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The uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study: Raw Water

SUPPORTING DOCUMENT 4:

LANGA BALANCING DAM: MATERIALS AND GEOTECHNICAL INVESTIGATION

FINAL

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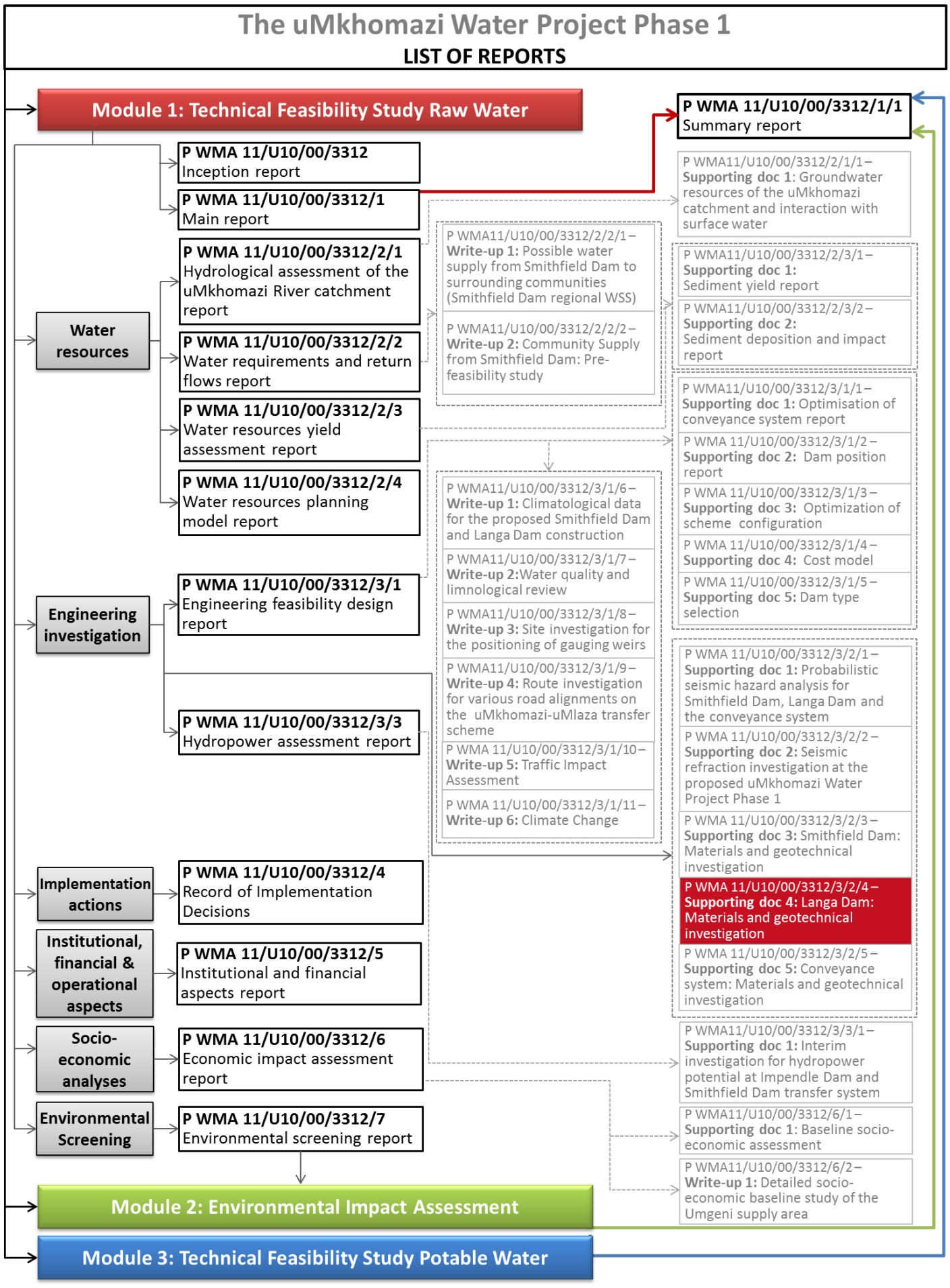
PREAMBLE

In June 2014, two years after the commencement of the uMkhomazi Water Project Phase 1 Feasibility Study, a new Department of Water and Sanitation was formed by Cabinet, including the formerly known Department of Water Affairs.

In order to maintain consistent reporting, all reports emanating from Module 1 of the study will be published under the Department of Water Affairs name.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Executive summary

The objectives of this report are to describe the results of construction materials and geotechnical investigations for the proposed Langa Balancing Dam as part of the uMkhomazi Water Project. The following aspects are dealt with:

- *Foundations for earth core rockfill or zoned embankment dams both with approach channel, side spillway with chute and plunge pool on the left flank.*
- *Alternatively, foundations for a concrete faced rockfill dam with approach channel, side spillway with chute and plunge pool on the left flank.*
- *Construction material sources for the above dams.*

Information from published geological maps was used to describe the general geology of the area, while the site geology was determined by means of surface mapping, test pits and rotary core drilling.

The area around the site is underlain by rocks of the Pietermaritzburg Formation of the Ecca Group, comprising shales and siltstones with subordinate sandstones. One near-horizontal dolerite sill had intruded concordantly into the sedimentary strata.

Due to the presence of an extensive wetland in the dam basin and of cultivated lands on the left flank, environmental restrictions were placed on seismic surveys, test pits and boreholes in certain areas.

Seismic refraction surveys were conducted across the dam centre line. Although the seismic velocities tended to over-estimate the depth of sound rock, they were useful in showing the presence of the dolerite sill below a cover of shale and also to identify the position of a fault.

A Probabilistic Seismic Hazard Analysis (PSHA) for both the Smithfield Dam and Langa Balancing Dam sites was conducted by Dr A Kijko of the Natural Hazards Assessment Consultancy and classified the site as of low seismic risk. The Langa Balancing Dam site is located in the same seismo-tectonic province and the seismic risk is considered to be similarly low.

Four potential sources for construction materials were investigated, namely (i) spoil from the tunnel excavation, (ii) material excavated for the tunnel outlet portal, (iii) material excavated from the spillway approach area, and (iv) material from a quarry located below FSL in the dam basin.

It appears that none of the available materials qualify as impervious fill, and that the available quantity of semi-pervious material is not quite sufficient to provide twice the required volume for a zoned embankment dam.

A considerable volume of soft rockfill (weathered shale) will have to be removed from the quarry in order to reach the underlying hard shale and dolerite for rockfill. This soft material can be used in certain zones of any of the alternative embankment dam types.

There is sufficient hard shale and dolerite rockfill for construction of a Concrete Faced Rockfill (CFR) Dam or Earth Core Rockfill (ECR) Dam. For any of these dam types, durable dolerite may have to be imported from a commercial quarry (Pietermaritzburg) to serve as protective layer above the shale or dolerite/shale mixture from the tunnel excavation and the quarry. However, it is possible that some or all of this dolerite might be obtained from the quarry but this will require further investigation.

Spoil from the tunnel excavation is expected to have the properties of G5 gravel and can be compacted to form part of a rockfill embankment. Due to the absence of impervious core material, consideration will have to be given to a CFR dam or a CCR dam with impervious core comprising a mixture of soil and bentonite. The CFR option appears to be the more feasible, since the available soils contain too much clay to mix with bentonite.

For the shells of an earth embankment, 0.6 m – 1.5 m organic topsoil and loose transported soil has to be removed along the centre line and founding will take place on stiff transported sandy clay or weak completely weathered shale or weak residual dolerite.

For the shells of a rockfill embankment, between 1.6 m and 5.3 m of colluvium and residual soil/completely weathered shale has to be removed along most parts of the centre line. However in an area on the right flank, weak completely weathered shale and dolerite extend to a depth of over 17 m and will have to be removed.

*For the **core of an embankment dam** the depth of excavation will vary between 3.1 m to 5 m along the centre line. The depth for the **plinth of a concrete faced rockfill** dam will be the same or slightly deeper than for a core trench, except in an area on the right flank where it is much deeper.*

*Excavation depths for a **concrete gravity dam** will reach between 5 m and 8.5 m in the river section and up to 23 m along a section of the right flank.*

It will be necessary to make provision for a grout curtain to a depth of about 66% of the water head along the centre line.

A spillway control structure and concrete lined return channel can be founded on moderately weathered shale at an average depth of about 5.5 m. A stilling basin and apron will have to be provided at the end of the chute.

The risk for slope failures around the rim of the reservoir that might endanger the dam wall is considered negligible.

As a result of environmental restrictions on the positioning of seismic lines, test pits and boreholes, this investigation was limited.

Recommendations are made for additional test pitting, core drilling, sampling and laboratory tests during the design stage to confirm the properties and volumes of construction materials actually required and to confirm founding conditions for the selected type of dam and spillway structure.

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LIST OF ABBREVIATIONS

ACV	Aggregate Crushing Value
AEG	Association of Engineering Geologists
BKS	BKS (Pty) Ltd
CCR	Clay Core Rockfill
CFR	Concrete Faced Rockfill
CGS	Council for Geoscience
D:NWRP	Directorate: National Water Resource Planning
D:NWRP	Directorate: National Water Resource Planning
D_{10}	Effective size (sieve size passing 10% of soil)
FSL	Full Supply Level
KZN	KwaZulu-Natal
LL	Liquid Limit
LM	Local Municipality
LS	Linear Shrinkage
masl	Metres above sea level
MDD	Maximum Dry Density
MMA	Mogoba Maphuthi and Associates
OMC	Optimum Moisture Content
PE	Potential Expansiveness
PI	Plasticity Index
SAICE	South African Institution of Civil Engineering
SAIEG	South African Institute of Engineering and Environmental Geologists
TLB	Tractor Loader Backhoe
UCS	Unconfined Compressive Strength
uMWP	uMkhomazi Water Project
uMWP-1	uMkhomazi Water Project – Phase 1
uMWP-2	uMkhomazi Water Project – Phase 2
USCS	Unified Soil Classification System

LIST OF UNITS

a	annum
ha	hectare
hrs	hours
kℓ	kilolitre
km	kilometre
km^2	square kilometre
kW/m^2	kilowatt per square metre
ℓ	litre
ℓ/c/d	litre per capita per day
ℓ/cap/day	litre per capita per day
m	metre
m/s	metre per second
m^3	cubic meter
m^3/s	cubic metre per second
masl	metre above sea level
million m^3	million cubic metre
million m^3/a	million cubic metres per annum
Mℓ/day	mega litre per day
mm	millimetre
MW	megawatt
Ø	diameter in millimetres
s	second

1 INTRODUCTION

The Department of Water Affairs appointed **BKS (Pty) Ltd** in association with three sub-consultants **Africa Geo-Environmental Services, MM&A and Urban-Econ** with effect from 1 December 2011 to undertake the **uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study Raw Water** study.

On 1 November 2012, BKS (Pty) Ltd was acquired by **AECOM Technology Corporation**. The new entity is a fully-fledged going concern with the same company registration number as that for BKS. As a result of the change in name and ownership of the company during the study period, all the final study reports are published under the AECOM name.

In 2010, the Department of Arts and Culture published a list of name changes in the Government Gazette (GG No 33584, 1 October 2010). In this list, the Mkomazi River's name was changed to the **uMkhomazi River***. The published spelling will thus be used throughout this technical feasibility study.*

1.1 BACKGROUND TO THE PROJECT

The current water resources of the Mgeni system are insufficient to meet the long-term water demands of the system. The Mgeni System is the main water source that supplies about five million people and industries in the eThekwini Municipality, uMgungundlovu District Municipality (DM) and Msunduzi Local Municipality (LM), all of which comprise the economic powerhouse of the KwaZulu-Natal Province.

The Mgeni System comprises the Midmar, Albert Falls, Nagle and Inanda Dams in KwaZulu-Natal, a water transfer scheme from the Mooi River including the newly constructed Spring Grove Dam. The current system (Midmar, Albert Falls, Nagel and Inanda Dams and the MMTS-1) has a stochastic yield of 334 million m^3/annum (measured at Inanda Dam) at a 99% assurance of supply. The short-term augmentation measure, Phase 2 of the Mooi Mgeni Transfer Scheme (MMTS-2), currently being implemented with the construction of Spring Grove Dam, will increase water supply from the Mgeni system by 60 million m^3/year. However, this will not be sufficient to meet the long-term requirements of the system.

Pre-feasibility investigations indicated that Phase 1 of the uMkhomazi Water Project (uMWP 1), which entails the transfer of water from the undeveloped uMkhomazi River to the existing Mgeni system, is the scheme most likely to fulfil this requirement. The uMkhomazi River is the third-largest river in KwaZulu-Natal in terms of mean annual runoff (MAR).

Eight alternative schemes were initially identified as possible alternatives, and the Impendle and Smithfield scheme configurations have emerged as suitable for further investigation. The pre-feasibility investigation, concluded in 1998, recommended that the Smithfield Scheme be taken to a detailed feasibility-level investigation as its transfer conveyances would be independent of the existing Mgeni System, thus reducing the risk of limited or non-supply to eThekwini and some areas of Pietermaritzburg, and providing a back-up to the Mgeni System.

The ***Mkomazi-Mgeni Transfer Pre-feasibility Study*** concluded that the first phase of the uMWP would comprise a new dam at Smithfield on the uMkhomazi River near Richmond, a multi-level intake tower and pump station, a water transfer pipeline/tunnel to a balancing dam at Baynesfield Dam or a similar in-stream dam, a water treatment works at Baynesfield in the uMlaza River valley and a gravity pipeline to the Umgeni bulk distribution reservoir system, below the reservoir at Umlaas Road. From here, water will be distributed under gravity to eThekwini and possibly low-lying areas of Pietermaritzburg. Phase two of the uMWP may be implemented when needed, and could comprise the construction of a large dam at Impendle further upstream on the uMkhomazi River to release water to the downstream Smithfield Dam. Together, these developments have been identified as having a 99% assured stochastic yield of about 388 million m^3/year.

The DWA aims to have this scheme implemented by 2022.

1.2 STUDY AREA

The study focus and key objective are related to the feasibility investigation of the Smithfield Dam and related raw water conveyance infrastructure. However, this is a multi-disciplinary project with the study area defined as the uMkhomazi River catchment, stretching to the north to include the uMngeni River catchment, refer to **Figure A1.1** included in **Annexure A**. The various tasks have specific focus area, defined as:

- Water Resources: uMkhomazi and Mgeni River catchments;
- Water requirements: water users in the Mgeni System and the uMkhomazi River catchment;
- Engineering Investigations: proposed dams at Impendle (only for costing purposes) and Smithfield, and the raw water conveyance infrastructure corridor between Smithfield Dam and the Water Treatment Plant of Umgeni Water;
- Environmental screening as input for the Environmental Impact Assessment; and
- Socio-economic impact assessment: regional, provincial (KwaZulu-Natal (KZN)) and national.

1.3 OBJECTIVE OF THE STUDY

According to the Terms of Reference (November 2010), the objective of the study project is to undertake a feasibility study to finalise the planning of the proposed uMkhomazi Water Project (uMWP) at a very detailed level for the scheme to be accurately compared with other possible alternatives and be ready for implementation (detailed design and construction) on completion of the study.

The feasibility study has been divided into the following modules, which will run concurrently:

- Module 1: Technical Feasibility Raw Water (DWA) (*defined below*);
- Module 2: Environmental Impact Assessment (DWA); and
- Module 3: Technical Feasibility Potable Water (Umgeni Water) (*ranging from the Water Treatment Plant to the tie-in point with the eThekwini distribution system*).

This module, the raw water technical feasibility study considers water resources aspects, engineering investigations and project planning and scheduling and implementation tasks, as well as an environmental screening and assessment of socio-economic impacts of the proposed project.

Some specific objectives for this study, recommended in the Mkomazi-Mgeni Transfer Scheme Pre-feasibility are listed below:

- Smithfield Dam (Phase 1) to be investigated to a detailed feasibility level;
- Investigate the availability of water from Impendle Dam (Phase 2) as a future resource to release to Smithfield Dam, and refine the phasing of the selected schemes;
- Optimise the conveyance system between Smithfield Dam and the proposed Baynesfield Water Treatment Plant;
- Undertake a water resources assessment of the uMkhomazi River Catchment, including water availability to the lower uMkhomazi;
- Evaluate the use of Baynesfield dam (now Langa Balancing Dam) as a balancing dam; and
- Investigate the social and economic impact of the uMWP.

This one of three studies was undertaken in close collaboration with the DWA, Umgeni and the PSPs of the other modules.

1.4 SCOPE OF THIS REPORT

This report deals exclusively with the construction materials and geotechnical investigations conducted at the site for the Langa Balancing Dam located on Baynesfield Estate near the outlet of the conveyance tunnel leading from the proposed Smithfield Dam. The name Langa has evolved after the field investigations were completed and the field data records in **Annexures B** and **C** therefore still contain the name Nooitgedacht (after the name of the farm).

A site for a balancing dam, located just upstream of the existing Mbangweni Dam was initially considered and called the New Mbangweni site. Seismic refraction surveys were conducted there, but due to poor foundation conditions and a wide river section, that site was not further investigated. The centre line for the Langa site was selected where the width of the wetland was the least and where shallow bedrock was visible on both sides of the river.

The activities specific to the ***geotechnical and materials task*** included:

- Review the available geotechnical information.
- Describe the general geology of the area.
- Conduct seismic refraction surveys along the centre line for the Langa Balancing Dam site.
- Consider the seismic risk.

- Conduct investigations for sources of dam construction materials by means of test pitting rotary core drilling and laboratory testing,
- Undertake geotechnical investigations for the foundations of the dam and spillway structure by means of rotary core drilling and Lugeon water pressure testing.
- Assess the stability of slopes around the reservoir rim.

1.5 PURPOSE OF THE REPORT

The objectives of this report are to describe the results of construction materials and geotechnical investigations for the proposed Langa Balancing Dam. The following components were dealt with:

- Foundations for an Earth Core Rockfill or zoned embankment dam with approach channel and side spillway with chute and plunge pool on the left flank.
- Alternatively, foundations for a Concrete Faced Rockfill dam with approach channel and side spillway with chute and plunge pool on the left flank.
- Construction material sources for the above dams.

The report presents the site conditions, methodology and results of the geological and materials investigation task of the study. The information is based on a desktop study and field investigations conducted between January and April 2013. The seismic survey report was completed in April 2013 and most of the laboratory testing was completed in July 2013.

The information from this report is required input into the engineering, financial and institutional investigations tasks, and this report is thus a supporting report to the main study report.

1.6 CONTENTS OF THE REPORT

This report is the ***Supporting Document 4*** for the main ***Geotechnical Report*** and refers to ***Supporting Document 1*** on the Seismic Hazard Assessment for both the Smithfield and Langa Dam sites, ***Supporting Document 2*** on the Seismic Refraction Survey and ***Supporting Document 3*** on the Materials and Geotechnical Investigation for the Smithfield Dam site.

This report comprises of the following parts:

- Text *(Volume 1 of 2);*
- Annexure A: Figures referred to in the text *(Volume 2 of 2);*
- Annexure B: Test pit profiles and laboratory tests *(Volume 2 of 2); and*
- Annexure C: Drilling results *(Volume 2 of 2)*

2 PREVIOUS INVESTIGATIONS

No previous investigations had been conducted at sites for a balancing dam.

3 PRESENT INVESTIGATIONS

3.1 NEED FOR GEOTECHNICAL INVESTIGATIONS

Based on a study of the available information, AECOM identified the need for the following geotechnical investigations:

3.1.1 Geological mapping

Geological mapping of the Langa Balancing Dam site, based on the observation of surface outcrops and the results of core drilling and test pitting must be conducted.

