.5-8m). NOTE: 1. In places completely weathered to clayey sand 2. Completely broken zone at 6.4-6.9m 3. Mudstone susceptible to slaking
72.42	10.94	0 30 90	VCJ MJ -	S S R/S	- - St	🟩	Light brown, highly weathered, very closely jointed (50-60mm), medium hard rock to hard rock sandstone. NOTE: 1. Hard rock = wall rock
70.26	13.10	0-10 30	VCJ -	S S	- -	🟩	Yellow to grey-brown, highly weathered, closely jointed (60-150mm), soft rock to medium hard rock / hard rock, mainly mudstone with subordinate interbedded sandstone 13.27-13.44m NOTE: 1. Also fine silty sandstone 2. Mudstone 14.5+m very broken
68.35	15.01						

Material Recovery %	Core Recovery %	RQD (%)
80	0	0
102	0	0
21	0	0
33	0	0
38	11	0
117	0	0
33	0	0
79	0	0
73	16	0
133	83	0
99	90	40
97	97	43
105	96	17
115	27	0
94	94	50
107	107	66
95	91	43
97	95	25
93	88	17
96	76	21

Frac Freq No / m
14
17
20
20
11
10
16
11
20
20
14
15



Reduced Level | Material Recovery % | Core Recovery % | RQD (%) | Frac Freq No / m | Joint Inclin. (deg) | Joint Spacing | Joint Rough-ness | Joint Infill | Weathering | Scale 1:175

<u>NOTES</u>:

Water level at 13.75m, as measured on 03 October 2018

Contractor: RWBE	**Logged by: Gary Davis**	**Elevation: 83.36**
Machine: D90 YWE	**Logged date: 4/10/2018**	**North: -58099.59**
Drilled by: Mothu	**Drilled date: -**	**East: 3702689.25**

ABREVIATIONS	
N/A	*not applicable*
N/M	*not measureable*
IT	*invalid test*
NT	*no test*

JOINT INFILL	
Cl	*Clay*
Slt	*Silt*
Snd	*Sand*
St	*Stained*
Cn	*Clean*

JOINT SPACING	
VCJ	*very close spacing*
CJ	*close spacing*
MJ	*medium spacing*
WJ	*wide spacing*
VWJ	*very wide spacing*

JOINT ROUGHNESS	
S	*smooth*
SR	*slightly rough*
R	*rough*

WEATHERING SHADING	
BROWN	*soil*
100%	*completely weathered*
75%	*highly weathered*
50%	*moderately weathered*
25%	*slightly weathered*
0%	*unweathered*

Lower Coerney

HOLE No: LC2

Sheet 1 of 1

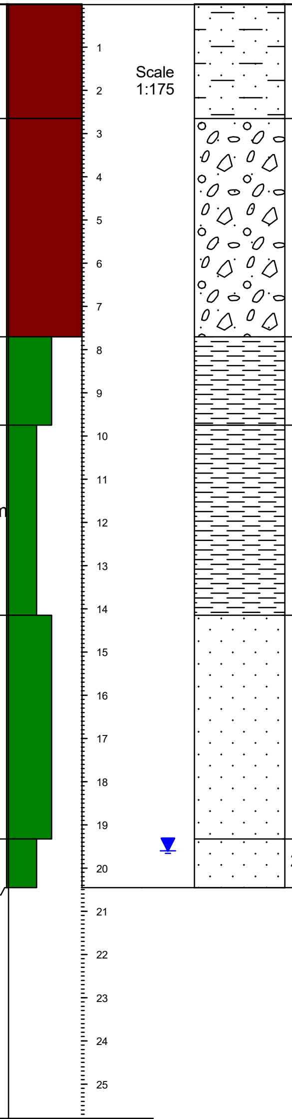
Material Recovery %	Core Recovery %	RQD (%)
87	0	0
82	0	0
98	0	0
71	0	0
89	0	0
108	0	0
96	0	0
43	14	0
70	0	0
95	0	0
83	0	0
39	0	0
43	0	0
65	18	0
76	47	22
71	41	31
98	92	25
103	43	0
95	93	49
102	98	77
72	59	0
86	84	64
97	97	80
91	87	68
96	96	75
108	108	79

Frac Freq No / m
12
13
12
11
11
15
7
7
2
11
11
6

SPT Test
43

Packer Test
NT
64
12
0
35

Joint Inclin. (deg)	Joint Spacing	Joint Rough-ness	Joint Infill
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
10 40	VCJ VCJ	R/S S	Cl -
10 50	VC-MJ VC-MJ	R/S S	St with film of Cl -
0-20 90	VCJ WJ	R R/S	St -
0-10 60	VCJ MJ	R/S R/S	- -



Reduced Level	Depth	Description
89.15	0.00	Pale reddish brown, slightly clayey silty sand. Colluvium.
86.50	2.65	Round to sub-round matrix supported, medium to coarse gravel (10-60mm) of very hard rock quartzite in matrix of silty to clayey sand. Alluvium. NOTE: 1. Matrix typically lost 2. 6.5-7.7m alluvial gravel cemented by hardpan calcrete
81.45	7.70	Yellow-brown (khaki) to grey-brown, highly to completely weathered, closely jointed (60-200mm), generally soft rock to very soft rock (but in places weathered to clay) mudstone. NOTE: 1. Weathered zones (to clay) 8.1-8.2m, 8.42-8.46m, 9.17-9.47m
79.40	9.75	Brown to dark grey, highly to moderately weathered, generally close to medium jointed (60-250mm) occasionally very closely jointed, generally medium hard rock to hard rock, but soft rock / very soft rock in places, interbedded mudstone / sandstone. NOTE: 1. Significant material loss, assumed 13.5m+ ascribed to completely weathered (clay) horizon 2. Mudstone beds at 11.0-11.28m, 11.45-11.68m, 12.5-14.0m
75.00	14.15	Brown, highly weathered, close to widely jointed (100-1000mm), hard rock, medium to coarse sandstone. NOTE: 1. Minor interbedded mudstone at 14.45-14.55m 2. Prominent weathered zone at 15.75-15.95m, joints prominently stained, possible seepage path
69.82	19.33	Grey to brown, moderately weathered, close to medium jointed (100-550mm), hard rock, fine to medium sandstone, laminated in places. NOTE: 1. With pieces of charcoal 2. Laminations = planes of weakness - also susceptible to slaking
68.70	20.45	

NOTES:

Water level at 19.60m, as measured on 03 October 2018

Contractor: RWBE	**Logged by: Gary Davis**	**Elevation: 89.15**
Machine: D90 YWE	**Logged date: 4/10/2018**	**North: -58215.9**
Drilled by: Mothu	**Drilled date: -**	**East: 3702532.15**

ABBREVIATIONS	
N/A	not applicable
N/M	not measureable
IT	invalid test
NT	no test

JOINT INFILL	
Cl	Clay
Slt	Silt
Snd	Sand
St	Stained
Cn	Clean

JOINT SPACING	
VCJ	very close spacing
CJ	close spacing
MJ	medium spacing
WJ	wide spacing
VWJ	very wide spacing

JOINT ROUGHNESS	
S	smooth
SR	slightly rough
R	rough

WEATHERING SHADING	
BROWN	soil
100%	completely weathered
75%	highly weathered
50%	moderately weathered
25%	slightly weathered
0%	unweathered

aurecon

Lower Coerney

HOLE No: LC3

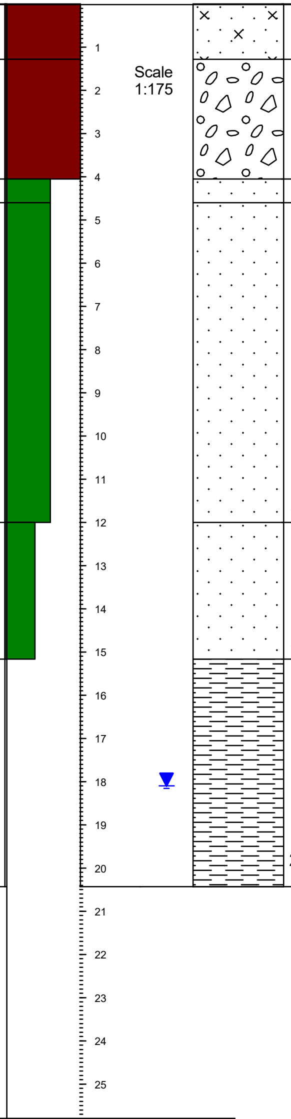
Sheet 1 of 1

Reduced Level	Depth	Joint Inclin. (deg)	Joint Spacing	Joint Rough-ness	Joint Infill	Description
84.30	0.00					
83.02	1.28	N/A	N/A	N/A	N/A	Orange-brown, silty sand. Colluvium.
80.25	4.05	N/A	N/A	N/A	N/A	Orange-brown, silty to slightly clayey sand (matrix) with medium to coarse (1-6cm) gravel, round to sub-round, very hard rock quartzite. Alluvium. NOTE: 1. Matrix mostly lost
79.70	4.60	10	VCJ	S	W	Yellow to grey-brown, highly to completely weathered, very closely jointed (up to 60mm), very soft rock to soft rock sandstone with subordinate mudstone. Occasionally weathered to sand.
72.30	12.00	0-10 80	VC-CJ -	S R/S	W, St St	Brown to grey-brown, highly weathered (moderately weathered zone at 6.9-7.7m), very closely to closely jointed (<60-200mm), soft rock to medium hard rock (to 6m) then medium hard rock (hard rock where moderately weathered and medium hard rock to soft rock in mudstone), mainly sandstone with interbedded mudstone. NOTE: 1. Mudstone to muddy siltstone at 4.6-4.8m, 4.9-5.1m, 9.1-10.0m
69.14	15.16	0-10	VC-WJ	S	-	Mainly grey to brown, moderately weathered to unweathered, closely to medium jointed (150-500mm), hard rock, mainly sandstone. NOTE: 1. From 14m, laminations of mudstone becoming more common, weakness - susceptible to slaking, some poor zones.
63.87	20.43	0-10	MJ	S	-	Dark grey, unweathered, medium to widely jointed (but note susceptible to slaking/disintegration), hard rock mudstone / carbonaceous mudstone. NOTE: 1. Varying susceptibility to slaking (particularly susceptible at 15.9-17.8m; 18.95-19.05m). Some zones of complete disintegration.

Material Recovery %	Core Recovery %	RQD (%)
100	0	0
100	0	0
85	0	0
66	0	0
33	0	0
155	0	0
67	0	0
100	0	0
18	0	0
45	0	0
100	12	0
100	86	0
99	94	30
100	100	33
76	76	41
91	88	7
15	15	0
108	95	0
75	75	65
125	125	123
85	82	41
93	81	54
97	66	34
93	93	88
63	57	38
259	259	212

Frac Freq No / m
15
15
20
14
7
20
11
13
3
8
11
6
12
8
3
4

Packer Test
NT
0
15
1
0



NOTES:

Water level at 18.10m, as measured on 03 October 2018

Contractor: RWBE	**Logged by: Gary Davis**	**Elevation: 84.3**
Machine: D90 YWE	**Logged date: 4/10/2018**	**North: -58252.35**
Drilled by: Mothu	**Drilled date: -**	**East: 3702625.65**

ABREVIATIONS
N/A not applicable
N/M not measureable
IT invalid test
NT no test

JOINT INFILL
Cl Clay
Slt Silt
Snd Sand
St Stained
Cn Clean

JOINT SPACING
VCJ very close spacing
CJ close spacing
MJ medium spacing
WJ wide spacing
VWJ very wide spacing

JOINT ROUGHNESS
S smooth
SR slightly rough
R rough

WEATHERING SHADING
BROWN soil
100% completely weathered
75% highly weathered
50% moderately weathered
25% slightly weathered
0% unweathered

aurecon

Lower Coerney

HOLE No: LC4

Sheet 1 of 1

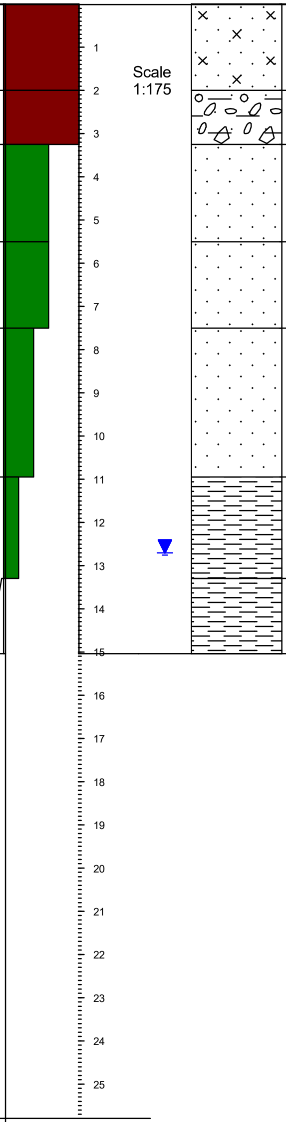
Reduced Level	Material Recovery %	Core Recovery %	RQD (%)
81.82	100	0	0
	72	0	0
	100	0	0
	43	0	0
79.82	87	0	0
	34	0	0
78.57	600	100	0
	53	0	0
	85	77	11
76.32	93	93	61
	102	102	70
74.32	81	81	63
	91	77	64
	98	98	80
	94	94	50
70.87	103	103	83
	67	67	11
68.52	138	123	13
	59	55	0
66.78	101	101	61

Frac Freq No / m
12
14
10
9
6
5
10
8
9
20
20
11

SPT Test
66

Packer Test
NT
0
13
0

Joint Inclin. (deg)	Joint Spacing	Joint Rough-ness	Joint Infill
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
10 50-60	CJ ?	S R/S	Snd/W/Cl W/Snd
10-30	C-MJ	R/S	W film
10 60 30 90	VCJ MJ C-WJ ?	S/R S S S	- - - -
10 30 60 90	VC-CJ MJ ? ?	S S S S	St St St St
10 80-90	VC-MJ ?	S S	- -



0.00	Slightly reddish brown, slightly clayey silty sand. Colluvium.
2.00	Rounded to sub-rounded, coarse gravel (20-60mm) of very hard rock quartzite with matrix of clayey sand. Alluvial. NOTE: 1. Matrix lost
3.25	Light brown, occasionally grey-brown, highly weathered, very close to closely jointed (generally 60-150mm), generally coarse, soft to very soft rock sandstone with interbedded mudstone lenses. NOTE: 1. Assume material loss in upper 50mm due to very soft rock / soil 2. Also other minor losses
5.50	Light brown, highly weathered, close to medium jointed (generally 60-200mm, up to 450mm), medium hard rock, generally medium to coarse sandstone with minor mudstone interbeds.
7.50	Light brown to grey brown, moderately weathered, locally highly weathered, close to medium jointed (100-600mm), generally hard rock with medium to fine sandstone, occasionally coarse grained with occasional muddy sandstone interbeds.
10.95	Generally grey-brown to dark grey, slightly to moderately weathered, very close to closely jointed (<60-100mm), soft rock to medium hard rock mudstone with minor interbeds of fine sandstone. NOTE: 1. Material loss at 11.5-12m estimated. Assume completely weathered clay interbed. 2. From 12.6m, horizon very closely jointed (completely fractured), weak horizons to very soft rock / clay. 3. Mudstone assumed susceptible to slaking
13.30	Dark grey, unweathered, very closely to medium jointed (<60-550mm), medium hard rock to hard rock in places, to soft rock, carbonaceous mudstone with occasional interbedded sandstone / susceptible to slaking (particularly to depth of 14m)
15.04	

<u>NOTES</u>:

Water level at 12.70m, as measured on 03 October 2018

Contractor: RWBE
Machine: D90 YWE
Drilled by: Mothu

Logged by: Gary Davis
Logged date: 4/10/2018
Drilled date: -

Elevation: 81.82
North: -58170.99
East: 3702620.43

ABREVIATIONS
N/A not applicable
N/M not measureable
IT invalid test
NT no test

JOINT INFILL
Cl Clay
Slt Silt
Snd Sand
St Stained
Cn Clean

JOINT SPACING
VCJ very close spacing
CJ close spacing
MJ medium spacing
WJ wide spacing
VWJ very wide spacing

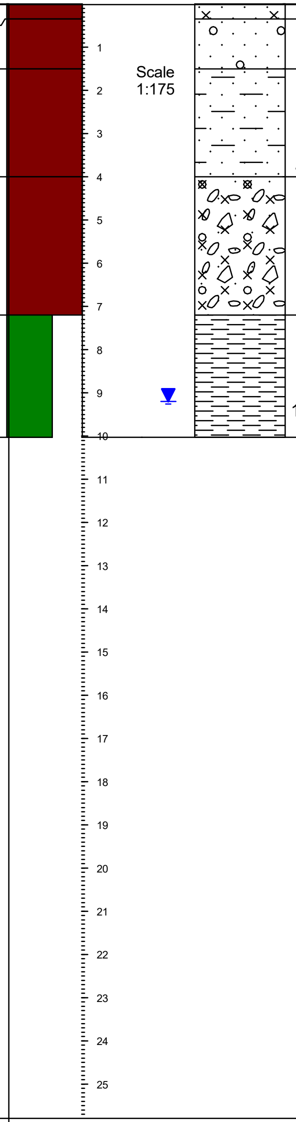
JOINT ROUGHNESS
S smooth
SR slightly rough
R rough

WEATHERING SHADING
BROWN soil
100% completely weathered
75% highly weathered
50% moderately weathered
25% slightly weathered
0% unweathered

Lower Coerney

HOLE No: LC5
Sheet 1 of 1

Reduced Level	Material Recovery %	Core Recovery %	RQD (%)	Frac Freq No / m	Joint Inclin. (deg)	Joint Spacing	Joint Rough-ness	Joint Infill
102.01 101.66	90	0	0		N/A	N/A	N/A	N/A
	57	0	0		N/A	N/A	N/A	N/A
	125	0	0					
100.51	124	0	0					
	100	0	0		N/A	N/A	N/A	N/A
98.01	95	0	0					
	98	0	0		N/A	N/A	N/A	N/A
	96	0	0					
94.81	99	0	0					
	97	90	50	5	0-10	MJ	S	W
91.98	100	100	68	6				



0.00	Orange to red-brown, silty sand. Colluvium / topsoil.
0.35	Red-brown, silty sand with scattered pockets / nodules calrete. Colluvium with some Pedogenic.
1.50	Yellow-brown to red-brown, clayey sand. Colluvium.
4.00	Red-brown, becoming olive-brown near base, slightly clayey silty sand (matrix) with scattered medium to coarse gravel (1-6 and up to 10cm), occasionally cobbles of very hard rock quartzite. Alluvium, reworked terrace gravel? NOTE: 1. Scattered calcrete development.
7.20	Grey-brown to yellow-brown, highly weathered (to completely weathered in places), medium to widely jointed, very soft rock to soft rock, predominantly mudstone with subordinate sandstone. NOTE: 1. Susceptible to slaking.
10.03	

NOTES:

Water level at 9.20m, as measured on 03 October 2018

Contractor: RWBE
Machine: D90 YWE
Drilled by: Mothu

Logged by: Gary Davis
Logged date: 4/10/2018
Drilled date: -

Elevation: 102.01
North: -58427.33
East: 3702391.34

ABREVIATIONS
N/A not applicable
N/M not measureable
IT invalid test
NT no test

JOINT INFILL
Cl Clay
Slt Silt
Snd Sand
St Stained
Cn Clean

JOINT SPACING
VCJ very close spacing
CJ close spacing
MJ medium spacing
WJ wide spacing
VWJ very wide spacing

JOINT ROUGHNESS
S smooth
SR slightly rough
R rough

WEATHERING SHADING
BROWN soil
100% completely weathered
75% highly weathered
50% moderately weathered
25% slightly weathered
0% unweathered

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Lower Coerney

HOLE No: LC6

Sheet 1 of 1

Reduced Level	Material Recovery %	Core Recovery %	RQD (%)	Frac Freq No / m	Joint Inclin. (deg)	Joint Spacing	Joint Rough-ness	Joint Infill	Weathering	Depth
89.98	95	0	0		N/A	N/A	N/A	N/A	🟥	0.00
	100	0	0							
	99	0	0							
	92	0	0							
	99	0	0							
	100	0	0							
84.53	105	0	0							5.45
	99	0	0		N/A	N/A	N/A	N/A	🟥	
83.28	94	0	0							6.70
81.98	100	94	90	2	60	MJ	R/S	W	🟩	8.00
79.88	100	93	34	10 15	0-10	VC-CJ	S	W film	🟩	10.1
	108	92	28							

Scale 1:175

Red to orange-brown, silty to clayey sand. Colluvium.

Orange-brown to brown, silty sand (matrix) with scattered, sub-rounded to sub-angular, medium to coarse (10-40mm) gravel of very hard rock quartzite / loosely packed, matrix supported but concentrated from 6m+. Alluvium (or reworked terrace gravel).

Yellow to grey-brown to whitish, highly to completely weathered, medium jointed (400-600mm), very soft rock to sand, sandstone (saprolite mainly) but includes bands of hard rock quartzite.

NOTE:
1. From 7.9m weathered to clay

Light yellow-brown, highly weathered, closely jointed (60-200mm), generally soft rock to medium hard rock, but some very soft rock interbedded, fine sandstone and mudstone from 9.55m, completley brown to 9.7m, also very soft rock mudstone interbeds.

NOTES:

Water level at 8.80m, as measured on 03 October 2018

Contractor: RWBE
Machine: D90 YWE
Drilled by: Mothu

Logged by: Gary Davis
Logged date: 4/10/2018
Drilled date: -

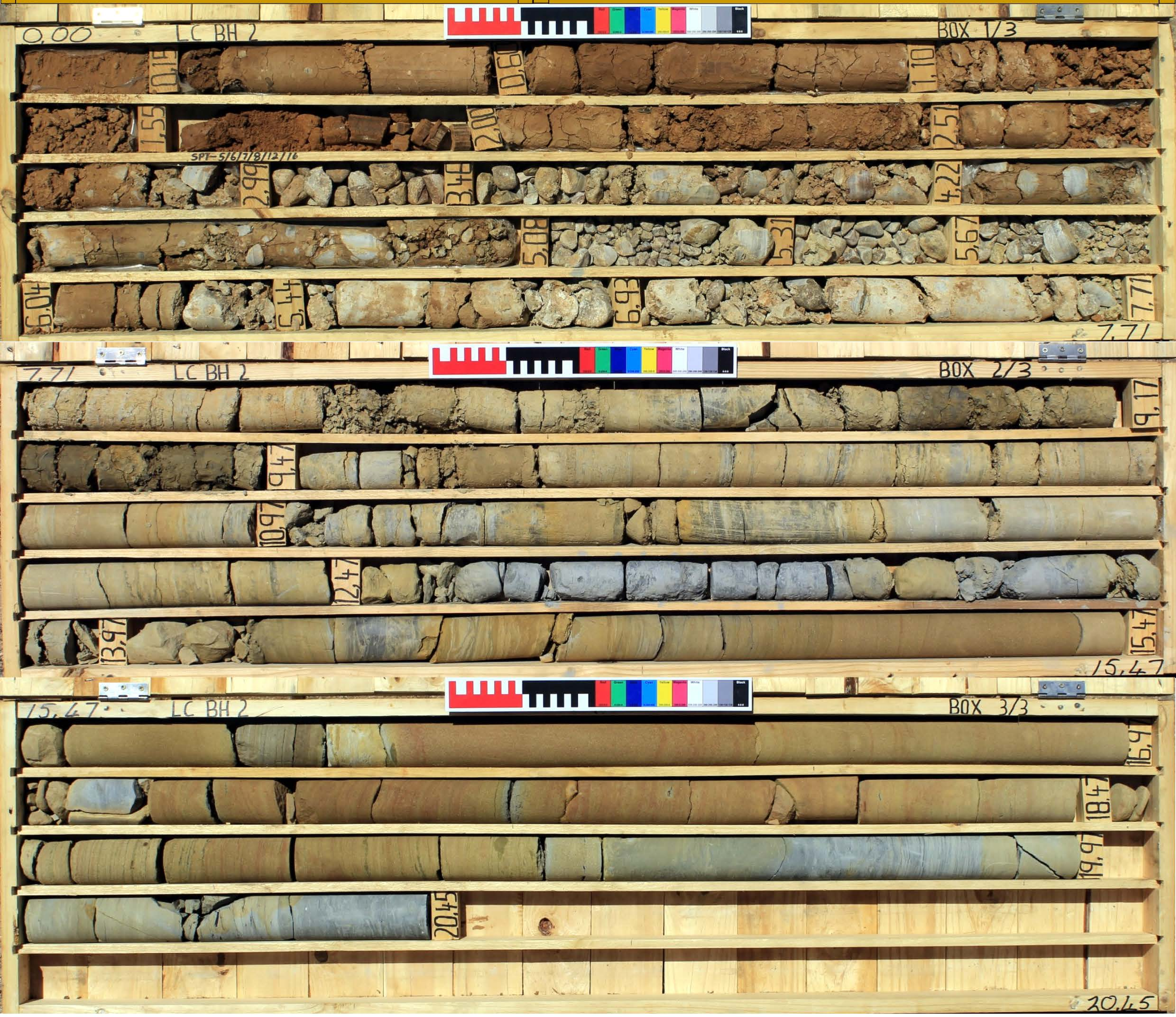
Elevation: 89.98
North: -58387.47
East: 3702608.97

Appendix C:
Core photographs

Aurecon
Lower Coerney Dam

Location: Kirkwood
Bore Hole No.: BH LC 2
Box No.: 1 to 3
Depth Range: 0.00 to 20.45
Date of Works: Sep - Oct

RWBE Geotechnical Drilling



Aurecon
Lower Coerney Dam

Location: Kirkwood

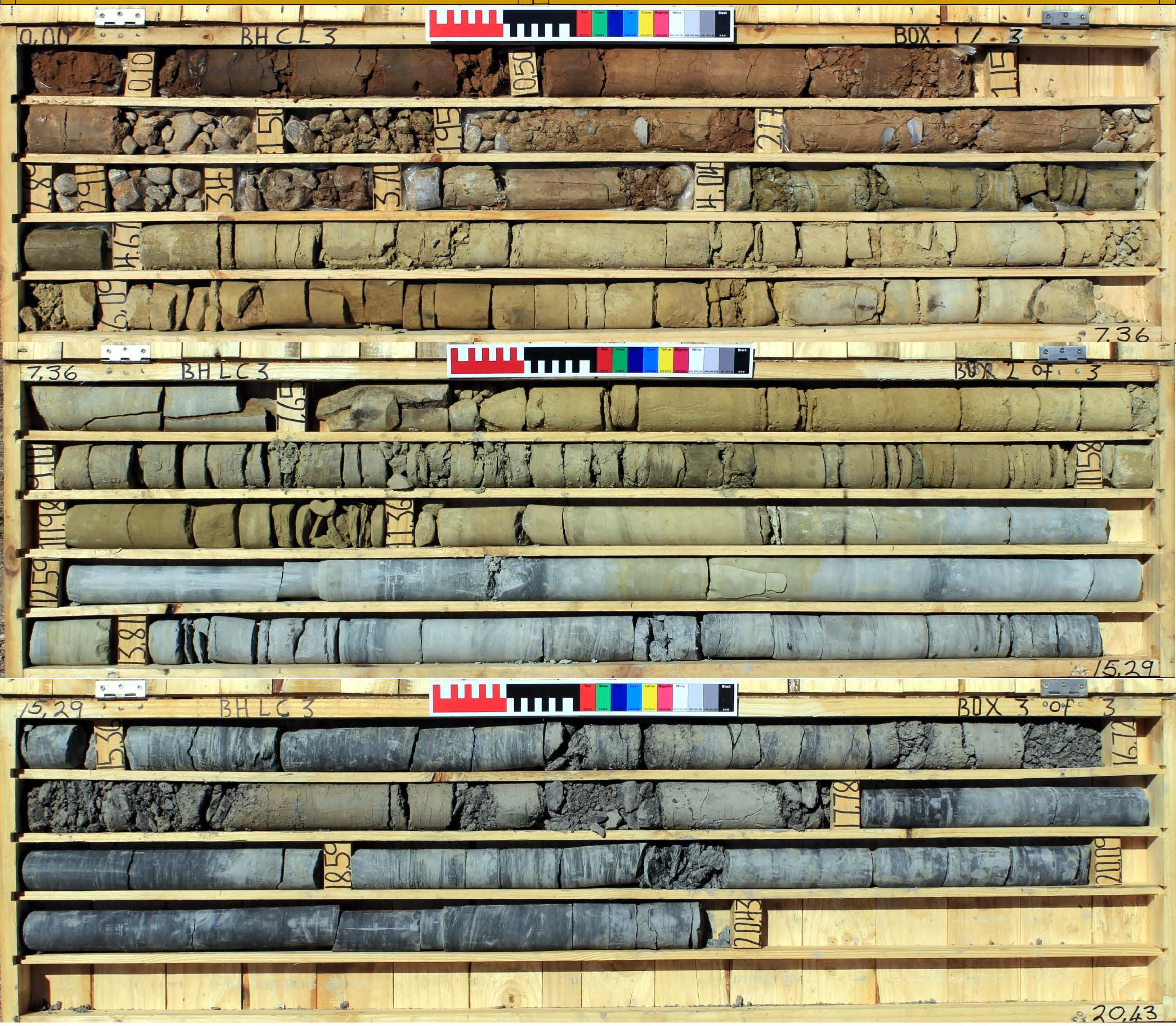
Bore Hole No.: BH LC 3

Box No.: 1 to 3

Depth Range: 0.00 to 20.43

Date of Works: Sep - Oct

RWBE Geotechnical Drilling



Aurecon
Lower Coerney Dam

Location: Kirkwood

Bore Hole No.: BH LC 4

Box No.: 1 to 2

Depth Range: 0.00 to 15.04

Date of Works: Sep - Oct

RWBE Geotechnical Drilling

Aurecon
Lower Coerney Dam

Location: Kirkwood

Bore Hole No.: BH LC5

Box No.: 1 to 2

Depth Range: 0.00 to 10.03

Date of Works: Sep - Oct

RWBE Geotechnical Drilling

Aurecon
Lower Coerney Dam

RWBE Geotechnical Drilling

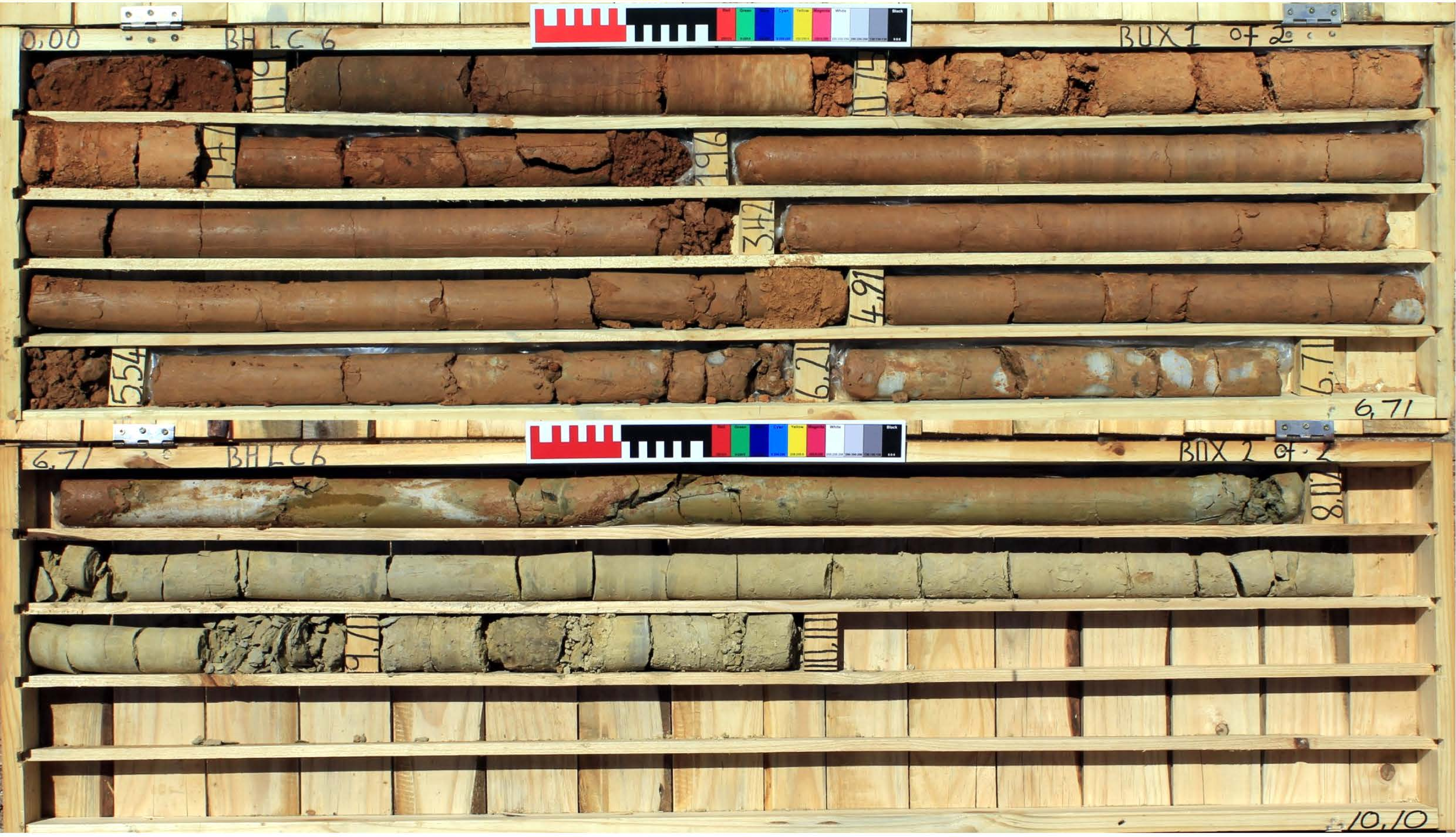
Location: Kirkwood

Bore Hole No.: BH LC 6

Box No.: 1 to 2

Depth Range: 0.00 to 10.10

Date of Works: Sep - Oct



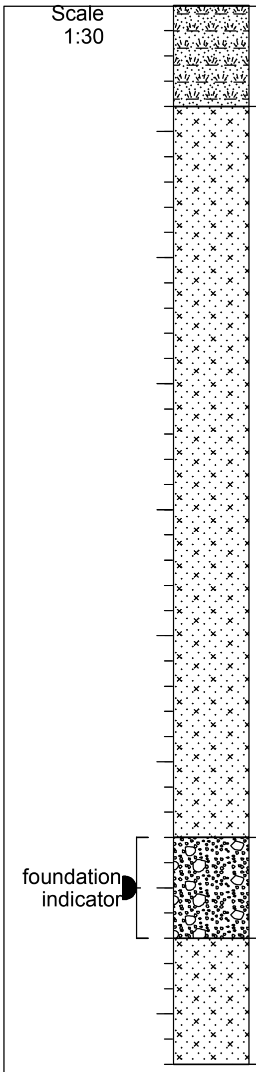
Appendix D:
Soil profiles

aurecon

DWS
Lower Coerney Dam Site

HOLE No: **TP 101**
Sheet 1 of 1

JOB NUMBER: **112546**



Depth	Description
0.00	Dry, dark brown, VERY DENSE, silty sand with abundant roots and minor rounded gravel. Topsoil
0.40	Slightly moist, light brown, VERY DENSE, intact, silty sand. Colluvium
3.30	Tightly packed gravel and cobbles with occasional sandstone and mudstone gravel in a matrix of slightly moist, brown, silty sand. Overall consistency is DENSE. Reworked terrace gravel. (Mixed origin)
3.70	Slightly moist, light grey and red brown, VERY DENSE, slightly ferrugenised, silty sand. Residual sandstone
4.20	

<u>NOTES</u>:

Next to borehole LC1.
No water seepage encountered.
Sidewalls stable.
Foundation indicator sampled at 3.3-3.7m.
No refusal; pit stopped at 4.2m.

CONTRACTOR:	Controlab	*INCLINATION:*		*ELEVATION:*	
MACHINE:	Excavator - JCBJS290LC	*DIAM:*		*X COORD:*	58062
PROFILED BY:	S. Nyathi and G. Davis	*DATE DRILLED:*	6/10/2019	*Y COORD:*	- 3702708
TYPE SET BY:		*DATE PROFILED:*			

ALGOA TEST PITS GA.GPJ

HOLE No: **TP 101**

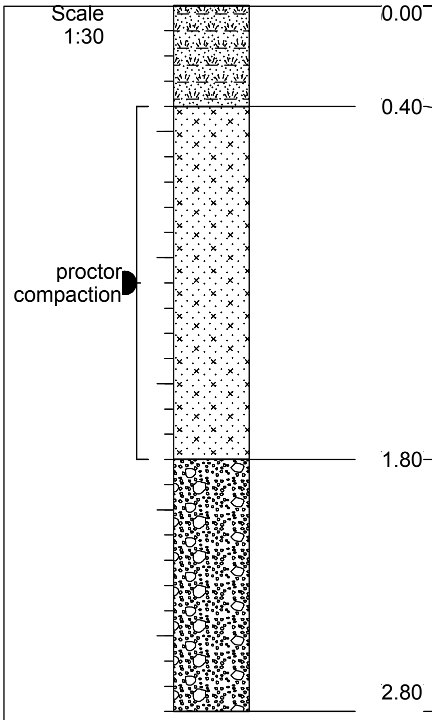
Report ID: _ZA TRAIL PIT LOG || Project: ALGOA TEST PITS GA.GPJ || Library: GINT STD AGS 4_0_SA.GLB || Date: August 12, 2019

aurecon

DWS
Lower Coerney Dam Site

HOLE No: **TP 102**
Sheet 1 of 1

JOB NUMBER: **112546**



Depth (m)	Description
0.00 – 0.40	Dry, dark brown, VERY DENSE, silty sand with abundant roots and minor rounded gravel. Topsoil
0.40 – 1.80	Slightly moist, light brown, VERY DENSE, intact, silty sand. Colluvium
1.80 – 2.80	Tightly packed gravel and cobbles with occasional sandstone and mudstone gravel in a matrix of slightly moist, brown, silty sand. Overall consistency is DENSE. Reworked terrace gravel. (Mixed origin).

NOTES:

No water seepage encountered.
Sidewalls stable.
Proctor compaction sampled at 0.4-1.8m.
Refusal on sandstone boulders at 2.8m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

ELEVATION:
X COORD: 58165
Y COORD: - 3702624

HOLE No: **TP 102**

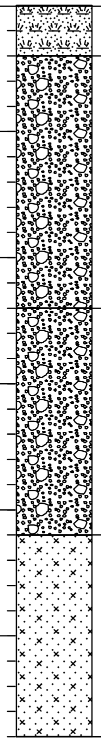
Report ID: _ZA TRAIL PIT LOG || Project: ALGOA TEST PITS GA.GPJ || Library: GINT STD AGS 4_0_SA.GLB || Date: August 12, 2019

DWS
Lower Coerney Dam Site

HOLE No: **TP 103**
Sheet 1 of 1

JOB NUMBER: **112546**

Scale
1:30



0.00	Dry, dark brown, VERY DENSE, silty sand with abundant roots and minor rounded gravel. Topsoil
0.20	Slightly moist, dark brown, DENSE, intact, clayey /silty sand with indistinct sub-rounded to sub-angular gravel. Colluvium
1.20	Slightly moist, brown, DENSE to VERY DENSE, intact, silty sand with minor indistinct sub-angular to rounded gravel. Colluvium
2.10	Slightly moist, brown, off-white and occasionally black, VERY DENSE, intact, calcretised, silty sand with minor indistinct sub-angular to rounded gravel. Residual sandstone, part pedogenic
2.90	

NOTES:

No water seepage encountered.
Sidewalls stable.
No sample taken.
No refusal; pit stopped at 2.9m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

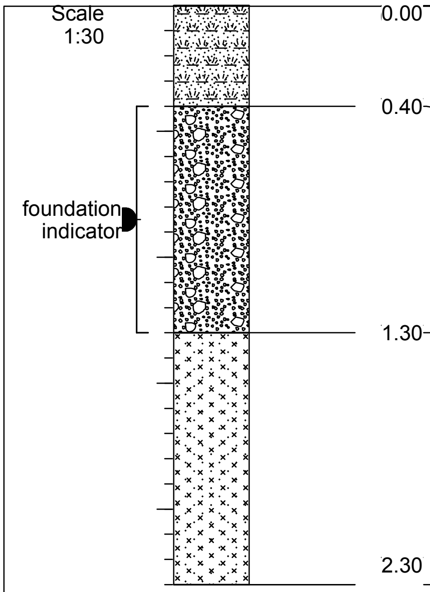
ELEVATION:
X COORD: 58338
Y COORD: - 3702744

HOLE No: **TP 103**

DWS
Lower Coerney Dam Site

HOLE No: **TP 104**
Sheet 1 of 1

JOB NUMBER: **112546**



Dry, dark brown, VERY DENSE, silty sand with abundant roots and minor rounded gravel.
Topsoil

Dry, dark brown and off-white, VERY DENSE, blocky, calcretised, sandy silt.
Colluvium, part pedogenic

Dry, dark red speckled black, VERY DENSE, intact, sandy silt.
Colluvium, part pedogenic

NOTES:

No water seepage encountered.
Sidewalls stable.
Foundation indicator sampled at 0.4-1.3m and 1.3-2.3m.
Partial refusal on very dense colluvium.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

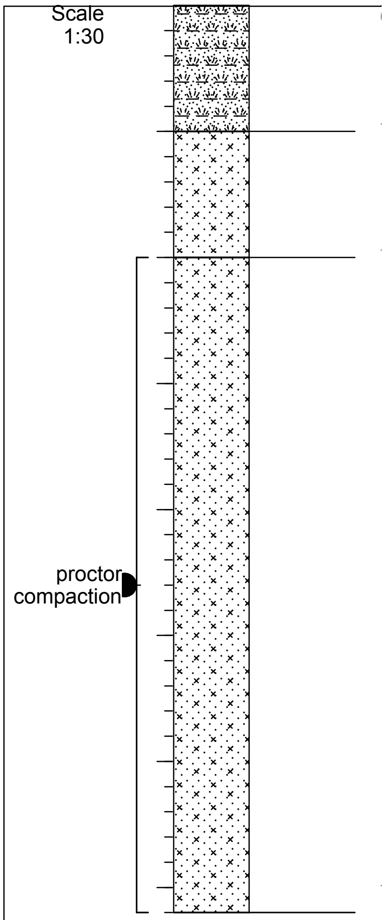
ELEVATION:
X COORD: 58252
Y COORD: - 3702577

HOLE No: **TP 104**

DWS
Lower Coerney Dam Site

HOLE No: **TP 105**
Sheet 1 of 1

JOB NUMBER: **112546**



0.00	Dry, brown, DENSE, intact, silty sand with occasional gravel. Topsoil
0.50	Slightly moist, brown and off-white, VERY DENSE, calcretised, silty sand. Colluvium
1.00	Slightly moist, brown, VERY DENSE, intact, slightly calcretised, silty sand. Colluvium
3.60	

<u>NOTES</u>:

No water seepage encountered.
Sidewalls stable.
Proctor compaction sampled at 1.0-3.6m.
Partial refusal.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

ELEVATION:
X COORD: 57929
Y COORD: - 3702599

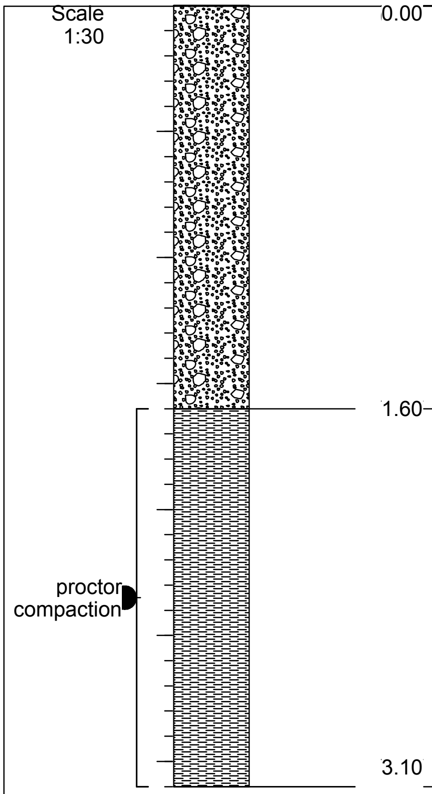
HOLE No: **TP 105**

Report ID: _ZA TRAIL PIT LOG || Project: ALGOA TEST PITS GA.GPJ || Library: GINT STD AGS 4_0_SA.GLB || Date: August 12, 2019

DWS
Lower Coerney Dam Site

HOLE No: **TP 106**
Sheet 1 of 1

JOB NUMBER: **112546**



0.00 – 1.60: Tightly packed gravel and cobbles with occasional sandstone and mudstone gravel in a matrix of slightly moist, brown, silty sand. Overall consistency is DENSE.
Reworked terrace gravel. (Mixed origin)

1.60 – 3.10: Dark grey and red brown, highly weathered, massive, very fine grained, slaking, VERY SOFT ROCK.
Mudstone

<u>NOTES</u>:

No water seepage encountered.
Sidewalls stable.
Proctor compaction sampled at 1.6-3.1m.
No refusal; pit stopped at 3.1m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

ELEVATION:
X COORD: 58045
Y COORD: - 3702532

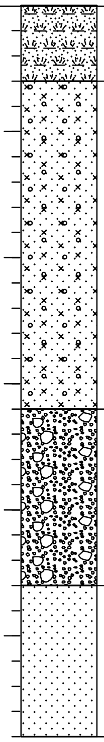
HOLE No: **TP 106**

DWS
Lower Coerney Dam Site

HOLE No: **TP 107**
Sheet 1 of 1

JOB NUMBER: **112546**

Scale
1:30



0.00	Dry, brown, DENSE, intact, silty sand with roots. Topsoil
0.30	Slightly moist, reddish brown, VERY DENSE, intact, silty sand with prominent gravelly layer of 0.2m thick at about 1.0m depth. Colluvium
1.60	Tightly packed, calcretised gravel of rounded to sub-rounded, of different origin, in a matrix of slightly moist, brown, silty sand. Overall consistency is VERY DENSE. Reworked terrace gravel, part pedogenic. (Mixed origin)
2.30	Bedrock, greyish brown, highly weathered, fine grained, VERY SOFT ROCK sandstone transitioning into fine siltstone by the base of the pit. Sandstone
2.90	

<u>NOTES</u>:

No water seepage encountered.
Sidewalls stable.
No sample taken.
Refusal on sandstone at 2.9m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

ELEVATION:
X COORD: 58129
Y COORD: - 3702468

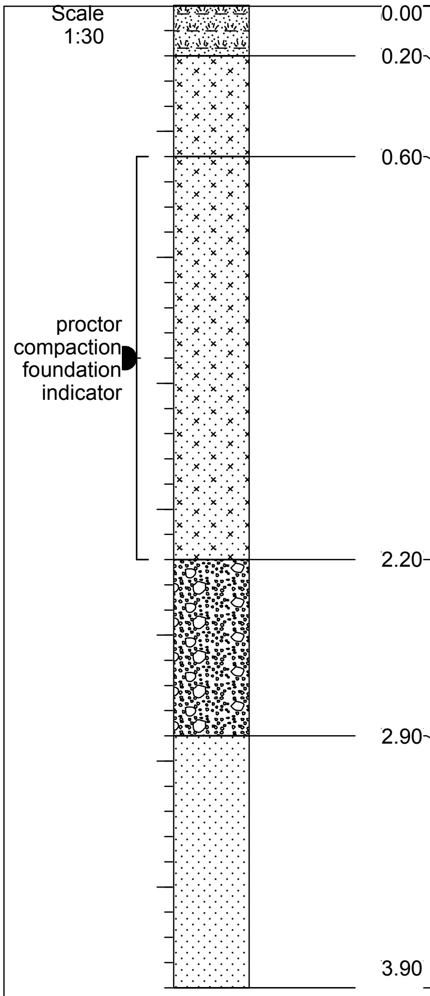
HOLE No: **TP 107**

Report ID: _ZA TRAIL PIT LOG || Project: ALGOA TEST PITS GA.GPJ || Library: GINT STD AGS 4_0_SA.GLB || Date: August 12, 2019

DWS
Lower Coerney Dam Site

HOLE No: **TP 108**
Sheet 1 of 1

JOB NUMBER: **112546**



Dry, brown, LOOSE to MEDIUM DENSE, intact, silty sand with roots.
Topsoil

Dry, brown, VERY DENSE, intact, silty sand.
Colluvium

Slightly moist, brown and off-white, VERY DENSE, intact, calcretised, silty sand.
Colluvium, part pedogenic

Tightly packed, calcretised gravel of rounded to sub-rounded, different origin, in a matrix of slightly moist, brown, silty sand. Overall consistency is VERY DENSE.
Reworked terrace gravel, part pedogenic. (Mixed origin)

Light brown, completely weathered with patched of highly weathered material, fine grained, VERY SOFT ROCK.
Sandstone

NOTES:

No water seepage encountered.
Sidewalls stable.
Proctor compaction sampled at 0.6-2.2m.
Foundation indicator sampled at 0.6-2.2m.
Refusal on sandstone at 3.9m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

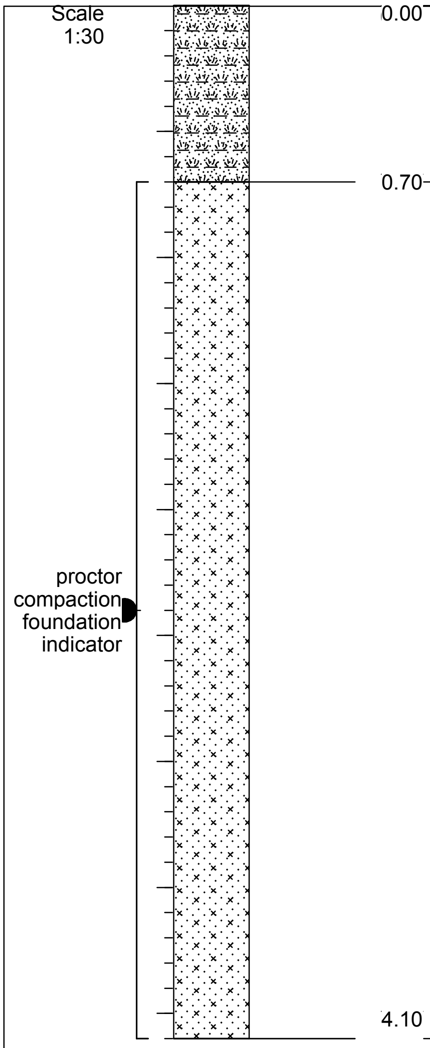
ELEVATION:
X COORD: 58195
Y COORD: - 3702391

HOLE No: **TP 108**

DWS
Lower Coerney Dam Site

HOLE No: **TP 109**
Sheet 1 of 1

JOB NUMBER: **112546**



Slightly moist, red brown, DENSE, silty sand with roots, blocky structure with occasional round gravel.
Colluvium

Slightly moist, brown, DENSE to VERY DENSE, intact, slightly calcretised, silty sand.
Colluvium, part pedogenic

<u>NOTES</u>:

No water seepage encountered.
Sidewalls stable.
Proctor compaction sampled at 0.7-4.1m.
Foundation indicator sampled at 0.7-4.1m.
No refusal but slow at at 4.1m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

ELEVATION:
X COORD: 57867
Y COORD: - 3702499

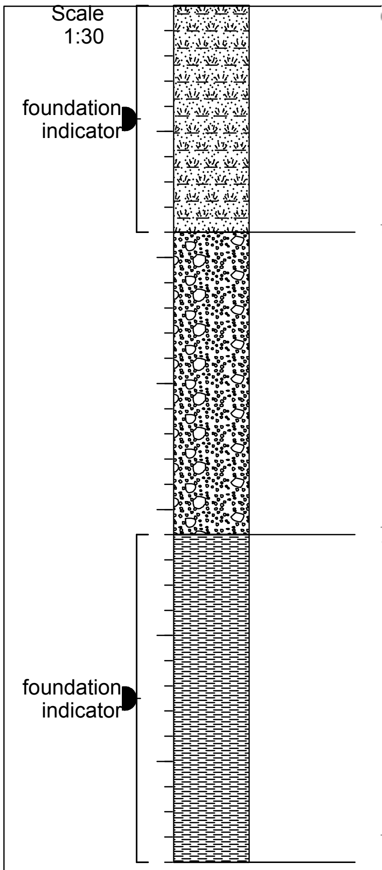
HOLE No: **TP 109**

Report ID: _ZA TRAIL PIT LOG || Project: ALGOA TEST PITS GA.GPJ || Library: GINT STD AGS 4_0_SA.GLB || Date: August 12, 2019

DWS
Lower Coerney Dam Site

HOLE No: **TP 110**
Sheet 1 of 1

JOB NUMBER: **112546**



0.00	Dry, brown, VERY DENSE, intact, silty sand with roots and rounded fine to coarse gravel. Colluvium
0.90	Tightly packed gravel and cobbles with occasional sandstone and mudstone gravel in a matrix of slightly moist, brown, silty sand. Overall consistency is VERY DENSE. Reworked terrace gravel. (Mixed origin)
2.10	Dark grey and red brown, highly weathered, massive, very fine grained, slaking, VERY SOFT ROCK. Mudstone
3.40	

NOTES:

No water seepage encountered.
Sidewalls stable.
Foundation indicator sampled at 0.0-0.9m and at 2.1-3.4m.
No refusal but slow at 3.4m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

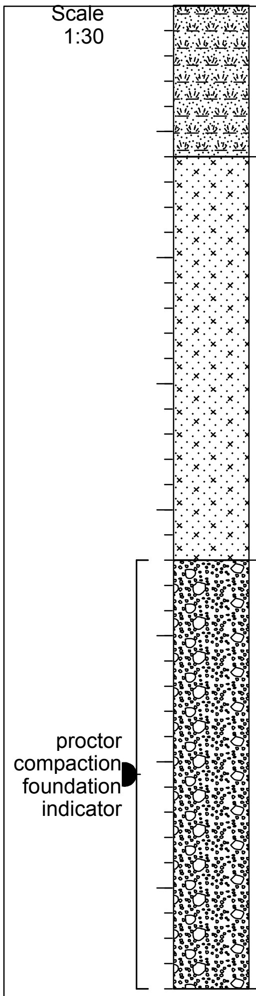
ELEVATION:
X COORD: 57988
Y COORD: - 3702433

HOLE No: **TP 110**

DWS
Lower Coerney Dam Site

HOLE No: **TP 111**
Sheet 1 of 1

JOB NUMBER: **112546**



0.00	Slightly moist, red brown, blocky, DENSE, silty sand with roots. Colluvium
0.60	Slightly moist, brown and occasionally off-white, VERY DENSE, intact, slightly calcretised, silty sand with occasional gravel. Colluvium, part pedogenic
2.20	Tightly packed, calcretised gravel of rounded to sub-rounded, of different origin, in a matrix of slightly moist, brown, silty sand. Overall consistency is VERY DENSE. Reworked terrace gravel. (Mixed origin)
3.90	

<u>NOTES</u>:

No water seepage encountered.
Sidewalls stable.
Foundation indicator sampled at 2.2-3.9m.
Proctor compaction sampled at 2.2-3.9m.
No refusal; pit stopped at 3.9m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

ELEVATION:
X COORD: 58103
Y COORD: - 3702367

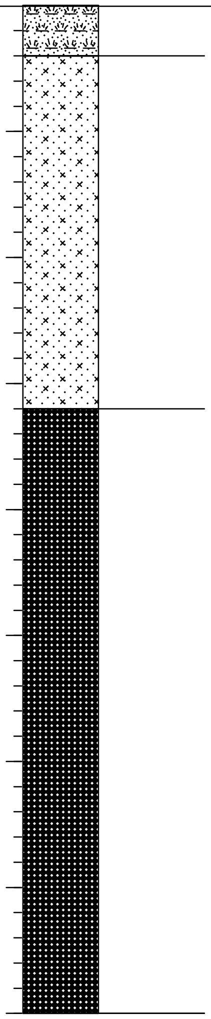
HOLE No: **TP 111**

HOLE No: **TP 112**
Sheet 1 of 1

DWS
Lower Coerney Dam Site

JOB NUMBER: **112546**

Scale
1:30



0.00 – 0.20	Dry, brown, MEDIUM DENSE, intact and shattered, silty sand with occasional gravel. Topsoil
0.20 – 1.60	Dry, brown and pockets of off-white, VERY DENSE, intact, slightly ferrugenised and calcretised, silty sand. Colluvium, part pedogenic
1.60 – 4.00	Dry to slightly moist, dark red, black and off-white, VERY DENSE, intact, ferrugenised and calcretised, silty sand with ferricrete nodules with pockets of hardpan ferricrete. Colluvium, part pedogenic

NOTES:

No water seepage encountered.
Sidewalls stable.
No sample taken.
No refusal but slow at 4.0m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

ELEVATION:
X COORD: 58209
Y COORD: - 3702277

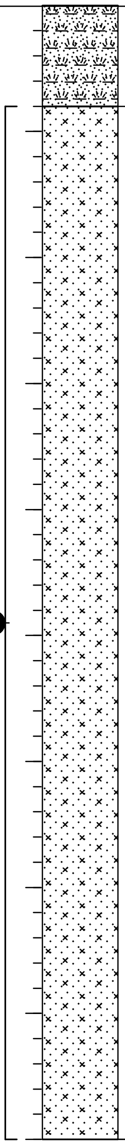
HOLE No: **TP 112**

DWS
Lower Coerney Dam Site

HOLE No: **TP 113**
Sheet 1 of 1

JOB NUMBER: **112546**

Scale
1:30



proctor
compaction
foundation
indicator

Depth	Description
0.00 – 0.40	Dry, brown, DENSE, intact and shattered, silty sand with roots. Topsoil
0.40 – 4.50	Dry, red brown speckled back, VERY DENSE, ferrugenised, silty sand, at 1.0m change into slightly moist and no ferrugenisation with occasional rounded gravel. Colluvium, part pedogenic

NOTES:

No water seepage encountered.
Sidewalls stable.
Foundation indicator sampled at 0.4-4.5m.
Proctor compaction sampled at 0.4-4.5m.
No refusal; pit stopped at 4.5m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

ELEVATION:
X COORD: 57805
Y COORD: - 3702363

HOLE No: **TP 113**

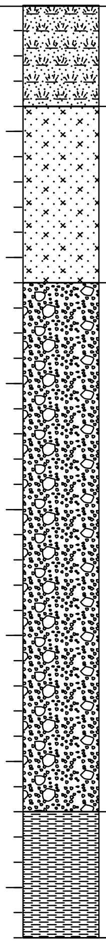
aurecon

DWS
Lower Coerney Dam Site

HOLE No: **TP 114**
Sheet 1 of 1

JOB NUMBER: **112546**

Scale
1:30



0.00	Dry, dark brown, MEDIUM DENSE, intact, silty sand. Topsoil
0.40	Slightly moist, brown, VERY DENSE, intact, silty sand with rounded gravel. Colluvium
1.10	Tightly packed, rounded, fine to coarse grained gravel, in a matrix of slightly moist, brown, silty sand. Overall consistency VERY DENSE. Reworked terrace gravel. (Mixed origin)
3.20	Grey and light brown, completely weathered, very fine grained, massive, slaking, VERY SOFT ROCK. Mudstone
3.70	

NOTES:

No water seepage encountered.
Sidewalls stable.
No sample taken.
Refusal on very soft rock mudstone.