3.1.2 Seismic risk analysis

The seismic risk must be assessed.

3.1.3 Seismic refraction survey

Seismic refraction surveys must be conducted along the proposed dam centre line to ensure that boreholes are drilled at the most appropriate locations and to interpret geological conditions between boreholes.

3.1.4 Test pitting, soil sampling and laboratory testing

Test pits (up to 5 m deep) must be dug within the dam basin to investigate sources for embankment material, particularly impervious material for the core. The test pits must be geotechnically logged and representative samples taken for additional laboratory testing. Laboratory tests must include Grading and Atterberg Limits. In addition, samples of rock must be subjected to tests for rockfill.

3.1.5 Core drilling

It was considered necessary to drill boreholes and conduct water pressure tests to assess the required depths of foundation excavation and to determine the permeability and need for grouting. The drilling of boreholes to investigate foundation conditions for a spillway structure was also necessary. Core drilling was also required to investigate the quantity and quality of material for rockfill. Drilling and test pit information from the tunnel outlet portal area could be used to assess the suitability of excavated material for dam construction.

3.1.6 Reservoir slope stability

Slopes within the dam basin must be studied in order to determine the risk of failures and the effect of such failures on the dam structure.

3.2 GEOLOGICAL MAPPING

A regional geological map of the area around the site for the proposed Langa Balancing Dam was compiled from information on the published Geological Map, The regional geological map is attached as **Figure A4.1** included in **Annexure A**.

Due to the limited outcrops of rock other than shale, the detailed geological map on **Figure A4.2** included in **Annexure A** mainly serves to indicate the extent of the wetland areas and the suspected fault that intersects the dam centre line.

3.3 SEISMIC HAZARD ANALYSIS

A Probabilistic Seismic Hazard Analysis (PSHA) for both the Smithfield and Langa sites was conducted by Dr A Kijko of the Natural Hazards Assessment Consultancy in Centurion (*Report no P WMA 11/U10/00/3312/3/2/1: Supporting document 1: Probabilistic hazard analysis for Smithfield Dam, Langa Balancing Dam and the conveyance system*).

The PHSA was performed using conventional Cornell-McGuire procedures where the integration across the uncertainty in the peak ground acceleration (PGA) prediction equation is an integral part of the methodology.

In accordance with current seismic regulations provided in Bulletin 72 of ICOLD (1989), Eurocode 8 (2004) and ASCE (2005), three seismic designated levels were considered namely the Operating Basis Earthquake (OBE), Maximum Design Earthquake (MDE) and Maximum Credible Earthquake (MCE).

Results for the horizontal component of earthquake acceleration are as follows:

- Operating Basis Earthquake (Return period 144 years) =0.016 g
- Maximum Design Earthquake (Return Period 475 years) =0.021 g
- Maximum Credible Earthquake (Return period 10 000 years) =0.113 g

The above results classify the site as of low seismic risk.

3.4 SEISMIC REFRACTION SURVEY

Seismic refraction surveys were undertaken by Open Ground Resources to determine the succession of seismic velocity layers and depth to sound bedrock at the following locations (*Report no P WMA 11/U10/00/3312/3/2/2: Supporting document 2: Seismic refraction investigation at the proposed uMkhomazi Water Project Phase 1*):

- New Mbangweni dam site - left flank: 160 m
- New Mbangweni dam site – right flank: 115 m
- Tunnel outlet portal area: 475 m
- Langa dam site – left flank: 115 m
- Langa dam site – river section: 115 m
- Langa dam site – right flank: 235 m

Figure A5.1 included in **Annexure A** shows the positions of the seismic lines at the Langa site.

3.5 TEST PITS

Test pits were excavated to investigate the subsurface conditions to a maximum depth of about 5 m. A 20-ton excavator was used (instead of a TLB) to speed up the work and to penetrate possible zones of hardpan ferricrete.

Large parts of the dam basin are classified as a wetland or contain rare plant species and could not be investigated (see **Figure A4.2** included in **Annexure A**). The flat areas just above FSL on the left flank are potential sources for impervious embankment material but they were under cultivation by maize and could not be investigated in detail. A few test pits were dug along tracks within and around the lands.

Table 3.1 provides details of 19 test pits that were excavated along the dam centre line, the proposed borrow area and the tunnel outlet portal.

Table 3.1: Summary of test pits

Project area	Number of test pits	Test pit numbers
Langa dam centre line	3	MTP1, MTP2, MTP4
Borrow area	12	MTP5, MTP7-MTP16, MTP18
Tunnel outlet portal	4	TP01 – TP 04

The test pits were excavated to a maximum reach of machine or to partial refusal (caused by dense/stiff material), whichever occurred first. Test pits were profiled by an engineering geologist according to the current standards and practice in South Africa *(IAEG/AEG/SAICE-Geotechnical Division, 2002)*. Representative samples were taken for laboratory testing.

Immediately after completing the profiling and sampling of each test pit, the excavated material was placed back into the hole and compacted in layers. Material from the upper fertile soil layer was kept separate and placed on top of the backfilled material. The ground surface was restored as near as possible to its original condition.

Each test pit was positioned using a hand-held GPS. **Figure A5.1** included in **Annexure A** shows the positions of test pits.

3.6 ROTARY CORE DRILLING

Rotary core drilling was undertaken to obtain relatively undisturbed samples of soil and rock to depths of 20 m - 25 m below ground surface and to conduct packer permeability tests to these depths along the dam centre line.

Borehole cores were profiled by an engineering geologist according to the current standards and practice in South Africa *(SAIEG/AEG/SAICE-Geotechnical Division, 2002)*.

Water pressure testing was carried out within the boreholes along the dam centreline to assess the permeability of the foundation materials. Special provision was made in the drilling contract for water pressure (Lugeon) testing in weathered rock conditions where conventional packers cannot be used. In these materials the packers were seated within a tight-fitted (drilled-in) casing so that packer tests could be conducted from about 2 m depth.

Samples comprising moderately and slightly weathered shale from boreholes in the proposed quarry were taken for laboratory tests to determine their properties with respect to use as soft rockfill.

Table 3.2 summarises the distribution of the core-drilled boreholes. Positions of boreholes were surveyed to an accuracy of 200 mm both horizontally and vertically. The positions of boreholes are shown on **Figure A5.1** included in **Annexure A**.

Table 3.2: Summary of cored boreholes

Project area	Number of boreholes	Borehole No's
Langa Dam site, left flank	3	NM1, NM2, NM9
Langa Dam site, river section	1	NM3
Langa Dam site, right flank	4	NM4 – NM7
Langa Dam, left spillway	1	NM10
Langa Dam, right spillway	1	NM8
Langa Quarry site	3	NQ1 – NQ3
Tunnel outlet	1	BH8

Borehole cores were profiled by an engineering geologist according to the current standards and practice in South Africa (*SAIEG/AEG/SAICE-Geotechnical Division, 2002*).

At the end of the drilling investigation, all the borehole cores were transported to the DWA offices at Midmar Dam where the core boxes were stacked in a dedicated carport. The results of the drilling (i.e. driller's journals, borehole logs, core photographs and water test results) are included in **Annexure C**.

3.7 LABORATORY TESTING

Soil samples taken from the cultivated lands on the left flank and from the dam basin were taken to Geostrada soils laboratory for grading, Atterberg testing and double hydrometer dispersivity testing.

Samples from the tunnel outlet portal were subjected to the following tests (as part of the tunnel investigation):

- Grading to minus 0.002 mm and Atterberg Limits
- Mod. AAHSTO Compaction
- Chemical dispersion

- Shear box
- Flexible wall permeability.

Samples of moderately and slightly weathered shale from boreholes in the proposed quarry area were subjected to the following laboratory tests to determine their properties with respect to their use as soft rockfill:

- Crushing to minus 53 mm
- Grading analysis
- Determination of the Atterberg Limits, where possible
- Aggregate Crushing Values (wet and dry)

The results of the laboratory tests are contained in **Annexure B** of this report.

3.8 RESERVOIR SLOPE STABILITY STUDY

The available contour map of the basin area was used to determine the slope angles of the area above and below FSL around the rim of the reservoir. From observations of rock outcrops and overburden along the steeper slopes, an assessment of the stability of slopes as a result of fluctuating water levels could be made.

4 GEOLOGY

The area of interest is underlain by sedimentary strata of the Karoo Supergroup that were subsequently intruded by younger dolerites in the form of sills and dykes (**Figure A4.1** included in **Annexure A**)

The dam site is underlain by rocks of the Pietermaritzburg Formation of the Ecca Group, comprising shales and siltstones with sub-ordinate sandstones. The sedimentary strata are essentially horizontal, and largely undisturbed. Regional dips of 3 - 5 degrees were recorded.

Neither the rocks of the Pietermaritzburg Formation nor the intrusive dolerites which underlie the dam basin are typically associated with economically-important mineral deposits.

At the dam site the shales had been intruded by at least one near-horizontal dolerite sill. It varies in thickness between about 5 m and 10 m and occurs along the dam centre line and in the main quarry area where it is covered by shale. On the left flank, the sill had been displaced downwards along a fault by about 8 m. This fault appears to intersect the dam centre line along the lower right flank. The dolerite does not crop out anywhere on site (**Figure A4.2** included in **Annexure A**).

Bedrock is mostly very shallow and it is only along the lower right flank where there is a deposit of colluvium overlying the dolerite. The river section is occupied by a wetland that varies in width between 50 m and 150 m.

5 CONSTRUCTION MATERIALS INVESTIGATION

During the present feasibility stage of the project, various types of dams are being considered, and therefore the available quantities and properties of different types of construction materials were investigated. The aim of the construction materials investigation was to locate sources of natural construction materials (soil and rock) in environmentally suitable locations, capable of providing the volumes as shown in **Table 5.1**. These quantities include the normal "safety factor" whereby twice the volume of material required for construction, is proved during the site investigation.

Table 5.1: Approximate volumes of construction material (2 x required)

Structure	Type of material (m^3)				
	Impervious core	Semi-pervious	Rockfill	Rip-rap	Rock for aggregate, filters, drains
Zoned embankment dam	350 000	1 020 000	-	80 000	200 000
Clay Core Rockfill dam	250 000	-	800 000	-	110 000
Concrete Faced Rockfill dam	-	-	1 000 000	-	-

A typical specification for embankment materials is given in **Table 5.2**.

Table 5.2: Typical specifications for earth fill materials (Badenhorst, 1988)

Property	Embankment zones		
	Impervious	Semi-pervious	Pervious
Clay content (%)	10-30	<55	<10
PI (%)	12-35	<12	<5
LL (%)	30-60	<30	<20
LS (%)	6-10	<7	<2
Standard Proctor MDD (kg/m^3)	1450-1880	1750-2000	1700-2100
Standard Proctor OMC (%)	12-25	10-15	6-12
Cohesion (kPa)	12-30	8-15	<10
Friction angle (^{0})	18-30	28-38	>35
Permeability (m/sec)	<1x10^{-8}	1x10^{-7} – 1x10^{-5}	>1x10^{-5}

Five potential sources for embankment construction materials were identified, namely:

- Spoil from the conveyance tunnel excavation;
- Excavated material from the tunnel outlet portal;
- Excavated material from the spillway approach on the upper left flank;
- Borrow area within the dam basin; and
- Quarry in the dam basin.

5.1 TEST PITS AND BOREHOLES

Test pits were dug by means of a 20 ton tracked excavator with a maximum reach of about 5 m depth while boreholes were drilled with a rotary core drill. The positions of test pits and boreholes at the Langa site are shown on **Figure A5.1** included in **Annexure A**.

Material to be excavated for the outlet portal of the conveyance tunnel was investigated by means of four test pits (TPO 1 – TPO 4) and Borehole BH 8. The positions of these test pits and borehole are shown on **Figure A5.2**, while the position of the portal is shown on **Figure A1.1**, both included in **Annexure A**.

The area of the proposed spillway approach cut was under cultivation by maize, and four test pits (MTP 5, MTP 7, MTP 15 and MTP 18) were dug around the cultivated

lands and along tracks between the lands. The results from Boreholes NM 9 and NM 10 are also considered to be representative of conditions in this area.

The proposed borrow area within the dam basin were investigated by means of eight test pits (MTP 8 – MTP 14 and MTP 16). The positions for test pits had to be carefully selected to fall outside the extensive wetland within the dam basin.

The only potential quarry site within the dam basin was identified as a spur within the proposed borrow area. A potential quarry area of about 60 000 m^2 was identified (see **Figure A5.1** included in **Annexure A**). Here also, the positions for boreholes had to be carefully selected to fall outside the extensive wetland within the dam basin.

The detailed test pit and borehole logs are provided in Annexure B and summaries of the results are presented in **Table 5.3** and **Table 5.4**.

Table 5.3: Summary of test pit results

TP No.	LAYER THICKNESS (m)				COMMENTS
	Organic soil	**Clayey sand/silt** A = Alluvium C = Colluvium P = Pedogenic ferricrete RD = Residual dolerite RS = Residual shale	**Boulders and clayey silt** C = Colluvium A = Alluvium	**Soft rock** P = pedogenic S = Shale D = Dolerite	DE = Difficult excavation
MTP 5	0.0 – 0.4	0.4 – 1.1 (C)		1.1 – 3.8 (S)	DE
MTP 7	0.0 – 0.5	0.5 – 2.1 (C)		2.1 – 4.0(S)	DE
MTP 8	0.0 – 0.5	0.5 – 1.5 (C)		1.5 – 3.0(S)	DE
MTP 9	0.0 – 0.5		0.5 – 1.5 (C)	1.5 – 3.5(S)	DE
MTP 10	0.0 – 0.2			0.2 – 2.0(S)	DE
MTP 11	0.0 – 0.5	0.5 – 1.2 (C)		1.2 – 3.5(S)	DE
MTP 12	0.0 – 0.2			0.2 – 2.0(S)	DE
MTP 13	0.0 – 0.2			0.2 – 4.0(S)	DE
MTP 14	0.0 – 0.2			0.2 – 2.4(S)	DE
MTP 15	0.0 – 0.5			0.2 – 3.5(S)	DE
MTP 16	0.0 – 0.7			0.7 – 2.4(S)	DE
MTP 18	0.0 – 0.4	0.4 – 1.1 (A)		1.1 – 3.8(S)	DE
TPO 1		0.6 – 1.8(RS)	0.0 – 0.6 (C)	1.8 – 4.6(S)	DE
TPO 2	0.0 – 0.6	2.6 – 5.0(RS)	0.6 – 2.6 (C)		DE (water 1m)
TPO 3	0.0 – 0.6		0.6 – 1.0 (C)	1.0 – 4.3(S)	DE(water 3m)
TPO 4		0.4 – 2.3(RS)	0.0 – 0.4 (C)	2.3 – 5.0(S)	DE

Table 5.4: Summary of results from boreholes in the quarry

BH No.	TYPE OF MATERIAL/DEGREE OF WEATHERING Organic soil = O, Sandy clay = SC, Gravel in clay = GC, Gravel in sand = GS Shale = S; Indurated shale = I, Dolerite = D					
	LAYER THICKNESS (m)					
	TRANSPORTED SOIL	RESIDUAL SOIL/ COMPLETELY WEATHERED	HIGHLY	MODERATELY	SLIGHTLY	UNWEATHERED
NQ 1	0.0 – 0.55(O)	0.55 – 1.35 (S)	1.35 – 5.16(S)	5.16–11.5 (S)		11.5-20.19(S)
NQ 2			0.0-5.12(S) 6.57-8.07(S)	5.12-6.57(S) 8.07-10.07(S)		10.07-10.07(S)
NQ 3		0.0 – 2.0(S)	2.0-3.48(S)	3.48-4,35(S)	4.35-9.0(S)	9.0-10.73(S) 10.73-17.67(D) 17.67-20.18(S)
NM 9	0.0 – 0.25(O)	0.25-1.7(S)	1.7-3.1(S) 4.2-5.14)S) 6.25-8.73(S)	3.1-4.2(S) 5.14-6.25(S) 8.73-9.30(S)	9.3-12.0(S)	12.0-20.11(S)
NM 10		0.9 – 1.5(S) 5.14-5.28(S)	0.0 – 0.9(S) 1.5-5.14(S)		5.28-7.4(S)	7.4-20.02(S)
BH 8*	0.0 – 0.26(O)	0.26 – 8.77(S)		8.77 – 11.22(S)	11.22-20.17(S)	

**BH8 is located at the tunnel outlet portal*

The quarry is underlain by a very thin layer of topsoil, followed by 2 m – 3 m of completely weathered shale. A layer of moderately to highly weathered shale varies in thickness between 2 m and 10 m and this is underlain by slightly weathered and unweathered shale.

Borehole NQ 3 in the quarry encountered a 7 m thick dolerite sill that may continue all the way to the dam centre line (see **Figure A5.3** included in **Annexure A**). This might provide a considerable volume of unweathered dolerite and needs to be further investigated by means of deeper boreholes during the design stage investigation

5.2 LABORATORY TESTS ON SOIL SAMPLES

Small samples for foundation indicator tests and duplicate large samples for compaction and other tests were taken from representative soil horizons encountered in the test pits.

Geostrada Soils Laboratory in Pretoria conducted three foundation indicator tests consisting of grading analysis to minus 0.002 mm, and determination of the Atterberg Limits.

Samples from the tunnel outlet portal were also tested for grading, Atterberg Limits, Mod. AAHSTO Compaction, CBR, chemical dispersion, shear box and permeability.

The results of the grading and Atterberg tests are summarised in **Table 5.5**, and the detailed results are provided in **Annexure B**. The selection of samples for laboratory testing was based on the soil type (grain size), which was visually determined during the soil profiling. Since this determination is a rough estimate that is affected by the moisture condition of the soil, grain shape, grain composition and experience of the profiler, both the profile descriptions and the laboratory results (in italics) for grain sizes are given in the fourth column of **Table 5.5**.

Table 5.5: Summary of laboratory foundation indicator test

Site	Test Pit No.	Depth (m)	Visual Soil Profile Description (*Lab result in italics %*)	Soil Properties				
				Atterberg Limits (%)			USCS	PE
				LL	PI	LS		
Langa borrow area	MTP 7	0.5 – 2.1	Clayey silt *Clayey(11) gravelly(15)* *Silty(29) sand(45)*	47	21	8.5	CL	Low to Medium
	MTP 13	1.2 – 4.0	Shale *Clayey(9) silty(23)* *Gravelly(29) sand(39)*	42	15	5.5	ML	Low
	MTP 18	0.4 – 1.1	Clayey silt *Gravelly(14) clayey(20)* *Silty(31) sand(35)*	48	15	6.5	ML	Low to Medium
	TPO 2	0.6.2.6	Clayey silt Gravelly (12) silty (36) clay (50)	57	27	12	MH	Low to medium
Legend	LL		=	Liquid Limit				
	PI		=	Plasticity Index				
	LS		=	Linear Shrinkage				
	PE		=	Potential Expansiveness				
	USCS		=	Unified Soil Classification System				

The above samples comply with the specification for impervious core material in terms of the Atterberg Limits. However, the permeabilities are likely to be too high.

The results of other tests on samples from the tunnel outlet portal are summarised in **Table 5.6**. Some of these tests were done for the tunnel investigation and are of limited use for the dam materials investigation.

Table 5.6: Summary of other laboratory test results

Test pit number, depth and material type	TPO2 0.6 – 2.6 m Clayey silt colluvium	TPO1 0.6 – 4.6 m Residual and highly weathered shale	MTP7 0.5 – 2.1 m Clayey silt colluvium	MTP13 0.2 – 4.0 m Highly weathered shale
Mod. AASHTO Density (kg/m³)	1881	-	-	-
OMC (%)	16.4	-	-	-
Chemical Dispersivity	Non-dispersive	-	-	-
Double Hydrometer Dispersivity (%)	-	-	12	10
Shear box Φ (degrees)	-	33	-	-
Shear box cohesion (kPa)	-	8	-	-
Flexible wall permeability (m/s)	-	2×10^{-10}	-	-

5.3 LABORATORY TESTS ON ROCK SAMPLES

Only limited laboratory testing was undertaken since results from similar materials are available from recent investigations at the conveyance tunnel, the Smithfield Dam and the Zalu Dam near Lusikisiki.

5.3.1 Unconfined compressive strength and E-Modulus

Core samples of slightly weathered and unweathered shale and dolerite from drilling along the conveyance tunnel were submitted to Rocklab for various tests. Some of these results are relevant for tunnel spoil materials earmarked for possible use as embankment fill (rockfill).The relevant results are given in **Table 5.7**.

Table 5.7: Summary of laboratory tests on slightly weathered and unweathered shale and dolerite

BH No.	DEPTH (m)	ROCK TYPE	UCS range (MPa)	TANGENT E MODULUS RANGE (GPa)	BRAZILIAN TENSILE STRENGTH RANGE (MPa)	DENSITY (kg/m^3)
2	5.95 – 12.0	Slightly weathered indurated shale	166 - 228	32.8 - 34.8	14.7 - 18.2	2660
3	27.0 – 40.0	Slightly weathered indurated shale	213 - 243	36.1 - 38.4	37 - 48.5	2680
5	387.0-397.0	Unweathered dolerite	212 - 349	44.7 - 63.6	31.3 - 41.6	2720

The above strengths and E-moduli are well above the required values of about 50 MPa – 100 MPa for UCS and 15 GPa for E-modulus of rockfill. It must however be remembered that the shale is prone to rapid deterioration and that these values are only applicable for the unslaked material.

Samples of material from the TBM excavation are not available for testing, but from previous experience it is anticipated that the material will be in the form of flaky shards of rock with average maximum size of about 100 mm and with properties of a G5 gravel. It is possible to compact these materials in a rockfill embankment to achieve high density and shear strength.

5.3.2 Tests on slightly weathered and moderately weathered shale

Core samples of slightly weathered and moderately weathered shale from the drilling at the Langa Dam site were submitted to Geostrada for crushing, grading to minus 53 mm, Atterberg Limits and ACV (wet and dry) tests. The results are summarised in **Table 5.8**.

Table 5.8: Summary of laboratory test on crushed slightly weathered and moderately weathered shale

SAMPLE TYPE / PROPERTY	Moderately weathered	Slightly weathered
-19 mm (%)	68	81
-4.75 mm (%)	18	24
- 2.36mm (%)	12	14
-0.425 mm (%)	6	5
-0.075 mm (%)	4	2
GM	2.04	2.70
LL (%)	30	24
PI (%)	8	6
LS (%)	4.5	2.5
ACV Dry (%)	33.3	23.9
ACV Wet (%)	44.2	28.4
Dry/Wet Ratio (%)	75	84

5.3.3 Exposure tests on slightly weathered and moderately weathered shale

The results of **Table 5.8** are very similar to the results obtained from the testing of the Smithfield Dam site samples. The Smithfield Dam site results on exposure tests are therefore considered relevant, and are described below.

Core samples of unweathered and moderately weathered shale from the drilling at the Smithfield Dam site were submitted to exposure and other durability tests.

Unweathered to moderately weathered shale can be subdivided into two types, namely (i) rock that is prone to slaking (carbonaceous shale) and (ii) rock that is indurated and relatively durable. The following core samples were taken for laboratory testing:

- MW: Moderately weathered shale (not prone to slaking);
- MWS: Moderately weathered shale prone to slaking;
- SW: Slightly weathered shale (not prone to slaking); and
- SWS: Slightly weathered shale prone to slaking.

Each of the above samples was split into two parts. The one part (Part 1) was crushed to minus 19 mm and the other part (Part B) was placed outside for a period of 3 weeks where it was exposed to the atmosphere and was sprayed with water every second day. It was then crushed to a size of minus 19 mm.

Both sets of samples (Part 1 and Part 2) were then graded and subjected to Atterberg Limit tests. ACV tests (Wet and Dry) were done on the Part 1 samples.

The results of the laboratory tests appear in Annexure B, and summaries are given in **Table 5.9** and **Table 5.10**.

Table 5.9: Summary of laboratory tests on slightly weathered shale

SAMPLE No PROPERTY	SW Part 1 Crushed	SW Part 2 Exposed	SWS Part 1 Crushed	SWS Part 2 Exposed
-19 mm (%)	100	69	100	82
-4.75 mm (%)	46	15	54	31
- 2mm (%)	21	7	26	13
-0.425 mm (%)	7	3	10	5
-0.075 mm (%)	2	2	4	3
GM	2.7	2.88	2.6	2.79
LL (%)	NP[1]	NP	20	20
PI (%)	NP	NP	3	5
LS (%)	NP	NP	1.5	1.5
ACV Dry (%)	26.7	NT[2]	35.3	NT
ACV Wet (%)	29.5	NT	46.2	NT
Dry/Wet Ratio (%)	91	NT	76	NT

[1] *Non Plastic*

[2] *Not Tested*

Table 5.10: Summary of laboratory tests on moderately weathered shale

SAMPLE No PROPERTY	MW Part 1 crushed	MW Part 2 exposed	MWS Part 1 crushed	MWS Part 2 exposed
-19 mm (%)	100	80	100	89
-4.75 mm (%)	48	18	41	34
- 2mm (%)	25	8	17	12
-0.425 mm (%)	9	4	7	4
-0.075 mm (%)	4	3	2	3
GM	2.62	2.85	2.74	2.81
LL (%)	NP	NP	NP	NP
PI (%)	NP	NP	NP	NP
LS (%)	NP	NP	NP	NP
ACV Dry (%)	33.5	NT	38.3	NT
ACV Wet (%)	42	NT	47.4	NT
Dry/Wet Ratio (%)	80	NT	81	NT

[1] *Non Plastic*

[2] *Not Tested*

The results of the grading before and after exposure are not as expected since the percentage fines (-0.425 mm and -2.0 mm) decreased after the samples were exposed to the atmosphere. This is ascribed to differences in the crushing of Part I and Part II samples.

From the above results it appears that slightly weathered shale (that is prone to slaking) has a clay mineral content large enough to give some plasticity (PI = 3% – 6%).

The effect of short-term (3 weeks) exposure on the grading of the crushed shale does not seem to be dramatic (GM = 2.6 – 2.88).

The reduction in strength (ACV) after wetting varies between 24% for the slightly weathered shale that is prone to slaking to about 9% for the slightly weathered shale that is not prone to slaking. The latter type of shale meets the ACV specification for concrete aggregate. For the moderately weathered shale, the reduction in ACV after wetting is about 20 %.

The overall result of the durability testing is reassuring in that it appears that the indurated shale (visually not prone to slaking) is strong, most of the decrease in

strength takes place within a short period (days rather than weeks), and that all slightly weathered and unweathered shale can be considered suitable as hard rockfill, provided that it is protected by an outer shell of durable rock.

5.3.4 Tests on highly and moderately weathered shale

These materials were not tested during the current investigation, but similar materials were tested during the investigation for the Zalu Dam site near Lusikisiki.

The samples were subjected to primary crushing to the minus 25 mm size and subjected to grading, Atterberg, Aggregate Crushing Value (ACV), Standard Proctor and consolidated undrained triaxial testing.

Since it is not known to what extent the weathered shale will break up during quarrying, transport, compaction and consolidation in a dam embankment, it was decided, for the sake of conservatism, to conduct the triaxial tests on the minus D_{10} fraction. However, after the primary crushing (to minus 25 mm) the minus D_{10} fraction of the highly weathered and moderately weathered shale produced too little material and it was then decided to crush the entire sample to minus 0.425 mm for the triaxial testing. The samples were compacted to 95% of Standard Proctor density and the moisture content adjusted to about 20% before testing. The results are shown in **Table 5.11**.

Table 5.11: Summary of laboratory tests on crushed rock cores

Sample Origin	Highly weathered shale	Moderately weathered shale
Laboratory Number	2/4971	2/4972
Grading description (after crushing to minus 25 mm)	Silty (11%) sandy (34%) gravel (51%)	Sandy (22%) gravel (78%)
LL (%)	27	Non plastic
PI (%)	7	Non plastic
LS (%)	2,5	1.5
PE	Low	Low
ACV (%)	39,9	29,2
Standard Proctor MDD (kg/m^3)	1960	2049
Standard Proctor OMC (%)	13,4	10,3
Cohesion (effective) (kPa)	0	13
Friction angle (effective) (degrees)	35	35

5.4 AVAILABLE VOLUMES OF VARIOUS MATERIALS

The proposed borrow area in the dam basin has a very thin cover of soil above weathered shale and it was decided to abandon the idea of a borrow area and to investigate the rock quarry in the same area. The estimated volumes of the above materials are given in **Table 5.12**.

Table 5.12: Estimated volumes of embankment materials from borrow areas, tunnel spoil and the tunnel outlet portal

Type of material	Required (x 1000 m^3) Percentages available are given in brackets.			Available (x 1000 m^3)			
	For CFR Dam	For CCR Dam	For zoned embank-ment	Tunnel spoil (outlet section)	Portal excavation	Spillway approach	Quarry
Overburden for spoil: Organic topsoil	0	0	0	0	8	15	20
Impervious core	0	250 (0%)	350 (0%)	0	0	0	0
Semi-pervious fill: Residual silty clayey sand and sandy silty clay	0	0	1 020 (90%)	0	230	35	120
Semi-pervious fill: Highly weathered shale					70	280	180
Soft rockfill: Moderately weathered shale	1000 (191%)	910 (210%)	280 (682%)	0	50	20	350
Hard rockfill: Unweathered shale and dolerite				250	40	0	1 200

5.5 MATERIAL PARAMETERS FOR DESIGN

Based on the information from the drilling and laboratory testing, the various types of material available from all the sources can be described as follows:

- Residual clayey gravelly silty sand and highly to completely weathered shale comply with the specification for semi-pervious earthfill.
- Moderately weathered shales are generally medium strong rocks in situ, but are prone to rapid slaking upon exposure to the atmosphere. This shale material can be considered as soft rockfill, but must be covered by durable (dolerite) rock outer zones.
- Unweathered shale and dolerite (mixture from tunnel excavation and quarry) are suitable as hard rockfill but must be covered by durable (dolerite) rock outer zones.

The estimated average properties of the above types of materials are given in **Table 5.13**.

Table 5.13: Estimated material parameters for design

Material type	Properties of compacted material n/p = non-plastic n/a = not applicable n/t = not tested est = estimates based on other projects						
	Liquid Limit (%)	Plasticity Index (%)	Density (kg/m^3)	OMC (%)	Permeability (m/s)	Cohesion (kPa)	Phi (^{o})
Semi-pervious fill: Residual silty clayey sand and sandy silty clay	47	18	1730	16	4 x 10^{-6}*	n/t	n/t
Semi-pervious fill: Highly weathered shale	27	7	1960	13.4	2,7 x 10^{-3}* 2 x 10^{-10}**	8***	33***
Soft rockfill: Moderately weathered shale	n/p	n/p	2049	10.3	1 x 10^{-1}*	0 (est)	35 (est)
Hard rockfill: Slightly weathered and unweathered shale, non-slaking	n/p	n/p	2100 (est)	n/a	n/t	0 (est)	38 (est)
Hard rockfill: Slightly weathered and unweathered shale, slaking	20	5	2100 (est)	n/t	n/t	0 (est)	36 (est)
Hard rockfill : Slightly weathered and unweathered dolerite	n/p	n/p	2200 (est)	n/a	n/t	0 (est)	40 (est)

* *Permeability based on Hazen's equation on D_{10} of samples crushed to minus 25 mm.*

** *Permeability from flexible wall permeates*

*** *Shear box test results*

From **Table 5.12** and **Table 5.13** it appears that none of the available materials qualify as impervious fill. The residual silty clayey sand qualifies as impervious material in terms of the Atterberg Limits, but its permeability is likely to be too high and can therefore best be used in semi-pervious zones.

The available quantity of semi-pervious material is not quite sufficient to provide twice the required volume for a zoned embankment dam.

A considerable volume of soft rockfill will have to be removed from the quarry in order to reach the hard rockfill. This material can be used in certain zones of any of the alternative embankment dams.

There is sufficient hard rockfill for construction of a CFR or ECR Dam. For any of these dam types, durable dolerite may have to be imported from a commercial quarry (Pietermaritzburg) to serve as protective layer above the shale or dolerite shale mixture. Some or all of this dolerite might be obtained from the quarry, but will have to be further investigated during the design stage.

Due to the absence of impervious core material, consideration will have to be given to a Concrete Faced Rockfill or Earth Core Rockfill Dam with impervious core comprising a mixture of soil and bentonite. The Concrete Faced Rockfill option appears to be the more feasible, since the available soils contain too much clay to mix with bentonite.

6 GEOTECHNICAL INVESTIGATIONS

Geotechnical investigations were conducted along the proposed dam centre line and along the proposed spillway return channel on the left flank.

The position of the centre line was selected where the width of the wetland was at a minimum and where rock outcrops were visible at surface on both sides of the river. For a dam with FSL at 919 masl, this meant that both flanks run in an upstream direction to make best use of the topography (see **Figure A5.1** included in **Annexure A**).

From a topographic point of view, a side spillway could be positioned on either flank, but the drilling results showed very deep weathering on the right flank and it was proposed to position the spillway on the left flank (**Figure A5.1** included in **Annexure A**).

The investigations comprised seismic refraction surveys, test pitting and rotary core drilling along the dam centre line and drilling for the spillway chute on the left flank.

6.1 SEISMIC REFRACTION SURVEYS

Seismic refraction surveys by Open Ground Resources were conducted along the following lines (*Report no P WMA 11/U10/00/3312/3/2/2: Supporting document 2: Seismic refraction investigation at the proposed uMkhomazi Water Project Phase 1*):

- Centre line left flank (Line G1-G2 = 115 m);
- Centre line river section (Line G2A-G3A = 115 m); and
- Centre line right flank (Line G3B-G4 = 235 m).

The positions of the seismic lines are shown on **Figure A5.1** included in **Annexure A**.

Due to the presence of cultivated lands on the upper left flank, seismic surveys could not be conducted there.

The 3 500 m/s seismic velocity line usually represents slightly weathered, medium to closely jointed dolerite, suitable as foundation for a concrete dam. Lines depicting

this velocity have been drawn on sections containing the results of boreholes along the centre line (**Figure A6.1** included in **Annexure A**).

Seismic line G1-G2 along the lower left flank overestimates the depth to sound rock dolerite by about 7 m at Borehole NM 1 and by about 4 m at Borehole NM 2. This might be due to the thick layer of shale above the dolerite in this area.

Seismic line G2A-G3A in the river section and lower right flank shows a deep seismic low to the left of Borehole NM 5 and this is interpreted as weathering associated with a suspected fault that displaces the dolerite sill by about 8 m in this area.

Seismic line G3B-G4 along the right flank shows the 3 500 m/s seismic line to be very deep (>30 m) along the lower part of the flank and then rises abruptly near section chainage 600 m, probably as a result of the dolerite sill that becomes unweathered at that location.

6.2 CORE DRILLING AND WATER TESTING

A total of ten cored boreholes with Lugeon water testing were drilled to investigate the anomalies revealed by the seismic refraction survey and to provide information on founding conditions and the need for grouting. The positions of the boreholes are shown on **Figure A5.1** included in **Annexure A**.

On the left flank only Borehole NM 9 could be drilled near the centre line due to the presence of cultivated lands and environmental restrictions. Borehole NM 10 was drilled near the left flank tributary to investigate conditions for the proposed spillway chute.

Boreholes NM 1 – NM 3 were drilled in the river section and Boreholes NM 4 – NM 7 along the right flank. Borehole NM 8 was drilled closer to the right flank tributary to investigate conditions for the proposed side spillway. A summary of the borehole results is given in **Table 6.1**.

Table 6.1: Summary of boreholes results at the dam site

BH No.	TYPE OF MATERIAL/DEGREE OF WEATHERING Organic soil = O, Sandy clay = SC, Gravel in clay = GC, Gravel in sand = GS Shale = S; Indurated shale = I, Dolerite = D					
	TRANSPORTED SOIL	RESIDUAL SOIL/ COMPLETELY WEATHERED	HIGHLY	MODERATELY	SLIGHTLY	UNWEATHERED
	LAYER THICKNESS (m)					
NM 1	0.0 - 0.5 (O)	0.5 – 1.57 (S)	2.15 – 2.39(S) 2.79 – 3.1 (S) 4.3 – 4.37 (S) 5.29 – 5.63(S) 5.87 – 5.95(S) 7.14 – 7.35(S) 8.61 – 9.12(S) 10.2–10.30(S)	1.57 – 2.15 (S) 2.39 – 2.79(S) 3.1 – 4.3 (S) 4.37 – 5.29 (S) 5.63 – 5.87 (S) 5.95 – 7.14(S) 7.35 – 8.61(S) 9.12 – 10.2(S) 10.30– 10.6(S)	10.6– 13.6(S) 13.6 – 20.0(D) 20.0– 25.16(I)	
NM 2	0.0 – 0.5 (O)	0.5 – 3.2(S)	5.0 – 6.1 (S)	3.2 – 5.0(S) 6.1 – 7.0 (S) 7.0 – 8.2(D)		8.2 – 13.56(D) 13.56 – 20.0(S)
NM 3	0.0 – 2.3(GC)		2.3 – 3.36(D)	3.36 – 4.42(D)	4.42 20.0 (S)	
NM 4	0.0 – 0.2 (O)	0.2 – 1.67(S)	1.67 – 2.67(S)	2.67 – 4.6(S)	4.6 – 20.0(S)	
NM 5	0.0 – 0.24 (O) 0.24 – 3.29 (SC)	3.29 – 5.13 (S)	5.13 – 7.1(S)	7.1 – 10.12 (S)	10.1-11.53(S)	11.53-25.27(S)
NM 6	0.0 – 0.5 (O)	0.5 – 9.76 (S) 9.76 – 17.3 (D)	17.3–18.2(D)	18.2-18.53(D) 18.53-19.6(S)	19.6 – 25.6(S)	
NM 7	0.0 – 0.2(O)	0.2 – 1.32 (S) 14.1-18.5(D)	1.32 – 5.5(S) 12.85–14.1(S) 18.5-20.2(D)	5.5 – 12.85(S) 20.2-23.0(D)	23.0-25.0(S)	
NM8	0.0 – 0.9 (O)	0.9 – 4.0 (S)	4.0 – 7.75(S) 19.6 – 20.0(S)	7.75 – 19.6(S)		
NM9	0.0 – 0.25(O)	0.25-1.7(S)	1.7-3.1(S) 4.2-5.14)S) 6.25-8.73(S)	3.1-4.2(S) 5.14-6.25(S) 8.73-9.30(S)	9.3-12.0(S)	12.0-20.11(S)
NM10		0.9 – 1.5(S) 5.14-5.28(S)	0.0 – 0.9(S) 1.5-5.14(S)		5.28-7.4(S)	7.4-20.02(S)

Water pressure tests were conducted by using single packers in sections of 3 m length and maximum water pressures of about 15 x D for packers set in soil and 22 x D for packers set in rock (where D is the depth of the packer below ground surface). Each test section was subjected to five (ascending and descending) water pressures (each for a period of 10 minutes), and the corresponding water losses were measured. The Lugeon value for each increment of water pressure was calculated as follows:

Lugeon = (1000 x V)/(T x L x P)

Where: V = Volume of water pumped in litres

T = Time of water pumped in minutes

L = Length of test section in metres

P = Pumping pressure in kPa

For each test section, five Lugeon values (one for each pressure increment) were calculated, and the most appropriate Lugeon value was selected from the flow pattern (laminar, turbulent, dilation, blockage or wash-out) according to the guidelines produced by *Houlsby (1976)*.