CONTRACTOR:	Controlab	INCLINATION:		ELEVATION:	
MACHINE:	Excavator - JCBJS290LC	DIAM:		X COORD:	57907
PROFILED BY:	S. Nyathi and G. Davis	DATE DRILLED:	6/10/2019	Y COORD:	- 3702336
TYPE SET BY:		DATE PROFILED:			

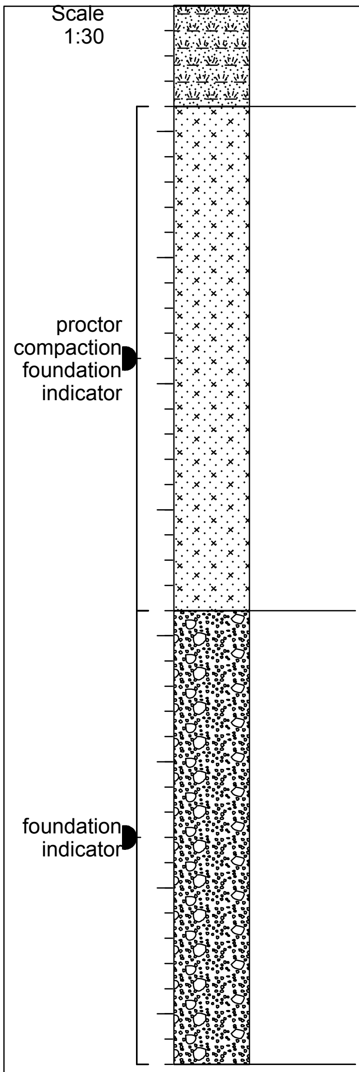
ALGOA TEST PITS GA.GPJ

HOLE No: **TP 114**

Report ID: _ZA TRAIL PIT LOG || Project: ALGOA TEST PITS GA.GPJ || Library: GINT STD AGS 4_0_SA.GLB || Date: August 12, 2019

HOLE No:	**TP 115**
	Sheet 1 of 1
JOB NUMBER:	**112546**

DWS
Lower Coerney Dam Site



0.00	Dry, brown, DENSE, silty sand with roots. Topsoil
0.40	Dry, red brown speckled black, VERY DENSE, ferrugenised silty sand, at 1.4m it is slightly moist and no ferrugenisation. Colluvium, part pedogenic
2.40	Tightly packed, rounded, fine to coarse grained gravel, in a matrix of slightly moist, brown, silty sand. Overall consistency VERY DENSE. Reworked terrace gravel. (Mixed origin)
4.20	

<u>NOTES</u>:

No water seepage encountered.
Sidewalls stable.
Foundation indicator sampled at 0.4-2.4m and at 2.4-4.2m.
Proctor compactor sampled at 0.4-2.4m.
No refusal but slow at 4.2m.

CONTRACTOR:	Controlab	*INCLINATION:*		*ELEVATION:*	
MACHINE:	Excavator - JCBJS290LC	*DIAM:*		*X COORD:*	58024
PROFILED BY:	S. Nyathi and G. Davis	*DATE DRILLED:*	6/10/2019	*Y COORD:*	- 3702289
TYPE SET BY:		*DATE PROFILED:*			

ALGOA TEST PITS GA.GPJ

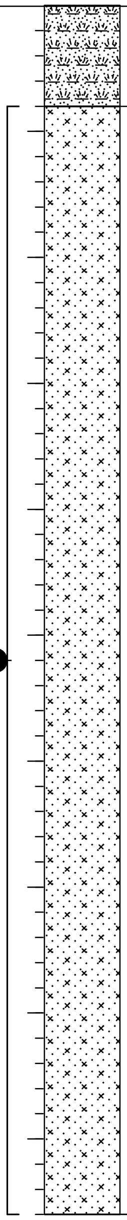
HOLE No: **TP 115**

DWS
Lower Coerney Dam Site

HOLE No: **TP 116**
Sheet 1 of 1

JOB NUMBER: **112546**

Scale
1:30



0.00

Dry, dark red brown, DENSE, intact, silty sand with roots.
Topsoil

0.40

Dry from surface to 1.3m, red brown speckled back, VERY DENSE, ferrugenised, slightly calcretised between 0.6-1.3m, silty sand, at 1.0m change into slightly moist and no ferrugenisation with occasional rounded gravel.
Colluvium, part pedogenic

proctor
compaction
foundation
indicator

4.80

<u>NOTES</u>:

No water seepage encountered.
Sidewalls stable.
Foundation indicator sampled at 0.4-4.8m.
Proctor compaction sampled at 0.4-4.8m.
No refusal; pit stopped at 4.8m.

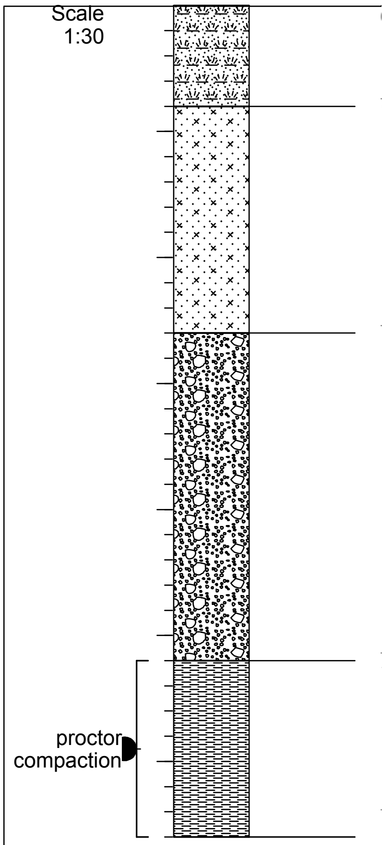
CONTRACTOR:	Controlab	*INCLINATION:*		*ELEVATION:*	
MACHINE:	Excavator - JCBJS290LC	*DIAM:*		*X COORD:*	57691
PROFILED BY:	S. Nyathi and G. Davis	*DATE DRILLED:*	6/10/2019	*Y COORD:*	- 3702130
TYPE SET BY:		*DATE PROFILED:*			
	ALGOA TEST PITS GA.GPJ				

HOLE No: **TP 116**

DWS
Lower Coerney Dam Site

HOLE No: **TP 117**
Sheet 1 of 1

JOB NUMBER: **112546**



0.00	Dry, brown, MEDIUM DENSE, intact, silty sand with roots. Topsoil
0.40	Slightly moist, red brown, VERY DENSE, intact, silty sand. Colluvium
1.30	Tightly packed, rounded, fine to coarse grained gravel, in a matrix of slightly moist, brown, silty sand. Overall consistency VERY DENSE. Reworked terrace gravel. (Mixed origin)
2.60	Dark grey and red brown, highly weathered, massive, very fine grained, slaking, VERY SOFT ROCK. Mudstone
3.30	

<u>NOTES</u>:

No water seepage encountered.
Sidewalls stable.
Proctor compaction sampled at 2.6-3.3m.
Refusal on sandstone at 3.3m.

CONTRACTOR:	Controlab	*INCLINATION:*		*ELEVATION:*	
MACHINE:	Excavator - JCBJS290LC	*DIAM:*		*X COORD:*	57832
PROFILED BY:	S. Nyathi and G. Davis	*DATE DRILLED:*	6/10/2019	*Y COORD:*	- 3702102
TYPE SET BY:		*DATE PROFILED:*			

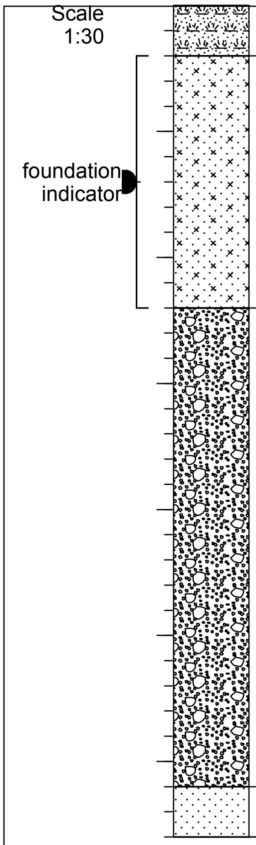
ALGOA TEST PITS GA.GPJ

HOLE No: **TP 117**

DWS
Lower Coerney Dam Site

HOLE No: **TP 118**
Sheet 1 of 1

JOB NUMBER: **112546**



0.00 0.20	Dry, brown, MEDIUM DENSE, intact, silty sand with roots. Topsoil
0.20 1.20	Dry, red brown, VERY DENSE, intact, silty sand with occasional gravel. Colluvium
1.20 3.10	Tightly packed, rounded to sub-angular gravel and cobbles in a matrix of slightly moist, brown, slightly calcretised silty sand. Overall consistency is VERY DENSE. Reworked terrace gravel. (Mixed origin)
3.10 3.30	Light grey, highly weathered fine grained, thinly bedded, MEDIUM HARD ROCK. Sandstone bedrock

<u>NOTES</u>:

No water seepage encountered.
Sidewalls stable.
Foundation indicator sampled at 0.2-1.2m.
Refusal on sandstone at 3.3m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

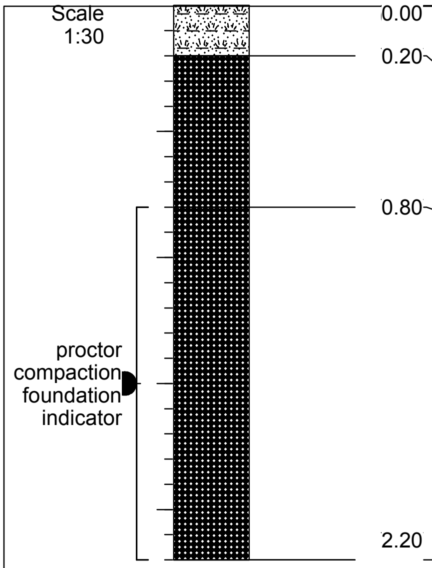
ELEVATION:
X COORD: 58004
Y COORD: - 3702086

HOLE No: **TP 118**

DWS
Lower Coerney Dam Site

HOLE No: **TP 119**
Sheet 1 of 1

JOB NUMBER: **112546**



Dry, brown, MEDIUM DENSE, intact and shattered, silty sand with occasional gravel.
Topsoil

Dry, red brown, VERY DENSE, intact, ferrugenised silty sand.
Colluvium / into pedogenic

Dry, red brown, VERY DENSE to VERY SOFT ROCK, ferrugenised silty sand with ferricrete nodules, cemented into almost hardpan with pockets of light grey, calcretised gravel.
Colluvium / into pedogenic / hardpan

NOTES:

No water seepage encountered.
Sidewalls stable.
Foundation indicator sampled at 0.8-2.2m.
Proctor compaction sampled at 0.8-2.2m.
Refusal on hardpan ferricrete at 2.2m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

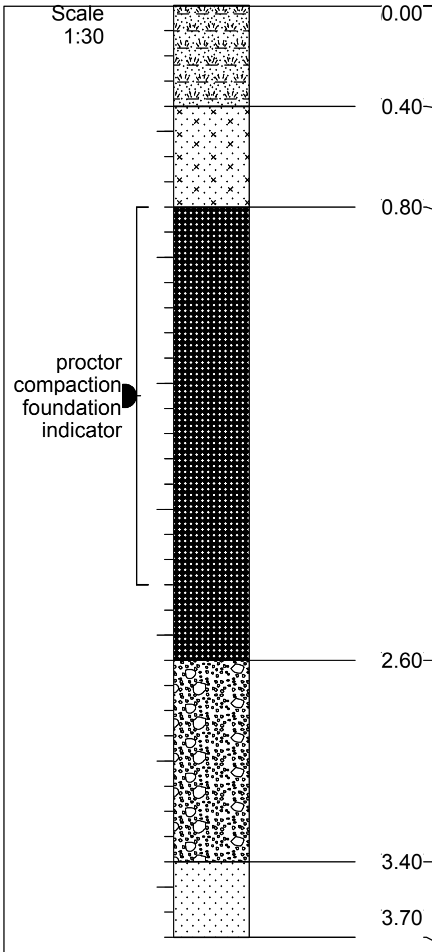
ELEVATION:
X COORD: 57671
Y COORD: - 3701972

HOLE No: **TP 119**

DWS
Lower Coerney Dam Site

HOLE No: **TP 120**
Sheet 1 of 1

JOB NUMBER: **112546**



0.00	Dry, brown, MEDIUM DENSE, intact, silty sand with occasional rounded gravel and roots. Topsoil
0.40	Dry, red brown, DENSE, intact, silty sand with occasional rounded gravel. Colluvium
0.80	Dry, red brown and off-white, DENSE to VERY DENSE, intact, calcretised silty sand, calcrete concentration in a layer and patched. Colluvium / pedogenic
2.60	Tightly packed, rounded, calcretised gravel and cobbles in a matrix of brown, slightly moist, silty sand. Overall consistency is VERY DENSE. Reworked terrace gravel. (Mixed origin)
3.40	Light grey, completely to highly weathered, very fine grained, thinly bedded, VERY SOFT ROCK. Sandstone bedrock
3.70	

<u>NOTES</u>:

No water seepage encountered.
Sidewalls stable.
Foundation indicator sampled at 0.8-2.0m.
Proctor compactor sampled at 0.8-2.0m.
Refusal on very soft rock sandstone at 3.7m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

ELEVATION:
X COORD: 57836
Y COORD: - 3701938

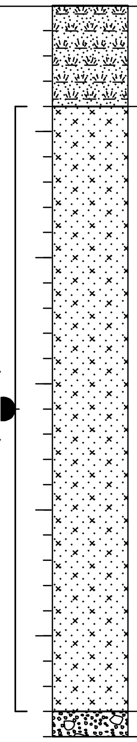
HOLE No: **TP 120**

HOLE No: **TP 121**
Sheet 1 of 1

JOB NUMBER: **112546**

DWS
Lower Coerney Dam Site

Scale
1:30



0.00	Dry, red brown, DENSE, intact, silty sand with roots. Topsoil
0.40	Dry, red brown, VERY DENSE, intact, silty sand with occasional gravel. Colluvium
2.80	Tightly packed, rounded to sub-angular gravel and cobbles in a matrix of slightly moist, brown, slightly calcretised silty sand. Overall consistency is VERY DENSE. Reworked terrace gravel. (Mixed origin)
2.90	

NOTES:

No water seepage encountered.
Sidewalls stable.
Foundation indicator sampled at 0.4-2.8m.
Proctor compaction sampled at 0.4-2.8m.
No refusal but slow at 2.9m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

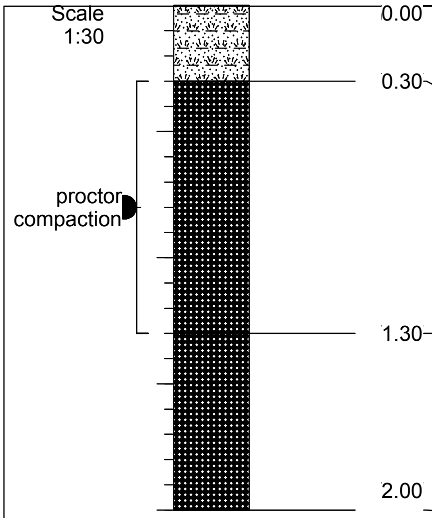
ELEVATION:
X COORD: 58020
Y COORD: - 3701894

HOLE No: **TP 121**

DWS
Lower Coerney Dam Site

HOLE No: **TP 122**
Sheet 1 of 1

JOB NUMBER: **112546**



Dry, brown, MEDIUM DENSE, intact and shattered, silty sand with occasional rounded gravel.
Topsoil

Dry, red brown, VERY DENSE, intact, silty sand.
Colluvium

Dry, light grey, VERY DENSE to VERY SOFT ROCK, ferrugenised silty sand with ferricrete nodules, cemented into almost hardpan with pockets of light grey, calcretised gravel.
Colluvium / into pedogenic / hardpan

NOTES:

No water seepage encountered.
Sidewalls stable.
Proctor compaction sampled at 0.3-1.3m.
Refusal on hardpan ferricrete at 2.0m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

ELEVATION:
X COORD: 57728
Y COORD: - 3701805

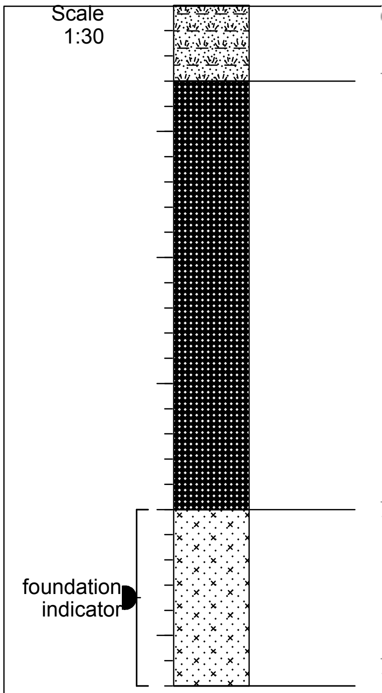
HOLE No: **TP 122**

Report ID: _ZA TRAIL PIT LOG || Project: ALGOA TEST PITS GA.GPJ || Library: GINT STD AGS 4_0_SA.GLB || Date: August 12, 2019

DWS
Lower Coerney Dam Site

HOLE No: **TP 123**
Sheet 1 of 1

JOB NUMBER: **112546**



0.00	Dry, dark brown, MEDIUM DENSE, shattered, silty sand with roots and occasionally gravel. Topsoil
0.30	Dry to slightly moist, DENSE, shattered and blocky, ferrugenised, silty sand with calcrete concretions in patched and ferricrete nodules. Colluvium / Pedogenic
2.00	Moist, light grey and red brown, very often ferrugenised, VERY DENSE, clayey silty sand with sandstone gravel and ferricrete nodules. Reworked terrace gravel. (Mixed origin)
2.70	

<u>NOTES</u>:

No water seepage encountered.
Sidewalls stable.
Foundation indicator sampled at 2.0-2.7m.
Near refusal.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

ELEVATION:
X COORD: 57767
Y COORD: - 3701695

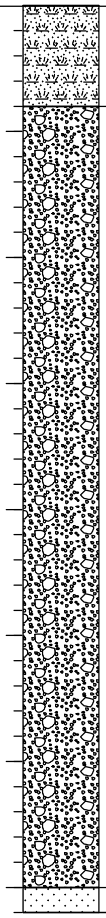
HOLE No: **TP 123**

DWS
Lower Coerney Dam Site

HOLE No: **TP 124**
Sheet 1 of 1

JOB NUMBER: **112546**

Scale
1:30



0.00	Dry, brown, LOOSE to MEDIUM DENSE, intact, silty sand with occasional sub-angular to rounded gravel. Topsoil
0.40	Tightly packed, rounded to sub-angular gravel and cobbles in a matrix of slightly moist, brown, silty sand. Overall consistency is VERY DENSE. Reworked terrace gravel. (Mixed origin)
3.50	Light grey, highly weathered, fine grained, SOFT ROCK. Sandstone
3.60	

<u>NOTES</u>:

No water seepage encountered.
Sidewalls stable.
No sample taken.
Refusal on sandstone at 3.6m.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

ELEVATION:
X COORD: 57899
Y COORD: - 3701616

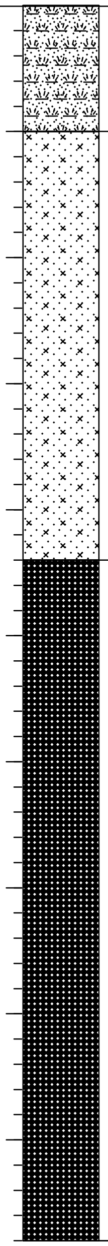
HOLE No: **TP 124**

DWS
Lower Coerney Dam Site

HOLE No: **TP 125**
Sheet 1 of 1

JOB NUMBER: **112546**

Scale
1:30



Depth	Description
0.00	Dry, dark brown, LOOSE to MEDIUM DENSE, intact and shattered, silty sand with roots and occasional sub-rounded gravel. Topsoil
0.50	Dry, brown, DENSE to VERY DENSE, intact, silty sand with occasional gravel. Colluvium
2.20	Dry to slightly moist, brown and off-white, VERY DENSE, intact, calcretised silty sand with occasional quartzite gravel and calcrete nodules / gravel. Colluvium, part pedogenic
4.90	

NOTES:

No water seepage encountered.
Sidewalls stable.
No sample taken.
Refusal on slightly weathered, hard rock sandstone.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

ELEVATION:
X COORD: 58386
Y COORD: - 3702712

HOLE No: **TP 125**

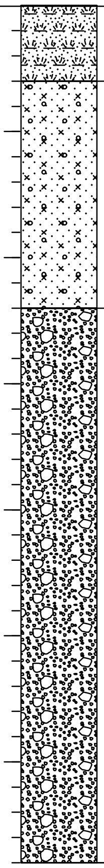
Report ID: _ZA TRAIL PIT LOG || Project: ALGOA TEST PITS GA.GPJ || Library: GINT STD AGS 4_0_SA.GLB || Date: August 12, 2019

DWS
Lower Coerney Dam Site

HOLE No: **TP 126**
Sheet 1 of 1

JOB NUMBER: **112546**

Scale
1:30



0.00	Dry, dark brown, LOOSE to MEDIUM DENSE, intact and shattered, silty sand with roots and occasional sub-rounded gravel. Topsoil
0.30	Dry, brown, DENSE to VERY DENSE, intact, silty sand with occasional gravel. Colluvium
1.20	Tightly packed, sub-rounded to sub-angular, calcretised quartzite gravel and cobbles and calcrete nodules/gravel in a matrix of brown, slightly moist, silty sand. Overall consistency is VERY DENSE with occasional big boulders. Residual terrace gravel, part pedogenic. (Mixed origin)
3.40	

NOTES:

No water seepage encountered.
Sidewalls stable.
No sample taken.
Refusal on hard rock sandstone.

CONTRACTOR: Controlab
MACHINE: Excavator - JCBJS290LC
PROFILED BY: S. Nyathi and G. Davis
TYPE SET BY:
ALGOA TEST PITS GA.GPJ

INCLINATION:
DIAM:
DATE DRILLED: 6/10/2019
DATE PROFILED:

ELEVATION:
X COORD: 58409
Y COORD: - 3702695

HOLE No: **TP 126**

Report ID: _ZA TRAIL PIT LOG || Project: ALGOA TEST PITS GA.GPJ || Library: GINT STD AGS 4_0_SA.GLB || Date: August 12, 2019

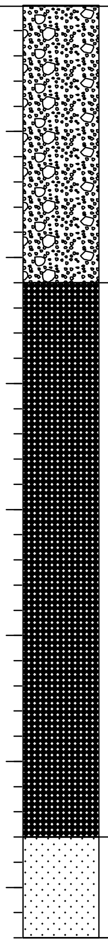
aurecon

DWS
Lower Coerney Dam Site

HOLE No: **TP 127**
Sheet 1 of 1

JOB NUMBER: **112546**

Scale
1:30



0.00	Tightly packed, dark brown and off-white, rounded to sub-angular quartzite gravel in a matrix of dry, brown, silty sand. Overall consistency is DENSE. Reworked terrace origin. (Mixed origin)
1.10	Tightly packed, brown and off-white, rounded to sub-angular, calcretised gravel in a silty sand matrix. Overall consistency is DENSE to VERY DENSE. Reworked terrace gravel, part pedogenic. (Mixed origin)
3.30	Light brown, completely to highly weathered, fine grained, SOFT to MEDIUM HARD ROCK. Sandstone
3.70	

<u>NOTES</u>:

No water seepage encountered.
Sidewalls stable.
No sample taken.
Refusal on sandstone at 3.7m.

CONTRACTOR:	Controlab	INCLINATION:		ELEVATION:	
MACHINE:	Excavator - JCBJS290LC	DIAM:		X COORD:	58029
PROFILED BY:	S. Nyathi and G. Davis	DATE DRILLED:	6/10/2019	Y COORD:	- 3702727
TYPE SET BY:		DATE PROFILED:			

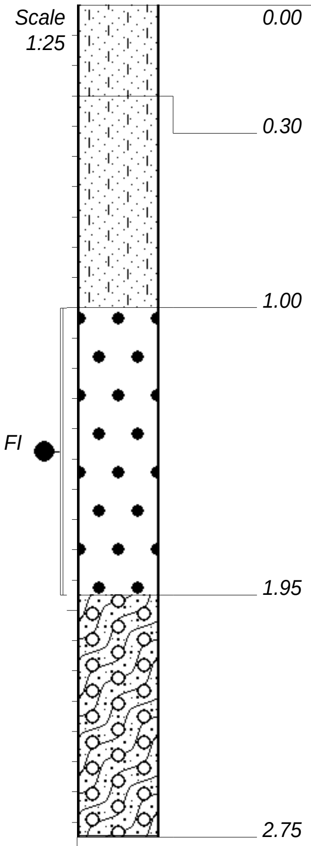
ALGOA TEST PITS GA.GPJ

HOLE No: **TP 127**

DEPARTMENT OF WATER AND SANITATION

LOWER COERNEY DAM

HOLE No: **LC02**	*Sheet 1 of 1*
JOB NUMBER: 112546	



Dry, brown, LOOSE to MEDIUM DENSE, intact to shattered, silty sand with roots.
Topsoil.

Slightly moist, reddish light brown, MEDIUM DENSE, intact with micro pinholes, silty sand with roots.
Colluvium.

Slightly moist, reddish brown, LOOSE to MEDIUM DENSE, intact with fine ferricrete nodules.
Colluvium with pedogenic action.

Tightly packed, rounded quartzite gravels and cobbles of VERY HARD ROCK with matrix of slightly moist, light brown, sand with overall consistency of loose to medium dense.
Colluvium.

END OF HOLE.

NOTES

1) Loose materials on sidewalls.
2) Profiled from surface and spoil, considering risk of failure.
3) Raveling and undercutting in gravel horizon, assume overall consistency loose to medium dense
4) No refusal.
5) No water seepage encountered.
6) FI sample taken between 1.00--1.95m

CONTRACTOR : Rennasance Construction
MACHINE : JCB 3DX
DRILLED BY : LAWRENCE
PROFILED BY : DM & GD

TYPE SET BY : DM
SETUP FILE : AURETP.SET

INCLINATION :
DIAM :
DATE :
DATE : 17/05/2018

DATE : 14/12/2018 12:21
TEXT : ..ns\Logs\112546LogsDM.doc

ELEVATION : 86m
X-COORD : 25°37’30.00"E
Y-COORD : 33°26’56.00"S

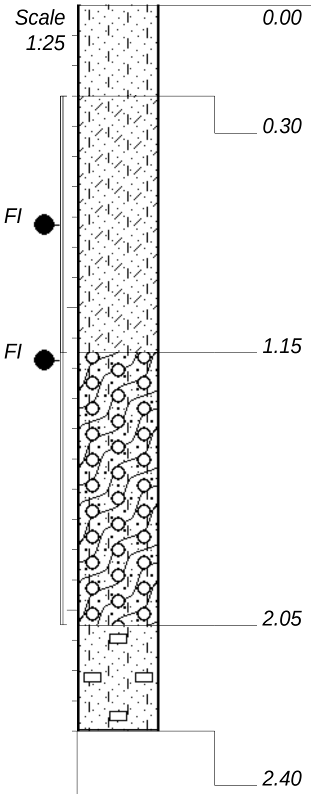
HOLE No: **LC02**
Right Flank

DEPARTMENT OF WATER AND SANITATION

LOWER COERNEY DAM

HOLE No: **LC03**
Sheet 1 of 1

JOB NUMBER: 112546



0.00	Dry, brown, VERY LOOSE to MEDIUM DENSE, intact to shattered, silty fine to medium sand with roots. Topsoil.
0.30	Slightly moist, brown, DENSE, intact, clayey silty sand with roots. Colluvium.
1.15	Slightly moist, light brown, MEDIUM DENSE to DENSE, intact with micro pinholes, silty fine sand with fine to coarse mostly sub-rounded and occasionally angular quartzite gravel and roots. Colluvium.
2.05	Slightly moist, light brown, DENSE, intact with micro pinholes, silty fine sand and calcrete (honeycomb powder patches with medium calcrete nodules). Colluvium, part pedogenic.
2.40	END OF HOLE.

NOTES

1) No water seepage encountered.
2) FI, Shear box, and Relative density sample taken between 0.30--1.15m.
3) FI and MOD/AASHTO sample taken between 0.30--2.05m.
4) Stable sidewalls.
5) No refusal.

CONTRACTOR : Rennasance Construction
MACHINE : JCB 3DX
DRILLED BY : LAWRENCE
PROFILED BY : DM & GD

TYPE SET BY : DM
SETUP FILE : AURETP.SET

INCLINATION :
DIAM :
DATE :
DATE : 17/05/2018

DATE : 14/12/2018 12:21
TEXT : ..ns\Logs\112546LogsDM.doc

ELEVATION : 86m
X-COORD : 25°37’32.90"E
Y-COORD : 33°26’53.50"S

HOLE No: **LC03**
River Section

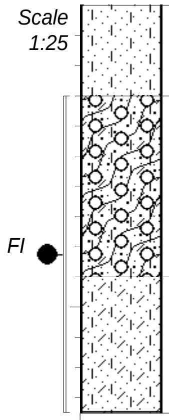
DEPARTMENT OF WATER AND SANITATION

LOWER COERNEY DAM

HOLE No: **LC04**
Sheet 1 of 1

JOB NUMBER: 112546

Scale 1:25



0.00	Dry, dark brown, DENSE, shattered, silty sand. Topsoil with roots.
0.30	Dry, brown, VERY DENSE, intact, clayey silty sand with medium to coarse angular to sub-rounded quartzite gravels and occasionally rounded quartzite cobbles and roots. Alluvium.
0.90	Slightly moist, greyish brown, VERY DENSE, intact, silty clayey sand. Alluvium.
1.35	END OF HOLE.

NOTES

1) No water seepage encountered.
2) Stable sidewalls.
3) FI and MOD/AASHTO sample taken between 0.30--1.35m
4) Near refusal at 1.35m

CONTRACTOR : Rennasance Construction
MACHINE : JCB 3DX
DRILLED BY : LAWRENCE
PROFILED BY : DM & GD

INCLINATION :
DIAM :
DATE :
DATE : 17/05/2018

ELEVATION : 84m
X-COORD : 25°37’31.10"E
Y-COORD : 33°26’54.60"S

HOLE No: **LC04**
River Section

TYPE SET BY : DM
SETUP FILE : AURETP.SET

DATE : 14/12/2018 12:21
TEXT : ..ns\Logs\112546LogsDM.doc

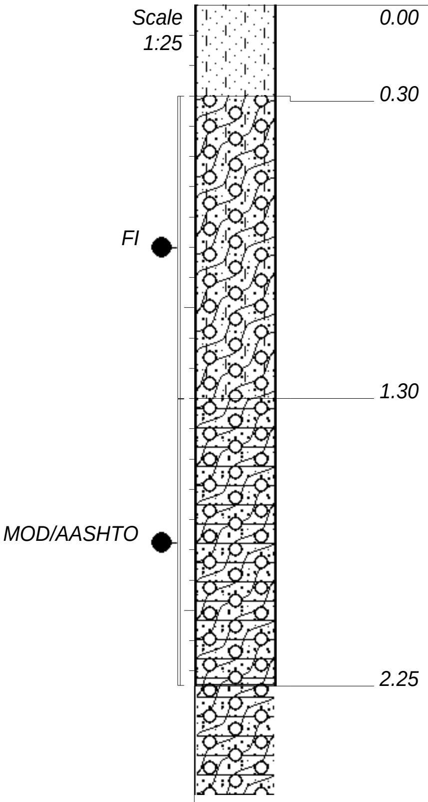
aurecon

DEPARTMENT OF WATER AND SANITATION

LOWER COERNEY DAM

HOLE No: **LC05**
Sheet 1 of 1

JOB NUMBER: 112546



Dry, brown, MEDIUM DENSE, shattered, silty sand with roots.
Topsoil.

Slightly moist to dry, light brown, MEDIUM DENSE to DENSE, intact with macro pinholes, silty fine sand with medium angular to sub-rounded quartzite gravel and occasional rounded quartzite cobbles and roots.
Mixed origin.

Slightly moist to dry, light brown, LOOSE to DENSE, intact, sand with coarse quartzite gravel and quartzite cobbles and occasional sandstone.
Potentially alluvium

END OF HOLE.

Note: Alternating horizons and stringers with lenses of LOOSE, medium to coarse sand, tight packed (clast supported), round to sub-round medium to coarse quartzite gravel, occasional cobbles (mainly) of VERY HARD ROCK and rare fragments of sandstone.
Alluvium.
Overall consistency is DENSE.

NOTES

1) Stable sidewalls.
2) No refusal.
3) No water seepage encountered.
4) FI sample taken between 0.30--1.30m.
5) MOD/AASHTO sample taken between 1.30--2.25m.

CONTRACTOR : Rennasance Construction
MACHINE : JCB 3DX
DRILLED BY : LAWRENCE
PROFILED BY : DM & GD

INCLINATION :
DIAM :
DATE :
DATE : 17/05/2018

ELEVATION : 86m
X-COORD : 25°37’30.13"E
Y-COORD : 33°26’53.10"S

TYPE SET BY : DM
SETUP FILE : AURETP.SET

DATE : 14/12/2018 12:21
TEXT : ..ns\Logs\112546LogsDM.doc

HOLE No: **LC05**
River Section

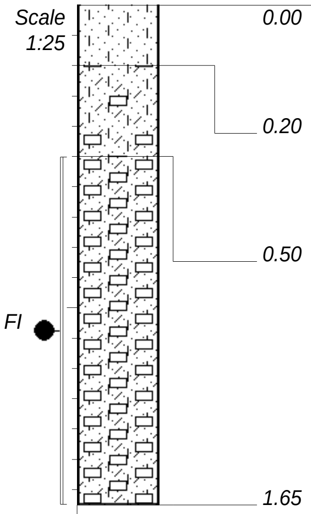
DEPARTMENT OF WATER AND SANITATION

LOWER COERNEY DAM

HOLE No: **LC06**
Sheet 1 of 1

JOB NUMBER: 112546

Scale 1:25



Dry, brown, MEDIUM DENSE, blocky to micro blocky with occasional animal burrows or pinholes, silty sand with roots.
Topsoil.

Dry, reddish brown, DENSE, intact, slightly clayey silty sand with minor fine calcrete nodules and roots.
Colluvium.

Slightly moist, dark brown to reddish brown mottled whitish, DENSE to VERY DENSE, intact, slightly clayey silty sand with scattered calcrete accretion (generally powder to honeycomb, occasionally associated with nodules).
Colluvium, part pedogenic.

END OF HOLE.

NOTES

1) Stable sidewalls.
2) No water seepage encountered.
3) No refusal, very slow excavation at 1.65m.
4) FI and MOD/AASHTO sample taken between 0.50--1.65m.

CONTRACTOR : Rennasance Construction
MACHINE : JCB 3DX
DRILLED BY : LAWRENCE
PROFILED BY : DM & GD

INCLINATION :
DIAM :
DATE :
DATE : 18/05/2018

ELEVATION : 96m
X-COORD : 25°37’38.02"E
Y-COORD : 33°26’48.75"S

TYPE SET BY : DM
SETUP FILE : AURETP.SET

DATE : 14/12/2018 12:21
TEXT : ..ns\Logs\112546LogsDM.doc

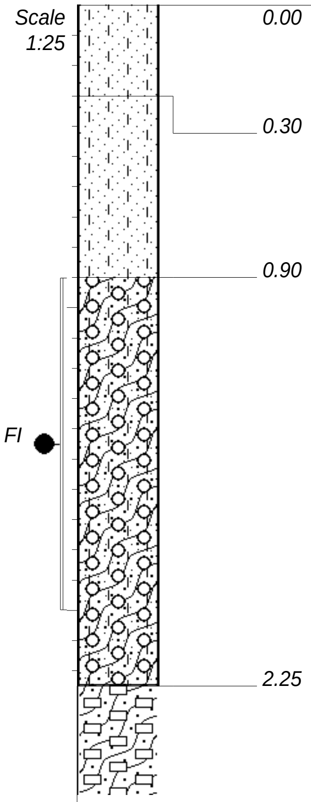
HOLE No: **LC06**
Left Flank

DEPARTMENT OF WATER
AND SANITATION

LOWER COERNEY DAM

HOLE No: **LC07**
Sheet 1 of 1

JOB NUMBER: 112546



Dry, brown, MEDIUM DENSE, shattered with macro pinholes, silty sand with roots.
Topsoil.

Slightly moist, light brown, MEDIUM DENSE to DENSE, intact, silty sand with roots.
Alluvium.

Slightly moist, yellow brown, LOOSE to MEDIUM DENSE, intact with macro pinholes, silty fine sand with medium to coarse sub-angular to sub-rounded quartzite gravel.
Alluvium.

END OF HOLE:

Note: near to refusal at concreted macro pinhole honeycomb calcrete and loose sub-angular to sub-rounded quartzite gravel.
Overall consistency is DENSE to VERY DENSE, intact but pinholed, calcretised sand (calcrete honeycomb across calcrete aggregated into becoming harden in places).

NOTES
1) No water seepage encountered.

2) Stable sidewalls.

3) FI sample taken between 0.90--2.00m.

4) Near refusal.

CONTRACTOR : Rennasance Construction
MACHINE : JCB 3DX
DRILLED BY : LAWRENCE
PROFILED BY : DM & GD

TYPE SET BY : DM
SETUP FILE : AURETP.SET

INCLINATION :
DIAM :
DATE :
DATE : 17/05/2018

DATE : 14/12/2018 12:21
TEXT : ..ns\Logs\112546LogsDM.doc

ELEVATION : 84
X-COORD : 25°37’32.49"E
Y-COORD : 33°26’56.31"S

HOLE No: **LC07**
River Section

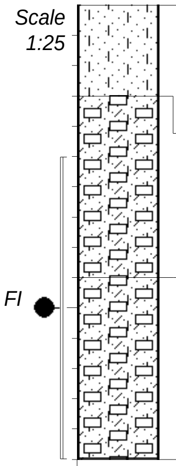
DEPARTMENT OF WATER AND SANITATION

LOWER COERNEY DAM

HOLE No: **LC08**
Sheet 1 of 1

JOB NUMBER: 112546

Scale 1:25



0.00	Dry, brown, MEDIUM DENSE, occasionally loose, intact with fine pinholes, silty sand with roots. Topsoil.
0.30	Slightly moist, pale orange brown, MEDIUM DENSE to DENSE, intact with minor pinholes, slightly clayey silty sand with calcrete accretion. Colluvium, part pedogenic.
0.90	Slightly moist, red brown, DENSE to VERY DENSE, intact, slightly clayey silty sand with minor calcrete accretions. Colluvium, part pedogenic.
1.50	END OF HOLE.

NOTES

1) Stables sidewalls.
2) No water seepage encountered.
3) FI and MOD/AASHTO sample taken between 0.50--1.50m.
4) No refusal, very slow excavation at 1.50m.

CONTRACTOR : Rennasance Construction
MACHINE : JCB 3DX
DRILLED BY : LAWRENCE
PROFILED BY : DM & GD

INCLINATION :
DIAM :
DATE :
DATE : 18/05/2018

ELEVATION : 103m
X-COORD : 25°37’41.20"E
Y-COORD : 33°26’46.70"S

TYPE SET BY : DM
SETUP FILE : AURETP.SET

DATE : 14/12/2018 12:21
TEXT : ..ns\Logs\112546LogsDM.doc

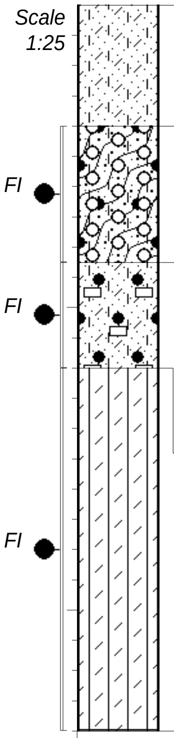
HOLE No: **LC08**
Left Flank

DEPARTMENT OF WATER AND SANITATION

LOWER COERNEY DAM

HOLE No: **LC09**
Sheet 1 of 1

JOB NUMBER: 112546



0.00

Dry, brown, LOOSE to MEDIUM DENSE, intact to shattered, silty clayey sand with roots.
Topsoil.

0.40

Slightly moist, orange brown, MEDIUM DENSE to DENSE, intact, silty sand with minor fine angular and occasional sub-rounded medium quartzite gravel with occasional fine ferricrete nodules and roots.
Colluvium, part pedogenic.

0.85

Slightly moist, orange, DENSE to VERY DENSE, intact with macro pinholes, clayey silty sand with ferruginised ferricrete and calcrete nodules.
Colluvium, part pedogenic.

1.20

Slightly moist, reddish brown, VERY STIFF, intact, clayey silt.
Mixed origin

2.40

END OF HOLE.

NOTES

1) No water seepage encountered.
2) Stable sidewalls.
3) FI and MOD/AASHTOO sample taken between 1.20--2.40m.
4) FI sample taken between 0.85--1.20m.
5) FI sample taken between 0.40--0.85m.

CONTRACTOR : Rennasance Construction
MACHINE : JCB 3DX
DRILLED BY : LAWRENCE
PROFILED BY : DM & GD
TYPE SET BY : DM
SETUP FILE : AURETP.SET

INCLINATION :
DIAM :
DATE :
DATE : 17/05/2018
DATE : 14/12/2018 12:21
TEXT : ..ns\Logs\112546LogsDM.doc

ELEVATION : 94m
X-COORD : 25°37’35.80"E
Y-COORD : 33°26’50.60"S

HOLE No: **LC09**
River Section

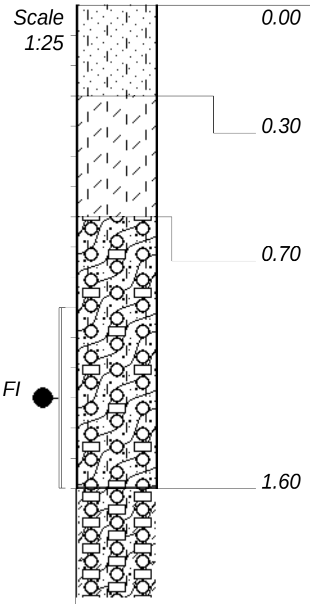
DEPARTMENT OF WATER AND SANITATION

LOWER COERNEY DAM

HOLE No: **LC10**
Sheet 1 of 1

JOB NUMBER: 112546

Scale 1:25



Dry, brown, LOOSE to MEDIUM DENSE, intact with macro pinholes, silty sand with roots.
Topsoil.

Slightly moist, reddish brown, VERY DENSE to DENSE, intact with minor pinholes, clayey silty with roots.
Colluvium.

Slightly moist, dark reddish brown, DENSE TO VERY DENSE, intact, silty sand with calcrete nodules and occasional honeycomb calcrete (lessening towards base) and medium sub-rounded quartzite gravel of VERY HARD ROCK.
Colluvium, part pedogenic.

END OF HOLE:

Note: Very difficult or slow excavation, cemented calcrete, VERY DENSE, clayey silty sand with loosely packed medium to coarse sub-rounded quartzite gravels of VERY HARD ROCK.
Colluvium.

NOTES

1) Stable sidewalls.
2) No water seepage encountered.
3) FI sample taken between 1.00--1.60m.
4) No refusal, slow excavation at 1.60m.

CONTRACTOR : Rennasance Construction
MACHINE : JCB 3DX
DRILLED BY : LAWRENCE
PROFILED BY : DM & GD

INCLINATION :
DIAM :
DATE :
DATE : 18/05/2018

ELEVATION : 107m
X-COORD : 25°37’42.95"E
Y-COORD : 33°26’46.30"S

HOLE No: **LC10**
Left Flank

TYPE SET BY : DM
SETUP FILE : AURETP.SET

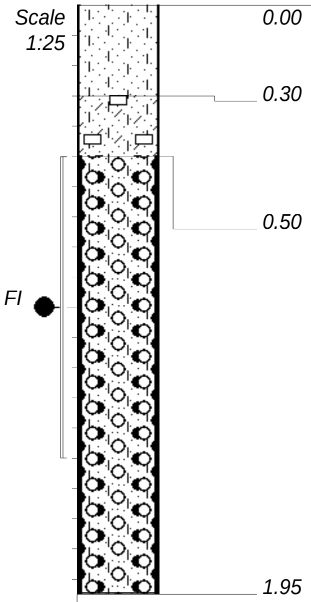
DATE : 14/12/2018 12:21
TEXT : ..ns\Logs\112546LogsDM.doc

DEPARTMENT OF WATER AND SANITATION

LOWER COERNEY DAM

HOLE No: **LC11**
Sheet 1 of 1

JOB NUMBER: 112546



Dry, light brown, DENSE, intact with pinholes, <u>silty sand</u> with roots.
Topsoil.

Dry, orange brown, DENSE, intact, slightly <u>clayey silty sand</u> with scattered <u>calcrete</u> nodules and diffuse <u>calcretisation</u> and fine roots.
Colluvium.

<u>Ferruginised sand</u>, near <u>hardpan ferricrete</u>. Dry, red-brown mottled black, intact, VERY DENSE, <u>silty</u> to <u>sandy gravel</u> (nodules).
Pedogenic.

END OF HOLE.

NOTES

1) Stable sidewalls.
2) No water seepage encountered.
3) FI and MOD/AASHTO compaction sample taken between 0.50--1.50m.
4) No refusal, slow excavation at 1.95m.

CONTRACTOR : Rennasance Construction
MACHINE : JCB 3DX
DRILLED BY : LAWRENCE
PROFILED BY : DM & GD

TYPE SET BY : DM
SETUP FILE : AURETP.SET

INCLINATION :
DIAM :
DATE :
DATE : 18/05/2018

DATE : 14/12/2018 12:21
TEXT : ..ns\Logs\112546LogsDM.doc

ELEVATION : 92m
X-COORD : 25°37’40.42"E
Y-COORD : 33°26’52.18"S

HOLE No: **LC11**
Left Flank

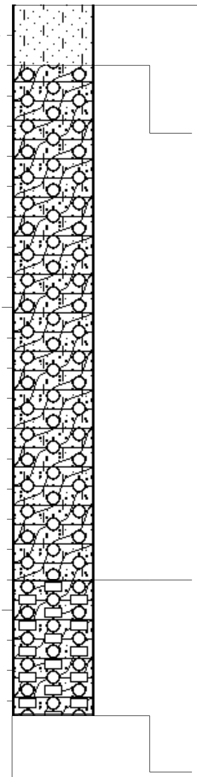
DEPARTMENT OF WATER AND SANITATION

LOWER COERNEY DAM

HOLE No: **LC12**
Sheet 1 of 1

JOB NUMBER: 112546

Scale 1:25



0.00

Dry, light brown, MEDIUM DENSE occasional DENSE, intact to shattered with pinholes, silty sand with roots.
Topsoil.

0.20

Dry, orange brown, DENSE, intact, silty sand with occasional scattered generally medium to coarse quartzite cobbles/ gravels of VERY HARD ROCK and minor sandstone.
Colluvium.

1.90

Tightly packed generally comprising fine to coarse sub-rounded quartzite gravel and occasional cobbles of VERY HARD ROCK, occasional MEDIUM HARD ROCK sandstone with matrix of fine to coarse sand and traces of calcrete.
Alluvium.

2.35

END OF HOLE.

NOTES

1) Sidewalls stable.

2) No water seepage encountered.

3) No sample taken.

4) Refusal on boulders at 2.35m.

CONTRACTOR : Rennasance Construction
MACHINE : JCB 3DX
DRILLED BY : LAWRENCE
PROFILED BY : DM & GD

INCLINATION :
DIAM :
DATE :
DATE : 18/05/2018

ELEVATION : 84m
X-COORD : 25°37'39.45"E
Y-COORD : 33°26'57.59"S

HOLE No: **LC12**
River Section

TYPE SET BY : DM
SETUP FILE : AURETP.SET

DATE : 14/12/2018 12:21
TEXT : ..ns\Logs\112546LogsDM.doc

aurecon

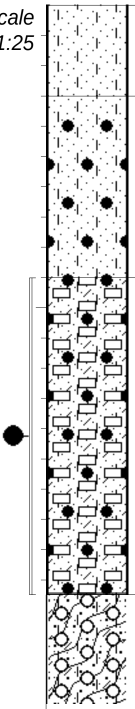
DEPARTMENT OF WATER AND SANITATION

LOWER COERNEY DAM

HOLE No: **LC20**
Sheet 1 of 1

JOB NUMBER: 112546

Scale 1:25



0.00	Dry, brown, MEDIUM DENSE, intact to blocky, silty sand with roots. Topsoil.
0.30	Dry, red brown, DENSE, intact, ferruginised silty sand with minor fine ferricrete nodules. Colluvium, partly pedogenic.
0.90	Slightly moist, dark red-brown, VERY DENSE, intact, ferruginised slightly clayey silty sand with fine ferricrete nodules, also scattered calcrete accretions with medium irregular nodules. Pedogenic.
1.95	END OF HOLE. Note: Ferruginised clayey silty sand with medium to coarse quartzite sub-rounded gravels of VERY HARD ROCK in places tending to hardpan (aggregated nodules).

NOTES

1) No refusal, very slow excavation at 1.95m.

2) No water seepage encountered.

3) Stable sidewalls.

4) FI and MOD/AASHTO compaction sample taken between 0.90--1.95m.

CONTRACTOR : Rennasance Construction
MACHINE : JCB 3DX
DRILLED BY : LAWRENCE
PROFILED BY : DM & GD

TYPE SET BY : DM
SETUP FILE : AURETP.SET

INCLINATION :
DIAM :
DATE :
DATE : 18/05/2018

DATE : 14/12/2018 12:21
TEXT : ..ns\Logs\112546LogsDM.doc

ELEVATION : 97m
X-COORD : 33°26’38.34"S
Y-COORD : 25°37’31.93"E

HOLE No: **LC20**
Basin Area

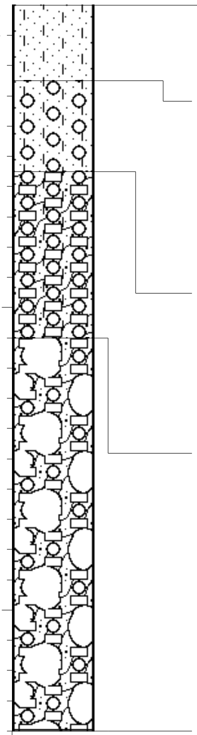
DEPARTMENT OF WATER AND SANITATION

LOWER COERNEY DAM

HOLE No: **LC22**
Sheet 1 of 1

JOB NUMBER: 112546

Scale 1:25



0.00	Dry, brown, MEDIUM DENSE, intact with pinholes, silty sand and roots. Topsoil.
0.25	Dry, pale orange, DENSE, intact, silty sand. Colluvium. Note: At 0.55m poorly developed, LOOSELY packed, medium to coarse, sub-angular to sub-rounded quartzite gravels (not pebble marker).
0.55	Dry, pale orange, DENSE, intact, silty sand with occasional medium to coarse sub-round quartzite gravels of VERY HARD ROCK with calcrete accretions more abundant near base. Terrace gravel, partly pedogenic.
1.10	Tightly packed, medium to coarse rounded to sub-rounded quartzite gravels and occasional cobbles and boulders of VERY HARD ROCK with occasional calcrete within horizon, matrix of VERY DENSE, sand. Terrace gravel, partly pedogenic.
2.40	END OF HOLE.

NOTES

1) No water seepage encountered.

2) No sample taken.

3) Stable sidewalls with caving.

4) Assessed refusal, on spoil, pieces of hardpan calcrete to cemented gravels and cobbles.

CONTRACTOR : Rennasance Construction
MACHINE : JCB 3DX
DRILLED BY : LAWRENCE
PROFILED BY : DM & GD

INCLINATION :
DIAM :
DATE :
DATE : 18/05/2018

ELEVATION : 89m
X-COORD : 25°37’20.34"E
Y-COORD : 33°26’40.45"S

TYPE SET BY : DM
SETUP FILE : AURETP.SET

DATE : 14/12/2018 12:21
TEXT : ..ns\Logs\112546LogsDM.doc

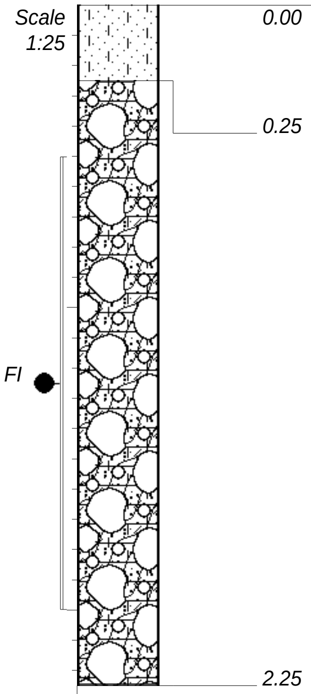
HOLE No: **LC22**
Basin Area

DEPARTMENT OF WATER
AND SANITATION

LOWER COERNEY DAM

HOLE No: **LC23**
Sheet 1 of 1

JOB NUMBER: 112546



Dry, brown, MEDIUM DENSE to DENSE, intact with micro pinholes, slightly silty sand and roots.
Topsoil.

Dry, light brown, MEDIUM DENSE, intact, slightly clayey silty sand with loosely packed angular to sub-rounded fine to coarse quartzite gravel and occasional medium sandstone gravel up to 1.10m depth and occasional sub-rounded boulders (200 - 300mm diameter) and medium to coarse sandstone gravel beyond 1.10m.
Terrace gravel.

END OF HOLE.

NOTES

1) No water seepage encountered.
2) FI, Proctor compaction and shear box sample taken between 0.50--2.00m.
3) No refusal.
4) Stable sidewalls.