The results of the water pressure tests are presented in **Table 6.2**.

Table 6.2: Summary of water pressure test results

BH No.	Depth untested	LUGEON VALUES (values <0.1 Lugeon not given))		
		0.1 -1	1.1 – 4 (actual Lugeons)	>4 (actual Lugeons)
		Depth in m	Depth in m	Depth in m
NM 1	0 – 2 23-25.16	5-11 14-20	11-14 (1.2) 20-23	2-5 (5.6)
NM 2	0-2	2-5 11-14 17-20	14-17 (1.5)	-
NM 3	0-2	-	-	-
NM 4	0-2	-	-	-
NM 5	0-2 23-25.27	2-5 8-11 14-23	5-8 (1.7) 11-14 (1.1)	-
NM 6	0-2 23-26.6	2-5 8-11 14-23	5-8 (1.7) 11-14 (1.1	-
NM 7	0-2 23-25	5-8 14-20	2-5 (1.2) 11-14 (2) 20-23 (1.4)	-
NM 8	0-2	-	-	-
NM 9	0-2	2-5 8-11	11-14 (1.6)	14 – 20 (TOTAL)

All boreholes along the dam centre line were equipped with standpipe piezometers. The water level readings are given in **Table 6.3**.

Table 6.3: Water rest levels in boreholes

BH No	Date completed	Date measured	Water level (m)	Water level Elevation (masl)
NM 1	2013-04-03	2103-03-04 2013-04-15	14.3 dry	880.5
NM 2	2013-04-08	2013-04-08 2013-04-15	6.5 dry	881.8
NM 3	2013-04-05	2013-04-15	dry	
NM 4	2013-03-23	2013-04-15	dry	
NM 5	2013-04-05	2013-04-05 2013-04-15	9.85 dry	881.5
NM 6	2013-03-22	3013-03-22 2013-04-15	13.2 dry	895.0
NM 7	2013-03-23	2013-03-23 2013-04-15	10.78 dry	901.8
NM 8	2013-04-15	2013-04-15	dry	

It is very unlikely that boreholes drilled within the wetland (Boreholes NM 2 and NM 3) can be dry at any time. This unfortunately puts a question mark on all the water level measurements that were done by the drilling contractor. Further piezometer readings and investigations into the probable cause for this anomaly will have to be done.

6.2.1 Discussion of drilling results

The results of the seismic survey, the drilling and the interpretation of the geology are shown on **Figure A6.1** included in **Annexure A**.

Most of the left flank (section chainage 0 – 250 m) is occupied by horizontally bedded shale under a thin (<0.3 m) cover of transported soil. A 7 m thick horizontal dolerite sill was encountered in the river section, and is expected to continue at depth under the left flank.

The shale is completely weathered to a depth of about 2 m and moderately weathered with layers of highly weathered shale to about 10 m. Deeper down the shale is slightly weathered or unweathered. The shale is thinly bedded, hence the borehole cores show moderate to low RQD values.

The river section (section chainage 250 m – 320 m) is underlain by shale, while between chainages 320 m and 480 m the underlying horizontal dolerite sill is covered only by a thin (2 m) layer of transported soil. A fault that intersects the centre line displaces the dolerite sill by about 8 m so that the dolerite occurs at a higher level on the right flank.

The shale is completely weathered to a depth of 2 m - 3 m and moderately weathered with layers of highly weathered shale to between 7 m and 10 m. Deeper down the shale is slightly weathered or unweathered. The dolerite below the shale is highly and moderately weathered to about 2 m after which it is slightly weathered.

Weathering conditions along the fault zone are unknown, but according to the seismic results, poor rock conditions might occur to a depth of 20 m.

The right flank (section chainage 480 m – 660 m) is occupied by horizontally bedded shale under a thin layer (<0.3 m) of transported soil. The horizontal dolerite sub-outcrops (outcrop covered by colluvium) between elevations 888 masl and 898 masl and it thins to about 4 m deeper into the flank.

In Borehole NM 6 the shale and the dolerite are completely weathered to 18 m depth, while in Borehole 7 the shale is completely weathered to the dolerite contact at about 18 m and the dolerite below is moderately weathered to its base at 23 m.

6.2.2 Founding conditions for alternative dam types

a) Earth embankment shells

The shells of an earth embankment are typically founded on material with low organic content, low compressibility and with shear strength similar to the dam wall material. This means that a 0.6 m – 1.5 m thick layer of organic topsoil and loose transported soil has to be removed along the centre line and that founding will take place on stiff transported sandy clay or weak completely weathered shale or weak residual dolerite.

b) Core trench

The clay core of an earthfill or rockfill dam is normally founded on material that is either sufficiently impervious or can be rendered impervious by means of grouting. These depths vary between 3.1 m to 5.0 m along the centre line (see **Figure A6.2** included in **Annexure A**).

c) Rockfill embankment shells

The shells of a rockfill embankment are typically founded on material with low organic content, low compressibility and with shear strength similar to the dam wall material. Along most of the centre line between 1.6 m and 5.3 m of colluvium and residual soil/completely weathered shale has to be removed. However in the area of Borehole NM 6 on the right flank, weak completely weathered shale and dolerite extend to a depth of over 17 m (see **Figure A6.3** included in **Annexure A**). This excavation will yield a considerable volume of material, some of which might be suitable as semi-pervious earthfill. The volume and properties of this material must be further investigated during the design stage.

d) Plinth for concrete faced rockfill

In the case of a concrete faced rockfill (CFR) dam, founding of the plinth will require material with either low permeability or good groutability. The depths vary between 5 m and 17.5 m (see **Figure A6.4** included in **Annexure A**).

e) Concrete gravity

A concrete gravity dam is normally founded on good quality rock with a minimum rock mass rating (RMR) of 50, giving it an E-value of at least 10 GPa and with shear strength parameters along the most critically orientated discontinuities of C = 250 kPa and φ = 34 degrees.

Due to the presence of closely spaced continuous weak bedding planes in the highly and moderately weathered shale, and to some extent also in the slightly weathered and unweathered shale, the above requirement for shear strength are only marginally met in slightly weathered and unweathered shale. This means that excavation depths for a concrete dam will extend to between 5 m and 8.5 m in the river section and up to 23 m along a section of the right flank. (see **Figure A6.3** included in **Annexure A**).

For concrete structures where shear strength is not critical (e.g. spillway chute), founding can take place on moderately weathered shale at considerably shallower depths. The recommended excavation depths at borehole positions are listed in **Table 6.4**.

Table 6.4: Recommended excavation depths at the various borehole positions

BH No.	ELEVATION (masl)	EXCAVATION DEPTHS IN METRES (VERTICAL)				
		Earth shells	Rock shells	Core	Concrete dam	Plinth
NM9	916.31	1.0	2.3	3.1	10.0	5.0
NM1	894.68	0.8	1.6	5.0	12.0	5.0
NM2	888.36	1.0	3.5	3.5	8.5	6.2
NM3	882.03	1.5	3.0	5.5	6.0	5.0
NM4	886.90	1.0	2.6	2.6	5.0	3.0
NM5	891.31	1.0	5.3	5.3	11.0	6.0
NM6	908.24	0.6	17.3	5.0	20.0	17.5
NM7	912.61	0.6	3.0	6.0	23.0	8.0
NM8	919.00	1.0	7.6	5.0	n/a	7.6
NM10	n/a	0.5	2.0	5.5	7.0	5.5

f) Grouting

In most of the boreholes along the centre line water losses of less than 4 Lugeon units were recorded. The only exceptions are Boreholes NM 1 and NM 6 where 5.6 Lugeons and 17 Lugeons respectively were measured between 2 m and 5 m and in Borehole NM 9 where total water loss occurred below 14 m depth. There are no indications in the core that high water losses might be encountered in these intervals, and it is possible that the packers did not seal properly.

All the boreholes were reported to be dry a few days or weeks after drilling was completed. These results are considered incorrect.

For a dam of this height, it will be necessary to make provision for a grout curtain to a depth of about 66% of the water head along the centre line. Although grout penetration might be small except in local zones, the drilling, water test and grout records from a grouting operation is very important and can be considered the final stage of a geotechnical investigation when sub-surface information is obtained at close intervals below the footprint of the dam.

6.3 SPILLWAY CONTROL AND RETURN CHANNEL

The layout of the proposed spillway control structure and return channel (chute) is shown in **Figure A5.1** included in **Annexure A**.

Borehole NM 10 was drilled in the general area for a control structure. It shows an excavation depth of about 5.5 m for a concrete control structure and concrete lined chute. This condition is considered representative for the area where the control structure and chute is presently proposed.

7 RESERVOIR RIM STABILITY

7.1 RESERVOIR RIM STABILITY

Slopes around the reservoir rim are generally flatter than 16 degrees and are underlain by a shallow cover of soil, followed by horizontally bedded shale. Small scale slumping of the thin soil layer may occur from time to time due to fluctuating water levels, but the risk for large slope failures that might endanger the dam is considered negligible.

8 CONCLUSIONS

8.1 AVAILABLE INFORMATION

Information from published geological maps was used to describe the general geology of the area.

8.2 GENERAL GEOLOGY

The area around the site is underlain by rocks of the Pietermaritzburg Formation of the Ecca Group, comprising shales (mudrocks) with sub-ordinate sandstones. The sedimentary strata are essentially horizontal, and largely undisturbed. Regional dips of 3 – 5 degrees are recorded. A near-horizontal dolerite sill had intruded into the sedimentary strata and occurs below a cover of shale at the dam centre line and the quarry. A fault with a throw of about 8 m intersects the dam centre line.

8.3 SEISMIC REFRACTION SURVEYS

Seismic refraction surveys were conducted along the proposed dam centre line. Although the seismic velocities tended to over-estimate the depth of sound rock, they were useful in showing the presence of the dolerite sill below a cover of shale and also to identify the positions of a fault.

8.4 SEISMIC RISK ANALYSIS

A Probabilistic Seismic Hazard Analysis (PSHA) was conducted for the Smithfield and Langa sites by Dr A Kijko of the Natural Hazards Assessment Consultancy.

Results for the horizontal component of earthquake acceleration are as follows:

- Operating Basis Earthquake (Return period 144 years) =0.016 g.
- Maximum Design Earthquake (Return Period 475 years) =0.021 g.
- Maximum Credible Earthquake (MCE (Return period 10 000 years) =0.113 g.

8.5 MATERIALS INVESTIGATION

An extensive wetland in the dam basin, and cultivated lands on the left flank placed severe environmental restrictions on the digging of test pits and drilling of boreholes for the investigation of potential construction material sources.

Four potential sources for construction materials have been investigated, namely (i) spoil from the tunnel excavation, (ii) material excavated for the tunnel outlet portal, (iii) material excavated from the spillway approach area and (iv) material from a quarry located below FSL in the dam basin. The estimated volumes available from these sources in relation to the required volumes are shown in **Table 8.1**.

Table 8.1: Estimated volume of embankment materials from borrow areas, tunnel spoil and the tunnel outlet portal

Type of material	Required (x 1000 m^3) Percentage of available materials in brackets			Available (x 1000 m^3)			
	For CFR Dam	For CCR Dam	For zoned embank-ment	Tunnel spoil (outlet section)	Portal excavation	Spillway approach	Quarry
Overburden for spoil: Organic topsoil	0	0	0	0	8	15	20
Impervious core:	0	250 (0%)	350 (0%)	0	0	0	0
Semi-pervious fill: Residual silty clayey sand and sandy silty clay	0	0	1 020 (90%)	0	230	35	120
Semi-pervious fill: Highly weathered shale					70	280	180
Soft rockfill: Moderately weathered shale	1200 (124%)	900 (165%)		0	50	20	350
Hard rockfill: Unweathered shale and dolerite			280 (532%)	250	40	0	1 200

It appears that none of the available materials qualifies as impervious fill and that the available quantity of semi-pervious material is not quite sufficient to provide twice the required volume for a zoned embankment dam.

A considerable volume of soft rockfill (weathered shale) will have to be removed from the quarry in order to reach the hard shale and dolerite rockfill. This soft material can be used in certain zones of any of the alternative embankment dam types.

There is sufficient hard rockfill for construction of a CFR or ECR Dam. For any of these dam types, durable dolerite may have to be imported from a commercial quarry (Pietermaritzburg) to serve as protective layer above the shale or dolerite shale mixture. Some or all of this dolerite might be obtained from the quarry.

Due to the absence of impervious core material, consideration will have to be given to a Concrete Faced Rockfill Dam or an Earth Core Rockfill Dam with impervious core comprising a mixture of soil and bentonite. The Concrete Faced Rockfill option appears to be the more feasible, since the available soils contain too much clay to be mixed with bentonite.

8.6 GEOTECHNICAL INVESTIGATION

Seismic surveys and core drilling between elevations 900 masl and 919 masl along the left flank were restricted due to the presence of cultivated lands. Although there is a gap of about 250 m between boreholes on this flank, the geology is fairly homogeneous and the interpretation of founding conditions should be reasonably accurate.

Founding conditions for all types of dams are unfavourable as a result of deep weathering, especially along the right flank. This will involve in moderate to very deep excavations for rockfill shell and the plinth of a CFR dam and very deep excavations for a concrete gravity dam

For the ***shells of an earth embankment*** 0.6 m – 1.5 m organic topsoil and loose transported soil has to be removed along the centre line and founding will take place on stiff transported sandy clay or weak completely weathered shale or weak residual dolerite.

For the ***shells of a rockfill embankment*** between 1.6 m and 5.3 m of colluvium and residual soil/completely weathered shale has to be removed along most parts of the

centre line. However in an area on the right flank, weak completely weathered shale and dolerite extend to a depth of over 17 m.

For the ***core of an embankment dam*** the depth of excavation will vary between 3 m to 5 m along the centre line. The depth for the ***plinth of a concrete faced rockfill*** dam will in many sections be only slightly deeper than for the core trench, except in an area on the right flank where it is much deeper.

Excavation depths for a ***concrete gravity dam*** will extend between 5 m and 8.5 m in the river section and up to 23 m along a section of the right flank.

It will be necessary to make provision for a grout curtain to a depth of about 66% of the water head along the centre line.

A spillway control structure and concrete lined return channel can be founded on moderately weathered shale at an average depth of about 5.5 m. A stilling basin and apron will have to be provided at the end of the chute.

8.7 STABILITY OF RESERVOIR RIM

Slopes around the reservoir rim are generally flatter than 16 degrees and are underlain by a shallow cover of soil, followed by horizontally bedded shale. The risk for slope failures that might endanger the dam wall is considered negligible.

As a result of environmental restrictions on the positioning of seismic lines, test pits and boreholes, this investigation was limited. Hence, additional investigations for the design stage are recommended.

9 RECOMMENDATIONS

It is recommended that the following additional materials and geotechnical investigations be conducted during the design stage:

- Test pitting in the spillway approach area, together with soil sampling and laboratory testing to determine the properties of material to be excavated. These tests should include grading, Atterberg Limits, Standard Proctor Compaction, permeability, triaxial shear strength and dispersivity.
- Additional test pitting in the tunnel outlet portal area, together with soil sampling and laboratory testing to determine the properties of material to be excavated. These tests should include grading, Atterberg Limits, Standard Proctor Compaction, permeability, triaxial shear strength and dispersivity.
- Additional rotary core drilling in the quarry area to determine the extent of the dolerite sill and its potential use for concrete aggregate, rip-rap and filters.
- Additional rotary core drilling, water testing and SPT testing along the dam centre line to provide information on founding conditions along the left flank, the suspected fault zone on the lower right flank and the area of deep weathering on the right flank.
- Additional drilling, soil sampling and testing in the area of Borehole NM 6 to determine the properties and volume of potential impervious soil from the dam excavation.
- Additional rotary core drilling at the spillway control structure, return channel and stilling basin to provide information on founding conditions.
- Further piezometer readings at existing boreholes and investigations to explain the anomalous water level observations.

10 REFERENCES

Badenhorst, D. (1988). *Die ontwerp van grond- en rotsvuldamstrukture; Unpublished dissertation for Masters Degree in Engineering.* Pretoria, South Africa: University of Pretoria.

Houlsby, A. (1976). *Routine interpretation of the Lugeon water test. Quart. Jnl. Engng. Geol., 9(4), 303-313.* Pretoria, South Africa.

SAIEG-AEG-SAICE (Geotechnical Division). (1990). *Guidelines for soil and rock logging: Geoterminology Workshop.* Pretoria, South Africa: SAIEG-AEG-SAICE (Geotechnical Division).

Annexure A

Figures

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

AECOM

Project Name :

uMkhomazi Water Project Phase 1: Module 1:
Technical Feasibility Study: Raw Water (uMWP1-1/RW)
Locality map - Study area

Legend

- Project Area
- Towns
- Minor Towns
- Proposed Dams
- Proposed Conveyance Structure

FIGURE A1.1

Drawn:	LC Gallagher
Checked:	A Combrinck
Date:	2014-03-04
Map Ref:	uMkhomazi.map
View Ref:	Locality Map - Study area (2)
Project No:	J01763

GEOLOGICAL LEGEND

AGE	SUPERGROUP	GROUP	FORMATION	SYMBOL	LITHOLOGY
Jurassic				Jd	Dolerite
Permian	Karoo Supergroup	Beaufort Group	Andelaide (Pa) Estcourt (Pes)	Pa/Pes	Siltstone; fine grained sandstone; subordinate mudrock (Pa)/ Dark grey shale often carbonaceous; siltstone; medium to coarse grained sandstone; subordinate thin conglomerate
		Ecca Group	Volkrust	Pvo	Dark blue grey shale; subordinate thin sandstone
			Vryheid	Pv	Medium to coarse grained sandstone with thin grit beds; subordinate grey shale and siltstone; sporadic coal
			Pietermaritzburg	Pp	Dark grey shale; siltstone; subordinate sandstone
Carboniferous			Dwyka	C-Pd	Diamictite; subordinate varved shale and boulder shale

Proposed Impendle Dam

INLET

Proposed Smithfield Dam

OUTLET

Baynesfield Dam

Proposed Langa Balancing Dam

29°30'0"S
29°36'0"S
29°42'0"S
29°48'0"S
29°54'0"S
30°0'0"E
30°6'0"E
30°12'0"E

Scale 1:200000
0 1 2 4 6 8 10 km

N

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

AECOM

Project Name :

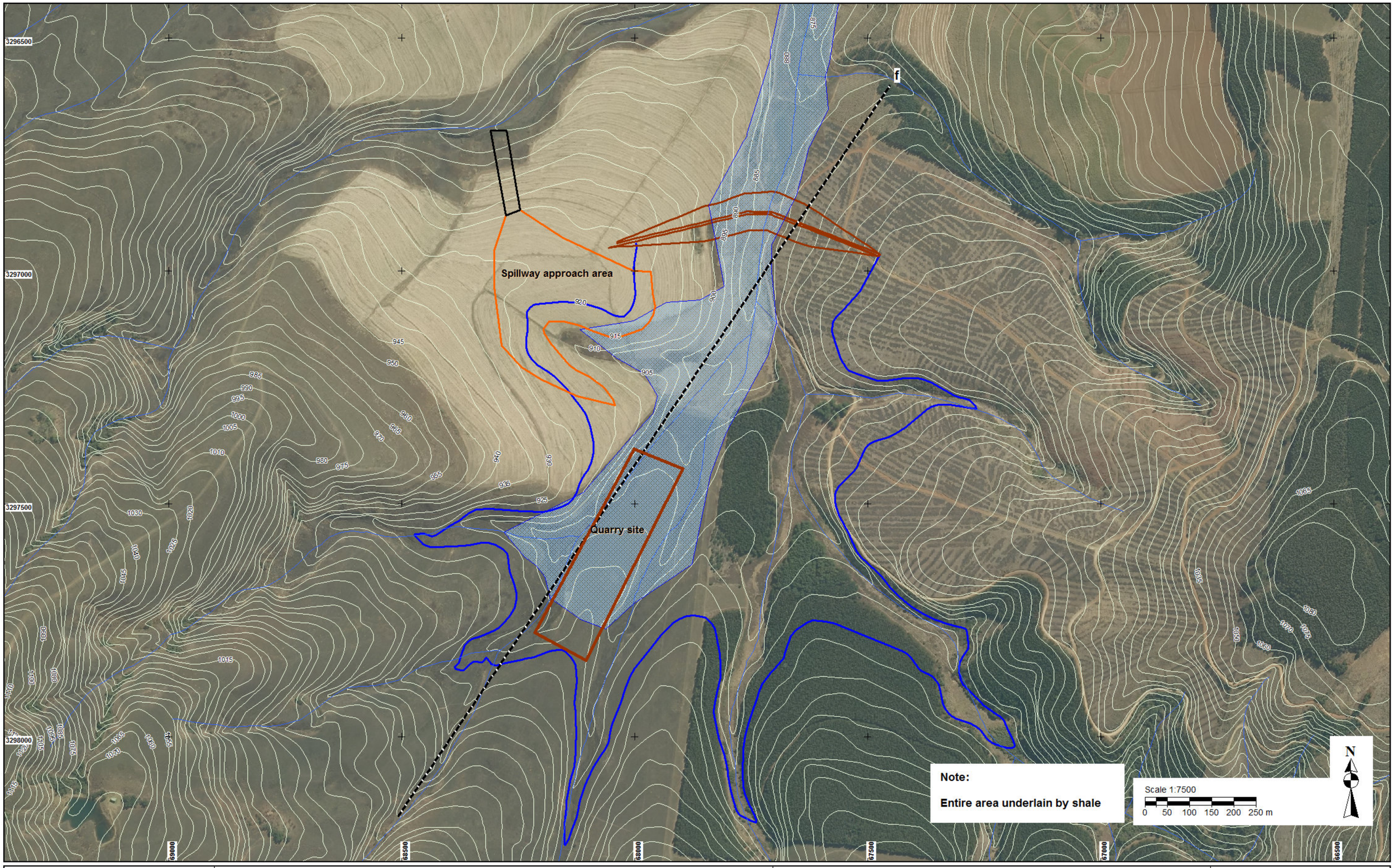
uMkhomazi Water Project Phase 1: Module 1:
Technical Feasibility Study: Raw Water (uMWP1-1/RW)
Regional Geology Map

Legend

- Existing Dams
- Proposed Dams
- Pressure tunnels to Baynesfield area (option B)
- Raw Water Pipeline Infrastructure

FIGURE A4.1

Drawn:	LC Gallagher
Checked:	G Rabodiba
Date:	2013-07-29
Map Ref:	P\GIS\Water\uMkhomazi_Geotecnical.map
View Ref:	Regional Geology Map
Project No:	J01763



water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

AECOM

Project Name :

uMkhomazi Water Project Phase 1: Module 1:
Technical Feasibility Study: Raw Water (uMWP1-1/RW)
Langa Dam - Geological Map

Legend

- 5 m Contours
- 920 contour
- Langa Dam Layout
- Main Rivers
- Wetland
- f Suspected fault
- Proposed quarry
- Approach Areas
- Spillway chute

FIGURE A4.2

Drawn:	LC Gallagher
Checked:	D van der Merwe
Date:	2013-07-30
Map Ref:	G\GIS\Water\uMkhomazi_WG31.map
View Ref:	Langa Dam - Geological Map
Project No:	J01763

Test pits
Coordinates list - Lat Long

MTP04 - Y - 67849
X - 3296898
MTP05 Y - 68039
X - 3297099
MTP07 - Y - 68251
X - 3297273
MTP08 - Y - 68228
X - 3297607
MTP09 - Y - 68170
X - 3297743
MTP10 - Y - 68040
X - 3297829
MTP11 - Y - 67964
X - 3297696
MTP12 - Y - 67870
X - 3297729
MTP13 - Y - 67870
X - 3297600
MTP14 - Y - 67849
X - 3297510
MPT15 - Y - 67994
X - 3297304
MTP16 - Y - 67803
X - 3297335
MTP18 - Y - 67883
X - 3297883

BH	Y	X	Z
NQ1	-125249.445	3298328.576	918.431
NQ2	-125341.516	3298146.686	909.826
NQ3	-125453.850	3297975.284	900.292

Borehole	X	Y	Height
NM1	-125595.338	3297338.564	894.686
NM2	-125625.143	3297326.444	888.362
NM3	-125672.084	3297332.197	882.029
NM4	-125700.914	3297379.638	886.896
NM5	-125735.854	3297372.024	891.309
NM6	-125823.200	3297408.093	908.239
NM7	-125855.854	3297437.009	912.606
NM8	-125976.923	3297416.905	918.999
NM9	-125351.076	3297377.864	916.316
NM10	-125224.410	3297164.243	897.106

Seismic lines		X
G1G2+00	67831.57	3296853
G2AG3A+00	67731.57	3296805
G3BG4+00	67691.72	3296851

Scale 1:7500
0 50 100 150 200 250 m

N

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

AECOM

Project Name :

uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study: Raw Water (uMWP1-1/RW)\ Langa Dam Site - Plan showing proposed layout of structure, seismic lines, sections, test pits and boreholes

Legend

- 5 m Contours
- 920 contour
- Langa Balancing Dam Layout
- Main Rivers
- Borehole Positions
- Test Pits
- Quarry
- Approach Areas
- Spillway chute
- Sections
- Seismic Lines

FIGURE A5.1

Drawn: LC Gallagher
Checked: D van der Merwe
Date: 2013-07-30
Map Ref: G\GIS\Water\uMkhomazi_WG31.map
View Ref: Proposed Layout of Structure
Project No: J01763

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

AECOM

Project Name :

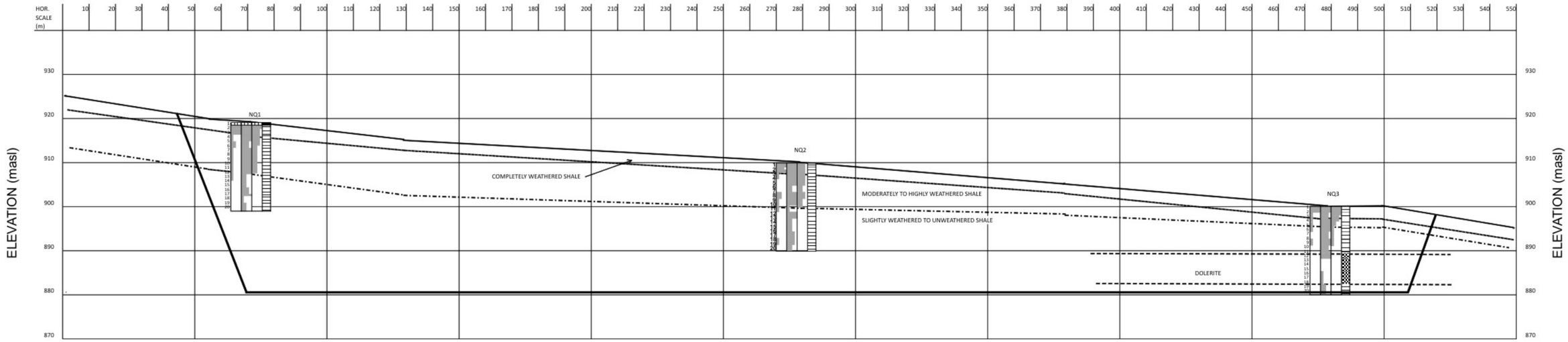
uMkhomazi Water Project Phase 1: Module 1:
Technical Feasibility Study: Raw Water (uMWP1-1/RW)
Proposed tunnel outlet portal excavation

Legend

- 5 m Contours
- Tunnel Exit Portal Test Pits
- New Proposed Conveyance Structure

FIGURE A5.2

Drawn:	LC Gallagher
Checked:	D van der Merwe
Date:	2013-07-29
Map Ref:	G\GIS\Water\uMkhomazi_WG31.map
View Ref:	Proposed tunnel Outlet Poratl excavation
Project No:	J01763



SECTION LEGEND

- GROUND SURFACE LINE
- SOIL/ROCK CONTACT
- WEATHERED ROCK/HARD ROCK CONTACT
- DOLERITE /SHALE CONTACT
- f SUSPECTED FAULT
- QUARRY BOUNDARY

SECTION LEGEND

REC = CORE RECOVERY (C) AND RQD (R)
W = DEGREE OF WEATHERING. T= MATERIAL TYPE

- CORE RECOVERY AND RQD 95-100%
- CORE RECOVERY AND RQD 75-94%
- CORE RECOVERY AND RQD 50-74%
- CORE RECOVERY AND RQD 26-49%
- CORE RECOVERY AND RQD 0-25%
- UNWEATHERED ROCK
- SLIGHTLY WEATHERED ROCK
- MODERATELY WEATHERED ROCK
- HIGHLY WEATHERED ROCK
- COMPLETELY WEATHERED ROCK
- RESIDUAL AND TRANSPORTED SOILS
- ORGANIC TOPSOIL
- CLAYEY SILTY SAND
- CLAYER SILTY SAND WITH BOULDERS AND GRAVEL
- SHALE
- INDURATED SHALE
- DOLERITE

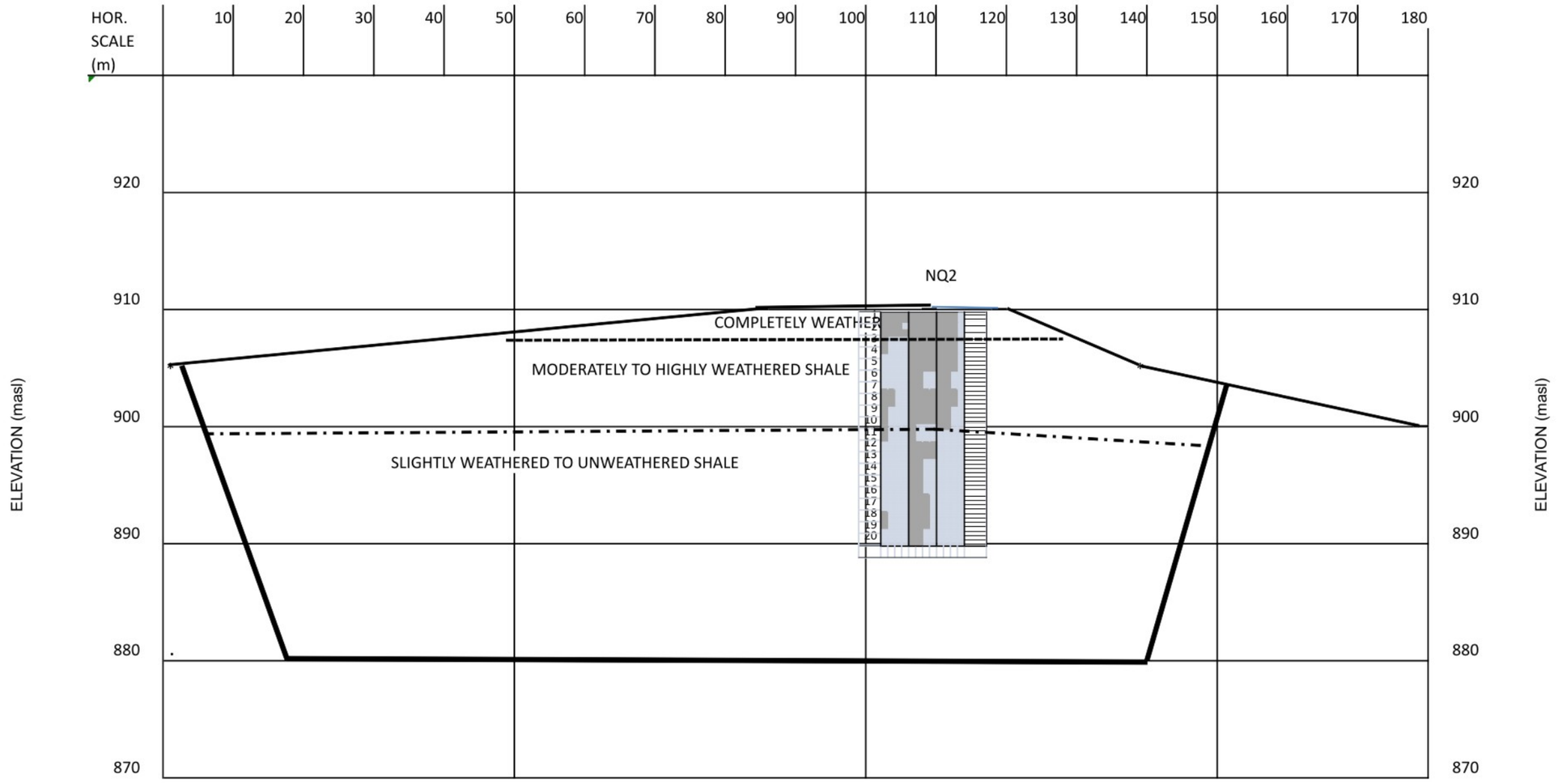
Not to be scaled

MvS27_2013/J01763

AECOM

uMKHOMAZI WATER PROJECT PHASE 1: MODULE 1
TECHNICAL FEASIBILITY STUDY: RAW WATER (UMWP1-1RW) - LANGA DAM SITE

Section B - B: Long section through proposed quarry **FIG A5.3**



SECTION LEGEND	
	GROUND SURFACE LINE
	SOIL/ROCK CONTACT
	WEATHERED ROCK/HARD ROCK CONTACT
	QUARRY BOUNDARY

SECTION LEGEND	
REC	REC = CORE RECOVERY (C) AND RQD (R)
W	W = DEGREE OF WEATHERING. T= MATERIAL TYPE
C R W T	
	CORE RECOVERY AND RQD 95-100%
	CORE RECOVERY AND RQD 75-94%
	CORE RECOVERY AND RQD 50-74%
	CORE RECOVERY AND RQD 26-49%
	CORE RECOVERY AND RQD 0-25%
	UNWEATHERED ROCK
	SLIGHTLY WEATHERED ROCK
	MODERATELY WEATHERED ROCK
	HIGHLY WEATHERED ROCK
	COMPLETELY WEATHERED ROCK
	RESIDUAL AND TRANSPORTED SOILS
	ORGANIC TOPSOIL
	CLAYEY SILTY SAND
	CLAYER SILTY SAND WITH BOULDERS AND GRAVEL
	SHALE
	INDURATED SHALE
	DOLERITE

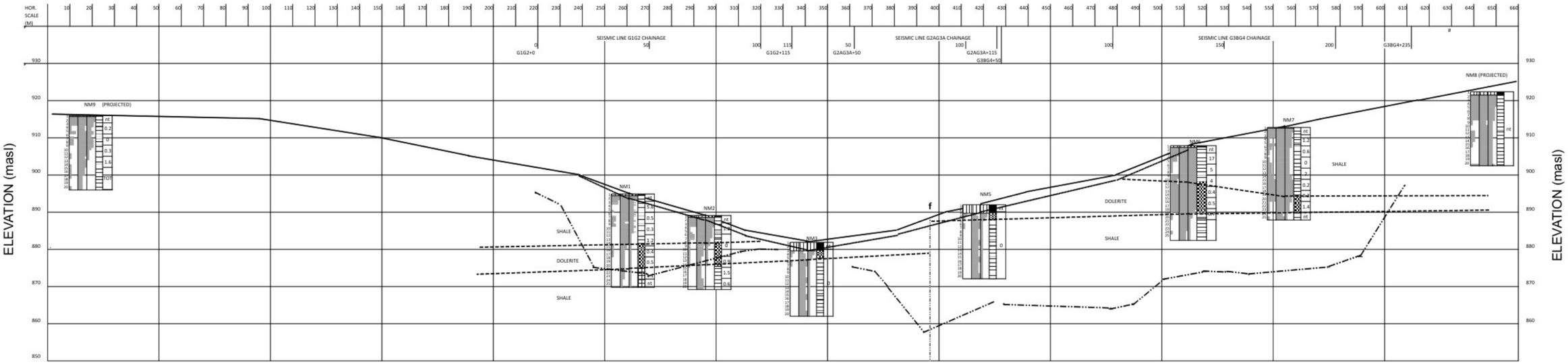
Not to be scaled

MvS28_2013/J01763

AECOM

uMKHOMAZI WATER PROJECT PHASE 1: MODULE 1
TECHNICAL FEASIBILITY STUDY: RAW WATER (UMWP1-1RW) - LANGA DAM SITE

Section C - C: Cross section through proposed quarry **FIG A5.4**



SECTION LEGEND

- GROUND SURFACE LINE
- SOIL/ROCK CONTACT
- DOLERITE /SHALE CONTACT
- f — SUSPECTED FAULT
- 3 500m/s SEISMIC LINE

SECTION LEGEND

REC = CORE RECOVERY (C) AND RQD (R)
W = DEGREE OF WEATHERING. T= MATERIAL TYPE

C	R	W	T	
				CORE RECOVERY AND RQD 95-100%
				CORE RECOVERY AND RQD 75-94%
				CORE RECOVERY AND RQD 50-74%
				CORE RECOVERY AND RQD 26-49%
				CORE RECOVERY AND RQD 0-25%
				UNWEATHERED ROCK
				SLIGHTLY WEATHERED ROCK
				MODERATELY WEATHERED ROCK
				HIGHLY WEATHERED ROCK
				COMPLETELY WEATHERED ROCK
				RESIDUAL AND TRANSPORTED SOILS
				ORGANIC TOPSOIL
				CLAYEY SILTY SAND
				CLAYER SILTY SAND WITH BOULDERS AND GRAVEL
				SHALE
				INDURATED SHALE
				DOLERITE

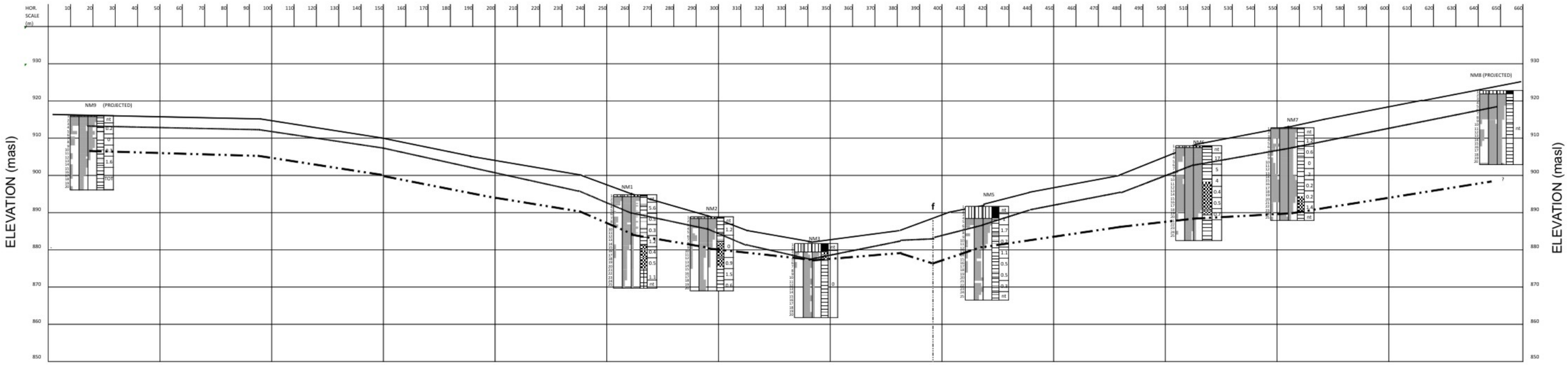
Not to be scaled

MvS29_2013/J01763

AECOM

uMKHOMAZI WATER PROJECT PHASE 1: MODULE 1
TECHNICAL FEASIBILITY STUDY: RAW WATER (UMWP1-1RW) - LANGA DAM SITE

Section A - A: Centre line with seismic and geology **FIG A6.1**



SECTION LEGEND	
	GROUND SURFACE LINE
f	SUSPECTED FAULT
	EXCAVATION LINE FOR CORE TRENCH
	EXCAVATION LINE FOR CONCRETE CHUTE