CONTRACTOR : Rennasance Construction
MACHINE : JCB 3DX
DRILLED BY : LAWRENCE
PROFILED BY : DM & GD

INCLINATION :
DIAM :
DATE :
DATE : 18/05/2018

ELEVATION : 94m
X-COORD : 25°37’15.33"E
Y-COORD : 33°26’40.96"S

HOLE No: **LC23**
Basin Area

TYPE SET BY : DM
SETUP FILE : AURETP.SET

DATE : 14/12/2018 12:21
TEXT : ..ns\Logs\112546LogsDM.doc

Appendix E:
Laboratory test data

ControLab South Africa (Pty) Ltd
201000682907
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
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HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7859, Fax: 043 726 7426
CENTRAL LABORATORY: 10 St Pauls Road, East London, 5201, Tel: 043 722 5420 / 722 8565, Fax 043 743 9942, P O Box 346, East London, 5200
OTHER BRANCH OFFICES: Cape Town, Kokstad, Johannesburg, Mthatha, Queenstown, Lusaka - Zambia

CLIENT : Aurecon South Africa (Pty) Ltd
P O Box 494
CAPE TOWN
8000
ATT: Mr S Nyathi

PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-22
DATE REPORTED: 2019-08-02
TEST REPORT NO.: 95506

MATERIALS TEST REPORT

SAMPLE NO:	3460	3466	3467	3474	3475	
POSITION / CHAINAGE	TP 105	TP 111	TP 113	TP 120	TP 121	
DEPTH	1,0 - 3,6	2,2 - 3,9	0,4 - 4,5	0,8 - 2,6	0,4 - 2,8	
DESCRIPTION	lt R O	lt R O	lt R O	lt R O	lt R O	
	cly s	cly s	cly s	sdy slt	cly s	

Sieve Analysis (Wet Preparation) SANS 3001 - Part AG1

% PASSING 75 mm						
63 mm						
50 mm						
37.5 mm						
28 mm						
20 mm						
14 mm						
5 mm						
2.00 mm						
0.425 mm						
0.075 mm						

Soil Mortar Analysis - SANS 3001 - PR5

COURSE SAND (%)						
FINE SAND (%)						
SILT / CLAY (%)						
GRADING MODULUS						

Atterberg Limits - SANS 3001 - GR10 & GR11

LIQUID LIMIT (%)						
PLASTICITY INDEX (%)						
LINEAR SHRINKAGE (%)						

Maximum Dry Density & Optimum Moisture Content - SANS 3001 - GR30 / California Bearing Ratio - SANS 3001 - GR40

Proctor Dry Density (kg/m^3)	1776	1962	1803	1872	1874	
Optimum Moisture Content (%)	15.7	10.6	14.9	14.3	14.4	
C.B.R. @ 100% COMPACTION						
C.B.R. @ 98 % COMPACTION						
C.B.R. @ 95 % COMPACTION						
C.B.R. @ 93 % COMPACTION						
C.B.R. @ 90 % COMPACTION						
SWELL @ 100% COMP. (%)						
T R H 14 CLASSIFICATION						

Technical Signatory:
J Atterbury

Remarks:
Sample Delivered by Customer ☒
Sampled by Controlab ☐

Page 1 of 1

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

CLIENT : Aurecon South Africa (Pty) Ltd
P O Box 494
CAPE TOWN
8000
ATT: Mr S Nyathi

PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-24
DATE REPORTED: 2019-08-06
TEST REPORT NO.: 95506

MATERIALS TEST REPORT

SAMPLE NO:	3457	3461	3462	3463		
POSITION / CHAINAGE	TP 101	TP 106	TP 108	TP 109		
DEPTH	3,3 - 3,7	1,6 - 3,1	0,6 - 2,2	0,7 - 4,1		
DESCRIPTION	dk R	lt Ol	lt R O	lt R O		
	sdy st	Ms	Calc +	cly s		
			cly s			

Sieve Analysis (Wet Preparation) SANS 3001 - Part AG1

% PASSING 75 mm						
63 mm						
50 mm						
37.5 mm						
28 mm						
20 mm						
14 mm						
5 mm						
2.00 mm						
0.425 mm						
0.075 mm						

Soil Mortar Analysis - SANS 3001 - PR5

COURSE SAND (%)						
FINE SAND (%)						
SILT / CLAY (%)						
GRADING MODULUS						

Atterberg Limits - SANS 3001 - GR10 & GR11

LIQUID LIMIT (%)						
PLASTICITY INDEX (%)						
LINEAR SHRINKAGE (%)						

Maximum Dry Density & Optimum Moisture Content - SANS 3001 - GR30 / California Bearing Ratio - SANS 3001 - GR40

Proctor Dry Density (kg/m^3)	1990	1966	1773	1786		
Optimum Moisture Content (%)	10.6	11.4	9.3	16.3		
C.B.R. @ 100% COMPACTION						
C.B.R. @ 98 % COMPACTION						
C.B.R. @ 95 % COMPACTION						
C.B.R. @ 93 % COMPACTION						
C.B.R. @ 90 % COMPACTION						
SWELL @ 100% COMP. (%)						
T R H 14 CLASSIFICATION						

Technical Signatory:
J Atterbury

Remarks:
Sample Delivered by Customer ☒
Sampled by Controlab ☐

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CLIENT : Aurecon South Africa (Pty) Ltd
P O Box 494
CAPE TOWN
8000
ATT: Mr S Nyathi

PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-24
DATE REPORTED: 2019-08-06
TEST REPORT NO.: 95506

MATERIALS TEST REPORT

SAMPLE NO:	3468	3470	3471	3473	3476	
POSITION / CHAINAGE	TP 115	TP 116	TP 117	TP 119	TP 22	
DEPTH	0,4 - 2,4	0,4 - 4,8	2,6 - 3,3	0,8 - 2,2	0,3 - 1,3	
DESCRIPTION	dk O	dk R Br	dk Ol	dk R O	dk R O	
	cly s	cly s	Sh +	cly s	sdy st	
			cly s			

Sieve Analysis (Wet Preparation) SANS 3001 - Part AG1

% PASSING 75 mm						
63 mm						
50 mm						
37.5 mm						
28 mm						
20 mm						
14 mm						
5 mm						
2.00 mm						
0.425 mm						
0.075 mm						

Soil Mortar Analysis - SANS 3001 - PR5

COURSE SAND (%)						
FINE SAND (%)						
SILT / CLAY (%)						
GRADING MODULUS						

Atterberg Limits - SANS 3001 - GR10 & GR11

LIQUID LIMIT (%)						
PLASTICITY INDEX (%)						
LINEAR SHRINKAGE (%)						

Maximum Dry Density & Optimum Moisture Content - SANS 3001 - GR30 / California Bearing Ratio - SANS 3001 - GR40

Proctor Dry Density (kg/m^3)	1870	1914	1954	1812	1918	
Optimum Moisture Content (%)	13.2	11.1	12.5	14.1	10.6	
C.B.R. @ 100% COMPACTION						
C.B.R. @ 98 % COMPACTION						
C.B.R. @ 95 % COMPACTION						
C.B.R. @ 93 % COMPACTION						
C.B.R. @ 90 % COMPACTION						
SWELL @ 100% COMP. (%)						
T R H 14 CLASSIFICATION						

Technical Signatory:
J Atterbury

Remarks:
Sample Delivered by Customer ☒
Sampled by Controlab ☐

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CLIENT: Aurecon South Africa (Pty) Ltd
P O Box 494
CAPE TOWN
8000
ATT : Mr S Nyathi

PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-30
DATE REPORTED: 2019-08-02 & 2019-08-06
TEST REPORT NO.: 95506

FOUNDATION INDICATOR REPORT

SAMPLE NO	3460	3466	3467	3474	3475	
POSITION	TP 105	TP 111	TP 113	TP 120	TP 121	
DEPTH m	1,0 - 3,6	2,2 - 3,9	0,4 - 4,5	0,8 - 2,6	0,4 - 2,8	
DESCRIPTION	lt R O	lt R O	lt R O	lt R O	lt R O	
	cly s	cly s	cly s	sdy st	cly s	

SIEVE ANALYSIS % PASSING SIEVES: Method :SANS 3001-AG1

% PASSING 75 mm						
63 mm						
50 mm						
37.5 mm		100				
28 mm		94			100	
20 mm		92	100		99	
14 mm		87	98	100	98	
10 mm		83	98	99	98	
7.1 mm		81	97	99	97	
5.00 mm	100	78	97	99	96	
2.00 mm	99	72	95	98	93	
1.00 mm	99	69	95	97	90	
0.600 mm	98.0	66.0	94.0	96.0	87.0	
0.425 mm	98.0	62.0	94.0	94.0	84.0	
0.300 mm	97.0	58.0	93.0	90.0	79.0	
0.150 mm	94.0	45.0	85.0	75.0	70.0	
0.075 mm	84.0	36.0	71.0	61.0	62.0	
GRADING MODULUS	0.2	1.3	0.4	0.5	0.6	

** HYDROMETER ANALYSIS: Method: SANS 3001-GR3 **

0.060 mm	75	32	62	52	57	
0.020 mm	42	19	31	24	33	
0.006 mm	29	14	19	14	24	
0.002 mm	25	12	16	11	21	

ATTERBERG LIMITS: Method: SANS 3001-GR10

LIQUID LIMIT	29	27	32	25	29	
PLASTICITY INDEX	14	11	16	8	14	
LINEAR SHRINKAGE	7.0	5.5	8.5	4.0	6.5	

** PREDICTION OF HEAVE (VAN DER MERWE METHOD) **

MOISTURE CONTENT	11.4	6.1	8.7	6.8	7.6	
PERCENT DISPERSION %	28.6	18.5	34.2	4.8	20.2	
DEGREE OF DISPERSION	Non	Non	Intermediate	Non	Non	
	Dispersive	Dispersive		Dispersive	Dispersive	

The above test results are pertinent to the samples received and tested only.
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Technical Signatory:
J Atterbury

Remarks:
Samples Delivered by Customer: YES
Sampled by Controlab

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8000
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PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-29
DATE REPORTED: 2019-08-02 & 2019-08-06
TEST REPORT NO.: 95506

FOUNDATION INDICATOR REPORT

SAMPLE NO	3456	3457	3458	3459		
POSITION	TP 101	TP 102	TP 104			
DEPTH m	3,3 - 3,7	0,4 - 1,8	0,4 - 1,3	1,3 - 2,3		
DESCRIPTION	dk R	lt R Br	lt Br	dk R		
	sdy st	sdy st	Calc +	cly s		
			cly s			

SIEVE ANALYSIS % PASSING SIEVES: Method :SANS 3001-AG1

% PASSING 75 mm						
63 mm						
50 mm						
37.5 mm			100			
28 mm			96			
20 mm			96			
14 mm			95			
10 mm			95			
7.1 mm	100		94	100		
5.00 mm	99		94	99		
2.00 mm	99	100	91	98		
1.00 mm	98	99	89	97		
0.600 mm	97.1	97.5	86.5	95.6		
0.425 mm	96.1	94.3	84.5	93.8		
0.300 mm	94.4	86.9	82.2	92.3		
0.150 mm	85.9	68.6	76.4	86.9		
0.075 mm	72.3	55.2	69.5	80.5		
GRADING MODULUS	0.3	0.5	0.6	0.3		

* *HYDROMETER ANALYSIS: Method: SANS 3001-GR3* *

0.060 mm	59	49	65	77		
0.020 mm	24	26	39	49		
0.006 mm	11	18	29	38		
0.002 mm	7	16	26	34		

ATTERBERG LIMITS: Method: SANS 3001-GR10

LIQUID LIMIT	24	17	42	42		
PLASTICITY INDEX	7	6	17	19		
LINEAR SHRINKAGE	4.0	3.0	8.0	9.0		

* *PREDICTION OF HEAVE (VAN DER MERWE METHOD)* *

MOISTURE CONTENT	6.6	4.6	3.9	9.2		
PI WHOLE SAMPLE	7.0	5.0	14.0	18.0		
POTENTIAL EXPANSIVENESS	LOW	LOW	MED	MED		

The above test results are pertinent to the samples received and tested only.
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Technical Signatory: J Atterbury

Remarks:
Samples Delivered by Customer: YES
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CLIENT: Aurecon South Africa (Pty) Ltd
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ATT : Mr S Nyathi

PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-29
DATE REPORTED: 2019-08-02 & 2019-08-06
TEST REPORT NO.: 95506

FOUNDATION INDICATOR REPORT

SAMPLE NO	3461	3462	3463	3464	3465	
POSITION	TP 106	TP 108	TP 109	TP 110		
DEPTH m	1,6 - 3,1	0,6 - 2,2	0,7 - 4,1	0,0 - 0,9	2,1 - 3,4	
DESCRIPTION	lt Ol	lt R O	lt R O	dk R	lt Br	
	Ms	Calc +	cly s	Ss +	cly s	
		cly s		sdy st		

SIEVE ANALYSIS % PASSING SIEVES: Method :SANS 3001-AG1

% PASSING 75 mm						
63 mm						
50 mm						
37.5 mm						
28 mm	100	100				
20 mm	96	96	100	100		
14 mm	94	95	99	98		
10 mm	93	93	99	95		
7.1 mm	92	89	99	93	100	
5.00 mm	90	86	99	93	99	
2.00 mm	88	75	97	91	97	
1.00 mm	87	67	96	89	95	
0.600 mm	86.7	61.4	95.6	85.4	92.8	
0.425 mm	86.1	58.2	95.0	80.7	91.4	
0.300 mm	84.7	57.1	94.6	74.0	89.5	
0.150 mm	78.9	53.0	91.6	59.4	83.7	
0.075 mm	69.6	47.9	83.0	48.6	76.4	
GRADING MODULUS	0.6	1.2	0.3	0.8	0.4	

**** HYDROMETER ANALYSIS: Method: SANS 3001-GR3 ****

0.060 mm	67	37	75	51	69	
0.020 mm	46	14	43	28	40	
0.006 mm	38	7	31	17	29	
0.002 mm	35	4	27	13	25	

ATTERBERG LIMITS: Method: SANS 3001-GR10

LIQUID LIMIT	32	34	35	CBD	39	
PLASTICITY INDEX	10	13	18	SP	13	
LINEAR SHRINKAGE	5.0	6.5	9.0	1.5	6.0	

**** PREDICTION OF HEAVE (VAN DER MERWE METHOD) ****

MOISTURE CONTENT	7.0	11.3	17.0	9.4	13.6	
PI WHOLE SAMPLE	8.0	8.0	17.0	0.0	12.0	
POTENTIAL EXPANSIVENESS	LOW	LOW	MED	LOW	MED	

The above test results are pertinent to the samples received and tested only.
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Technical Signatory: J Atterbury

Remarks:
Samples Delivered by Customer: YES
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CLIENT: Aurecon South Africa (Pty) Ltd
P O Box 494
CAPE TOWN
8000
ATT : Mr S Nyathi

PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-29
DATE REPORTED: 2019-08-02 & 2019-08-06
TEST REPORT NO.: 95506

FOUNDATION INDICATOR REPORT

SAMPLE NO	3468	3469	3470	3471	3472	3473
POSITION	TP 115		TP 116	TP 117	TP 118	TP 119
DEPTH m	0,4 - 2,4	2,4 - 4,2	0,4 - 4,8	2,6 - 3,3	0,2 - 1,2	0,8 - 2,2
DESCRIPTION	lt R O cly s	lt R Sh + sdy slt	lt R O cly s	lt Ol Sh + clay	dk R sdy st	dk R O cly s

SIEVE ANALYSIS % PASSING SIEVES: Method :SANS 3001-AG1

% PASSING 75 mm						
63 mm						
50 mm						
37.5 mm						
28 mm				100		
20 mm		100		99		
14 mm		99		92		
10 mm	100	99		84		
7.1 mm	99	99		79		
5.00 mm	99	99		77		100
2.00 mm	97	98	100	74	100	99
1.00 mm	95	97	99	73	98	99
0.600 mm	93.7	95.3	99.0	72.7	96.0	98.5
0.425 mm	92.8	93.8	98.6	72.4	93.8	97.9
0.300 mm	91.7	91.8	97.8	72.2	90.5	96.5
0.150 mm	87.2	84.1	87.7	71.5	80.7	88.1
0.075 mm	80.0	71.9	73.9	70.2	71.1	75.0
GRADING MODULUS	0.3	0.4	0.3	0.8	0.4	0.3

* *HYDROMETER ANALYSIS: Method: SANS 3001-GR3* *

0.060 mm	66	58	66	67	60	64
0.020 mm	30	23	40	41	23	31
0.006 mm	18	10	30	30	9	19
0.002 mm	14	7	27	27	6	16

ATTERBERG LIMITS: Method: SANS 3001-GR10

LIQUID LIMIT	33	25	27	32	22	26
PLASTICITY INDEX	17	8	13	15	9	10
LINEAR SHRINKAGE	8.0	4.0	6.0	7.0	4.0	5.0

* *PREDICTION OF HEAVE (VAN DER MERWE METHOD)* *

MOISTURE CONTENT	17.6	9.0	8.9	7.8	7.6	8.2
PI WHOLE SAMPLE	15.0	7.0	12.0	11.0	9.0	10.0
POTENTIAL EXPANSIVENESS	LOW	LOW	MED	LOW	LOW	LOW

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Technical Signatory: J Atterbury

Remarks:
Samples Delivered by Customer: YES
Sampled by Controlab

*** NON-ACCREDITED TESTS ***

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

CLIENT: Aurecon South Africa (Pty) Ltd
P O Box 494
CAPE TOWN
8000
ATT : Mr S Nyathi

PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-29
DATE REPORTED: 2019-08-02 & 2019-08-06
TEST REPORT NO.: 95506

FOUNDATION INDICATOR REPORT

SAMPLE NO	3476	3477				
POSITION	TP 122	TP 123				
DEPTH m	0,3 - 1,3	2,0 - 2,7				
DESCRIPTION	dk R O	dk R				
	sdy st	Calc +				
		cly s				

SIEVE ANALYSIS % PASSING SIEVES: Method :SANS 3001-AG1

% PASSING 75 mm						
63 mm						
50 mm						
37.5 mm						
28 mm		100				
20 mm		97				
14 mm		95				
10 mm		95				
7.1 mm		94				
5.00 mm		93				
2.00 mm		91				
1.00 mm	100	85				
0.600 mm	99.2	79.1				
0.425 mm	98.5	74.1				
0.300 mm	97.2	69.5				
0.150 mm	88.9	62.4				
0.075 mm	77.1	55.7				
GRADING MODULUS	0.2	0.8				

** HYDROMETER ANALYSIS: Method: SANS 3001-GR3 **

0.060 mm	66	49				
0.020 mm	33	23				
0.006 mm	20	14				
0.002 mm	17	11				

ATTERBERG LIMITS: Method: SANS 3001-GR10

LIQUID LIMIT	19	34				
PLASTICITY INDEX	7	15				
LINEAR SHRINKAGE	3.5	7.0				

** PREDICTION OF HEAVE (VAN DER MERWE METHOD) **

MOISTURE CONTENT	7.2	11.9				
PI WHOLE SAMPLE	7.0	11.0				
POTENTIAL EXPANSIVENESS	LOW	LOW				

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CLIENT: Aurecon South Africa (Pty) Ltd
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CAPE TOWN
8000
ATT : Mr S Nyathi

PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-30
DATE REPORTED: 2019-08-06
TEST REPORT NO.: 95506
O/N:

AGGREGATE ANALYSIS TEST REPORT

SAMPLE NO:	3462	3463	3466			
POSITION	TP 108	TP 109	TP 111			
DEPTH	0.6 - 2.2	0.7 - 4.1	2.2 - 3.9			
DESCRIPTION:	Calcritised	very dense	tightly packed			
	silty sand	silty sand	gravel			
	Pedogenic	Colluvium	Alluvium			

SIEVE ANALYSIS % PASSING SIEVES: Method SANS 3001: AG1

SIEVE APERTURE	**50.0 mm**						
	37.5 mm						
	28.0 mm						
	20.0 mm						
	14.0 mm						
	10.0 mm						
	7.1 mm						
	5.0 mm						
	2.0 mm						
	1.0 mm						
	0.600 mm						
	0.425 mm						
	0.300 mm						
	0.150 mm						
	0.075 mm						

MATERIAL CHARACTERISTICS

Finess Modulus	SANS 3001 PR5						
Apparent Density	SANS 3001 AG20/21	2601	2640	2633			
Loose Bulk Density	TMH1 B9						
Compacted Bulk Density	TMH1 B9						
Ave Least Dimension (ALD)	SANS 3001 AG2						
Flakiness Index	SANS 3001 AG4						
Sand Equivalent	SANS 3001 AG5						

STRENGTH TESTS

A.C.V. (%)	SANS 3001 AG10						
10 % FACT DRY (KN)	SANS 3001 AG10						
10 % FACT WET (KN)	SANS 3001 AG10						
Wet Dry Relationship (%)							

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CLIENT:	Aurecon South Africa (Pty) Ltd	**PROJECT:**	LOWER CORNEY DAM - KIRKWOOD
	P O Box 494	**DATE RECEIVED:**	2019-06-18
	CAPE TOWN	**DATE TESTED:**	2019-07-30
	8000	**DATE REPORTED:**	2019-08-06
ATT :	Mr S Nyathi	**TEST REPORT NO.:**	95506 **O/N:**

AGGREGATE ANALYSIS TEST REPORT

SAMPLE NO:	3457	3460	3461			
POSITION	TP 02	TP 105	TP 106			
DEPTH	0.4 - 1.8	1.0 - 3.6	1.6 - 3.1			
DESCRIPTION:	very dense	very dense	very soft			
	silty sand	silty sand	Rock			
	Colluvium	Colluvium	Mudstone			

SIEVE ANALYSIS % PASSING SIEVES: Method SANS 3001: AG1

SIEVE APERTURE	**50.0 mm**						
	37.5 mm						
	28.0 mm						
	20.0 mm						
	14.0 mm						
	10.0 mm						
	7.1 mm						
	5.0 mm						
	2.0 mm						
	1.0 mm						
	0.600 mm						
	0.425 mm						
	0.300 mm						
	0.150 mm						
	0.075 mm						

MATERIAL CHARACTERISTICS

Finess Modulus	SANS 3001 PR5						
Apparent Density	SANS 3001 AG20/21	2632	2611	2669			
Loose Bulk Density	TMH1 B9						
Compacted Bulk Density	TMH1 B9						
Ave Least Dimension (ALD)	SANS 3001 AG2						
Flakiness Index	SANS 3001 AG4						
Sand Equivalent	SANS 3001 AG5						

STRENGTH TESTS

A.C.V. (%)	SANS 3001 AG10						
10 % FACT DRY (KN)	SANS 3001 AG10						
10 % FACT WET (KN)	SANS 3001 AG10						
Wet Dry Relationship (%)							

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CLIENT: Aurecon South Africa (Pty) Ltd
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PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-30
DATE REPORTED: 2019-08-06
TEST REPORT NO.: 95506
O/N:

AGGREGATE ANALYSIS TEST REPORT

SAMPLE NO:	3470	3471	3473			
POSITION	TP 116	TP 117	TP 119			
DEPTH	0.4 - 4.8	2.6 - 3.3	0.8 - 2.2			
DESCRIPTION:	Ferruginised	very soft	Ferruginised			
	silty sand	Rock	silty sand			
	Pedogenic	Mudstone	Pedogenic			

SIEVE ANALYSIS % PASSING SIEVES: Method SANS 3001: AG1

SIEVE APERTURE	**50.0 mm**						
	37.5 mm						
	28.0 mm						
	20.0 mm						
	14.0 mm						
	10.0 mm						
	7.1 mm						
	5.0 mm						
	2.0 mm						
	1.0 mm						
	0.600 mm						
	0.425 mm						
	0.300 mm						
	0.150 mm						
	0.075 mm						

MATERIAL CHARACTERISTICS

Finess Modulus	SANS 3001 PR5						
Apparent Density	SANS 3001 AG20/21	2652	2679	2619			
Loose Bulk Density	TMH1 B9						
Compacted Bulk Density	TMH1 B9						
Ave Least Dimension (ALD)	SANS 3001 AG2						
Flakiness Index	SANS 3001 AG4						
Sand Equivalent	SANS 3001 AG5						

STRENGTH TESTS

A.C.V. (%)	SANS 3001 AG10						
10 % FACT DRY (KN)	SANS 3001 AG10						
10 % FACT WET (KN)	SANS 3001 AG10						
Wet Dry Relationship (%)							

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PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-08-02
DATE REPORTED: 2019-08-08
TEST REPORT NO.: 95506
O/N:

AGGREGATE ANALYSIS TEST REPORT

SAMPLE NO:	3468	3476				
POSITION	TP 115	TP 122				
DEPTH	0.4 - 2.4	0.3 - 1.3				
DESCRIPTION:	Ferruginised	very dense				
	sty and	sty sand				
	Pedogenic	Colluvium				

SIEVE ANALYSIS % PASSING SIEVES: Method SANS 3001: AG1

SIEVE APERTURE	**50.0 mm**						
	37.5 mm						
	28.0 mm						
	20.0 mm						
	14.0 mm						
	10.0 mm						
	7.1 mm						
	5.0 mm						
	2.0 mm						
	1.0 mm						
	0.600 mm						
	0.425 mm						
	0.300 mm						
	0.150 mm						
	0.075 mm						

MATERIAL CHARACTERISTICS

Finess Modulus	SANS 3001 PR5						
Apparent Density	SANS 3001 AG20/21	2674	2682				
Loose Bulk Density	TMH1 B9						
Compacted Bulk Density	TMH1 B9						
Ave Least Dimension (ALD)	SANS 3001 AG2						
Flakiness Index	SANS 3001 AG4						
Sand Equivalent	SANS 3001 AG5						

STRENGTH TESTS

A.C.V. (%)	SANS 3001 AG10						
10 % FACT DRY (KN)	SANS 3001 AG10						
10 % FACT WET (KN)	SANS 3001 AG10						
Wet Dry Relationship (%)							

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PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-06
DATE REPORTED: 2019-08-07
TEST REPORT NO.: 95506

PERMEABILITY FALLING HEAD

SAMPLE	SAMPLE DATA	O.M.C	PROCTOR	REMOULDED	PERCENT	Start	Finish	Time	PERMEABILITY
NO.	Client ID No	%	COMP	DRY DENSITY	COMPACT.	Head	Head	Sec	cm / SECOND
3471	TP117 @ 2.6 - 3.3m	12.5	1954	1860	95.2	2180	1965	10800	2.59×10^{-7}
3473	TP119 @ 0.8 - 2.2m	14.1	1812	1726	95.3	2180	1853	7200	6.07×10^{-7}
3476	TP122 @ 0.3 - 1.3m	10.6	1918	1826	95.2	2180	1869	7200	5.75×10^{-7}

DEGREE OF PERMEABILITY

over	$X 10^{-1}$	-------------	HIGH
$1 X 10^{-1}$	to $1 X 10^{-3}$	-------------	MEDIUM
$1 X 10^{-3}$	to $1 X 10^{-5}$	-------------	LOW
$1 X 10^{-5}$	to $1 X 10^{-7}$	-------------	VERY LOW
less than	$1 X 10^{-7}$	-------------	PRACTICALLY IMPERMEABLE

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PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-01
DATE REPORTED: 2019-08-02
TEST REPORT NO.: 95506

PERMEABILITY FALLING HEAD

SAMPLE	SAMPLE DATA	O.M.C	PROCTOR	REMOULDED	PERCENT	Start	Finish	Time	PERMEABILITY
NO.	Client ID No	%	COMP	DRY DENSITY	COMPACT.	Head	Head	Sec	cm / SECOND
3457	TP102 @ 0.4 - 1.8m	10.6	1990	1891	95.0	2180	630	9000	3.71×10^{-6}
3461	TP106 @ 1.6 - 3.1m	11.40	1966	1882	95.7	2180	1980	9000	2.88×10^{-7}
3462	TP108 @ 0.6 - 2.2m	9.3	1773	1690	95.3	2180	680	9000	3.48×10^{-6}

DEGREE OF PERMEABILITY

over	$X 10^{-1}$	-------------	HIGH
$1 X 10^{-1}$	to $1 X 10^{-3}$	-------------	MEDIUM
$1 X 10^{-3}$	to $1 X 10^{-5}$	-------------	LOW
$1 X 10^{-5}$	to $1 X 10^{-7}$	-------------	VERY LOW
less than	$1 X 10^{-7}$	-------------	PRACTICALLY IMPERMEABLE

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DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-02
DATE REPORTED: 2019-08-05
TEST REPORT NO.: 95506

PERMEABILITY FALLING HEAD

SAMPLE	SAMPLE DATA	O.M.C	PROCTOR	REMOULDED	PERCENT	Start	Finish	Time	PERMEABILITY
NO.	Client ID No	%	COMP	DRY DENSITY	COMPACT.	Head	Head	Sec	cm / SECOND
3463	TP109 @ 0.7 - 4.1m	16.3	1786	1700	95.2	2180	1720	9000	7.08×10^{-7}
3468	TP115 @ 0.4 - 2.4m	13.2	1870	1782	95.3	2180	1760	9000	6.40×10^{-7}
3470	TP116 @ 0.4 - 4.8m	11.1	1914	1820	95.1	2180	1980	18000	1.44×10^{-7}

DEGREE OF PERMEABILITY

over X 10^{-1} ------------ HIGH
1 X 10^{-1} to 1 X 10^{-3} ------------ MEDIUM
1 X 10^{-3} to 1 X 10^{-5} ------------ LOW
1 X 10^{-5} to 1 X 10^{-7} ------------ VERY LOW
less than 1 X 10^{-7} ------------ PRACTICALLY IMPERMEABLE

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PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-24
DATE REPORTED: 2019-08-01
TEST REPORT NO.: 95506

PINHOLE TEST - ASTM D4221-90 METHOD

SAMPLE NO: 3460
SOURCE: TP105 @ 1.0 - 3.6m
TEST CONDITIONS: Remoulded @ 95% Proctor

PROCTOR (Kg/m3): 1776
OMC %: 15.7
CLIENT DESCRIPTION: very dense sty s. Colluvium

TIME	HEAD	FLOW PARAMETERS ml.	FLOW PARAMETERS sec.	FLOW RATE ml/s	FINAL FLOWRATE ml/s	TURBIDITY FROM SIDE	HOLE SIZE AFTER TEST
0	55mm	10	17	0.588			
		20	50	0.400			
		30	76	0.395			
		50	120	0.417			
		100	210	0.476			
5min		150	300	0.500	0.500		
AVERAGE FLOWRATE		150	300	0.463		MODERATELTY DARK	2.0mm
0	180mm	10	5	2.000			
		20	10	2.000			
		30	17	1.765			
		50	26	1.923			
5min		100	60	1.667			
		200	160	1.250			
		300	200	1.500			
		400	270	1.481			
		450	300	1.500	1.500		
AVERAGE FLOWRATE		450	300	1.676		DARK	2.0mm
AVERAGE FLOWRATE							
						DISPERSIVE GRADE CLASSIFICATION	**ND3 or ND4**

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PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-24
DATE REPORTED: 2019-08-01
TEST REPORT NO.: 95506

PINHOLE TEST - ASTM D4221-90 METHOD

SAMPLE NO: 3466
SOURCE: TP111 @ 2.2 - 3.9m
TEST CONDITIONS: Remoulded @ 95% Proctor

PROCTOR (Kg/m3): 1962
OMC %: 10.6
CLIENT DESCRIPTION: tightly packed gravel. Alluvium

TIME	HEAD	FLOW PARAMETERS		FLOW RATE ml/s	FINAL FLOWRATE ml/s	TURBIDITY FROM SIDE	HOLE SIZE AFTER TEST
		ml.	sec.				
0	55mm	10	20	0.500			
		20	40	0.500			
		30	60	0.500			
		50	125	0.400			
		100	255	0.392			
5min		120	300	0.400	0.400		
AVERAGE FLOWRATE		120	300	0.449		SLIGHTLY DARK	1.5mm
0	180mm	10	6	1.667			
		20	15	1.333			
		30	25	1.200			
		50	40	1.250			
		100	85	1.176			
		200	180	1.111			
		300	290	1.034			
5min		350	300	1.167	1.167		
AVERAGE FLOWRATE		350	300	1.242		SLIGHTLY DARK	1.5mm
0	385	10	4	2.500			
		20	8	2.500			
		30	15	2.000			
		50	20	2.500			
		100	40	2.500			
		200	90	2.222			
2min		250	120	2.083	2.083		
AVERAGE FLOWRATE		250	120	2.329		MODERATLEY DARK	1.5mm
DISPERSIVE GRADE CLASSIFICATION							ND3 or ND4

Technical Signatory:
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PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-24
DATE REPORTED: 2019-08-01
TEST REPORT NO.: 95506

PINHOLE TEST - ASTM D4221-90 METHOD

SAMPLE NO: 3467
SOURCE: TP113 @ 0.4 - 4.5m
TEST CONDITIONS: Remoulded @ 95% Proctor

PROCTOR (Kg/m3): 1853
OMC %: 14.9
CLIENT DESCRIPTION: Ferruginised sty s. Pedogenic

TIME	HEAD	FLOW PARAMETERS		FLOW RATE ml/s	FINAL FLOWRATE ml/s	TURBIDITY FROM SIDE	HOLE SIZE AFTER TEST
		ml.	sec.				
0	55mm	10	10	1.000			
		20	25	0.800			
		30	50	0.600			
		50	110	0.455			
		100	235	0.426			
5min		120	300	0.400	0.400		
AVERAGE FLOWRATE		120	300	0.613		SLIGHTLY DARK	1.0mm
0	180mm	10	10	1.000			
		20	30	0.667			
		30	45	0.667			
		50	75	0.667			
		100	140	0.714			
		200	270	0.741			
5min		220	300	0.733	0.733		
AVERAGE FLOWRATE		350	300	0.741		SLIGHTLY DARK	1.0mm
0	385	10	5	2.000			
		20	10	2.000			
		30	15	2.000			
		50	30	1.667			
		100	60	1.667			
		200	170	1.176			
		300	220	1.364			
5min		400	300	1.333	1.333		
AVERAGE FLOWRATE		400	300	1.651		SLIGHTLY DARK	1.0mm
DISPERSIVE GRADE CLASSIFICATION							ND4

Technical Signatory:
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CLIENT: Aurecon SA (Pty) Ltd
P O Box 494
CAPE TOWN
8000
ATT: Mr S Nyathi

PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-24
DATE REPORTED: 2019-08-01
TEST REPORT NO.: 95506

PINHOLE TEST - ASTM D4221-90 METHOD

SAMPLE NO: 3474
SOURCE: TP120 @ 0.8 - 2.6m
TEST CONDITIONS: Remoulded @ 95% Proctor

PROCTOR (Kg/m3): 1872
OMC %: 14.3
CLIENT DESCRIPTION: Ferruginised sty s. Pedogenic

TIME	HEAD	FLOW PARAMETERS		FLOW RATE ml/s	FINAL FLOWRATE ml/s	TURBIDITY FROM SIDE	HOLE SIZE AFTER TEST
		ml.	sec.				
0	55mm	10	10	1.000			
		20	30	0.667			
		30	55	0.545			
		50	100	0.500			
		100	200	0.500			
5min		160	300	0.533	0.533		
AVERAGE FLOWRATE		120	300	0.624		SLIGHTLY DARK	1.5mm
0	180mm	10	5	2.000			
		20	10	2.000			
		30	20	1.500			
		50	40	1.250			
		100	80	1.250			
		200	160	1.250			
5min		350	300	1.167	1.167		
AVERAGE FLOWRATE		350	300	1.488		SLIGHTLY DARK	1.5mm
0	385	10	5	2.000			
		20	10	2.000			
		30	15	2.000			
		50	30	1.667			
		100	60	1.667			
		200	150	1.333			
		300	225	1.333			
5min		390	300	1.300	1.300		
AVERAGE FLOWRATE		390	300	1.663		MODERATELY DARK	1.5mm
DISPERSIVE GRADE CLASSIFICATION							**ND3 or ND4**

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PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-24
DATE REPORTED: 2019-08-01
TEST REPORT NO.: 95506

PINHOLE TEST - ASTM D4221-90 METHOD

SAMPLE NO: 3475
SOURCE: TP121 @ 0.4 - 2.8m
TEST CONDITIONS: Remoulded @ 95% Proctor

PROCTOR (Kg/m3): 1874
OMC %: 14.4
CLIENT DESCRIPTION: very dense sty s. Colluvium

TIME	HEAD	FLOW PARAMETERS ml.	sec.	FLOW RATE ml/s	FINAL FLOWRATE ml/s	TURBIDITY FROM SIDE	HOLE SIZE AFTER TEST
0	55mm	10	20	0.500			
		20	50	0.400			
		30	90	0.333			
		50	150	0.333			
5min		100	300	0.333	0.333		
AVERAGE FLOWRATE		100	300	0.380		SLIGHTLY DARK	1.5mm
0	180mm	10	10	1.000			
		20	20	1.000			
		30	30	1.000			
		50	60	0.833			
		100	120	0.833			
		200	240	0.833			
5min		250	300	0.833	0.833		
AVERAGE FLOWRATE		250	300	0.905		MODERATELY DARK	1.5mm
0	385	10	4	2.500			
		20	10	2.000			
		30	15	2.000			
		50	30	1.667			
		100	70	1.429			
		200	135	1.481			
		300	215	1.395			
5min		410	300	1.367	1.367		
AVERAGE FLOWRATE		410	300	1.730		MODERATELY DARK	1.5mm
DISPERSIVE GRADE CLASSIFICATION							**ND3 or ND4**

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DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-18
DATE REPORTED: 2019-08-01
TEST REPORT NO.: 95506

DETERMINATION OF CRUMB TEST

SAMPLE NO.	POSITION	SOLUTION	CRUMB CONDITION	TIME	CLASSIFICATION
3460	TP105 @ 1.0 - 3.6m	0.001N NaOH	AIR DRIED	10 min	1
				2 hrs	1
				>16 hrs	1
3466	TP111 @ 2.2 - 3.9m	0.001N NaOH	AIR DRIED	10 min	2
				2 hrs	2
				>16 hrs	2
3467	TP113 @ 0.4 - 4.5m	0.001N NaOH	AIR DRIED	10 min	2
				2 hrs	2
				>16 hrs	2
3474	TP120 @ 0.8 - 2.6m	0.001N NaOH	AIR DRIED	10 min	1
				2 hrs	1
				>16 hrs	1
3475	TP121 @ 0.4 - 2.8m	0.001N NaOH	AIR DRIED	11 min	1
				3 hrs	1
				>16 hrs	2

GRADE CLASSIFICATION FOR A CRUMB TEST (WALKER, 1997)

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

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

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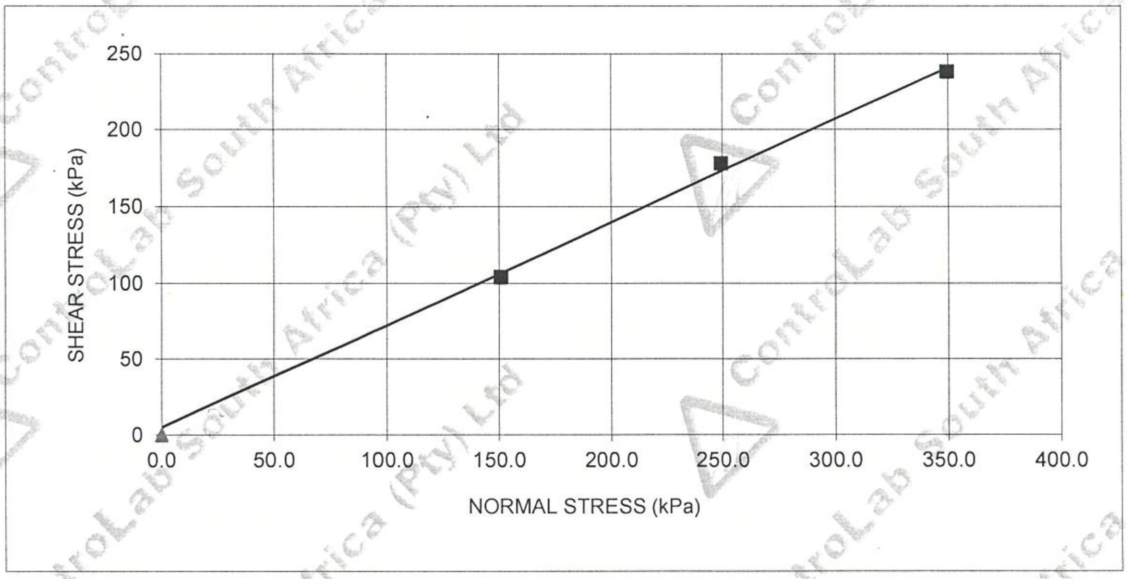
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-24
DATE REPORTED: 2019-08-01
TEST REPORT NO.: 95506.00

DIRECT SHEAR TEST (ASTM D3080)

Sample Number	31770	**Test type**	Drained Consolidated
Description		**Sample Position**	TP102 @ 0,4-1,80m
Sample Preparation	Remoulded		
Displacement Rate mm/min	0.048mm/min		
RESULTS AT START OF TEST			
Void Ratio	0.47	0.40	0.37
Moisture Content %	10.40	10.40	10.40
Dry Density	1891	1890	1891
RESULTS AT END OF TEST			
Void Ratio	0.42	0.37	0.34
Moisture Content %	15.65	14.41	13.49
PEAK SHEAR STRENGTH			
Shear Stress kPa	104.00	178.00	238.00
Normal Stress kPa	150.76	249.43	349.48



	C kPa	Degrees
Peak	4.9	34.0

Apparent angle of internal shearing resistance given by regression (°)	34.0
Apparent cohesion given by regression (kPa)	4.9

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PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-24
DATE REPORTED: 2019-08-06
TEST REPORT NO.: 95506

DIRECT SHEAR TEST (ASTM D3080)

Sample Number	31771	**Test type**	Drained Consolidated
Description		**Sample Position**	TP106 @ 1,6-3,1m
Sample Preparation	Remoulded		
Displacement Rate mm/min	0.048mm/min		

RESULTS AT START OF TEST

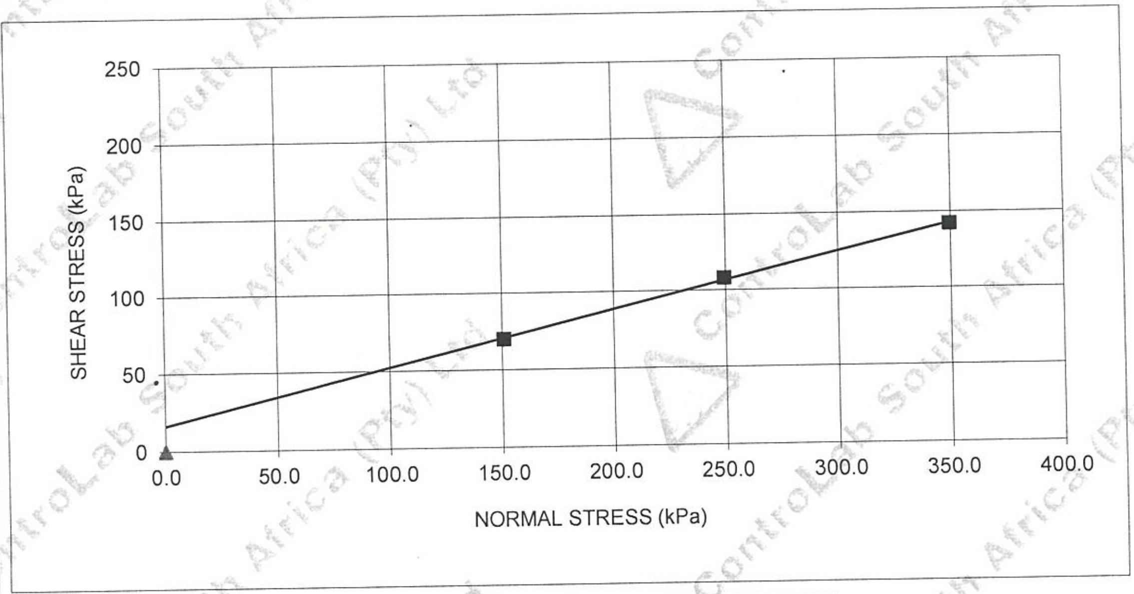
Void Ratio	0.89	0.81	1.17
Moisture Content %	11.50	11.50	11.50
Dry Density	1868	1869	1868

RESULTS AT END OF TEST

Void Ratio	0.81	0.73	0.81
Moisture Content %	23.89	22.22	22.57

PEAK SHEAR STRENGTH

Shear Stress kPa	70.00	108.00	142.00
Normal Stress kPa	150.76	249.43	349.48



	C kPa	Degrees
Peak	16.1	19.9

Apparent angle of internal shearing resistance given by regression (°)	19.9
Apparent cohesion given by regression (kPa)	16.1

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PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-30
DATE REPORTED: 2019-08-07
TEST REPORT NO.: 95506

DIRECT SHEAR TEST (ASTM D3080)

Sample Number	31773	**Test type**	Drained Consolidated
Description		**Sample Position**	TP109 @ 0,7-4,1m
Sample Preparation	Remoulded		
Displacement Rate mm/min	0.048mm/min		

RESULTS AT START OF TEST

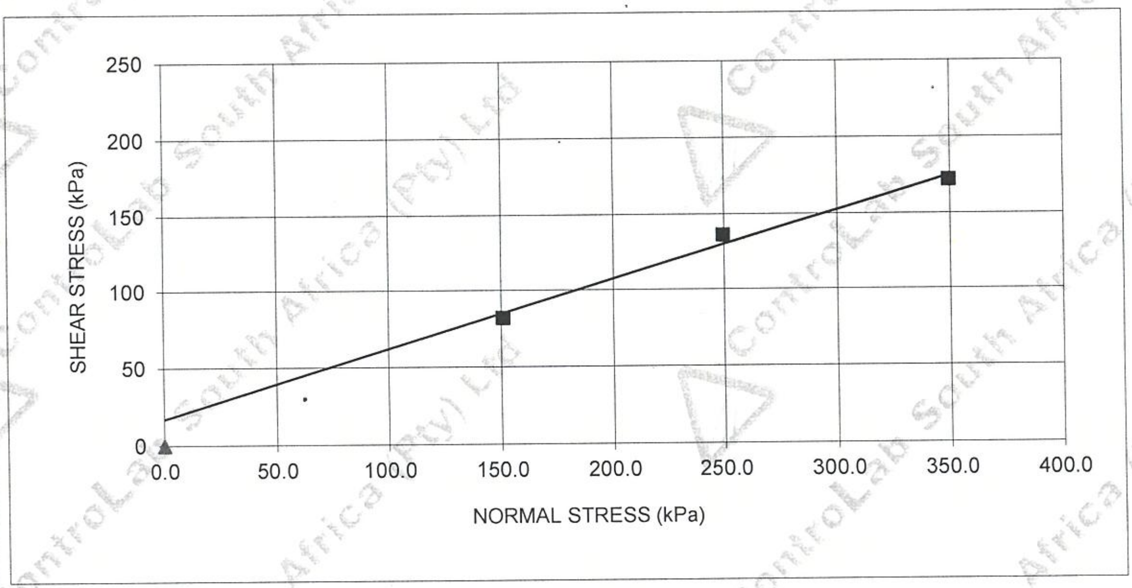
Void Ratio	0.95	0.96	0.89
Moisture Content %	17.40	17.40	17.40
Dry Density	1704	1695	1695

RESULTS AT END OF TEST

Void Ratio	0.84	0.83	0.75
Moisture Content %	27.47	26.63	25.83

PEAK SHEAR STRENGTH

Shear Stress kPa	82.00	136.00	172.00
Normal Stress kPa	150.76	249.43	349.48



	C kPa	Degrees
Peak	16.9	24.4

Apparent angle of internal shearing resistance given by regression (°)	24.4
Apparent cohesion given by regression (kPa)	16.9

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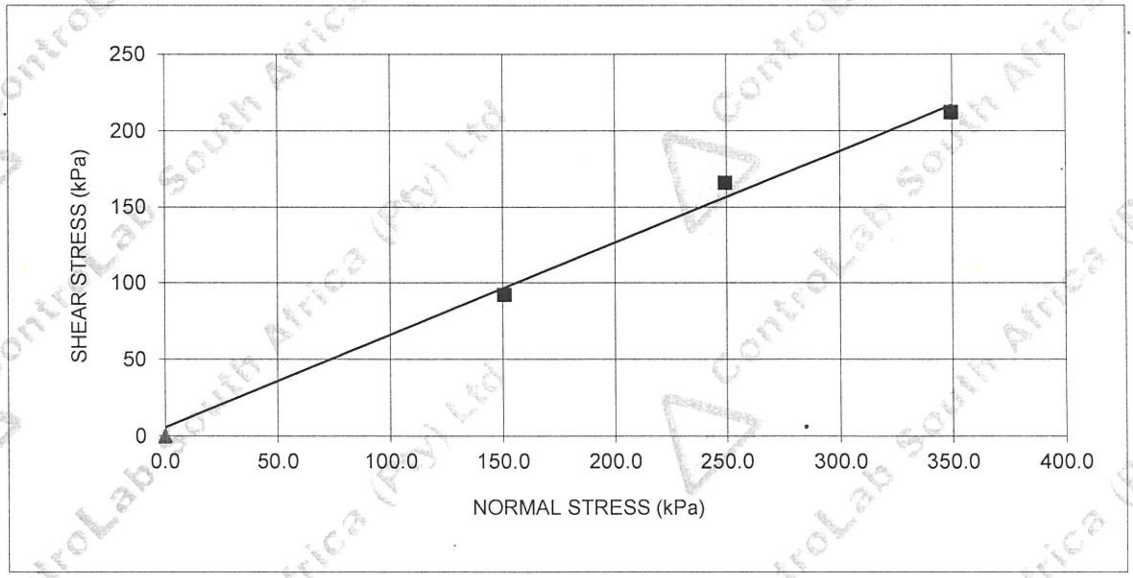
PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-07-31
DATE REPORTED: 2019-08-08
TEST REPORT NO.: 95506

DIRECT SHEAR TEST (ASTM D3080)

Sample Number	31772	**Test type**	Drained Consolidated
Description		**Sample Position**	TP108 @ 0,6-2,2m
Sample Preparation	Remoulded		
Displacement Rate mm/min		0.048mm/min	
RESULTS AT START OF TEST			
Void Ratio	1.47	1.32	1.43
Moisture Content %	12.90	12.90	12.90
Dry Density	1684	1684	16843
RESULTS AT END OF TEST			
Void Ratio	1.46	1.24	1.24
Moisture Content %	36.11	33.22	31.23
PEAK SHEAR STRENGTH			
Shear Stress kPa	92.00	166.00	212.00
Normal Stress kPa	150.76	249.43	349.48



	C kPa	Degrees
Peak	5.9	31.1

Apparent angle of internal shearing resistance given by regression (°)	31.1
Apparent cohesion given by regression (kPa)	5.9

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PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-08-08
DATE REPORTED: 2019-08-12
TEST REPORT NO.: 95506

DIRECT SHEAR TEST (ASTM D3080)

Sample Number	31774	**Test type**	Drained Consolidated
Description		**Sample Position**	TP115 @ 0,4-2,4m
Sample Preparation	Remoulded		
Displacement Rate mm/min	0.048mm/min		

RESULTS AT START OF TEST

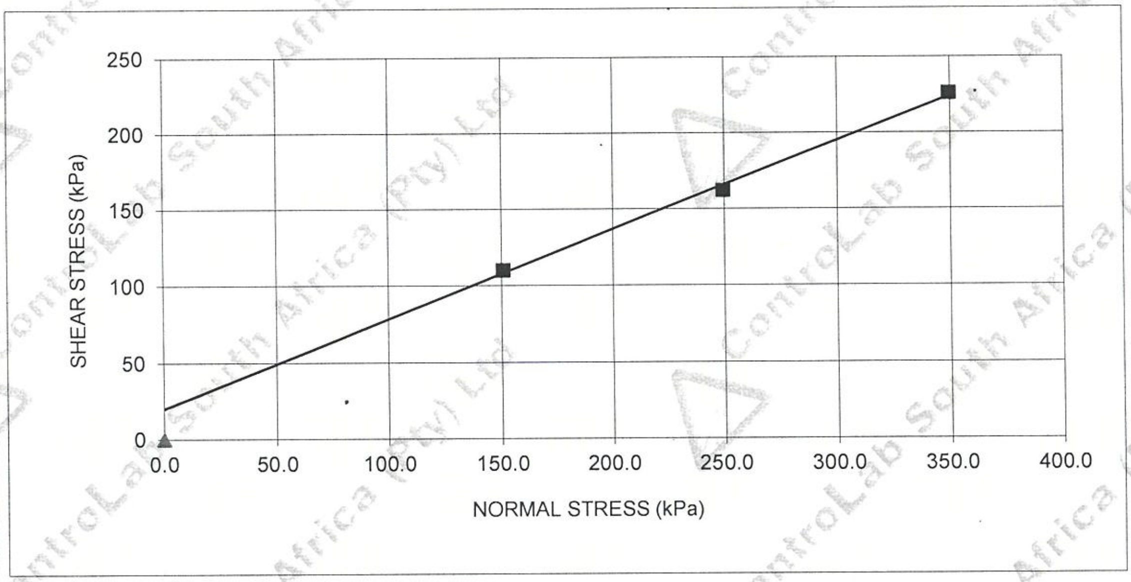
Void Ratio	1.04	0.91	0.81
Moisture Content %	13.90	13.90	13.90
Dry Density	1777	1777	1777

RESULTS AT END OF TEST

Void Ratio	0.96	0.82	0.67
Moisture Content %	29.47	27.83	23.16

PEAK SHEAR STRENGTH

Shear Stress kPa	110.00	162.00	226.00
Normal Stress kPa	150.76	249.43	349.48



	C kPa	Degrees
Peak	20.1	30.3

Apparent angle of internal shearing resistance given by regression (°)	30.3
Apparent cohesion given by regression (kPa)	20.1

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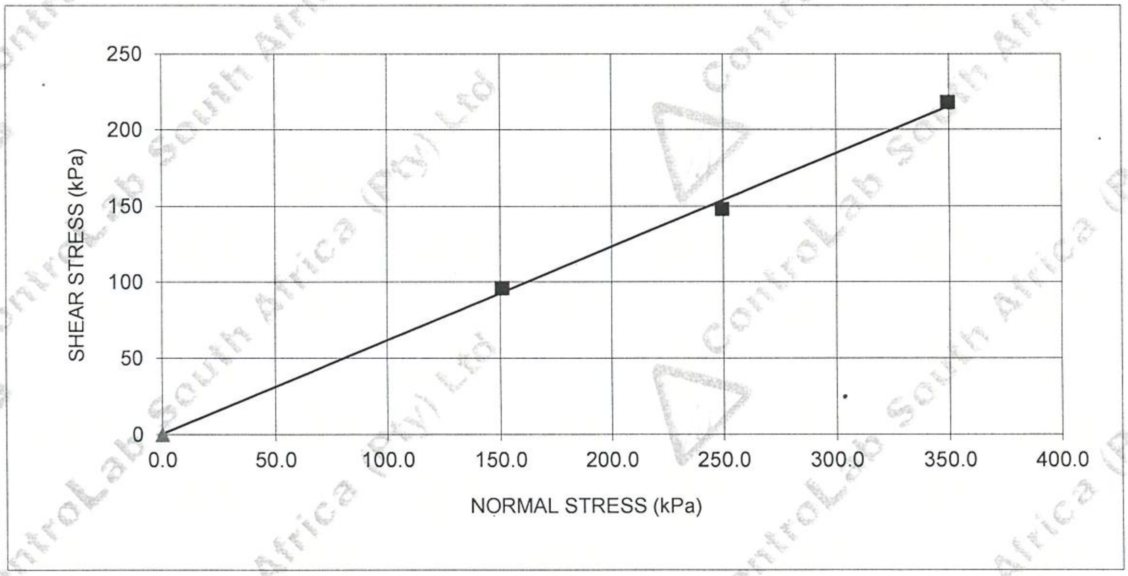
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-08-12
DATE REPORTED: 2019-08-14
TEST REPORT NO.: 95506

DIRECT SHEAR TEST (ASTM D3080)

Sample Number	31775	**Test type**	Drained Consolidated
Description		**Sample Position**	TP116 @ 0,4-4,8m
Sample Preparation	Remoulded		
Displacement Rate mm/min	0.048mm/min		
RESULTS AT START OF TEST			
Void Ratio	0.73	0.73	0.68
Moisture Content %	10.60	10.60	10.60
Dry Density	1819	1817	1817
RESULTS AT END OF TEST			
Void Ratio	0.64	0.63	0.58
Moisture Content %	24.03	24.00	20.94
PEAK SHEAR STRENGTH			
Shear Stress kPa	96.00	148.00	218.00
Normal Stress kPa	150.76	249.43	349.48



	C kPa	Degrees
Peak	0.5	31.6

Apparent angle of internal shearing resistance given by regression (°)	31.6
Apparent cohesion given by regression (kPa)	0.5

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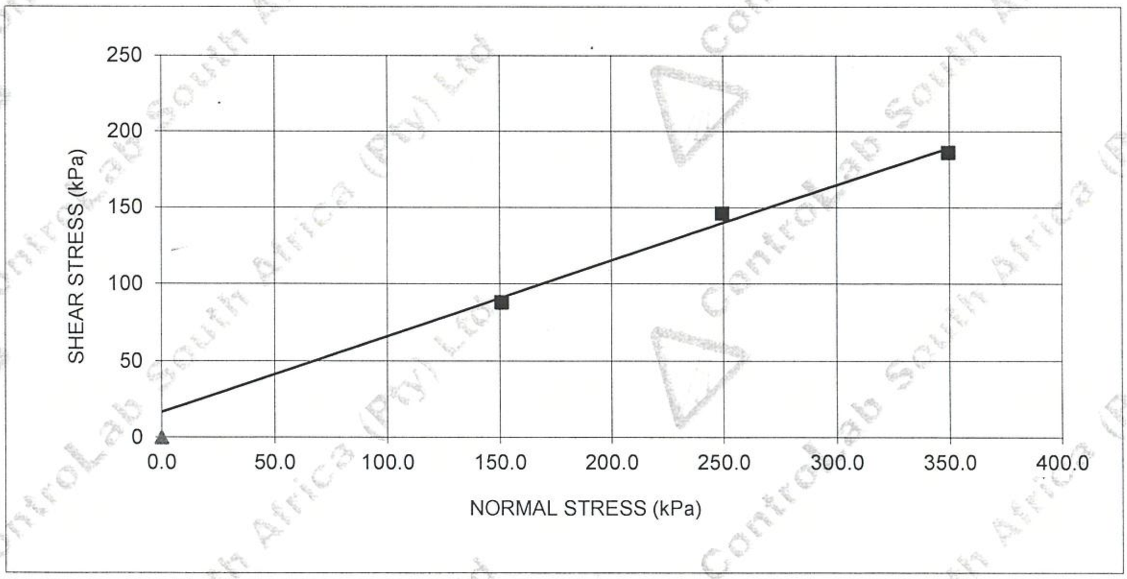
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-08-14
DATE REPORTED: 2019-08-15
TEST REPORT NO.: 95506

DIRECT SHEAR TEST (ASTM D3080)

Sample Number	31776	**Test type**	Drained Consolidated
Description		**Sample Position**	TP117 @ 2,6-3,3m
Sample Preparation	Remoulded		
Displacement Rate mm/min		0.048mm/min	
	RESULTS AT START OF TEST		
Void Ratio	0.75	0.69	0.87
Moisture Content %	13.60	13.60	13.60
Dry Density	1856	1856	1856
	RESULTS AT END OF TEST		
Void Ratio	0.68	0.57	0.62
Moisture Content %	21.89	19.50	18.79
	PEAK SHEAR STRENGTH		
Shear Stress kPa	88.00	146.00	186.00
Normal Stress kPa	150.76	249.43	349.48



	C kPa	Degrees
Peak	16.8	26.2

Apparent angle of internal shearing resistance given by regression (°)	26.2
Apparent cohesion given by regression (kPa)	16.8

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DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-08-15
DATE REPORTED: 2019-08-16
TEST REPORT NO.: 95506

DIRECT SHEAR TEST (ASTM D3080)

Sample Number	31777	**Test type**	Drained Consolidated
Description		**Sample Position**	TP119 @ 0,8-2,2m
Sample Preparation		Remoulded	
Displacement Rate mm/min		0.048mm/min	

RESULTS AT START OF TEST

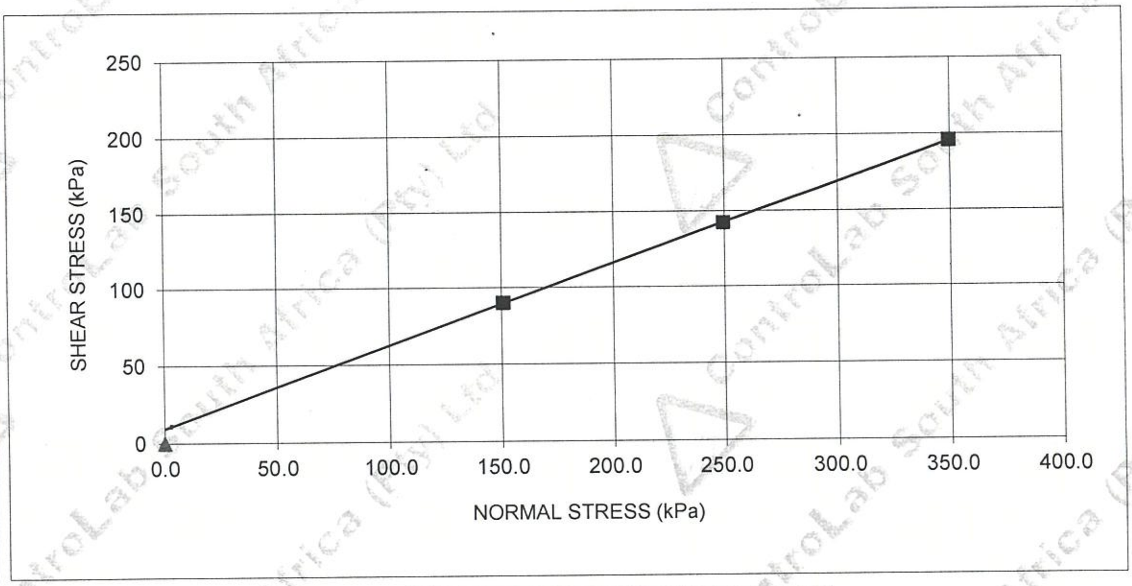
Void Ratio	0.56	0.70	0.61
Moisture Content %	14.20	14.20	14.20
Dry Density	1721	1721	1721

RESULTS AT END OF TEST

Void Ratio	0.50	0.60	0.50
Moisture Content %	27.40	21.81	19.54

PEAK SHEAR STRENGTH

Shear Stress kPa	90.00	142.00	196.00
Normal Stress kPa	150.76	249.43	349.48



	C kPa	Degrees
Peak	9.4	28.1

Apparent angle of internal shearing resistance given by regression (°)	28.1
Apparent cohesion given by regression (kPa)	9.4

Technical Signatory:
J Atterbury

ControLab South Africa (Pty) Ltd
201000682907
CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY
www.controlab.co.za

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CENTRAL LABORATORY: 10 St Pauls Road, East London, 5201, Tel: 043 722 5420 / 722 8565, Fax 043 743 9942, P O Box 346, East London, 5200
OTHER BRANCH OFFICES: Cape Town, Kokstad, Johannesburg, Mthatha, Queenstown, Lusaka - Zambia

CLIENT: Aurecon SA (Pty) Ltd
P O Box 494
CAPE TOWN
8000
ATT: Mr S Nyathi

PROJECT: LOWER CORNEY DAM - KIRKWOOD
DATE RECEIVED: 2019-06-18
DATE TESTED: 2019-08-15
DATE REPORTED: 2019-08-16
TEST REPORT NO.: 95506

DIRECT SHEAR TEST (ASTM D3080)

Sample Number	31778	**Test type**	Drained Consolidated
Description		**Sample Position**	TP122 @ 0,3-1,3m
Sample Preparation	Remoulded		
Displacement Rate mm/min	0.048mm/min		

RESULTS AT START OF TEST

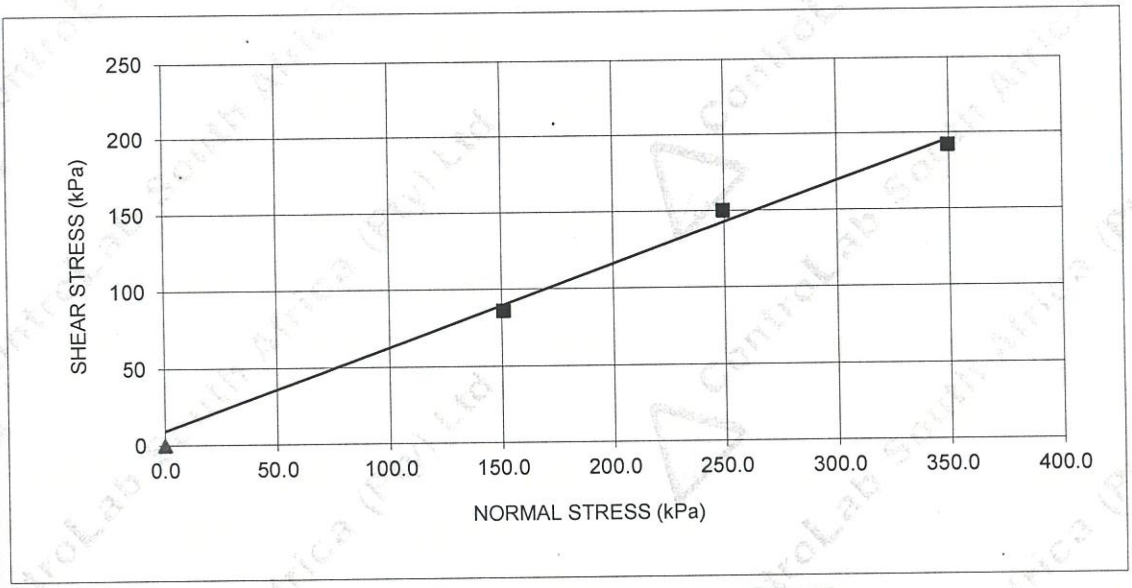
Void Ratio	0.55	0.53	0.59
Moisture Content %	11.10	11.10	11.10
Dry Density	1821	1821	1821

RESULTS AT END OF TEST

Void Ratio	0.48	0.45	0.47
Moisture Content %	18.23	16.90	16.72

PEAK SHEAR STRENGTH

Shear Stress kPa	86.00	150.00	192.00
Normal Stress kPa	150.76	249.43	349.48



	C kPa	Degrees
Peak	9.4	28.1

Apparent angle of internal shearing resistance given by regression (°)	28.1
Apparent cohesion given by regression (kPa)	9.4

Technical Signatory: ______
J Atterbury

Labco Southern Africa (Pty) Ltd
sanas
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Phone: +27 (0)41 364 1290 ■ Fax: +27 (0)41 364 1291
Port Elizabeth (Head Office) ■ 49 Pickering Street, Newton Park, 6045. ■ PO Box 10114 Linton Grange 6015

Client : Aurecon South Africa (Pty) Ltd
Address : P.O. Box 74381
: Lynnwood Ridge
: South Africa, 0040

Client Reference : -
Order No. : 112546

Attention : Mr. S. Nyathi
Facsimile : -
E-mail : Siya.Nyathi@aurecongroup.com

Date Received : 26/06/2019
Date Tested : 11/07/2019
Date Reported : 12/07/2019 AB

Project : Algoa Water Supply System
Project No. : 2019-P-1435

Report Status : Proctor Mod's
Page : 1 of 4

Herewith please find the test report(s) pertaining to the above project. All tests were conducted in accordance with prescribed test method(s). Information herein consists of the following:

Test(s) conducted / Item(s) measured	Qty.	Test Method(s)	Authorized By**	Page(s)
Moisture Density Relationship	3.000	SANS 3001-GR30	A Bisiwe	2-4

Any test results contained in this report and marked with * in the table above are "not SANAS accredited" and are not included in the schedule of accreditation for this laboratory.