SECTION LEGEND	
REC	REC = CORE RECOVERY (C) AND RQD (R)
W	W = DEGREE OF WEATHERING. T= MATERIAL TYPE
	CORE RECOVERY AND RQD 95-100%
	CORE RECOVERY AND RQD 75-94%
	CORE RECOVERY AND RQD 50-74%
	CORE RECOVERY AND RQD 26-49%
	CORE RECOVERY AND RQD 0-25%
	UNWEATHERED ROCK
	SLIGHTLY WEATHERED ROCK
	MODERATELY WEATHERED ROCK
	HIGHLY WEATHERED ROCK
	COMPLETELY WEATHERED ROCK
	RESIDUAL AND TRANSPORTED SOILS
	ORGANIC TOPSOIL
	CLAYEY SILTY SAND
	CLAYER SILTY SAND WITH BOULDERS AND GRAVEL
	SHALE
	INDURATED SHALE
	DOLERITE

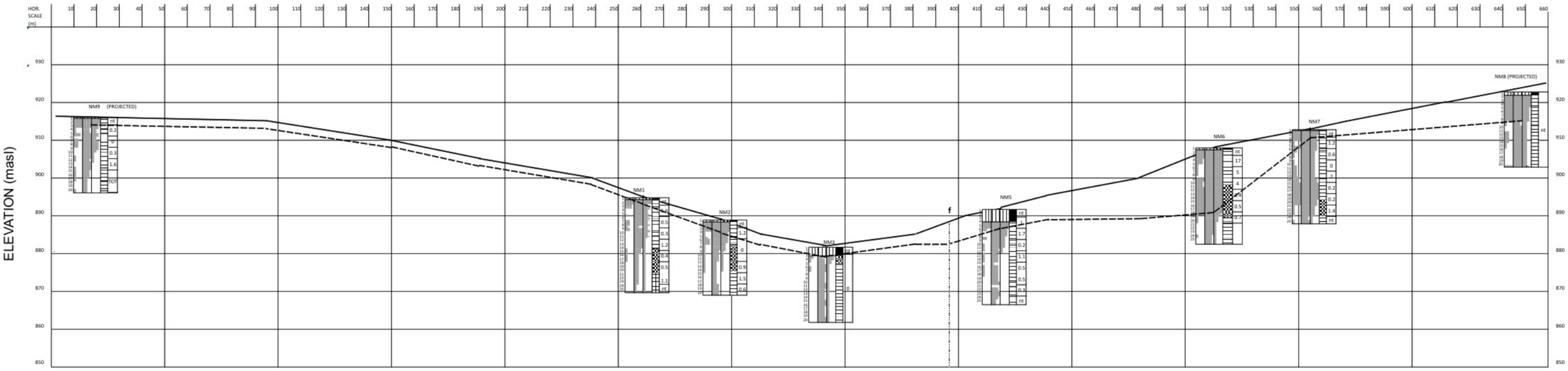
Not to be scaled

MvS30_2013/J01763

AECOM

uMKHOMAZI WATER PROJECT PHASE 1: MODULE 1
TECHNICAL FEASIBILITY STUDY: RAW WATER (UMWP1-1RW) - LANGA DAM SITE

Section A - A: Centre line with core trench and concrete gravity excavation **FIG A6.2**



SECTION LEGEND	
	GROUND SURFACE LINE
	EXCAVATION LINE FOR ROCKFILL SHELLS
f	SUSPECTED FAULT

SECTION LEGEND	
REC / C / R	REC = CORE RECOVERY (C) AND RQD (R)
W / W	W = DEGREE OF WEATHERING. T= MATERIAL TYPE
	CORE RECOVERY AND RQD 95-100%
	CORE RECOVERY AND RQD 75-94%
	CORE RECOVERY AND RQD 50-74%
	CORE RECOVERY AND RQD 26-49%
	CORE RECOVERY AND RQD 0-25%
	UNWEATHERED ROCK
	SLIGHTLY WEATHERED ROCK
	MODERATELY WEATHERED ROCK
	HIGHLY WEATHERED ROCK
	COMPLETELY WEATHERED ROCK
	RESIDUAL AND TRANSPORTED SOILS
	ORGANIC TOPSOIL
	CLAYEY SILTY SAND
	CLAYER SILTY SAND WITH BOULDERS AND GRAVEL
	SHALE
	INDURATED SHALE
	DOLERITE

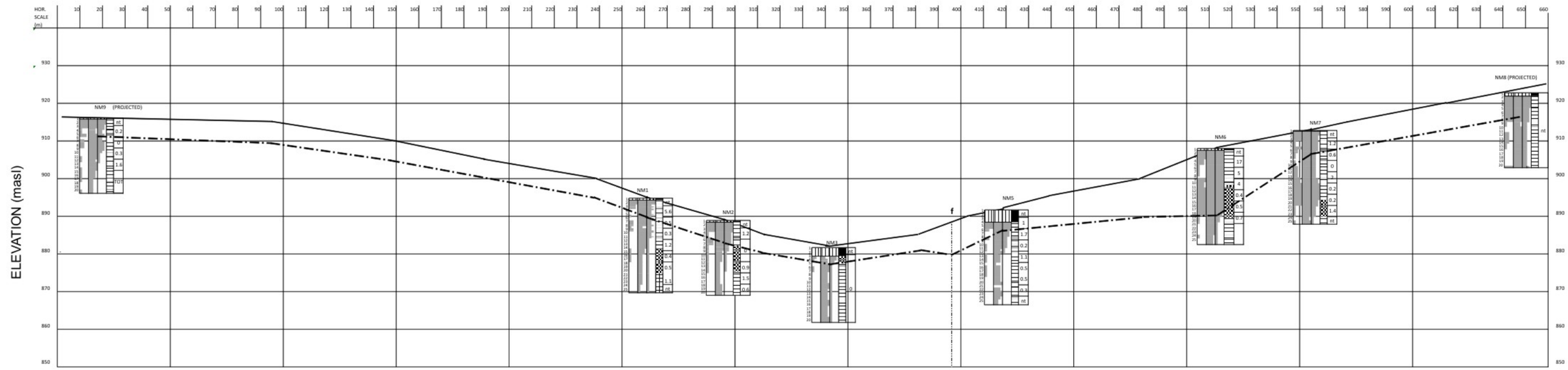
Not to be scaled

MvS31_2013/J01763

AECOM

uMKHOMAZI WATER PROJECT PHASE 1: MODULE 1
TECHNICAL FEASIBILITY STUDY: RAW WATER (UMWP1-1RW) - LANGA DAM SITE

Section A - A: Centre line with rockfill shell excavation **FIG A6.3**



SECTION LEGEND	
	GROUND SURFACE LINE
f	SUSPECTED FAULT
	EXCAVATION LINE FOR PLINTH

SECTION LEGEND	
REC C R	REC = CORE RECOVERY (C) AND RQD (R)
W SM HC T	W = DEGREE OF WEATHERING. T= MATERIAL TYPE
	CORE RECOVERY AND RQD 95-100%
	CORE RECOVERY AND RQD 75-94%
	CORE RECOVERY AND RQD 50-74%
	CORE RECOVERY AND RQD 26-49%
	CORE RECOVERY AND RQD 0-25%
	UNWEATHERED ROCK
	SLIGHTLY WEATHERED ROCK
	MODERATELY WEATHERED ROCK
	HIGHLY WEATHERED ROCK
	COMPLETELY WEATHERED ROCK
	RESIDUAL AND TRANSPORTED SOILS
	ORGANIC TOPSOIL
	CLAYEY SILTY SAND
	CLAYER SILTY SAND WITH BOULDERS AND GRAVEL
	SHALE
	INDURATED SHALE
	DOLERITE

Not to be scaled

MvS32_2013/J01763

AECOM

uMKHOMAZI WATER PROJECT PHASE 1: MODULE 1
TECHNICAL FEASIBILITY STUDY: RAW WATER (UMWP1-1RW) - LANGA DAM SITE

Section A - A: Centre line with rockfill plinth excavation **FIG A6.4**

Annexure B

Test pit profiles

Langa Dam centre line

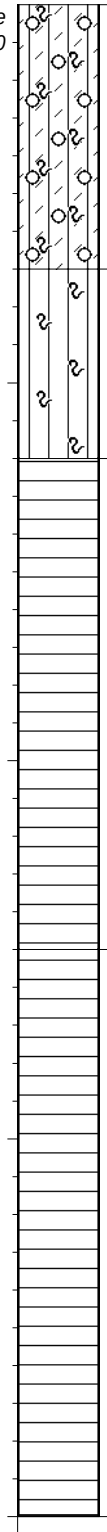
(MTP1, MTP2, MTP4)

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 1
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:20



0.00

Moist reddish brown firm clayey SILT with scattered sub angular soft rock shale gravel and roots. COLLUVIUM.

0.70

Slightly moist reddish brown blotched light brown firm fissured SILT with roots. ALLUVIUM.

1.20

Khaki brown highly weathered to moderately weathered laminated jointed (sub vertical joints closely spaced reddish brown clay infill at joints) soft rock SHALE. Northern face dip and dip direction; 90/284, 55/305, 70/300,85/035 & 10/341 eastern face 10/305, 65/231, 80/155, 85/214 & 75/149.

2.50

Reddish brown becoming light yellow orange highly weathered laminated jointed (sub vertical joints closely spaced reddish brown clay infill at joints) soft rock SHALE with lenses of grey unweathered hard rock shale.

4.00

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) No samples taken.

4) Difficult excavation at 4.0m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 12/02/2013

ELEVATION :
X-COORD : X3296981
Y-COORD : 31 Y0067498

HOLE No: MTP 1

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

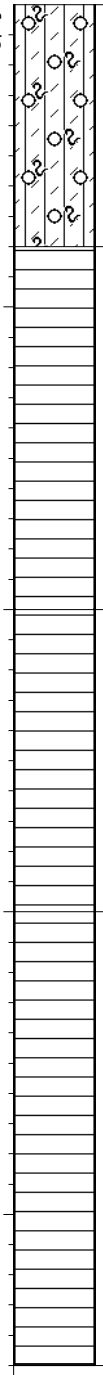
DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 2
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:25



0.00

Moist reddish brown firm clayey SILT with scattered sub angular soft rock shale gravel and roots.COLLUVIUM.

0.80

Khaki brown highly weathered very soft to soft rock SHALE with reddish brown clay infill at joints.

2.00

Khaki brown highly weathered to moderately weathered laminated jointed (sub vertical joints closely spaced reddish brown clay infill at joints) soft rock SHALE. Northern face dip and dip direction; 83/293, 80/100, 85/174,85/353 & 82/104 western face 85/256, 80/159 & 25/002.

3.00

Grey slightly weathered laminated jointed medium hard rock SHALE. Northern face dip and dip direction; 50/261 & 23/293. Eastern face 85/278 & 82/345.

4.50

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) No samples taken.

4) Difficult excavation at 4.5m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 12/02/2013

ELEVATION :
X-COORD : X3296922
Y-COORD : 31 Y0067547

HOLE No: MTP 2

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

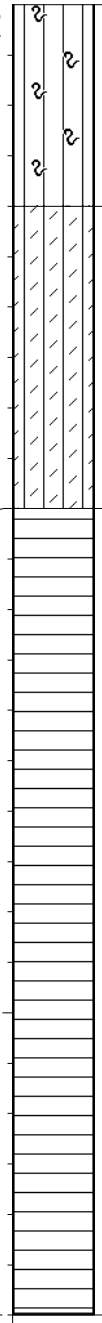
DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 4
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:15



0.00

Moist reddish brown firm intact SILT with roots. TRANSPORTED.

0.40

Moist reddish brown blotched light yellow firm fissured clayey SILT. ALLUVIUM.

1.00

Khaki brown highly weathered thinly bedded soft rock SHALE.

1.0--2.6m

2.60

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) Bulk and disturbed samples taken 1.0--2.6m.

4) Difficult excavation at 2.6m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 13/02/2013

ELEVATION :
X-COORD : X3296898
Y-COORD : 31 Y0067849

HOLE No: MTP 4

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

Borrow area

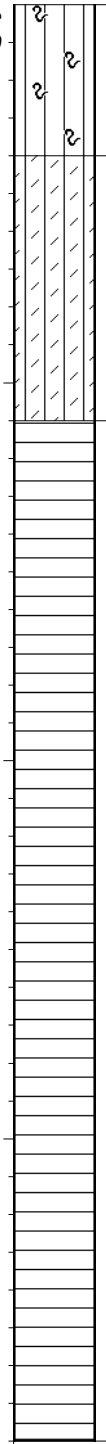
(MTP5, MTP7-MTP18)

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 5
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:20



0.00

Moist reddish brown firm intact SILT with roots. TRANSPORTED.

0.40

Moist reddish brown blotched light yellow brown firm fissured clayey SILT. ALLUVIUM.

1.10

Khaki brown laminated grey highly weathered thinly bedded soft rock SHALE.

3.80

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) No samples taken.

4) Difficult excavation at 3.8m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM : Trench
DATE :
DATE : 13/02/2013

DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

ELEVATION :
X-COORD : X3297099
Y-COORD : 31 Y0068039

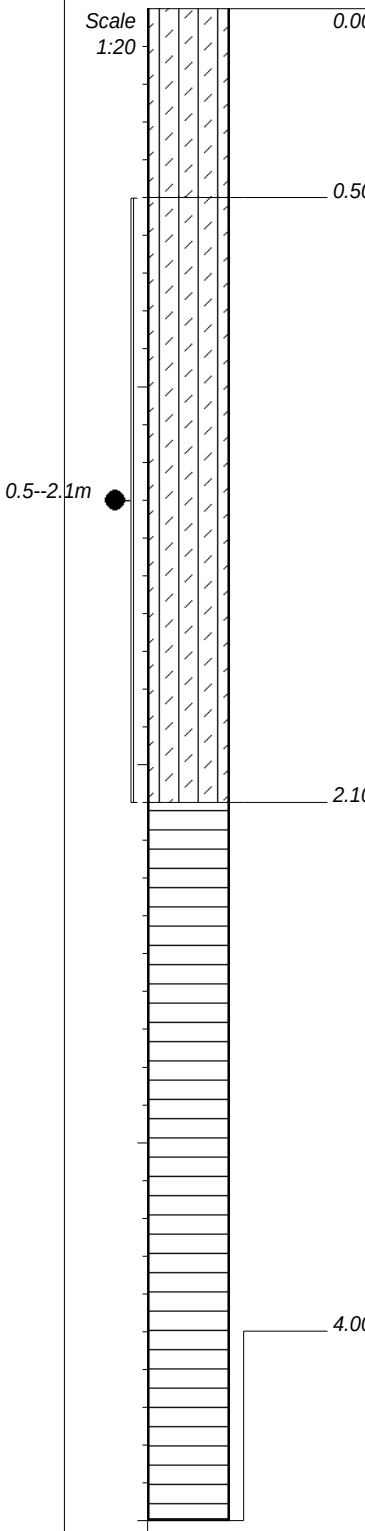
HOLE No: MTP 5

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 7
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:20



0.00

Moist brown firm intact clayey SILT. TRANSPORTED.

0.50

Moist reddish brown blotched light brown firm fissured clayey SILT. ALLUVIUM.

2.10

Khaki brown highly weathered very soft rock to soft rock SHALE.

4.00

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) Bulk and disturbed samples taken at 0.5--2.1m.

4) Difficult excavation at 4.0m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 13/02/2013

ELEVATION :
X-COORD : X3297273
Y-COORD : 31 Y0068251

HOLE No: MTP 7

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

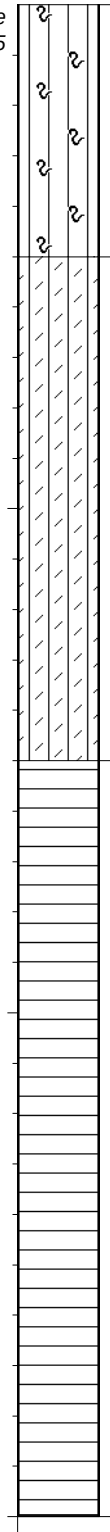
DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 8
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:15



0.00

Moist brown firm intact SILT with roots. TRANSPORTED.

0.50

Moist reddish brown blotched light brown firm fissured clayey SILT. ALLUVIUM.

1.50

Khaki brown streaked pink highly weathered thinly bedded soft rock SHALE.

3.00

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) No samples taken.

4) Difficult excavation at 3.0m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 12/02/2013

ELEVATION :
X-COORD : X3297600
Y-COORD : 31 Y0068100

HOLE No: MTP 8

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

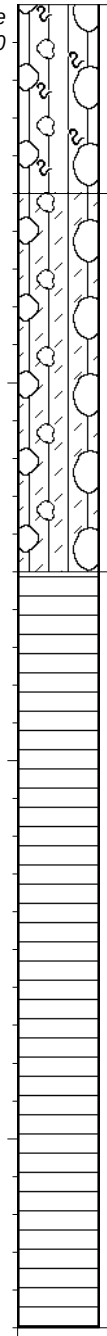
DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 9
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:20



0.00

Abundant (>60%) of khaki brown highly weathered angular soft rock shale COBBLES with minor brown silt and roots. TRANSPORTED.

0.50

Moist reddish brown laminated grey clayey SILT with abundant angular soft rock shale cobbles (max size. 200mm). Overall consistency is firm. COLLUVIUM.

1.50

Khaki brown highly weathered with lenses of completely weathered zones (100mm) thinly bedded soft rock SHALE.

3.50

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) No samples taken.

4) Difficult excavation at 3.5m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 12/02/2013

ELEVATION :
X-COORD : X3297800
Y-COORD : 31 Y0068169

HOLE No: MTP 9

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

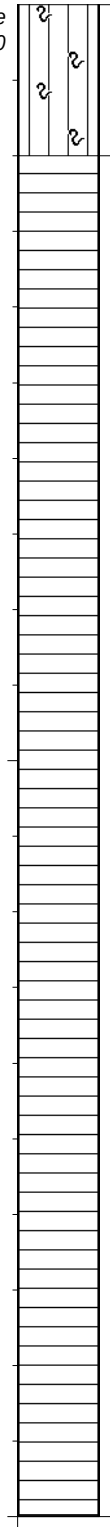
DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 10
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:10



0.00

Moist brown firm intact SILT with roots. TRANSPORTED.

0.20

Khaki brown highly weathered to moderately weathered thinly bedded with lenses of reddish brown clay infill (200mm) soft rock to medium hard rock SHALE.

2.00

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) No samples taken.