Any information contained in this test report pertain only to the areas and/or samples tested. Documents may only be reproduced or published in their full context. • Any information gained by the laboratory prior, during or after test process will be treated as confidential and will not be reproduced or disclosed to any person or organization, unless required by law.
All interpretations, Interpolations, Opinions and/or Classifications contained in this report falls outside our scope of accreditation.

The following parameters, where applicable, were excluded from the classification procedure: Chemical modifications, Additional fines, Fractured Faces, Soluble Salts, pH, Conductivity, Coarse Sand Ratio, Durability (COLTO: G4-G9).
The following parameters, where applicable, were assumed: Rock types were assumed to be of an Arenaceous nature with Siliceous cementing material.

Unless otherwise requested or stated, all samples will be discarded after a period of 3 months.

Deviations in Test Methods:

05.07.19

Technical Signatory.

**All results are authorized by technical signatories.

Client :	Aurecon South Africa (Pty) Ltd	Date Received:	26/06/2019
Project :	Algoa Water Supply System	Date Reported:	12/07/2019
Project No:	2019-P-1435	Page No. :	2 of 4

MOISTURE DENSITY RELATIONSHIP

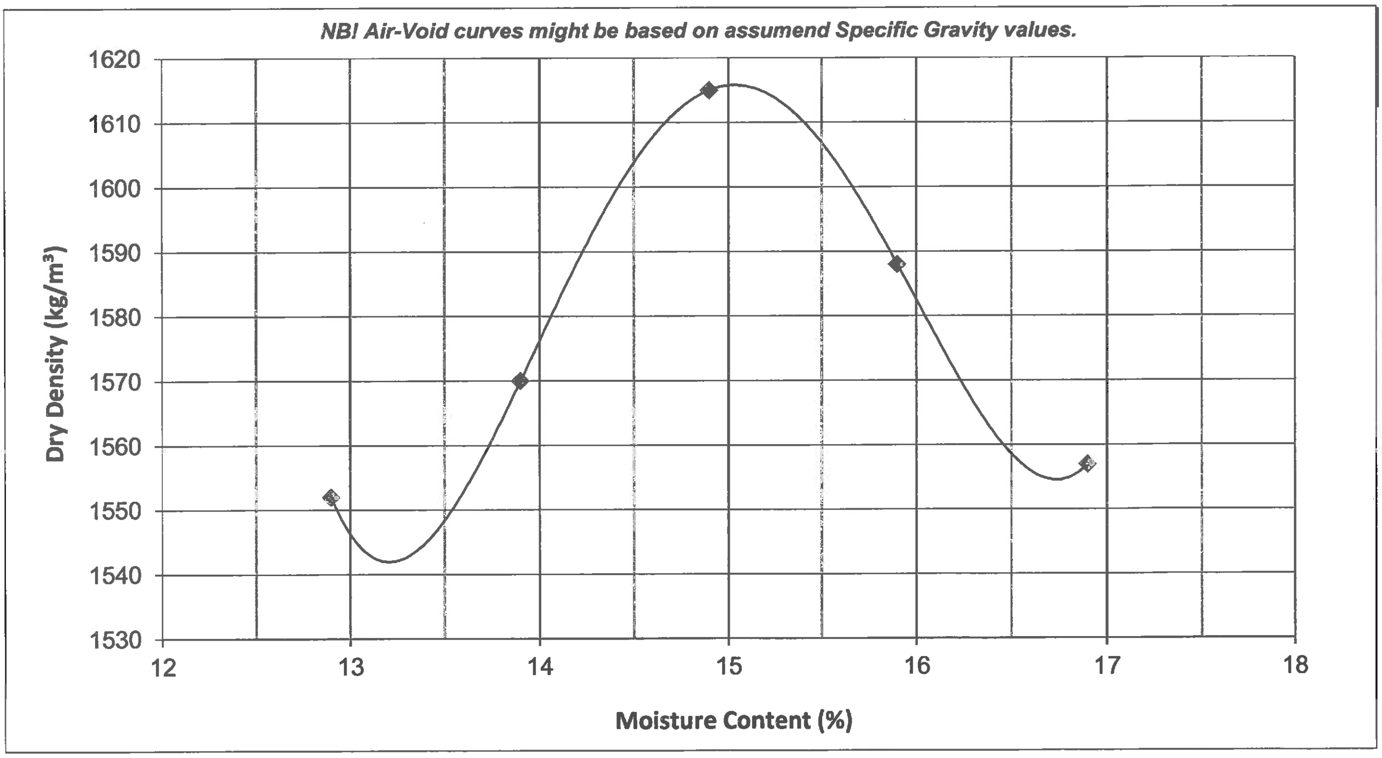
Laboratory Number		1
Field Number		P1435/1
Client Reference		TP 105
Depth (m)		1.0-3.6
Position		-
Coordinates	X	-
	Y	-
Description		Very Dense silty Sand, Colluvium
Additional Information		-
Calcrete / Crushed		-
Stabilizing Agent		-

Maximum Dry Density & Optimum Moisture Content - SANS 3001-GR30

Compactive Effort:	Modified AASHTO

Dry Density	kg/m³	1552	1570	1615	1588	1557	
Moisture Content	%	12.9	13.9	14.9	15.9	16.9	

Max. Dry Density	kg/m³	1616
Optimum Moisture	%	15



Client : Aurecon South Africa (Pty) Ltd
Project : Algoa Water Supply System
Project No: 2019-P-1435

Date Received: 26/06/2019
Date Reported: 12/07/2019

MOISTURE DENSITY RELATIONSHIP

Laboratory Number		2
Field Number		P1435/2
Client Reference		TP 108
Depth (m)		0.6-2.2
Position		-
Coordinates	X	-
	Y	-
Description		Calcritised silty Sand, Pedogenic
Additional Information		-
Calcrete / Crushed		-
Stabilizing Agent		-

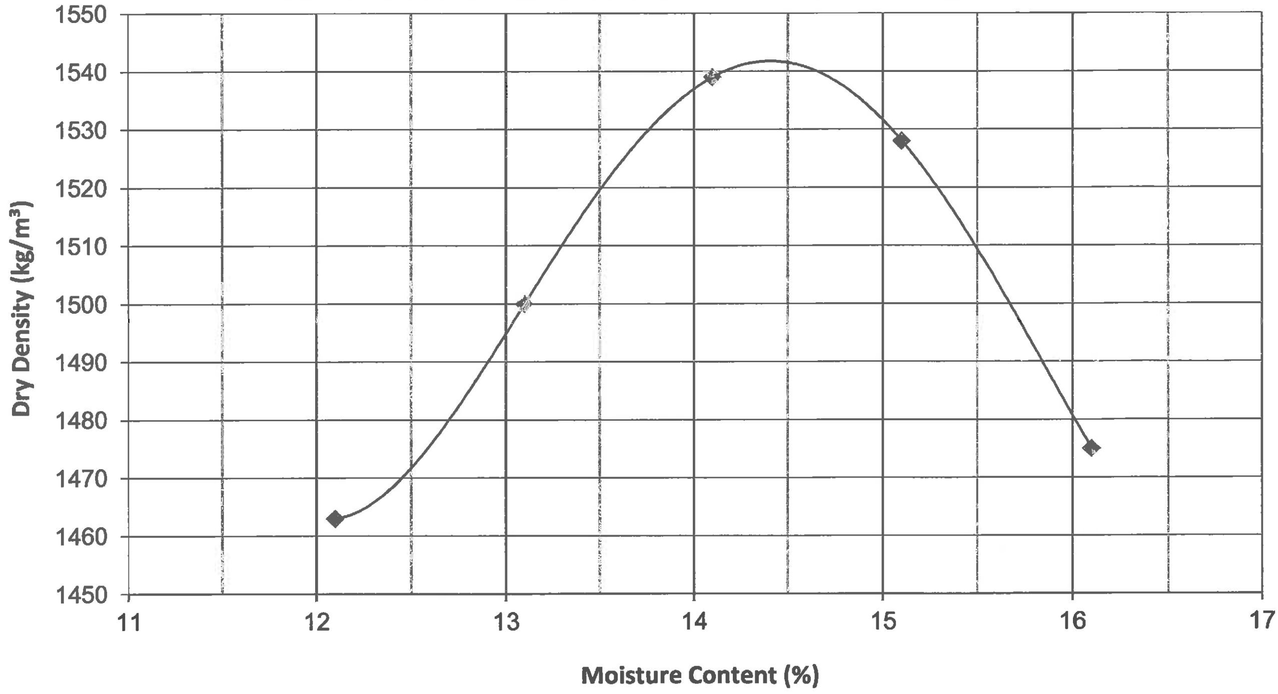
Maximum Dry Density & Optimum Moisture Content - SANS 3001-GR30

Compactive Effort:	Modified AASHTO

Dry Density	kg/m³	1463	1500	1539	1528	1475	
Moisture Content	%	12.1	13.1	14.1	15.1	16.1	

Max. Dry Density	kg/m³	1542
Optimum Moisture	%	14.4

NB! Air-Void curves might be based on assumend Specific Gravity values.



Client :	Aurecon South Africa (Pty) Ltd	Date Received:	26/06/2019
Project :	Algoa Water Supply System	Date Reported:	12/07/2019
Project No:	2019-P-1435	Page No. :	4 of 4

MOISTURE DENSITY RELATIONSHIP

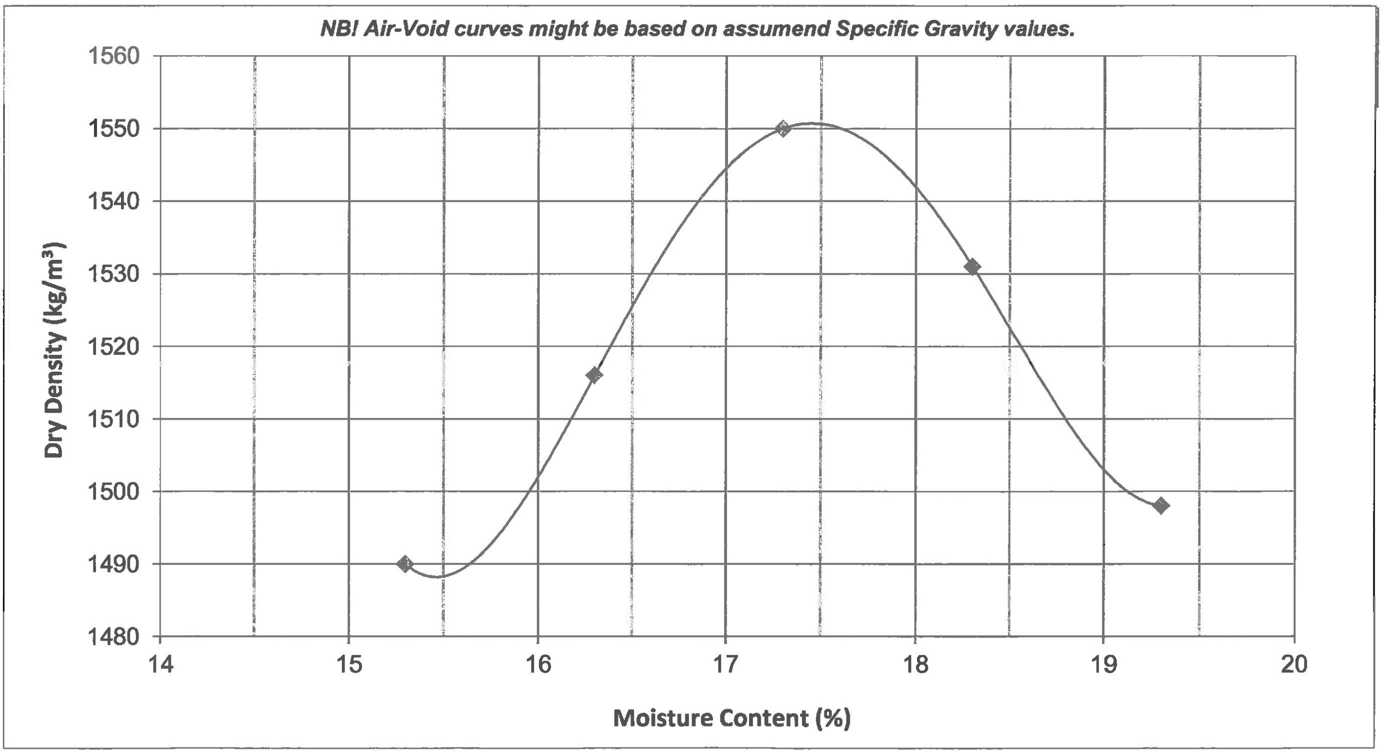
Laboratory Number		5
Field Number		P1435/5
Client Reference		TP 115
Depth (m)		0.4-2.4
Position		-
Coordinates	X	-
	Y	-
Description		Ferruginised silty Sand, Pedogenic
Additional Information		-
Calcrete / Crushed		-
Stabilizing Agent		-

Maximum Dry Density & Optimum Moisture Content - SANS 3001-GR30

Compactive Effort:	Modified AASHTO

Dry Density	kg/m³	1490	1516	1550	1531	1498	
Moisture Content	%	15.3	16.3	17.3	18.3	19.3	

Max. Dry Density	kg/m³	1551
Optimum Moisture	%	17.5



TOSCALAB (Pty) Ltd.

sanas
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E-mail: info@toscalab.co.za

LABORATORY ANALYTICAL REPORT

CLIENT : Aurecon

CUSTOMERSAMPLE ID LC3 - Big (0.3-2.05)

TOSCA LAB SAMPLE NO. WL0500

EXTRACTION: 100 (Soil) : 200 (d-H2O)

PARTICLE SIZE 300um

DILUTION FACTOR: 2 (factored in)

ATT: Mr. Gary Davies

PROJECT: Kirkwood

JOB CARD No. : C19226

DATE SAMPLED: -

DATE DELIVERED: -

DATE REPORTED: 13.12.2018

SAMPLED BY: CUSTOMER

SAMPLING PROCEDURE : N/A

PARAMETER	UNITS	METHOD REF.	MEASUREMENT UNCERTAINTY	LC3 - Big (0.3-2.05)		
				RESULT	FACTOR	FINAL RESULT (m.mol/kg)
Conductivity at 25degC	mS/m	SANS 7888	0.02	101,6		
pH at 25degC	pH Units	SANS	1,05	8,15		
Sodium* as Na	mg/L	SANS 11885	_	135	$2*23^{-1}$	6,54
Calcium* as Ca	mg/L	SANS 11885	_	10	$2*40^{-1}$	0,50
Magnesium* as Mg	mg/L	SANS 11885	_	3,8	$2*24^{-1}$	0,32

Soil Sodium Adsorption Ratio (SAR)		Calc (SAR = Na+/ $(Ca^{2+} + Mg^{2+})^{1/2}$	_	7,22
Extractable Sodium Percentage		Calc (ESP = 1.475 SAR / (1 + 0.0147 SAR))	_	9,63

RELATIONSHIP BETWEEN ESP AND DEGREE OF DISPERSION

Exchangeable Sodium Percentage Values (ESP) (Source: Bulletin 4343 Soil Guide)

ESP	RATING	SOIL DISPERSION TEST
<6	Non-Sodic	No dispersion evident after 24 hours. Aggregates slaked but not dispersed (milky) clay.
6-10	Slightly sodic	Dispersion (milky halo) evident after 24 hours. Soil aggregates slightly disperse
10-15	Moderately sodic	Dispersion (milky halo) evident after several hours. Soil aggregates partially disperse.
>15	Highly sodic	Dispersion (milky halo) evident in less than 30 minutes. Soil aggregates completely disperse.

Remarks:
The above test results are pertinent only to the samples received and tested at the laboratory. This report shall not be reproduced, except in full, without the prior consent of Tosca Lab (Pty) Ltd. Raw sample data is available on request. * = non-accredited test (s) = Subcontracted test. Deviation from Test Method SANS 5213. Use oven temperature at 105ºC instead of 180ºC.

Name: Frederik Eijbers

Position: Technical Signatory (Chemistry)

END OF REPORT

TOSCALAB (Pty) Ltd.

sanas Testing Laboratory
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E-mail: info@toscalab.co.za

LABORATORY ANALYTICAL REPORT

CLIENT :	Aurecon	**ATT:**	Mr. Gary Davies
CUSTOMERSAMPLE ID	**TOSCA LAB SAMPLE NO.**	**PROJECT:**	Kirkwood
LC6 - Big (0.5-1.65)	WL0501	**JOB CARD No. :**	C19226
		DATE SAMPLED:	-
		DATE DELIVERED:	-
EXTRACTION:	100 (Soil) : 200 (d-H2O)	**DATE REPORTED:**	13.12.2018
PARTICLE SIZE	300um	**SAMPLED BY:**	CUSTOMER
DILUTION FACTOR:	2 (factored in)	**SAMPLING PROCEDURE :**	N/A

PARAMETER	UNITS	METHOD REF.	MEASUREMENT UNCERTAINTY	LC6 - Big (0.5-1.65)		
				RESULT	FACTOR	FINAL RESULT (m.mol/kg)
Conductivity at 25degC	mS/m	SANS 7888	0.02	91,7		
pH at 25degC	pH Units	SANS	1,05	7,82		
Sodium* as Na	mg/L	SANS 11885	_	121	$2*23^{-1}$	7,58
Calcium* as Ca	mg/L	SANS 11885	_	16	$2*40^{-1}$	0,80
Magnesium* as Mg	mg/L	SANS 11885	_	4,9	$2*24^{-1}$	0,40
Soil Sodium Adsorption Ratio (SAR)		Calc (SAR = Na+/ $(Ca^{2+} + Mg^{2+})^{1/2}$	_	6,92		
Extractable Sodium Percentage		Calc (ESP = 1.475 SAR / (1 + 0.0147 SAR))	_	9,26		

RELATIONSHIP BETWEEN ESP AND DEGREE OF DISPERSION

Exchangeable Sodium Percentage Values (ESP) (Source: Bulletin 4343 Soil Guide)

ESP	RATING	SOIL DISPERSION TEST
<6	Non-Sodic	No dispersion evident after 24 hours. Aggregates slaked but not dispersed (milky) clay.
6-10	Slightly sodic	Dispersion (milky halo) evident after 24 hours. Soil aggregates slightly disperse
10-15	Moderately sodic	Dispersion (milky halo) evident after several hours. Soil aggregates partially disperse.
>15	Highly sodic	Dispersion (milky halo) evident in less than 30 minutes. Soil aggregates completely disperse.

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Name: Frederik Eijbers

Position: Technical Signatory (Chemistry)

END OF REPORT

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LABORATORY ANALYTICAL REPORT

CLIENT :	Aurecon	**ATT:**	Mr. Gary Davies
CUSTOMERSAMPLE ID	**TOSCA LAB SAMPLE NO.**	**PROJECT:**	Kirkwood
US6 - Big (0.5-2.0)	WL0502	**JOB CARD No. :**	C19226
		DATE SAMPLED:	-
		DATE DELIVERED:	-
EXTRACTION:	100 (Soil) : 200 (d-H2O)	**DATE REPORTED:**	13.12.2018
PARTICLE SIZE	300um	**SAMPLED BY:**	CUSTOMER
DILUTION FACTOR:	2 (factored in)	**SAMPLING PROCEDURE :**	N/A

PARAMETER	UNITS	METHOD REF.	MEASUREMENT UNCERTAINTY	US6 - Big (0.5-2.0)		
				RESULT	FACTOR	FINAL RESULT (m.mol/kg)
Conductivity at 25degC	mS/m	SANS 7888	0.02	98,7		
pH at 25degC	pH Units	SANS	1,05	8,01		
Sodium* as Na	mg/L	SANS 11885	_	127	$2*23^{-1}$	8,00
Calcium* as Ca	mg/L	SANS 11885	_	13	$2*40^{-1}$	0,90
Magnesium* as Mg	mg/L	SANS 11885	_	4,3	$2*24^{-1}$	0,30

Soil Sodium Adsorption Ratio (SAR)		Calc (SAR = Na+/ (Ca^{2+} + Mg^{2+})$^{1/2}$	_	7,30
Extractable Sodium Percentage		Calc (ESP = 1.475 SAR / (1 + 0.0147 SAR))	_	9,73

RELATIONSHIP BETWEEN ESP AND DEGREE OF DISPERSION

Exchangeable Sodium Percentage Values (ESP) (Source: Bulletin 4343 Soil Guide)

ESP	RATING	SOIL DISPERSION TEST
<6	Non-Sodic	No dispersion evident after 24 hours. Aggregates slaked but not dispersed (milky) clay.
6-10	Slightly sodic	Dispersion (milky halo) evident after 24 hours. Soil aggregates slightly disperse
10-15	Moderately sodic	Dispersion (milky halo) evident after several hours. Soil aggregates partially disperse.
>15	Highly sodic	Dispersion (milky halo) evident in less than 30 minutes. Soil aggregates completely disperse.

Remarks:
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Name: Frederik Eijpers

Position: Technical Signatory (Chemistry)

END OF REPORT

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E-mail: info@toscalab.co.za

LABORATORY ANALYTICAL REPORT

CLIENT :	Aurecon	**ATT:**	Mr. Gary Davies
CUSTOMERSAMPLE ID	**TOSCA LAB SAMPLE NO.**	**PROJECT:**	Kirkwood
LC3 (0.3-1.15)	WL0503	**JOB CARD No. :**	C19226
		DATE SAMPLED:	-
		DATE DELIVERED:	-
EXTRACTION:	100 (Soil) : 200 (d-H2O)	**DATE REPORTED:**	13.12.2018
PARTICLE SIZE	300um	**SAMPLED BY:**	CUSTOMER
DILUTION FACTOR:	2 (factored in)	**SAMPLING PROCEDURE :**	N/A

PARAMETER	UNITS	METHOD REF.	MEASUREMENT UNCERTAINTY	LC3 (0.3-1.15)		
				RESULT	FACTOR	FINAL RESULT (m.mol/kg)
Conductivity at 25degC	mS/m	SANS 7888	0.02	85,2		
pH at 25degC	pH Units	SANS	1,05	9,01		
Sodium* as Na	mg/L	SANS 11885	-	123	$2*23^{-1}$	7,50
Calcium* as Ca	mg/L	SANS 11885	-	15	$2*40^{-1}$	0,85
Magnesium* as Mg	mg/L	SANS 11885	-	3,8	$2*24^{-1}$	0,40

Soil Sodium Adsorption Ratio (SAR)		Calc (SAR = Na+/ $(Ca^{2+} + Mg^{2+})^{1/2}$	-	6,71
Extractable Sodium Percentage		Calc (ESP = 1.475 SAR / (1 + 0.0147 SAR))	-	9,01

RELATIONSHIP BETWEEN ESP AND DEGREE OF DISPERSION

Exchangeable Sodium Percentage Values (ESP) (Source: Bulletin 4343 Soil Guide)

ESP	RATING	SOIL DISPERSION TEST
<6	Non-Sodic	No dispersion evident after 24 hours. Aggregates slaked but not dispersed (milky) clay.
6-10	Slightly sodic	Dispersion (milky halo) evident after 24 hours. Soil aggregates slightly disperse
10-15	Moderately sodic	Dispersion (milky halo) evident after several hours. Soil aggregates partially disperse.
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Remarks:
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Name: Frederik Elbers

Position: Technical Signatory (Chemistry)

END OF REPORT

TOSCALAB (Pty) Ltd.

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E-mail: info@toscalab.co.za

LABORATORY ANALYTICAL REPORT

CLIENT : Aurecon

ATT: Mr. Gary Davies

PROJECT: Kirkwood

CUSTOMERSAMPLE ID: LC4 (0.3-1.35)

TOSCA LAB SAMPLE NO.: WL0504

JOB CARD No. : C19226

DATE SAMPLED: -

DATE DELIVERED: -

EXTRACTION: 100 (Soil) : 200 (d-H2O)

DATE REPORTED: 13.12.2018

PARTICLE SIZE 300um

SAMPLED BY: CUSTOMER

DILUTION FACTOR: 2 (factored in)

SAMPLING PROCEDURE : N/A

PARAMETER	UNITS	METHOD REF.	MEASUREMENT UNCERTAINTY	LC4 (0.3-1.35)		
				RESULT	FACTOR	FINAL RESULT (m.mol/kg)
Conductivity at 25degC	mS/m	SANS 7888	0.02	108,7		
pH at 25degC	pH Units	SANS	1,05	8,3		
Sodium* as Na	mg/L	SANS 11885	_	132	$2*23^{-1}$	7,00
Calcium* as Ca	mg/L	SANS 11885	_	12	$2*40^{-1}$	0,90
Magnesium* as Mg	mg/L	SANS 11885	_	4,2	$2*24^{-1}$	0,50

Soil Sodium Adsorption Ratio (SAR)		Calc (SAR = Na+/ $(Ca^{2+} + Mg^{2+})^{1/2}$	_	5,92
Extractable Sodium Percentage		Calc (ESP = 1.475 SAR / (1 + 0.0147 SAR))	_	8,03

RELATIONSHIP BETWEEN ESP AND DEGREE OF DISPERSION

Exchangeable Sodium Percentage Values (ESP) (Source: Bulletin 4343 Soil Guide)

ESP	RATING	SOIL DISPERSION TEST
<6	Non-Sodic	No dispersion evident after 24 hours. Aggregates slaked but not dispersed (milky) clay.
6-10	Slightly sodic	Dispersion (milky halo) evident after 24 hours. Soil aggregates slightly disperse
10-15	Moderately sodic	Dispersion (milky halo) evident after several hours. Soil aggregates partially disperse.
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Remarks:

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Name: Frederik Eilbers

Position: Technical Signatory (Chemistry)

END OF REPORT

TOSCALAB (Pty) Ltd.
CIVIL ENGINEERING MATERIALS LABORATORY
Reg.No. 2014/263692/07

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ISO/IEC 17025 ACCREDITED

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Testing Laboratory
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CLIENT: Aurecon SA
4 Daventry Street
Lynwood Ridge

PROJECT : Kirkwood 112546
JOB/ROAD : C19226
REPORT DATE : 27.06.2018

ATT: Mr. G Davies

SAMPLING PROCEDURE: Delivered to the Laboratory

TEST RESULT SUMMARY

SAMPLE NUMBER	S98987	S98988	S98988	S98989	S98990	S98991	S98992
POSITION	LC2	LC3	LC3	LC3	LC4	LC5	LC5
DEPTH (M)	1.0-1.95	0.3-2.05	0.3-1.15	0.3-2.05	0.3-1.35	0.3-1.3	1.3-2.75
DESCRIPTION	Colluvium with fine FeO Nodules	Colluvium (Small)	Colluvium (Un-Disturbed)	Colluvium (Large)	Alluvium	Mixed Origin	Potentially Alluvium
UNIFIED SOIL CLASSIFICATION	CL	SM	SM	SM	SC	SM/SC	SC
HRB CLASSIFICATION							
SIEVE ANALYSIS - TMH 1 Test Method A1, A2, A3, A5 & A6							
PASSING 75.0 mm							
63.0 mm							
53.0 mm							100
37.5 mm					100		97
26.5 mm					98		95
19.0 mm					95		90
13.2 mm		100	100	100	94	100	80
4.75 mm	100	99	99	99	91	98	56
2.00 mm	99	99	98	99	90	97	47
0.425 mm	95	95	94	94	84	85	29
0.075 mm	76	50	47	45	49	41	13
0.060 mm	63	41	36	34	33	30	8
0.006 mm	4	4	5	3	5	3	1
0.0018 mm	0	0	1	0	1	0	0
SOIL MORTAR ANALYSIS - TMH 1 Test Method A5							
Soil Mortar Analysis % < 2.00mm 2.000 - 0.425	4	4	5	5	7	12	39
0.425 - 0.250	4	12	13	15	9	15	16
0.250 - 0.150	7	17	18	19	17	18	12
0.150 - 0.075	8	16	17	16	13	12	6
< 0.075	78	50	48	45	55	43	29
GRADING MODULUS	0,30	0,57	0,61	0,62	0,77	0,78	2,11
ATTERBERG LIMITS : TMH 1 Test Method A2 - A4							
LIQUID LIMIT	21	15	15	-	17	15	49
PLASTICITY INDEX	7	3	4	SP	7	5	20
LINEAR SHRINKAGE	3,5	1,5	2,0	1,0	3,5	2,5	10,0
PROCTOR : MOISTURE DENSITY RELATIONSHIP : BS 1377 PART 4							
Maximum Proctor Density (Kg/m^3)	-	-	-	1857	1868	-	-
O.M.C. (%)	-	-	-	11,1	12,7	-	-
RELATIVE DENSITY OF SOIL: TMH1 1986 A12T							
RELATIVE DENSITY	-	2,600	-	-	2,570	-	-
MOISTURE CONTENT: SANS 3001:GR20:2010							
MOISTURE CONTENT	-	9,8	-	-	6,1	-	-
PERMEABILITY AND DISPERSIVE TESTS							
PERMEABILITY (m/s)			2.31 x 10^{-7}	1.84 x 10^{-7}	3.16 x 10^{-8}		
DOUBLE HYDROMETER : ASTM D422 (%)			35,97	40,13	48,3		
PINHOLE TEST : ASTM D4647			ND 3	ND 3	ND 2		
CRUMB TEST : BS1377 (1990) PART 5: 6.3			Grade 2	Grade 2	Grade 2		
DRAINED SLOW SHEARBOX TEST : BS 1377 (1990) PART 7 :4 / 5							
MAXIMUM EFFECTIVE SHEAR STRESS... σ'd (kPa)		36,5	38,1	35,4	43,2		
APPARENT FRICTION ANGLE (degrees)		18,3	19,2	20,2	26,4		
Moulded Density (kg/m^3)		1676	1693	1704	1722		

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sanas
Testing Laboratory
T 0481

CLIENT: Aurecon SA
4 Daventry Street
Lynwood Ridge

ATT: Mr. G Davies

PROJECT : Kirkwood 112546
JOB/ROAD : C19226
REPORT DATE : 27.06.2018

SAMPLING PROCEDURE: Delivered to the Laboratory

TEST RESULT SUMMARY

SAMPLE NUMBER	S98993	S98994	S98995	S98996	S98997	S98998
POSITION	LC6	LC7	LC8	LC9	LC9	LC9
DEPTH (M)	0.5-1.65	0.9-2	0.5-1.5	0.4-0.85	0.85-1.2	1.2-2.4
DESCRIPTION	Colluvium Part Pedogenic	Alluvium	Colluvium Part Pedogenic	Colluvium with Fine FeO Nodules	Colluvium part Pedogenic	Mixed Origin
UNIFIED SOIL CLASSIFICATION	CL	CL	CL	CL	GC	CL
HRB CLASSIFICATION						
SIEVE ANALYSIS - TMH 1 Test Method A1, A2, A3, A5 & A6						
PASSING 75.0 mm						
63.0 mm						
53.0 mm						
37.5 mm					100	
26.5 mm					96	
19.0 mm					90	100
13.2 mm	100		100		83	99
4.75 mm	99		98		61	96
2.00 mm	98	100	97	100	52	94
0.425 mm	96	97	96	98	45	89
0.075 mm	75	65	70	81	25	79
0.060 mm	53	51	58	57	18	66
0.006 mm	5	3	1	3	2	11
0.0018 mm	0	0	0	0	0	4
SOIL MORTAR ANALYSIS - TMH 1 Test Method A5						
Soil Mortar Analysis % < 2.00mm 2.000 - 0.425	2	3	2	2	14	5
0.425 - 0.250	3	7	3	2	13	2
0.250 - 0.150	8	12	10	6	13	3
0.150 - 0.075	11	14	14	9	13	6
< 0.075	76	65	72	81	48	84
GRADING MODULUS	0,31	0,38	0,38	0,22	1,79	0,38
ATTERBERG LIMITS : TMH 1 Test Method A2 - A4						
LIQUID LIMIT	32	25	26	37	30	39
PLASTICITY INDEX	18	11	12	19	18	18
LINEAR SHRINKAGE	9,0	5,5	6,0	9,5	9,0	9,0
PROCTOR : MOISTURE DENSITY RELATIONSHIP : BS 1377 PART 4						
Maximum Proctor Density (Kg/m^3)	1676	-	1759	-	-	1617
O.M.C. (%)	18,9	-	17,8	-	-	23,8
RELATIVE DENSITY OF SOIL: TMH1 1986 A12T						
RELATIVE DENSITY	2,560	-	-	2,580	-	-
MOISTURE CONTENT: SANS 3001:GR20:2010						
MOISTURE CONTENT	12,4	-	8,3	-	-	17,3
PERMEABILITY AND DISPERSIVE TESTS						
PERMEABILITY (m/s)	4.11×10^{-9}		3.72×10^{-8}			
DOUBLE HYDROMETER : ASTM D422 (%)	43,26					
PINHOLE TEST : ASTM D4647	ND 2					
CRUMB TEST : BS1377 (1990) PART 5: 6.3	Grade 3					
DRAINED SLOW SHEARBOX TEST : BS 1377 (1990) PART 7 :4 / 5						
MAXIMUM EFFECTIVE SHEAR STRESS... σ'd (kPa)	41,6		40,9			32,8
APPARENT FRICTION ANGLE (degrees)	21,4		24,7			23,3
Moulded Density (kg/m^3)	1570		1634			1509

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Lynwood Ridge

ATT: Mr. G Davies

PROJECT : Kirkwood 112546

JOB/ROAD : C19226

REPORT DATE : 27.06.2018

SAMPLING PROCEDURE: Delivered to the Laboratory

TEST RESULT SUMMARY

SAMPLE NUMBER	S98999	S99000	S99001	S99002	S99003	S99004
POSITION	LC10	LC11	LC20	LC23	US1	US2
DEPTH (M)	1.0-1.6	0.5-1.5	0.9-1.95	0.5-2.0	1.1-1.4	0.1-1.5
DESCRIPTION	Colluvium Part Pedogenic	Pedogenic	Pedogenic	Colluvium	Pedogenic	Colluvium part Pedogenic
UNIFIED SOIL CLASSIFICATION	CL	SC	CL	CL	CL	CL
HRB CLASSIFICATION						

SIEVE ANALYSIS - TMH 1 Test Method A1, A2, A3, A5 & A6

PASSING	75.0 mm						
	63.0 mm						
	53.0 mm						
	37.5 mm		100				
	26.5 mm		94			100	
	19.0 mm		89		100	99	100
	13.2 mm	100	86	100	99	98	99
	4.75 mm	99	73	97	97	91	97
	2.00 mm	98	60	96	96	87	94
	0.425 mm	95	40	91	95	83	88
	0.075 mm	76	32	80	50	60	77
	0.060 mm	62	23	64	35	50	77
	0.006 mm	1	2	3	5	1	9
	0.0018 mm	0	1	0	1	0	3

SOIL MORTAR ANALYSIS - TMH 1 Test Method A5

Soil Mortar Analysis % < 2.00mm	2.000 - 0.425	3	34	5	2	4	6
	0.425 - 0.250	3	2	1	5	3	2
	0.250 - 0.150	7	5	4	23	8	4
	0.150 - 0.075	10	6	6	19	15	6
	< 0.075	78	54	84	52	70	82
GRADING MODULUS		0,32	1,68	0,33	0,59	0,70	0,40

ATTERBERG LIMITS : TMH 1 Test Method A2 - A4

LIQUID LIMIT	29	31	39	19	27	20
PLASTICITY INDEX	15	10	20	7	12	7
LINEAR SHRINKAGE	7,5	5,0	10,0	3,5	6,0	3,5

PROCTOR : MOISTURE DENSITY RELATIONSHIP : BS 1377 PART 4

Maximum Proctor Density (Kg/m^3)	-	1522	1739	1826	-	-
O.M.C. (%)	-	21,7	22,6	11,7	-	-

RELATIVE DENSITY OF SOIL: TMH1 1986 A12T

RELATIVE DENSITY	-	-	-	-	-	-

MOISTURE CONTENT: SANS 3001:GR20:2010

MOISTURE CONTENT	-	-	10,9	5,1	-	-

PERMEABILITY AND DISPERSIVE TESTS

PERMEABILITY (m/s)		1.88 x 10 -8	2.62 x 10 -9			
DOUBLE HYDROMETER : ASTM D422 (%)						
PINHOLE TEST : ASTM D4647						
CRUMB TEST : BS1377 (1990) PART 5: 6.3						

DRAINED SLOW SHEARBOX TEST : BS 1377 (1990) PART 7 :4 / 5

MAXIMUM EFFECTIVE SHEAR STRESS... σ'd (kPa)		33,9	35,7	33,4		
APPARENT FRICTION ANGLE (degrees)		20,2	24,8	19,2		
Moulded Density (kg/m^3)		1434	1596	1682		

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CLIENT: Aurecon SA
4 Daventry Street
Lynwood Ridge

ATT: Mr. G Davies

PROJECT : Kirkwood 112546
JOB/ROAD : C19226
REPORT DATE : 27.06.2018

SAMPLING PROCEDURE: Delivered to the Laboratory

TEST RESULT SUMMARY

SAMPLE NUMBER	S99005	S99006	S99007	S99007	S99008	S99009	S99010
POSITION	US3	US4	US5	US5	US5	US6	US7
DEPTH (M)	0.6-1.5	0.2-0.7	0.2-1.1	0.2-1.1	0.7-2.8	0.5-2.0	0.2-1.0
DESCRIPTION	Colluvium, Part Pedogenic	Colluvium	Colluvium (Undisturbed)	Colluvium	Colluvium	Colluvium Part Pedogenic	Pedogenic
UNIFIED SOIL CLASSIFICATION	CL	CL	CL	CL	CL	CL-ML	SC
HRB CLASSIFICATION							
SIEVE ANALYSIS - TMH 1 Test Method A1, A2, A3, A5 & A6							
PASSING 75.0 mm							
63.0 mm							
53.0 mm							
37.5 mm	100						100
26.5 mm	97	100	100	100	100		97
19.0 mm	96	99	96	95	98		89
13.2 mm	95	97	92	92	97		83
4.75 mm	88	93	85	83	95		62
2.00 mm	78	91	80	78	94	100	51
0.425 mm	69	89	76	74	93	96	40
0.075 mm	53	59	61	50	73	51	23
0.060 mm	36	50	55	39	61	41	17
0.006 mm	4	1	3	2	3	3	1
0.0018 mm	0	0	0	0	0	1	0
SOIL MORTAR ANALYSIS - TMH 1 Test Method A5							
Soil Mortar Analysis % < 2.00mm 2.000 - 0.425	12	2	5	6	2	4	22
0.425 - 0.250	3	3	3	4	3	11	8
0.250 - 0.150	7	12	7	10	8	18	13
0.150 - 0.075	10	18	9	16	11	16	11
< 0.075	69	65	76	64	77	52	45
GRADING MODULUS	1,00	0,61	0,84	0,98	0,41	0,53	1,87
ATTERBERG LIMITS : TMH 1 Test Method A2 - A4							
LIQUID LIMIT	29	23	30	32	26	16	34
PLASTICITY INDEX	16	10	14	16	12	4	11
LINEAR SHRINKAGE	8,0	5,0	7,0	8,0	6,0	2,0	5,5
PROCTOR : MOISTURE DENSITY RELATIONSHIP : BS 1377 PART 4							
Maximum Proctor Density (Kg/m^3)	1682	-	-	-	1684	1743	-
O.M.C. (%)	18,3	-	-	-	18,9	16,5	-
RELATIVE DENSITY OF SOIL: TMH1 1986 A12T							
RELATIVE DENSITY	2,570	-	2,600	-	-	2,580	-
MOISTURE CONTENT: SANS 3001:GR20:2010							
MOISTURE CONTENT	14,3	-	11,2	-	10,2	12,8	-
PERMEABILITY AND DISPERSIVE TESTS							
PERMEABILITY (m/s)	6.13 x 10-9		4.51 x 10-8			1.63 x 10-7	
DOUBLE HYDROMETER : ASTM D422 (%)					43,11	31,27	
PINHOLE TEST : ASTM D4647					ND 3	ND 3	
CRUMB TEST : BS1377 (1990) PART 5: 6.3					Grade 3	Grade 2	
DRAINED SLOW SHEARBOX TEST : BS 1377 (1990) PART 7 :4 / 5							
MAXIMUM EFFECTIVE SHEAR STRESS... σ'd (kPa)	39,6		33,5		31,6	38,1	
APPARENT FRICTION ANGLE (degrees)	21,3		22,4		23,8	19,4	
Moulded Density (kg/m^3)	1579		1611		1563	1600	

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CLIENT: Aurecon SA
4 Daventry Street
Lynwood Ridge

ATT: Mr. G Davies

PROJECT : Kirkwood 112546
JOB/ROAD : C19226
REPORT DATE : 27.06.2018

SAMPLING PROCEDURE: Delivered to the Laboratory

TEST RESULT SUMMARY

SAMPLE NUMBER	S99011	S99012	S99013	S99014	S99015	S99016
POSITION	US10	US21	US22	US23	US24	US25
DEPTH (M)	0.45-1.25	0.0-1.45	0.5-2.0	0.5-1.7	0.5-1.5	0.5-1.3
DESCRIPTION	Residual Sand	Colluvium	Colluvium Part Pedogenic	Colluvium part Pedogenic	Colluvium Part Pedogenic	Pedogenic
UNIFIED SOIL CLASSIFICATION	SC / SM	CL	CL	CL	CL	CL
HRB CLASSIFICATION						

SIEVE ANALYSIS - TMH 1 Test Method A1, A2, A3, A5 & A6

PASSING	75.0 mm						
	63.0 mm						
	53.0 mm	100					
	37.5 mm	94					
	26.5 mm	92		100			100
	19.0 mm	88		98	100		97
	13.2 mm	82		98	99		95
	4.75 mm	69	100	89	96		88
	2.00 mm	64	99	81	93	100	82
	0.425 mm	59	98	70	88	99	76
	0.075 mm	28	64	60	74	74	63
	0.060 mm	23	46	46	48	60	57
	0.006 mm	2	1	1	5	8	2
	0.0018 mm	0	0	0	0	2	0

SOIL MORTAR ANALYSIS - TMH 1 Test Method A5

Soil Mortar Analysis % < 2.00mm	2.000 - 0.425	7	1	14	5	1	7
	0.425 - 0.250	10	4	2	2	2	3
	0.250 - 0.150	21	11	5	5	9	6
	0.150 - 0.075	18	20	6	9	14	8
	< 0.075	44	64	73	80	75	77
GRADING MODULUS		1,49	0,39	0,89	0,45	0,28	0,79

ATTERBERG LIMITS : TMH 1 Test Method A2 - A4

LIQUID LIMIT	19	27	41	26	27	39
PLASTICITY INDEX	6	12	21	12	14	20
LINEAR SHRINKAGE	3,0	6,0	10,5	6,0	7,0	10,0

PROCTOR : MOISTURE DENSITY RELATIONSHIP : BS 1377 PART 4

Maximum Proctor Density (Kg/m^3)	-	1779	1635	-	1730	-
O.M.C. (%)	-	17,3	19,8	-	16,6	-

RELATIVE DENSITY OF SOIL: TMH1 1986 A12T

RELATIVE DENSITY	-	2,610	-	-	-	2,600

MOISTURE CONTENT: SANS 3001:GR20:2010

MOISTURE CONTENT	-	9,7	10,7	-	10,1	-

PERMEABILITY AND DISPERSIVE TESTS

PERMEABILITY (m/s)		5.02 x 10-9				
DOUBLE HYDROMETER : ASTM D422 (%)					38,72	
PINHOLE TEST : ASTM D4647					ND 3	
CRUMB TEST : BS1377 (1990) PART 5: 6.3					Grade 2	

DRAINED SLOW SHEARBOX TEST : BS 1377 (1990) PART 7 :4 / 5

MAXIMUM EFFECTIVE SHEAR STRESS... σ'd (kPa)		37,3			34,3	
APPARENT FRICTION ANGLE (degrees)		21,9			20,2	
Moulded Density (kg/m^3)		1635			1595	

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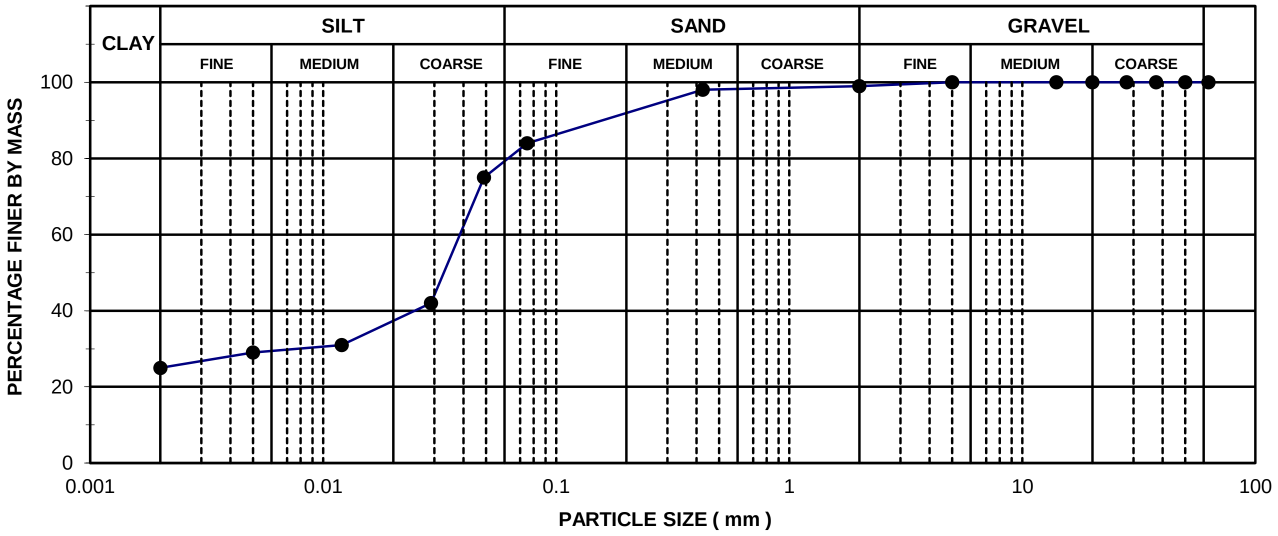
Name : Frederik Eilbers
Position : Technical Signatory

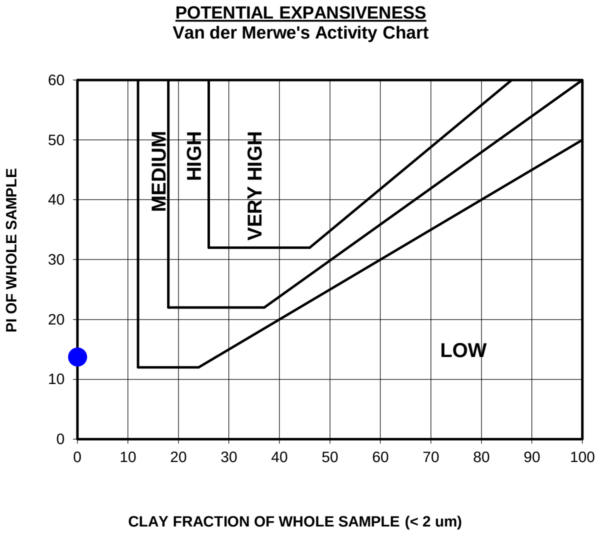
FOUNDATION INDICATOR TEST RESULTS

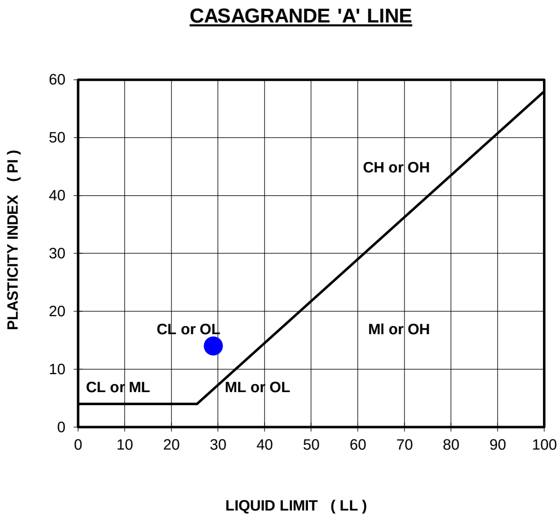
TEST LOCATION	TP105	PROJECT	Algoa Recon Support
SAMPLE NO.	3460	PROJECT NUMBER	112546
DEPTH	1.0-3.6 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**98**	Liquid limit	(%)	**29.0**	% Gravel	**1**
50.000	**100**	0.075	**84**	Plastic limit	(%)	**15**	% Sand	**15**
37.500	**100**	0.049	**75**	Plasticity Index	(%)	**14**	% Silt	**59**
28.000	**100**	0.029	**42**	Weighted PI	(%)	**14**	% Clay	**25**
20.000	**100**	0.012	**31**	Linear Shrinkage	(%)	**7.0**	Activity	**0.6**
14.000	**100**	0.002	**25**	Grading Modulus		**0.19**	Unified Classification	**CL**
5.000	**100**	0.000	**0**	Uniformity coefficient		**20**	TRB Classification	**A - 6**
2.000	**99**	0.000	**0**	Coefficient of curvature		**1.4**		

PARTICLE SIZE DISTRIBUTION





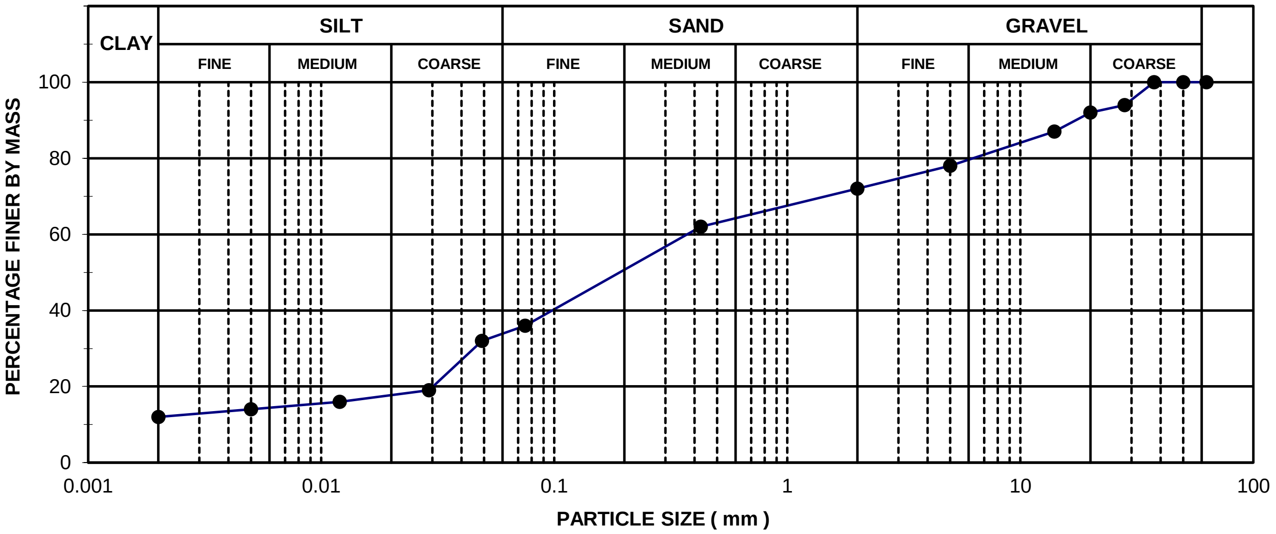


FOUNDATION INDICATOR TEST RESULTS

TEST LOCATION	TP111	PROJECT	Algoa Recon Support
SAMPLE NO.	3466	PROJECT NUMBER	112546
DEPTH	2.2-3.9 m	SITE	Lower Coerney Dam site

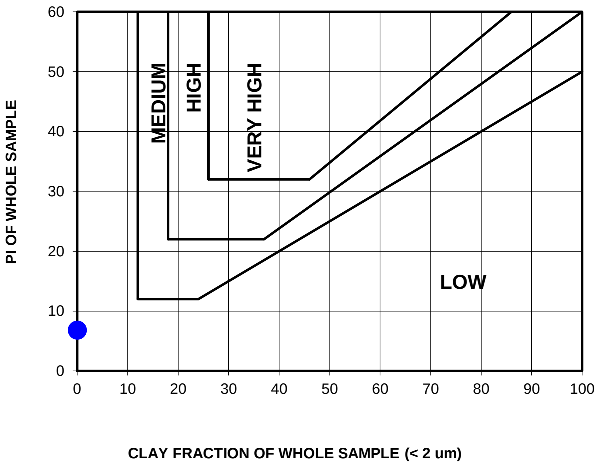
SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**62**	Liquid limit	(%)	**27.0**	% Gravel	**28**
50.000	**100**	0.075	**36**	Plastic limit	(%)	**16**	% Sand	**36**
37.500	**100**	0.049	**32**	Plasticity Index	(%)	**11**	% Silt	**24**
28.000	**94**	0.029	**19**	Weighted PI	(%)	**7**	% Clay	**12**
20.000	**92**	0.012	**16**	Linear Shrinkage	(%)	**5.5**	Activity	**0.9**
14.000	**87**	0.002	**12**	Grading Modulus		**1.30**	Unified Classification	**SC**
5.000	**78**	0.000	**0**	Uniformity coefficient		**199**	TRB Classification	**A - 6**
2.000	**72**	0.000	**0**	Coefficient of curvature		**2.9**		