4) Difficult excavation at 2.0m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 12/02/2013

ELEVATION :
X-COORD : X3297829
Y-COORD : 31 Y0068000

HOLE No: MTP 10

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

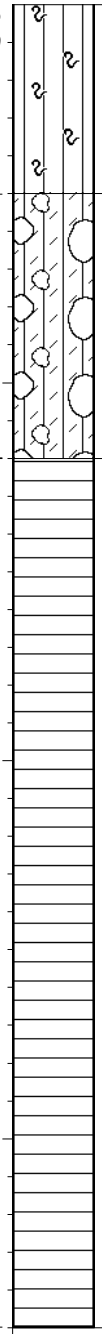
DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 11
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:20



0.5--1.2m

1.2--3.5m

0.00 Moist brown firm intact SILT with roots. TRANSPORTED.

0.50 Moist brown firm intact clayey SILT with abundant angular soft rock shale cobbles (max.size 50mm). COLLUVIUM.

1.20 Khaki brown highly weathered thinly bedded soft rock SHALE.

3.50

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) Disturbed samples taken at 0.5--1.2m and 1.2--3.5m.

4) Difficult excavation at 3.5m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 12/02/2013

ELEVATION :
X-COORD : X3297696
Y-COORD : 31 Y0067950

HOLE No: MTP 11

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

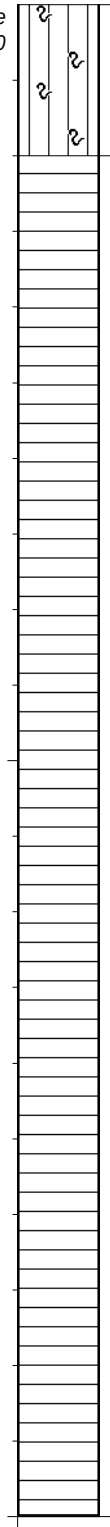
DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 12
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:10



0.00

Moist brown soft SILT with scattered and roots. TRANSPORTED.

0.20

Khaki brown highly weathered to moderately weathered thinly bedded with lenses of reddish brown clay infill (200mm) soft rock to medium hard rock SHALE with lenses of grey hard rock shale at 1.2m to 1.4m.

2.00

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) No samples taken.

4) Difficult excavation at 2.0m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 12/02/2013

ELEVATION :
X-COORD : X3297815
Y-COORD : 31 Y0067886

HOLE No: MTP 12

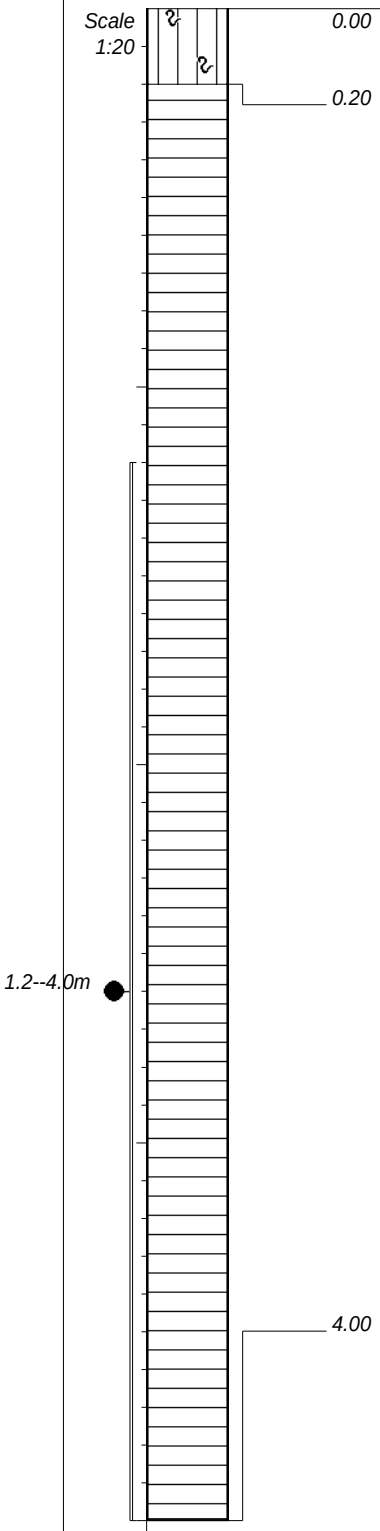
TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 13
Sheet 1 of 1

JOB NUMBER: J01763



0.00

Moist brown soft SILT with scattered and roots. TRANSPORTED.

0.20

Khaki brown highly weathered to moderately weathered thinly bedded with lenses of reddish brown clay infill soft rock to medium hard rock SHALE.

4.00

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) Bulk and disturbed samples taken at 1.2--4.0m.

4) Difficult excavation at 4.0m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 12/02/2013

ELEVATION :
X-COORD : X32975634
Y-COORD : 31 Y0067865

HOLE No: MTP 13

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

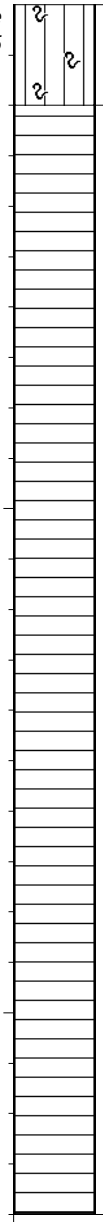
DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 14
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:15



0.00

Moist brown soft SILT with scattered and roots. TRANSPORTED.

0.20

Khaki brown highly weathered to moderately weathered thinly bedded jointed (sub vertical joints closely spaced reddish brown clay infill at joints) soft rock to medium hard rock SHALE.

2.40

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) No samples taken.

4) Difficult excavation at 2.4m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 12/02/2013

ELEVATION :
X-COORD : X3297509
Y-COORD : 31 Y0067849

HOLE No: MTP 14

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

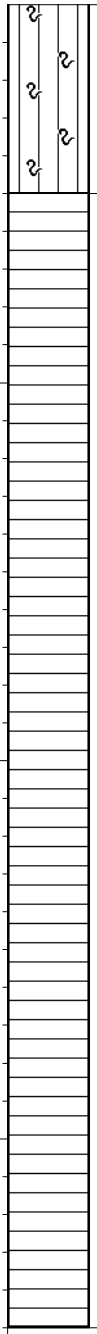
DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 15
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:20



0.5--3.5m

0.00

Abundant (>60%) of khaki brown highly weathered angular soft rock shale with minor brown silt and roots tending to soft rock. TRANSPORTED?

0.50

Khaki brown highly weathered thinly bedded soft rock SHALE.

3.50

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) Bulk and disturbed samples taken at 0.5--3.5m.

4) Difficult excavation at 3.5m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 13/02/2013

ELEVATION :
X-COORD : X3297310
Y-COORD : 31 Y0067986

HOLE No: MTP 15

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

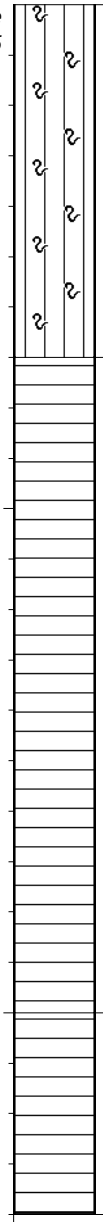
DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 16
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:15



0.00

Moist brown soft SILT with scattered and roots. TRANSPORTED.

0.70

Khaki brown highly weathered to moderately weathered thinly bedded jointed (sub vertical joints closely spaced reddish brown clay infill at joints) soft rock to medium hard rock SHALE.

2.00

Grey unweathered medium hard rock thinly bedded SHALE.

2.40

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) No samples taken.

4) Difficult excavation at 2.4m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 12/02/2013

ELEVATION :
X-COORD : X3297335
Y-COORD : 31 Y0067803

HOLE No: MTP 16

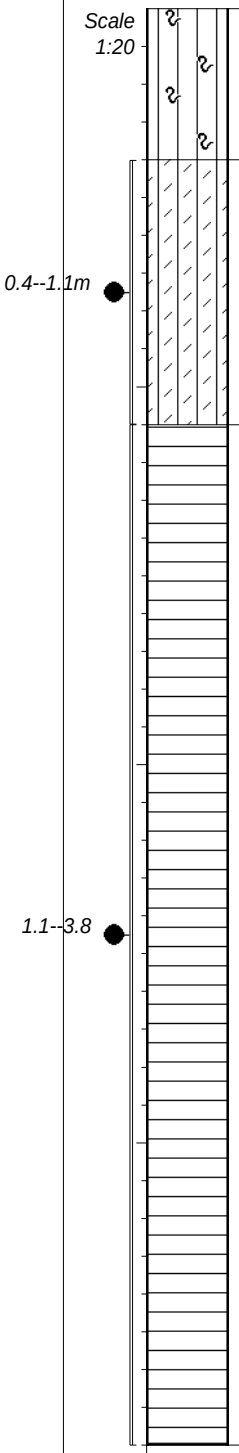
TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

Department: Water Affairs
New upper Mbalingwe
Borrow MTP

HOLE No: MTP 18
Sheet 1 of 1

JOB NUMBER: J01763



0.00

Moist reddish brown firm intact SILT with roots. TRANSPORTED.

0.40

Moist reddish brown blotched light yellow firm fissured clayey SILT. ALLUVIUM.

1.10

Khaki brown highly weathered thinly bedded soft rock SHALE.

3.80

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) Disturbed samples taken 0.4--1.1m and 1.1--3.8.

4) Difficult excavation at 3.8m.

CONTRACTOR : Geomechanics
MACHINE : 20 Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 13/02/2013

ELEVATION :
X-COORD : X3297081
Y-COORD : 31 Y0067883

HOLE No: MTP 18

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

DATE : 03/06/2013 14:29
TEXT : ..eaMTPTestpitprofiles.txt

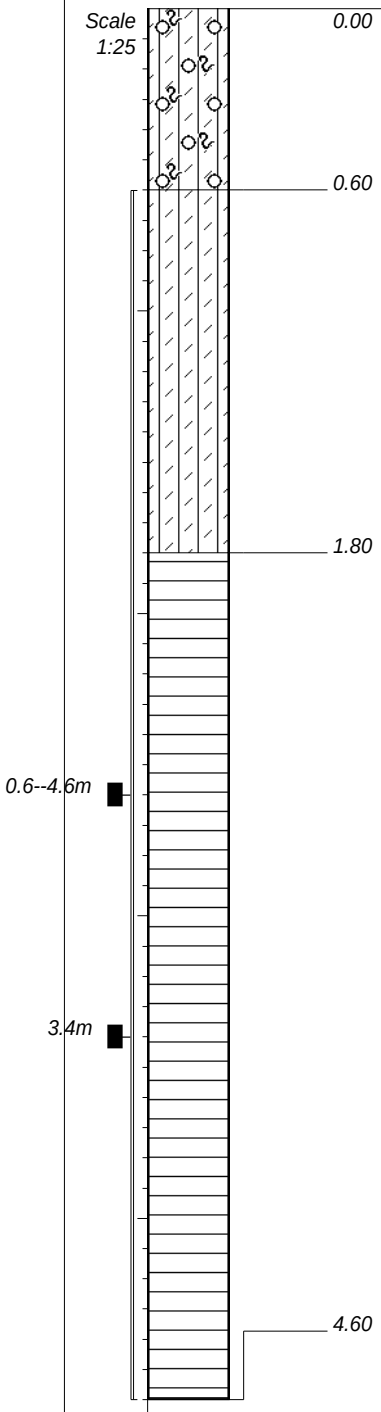
Tunnel outlet portal

(TP01-TP04)

Department: Water Affairs
Baynesfield
Tunnel Portal-Outlet

HOLE No: TPO1
Sheet 1 of 1

JOB NUMBER: J01763



0.00

Moist brown shattered firm clayey SILT with scattered sub-rounded slightly weathered soft rock siltstone fine gravel and roots. COLLUVIUM.

0.60

Moist light brown mottled red and grey firm to stiff clayey SILT. RESIDUAL SHALE with relict bedding and lamination.

1.80

Orange reddish brown grey highly weathered thinly bedded to laminated with subvertical jointing soft rock SHALE. Clay-infill at 2.7m and 3.4m. Jointing dip and dip directions: 30/323; 65/148; 55/106; 56/310 and 75/260.

4.60

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) Bulk, disturbed samples taken 0.6--4.6m and undisturbed sample taken at 3.4m.

4) Excavated to refusal at 4.6m.

CONTRACTOR : Geomechanics
MACHINE : 20Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 11/02/2013

ELEVATION :
X-COORD : X3295236
Y-COORD : 31 Y0067415

HOLE No: TPO1

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

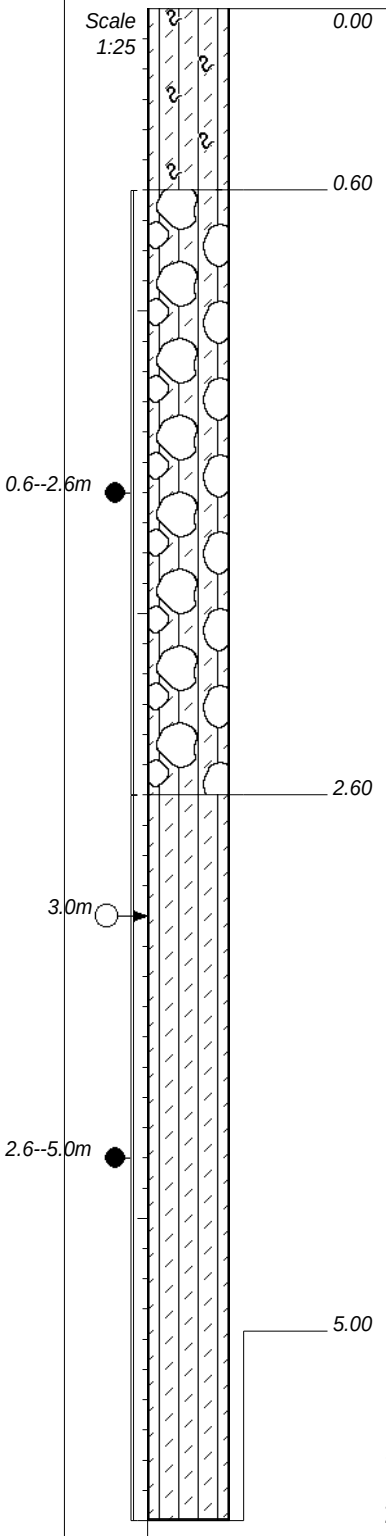
DATE : 18/06/2013 12:30
TEXT : ..\TunnelPortalsOutlet.txt

Department: Water Affairs
Baynesfield
Tunnel Portal-Outlet

HOLE No: TPO2
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:25



0.00

Moist brown to reddish brown fissured firm clayey SILT with roots. TRANSPORTED.

0.60

Moist light brown mottled reddish brown fissured clayey SILT with scattered angular slightly weathered hard rock siltstone and shale cobbles and boulders (max.size 600mm). Overall consistency is firm to stiff. COLLUVIUM.

2.60

Moist light brown blotched red and grey stiff clayey SILT. RESIDUAL SHALE.

5.00

NOTES

1) Groundwater seepage encountered at 3.0m.

2) Sidewalls unstable.

3) Disturbed samples taken 0.6--2.6m and 2.6--5.0m.

4) Excavated to maximum reach of machine.

CONTRACTOR : Geomechanics
MACHINE : 20Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 11/02/2013

ELEVATION :
X-COORD : X3295219
Y-COORD : 31 Y0067425

HOLE No: TPO2

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

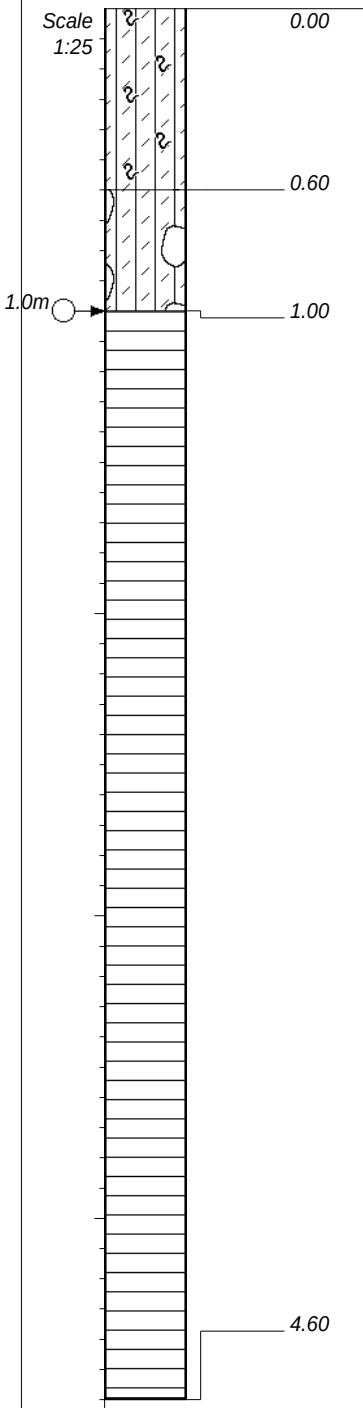
DATE : 18/06/2013 12:30
TEXT : ..\TunnelPortalsOutlet.txt

Department: Water Affairs
Baynesfield
Tunnel Portal-Outlet

HOLE No: TPO3
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:25



0.00

Moist brown shattered firm clayey SILT with roots. TRANSPORTED.

0.60

Moist light brown clayey SILT with scattered angular highly weathered hard rock siltstone and shale cobbles. Overall consistency is firm to stiff. COLLUVIUM.

1.00

Grey highly weathered thinly bedded closely jointed soft rock SHALE. Clay-infill at joints. Jointing dip and dip directions north face: 60/155; 75/278; south face 89/315; 80/156 and east face 60/160; 74/290; 50/351.

4.60

NOTES

1) Groundwater seepage encountered at 1.0m.

2) Sidewalls unstable.

3) No samples taken.

4) Excavated to refusal at 4.6m on highly weathered soft rock shale.

CONTRACTOR : Geomechanics
MACHINE : 20Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 11/02/2013

ELEVATION :
X-COORD : X3295191
Y-COORD : 31 Y0067456

HOLE No: TPO3

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

DATE : 18/06/2013 12:30
TEXT : ..\TunnelPortalsOutlet.txt

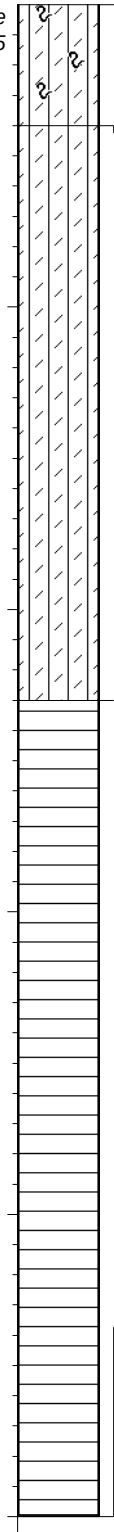
AECOM

Department: Water Affairs
Baynesfield
Tunnel Portal-Outlet

HOLE No: TPO4
Sheet 1 of 1

JOB NUMBER: J01763

Scale 1:25



0.00

Moist brown intact firm clayey SILT with sub-rounded to subangular highly weathered soft rock shale and roots. TRANSPORTED.

0.40

Moist reddish brown blotched light brown clayey SILT. RESIDUAL SHALE.

2.30

Khaki to light brown highly weathered thinly bedded soft rock SHALE.

5.00

NOTES

1) No groundwater seepage encountered.

2) Sidewalls stable.

3) No samples taken.

4) Excavated to maximum reach of the machine.