PARTICLE SIZE DISTRIBUTION

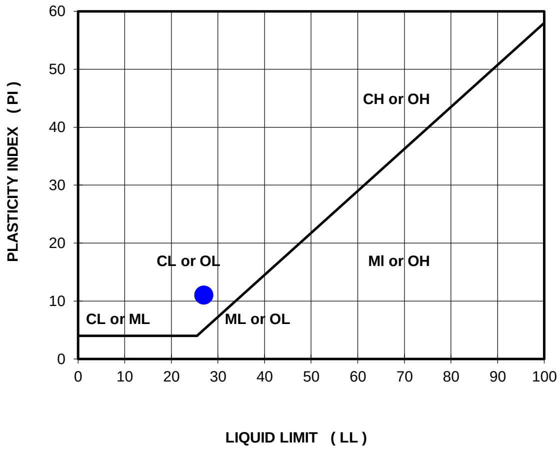


POTENTIAL EXPANSIVENESS

Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE

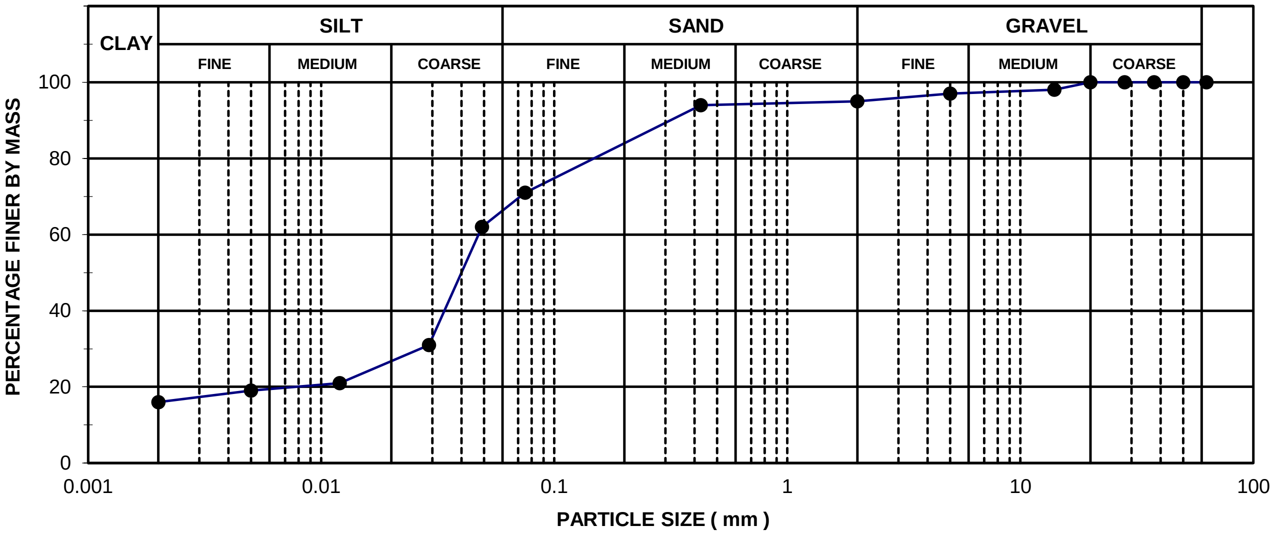


FOUNDATION INDICATOR TEST RESULTS

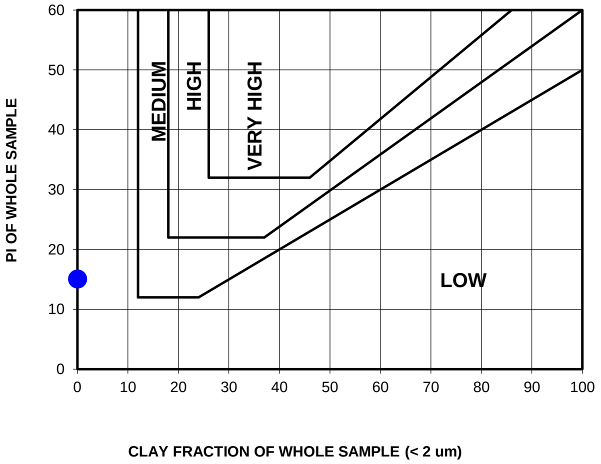
TEST LOCATION	TP113	PROJECT	Algoa Recon Support
SAMPLE NO.	3467	PROJECT NUMBER	112546
DEPTH	0.4-4.5 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**94**	Liquid limit	(%)	**32.0**	% Gravel	**5**
50.000	**100**	0.075	**71**	Plastic limit	(%)	**16**	% Sand	**24**
37.500	**100**	0.049	**62**	Plasticity Index	(%)	**16**	% Silt	**55**
28.000	**100**	0.029	**31**	Weighted PI	(%)	**15**	% Clay	**16**
20.000	**100**	0.012	**21**	Linear Shrinkage	(%)	**8.5**	Activity	**1.0**
14.000	**98**	0.002	**16**	Grading Modulus		**0.40**	Unified Classification	**CL**
5.000	**97**	0.000	**0**	Uniformity coefficient		**24**	TRB Classification	**A - 6**
2.000	**95**	0.000	**0**	Coefficient of curvature		**9.0**		

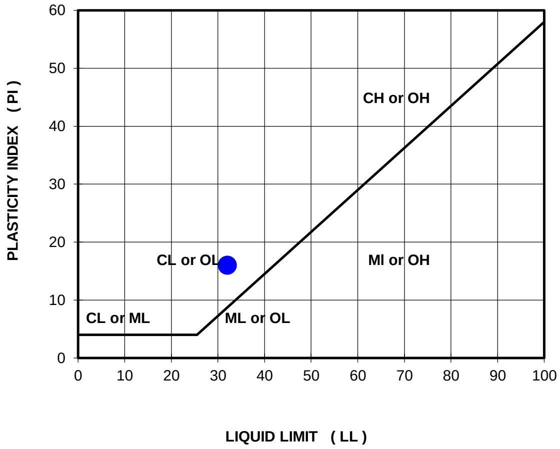
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE

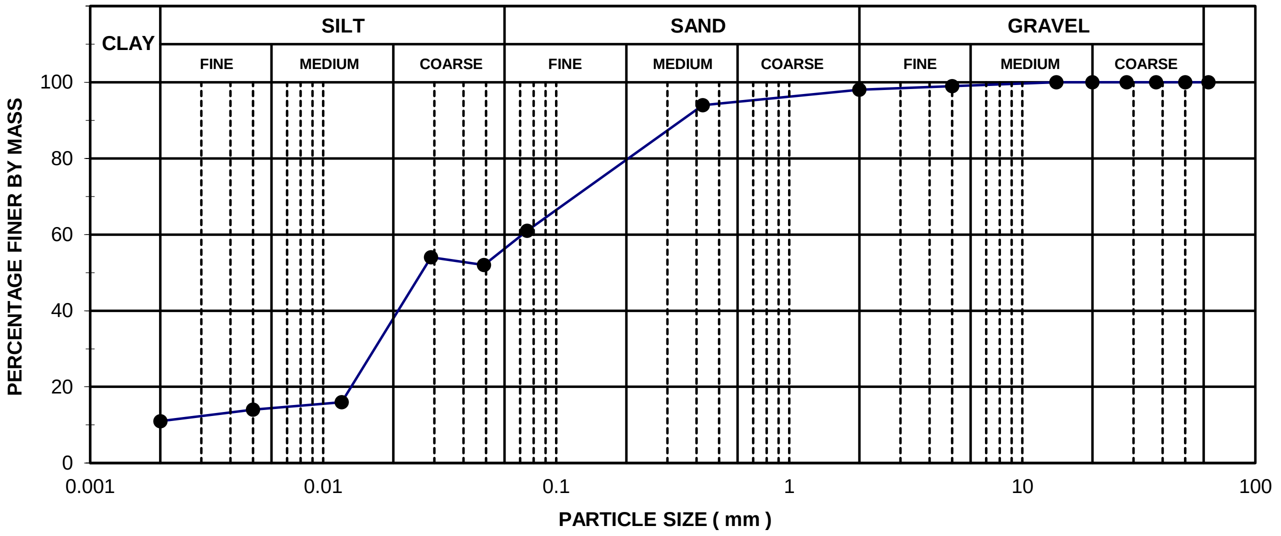


FOUNDATION INDICATOR TEST RESULTS

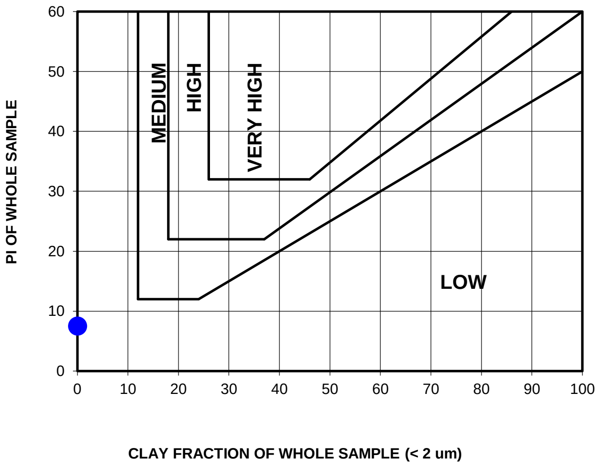
TEST LOCATION	TP120	PROJECT	Algoa Recon Support
SAMPLE NO.	3474	PROJECT NUMBER	112546
DEPTH	0.8-2.6 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**94**	Liquid limit	(%)	**25.0**	% Gravel	**2**
50.000	**100**	0.075	**61**	Plastic limit	(%)	**17**	% Sand	**37**
37.500	**100**	0.049	**52**	Plasticity Index	(%)	**8**	% Silt	**50**
28.000	**100**	0.029	**54**	Weighted PI	(%)	**8**	% Clay	**11**
20.000	**100**	0.012	**16**	Linear Shrinkage	(%)	**4.0**	Activity	**0.7**
14.000	**100**	0.002	**11**	Grading Modulus		**0.47**	Unified Classification	**CL**
5.000	**99**	0.000	**0**	Uniformity coefficient		**36**	TRB Classification	**A - 4**
2.000	**98**	0.000	**0**	Coefficient of curvature		**2.8**		

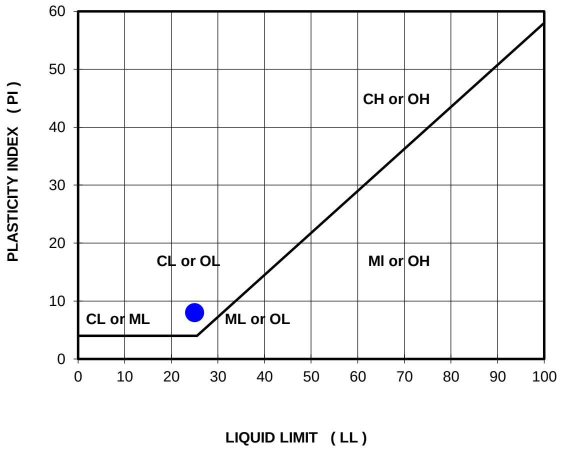
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE

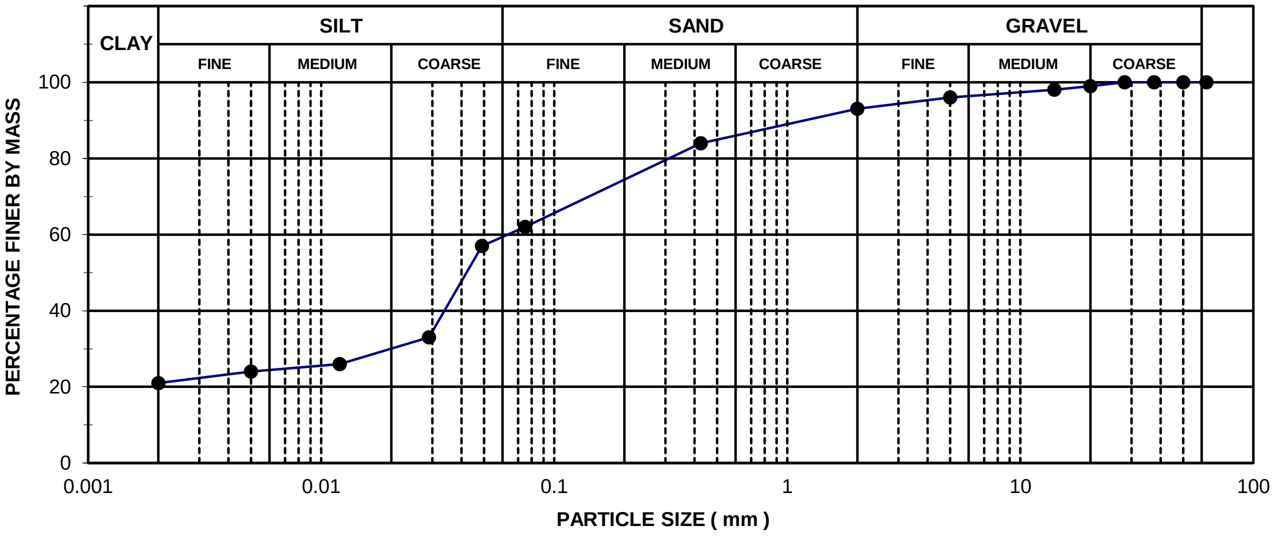


FOUNDATION INDICATOR TEST RESULTS

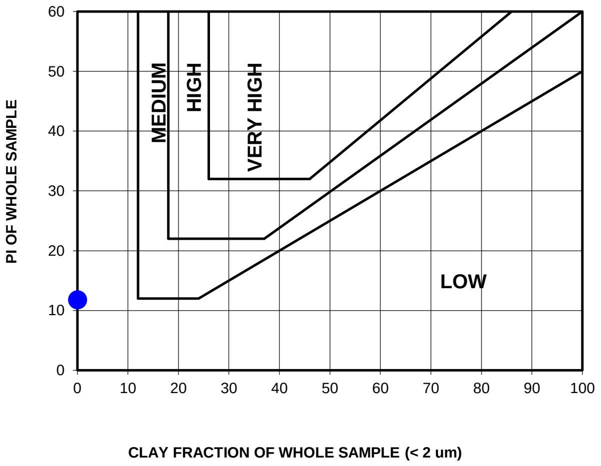
TEST LOCATION	TP121	PROJECT	Algoa Recon Support
SAMPLE NO.	3475	PROJECT NUMBER	112546
DEPTH	0.4-2.8 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**84**	Liquid limit	(%)	**29.0**	% Gravel	**7**
50.000	**100**	0.075	**62**	Plastic limit	(%)	**15**	% Sand	**31**
37.500	**100**	0.049	**57**	Plasticity Index	(%)	**14**	% Silt	**41**
28.000	**100**	0.029	**33**	Weighted PI	(%)	**12**	% Clay	**21**
20.000	**99**	0.012	**26**	Linear Shrinkage	(%)	**6.5**	Activity	**0.7**
14.000	**98**	0.002	**21**	Grading Modulus		**0.61**	Unified Classification	**CL**
5.000	**96**	0.000	**0**	Uniformity coefficient		**32**	TRB Classification	**A - 6**
2.000	**93**	0.000	**0**	Coefficient of curvature		**4.4**		

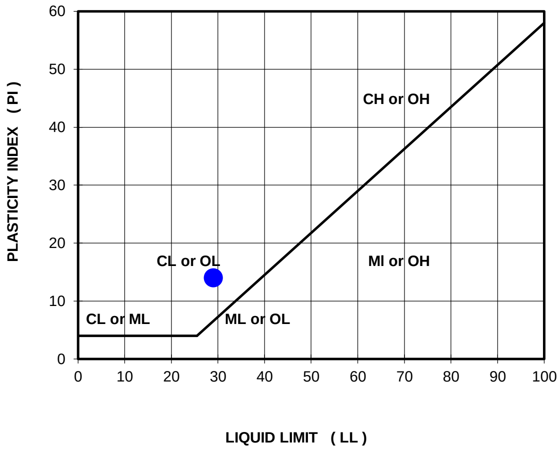
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



FOUNDATION INDICATOR TEST RESULTS

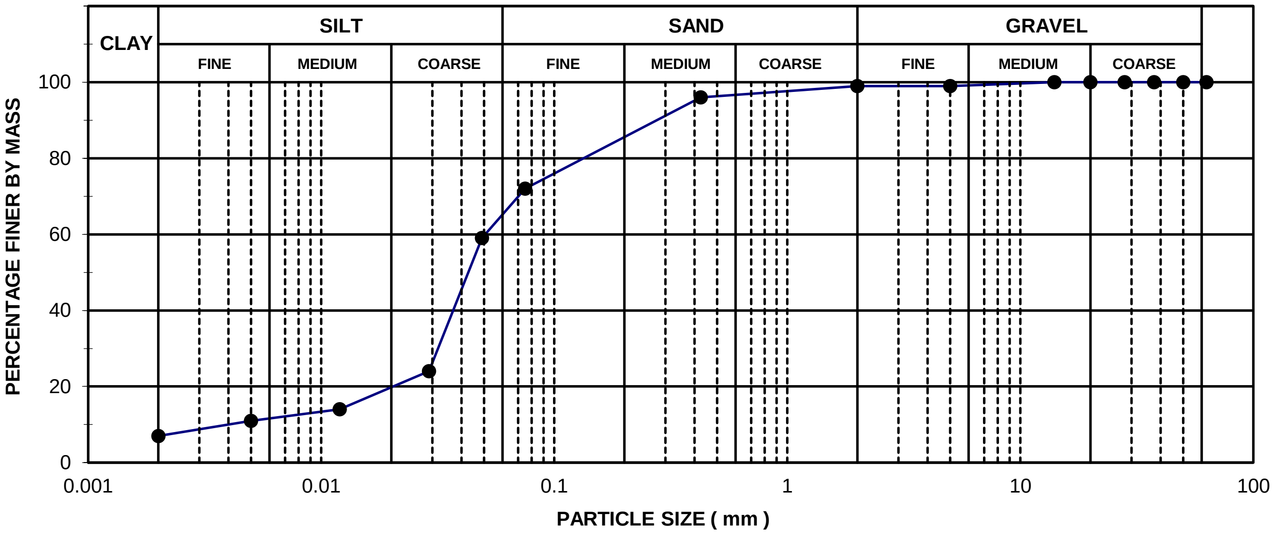
TEST LOCATION	TP101	PROJECT	Algoa Recon Support
SAMPLE NO.	3456	PROJECT NUMBER	112546
DEPTH	3.3-3.7 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS			
Sieve (mm)	% Passing	Sieve (mm)	% Passing
63.000	**100**	0.425	**96**
50.000	**100**	0.075	**72**
37.500	**100**	0.049	**59**
28.000	**100**	0.029	**24**
20.000	**100**	0.012	**14**
14.000	**100**	0.002	**7**
5.000	**99**	0.000	**0**
2.000	**99**	0.000	**0**

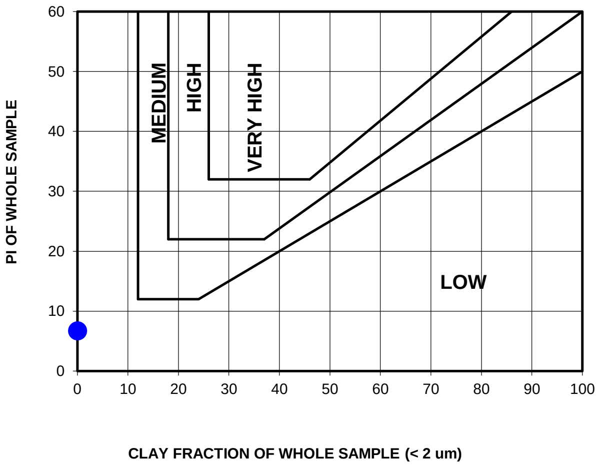
ATTERBERG LIMITS		
Liquid limit	(%)	**24.0**
Plastic limit	(%)	**17**
Plasticity Index	(%)	**7**
Weighted PI	(%)	**7**
Linear Shrinkage	(%)	**4.0**
Grading Modulus		**0.33**
Uniformity coefficient		**12**
Coefficient of curvature		**5.5**

SOIL CLASSIFICATION	
% Gravel	**1**
% Sand	**27**
% Silt	**65**
% Clay	**7**
Activity	**1.0**
Unified Classification	**CL**
TRB Classification	**A - 4**

PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



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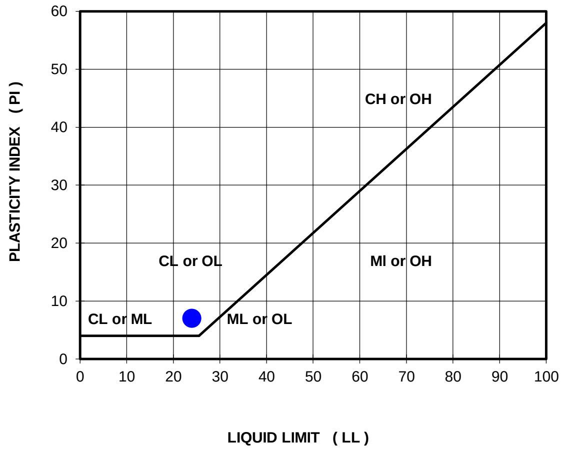


FOUNDATION INDICATOR TEST RESULTS

TEST LOCATION	TP102	PROJECT	Algoa Recon Support
SAMPLE NO.	3457	PROJECT NUMBER	112546
DEPTH	0.4-1.8 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS

Sieve (mm)	% Passing	Sieve (mm)	% Passing
63.000	**100**	0.425	**94**
50.000	**100**	0.075	**55**
37.500	**100**	0.049	**49**
28.000	**100**	0.029	**26**
20.000	**100**	0.012	**20**
14.000	**100**	0.002	**16**
5.000	**100**	0.000	**0**
2.000	**100**	0.000	**0**

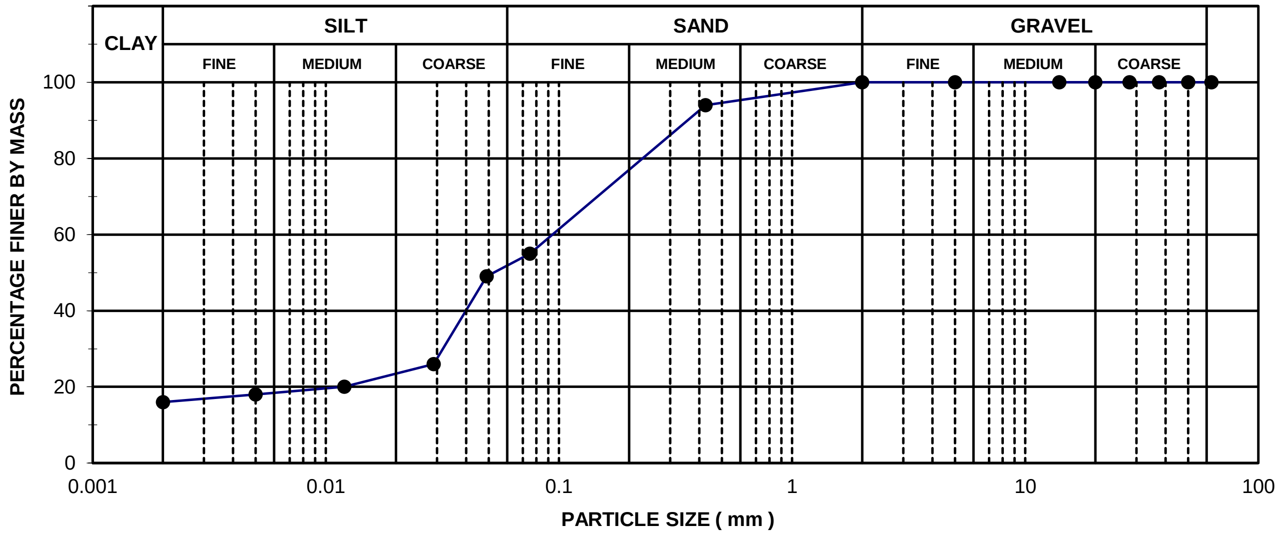
ATTERBERG LIMITS

Liquid limit	(%)	**17.0**
Plastic limit	(%)	**11**
Plasticity Index	(%)	**6**
Weighted PI	(%)	**6**
Linear Shrinkage	(%)	**3.0**
Grading Modulus		**0.51**
Uniformity coefficient		**60**
Coefficient of curvature		**5.0**

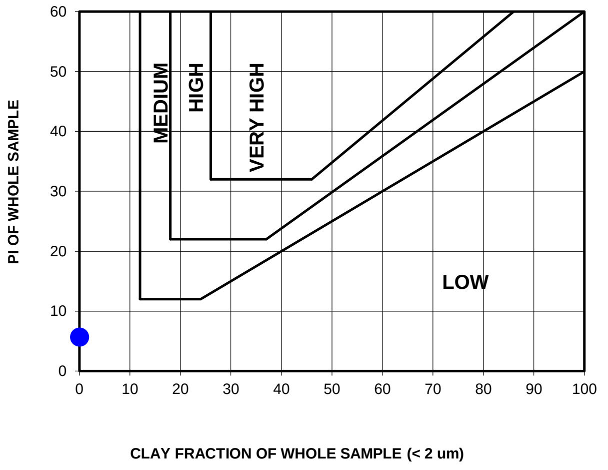
SOIL CLASSIFICATION

% Gravel	**0**
% Sand	**45**
% Silt	**39**
% Clay	**16**
Activity	**0.4**
Unified Classification	**CL**
TRB Classification	**A - 4**

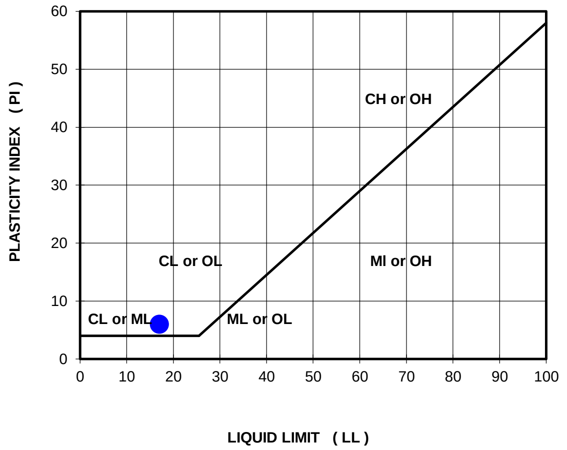
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



FOUNDATION INDICATOR TEST RESULTS

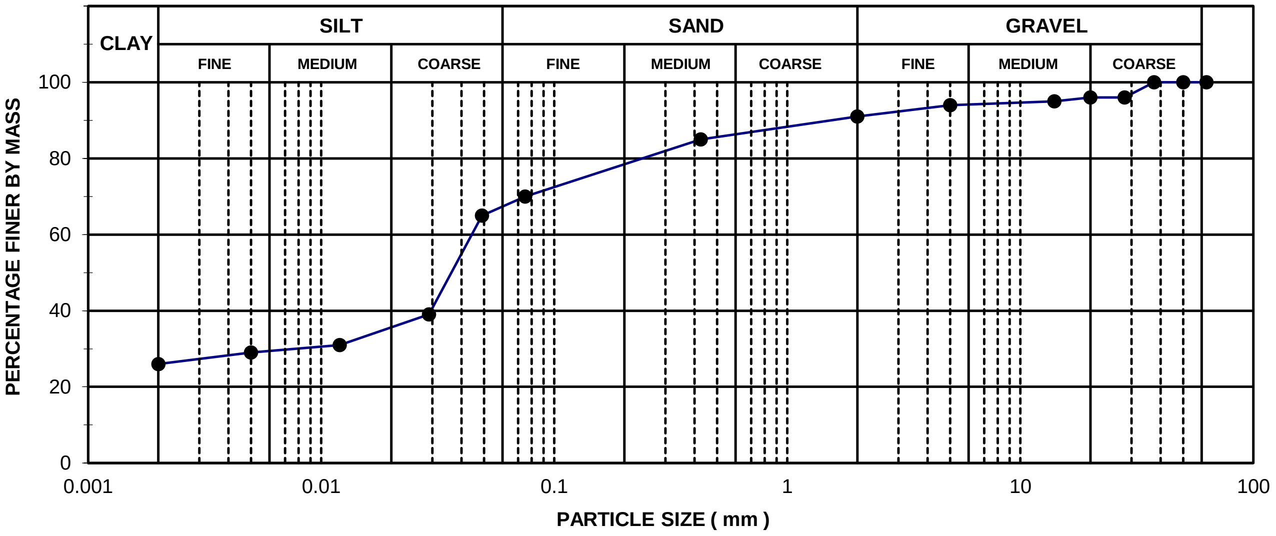
TEST LOCATION	TP104	PROJECT	Algoa Recon Support
SAMPLE NO.	3458	PROJECT NUMBER	112546
DEPTH	0.4-1.3 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS			
Sieve (mm)	% Passing	Sieve (mm)	% Passing
63.000	**100**	0.425	**85**
50.000	**100**	0.075	**70**
37.500	**100**	0.049	**65**
28.000	**96**	0.029	**39**
20.000	**96**	0.012	**31**
14.000	**95**	0.002	**26**
5.000	**94**	0.000	**0**
2.000	**91**	0.000	**0**

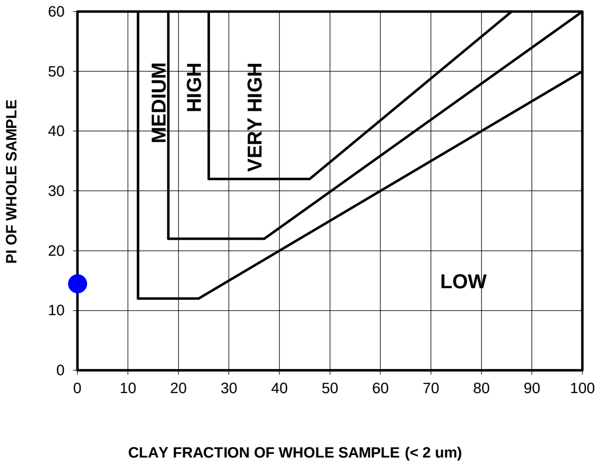
ATTERBERG LIMITS		
Liquid limit	(%)	**42.0**
Plastic limit	(%)	**25**
Plasticity Index	(%)	**17**
Weighted PI	(%)	**14**
Linear Shrinkage	(%)	**8.0**
Grading Modulus		**0.54**
Uniformity coefficient		**23**
Coefficient of curvature		**1.2**

SOIL CLASSIFICATION	
% Gravel	**9**
% Sand	**21**
% Silt	**44**
% Clay	**26**
Activity	**0.7**
Unified Classification	**CL**
TRB Classification	**A - 7 - 6**

PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



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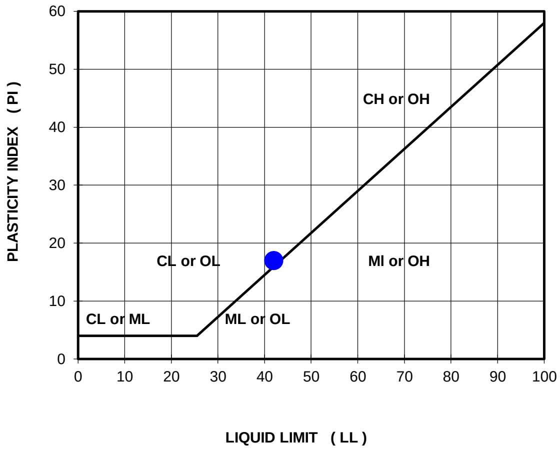


FOUNDATION INDICATOR TEST RESULTS

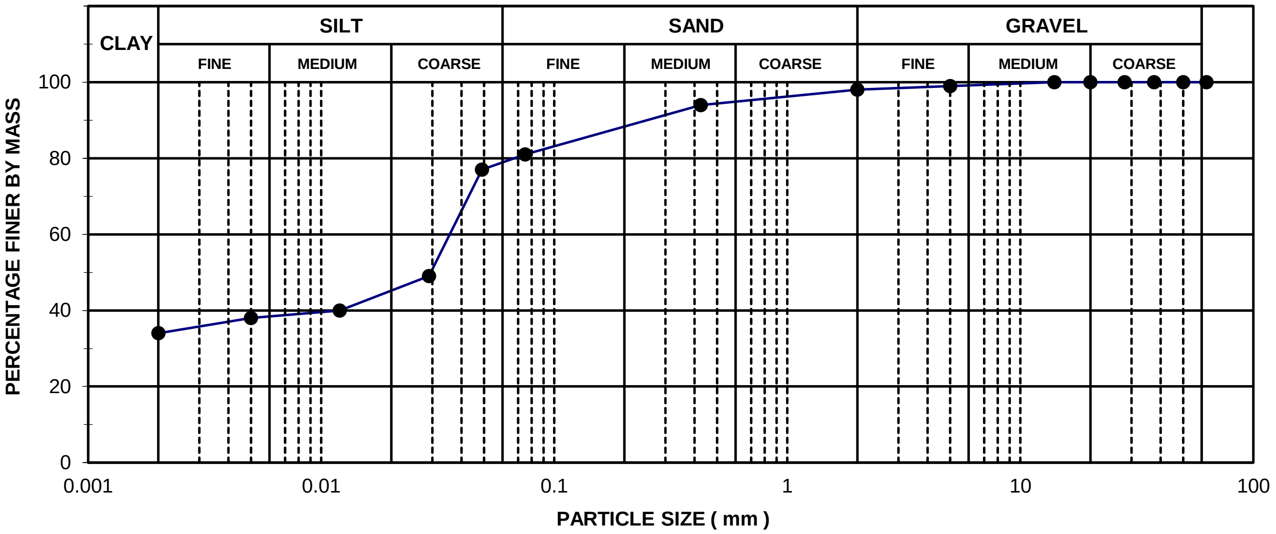
TEST LOCATION	TP104	PROJECT	Algoa Recon Support
SAMPLE NO.	3459	PROJECT NUMBER	112546
DEPTH	1.3-2.3 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS			
Sieve (mm)	% Passing	Sieve (mm)	% Passing
63.000	**100**	0.425	**94**
50.000	**100**	0.075	**81**
37.500	**100**	0.049	**77**
28.000	**100**	0.029	**49**
20.000	**100**	0.012	**40**
14.000	**100**	0.002	**34**
5.000	**99**	0.000	**0**
2.000	**98**	0.000	**0**

ATTERBERG LIMITS		
Liquid limit	(%)	**42.0**
Plastic limit	(%)	**23**
Plasticity Index	(%)	**19**
Weighted PI	(%)	**18**
Linear Shrinkage	(%)	**9.0**
Grading Modulus		**0.27**
Uniformity coefficient		**18**
Coefficient of curvature		**0.1**

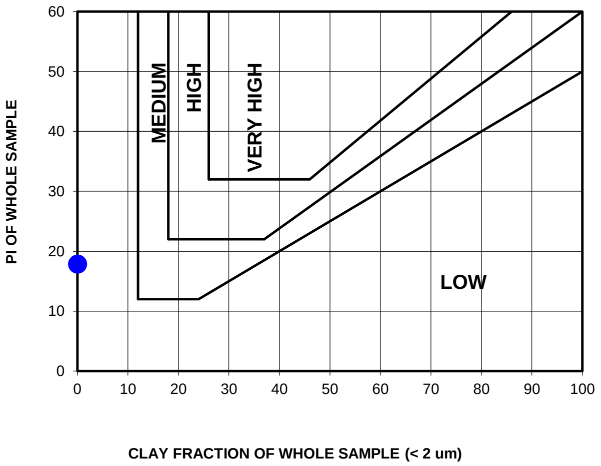
SOIL CLASSIFICATION	
% Gravel	**2**
% Sand	**17**
% Silt	**47**
% Clay	**34**
Activity	**0.6**
Unified Classification	**CL**
TRB Classification	**A - 7 - 6**

PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS

Van der Merwe's Activity Chart



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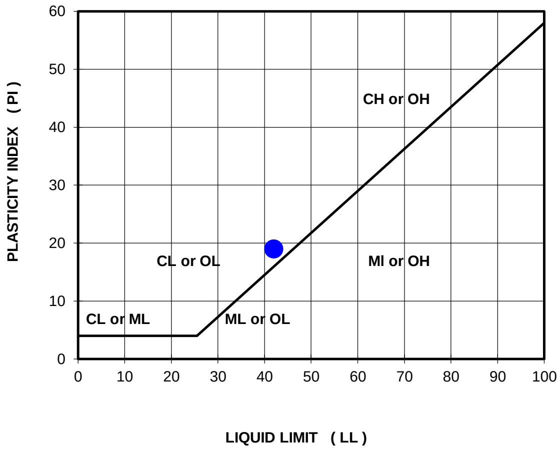


FOUNDATION INDICATOR TEST RESULTS

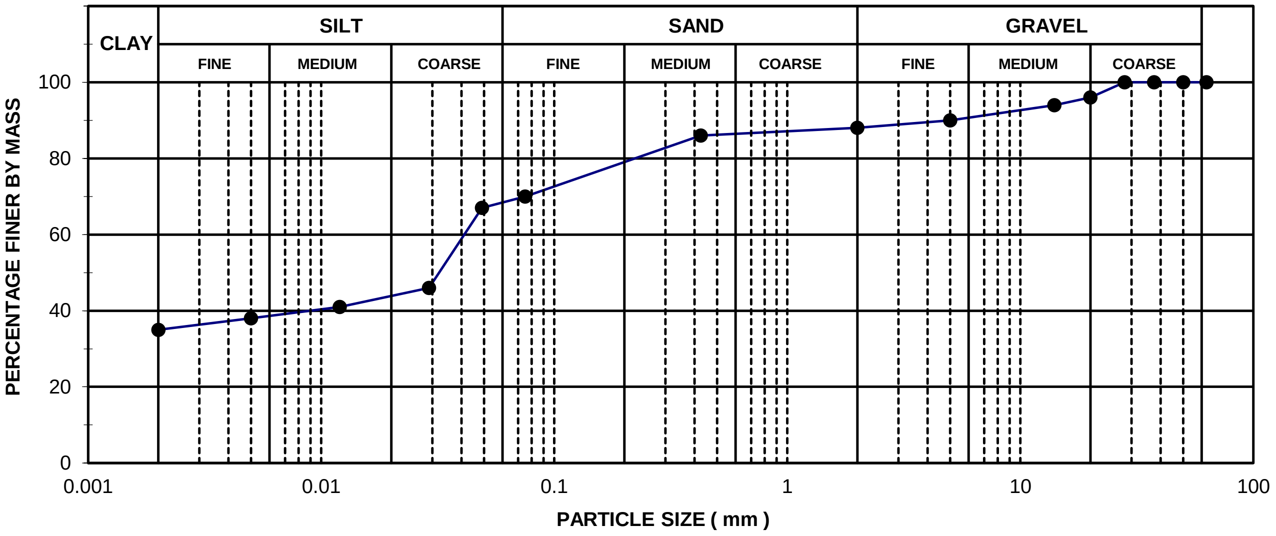
TEST LOCATION	TP106	PROJECT	Algoa Recon Support
SAMPLE NO.	3461	PROJECT NUMBER	112546
DEPTH	1.6-3.1 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS			
Sieve (mm)	% Passing	Sieve (mm)	% Passing
63.000	**100**	0.425	**86**
50.000	**100**	0.075	**70**
37.500	**100**	0.049	**67**
28.000	**100**	0.029	**46**
20.000	**96**	0.012	**41**
14.000	**94**	0.002	**35**
5.000	**90**	0.000	**0**
2.000	**88**	0.000	**0**

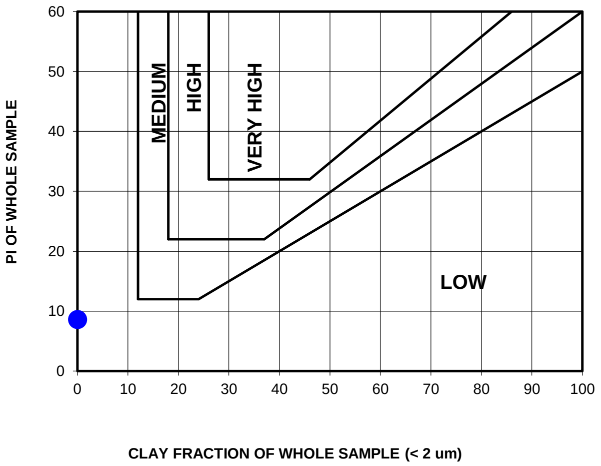
ATTERBERG LIMITS		
Liquid limit	(%)	**32.0**
Plastic limit	(%)	**22**
Plasticity Index	(%)	**10**
Weighted PI	(%)	**9**
Linear Shrinkage	(%)	**5.0**
Grading Modulus		**0.56**
Uniformity coefficient		**21**
Coefficient of curvature		**0.0**

SOIL CLASSIFICATION	
% Gravel	**12**
% Sand	**18**
% Silt	**35**
% Clay	**35**
Activity	**0.3**
Unified Classification	**CL**
TRB Classification	**A - 4**

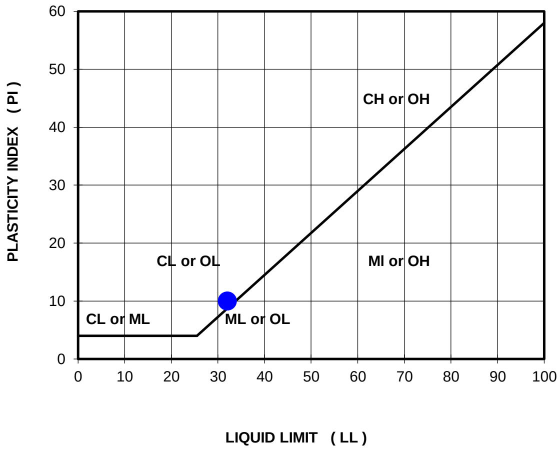
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE

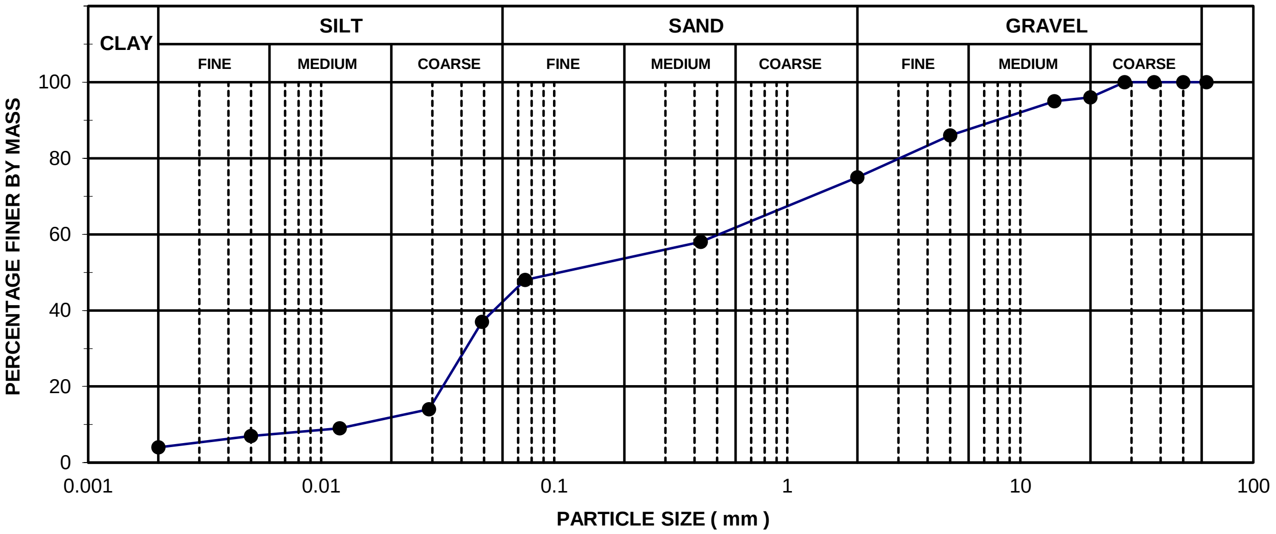


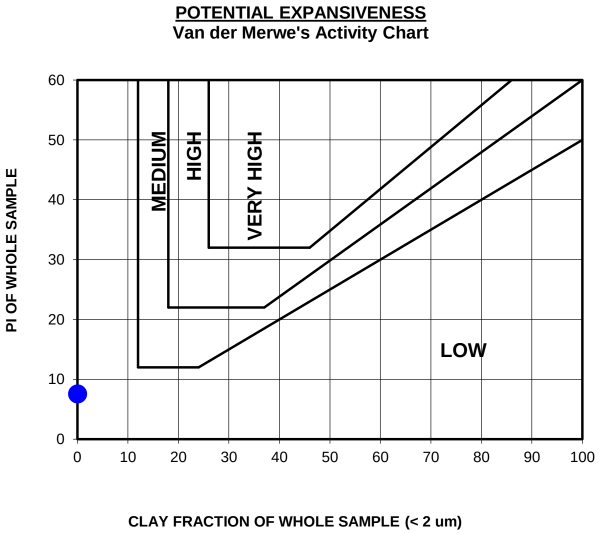
FOUNDATION INDICATOR TEST RESULTS

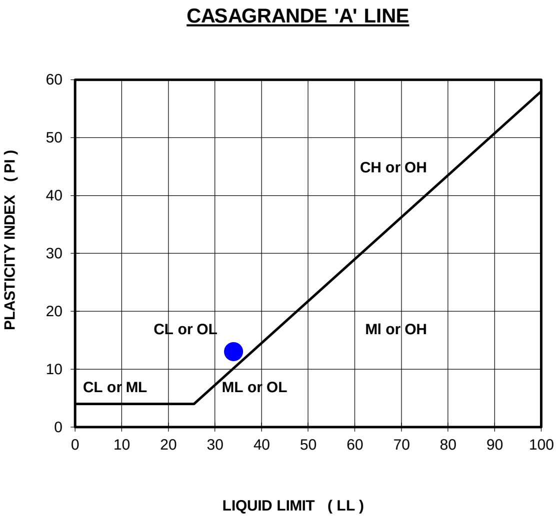
TEST LOCATION	TP108	PROJECT	Algoa Recon Support
SAMPLE NO.	3462	PROJECT NUMBER	112546
DEPTH	0.6-2.2 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**58**	Liquid limit	(%)	**34.0**	% Gravel	**25**
50.000	**100**	0.075	**48**	Plastic limit	(%)	**21**	% Sand	**27**
37.500	**100**	0.049	**37**	Plasticity Index	(%)	**13**	% Silt	**44**
28.000	**100**	0.029	**14**	Weighted PI	(%)	**8**	% Clay	**4**
20.000	**96**	0.012	**9**	Linear Shrinkage	(%)	**6.5**	Activity	**3.3**
14.000	**95**	0.002	**4**	Grading Modulus		**1.19**	Unified Classification	**SC**
5.000	**86**	0.000	**0**	Uniformity coefficient		**35**	TRB Classification	**A - 6**
2.000	**75**	0.000	**0**	Coefficient of curvature		**0.2**		

PARTICLE SIZE DISTRIBUTION





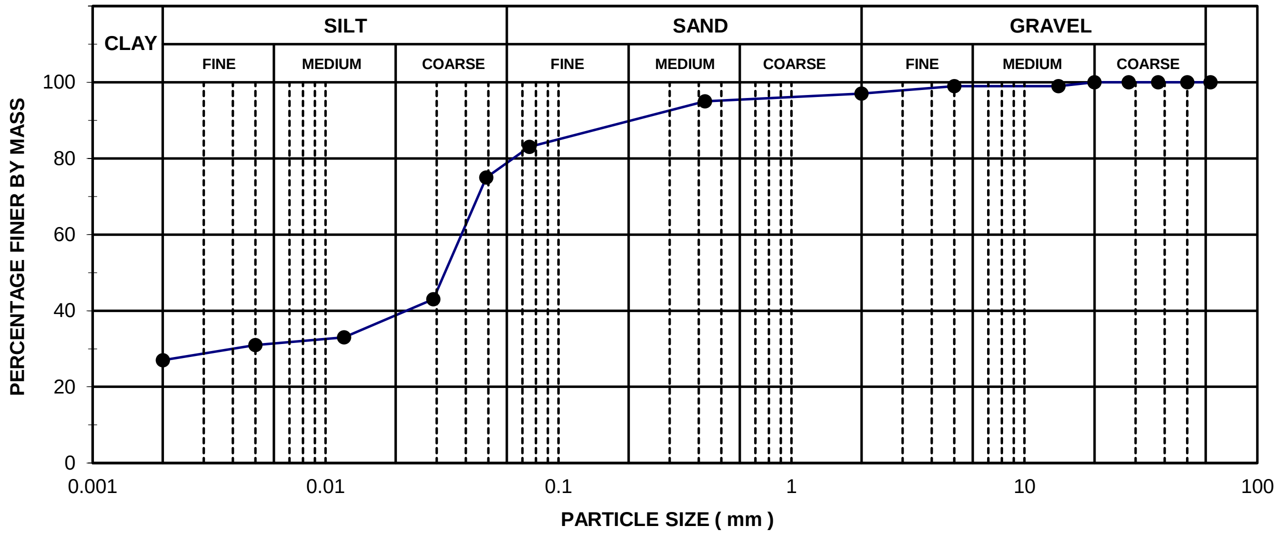


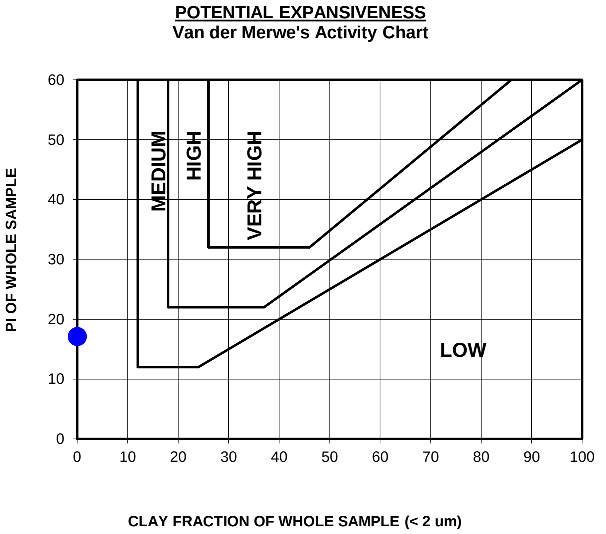
FOUNDATION INDICATOR TEST RESULTS

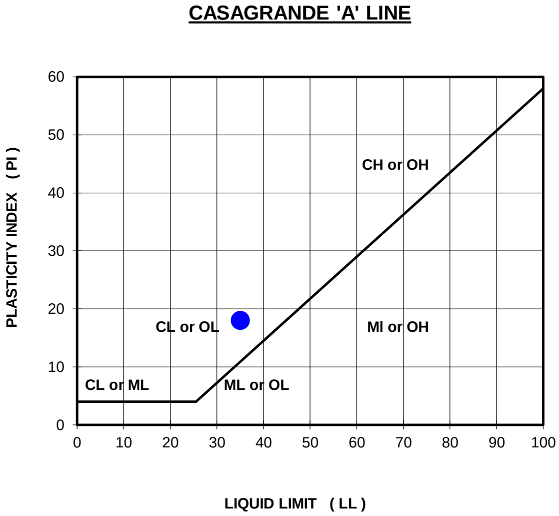
TEST LOCATION	TP109	PROJECT	Algoa Recon Support
SAMPLE NO.	3463	PROJECT NUMBER	112546
DEPTH	0.7-4.1 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**95**	Liquid limit	(%)	**35.0**	% Gravel	**3**
50.000	**100**	0.075	**83**	Plastic limit	(%)	**17**	% Sand	**14**
37.500	**100**	0.049	**75**	Plasticity Index	(%)	**18**	% Silt	**56**
28.000	**100**	0.029	**43**	Weighted PI	(%)	**17**	% Clay	**27**
20.000	**100**	0.012	**33**	Linear Shrinkage	(%)	**9.0**	Activity	**0.7**
14.000	**99**	0.002	**27**	Grading Modulus		**0.25**	Unified Classification	**CL**
5.000	**99**	0.000	**0**	Uniformity coefficient		**20**	TRB Classification	**A - 6**
2.000	**97**	0.000	**0**	Coefficient of curvature		**0.2**		

PARTICLE SIZE DISTRIBUTION





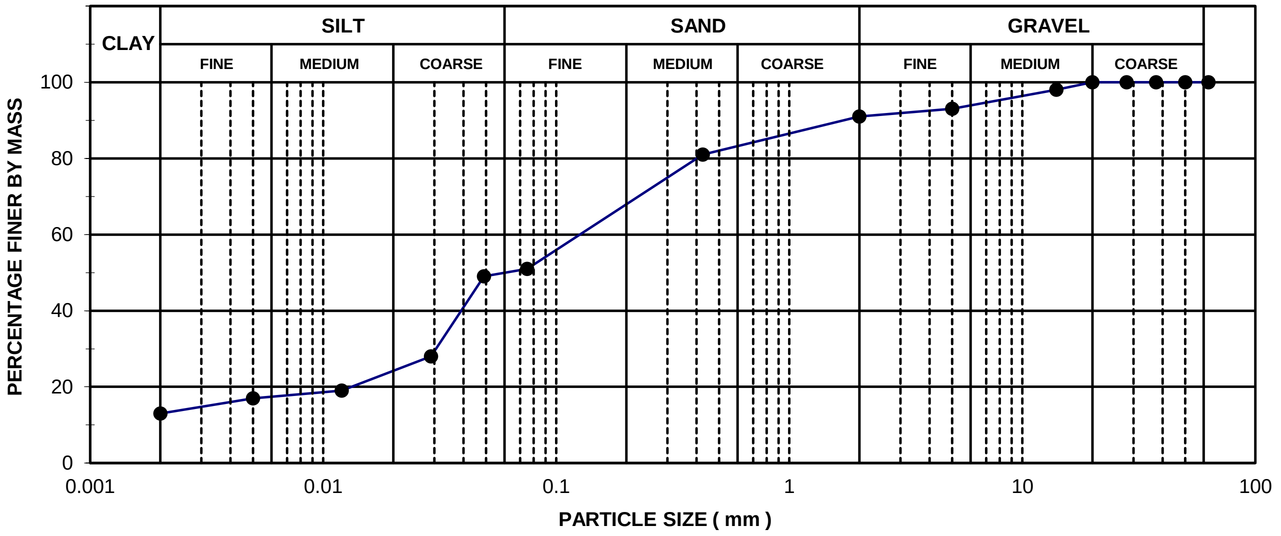


FOUNDATION INDICATOR TEST RESULTS

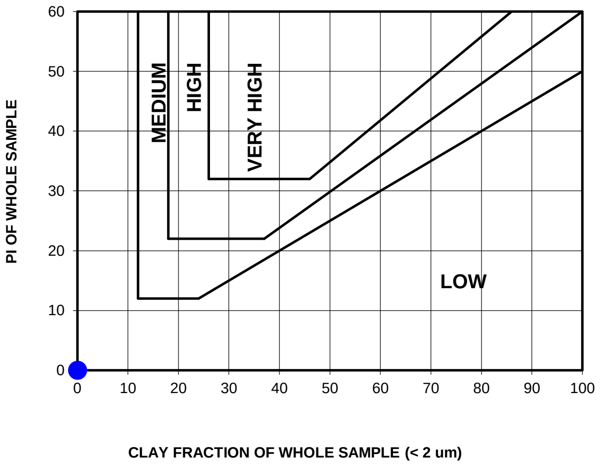
TEST LOCATION	TP110	PROJECT	Algoa Recon Support
SAMPLE NO.	3464	PROJECT NUMBER	112546
DEPTH	0.0-0.9 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**81**	Liquid limit	(%)	**0.0**	% Gravel	**9**
50.000	**100**	0.075	**51**	Plastic limit	(%)	**0**	% Sand	**40**
37.500	**100**	0.049	**49**	Plasticity Index	(%)	**SP**	% Silt	**38**
28.000	**100**	0.029	**28**	Weighted PI	(%)	**0**	% Clay	**13**
20.000	**100**	0.012	**19**	Linear Shrinkage	(%)	**1.5**	Activity	**0.0**
14.000	**98**	0.002	**13**	Grading Modulus		**0.77**	Unified Classification	**CL**
5.000	**93**	0.000	**0**	Uniformity coefficient		**90**	TRB Classification	**A - 6**
2.000	**91**	0.000	**0**	Coefficient of curvature		**3.0**		

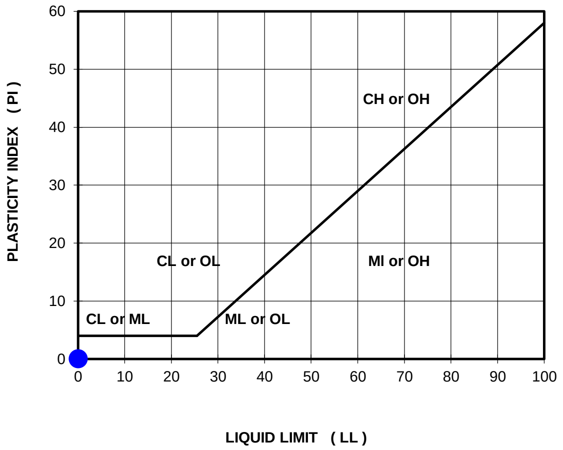
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE

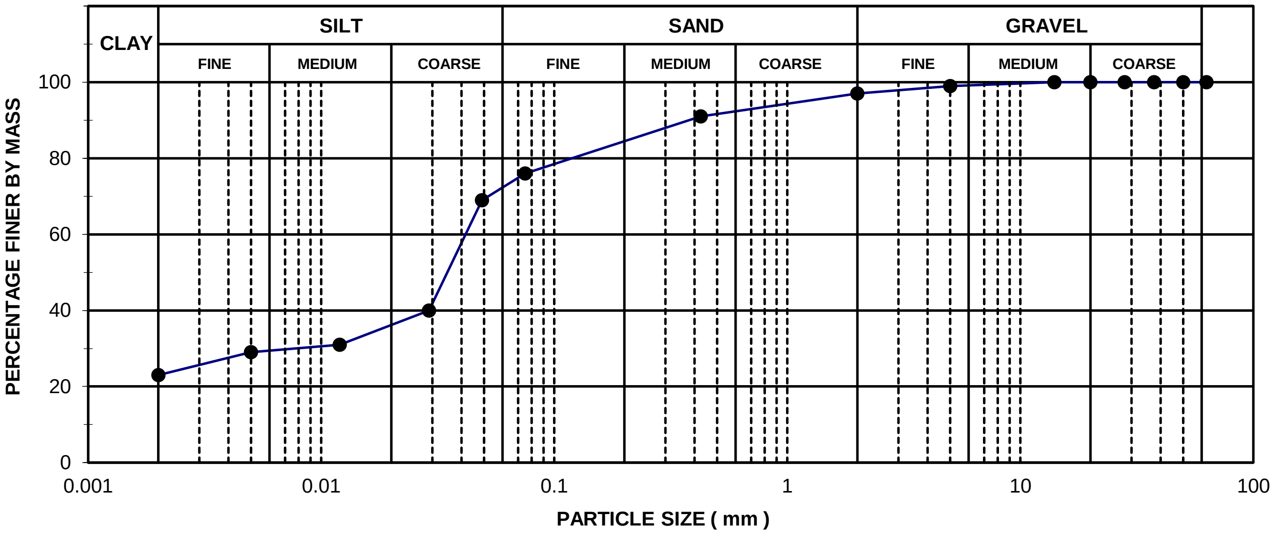


FOUNDATION INDICATOR TEST RESULTS

TEST LOCATION	TP110	PROJECT	Algoa Recon Support
SAMPLE NO.	3465	PROJECT NUMBER	112546
DEPTH	2.1-3.4 m	SITE	Lower Coerney Dam site

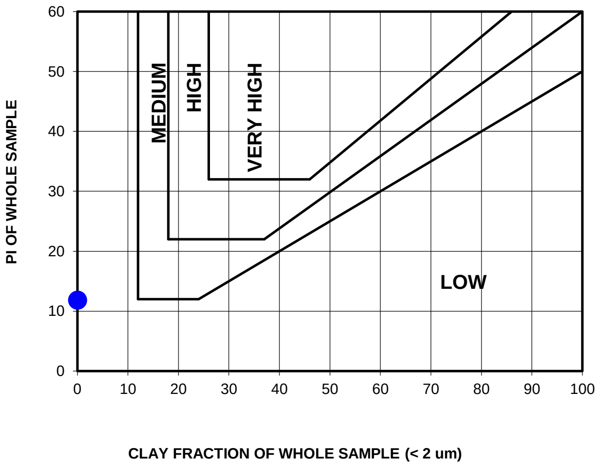
SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**91**	Liquid limit	(%)	**39.0**	% Gravel	**3**
50.000	**100**	0.075	**76**	Plastic limit	(%)	**26**	% Sand	**21**
37.500	**100**	0.049	**69**	Plasticity Index	(%)	**13**	% Silt	**53**
28.000	**100**	0.029	**40**	Weighted PI	(%)	**12**	% Clay	**23**
20.000	**100**	0.012	**31**	Linear Shrinkage	(%)	**6.0**	Activity	**0.6**
14.000	**100**	0.002	**23**	Grading Modulus		**0.36**	Unified Classification	**ML**
5.000	**99**	0.000	**0**	Uniformity coefficient		**21**	TRB Classification	**A - 6**
2.000	**97**	0.000	**0**	Coefficient of curvature		**1.3**		

PARTICLE SIZE DISTRIBUTION

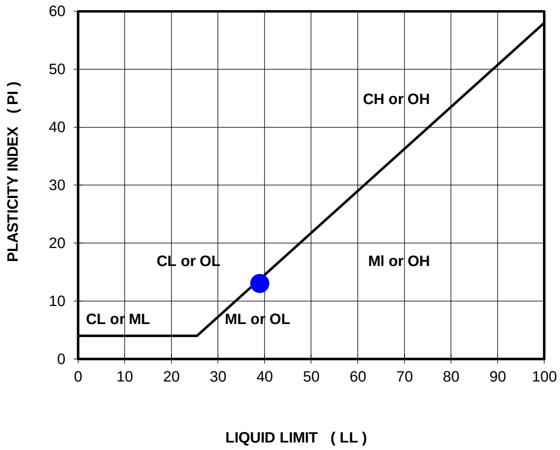


POTENTIAL EXPANSIVENESS

Van der Merwe's Activity Chart



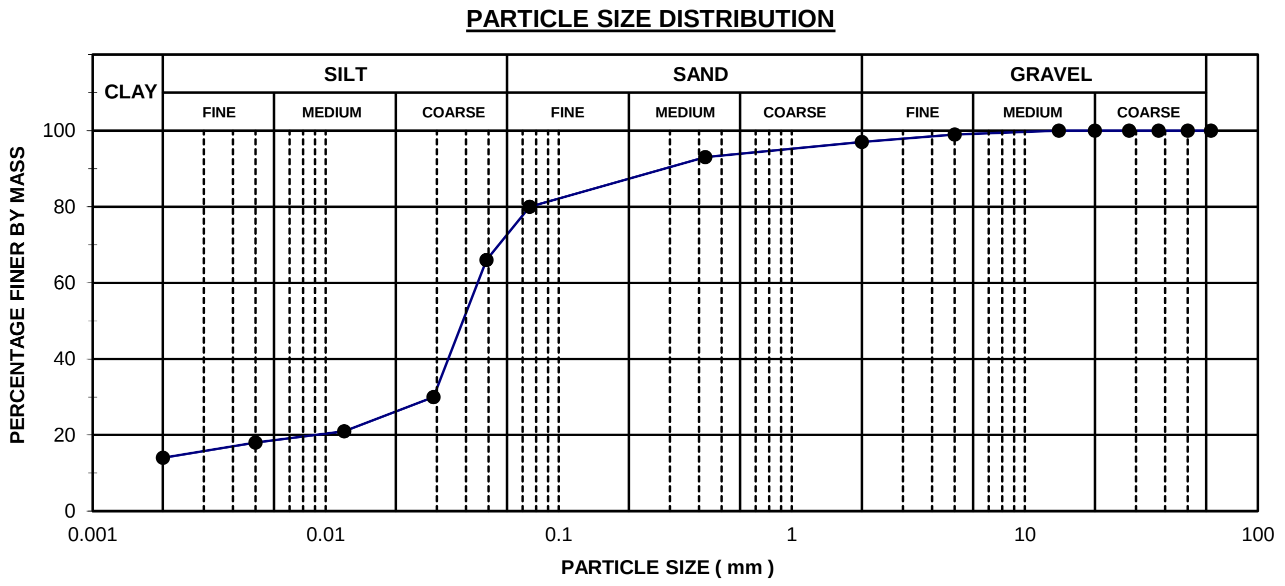
CASAGRANDE 'A' LINE

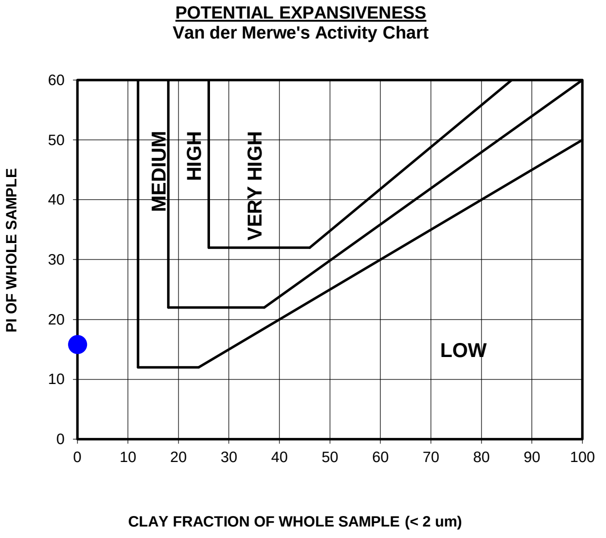


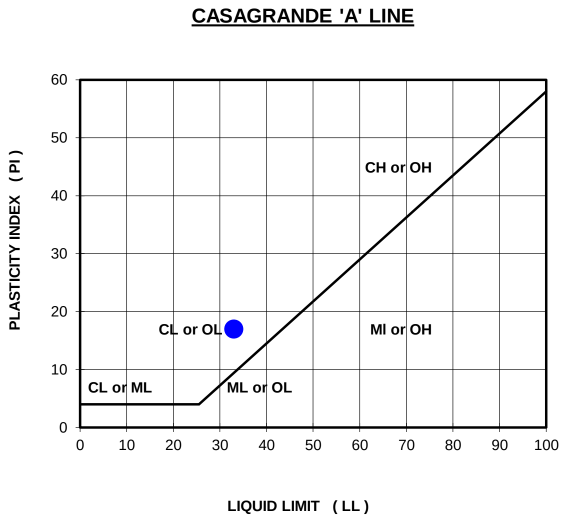
FOUNDATION INDICATOR TEST RESULTS

TEST LOCATION	TP115	PROJECT	Algoa Recon Support
SAMPLE NO.	3468	PROJECT NUMBER	112546
DEPTH	0.4-2.4 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**93**	Liquid limit	(%)	**33.0**	% Gravel	**3**
50.000	**100**	0.075	**80**	Plastic limit	(%)	**16**	% Sand	**17**
37.500	**100**	0.049	**66**	Plasticity Index	(%)	**17**	% Silt	**66**
28.000	**100**	0.029	**30**	Weighted PI	(%)	**16**	% Clay	**14**
20.000	**100**	0.012	**21**	Linear Shrinkage	(%)	**8.0**	Activity	**1.2**
14.000	**100**	0.002	**14**	Grading Modulus		**0.30**	Unified Classification	**CL**
5.000	**99**	0.000	**0**	Uniformity coefficient		**23**	TRB Classification	**A - 6**
2.000	**97**	0.000	**0**	Coefficient of curvature		**10.5**		







FOUNDATION INDICATOR TEST RESULTS

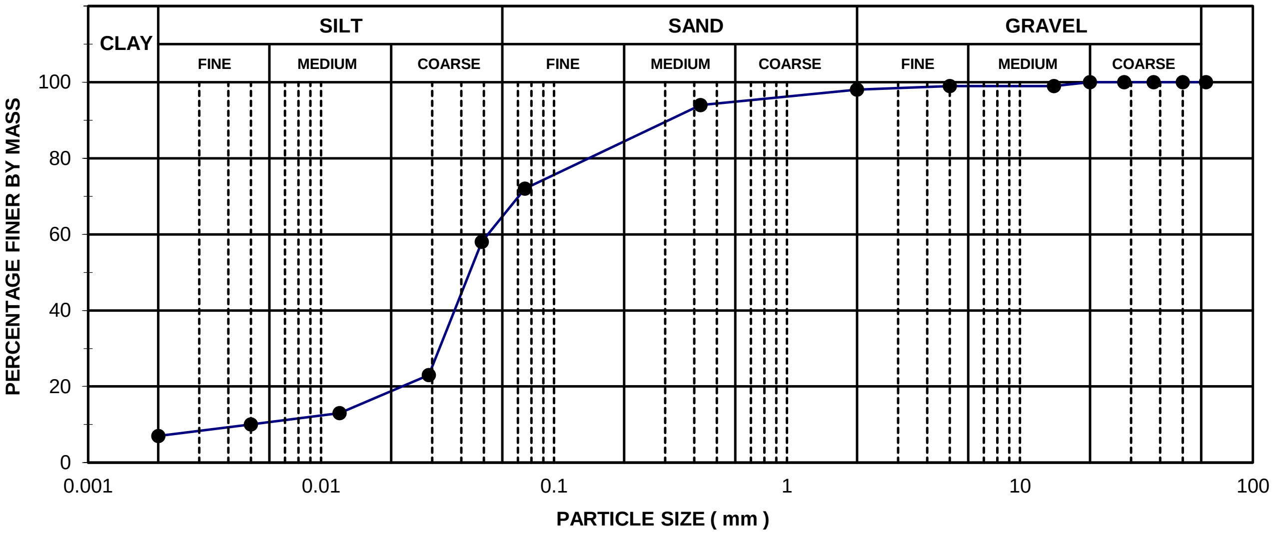
TEST LOCATION	TP115	PROJECT	Algoa Recon Support
SAMPLE NO.	3469	PROJECT NUMBER	112546
DEPTH	2.4-4.2 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS			
Sieve (mm)	% Passing	Sieve (mm)	% Passing
63.000	**100**	0.425	**94**
50.000	**100**	0.075	**72**
37.500	**100**	0.049	**58**
28.000	**100**	0.029	**23**
20.000	**100**	0.012	**13**
14.000	**99**	0.002	**7**
5.000	**99**	0.000	**0**
2.000	**98**	0.000	**0**

ATTERBERG LIMITS		
Liquid limit	(%)	**25.0**
Plastic limit	(%)	**17**
Plasticity Index	(%)	**8**
Weighted PI	(%)	**8**
Linear Shrinkage	(%)	**4.0**
Grading Modulus		**0.36**
Uniformity coefficient		**8**
Coefficient of curvature		**3.3**

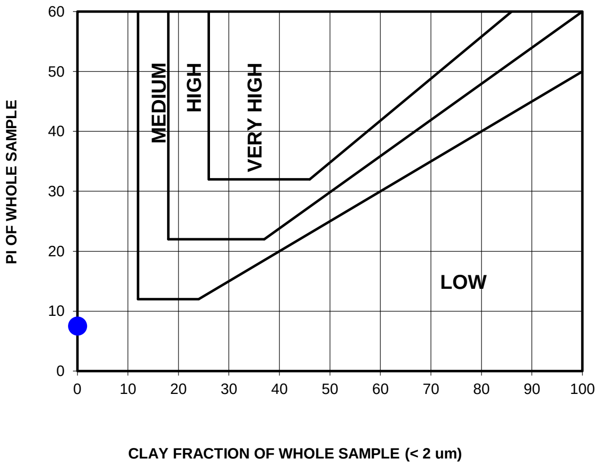
SOIL CLASSIFICATION	
% Gravel	**2**
% Sand	**26**
% Silt	**65**
% Clay	**7**
Activity	**1.1**
Unified Classification	**CL**
TRB Classification	**A - 4**

PARTICLE SIZE DISTRIBUTION

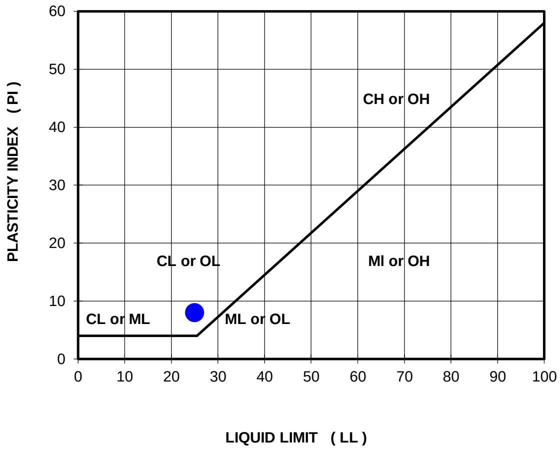


POTENTIAL EXPANSIVENESS

Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE

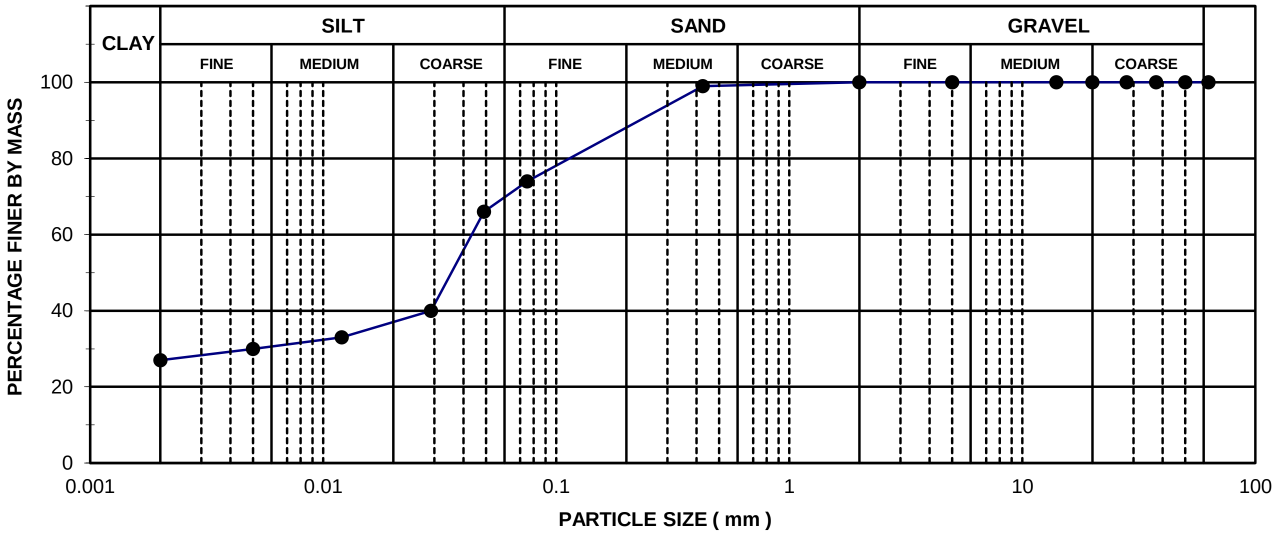


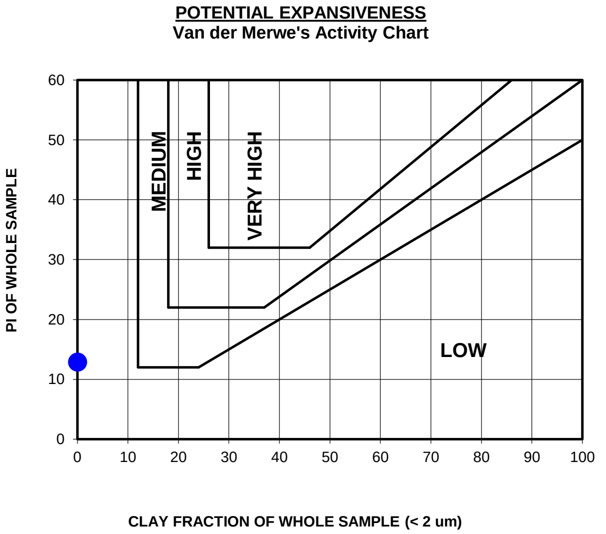
FOUNDATION INDICATOR TEST RESULTS

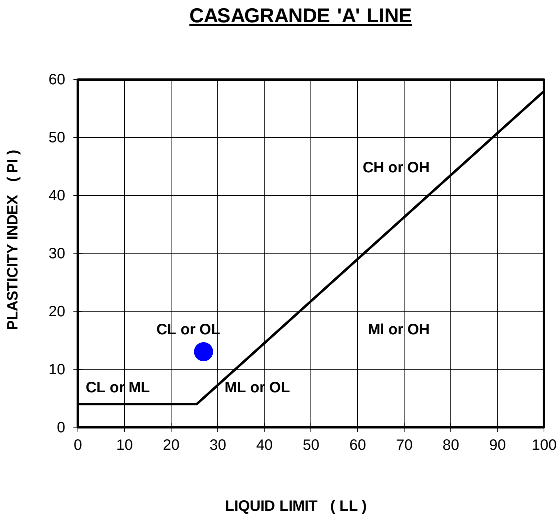
TEST LOCATION	TP116	PROJECT	Algoa Recon Support
SAMPLE NO.	3470	PROJECT NUMBER	112546
DEPTH	0.4-4.8 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**99**	Liquid limit	(%)	**27.0**	% Gravel	**0**
50.000	**100**	0.075	**74**	Plastic limit	(%)	**14**	% Sand	**26**
37.500	**100**	0.049	**66**	Plasticity Index	(%)	**13**	% Silt	**47**
28.000	**100**	0.029	**40**	Weighted PI	(%)	**13**	% Clay	**27**
20.000	**100**	0.012	**33**	Linear Shrinkage	(%)	**6.0**	Activity	**0.5**
14.000	**100**	0.002	**27**	Grading Modulus		**0.27**	Unified Classification	**CL**
5.000	**100**	0.000	**0**	Uniformity coefficient		**22**	TRB Classification	**A - 6**
2.000	**100**	0.000	**0**	Coefficient of curvature		**0.6**		

PARTICLE SIZE DISTRIBUTION





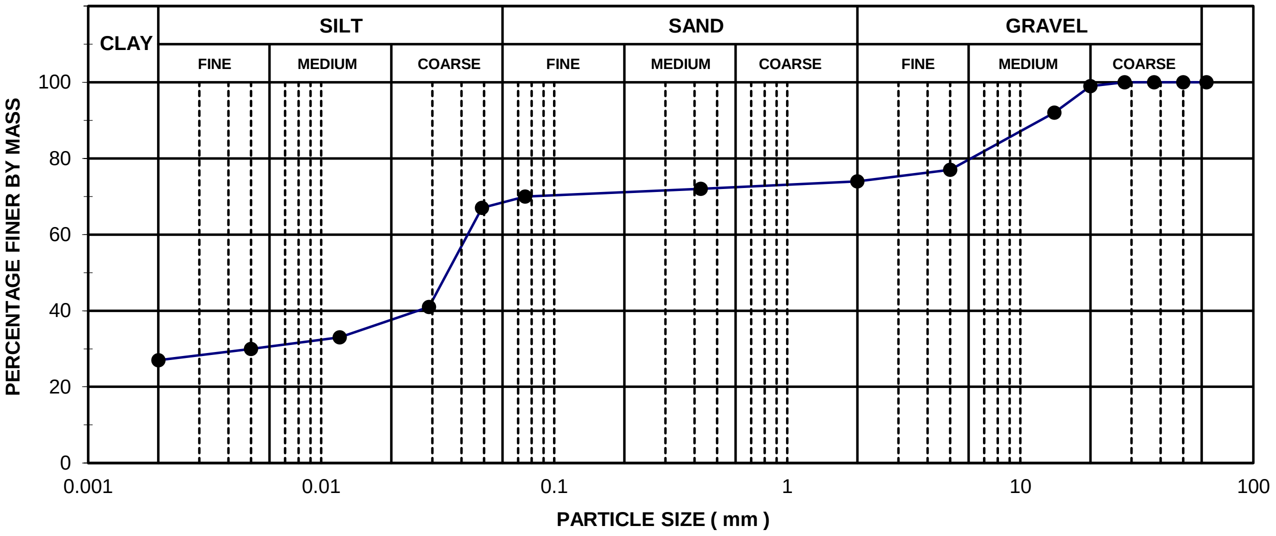


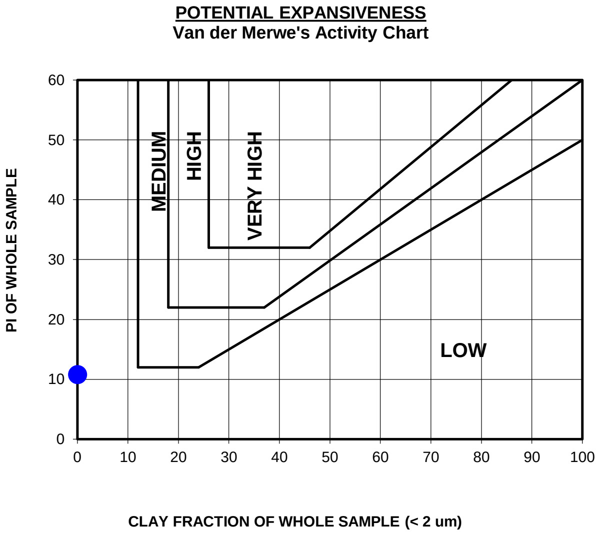
FOUNDATION INDICATOR TEST RESULTS

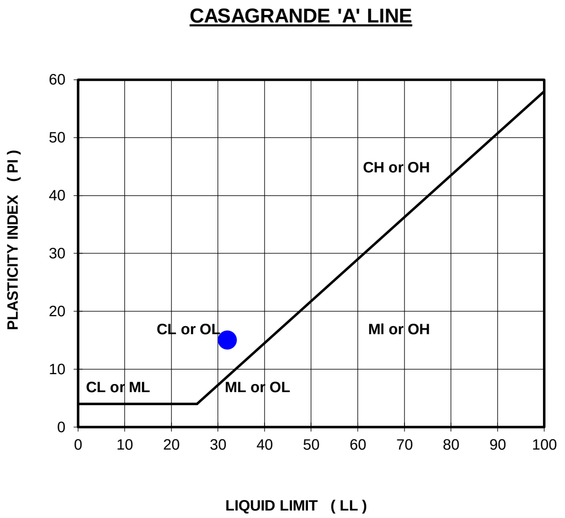
TEST LOCATION	TP117	PROJECT	Algoa Recon Support
SAMPLE NO.	3471	PROJECT NUMBER	112546
DEPTH	2.6-3.3 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**72**	Liquid limit	(%)	**32.0**	% Gravel	**26**
50.000	**100**	0.075	**70**	Plastic limit	(%)	**17**	% Sand	**4**
37.500	**100**	0.049	**67**	Plasticity Index	(%)	**15**	% Silt	**43**
28.000	**100**	0.029	**41**	Weighted PI	(%)	**11**	% Clay	**27**
20.000	**99**	0.012	**33**	Linear Shrinkage	(%)	**7.0**	Activity	**0.6**
14.000	**92**	0.002	**27**	Grading Modulus		**0.84**	Unified Classification	**CL**
5.000	**77**	0.000	**0**	Uniformity coefficient		**22**	TRB Classification	**A - 6**
2.000	**74**	0.000	**0**	Coefficient of curvature		**0.6**		

PARTICLE SIZE DISTRIBUTION







FOUNDATION INDICATOR TEST RESULTS

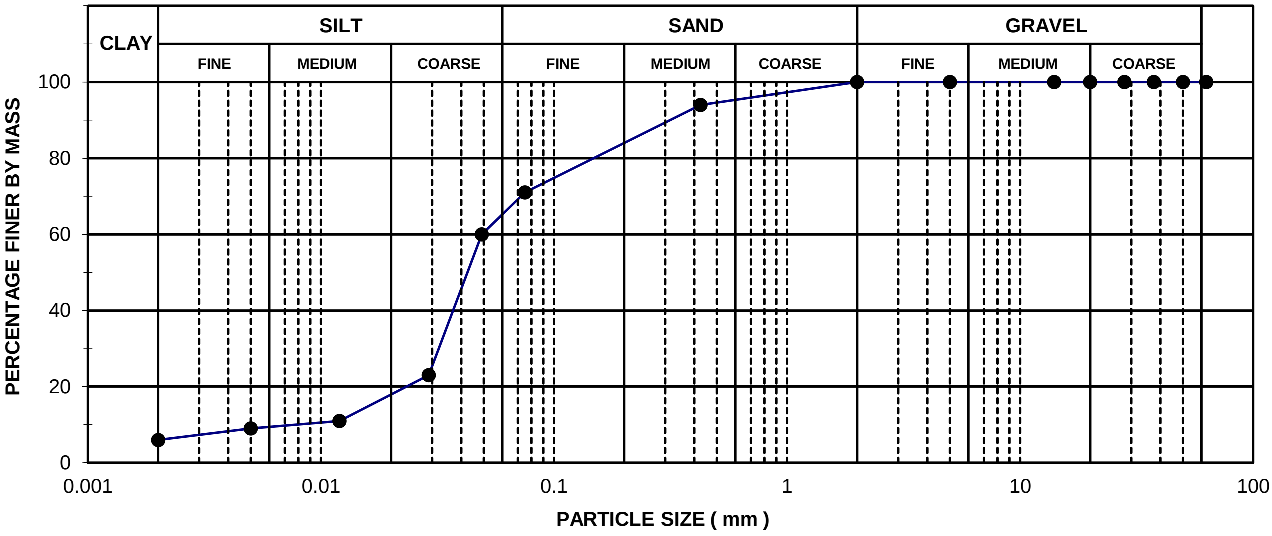
TEST LOCATION	TP118	PROJECT	Algoa Recon Support
SAMPLE NO.	3472	PROJECT NUMBER	112546
DEPTH	0.2-1.2 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS			
Sieve (mm)	% Passing	Sieve (mm)	% Passing
63.000	**100**	0.425	**94**
50.000	**100**	0.075	**71**
37.500	**100**	0.049	**60**
28.000	**100**	0.029	**23**
20.000	**100**	0.012	**11**
14.000	**100**	0.002	**6**
5.000	**100**	0.000	**0**
2.000	**100**	0.000	**0**

ATTERBERG LIMITS		
Liquid limit	(%)	**22.0**
Plastic limit	(%)	**13**
Plasticity Index	(%)	**9**
Weighted PI	(%)	**8**
Linear Shrinkage	(%)	**4.0**
Grading Modulus		**0.35**
Uniformity coefficient		**5**
Coefficient of curvature		**2.4**

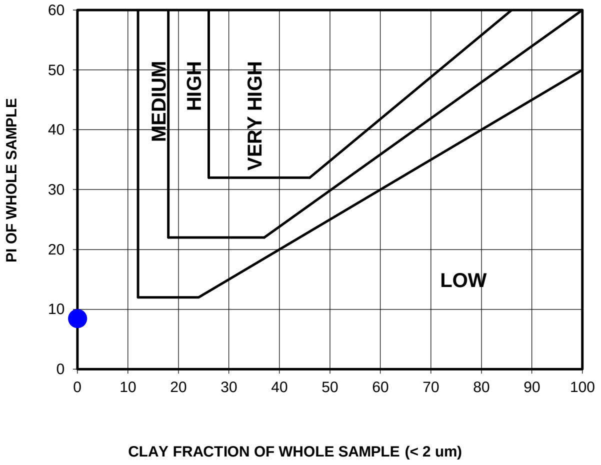
SOIL CLASSIFICATION	
% Gravel	**0**
% Sand	**29**
% Silt	**65**
% Clay	**6**
Activity	**1.5**
Unified Classification	**CL**
TRB Classification	**A - 4**

PARTICLE SIZE DISTRIBUTION

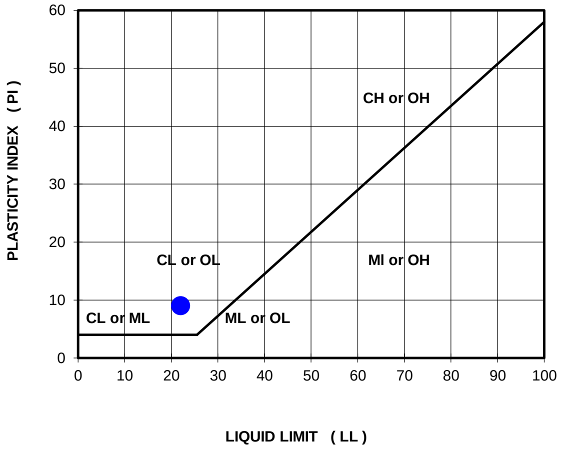


POTENTIAL EXPANSIVENESS

Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE

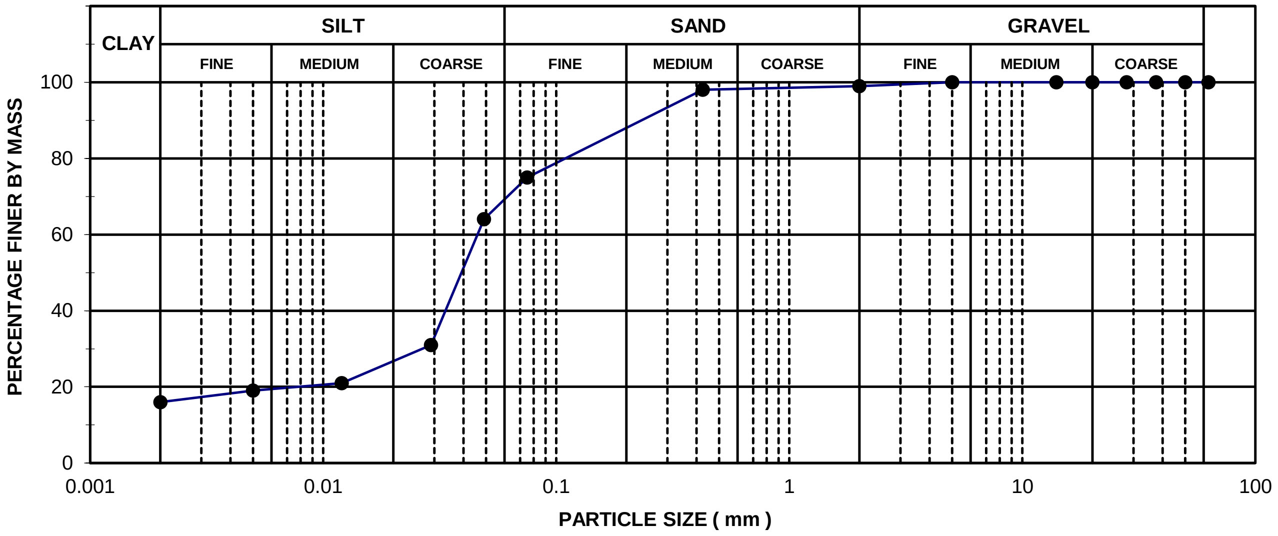


FOUNDATION INDICATOR TEST RESULTS

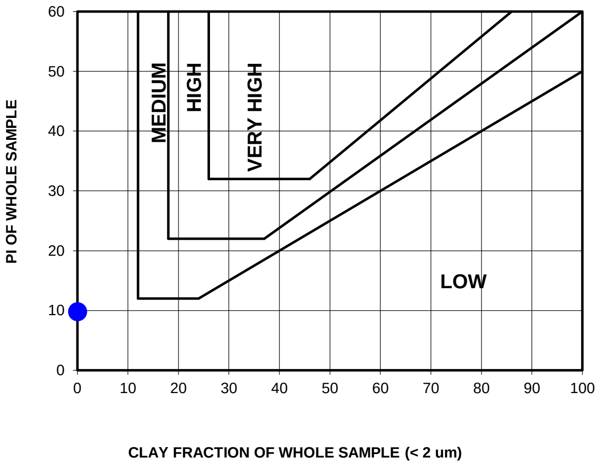
TEST LOCATION	TP119	PROJECT	Algoa Recon Support
SAMPLE NO.	3473	PROJECT NUMBER	112546
DEPTH	0.8-2.2 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**98**	Liquid limit	(%)	**26.0**	% Gravel	**1**
50.000	**100**	0.075	**75**	Plastic limit	(%)	**16**	% Sand	**24**
37.500	**100**	0.049	**64**	Plasticity Index	(%)	**10**	% Silt	**59**
28.000	**100**	0.029	**31**	Weighted PI	(%)	**10**	% Clay	**16**
20.000	**100**	0.012	**21**	Linear Shrinkage	(%)	**5.0**	Activity	**0.6**
14.000	**100**	0.002	**16**	Grading Modulus		**0.28**	Unified Classification	**CL**
5.000	**100**	0.000	**0**	Uniformity coefficient		**23**	TRB Classification	**A - 4**
2.000	**99**	0.000	**0**	Coefficient of curvature		**9.2**		

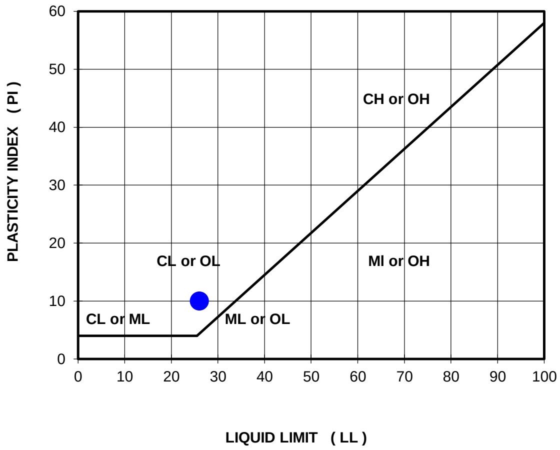
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE

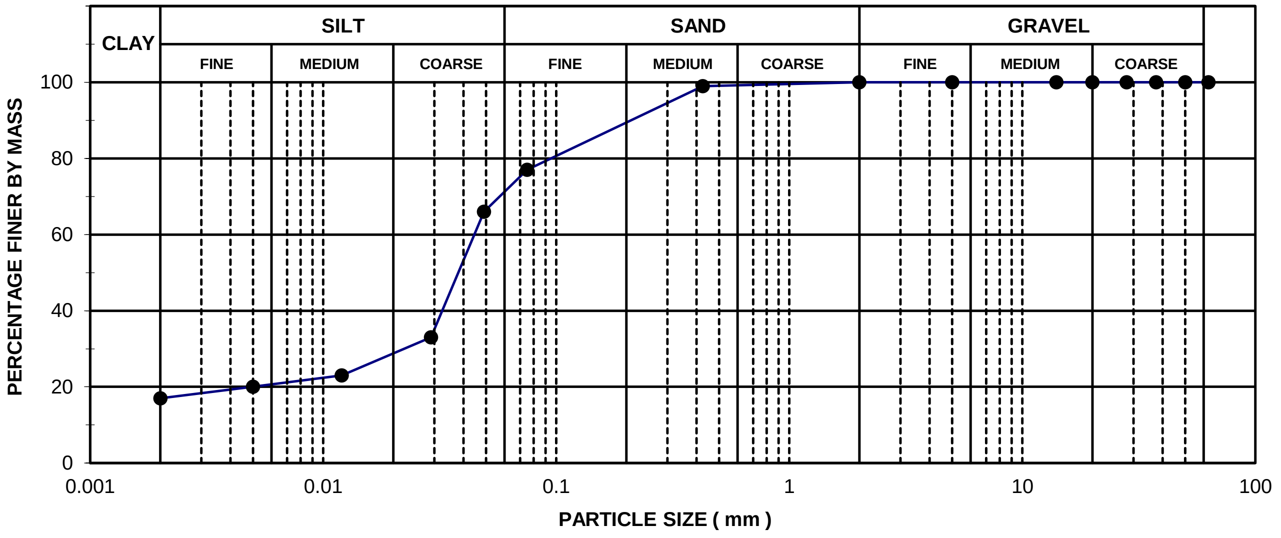


FOUNDATION INDICATOR TEST RESULTS

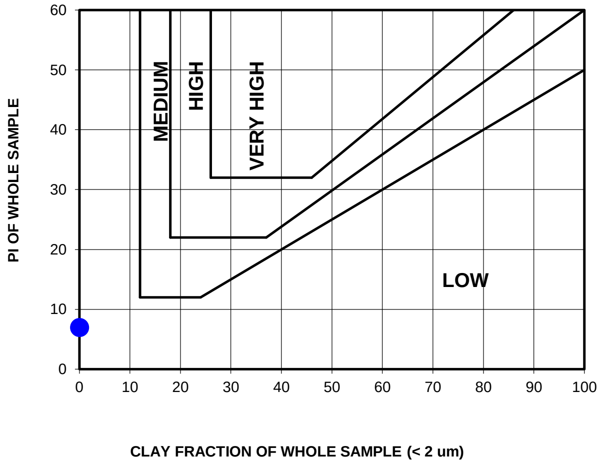
TEST LOCATION	TP122	PROJECT	Algoa Recon Support
SAMPLE NO.	3476	PROJECT NUMBER	112546
DEPTH	0.3-1.3 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**99**	Liquid limit	(%)	**19.0**	% Gravel	**0**
50.000	**100**	0.075	**77**	Plastic limit	(%)	**12**	% Sand	**23**
37.500	**100**	0.049	**66**	Plasticity Index	(%)	**7**	% Silt	**60**
28.000	**100**	0.029	**33**	Weighted PI	(%)	**7**	% Clay	**17**
20.000	**100**	0.012	**23**	Linear Shrinkage	(%)	**3.5**	Activity	**0.4**
14.000	**100**	0.002	**17**	Grading Modulus		**0.24**	Unified Classification	**CL**
5.000	**100**	0.000	**0**	Uniformity coefficient		**23**	TRB Classification	**A - 4**
2.000	**100**	0.000	**0**	Coefficient of curvature		**7.4**		

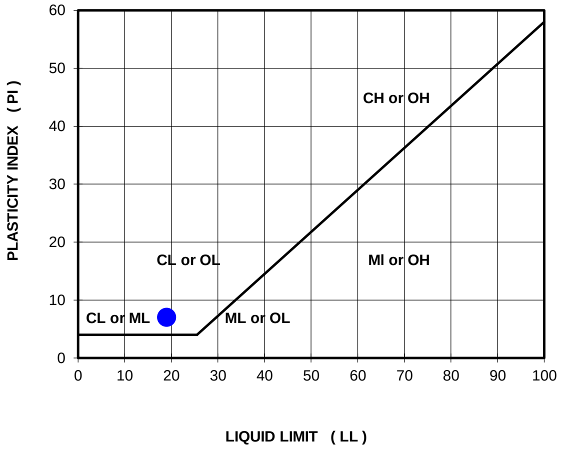
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



FOUNDATION INDICATOR TEST RESULTS

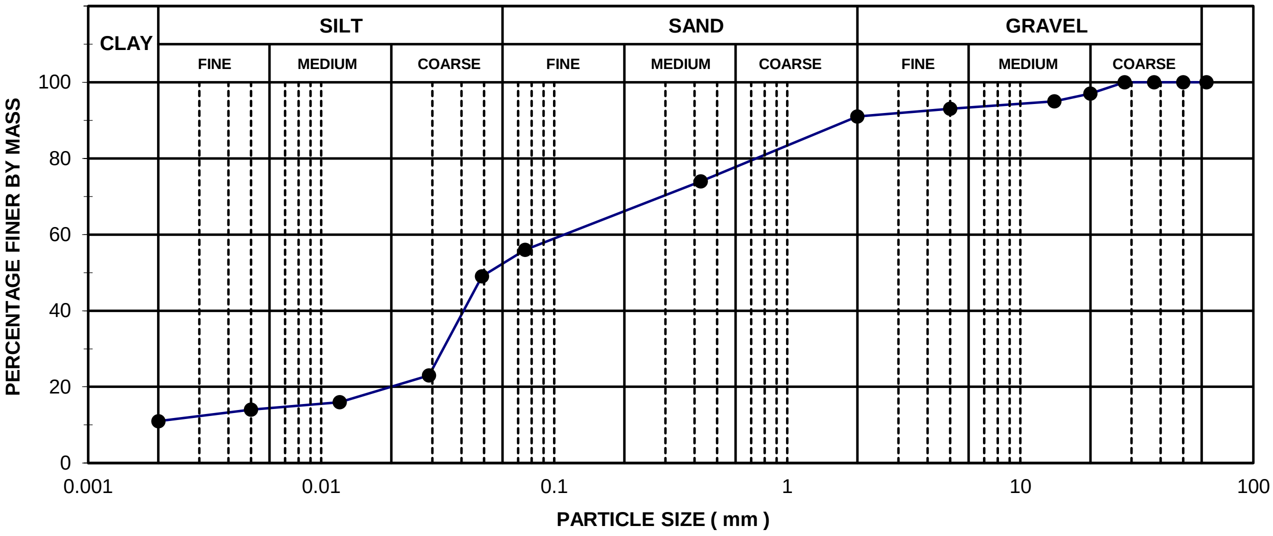
TEST LOCATION	TP123	PROJECT	Algoa Recon Support
SAMPLE NO.	3477	PROJECT NUMBER	112546
DEPTH	2.0-2.7 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS			
Sieve (mm)	% Passing	Sieve (mm)	% Passing
63.000	**100**	0.425	**74**
50.000	**100**	0.075	**56**
37.500	**100**	0.049	**49**
28.000	**100**	0.029	**23**
20.000	**97**	0.012	**16**
14.000	**95**	0.002	**11**
5.000	**93**	0.000	**0**
2.000	**91**	0.000	**0**

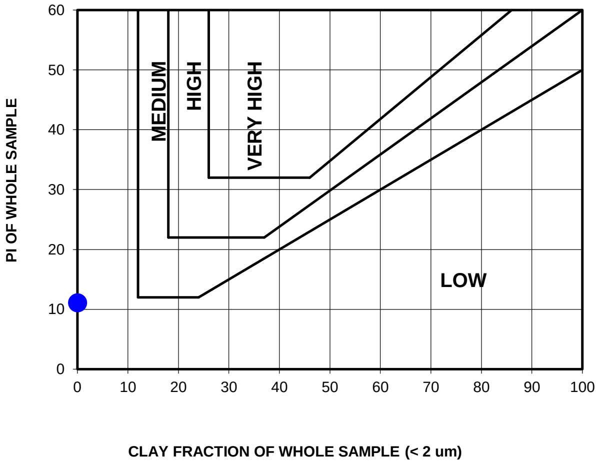
ATTERBERG LIMITS		
Liquid limit	(%)	**34.0**
Plastic limit	(%)	**19**
Plasticity Index	(%)	**15**
Weighted PI	(%)	**11**
Linear Shrinkage	(%)	**7.0**
Grading Modulus		**0.79**
Uniformity coefficient		**76**
Coefficient of curvature		**4.3**

SOIL CLASSIFICATION	
% Gravel	**9**
% Sand	**35**
% Silt	**45**
% Clay	**11**
Activity	**1.4**
Unified Classification	**CL**
TRB Classification	**A - 6**

PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



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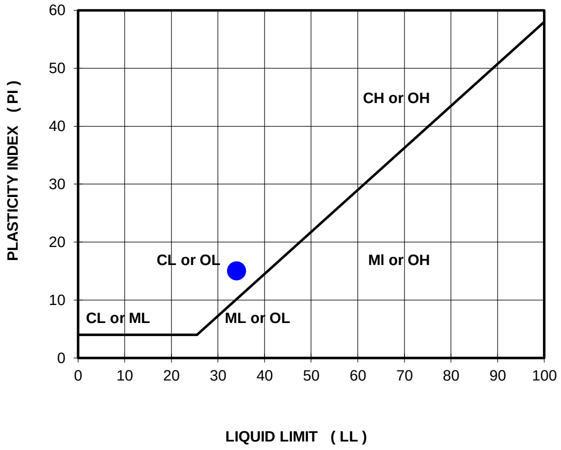

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Client : Aurecon South Africa (Pty) Ltd
Address : P.O. Box 74381
: Lynnwood Ridge
: South Africa, 0040

Client Reference : -
Order No. : 112546

Attention : Mr. S. Nyathi
Facsimile : -
E-mail : Siya.Nyathi@aurecongroup.com

Date Received : 14.06.2019
Date Tested : 15.07.2019
Date Reported : 19.07.2019 AB

Project : Algoa Water Supply System
Project No. : 2019-P-1435

Report Status : Final Report
Page : 1 of 5

Herewith please find the test report(s) pertaining to the above project. All tests were conducted in accordance with prescribed test method(s). Information herein consists of the following:

Test(s) conducted / Item(s) measured	Qty.	Test Method(s)	Authorized By**	Page(s)
Atterberg Limits <0.425mm	6.000	SANS 3001-GR10	A Bisiwe	2-4
Sieve Analysis 0.075mm	6.000	SANS 3001-GR1	A Bisiwe	2-4
Hydrometer Analysis	6.000	ASTM D422	A Bisiwe	2-4
Moisture Content	3.000	SANS 3001-GR20:2010	A. Bisiwe	5

Any test results contained in this report and marked with * in the table above are "not SANAS accredited" and are not included in the schedule of accreditation for this laboratory.

Any information contained in this test report pertain only to the areas and/or samples tested. Documents may only be reproduced or published in their full context. • Any information gained by the laboratory prior, during or after test process will be treated as confidential and will not be reproduced or disclosed to any person or organization, unless required by law.

All interpretations, Interpolations, Opinions and/or Classifications contained in this report falls outside our scope of accreditation.

The following parameters, where applicable, were excluded from the classification procedure: Chemical modifications, Additional fines, Fractured Faces, Soluble Salts, pH, Conductivity, Coarse Sand Ratio, Durability (COLTO: G4-G9).

The following parameters, where applicable, were assumed: Rock types were assumed to be of an Arenaceous nature with Siliceous cementing material.

Unless otherwise requested or stated, all samples will be discarded after a period of 3 months.

Deviations in Test Methods:

24-07-19

Technical Signatory.

**All results are authorized by technical signatories.

Client	:	Aurecon South Africa (Pty) Ltd	Date Received:	26/06/2019
Project	:	Algoa Water Supply System	Date Reported:	16/07/2019
Project No	:	2019-P-1435	Page No. :	2 of 5

SAMPLING PROCEDURE: Delivered to the Laboratory

FOUNDATION INDICATOR

Laboratory Number		1 ◆	2 ■
Field Number		P1435/1	P1435/2
Client Reference		TP 105	TP 108
Depth (m)		1.0-3.6	0.6-2.2
Position		-	-
Coordinates	X	-	-
	Y	-	-
Description		Very Dense silty Sand, Colluvium	Calcritised silty Sand, Pedogenic
Aditional Information		-	-
Calcrete / Crushed		-	-
Stabilizing Agent		-	-

Moisture Content & Relative Density SANS 3001-GR30

Moisture Content (%)		
Relative Density (S.G.)		

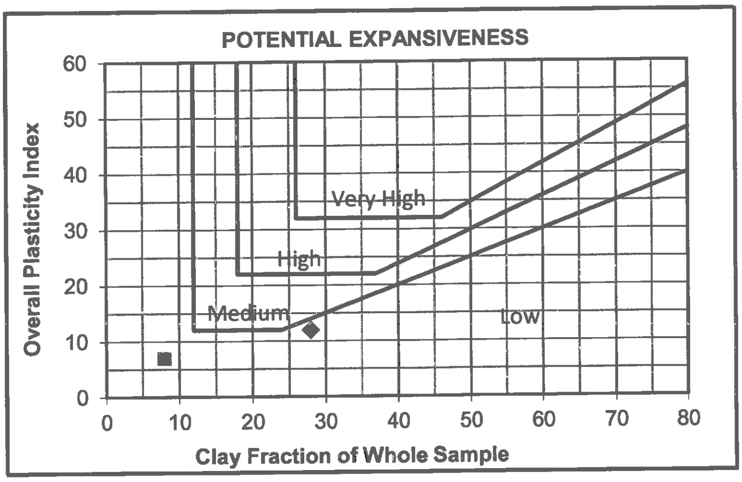
Sieve Analysis (Wet Prep) SANS 3001-GR1

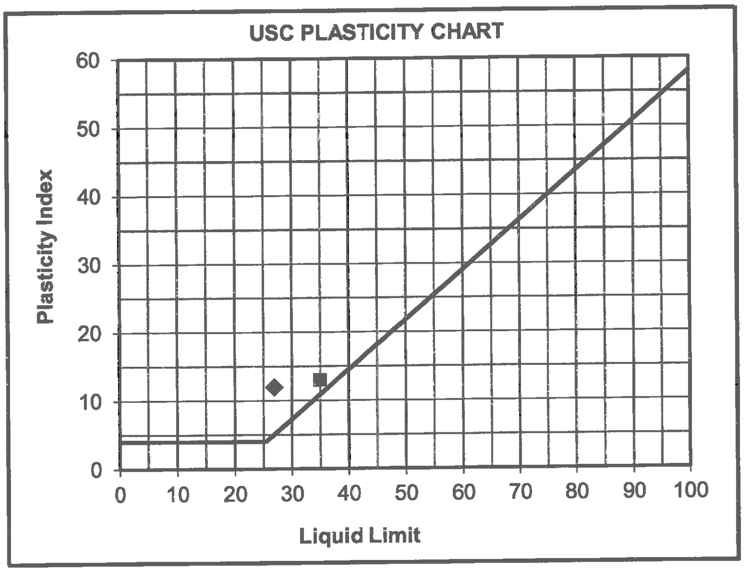
Percentage Passing	100 mm		
	75 mm		
	63 mm		
	50 mm		
	37.5 mm		
	28 mm		
	20 mm		100
	14 mm		99
	5 mm	100	90
	2 mm	99	76
	0.425 mm	98	56
	0.250 mm	98	51
	0.150 mm	92	44
	0.075 mm	78	36
Grading Modulus		0.25	1.32

Hydrometer Analysis ASTM D422

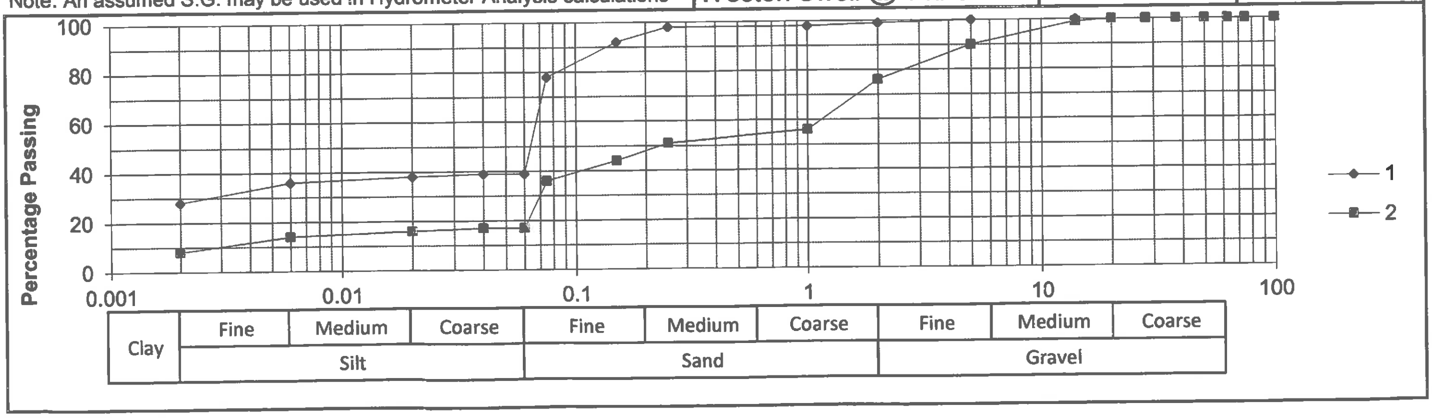
Percentage Passing	0.060 mm	39	17
	0.040 mm	39	17
	0.020 mm	38	16
	0.006 mm	36	14
	0.002 mm	28	8
Gravel	%	1	24
Sand	%	60	59
Silt	%	11	9
Clay	%	28	8

Note: An assumed S.G. may be used in Hydrometer Analysis calculations





Laboratory Number		1 ◆	2 ■
Atterberg Limits -425µ		SANS 3001-GR10	
Liquid Limit	%	27	35
Plasticity Index	%	12	13
Linear Shrinkage	%	5.0	6.0
Overall PI	%	12	7
Classifications			
HRB (AASHTO)		A-6(7)	A-6(1)
Unified (ASTM D2487)		CL	SC
Weston Swell @ 1 kPa			



Client	:	Aurecon South Africa (Pty) Ltd	Date Received:	26/06/2019
Project	:	Algoa Water Supply System	Date Reported:	16/07/2019
Project No	:	2019-P-1435	Page No. :	3 of 5

SAMPLING PROCEDURE: Delivered to the Laboratory

FOUNDATION INDICATOR

Laboratory Number		3 ◆	4 ■
Field Number		P1435/3	P1435/4
Client Reference		TP 109	TP 113
Depth (m)		0.7-4.1	0.4-4.5
Position		-	-
Coordinates	X	-	-
	Y	-	-
Description		Very dense silty Sand, Colluvium	Ferruginised silty Sand, Pedogenic
Aditional Information		-	-
Calcrete / Crushed		-	-
Stabilizing Agent		-	-

Moisture Content & Relative Density

Moisture Content (%)		
Relative Density (S.G.)		

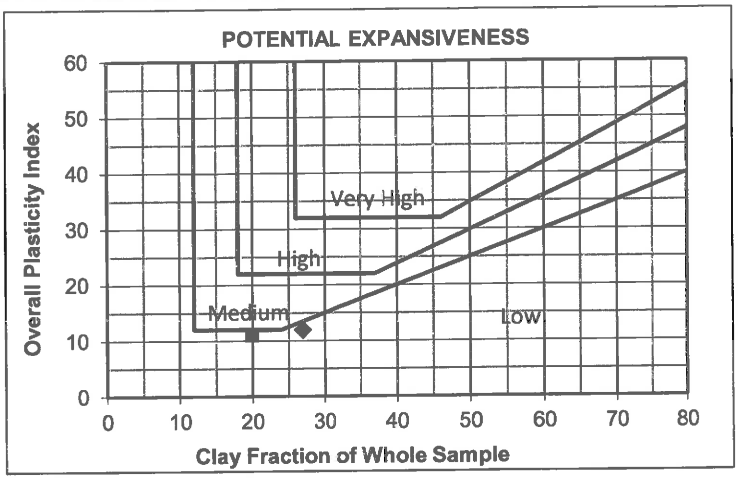
Sieve Analysis (Wet Prep) **SANS 3001-GR1**

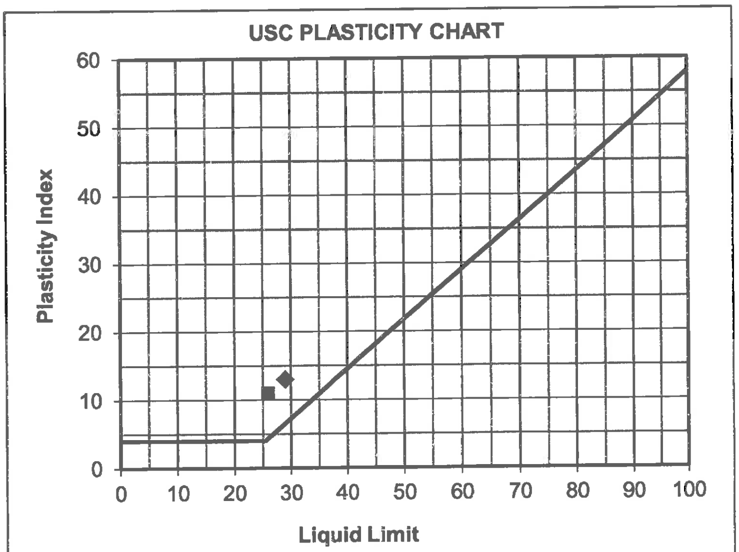
Percentage Passing	100 mm		
	75 mm		
	63 mm		
	50 mm		
	37.5 mm		
	28 mm		
	20 mm		
	14 mm	100	100
	5 mm	99	98
	2 mm	97	97
	0.425 mm	94	96
	0.250 mm	90	94
	0.150 mm	83	84
	0.075 mm	69	68
Grading Modulus		0.40	0.39

Hydrometer Analysis **ASTM D422**

Percentage Passing	0.060 mm	44	36
	0.040 mm	43	35
	0.020 mm	42	34
	0.006 mm	40	31
	0.002 mm	27	20
Gravel	%	3	3
Sand	%	53	61
Silt	%	17	16
Clay	%	27	20

Note: An assumed S.G. may be used in Hydrometer Analysis calculations

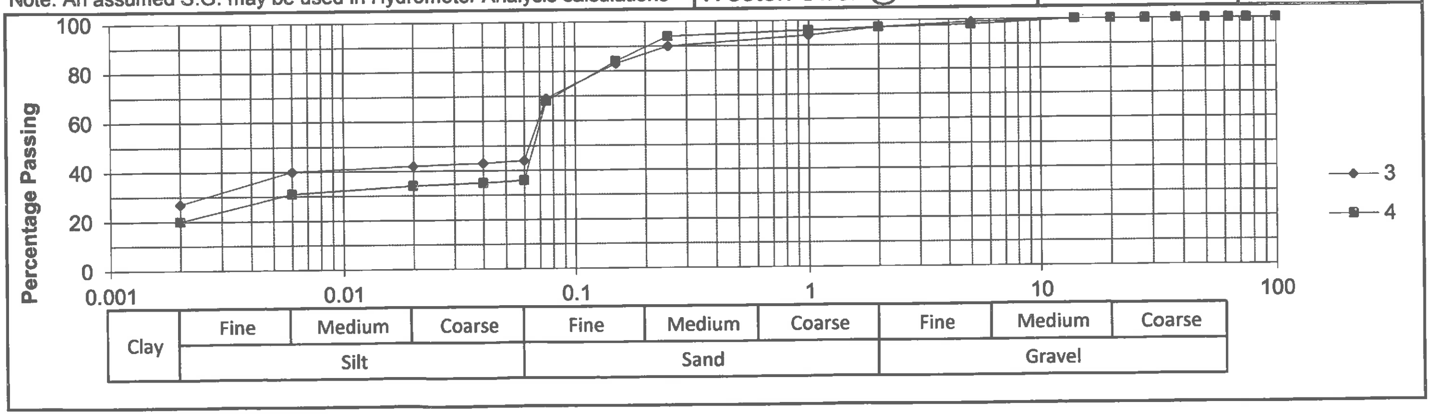




Laboratory Number		3 ◆	4 ■
Atterberg Limits -425µ		**SANS 3001-GR10**	
Liquid Limit	%	29	26
Plasticity Index	%	13	11
Linear Shrinkage	%	6.5	5.0
Overall PI	%	12	11

Classifications

HRB (AASHTO)	A-6(7)	A-6(5)
Unified (ASTM D2487)	CL	CL
Weston Swell @ 1 kPa		



Client	:	Aurecon South Africa (Pty) Ltd	Date Received:	26/06/2019
Project	:	Algoa Water Supply System	Date Reported:	16/07/2019
Project No	:	2019-P-1435	Page No. :	4 of 5

SAMPLING PROCEDURE: Delivered to the Laboratory

FOUNDATION INDICATOR

Laboratory Number		6 ◆	7 ■
Field Number		P1435/6	P1435/7
Client Reference		TP 119	TP 115
Depth (m)		0.8-2.2	2.4-4.2
Position		-	-
Coordinates	X	-	-
	Y	-	-
Description		Ferruginised silty Sand, Pedogenic	Tightly packed Gravel
Aditional Information		-	-
Calcrete / Crushed		-	-
Stabilizing Agent		-	-

Moisture Content & Relative Density

Moisture Content (%)		
Relative Density (S.G.)		

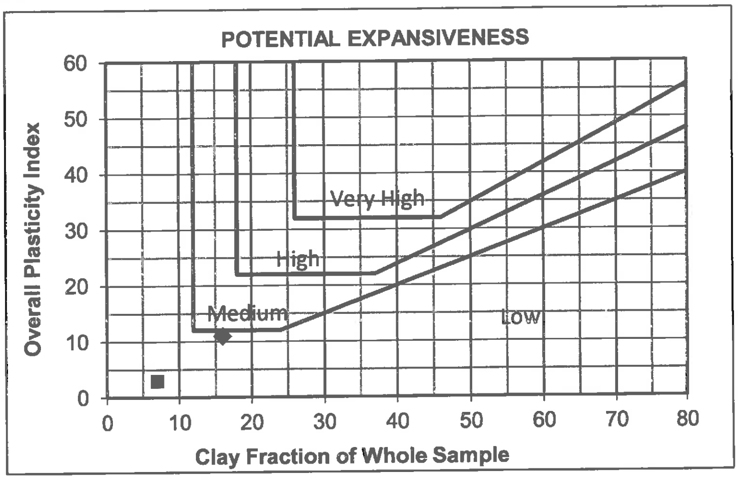
Sieve Analysis (Wet Prep) SANS 3001-GR1

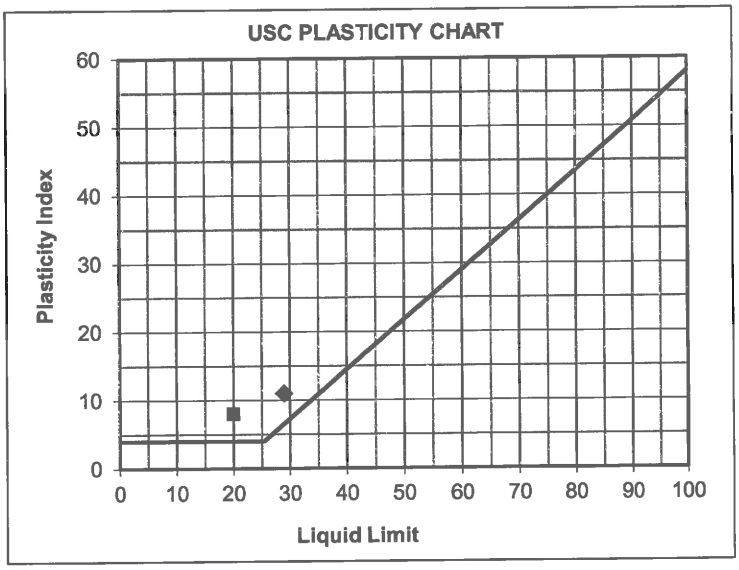
Percentage Passing	100 mm		
	75 mm		
	63 mm		
	50 mm		
	37.5 mm		
	28 mm		100
	20 mm		97
	14 mm		88
	5 mm		62
	2 mm	100	53
	0.425 mm	98	40
	0.250 mm	94	32
	0.150 mm	85	27
	0.075 mm	73	22
Grading Modulus		0.29	1.85

Hydrometer Analysis ASTM D422

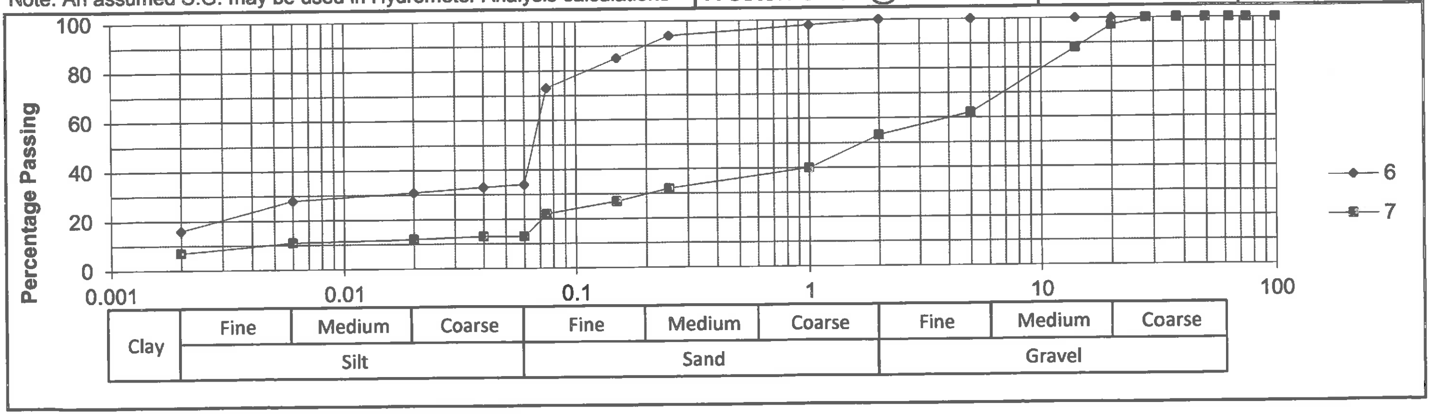
Percentage Passing	0.060 mm	34	13
	0.040 mm	33	13
	0.020 mm	31	12
	0.006 mm	28	11
	0.002 mm	16	7
Gravel	%	0	47
Sand	%	66	40
Silt	%	18	6
Clay	%	16	7

Note: An assumed S.G. may be used in Hydrometer Analysis calculations





Laboratory Number		6 ◆	7 ■
Atterberg Limits -425µ		**SANS 3001-GR10**	
Liquid Limit	%	29	20
Plasticity Index	%	11	8
Linear Shrinkage	%	5.0	3.5
Overall PI	%	11	3
Classifications			
HRB (AASHTO)		A-6(6)	A-2-4(0)
Unified (ASTM D2487)		CL	SC
Weston Swell @ 1 kPa			



Labco
SOUTHERN AFRICA (PTY) Ltd

49 Pickering Street, Newton Park, Port Elizabeth, 6045
PO Box 10114, Linton Grange, Port Elizabeth, 6015
E-Mail: info@labco.co.za Web: www.labco.co.za
Tel: 041 364-1290 Fax: 041 364-1291

CUSTOMER : Aurecon South Africa (Pty) Ltd
P. O. Box 74381
Lynnwood Ridge
South Africa, 0040

ATTENTION : Mr. S. Nyathi
JOB CARD No. : 2019-P-1435 / 112546
SAMPLING PROCEDURE: Delivered to the laboratory

PROJECT : Algoa Water Supply System

SUBMISSION DATE : 14.06.2019
DATE TESTED : 27.06.2019
REPORT DATE : 28.06.2019 AB

MOISTURE CONTENT SUMMARY

TMH1 METHOD A17

SAMPLE NUMBER	P1435/1	P1435/2	P1435/3			
TEST PIT NUMBER	TP 105	TP 108	TP 115			
STAKE VALUE	-	-	-			
DEPTH (m)	1.0-3.6	0.6-2.2	0.4-2.4			
DESCRIPTION	Very dense silty Sand, Colluvium	Calcritised silty Sand, Pedogenic	Ferruginised silty Sand, Pedogenic			
Moisture Content %	11.1	13.2	14.2			

SAMPLE NUMBER						
TEST PIT NUMBER						
STAKE VALUE						
DEPTH (m)						
DESCRIPTION						
Moisture Content %						

SAMPLE NUMBER						
TEST PIT NUMBER						
STAKE VALUE						
OFF SET						
DEPTH (m)						
DESCRIPTION						
Moisture Content %						

SAMPLE NUMBER						
TEST PIT NUMBER						
STAKE VALUE						
OFF SET						
DEPTH (m)						
DESCRIPTION						
Moisture Content %						

The above test results are pertinent only to the samples received and tested at the laboratory. This report shall not be reproduced, except in full,without the prior consent of Labco.
Deviation from Test Method : Moisture Contents dried overnight at 105 - 110°C.

Name : 24-07-19
Arnold Bisiwe
Position : Technical Signatory

Labco Southern Africa (Pty) Ltd
Email: info@labco.co.za ■ www.labco.co.za
Phone: +27 (0)41 364 1290 ■ Fax: +27 (0)41 364 1291
Port Elizabeth (Head Office) ■ 49 Pickering Street, Newton Park, 6045. ■ PO Box 10114 Linton Grange 6015

E-MAIL COVER

TO	:	Aurecon South Africa (Pty) Ltd	**DATE**	:	24.07.2019
ATTENTION	:	Mr. S. Nyathi	**PAGES**	:	4 (Including Cover)
FROM	:	Labco Southern Africa (Pty) Ltd			
E-MAIL	:	Siya.Nyathi@aurecongroup.com			

Good Day

Attached please find results on Subcontracting Tests:

Test Results:	Soil Testing
Job Card number:	2019-P-1435
Project:	Algoa Water Supply System
Samples in Total:	2

- Sample and Site reference number including material description
  - 2019-P-1435/1 – TP105
  - 2019-P-1435/5 – TP115

Regards,

Angelique Barnard

CONTROL GEOSCIENCES (PTY) LTD

CIVIL ENGINEERING MATERIAL AND GEOTECHNICAL LABORATORY,
GEOTECHNICAL AND ENVIRONMENTAL SERVICES

LABORATORY TEST RESULTS

CLIENT : Labco
PROJECT NAME : Newton Park

admin only
JOB NO : L190713
SAMPLE NO : 31743

COMPACTION MOULD PERMEAMETER

POSITION : TP 105 @ 1,0-3,6m
SOIL DESCRIPTION :
PERMEANT USED : TAP WATER

SAMPLE DATA		
Proctor	kg/m^3	1616
OMC	%	15,00
Percent of Proctor specified	%	95,00
Dry density of soil required	kg/m^3	1535,20
Moisture content of sample	%	15,00
Length of sample	mm	125,00
Diameter of sample	mm	150,00
Area of sample	mm^2	17671,46
Volume of sample	mm^3	2208932,33
Mass of dry soil required	g	3391,15
Mass of wet soil required	g	3899,83

ACTUAL DATA		
Mould Number		P3
Mass of Mould	g	4371
Mass of Mould and wet soil	g	8270,83
Mass of wet soil	g	3899,83
moisture content	%	15,00
Bulk Density	kg/m^3	1765,48
Dry Density	kg/m^3	1535,20
Percentage Proctor	%	95,00

Standpipe dia	mm	3,75
Standpipe area	mm^2	11,04

TEST READINGS								
	Start Test				End Test			Comments
Test	Height	Time			Height	Time		
	mm	min	sec		mm	min	sec	
1	1670				1620	13	44	
2	1670				1620	14	14	
3	1670				1620	17	31	
4	1670				1620	16	26	

Number of tests = 4

CALCULATIONS FOR FALLING HEAD		
Log H1/H2	Elapsed Time	COEFFICIENT OF PERMEABILITY
mm	sec	m/s
0,0132	824,00	2,88E-09
0,0132	854,00	2,78E-09
0,0132	1051,00	2,26E-09
0,0132	986,00	2,41E-09

AVERAGE =	2,58E-09	m/s
AVERAGE =	2,58E-07	cm/s

Notes :

CONTROL GEOSCIENCES (PTY) LTD
CIVIL ENGINEERING MATERIAL AND GEOTECHNICAL LABORATORY,
GEOTECHNICAL AND ENVIRONMENTAL SERVICES

LABORATORY TEST RESULTS

CLIENT : Labco
PROJECT NAME : Newton Park

admin only
JOB NO : L190713
SAMPLE NO : 31744

COMPACTION MOULD PERMEAMETER

POSITION : TP 115 @ 0,4-2,4m
SOIL DESCRIPTION :
PERMEANT USED : TAP WATER

SAMPLE DATA		
Proctor	kg/m^3	1551
OMC	%	17,50
Percent of Proctor specified	%	95,00
Dry density of soil required	kg/m^3	1473,45
Moisture content of sample	%	17,50
Length of sample	mm	125,00
Diameter of sample	mm	150,00
Area of sample	mm^2	17671,46
Volume of sample	mm^3	2208932,33
Mass of dry soil required	g	3254,75
Mass of wet soil required	g	3824,33

ACTUAL DATA		
Mould Number		P4
Mass of Mould	g	4724
Mass of Mould and wet soil	g	8548,33
Mass of wet soil	g	3824,33
moisture content	%	17,50
Bulk Density	kg/m^3	1731,30
Dry Density	kg/m^3	1473,45
Percentage Proctor	%	95,00

Standpipe dia	mm	3,75
Standpipe area	mm^2	11,04

TEST READINGS								
	Start Test				End Test			Comments
Test	Height	Time			Height	Time		
	mm	min	sec		mm	min	sec	
1	1670				1620	1	24	
2	1670				1620	1	38	
3	1670				1620	1	45	
4	1670				1620	1	54	

Number of tests = 4

CALCULATIONS FOR FALLING HEAD		
Log H1/H2	Elapsed Time	COEFFICIENT OF PERMEABILITY
mm	sec	m/s
0,0132	84,00	2,82E-08
0,0132	98,00	2,42E-08
0,0132	105,00	2,26E-08
0,0132	114,00	2,08E-08

AVERAGE =	2,40E-08	m/s
AVERAGE =	2,40E-06	cm/s

Notes :

CONTROL GEOSCIENCES (PTY) LTD

CLIENT: Labco
PO Box 10114
Linton Grange
Port Elizabeth
6015

PROJECT: Newton Park

REF: L190713

SPECIFIC GRAVITY (ASTM D854/92)

SAMPLE NO:	31743	31744						
POSITION:	TP 105	TP 115						
DEPTH:	1,0-3,6m	0,4-2,4m						
DESCRIPTION:								

SPECIFIC GRAVITY	2,593	2,552						

FOUNDATION INDICATOR TEST RESULTS

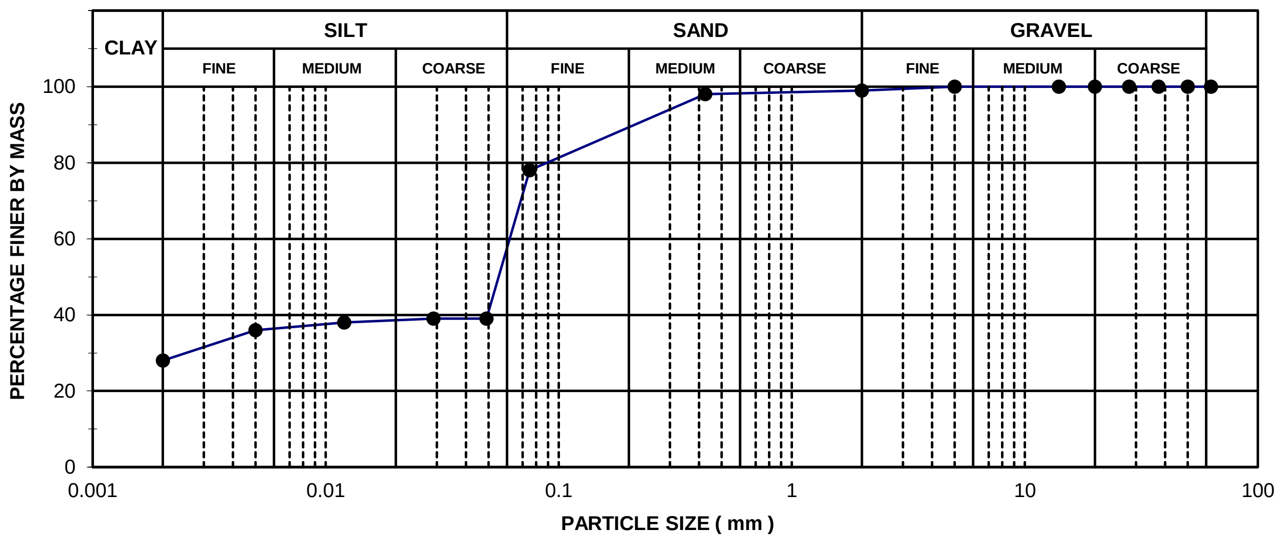
TEST LOCATION	TP105	PROJECT	Algoa Recon Support
SAMPLE NO.		PROJECT NUMBER	112546
DEPTH	1.0-3.6 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS			
Sieve (mm)	% Passing	Sieve (mm)	% Passing
63.000	**100**	0.425	**98**
50.000	**100**	0.075	**78**
37.500	**100**	0.049	**39**
28.000	**100**	0.029	**39**
20.000	**100**	0.012	**38**
14.000	**100**	0.002	**28**
5.000	**100**	0.000	**0**
2.000	**99**	0.000	**0**

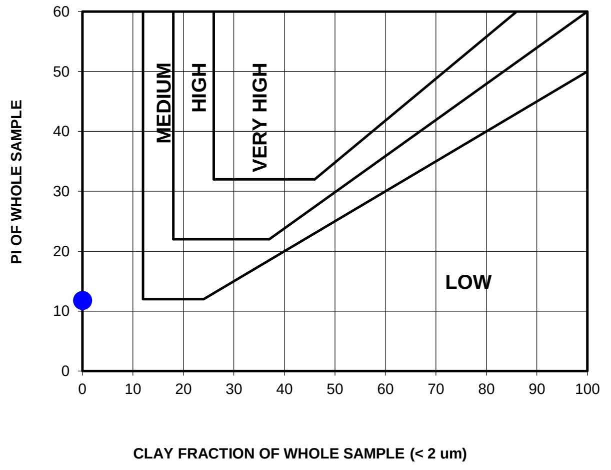
ATTERBERG LIMITS		
Liquid limit	(%)	**27.0**
Plastic limit	(%)	**15**
Plasticity Index	(%)	**12**
Weighted PI	(%)	**12**
Linear Shrinkage	(%)	**5.0**
Grading Modulus		**0.25**
Uniformity coefficient		**32**
Coefficient of curvature		**0.1**

SOIL CLASSIFICATION	
% Gravel	**1**
% Sand	**21**
% Silt	**50**
% Clay	**28**
Activity	**0.4**
Unified Classification	**CL**
TRB Classification	**A - 6**

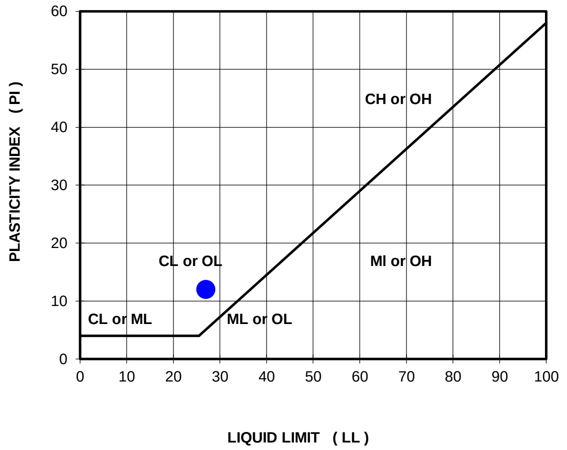
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE

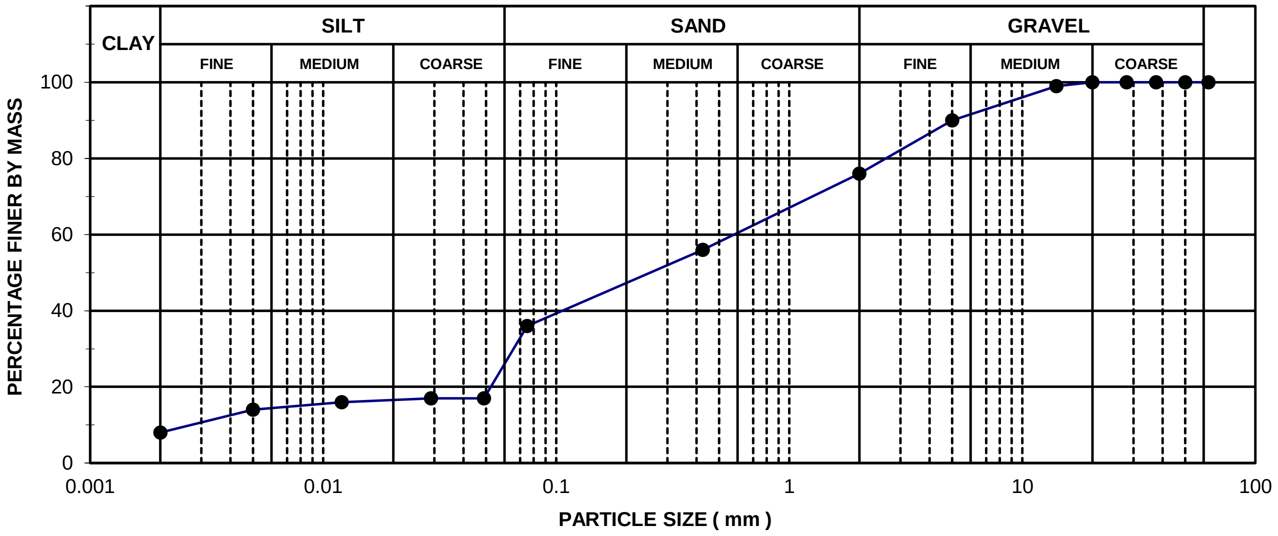


FOUNDATION INDICATOR TEST RESULTS

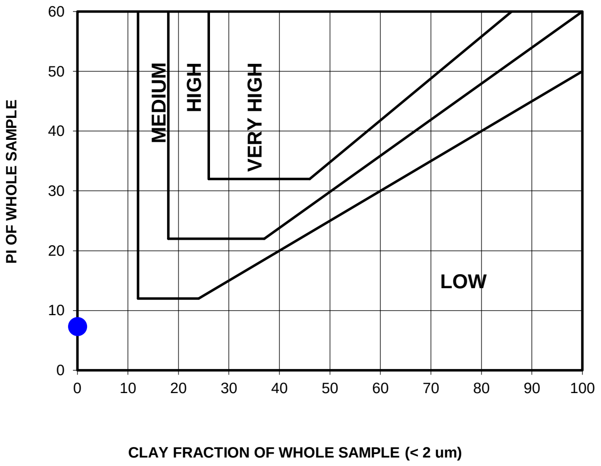
TEST LOCATION	TP108	PROJECT	Algoa Recon Support
SAMPLE NO.		PROJECT NUMBER	112546
DEPTH	0.6-2.2 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**56**	Liquid limit	(%)	**35.0**	% Gravel	**24**
50.000	**100**	0.075	**36**	Plastic limit	(%)	**22**	% Sand	**40**
37.500	**100**	0.049	**17**	Plasticity Index	(%)	**13**	% Silt	**28**
28.000	**100**	0.029	**17**	Weighted PI	(%)	**7**	% Clay	**8**
20.000	**100**	0.012	**16**	Linear Shrinkage	(%)	**6.0**	Activity	**1.6**
14.000	**99**	0.002	**8**	Grading Modulus		**1.32**	Unified Classification	**SC**
5.000	**90**	0.000	**0**	Uniformity coefficient		**247**	TRB Classification	**A - 6**
2.000	**76**	0.000	**0**	Coefficient of curvature		**2.1**		

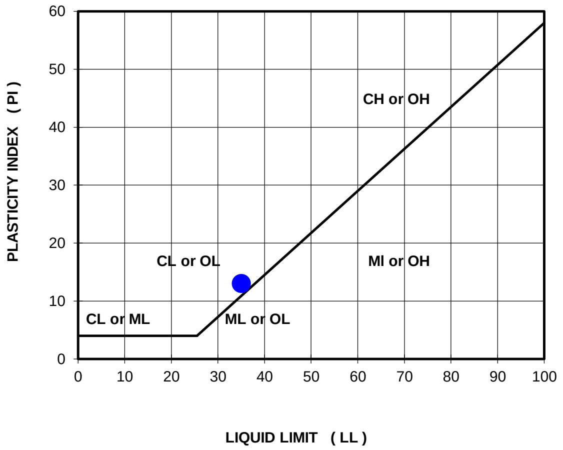
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE

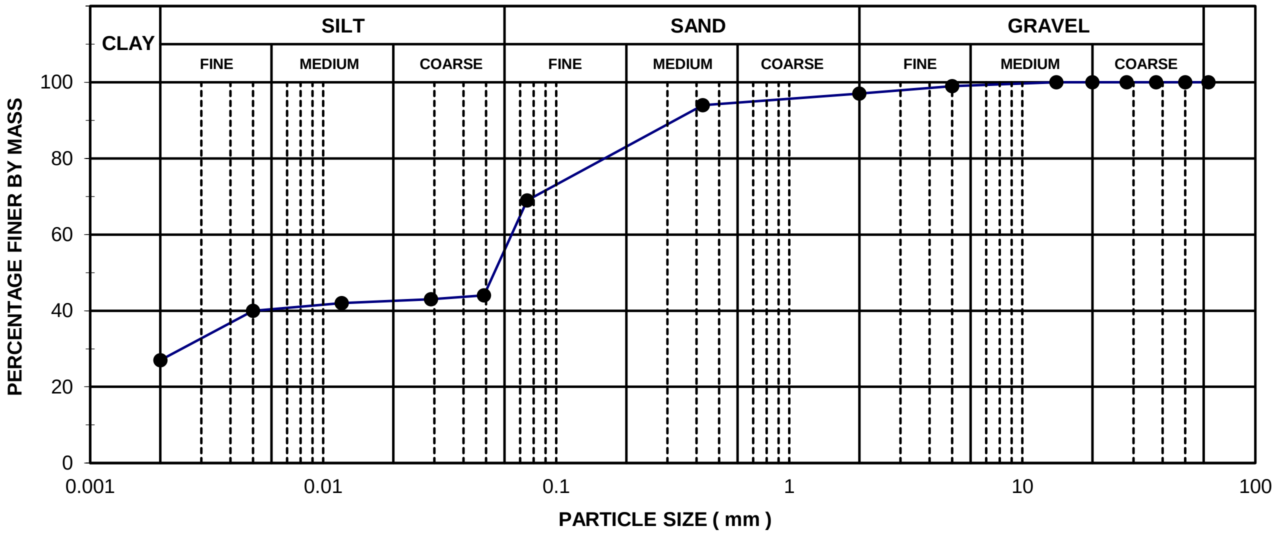


FOUNDATION INDICATOR TEST RESULTS

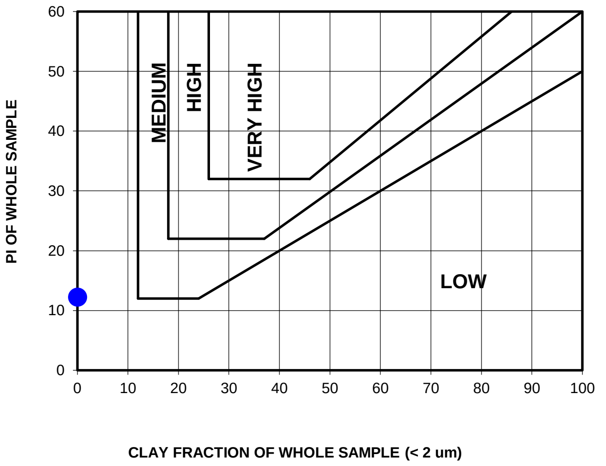
TEST LOCATION	TP109	PROJECT	Algoa Recon Support
SAMPLE NO.		PROJECT NUMBER	112546
DEPTH	0.7-4.1 m	SITE	Lower Coerney Dam site

SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**94**	Liquid limit	(%)	**29.0**	% Gravel	**3**
50.000	**100**	0.075	**69**	Plastic limit	(%)	**16**	% Sand	**28**
37.500	**100**	0.049	**44**	Plasticity Index	(%)	**13**	% Silt	**42**
28.000	**100**	0.029	**43**	Weighted PI	(%)	**12**	% Clay	**27**
20.000	**100**	0.012	**42**	Linear Shrinkage	(%)	**6.5**	Activity	**0.5**
14.000	**100**	0.002	**27**	Grading Modulus		**0.40**	Unified Classification	**CL**
5.000	**99**	0.000	**0**	Uniformity coefficient		**33**	TRB Classification	**A - 6**
2.000	**97**	0.000	**0**	Coefficient of curvature		**0.1**		

PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



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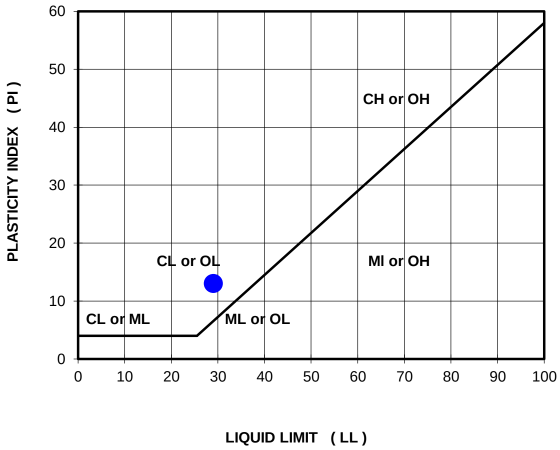
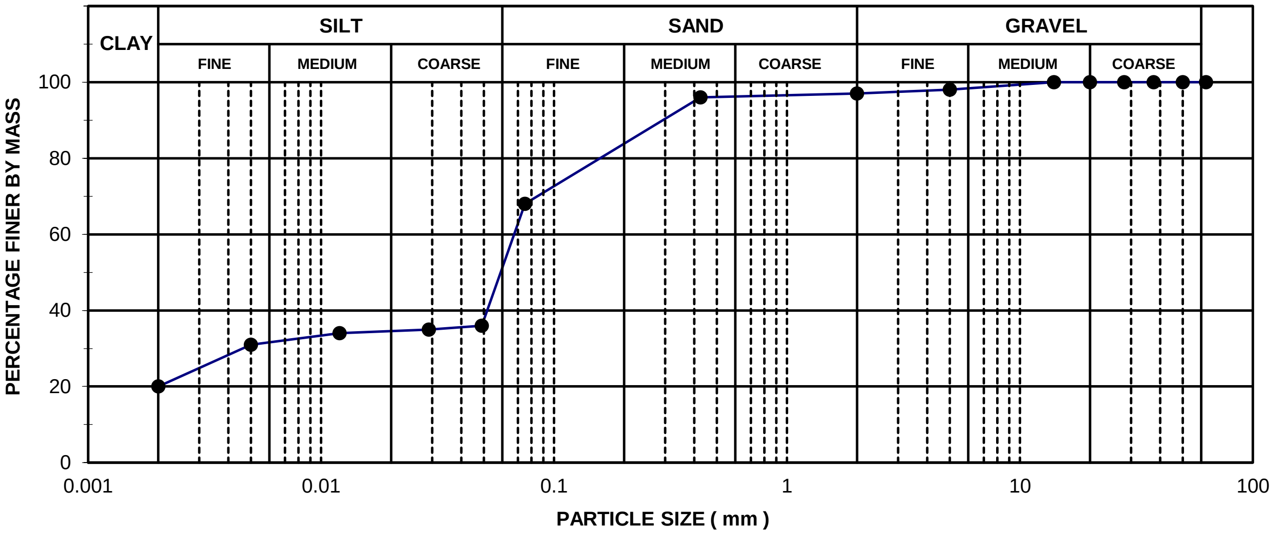


FOUNDATION INDICATOR TEST RESULTS

TEST LOCATION	TP113	PROJECT	Algoa Recon Support
SAMPLE NO.		PROJECT NUMBER	112546
DEPTH	0.4-4.5 m	SITE	Lower Coerney Dam site

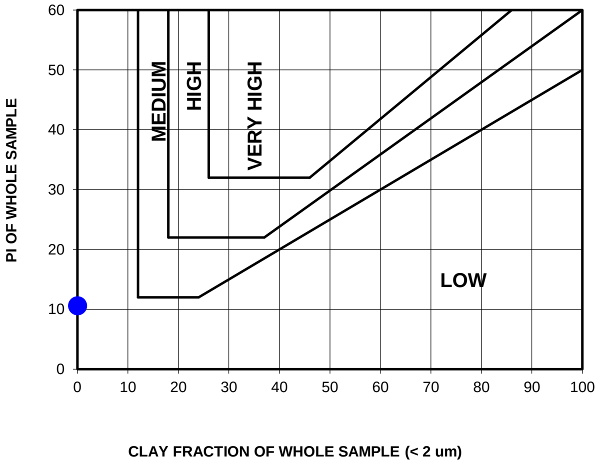
SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**96**	Liquid limit	(%)	**26.0**	% Gravel	**3**
50.000	**100**	0.075	**68**	Plastic limit	(%)	**15**	% Sand	**29**
37.500	**100**	0.049	**36**	Plasticity Index	(%)	**11**	% Silt	**48**
28.000	**100**	0.029	**35**	Weighted PI	(%)	**11**	% Clay	**20**
20.000	**100**	0.012	**34**	Linear Shrinkage	(%)	**5.0**	Activity	**0.6**
14.000	**100**	0.002	**20**	Grading Modulus		**0.39**	Unified Classification	**CL**
5.000	**98**	0.000	**0**	Uniformity coefficient		**34**	TRB Classification	**A - 6**
2.000	**97**	0.000	**0**	Coefficient of curvature		**0.2**		

PARTICLE SIZE DISTRIBUTION

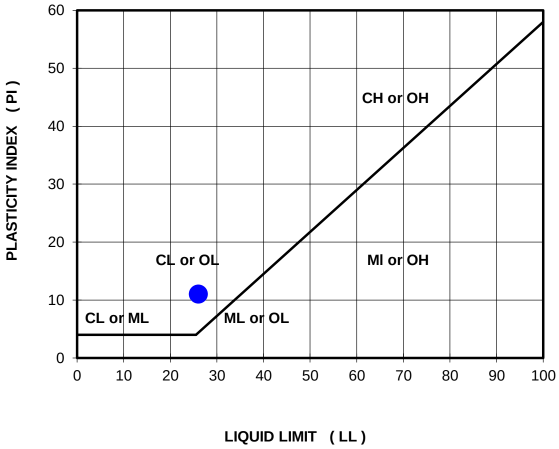


POTENTIAL EXPANSIVENESS

Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE

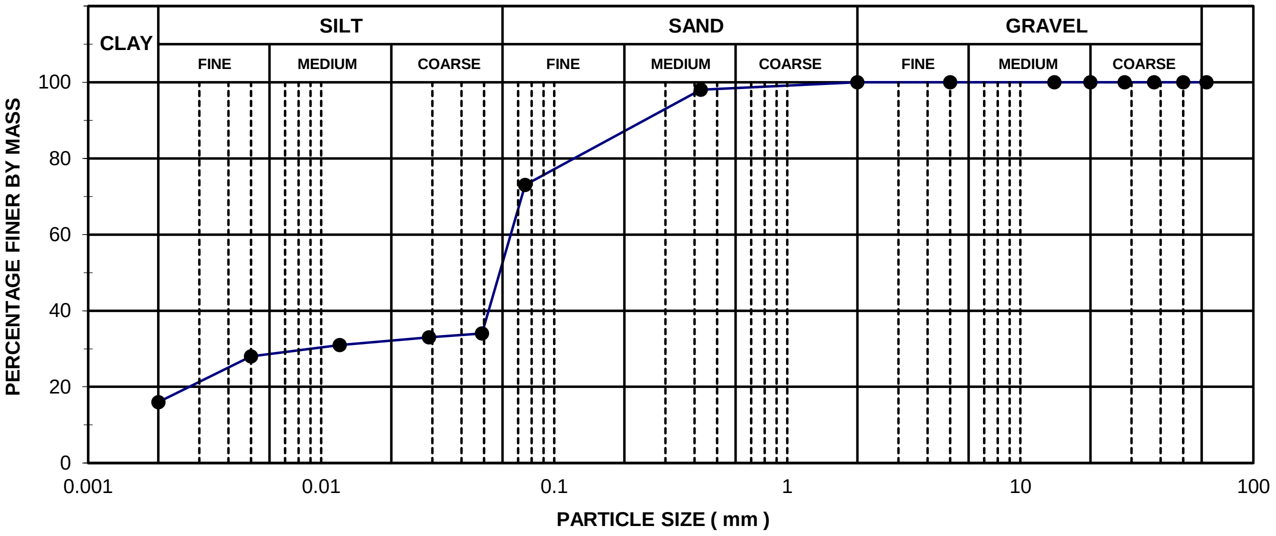


FOUNDATION INDICATOR TEST RESULTS

TEST LOCATION	TP119	PROJECT	Algoa Recon Support
SAMPLE NO.		PROJECT NUMBER	112546
DEPTH	0.8-2.2 m	SITE	Lower Coerney Dam site

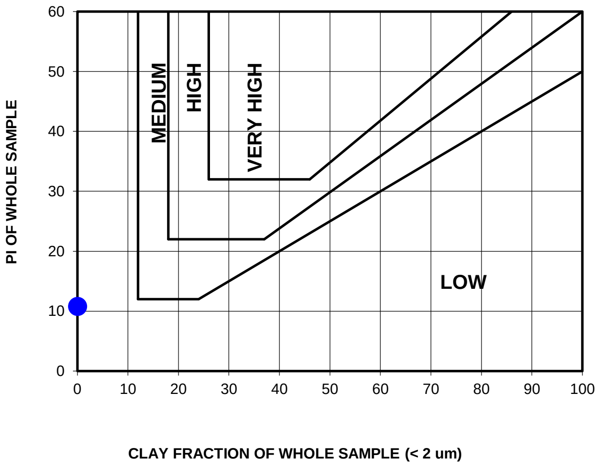
SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**98**	Liquid limit	(%)	**29.0**	% Gravel	**0**
50.000	**100**	0.075	**73**	Plastic limit	(%)	**18**	% Sand	**27**
37.500	**100**	0.049	**34**	Plasticity Index	(%)	**11**	% Silt	**57**
28.000	**100**	0.029	**33**	Weighted PI	(%)	**11**	% Clay	**16**
20.000	**100**	0.012	**31**	Linear Shrinkage	(%)	**5.0**	Activity	**0.7**
14.000	**100**	0.002	**16**	Grading Modulus		**0.29**	Unified Classification	**CL**
5.000	**100**	0.000	**0**	Uniformity coefficient		**33**	TRB Classification	**A - 6**
2.000	**100**	0.000	**0**	Coefficient of curvature		**1.0**		

PARTICLE SIZE DISTRIBUTION

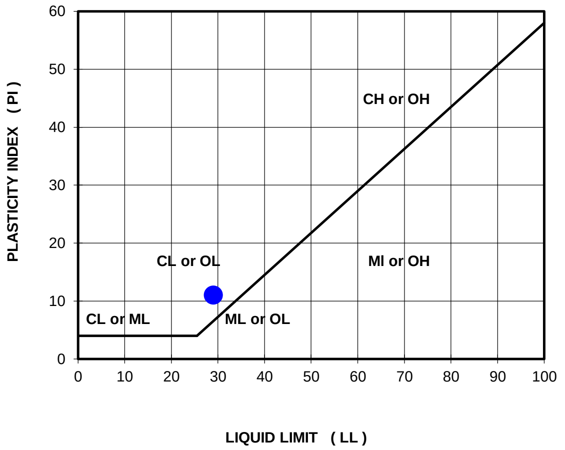


POTENTIAL EXPANSIVENESS

Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE

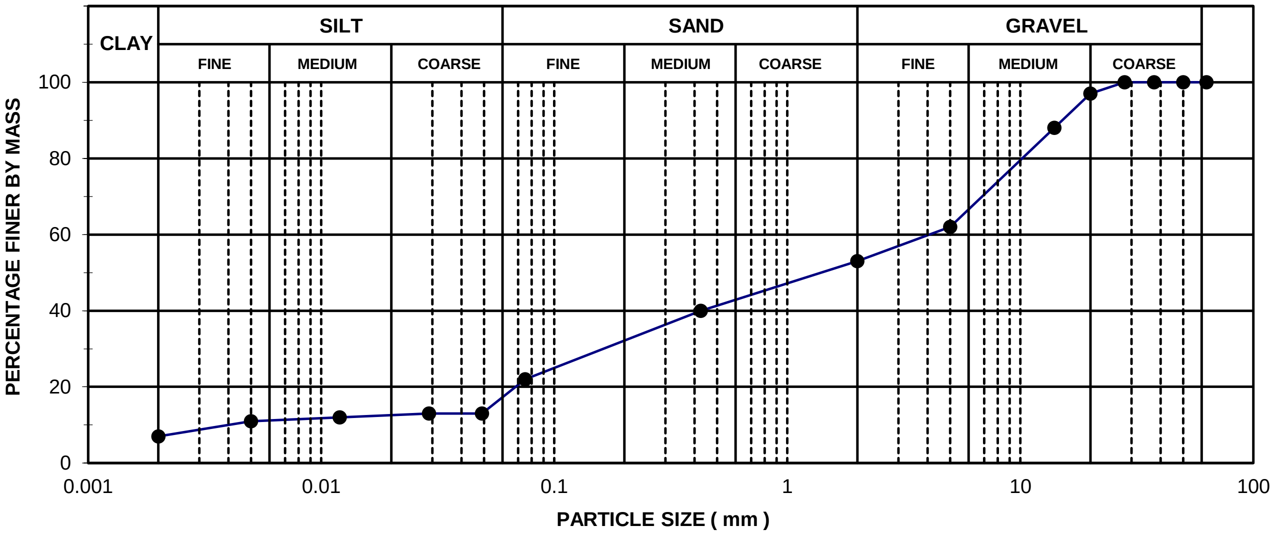


FOUNDATION INDICATOR TEST RESULTS

TEST LOCATION	TP115	PROJECT	Algoa Recon Support
SAMPLE NO.		PROJECT NUMBER	112546
DEPTH	2.4-4.2 m	SITE	Lower Coerney Dam site

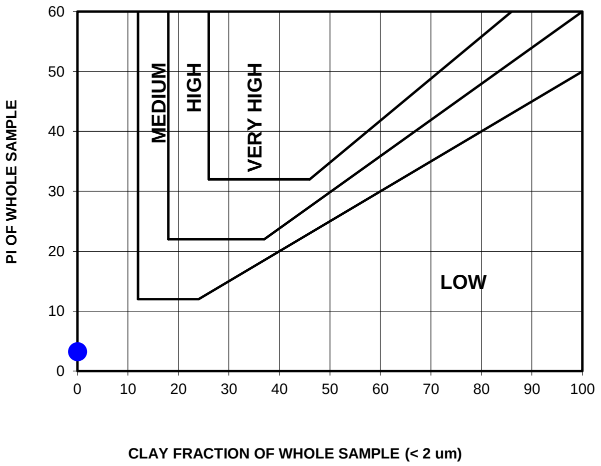
SIEVE ANALYSIS				ATTERBERG LIMITS			SOIL CLASSIFICATION	
Sieve (mm)	% Passing	Sieve (mm)	% Passing					
63.000	**100**	0.425	**40**	Liquid limit	(%)	**20.0**	% Gravel	**47**
50.000	**100**	0.075	**22**	Plastic limit	(%)	**12**	% Sand	**31**
37.500	**100**	0.049	**13**	Plasticity Index	(%)	**8**	% Silt	**15**
28.000	**100**	0.029	**13**	Weighted PI	(%)	**3**	% Clay	**7**
20.000	**97**	0.012	**12**	Linear Shrinkage	(%)	**3.5**	Activity	**1.1**
14.000	**88**	0.002	**7**	Grading Modulus		**1.85**	Unified Classification	**SC**
5.000	**62**	0.000	**0**	Uniformity coefficient		**1020**	TRB Classification	**A - 2 - 4**
2.000	**53**	0.000	**0**	Coefficient of curvature		**2.9**		

PARTICLE SIZE DISTRIBUTION

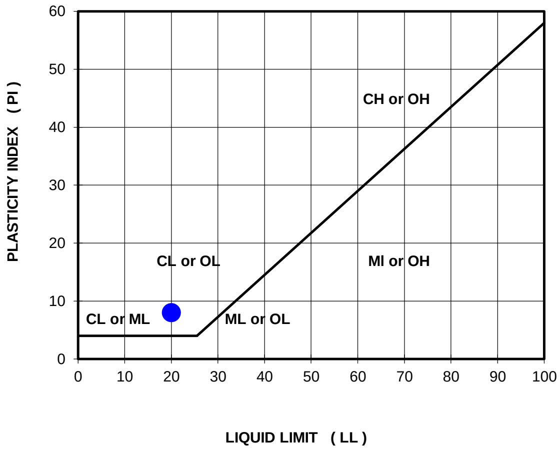


POTENTIAL EXPANSIVENESS

Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



Appendix F:
Packer (Lugeon) test data

RWBE GEOTECHNICAL DRILLING

P.O.Box 395
Graaff Reinet
6280

Fax No: 086 645 9149
Cell No: 082 851 5989
Email: rwbe@absamail.co.za

REPORT ON WATER PRESURE TESTING

SCHEME:	Lower Coerney Dam	**BOREHOLE NO:**	**LC 4**
DRILLER:	Mothau		

DATE	DEPTH STAGES	PRESSURE	TESTING TIMES	WATER GAUGE READING		
	Meters	Kpa	Minutes	From	To	Total Liters
Pump	Bean					
Calibration:						
28-Sep	From 7.50 to 10.97 m	65	10	402	494	92
		120	10	500	678	178
		170	10	685	933	248
		120	10	940	1158	218
	Water Level 6.70 m	65	10	1158	1302	144
28-Sep	From 11.00 to 13.97 m	100	10	350	361.8	11.8
		170	10	364	395	31
		250	10	397	459	62
		170	10	460	512	52
	Water Level 8.10 m	100	10	515	551	36
29-Sep	From 14.00 to 16.97 m	125	10	555.3	555.3	0
		220	10	556	556	0
		320	10	559	559	0
		220	10	565.9	565.9	0
	Water Level 9.70 m	125	10	566	566	0
29-Sep	From 17.00 to 20.45 m	155	10	570	925	355
		270	10	950	1375	425
	Max Kpa 340	385	10	390	855	465
		270	10	866	1276	410
	Water Level 13.00 m	155	10	290	590	300

Notes

RWBE GEOTECHNICAL DRILLING

P.O.Box 395
Graaff Reinet
6280

Fax No: 086 645 9149
Cell No: 082 851 5989
Email: rwbe@absamail.co.za

REPORT ON WATER PRESURE TESTING

SCHEME: Lower Coerney Dam

BOREHOLE NO: LC 3

DRILLER: Mothau

DATE	DEPTH STAGES	PRESSURE	TESTING TIMES	WATER GAUGE READING		
	Meters	Kpa	Minutes	From	To	Total Liters
Pump	Bean					
		10	**2**	**169**	**197**	**28**
Calibration:		**15**	**2**	**208**	**240**	**32**
		20	**2**	**249**	**292**	**43**
26-Sep	From 4.50 to 7.65 m	40	10	568.1	568.1	0
		70	10	580	580	0
		100	10	596.2	596.2	0
		70	10	599.5	599.5	0
	Water Level 4.30 m	40	10	603.4	603.4	0
26-Sep	From 7.50 to 10.58 m	65	10	784.1	790.7	6.6
		120	10	792	826.4	34.4
		170	10	830	880.8	50.8
		120	10	883	925.2	42.2
	Water Level 5.90 m	65	10	927.8	958	30.2
27-Sep	From 10.50 to 12.59 m	95	10	960	960	0
		165	10	961	962.6	1.6
		235	10	964	972.8	8.8
		165	10	973	977.8	4.8
	Water Level 4.00 m	95	10	978	979	1
27-Sep	From 12.50 to 13.36 m	115	10	13.5	13.5	0
		200	10	16.4	16.4	0
		280	10	21.2	21.2	0
		200	10	25.7	25.7	0
	Water Level 4.50 m	115	10	28.7	28.7	0
27-Sep	From 15.50 to 18.59 m	140	10	90.6	90.6	0
		245	10	92.8	92.8	0
		350	10	96.4	98	1.6
		245	10	99.9	99.9	0
	Water Level 4.70 m	140	10	101.5	101.5	0
28-Sep	From 18.50 to 20.43 m	165	10	123	123	0
		395	10	125.1	125.1	0
		420	10	135.9	135.9	0
		295	10	139.2	139.2	0
	Water Level 6.00 m	165	10	141.4	141.4	0

Notes

RWBE GEOTECHNICAL DRILLING

P.O.Box 395
Graaff Reinet
6280

Fax No: 086 645 9149
Cell No: 082 851 5989
Email: rwbe@absamail.co.za

REPORT ON WATER PRESURE TESTING

SCHEME:	Lower Coerney Dam	**BOREHOLE NO:**	**LC 4**
DRILLER:	Rasta		

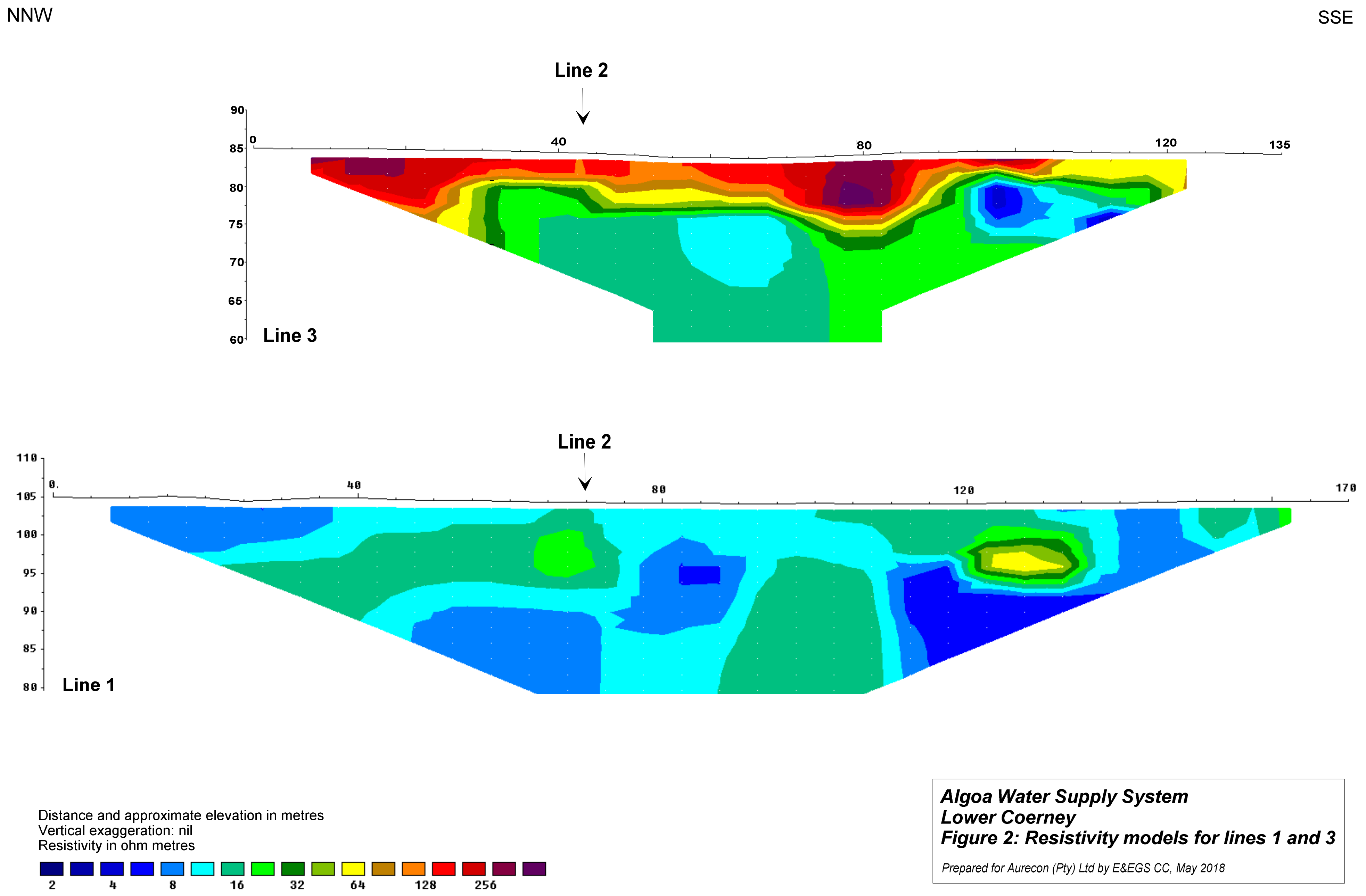
DATE	DEPTH STAGES	PRESSURE	TESTING TIMES	WATER GAUGE READING		
	Meters	Kpa	Minutes	From	To	Total Liters
Pump	Bean					
Calibration:						
25-Sep	From 4.00 to 7.78 m	35	10	516.2	516.2	0
		65	10	516.9	516.9	0
		90	10	519.3	519.3	0
		65	10	521.9	521.9	0
	Water Level 6.60 m	35	10	522.7	522.7	0
25-Sep	From 7.50 to 10.94 m	65	10	544.2	544.2	0
		120	10	546.5	549.1	2.6
		170	10	555	625.4	70.4
		120	10	630	670	40
	Water Level 3.50 m	65	10	672	700.2	28.2
25-Sep	From 11.00 to 13.94 m	100	10	705	705	0
		170	10	710	710	0
		250	10	713	713	0
		170	10	714	714	0
	Water Level 4.00 m	100	10	714	714	0
26-Sep	From 13.50 to 15.04 m	120	10	715.1	715.1	0
		215	10	715.9	715.9	0
		305	10	719.2	719.2	0
		215	10	722	722	0
	Water Level 10.00 m	120	10	724.8	724.8	0

Notes

Appendix G:
Geophysical survey results

Algoa Water Supply System
Lower Coerney
Figure 1: Resistivity traverse arrangement

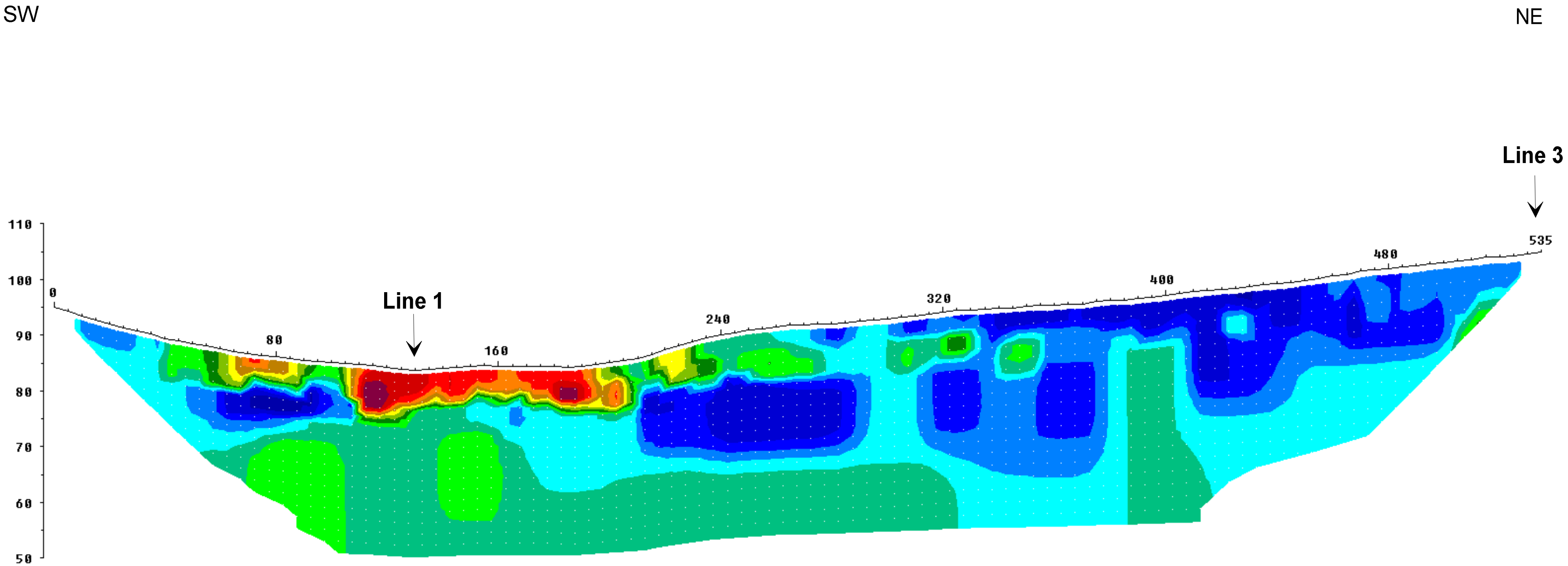
Prepared for Aurecon (Pty) Ltd by E&EGS CC, May 2018



Distance and approximate elevation in metres
Vertical exaggeration: nil
Resistivity in ohm metres

Algoa Water Supply System
Lower Coerney
Figure 2: Resistivity models for lines 1 and 3

Prepared for Aurecon (Pty) Ltd by E&EGS CC, May 2018



Distance and approximate elevation in metres
Vertical exaggeration 2:1
Resistivity in ohm metres

Algoa Water Supply System
Lower Coerney
Figure 3: Resistivity models for line 2

Prepared for Aurecon (Pty) Ltd by E&EGS CC, May 2018

ENGINEERING & EXPLORATION GEOPHYSICAL SERVICES CC
CK94/10526/23 Geophysical Contractors
[redacted]

170, Jakaranda Street,
Doringkloof,
Gauteng, 0157
012 - 6673369 (tel) 6675186(fax)

10th May, 2018

Aurecon South Africa (Pty) Ltd,
P O Box 905,
Pretoria,
0001.

Attn: Gary Davis

Dear Sir,

RESISTIVITY SURVEY ON LOWER COERNEY, KIRKWOOD

A resistivity survey has been carried out on Lower Coerney, near Kirkwood, at the planned site of a dam. The investigation for the dam is in support of the Algoa Water Supply Project.

The area is underlain by sedimentary rock of Cretaceous age. Two boreholes were drilled about 600 metres to the south of the site by Water Affairs in 1986 and 1987; they intersected siltstone along with mudstone and sandstone beneath a layer of hillwash and completely weathered siltstone that is two and a half metres thick.

The survey consists of three traverses, one along the centre line of the dam, one on the north-eastern side of the site and one in the valley itself. The required traverse positions were indicated on a kmz file supplied by Aurecon and followed cut lines prepared by a third party.

Fieldwork was undertaken from the 7th to 9th May. An ABEM LS2 was employed for the task using a Wenner-Schlumberger protocol and a five-metre electrode separation. The positions of the traverses were recorded with a Garmin GPS (appendix). Changes in elevation along the traverses were recorded with a dumpy level; these were assigned a realistic base level using elevations taken from Goggle Earth.

The data were modelled using Res2Dinv, a program that fits internally-generated model data to the field data over several iterations. The results of the operation are cross-sections showing lateral and vertical changes in resistivity.

The traverse arrangement is shown on figure 1 and the resistivity models in figures 2 and 3. Warm colours (yellow-red) in the models reflect resistors and cooler colours (green-blue), relative conductors.

The resistivity of a rock unit is controlled mostly by the content and quality of the water it holds and its clay content, hence a resistivity interpretation is based on inferences drawn from contrasts in these quantities. This site is characterised by conductors but there is a resistive layer about five metres thick within the valley (figures 2 and 3). Exposed at surface in the valley floor, this layer albeit with a reduction in resistivity can be traced for a little distance beneath the north-east bank. Its surface expression is taken to reflect hardpan and its extension also a layer of increased cementation. Apart from this layer, resistivity increases generally with depth, although often in an irregular fashion and with breaks in continuity, to give an impression of horizontal layering, especially on the model for line 2 (figure 3). The most conductive zone is up to twenty metres thick. This vertical change is expected to reflect a variation in the weathering with the most conductive area corresponding to weathered rock. The lateral changes that interrupt it may arise from a local variation in lithology, however, it is possible that they may indicate faults. If the latter, the most likely position for a fault zone is beneath the valley floor and between 320 and 400 metres on line 2.

In summary, the area has a hardpan layer exposed in the valley floor that may extend beneath below the valley side and a horizon of weathered rock up to twenty metres thick. There are no clearly defined anomalies indicative of a fault, but their absence cannot be entirely discounted.

Yours sincerely,

R W Day Pr.Sci.Nat.

The interpretation contained in this report is based on the training and experience of the author and information passed on during the course of the investigation. As with all geophysical data, other interpretations are possible.

Appendix

Resistivity traverse coordinates (Lo25 WGS84)
Lower Coerney

Line	Station	LoY	LoX
1	0	58102	-3702609
1	20	58113	-3702626
1	40	58125	-3702642
1	60	58136	-3702657
1	80	58149	-3702674
1	100	58159	-3702691
1	120	58168	-3702708
1	135	58176	-3702722
2	0	58025	-3702729
2	20	58045	-3702719
2	40	58061	-3702710
2	60	58080	-3702701
2	80	58098	-3702692
2	100	58115	-3702681
2	120	58132	-3702671
2	140	58148	-3702658
2	160	58163	-3702646
2	180	58178	-3702631
2	200	58193	-3702618
2	220	58203	-3702604
2	240	58218	-3702592
2	260	58232	-3702577
2	280	58246	-3702564
2	300	58261	-3702550
2	320	58277	-3702535
2	340	58290	-3702523
2	360	58304	-3702508
2	380	58317	-3702494
2	400	58333	-3702481
2	420	58346	-3702467
2	440	58360	-3702453
2	460	58374	-3702439
2	480	58389	-3702426
2	500	58402	-3702412
2	520	58418	-3702395
2	535	58429	-3702387
3	0	58406	-3702351
3	20	58416	-3702368
3	40	58425	-3702385
3	60	58437	-3702403
3	80	58447	-3702420
3	100	58458	-3702434
3	120	58470	-3702453
3	140	58480	-3702469
3	160	58493	-3702486
3	170	58500	-3702494

Appendix H:
Groundwater evaluation

GROUNDWATERAFRICA
GWA CONSULTING HYDROGEOLOGISTS cc T\A
Reg. No.: CK 2004-059516-23

38 Disa Avenue
Kommetjie
7975

Erik van der Berg
Erik.VanDerBerg@aurecongroup.com

19 November 2018

Groundwater concerns in the Lower Coerney Dam site area

This brief assessment of the groundwater situation in the Lower Coerney Dam site area follows from concerns about the shallow alluvial gravels that were encountered during core drilling at the proposed dam site. The issues raised are:

- Groundwater flow direction
- Groundwater flow rate
- Potential groundwater effect on the planned dam.

The discussion below attempts to present what can be deduced from the data supplied. This consists of the locations of the core boreholes (Figure 1), the geological logs of the core holes and groundwater levels (Table 1).

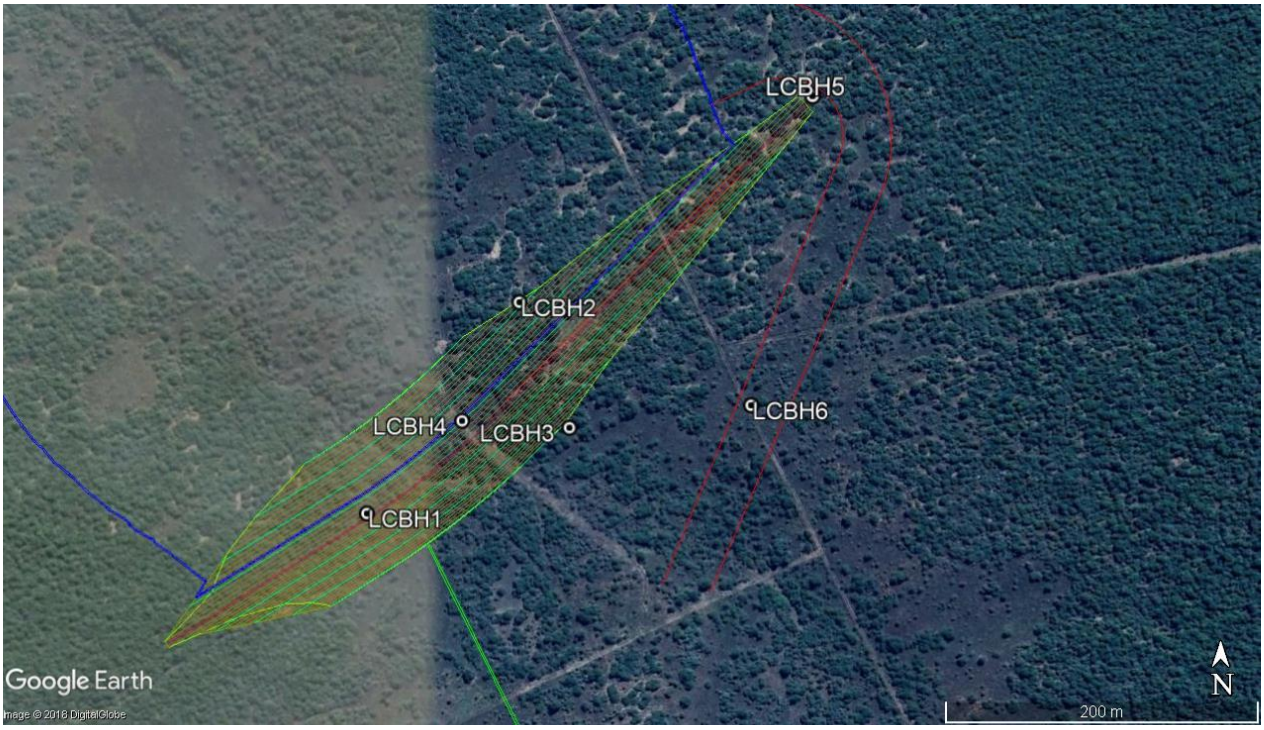


Figure 1. Borehole locations

Natural groundwater levels, flow direction & flow rate

Natural groundwater levels appear to mirror topography to produce a groundwater flow direction downstream in a roughly southerly direction (Figure 2). The hydraulic gradient is steep, around 0.03 – 0.05 (Table 1) which shows that the permeability of the saturated rocks are very low, as one would expect from the Kirkwood Formation mudstones, siltstones and sandstones. Even with the steep hydraulic gradients, the flow rates will be very low.

Table 1. Rest water levels and approximate hydraulic gradients

BH no	Collar elevation (mamsl)	RWL (mbgl)	RWL (mamsl)		Approximate Distance (m)	Difference in RWL (m)	Hydraulic gradient
LC1	83.36	13.75	69.61				
LC2	89.15	19.6	69.55				
LC3	84.30	18.1	66.20	LC2 - LC3	100	3.35	0.034
LC4	81.82	12.7	69.12				
LC5	102.01	9.2	92.81				
LC6	89.98	8.8	81.18	LC5 - LC6	220	11.63	0.053

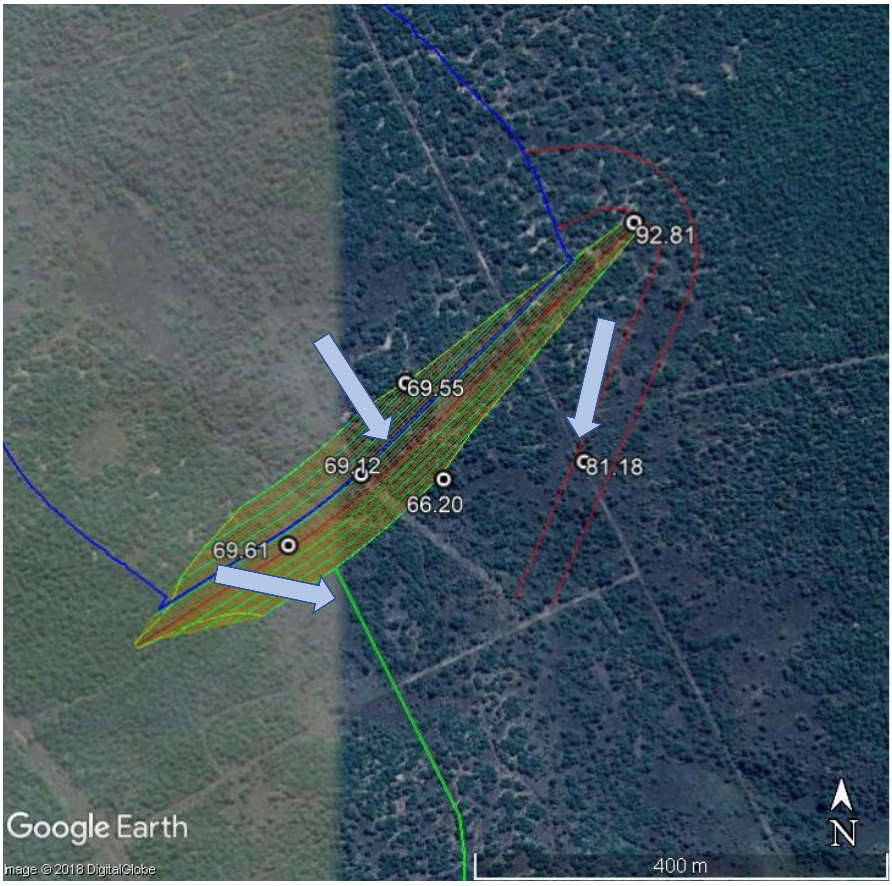


Figure 2. Rough groundwater flow direction

:

Perched groundwater flow rate after dam construction

The groundwater table lies below the alluvial gravels. However, after constructing the dam, water can be expected to leak through the upper, near-surface layers and saturate the gravel layer. The leakage may be slow due to the presence of clayey material in places, and with time it may reduce as additional clayey and silty material accumulates on the bottom of the dam. The hydraulic gradient, however, will be high and if the gravels are highly permeable, water will be able to flow relatively rapidly in this layer. The flow rate through the gravels, however, may not be a function of the permeability of the gravels but rather the leakage rate through the base of the dam, as this latter flow rate may be less than that of the gravels themselves. This is obviously unknown.

The maximum flow rate, ie the potential flow through the gravels can be estimated once the hydraulic conductivity or transmissivity of the gravels are known. This can be obtained by conducting injection tests on the core boreholes if they are still sufficiently open (they were not back-filled but may be blocked with debris); or alternatively new boreholes can be drilled for testing purposes. The results of the permeability tests done on the bedrock are obviously not suitable to be used to estimate the gavels' permeability.

It is likely that leakage via the base of the dam and through the gravels will not daylight as new springs downstream of the dam wall as it appears as if the vegetation is sufficiently dense to opportunistically utilize this shallow water – water that would naturally be in this zone during heavy rainfall periods. A botanist should be consulted to comment on this.

Potential effect on natural groundwater flow

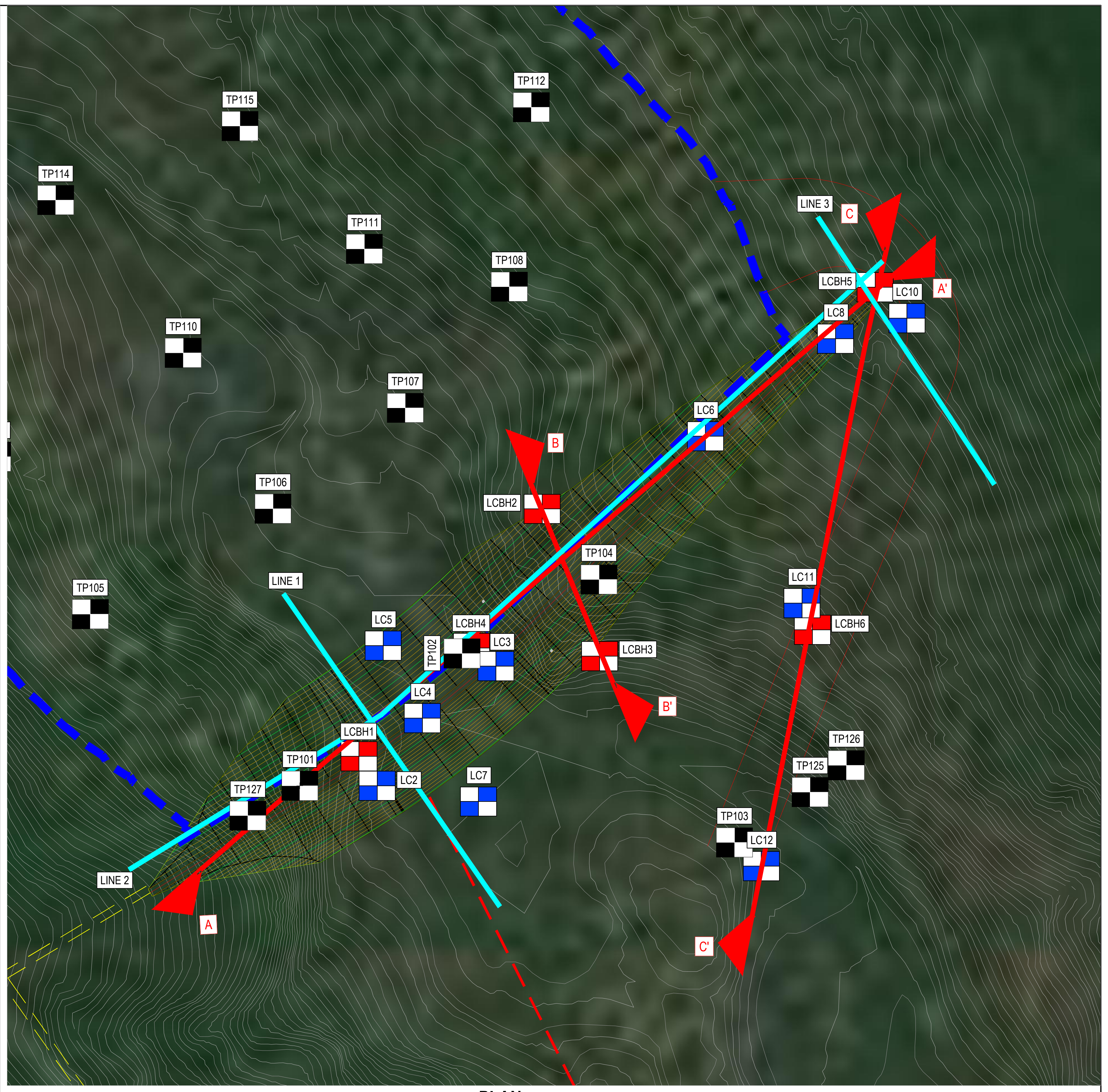
The leakage to the gravels and the underlying hard-rock geology would only produce a very limited impact on the hydrogeology of the area. The underlying hard-rock's permeability is probably too low to receive much water, and therefore the effect of the dam will likely be localized and small. The gravels have been discussed above; but the net effect on these will likely also be small because they are unlikely to be continuous for a great distance, and even if the are it is unlikely that they will be highly permeable throughout their length. This, however is not known, but 2D resistivity surveys can assist in mapping the gravel layer.

Potential groundwater effect on the planned dam

As stated above, the gravels will likely become permanently saturated below the dam and below the dam wall. I do not have the expertise to comment on whether this could have an effect on the stability of the dam wall.

Ricky Murray
19 November 2018

Appendix I:
Drawings



PLAN
SCALE 1:2500

LEGEND

- 🟥 BOREHOLE POSITION
- 🟦 TLB TEST PIT POSITION
- ⬛ EXCAVATOR TEST PIT POSITION
- FULL SUPPLY LEVEL (FSL)
- CANAL
- SPILLWAY
- A A' GEOLOGICAL LONGITUDINAL SECTIONS
- RESISTIVITY SURVEYS

	Lo 25 WGS	
	X	Y
TP101	-58062	3702708
TP102	-58165	3702624
TP103	-58338	3702744
TP104	-58252	3702577
TP105	-57929	3702599
TP106	-58045	3702532
TP107	-58129	3702468
TP108	-58195	3702391
TP109	-57867	3702499
TP110	-57988	3702433
TP111	-58103	3702367
TP112	-58209	3702277
TP113	-57805	3702363
TP114	-57907	3702336
TP115	-58024	3702289
TP116	-57691	3702130
TP117	-57832	3702102
TP118	-58004	3702086
TP119	-57671	3701972
TP120	-57836	3701938
TP121	-58020	3701894
TP122	-57728	3701805
TP123	-57767	3701695
TP124	-57899	3701616
TP125	-58386	3702712
TP126	-58409	3702695
TP127	-58029	3702727

Borehole and Test Pit ID	LO-25-WGS	
	X	Y
LCBH1	-58099.59	3702689.25
LCBH2	-58215.90	3702532.15
LCBH3	-58252.35	3702625.65
LCBH4	-58170.99	3702620.43
LCBH5	-58427.33	3702391.34
LCBH6	-58387.47	3702608.97
LC2	-58111.15	3702708.33
LC3	-58186.52	3702631.74
LC4	-58139.83	3702665.36
LC5	-58114.94	3702619.00
LC6	-58319.56	3702486.21
LC7	-58175.42	3702718.25
LC8	-58402.15	3702423.53
LC9	-58261.96	3702542.85
LC10	-58447.49	3702411.45
LC11	-58380.86	3702592.18
LC12	-58355.02	3702758.93
LC20	-58164.20	3702164.66
LC22	-57864.55	3702227.61
LC23	-57734.96	3702242.77

NOTES:

1. BOREHOLE (BH) CO-ORDINATES ACCURATELY SURVEYED
TEST PIT (TP) CO-ORDINATES - HANDHELD GPS.

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CLIENT

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

REV	DATE	REVISION DETAILS	APPROVED
A	16/10/18	ISSUED FOR INFORMATION	G DAVIS
B	30/07/19	ISSUED FOR INFORMATION	G DAVIS

SCALE	SIZE
1:750	A1

FOR INFORMATION

DRAWN
M SIBUYI

DESIGNED
S NYATHI

REVIEWED
G DAVIS

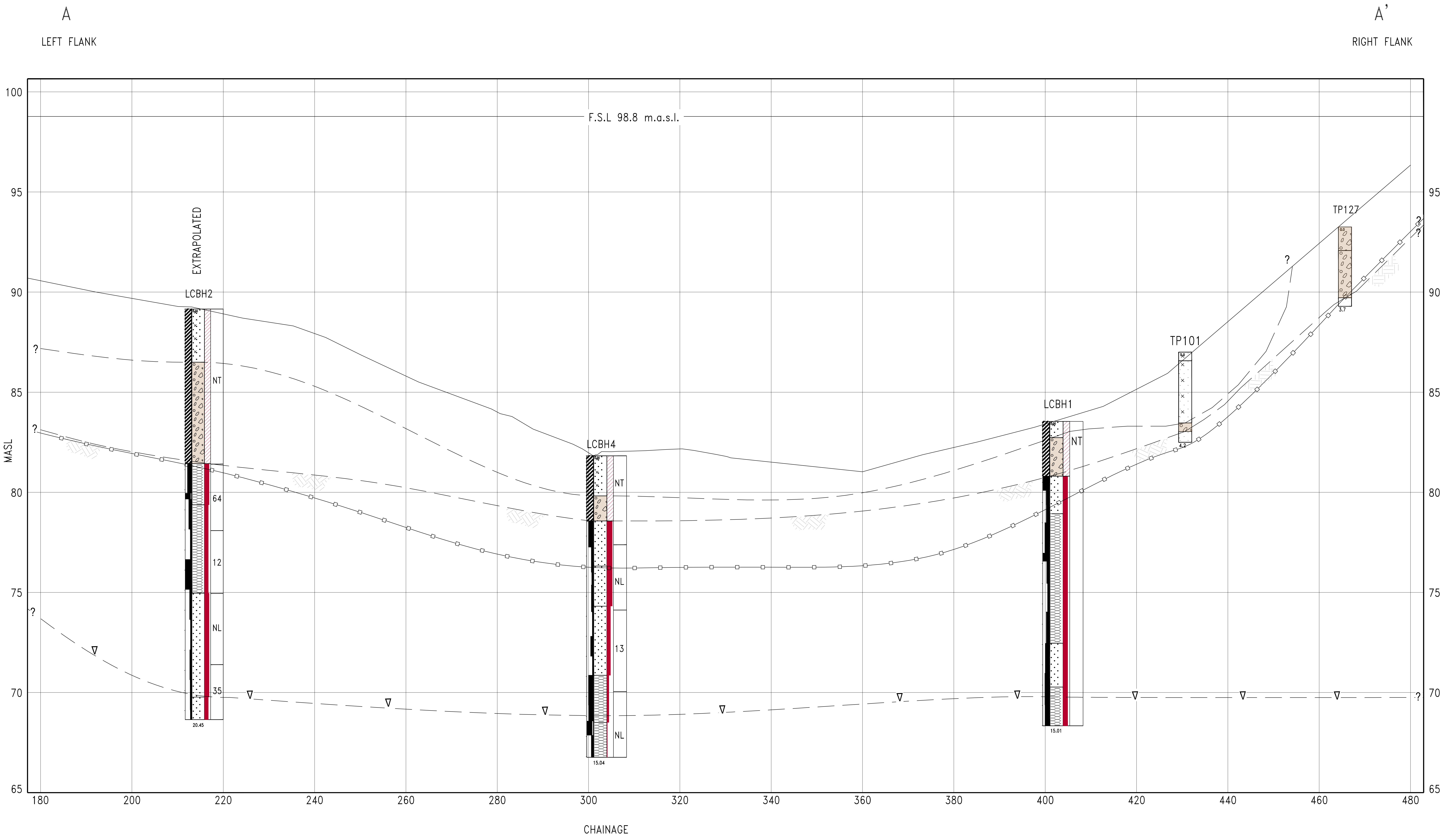
APPROVED
G DAVIS
DATE

PROJECT
SUPPORT OF WATER RECONCILATION
STRATEGY FOR THE ALGOA
WATER SUPPLY SYSTEM

TITLE
LOWER COERNEY DAM SITE
INVESTIGATION LAYOUT

DRAWING NUMBER

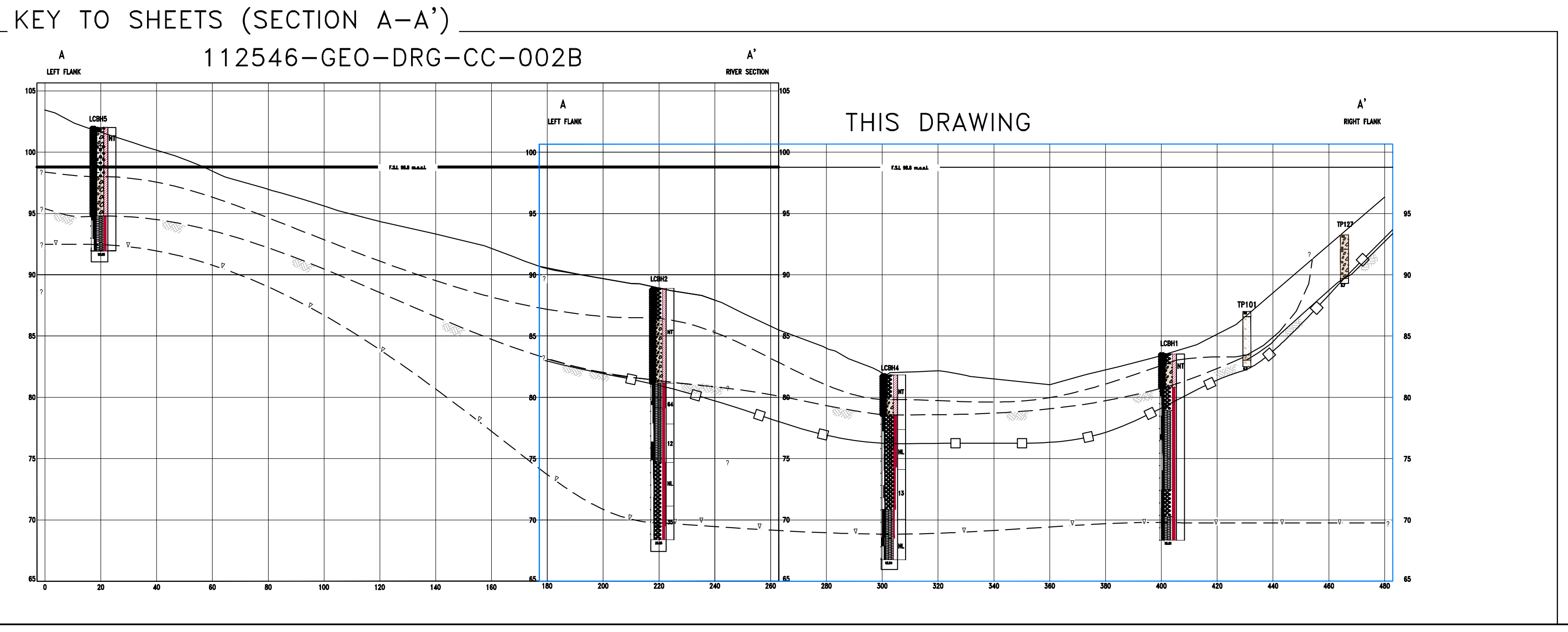
PROJECT No.		WBS		TYPE		DISC		NUMBER		REV
112546	-	GEO	-	DRG	-	CC	-	001	-	B



LITHOLOGY:

- ⁙ COLLUVIUM
- ▨ REWORKED TERRACE GRAVELS
- ▨ RESIDUAL SANDSTONE
- ☰ MUDSTONE } BEDROCK
- ⁙ SANDSTONE } BEDROCK

KEY TO SHEETS (SECTION A–A')



FOR BOREHOLE KEY, REFER TO
DRAWING NO: 112546–GEO–DRG–CC–005

LEGEND

- NATURAL GROUND LEVEL
- GEOLOGICAL BOUNDARY
- UPPER BOUNDARY OF BEDROCK
- ▽ WATER REST LEVEL
- RECOMMENDED EXCAVATION DEPTH

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water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

REV	DATE	REVISION DETAILS	APPROVED
A	17/10/18	ISSUED FOR INFORMATION	G DAVIS
B	07/08/19	ISSUED FOR INFORMATION	G DAVIS

SCALE	SIZE
1:750	A1

FOR INFORMATION

DRAWN
M SIBUYI

DESIGNED
S NYATHI

REVIEWED
G DAVIS

APPROVED
DATE
G DAVIS

PROJECT
SUPPORT OF WATER RECONCILATION
STRATEGY FOR THE ALGOA
WATER SUPPLY SYSTEM

TITLE
GEOTECHNICAL INVESTIGATION OF
LOWER COERNEY DAM SITE
RIVER SECTION & RIGHT FLANK : SECTION A-A'

DRAWING NUMBER

PROJECT No.		WBS		TYPE		DISC		NUMBER		REV
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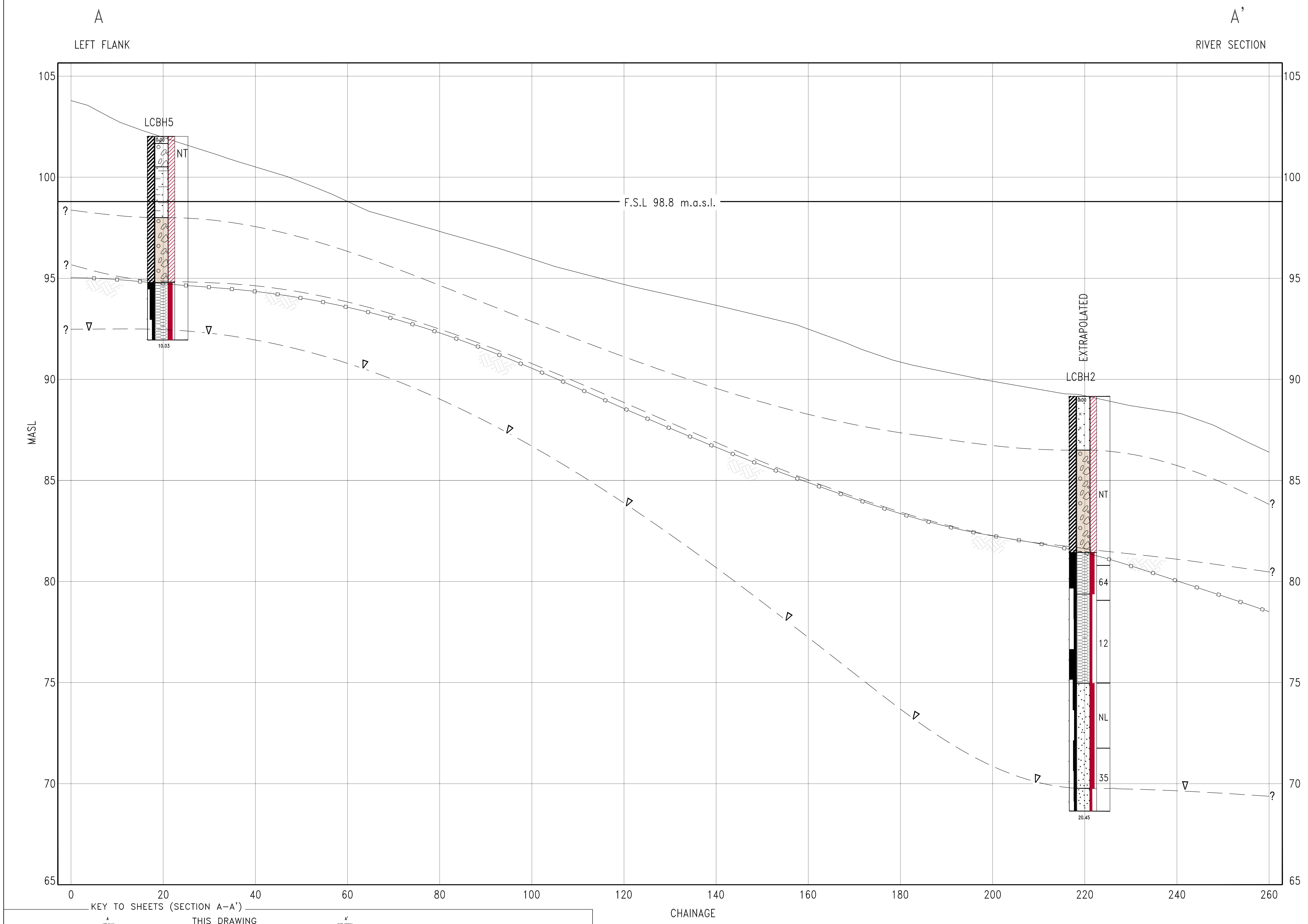
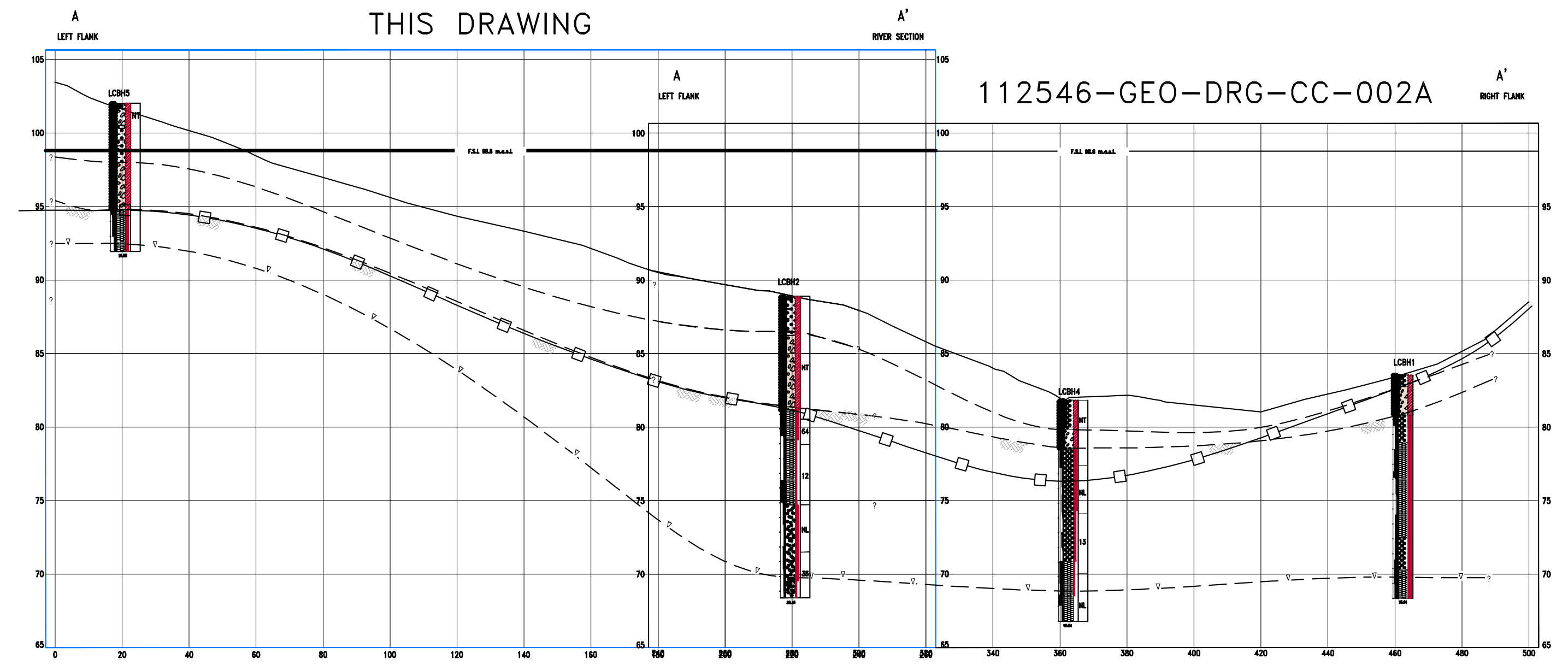


KEY TO SHEETS (SECTION A-A')



LEGEND

──	NATURAL GROUND LEVEL
— — —	GEOLOGICAL BOUNDARY
— — —	UPPER BOUNDARY OF BEDROCK
— ▽ — ▽ —	WATER REST LEVEL
—□—□—□—	RECOMMENDED EXCAVATION DEPTH

LITHOLOGY:

▨	TOPSOIL
▨	COLLUVIUM
▨	REWORKED TERRACE GRAVELS
▨	MUDSTONE } BEDROCK
▨	SANDSTONE } BEDROCK

FOR BOREHOLE KEY, REFER TO
DRAWING NO: 112546-GEO-DRG-CC-005

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Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

REV	DATE	REVISION DETAILS	APPROVED
A	17/10/18	ISSUED FOR INFORMATION	G DAVIS

SCALE	SIZE
1:750	A1

FOR INFORMATION

DRAWN
M SIBUYI

DESIGNED
S NYATHI

REVIEWED
G DAVIS

APPROVED
DATE
G DAVIS

PROJECT

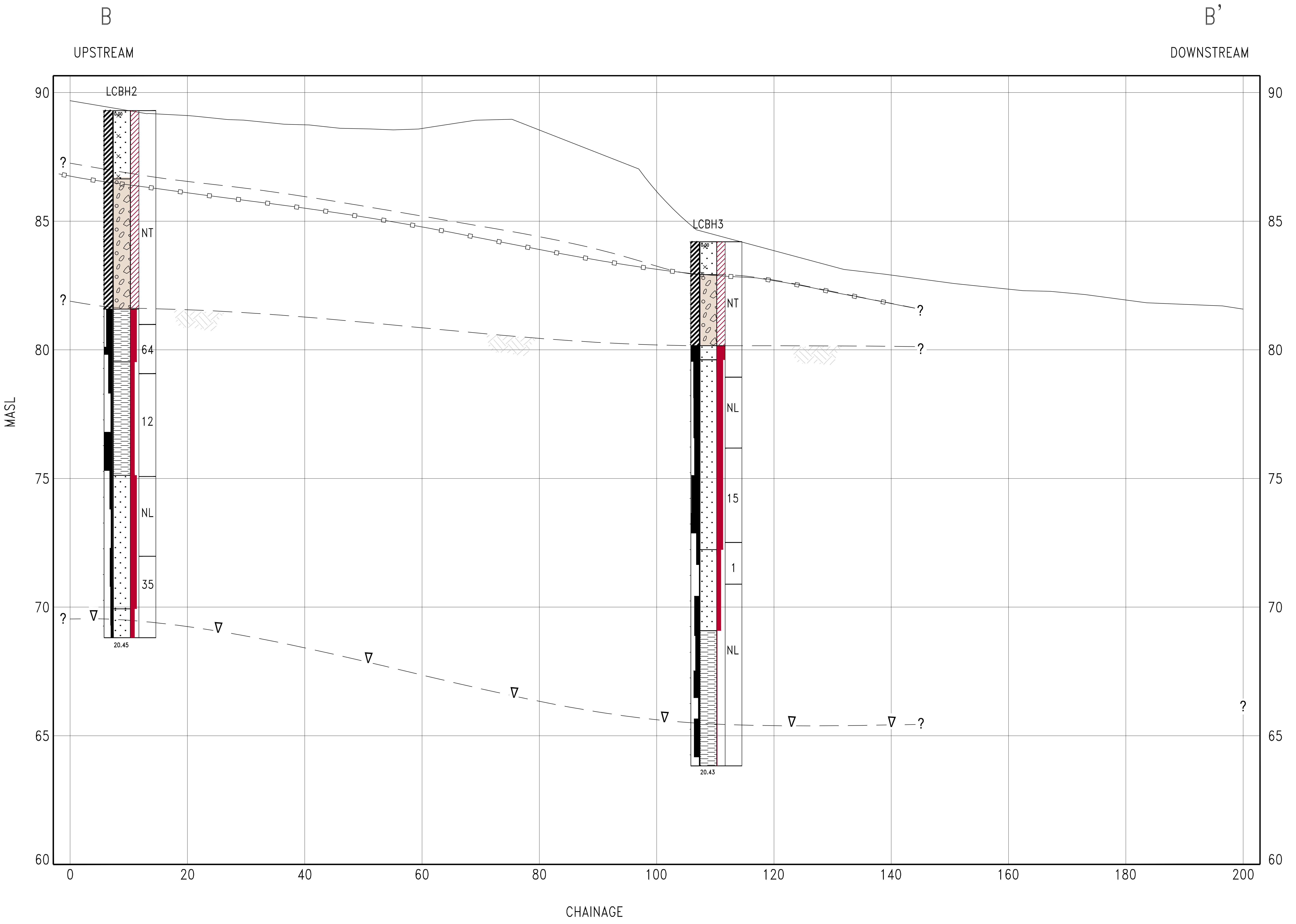
SUPPORT OF WATER RECONCILATION
STRATEGY FOR THE ALGOA
WATER SUPPLY SYSTEM

TITLE

GEOTECHNICAL INVESTIGATION OF
LOWER COERNEY DAM SITE
LEFT FLANK : SECTION A-A'

DRAWING NUMBER

PROJECT No.	WBS	TYPE	DISC	NUMBER	REV
112546 -	GEO -	DRG -	CC -	002B	- A



LITHOLOGY:

COLLUVIUM

REWORKED TERRACE GRAVELS

MUDSTONE
SANDSTONE } BEDROCK

FOR BOREHOLE KEY, REFER TO
DRAWING NO: 112546-GEO-DRG-CC-005

LEGEND

NATURAL GROUND LEVEL

GEOLOGICAL BOUNDARY

UPPER BOUNDARY OF BEDROCK

WATER REST LEVEL

RECOMMENDED EXCAVATION DEPTH

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REV	DATE	REVISION DETAILS	APPROVED
A	17/10/18	ISSUED FOR INFORMATION	G DAVIS

SCALE 1:750
SIZE A1
FOR INFORMATION

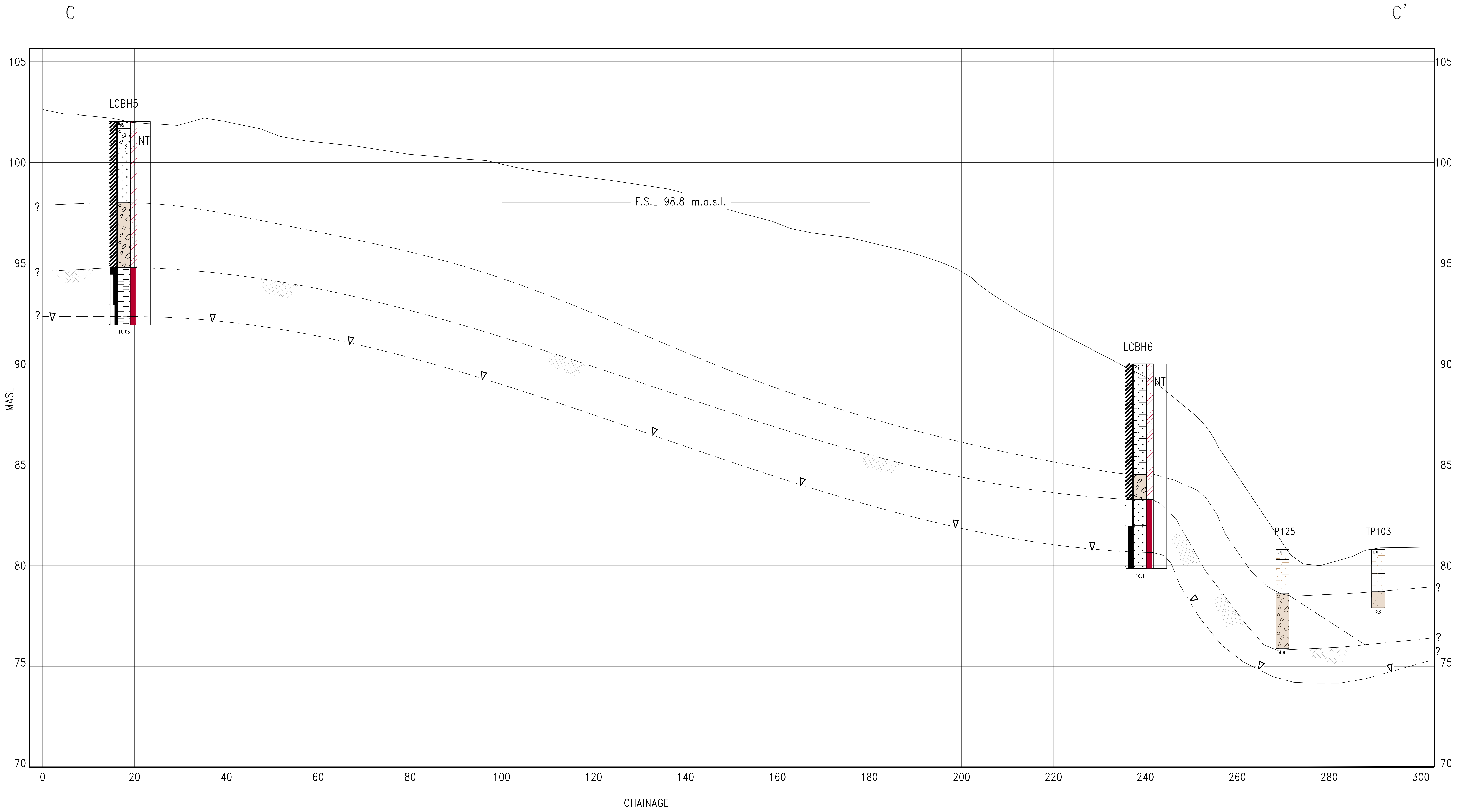
DRAWN M SIBUYI
DESIGNED S NYATHI
REVIEWED G DAVIS
APPROVED G DAVIS
DATE

PROJECT
SUPPORT OF WATER RECONCILATION
STRATEGY FOR THE ALGOA
WATER SUPPLY SYSTEM

TITLE
GEOTECHNICAL INVESTIGATION OF
LOWER COERNEY DAM
SECTION B-B'

DRAWING NUMBER

PROJECT No.	WBS	TYPE	DISC	NUMBER	REV
112546	GEO	DRG	CC	003	A



LEGEND

- NATURAL GROUND LEVEL
- GEOLOGICAL BOUNDARY
- UPPER BOUNDARY OF BEDROCK
- WATER REST LEVEL

LITHOLOGY:

- COLLUVIUM
- REWORKED TERRACE GRAVELS
- RESIDUAL SANDSTONE
- MUDSTONE } BEDROCK
- SANDSTONE } BEDROCK

FOR BOREHOLE KEY, REFER TO
DRAWING NO: 112546-GEO-DRG-CC-005

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REV	DATE	REVISION DETAILS	APPROVED
A	17/10/18	ISSUED FOR INFORMATION	G DAVIS
B	08/07/19	ISSUED FOR INFORMATION	G DAVIS

SCALE	SIZE
N.T.S	A1

FOR INFORMATION

DRAWN
M SIBUYI

DESIGNED
S NYATHI

REVIEWED
G DAVIS

APPROVED
DATE
G DAVIS

PROJECT
SUPPORT OF WATER RECONCILATION
STRATEGY FOR THE ALGOA
WATER SUPPLY SYSTEM

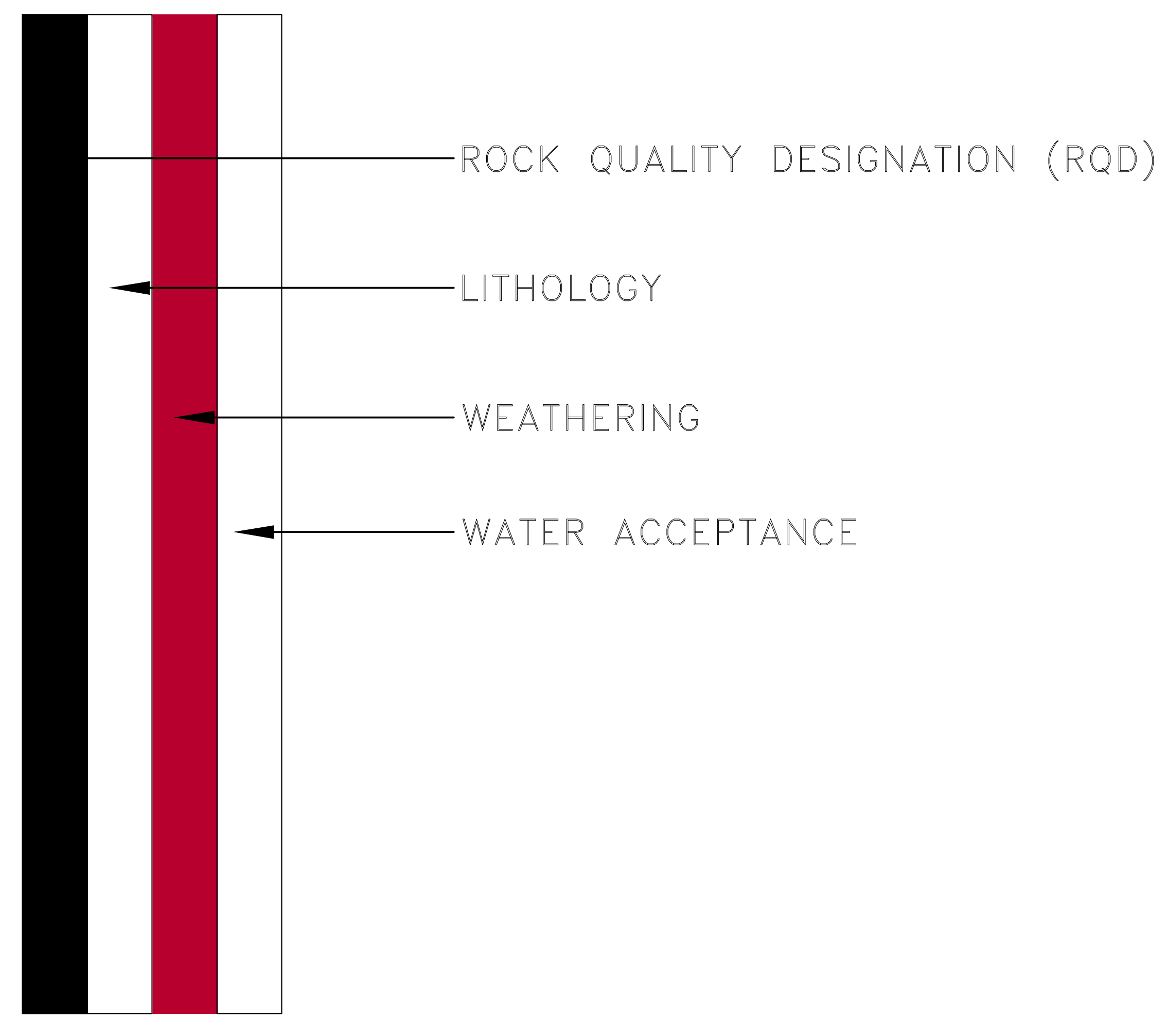
TITLE
GEOTECHNICAL INVESTIGATION OF
LOWER COERNEY DAM SITE
SPILLWAY : SECTION C-C'

DRAWING NUMBER

PROJECT No.	WBS	TYPE	DISC	NUMBER	REV
112546 -	GEO -	DRG -	CC -	004 -	B

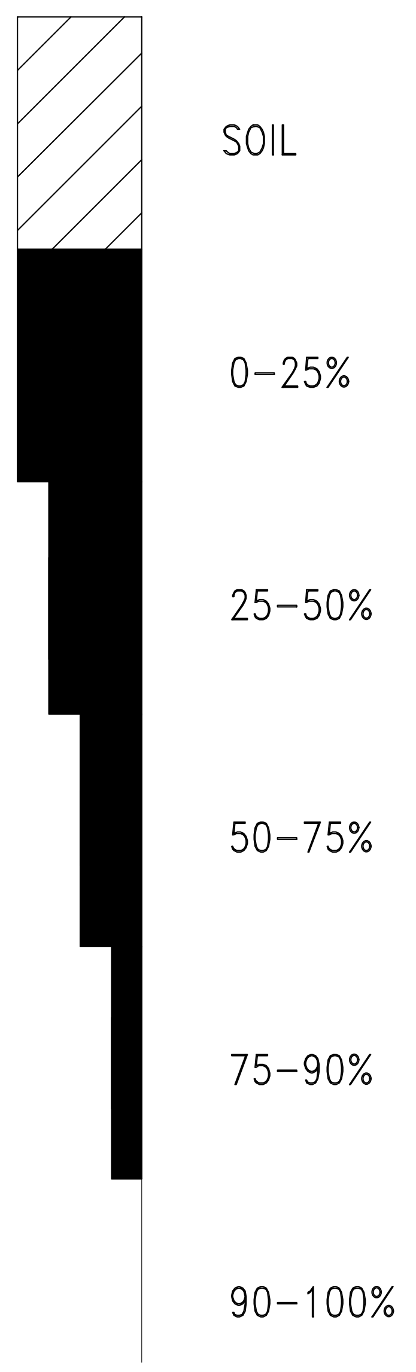
BOREHOLE KEY

KEY:

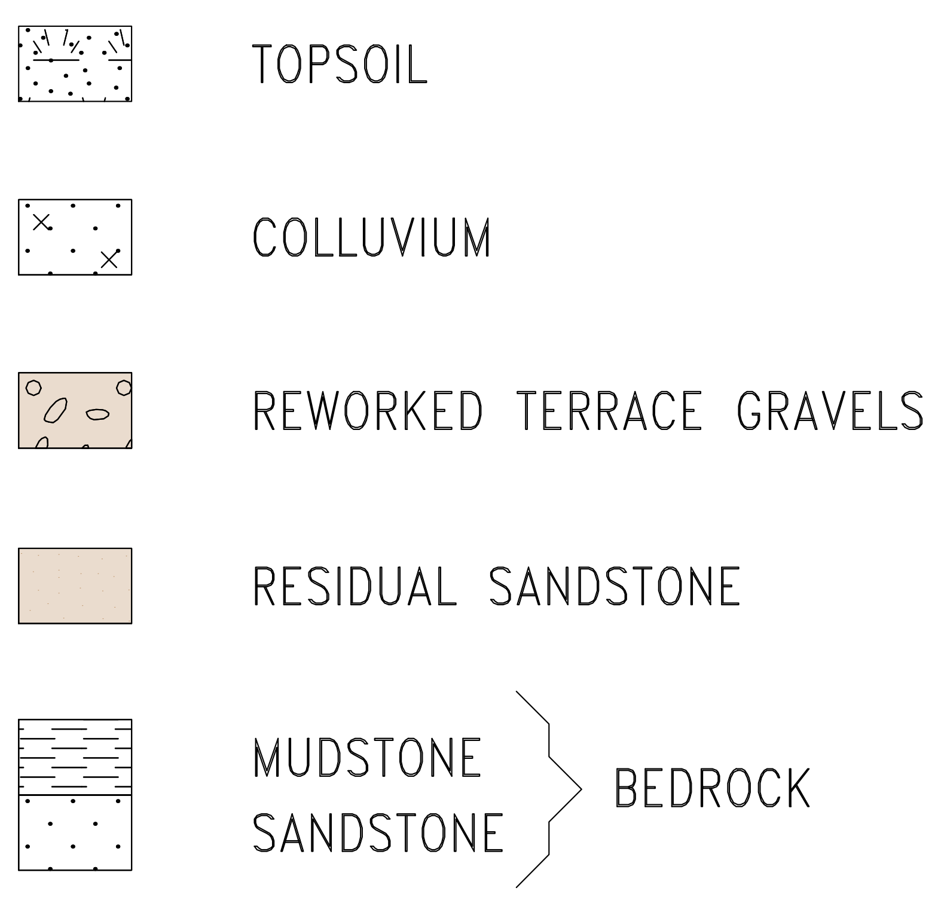


NOTE:
NOT DRAWN INTO SCALE

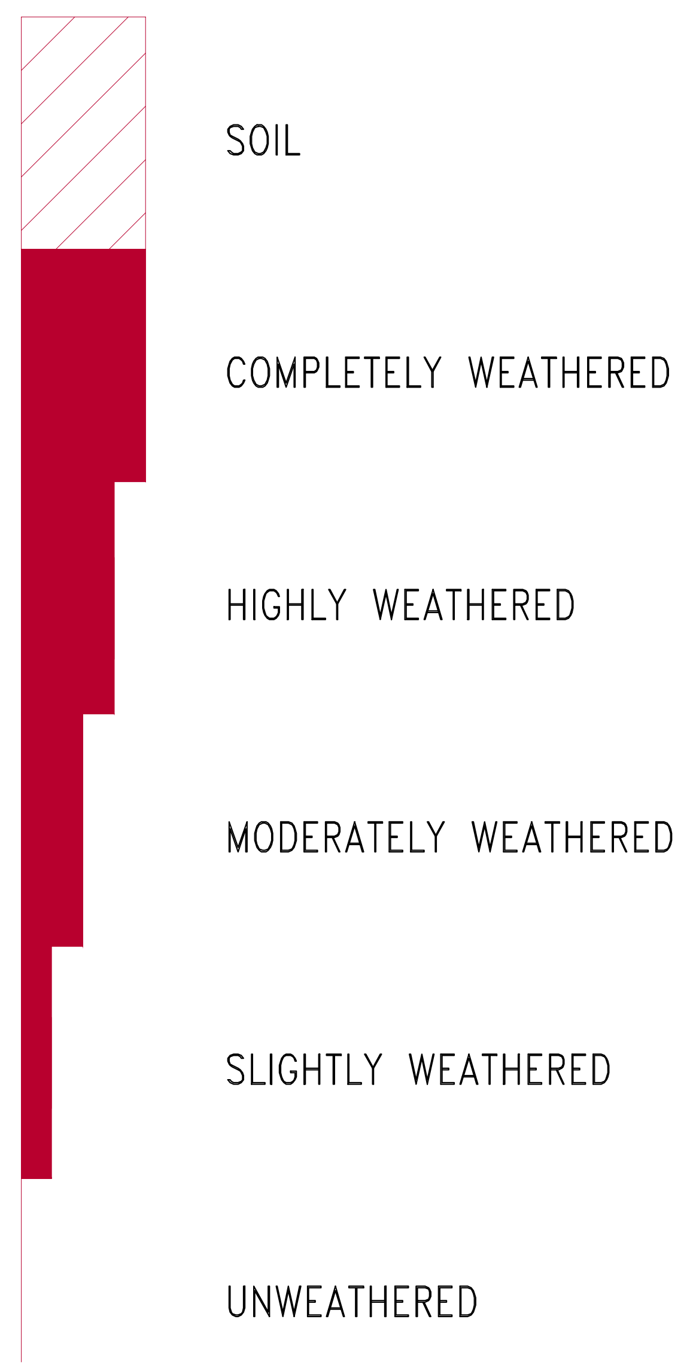
ROCK QUALITY DESIGNATION (RQD)



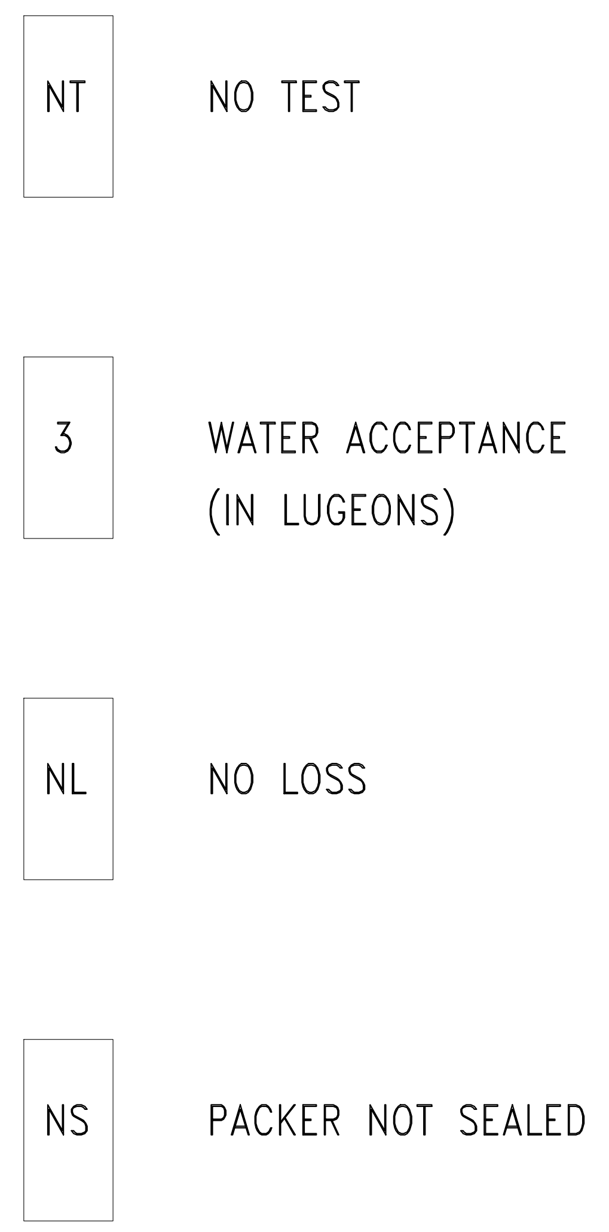
LITHOLOGY



WEATHERING



WATER ACCEPTANCE



NOTE:

LITHOLOGY IS INDICATED ON RESPECTIVE DRAWINGS
112546–GEO–DRG–CC–002A–A
112546–GEO–DRG–CC–002A–B
112546–GEO–DRG–CC–002B–A
112546–GEO–DRG–CC–003–A
112546–GEO–DRG–CC–004–A &
112546–GEO–DRG–CC–004–B:

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REV	DATE	REVISION DETAILS	APPROVED
A	16/10/18	ISSUED FOR INFORMATION	G DAVIS
B	08/08/19	ISSUED FOR INFORMATION	G DAVIS

SCALE: 1:1
SIZE: A1
FOR INFORMATION

DRAWN: M SIBUYI
DESIGNED: S NYATHI
REVIEWED: G DAVIS
APPROVED: G DAVIS
DATE

PROJECT
SUPPORT OF WATER RECONCILATION
STRATEGY FOR THE ALGOA
WATER SUPPLY SYSTEM

TITLE
GEOTECHNICAL INVESTIGATION OF
LOWER COERNEY DAM SITE
BOREHOLE KEY

DRAWING NUMBER

PROJECT No.	WBS	TYPE	DISC	NUMBER	REV
112546	GEO	DRG	CC	005	B

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