CONTRACTOR : Geomechanics
MACHINE : 20Tonne Excavator
DRILLED BY :
PROFILED BY : G.Rabodiba

INCLINATION :
DIAM : Trench
DATE :
DATE : 13/02/2013

ELEVATION :
X-COORD : X3295175
Y-COORD : 31 Y0067405

HOLE No: TPO4

TYPE SET BY : G.Rabodiba
SETUP FILE : STANDARD.SET

DATE : 18/06/2013 12:30
TEXT : ..\TunnelPortalsOutlet.txt

Laboratory test results

Foundation indicator tests

(borrow area)

sanas Testing Laboratory T0023

GEOSTRADA engineering materials laboratory

FOUNDATION INDICATOR TEST RESULTS - REP COM 7

Client:	**Geomechanics**	**Source/Location:**		**Job No:**	**2013-C-184**
Project Name:	**J01763: uMkhomazi Samples**	**Layer:**		**Sample No:**	**3/1361**
Project No:		**Lane:**		**Date:**	**2013/03/27**
Hole/TP No:	**MTP7**	**Stabilizing Agent:**		**Test Method:**	**TMH1 A1, A5 & MT1**
Depth:		**Section:**		**Client Ref No:**	
Description:	**Upper New Mbalingwe Dam**	**Chainage:**		**GPS X:**	
Additional Info:		**Offset:**		**GPS Y:**	

SIEVE ANALYSIS

Sieve (mm)	% Passing	Sieve (mm)	% Passing
75.0	**100**	0.425	**71**
63.0	**100**	0.250	**70**
53.0	**100**	0.150	**69**
37.5	**100**	0.075	**68**
26.5	**100**	0.060	**40**
19.0	**100**	0.050	**38**
13.2	**100**	0.020	**30**
9.5	**100**	0.005	**18**
4.75	**96**	0.002	**11**
2.00	**85**		

ATTERBERG LIMITS

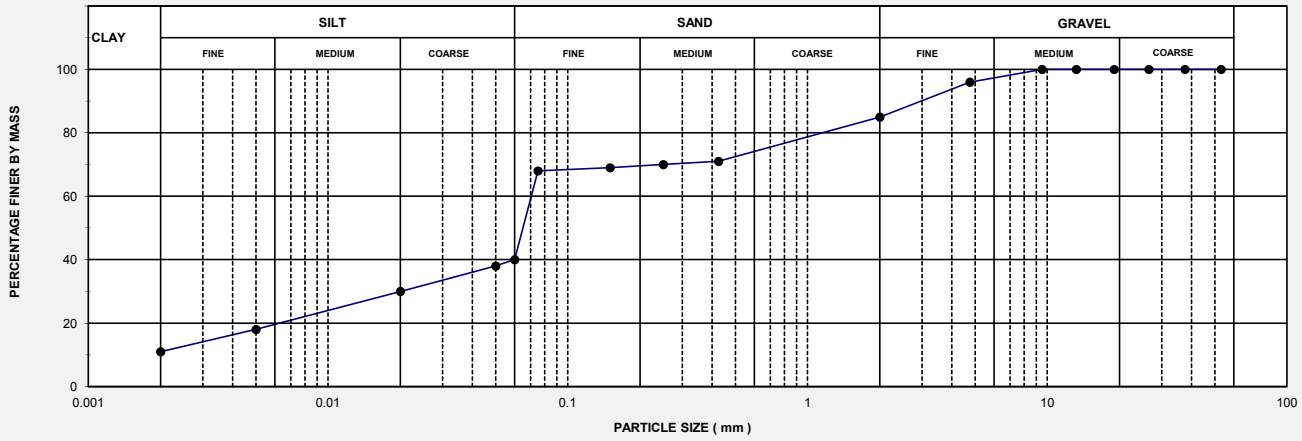
Liquid Limit	(%)	**47**
Plastic Limit	(%)	**26**
Plasticity Index	(%)	**21**
Weighted PI	(%)	**15**
Linear Shrinkage	(%)	**8.5**
Grading Modulus		**0.76**
Uniformity coefficient		**35**
Coefficient of curvature		**3.4**

Remarks:

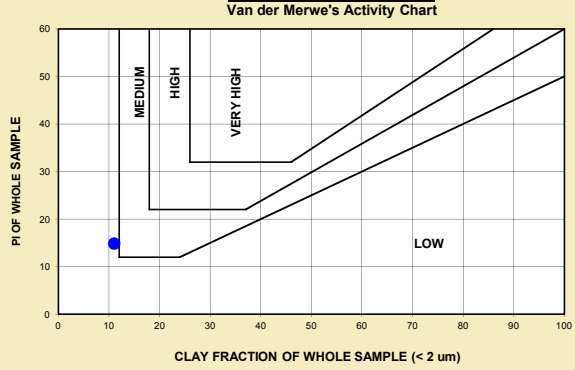
SOIL CLASSIFICATION

% Gravel	**15**
% Sand	**45**
% Silt	**29**
% Clay	**11**
Activity	**1.9**
Unified Classification	**CL**
TRB Classification	**A - 7 - 6**

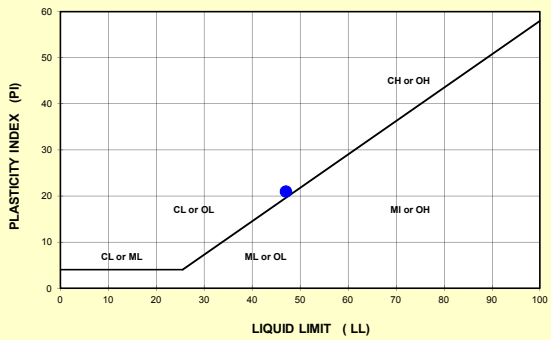
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



sanas Testing Laboratory T0023

GEOSTRADA engineering materials laboratory

FOUNDATION INDICATOR TEST RESULTS - REP COM 7

Client:	**Geomechanics**	**Source/Location:**		**Job No:**	**2013-C-184**
Project Name:	**J01763: uMkhomazi Samples**	**Layer:**		**Sample No:**	**3/1362**
Project No:		**Lane:**		**Date:**	**2013/03/27**
Hole/TP No:	**MTP13**	**Stabilizing Agent:**		**Test Method:**	**TMH1 A1, A5 & MT1**
Depth:		**Section:**		**Client Ref No:**	
Description:	**Upper New Mbalingwe Dam**	**Chainage:**		**GPS X:**	
Additional Info:		**Offset:**		**GPS Y:**	

SIEVE ANALYSIS

Sieve (mm)	% Passing	Sieve (mm)	% Passing
75.0	**100**	0.425	**61**
63.0	**100**	0.250	**60**
53.0	**100**	0.150	**59**
37.5	**100**	0.075	**58**
26.5	**100**	0.060	**32**
19.0	**96**	0.050	**31**
13.2	**91**	0.020	**28**
9.5	**86**	0.005	**17**
4.75	**79**	0.002	**9**
2.00	**71**		

ATTERBERG LIMITS

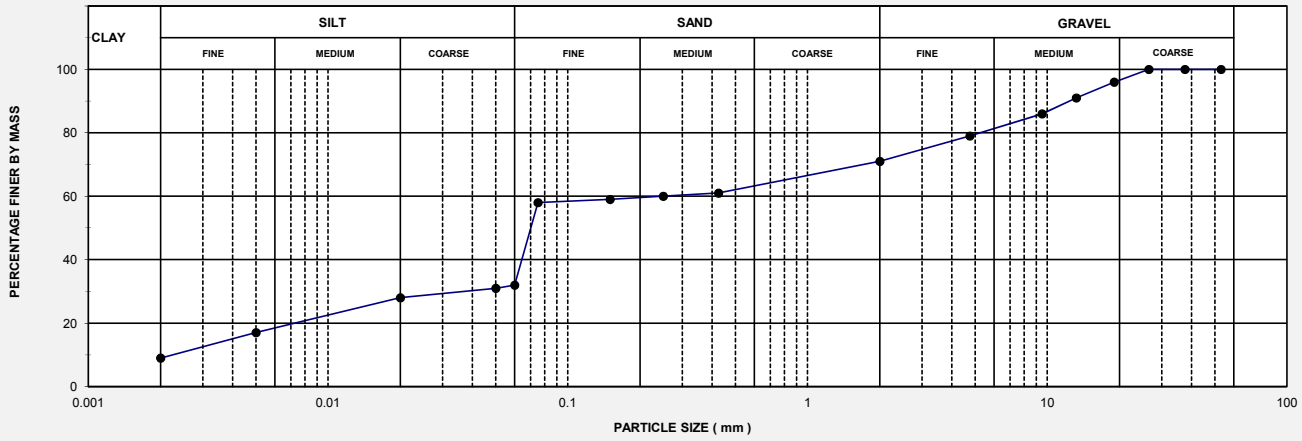
Liquid Limit	(%)	**42**
Plastic Limit	(%)	**27**
Plasticity Index	(%)	**15**
Weighted PI	(%)	**9**
Linear Shrinkage	(%)	**5.5**
Grading Modulus		**1.10**
Uniformity coefficient		**105**
Coefficient of curvature		**3.0**

Remarks:

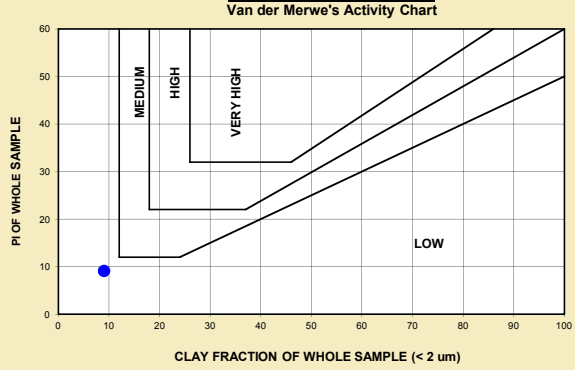
SOIL CLASSIFICATION

% Gravel	**29**
% Sand	**39**
% Silt	**23**
% Clay	**9**
Activity	**1.7**
Unified Classification	**ML or OL**
TRB Classification	**A - 7 - 6**

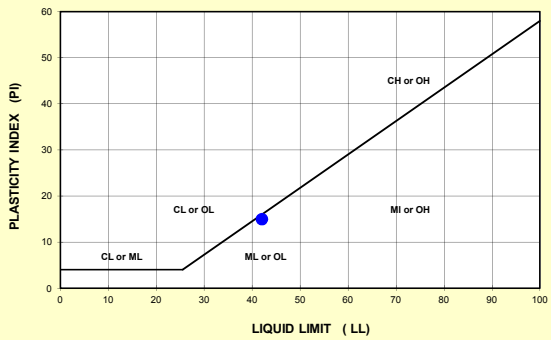
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



sanas Testing Laboratory T0023

GEOSTRADA engineering materials laboratory

FOUNDATION INDICATOR TEST RESULTS - REP COM 7

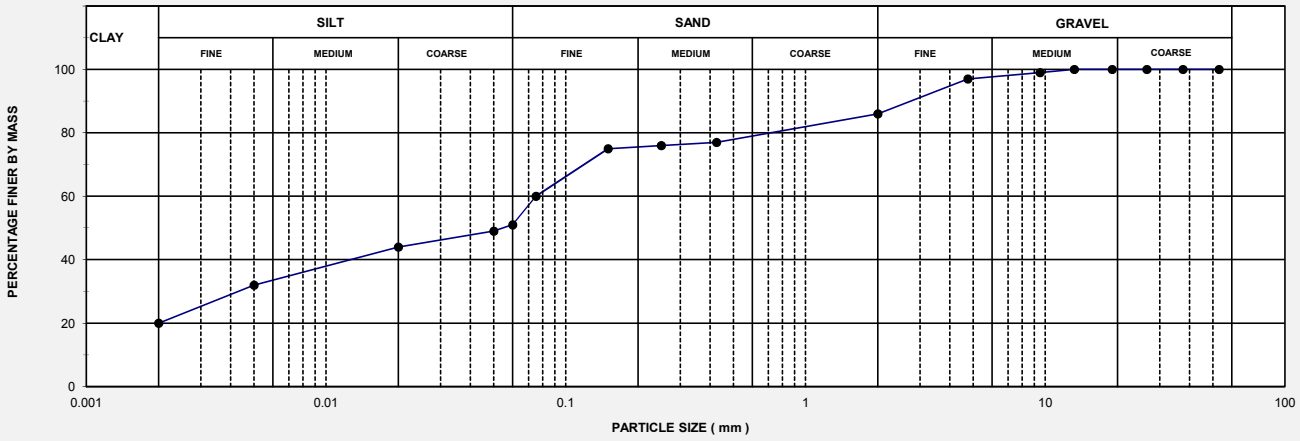
Client:	**Geomechanics**	**Source/Location:**		**Job No:**	**2013-C-184**
Project Name:	**J01763: uMkhomazi Samples**	**Layer:**		**Sample No:**	**3/1363**
Project No:		**Lane:**		**Date:**	**2013/03/27**
Hole/TP No:	**MTP18**	**Stabilizing Agent:**		**Test Method:**	**TMH1 A1, A5 & MT1**
Depth:	**0.4 - 1.1**	**Section:**		**Client Ref No:**	
Description:	**Upper New Mbalingwe Dam**	**Chainage:**		**GPS X:**	
Additional Info:		**Offset:**		**GPS Y:**	

SIEVE ANALYSIS			
Sieve (mm)	% Passing	Sieve (mm)	% Passing
75.0	**100**	0.425	**77**
63.0	**100**	0.250	**76**
53.0	**100**	0.150	**75**
37.5	**100**	0.075	**60**
26.5	**100**	0.060	**51**
19.0	**100**	0.050	**49**
13.2	**100**	0.020	**44**
9.5	**99**	0.005	**32**
4.75	**97**	0.002	**20**
2.00	**86**		

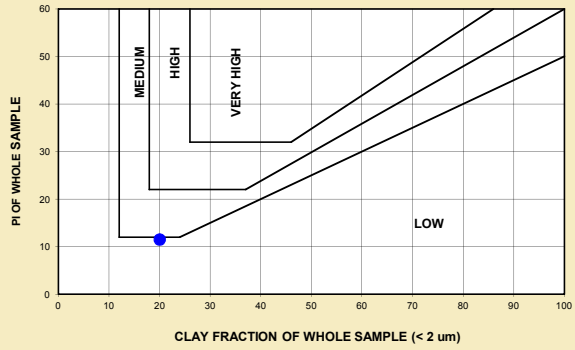
ATTERBERG LIMITS		
Liquid Limit	(%)	**48**
Plastic Limit	(%)	**33**
Plasticity Index	(%)	**15**
Weighted PI	(%)	**12**
Linear Shrinkage	(%)	**6.5**
Grading Modulus		**0.77**
Uniformity coefficient		**38**
Coefficient of curvature		**0.1**
Remarks:		

SOIL CLASSIFICATION	
% Gravel	**14**
% Sand	**35**
% Silt	**31**
% Clay	**20**
Activity	**0.8**
Unified Classification	**ML or OL**
TRB Classification	**A - 7 - 5**

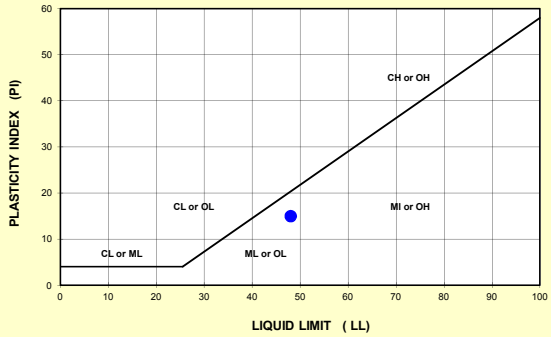
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



Double hydrometer tests

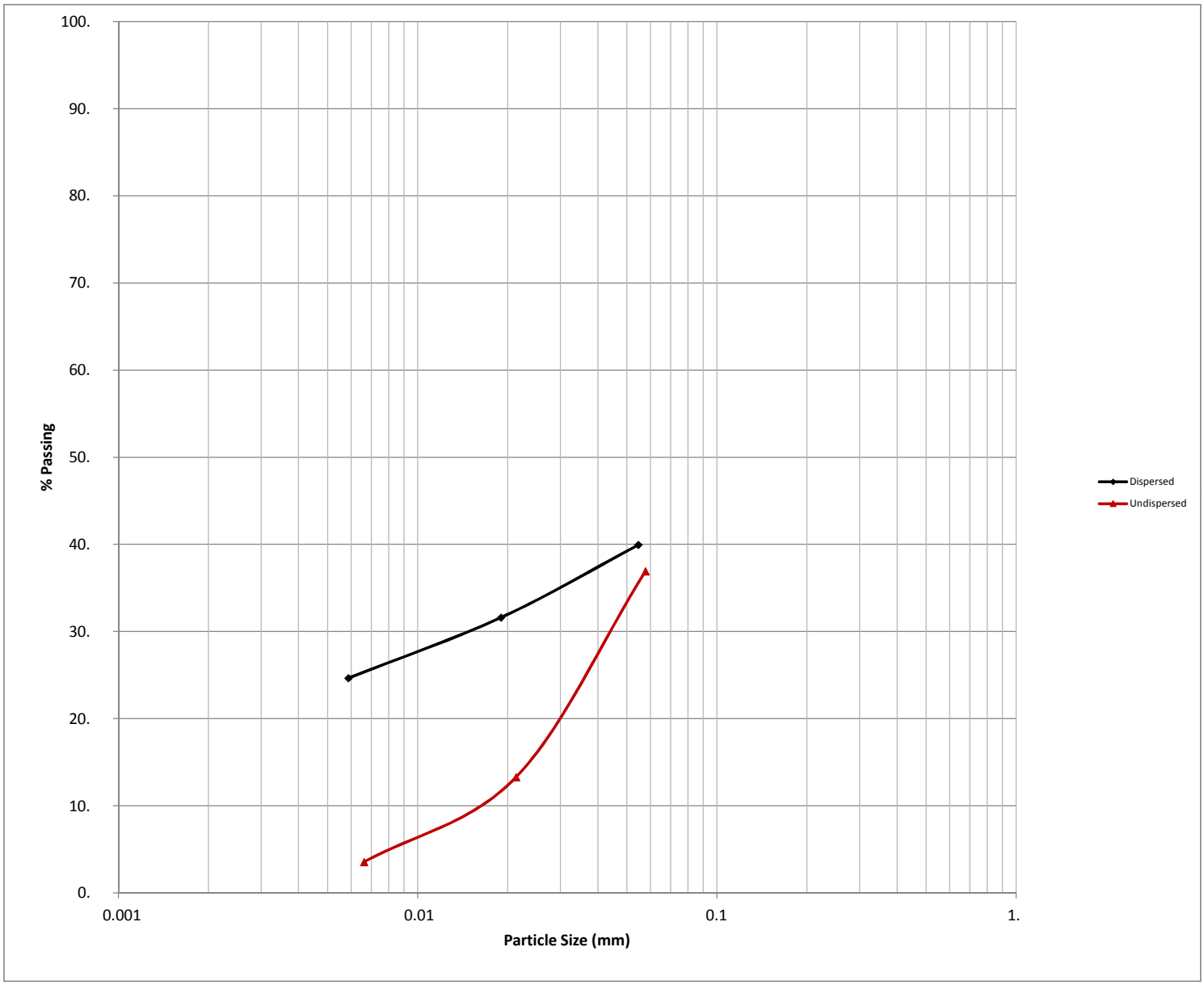
(borrow area)

GEOSTRADA	Double Hydrometer Test Result	ASTM D4221

Client Geomechanics **Project** J01763: uMkhomazi: Smithfield Dam **Job no** 2013-C-395

Sample no TP A10 + A17 + A19 **Depth (m)** - **Date** 10/05/2013

Lab no 3/2838



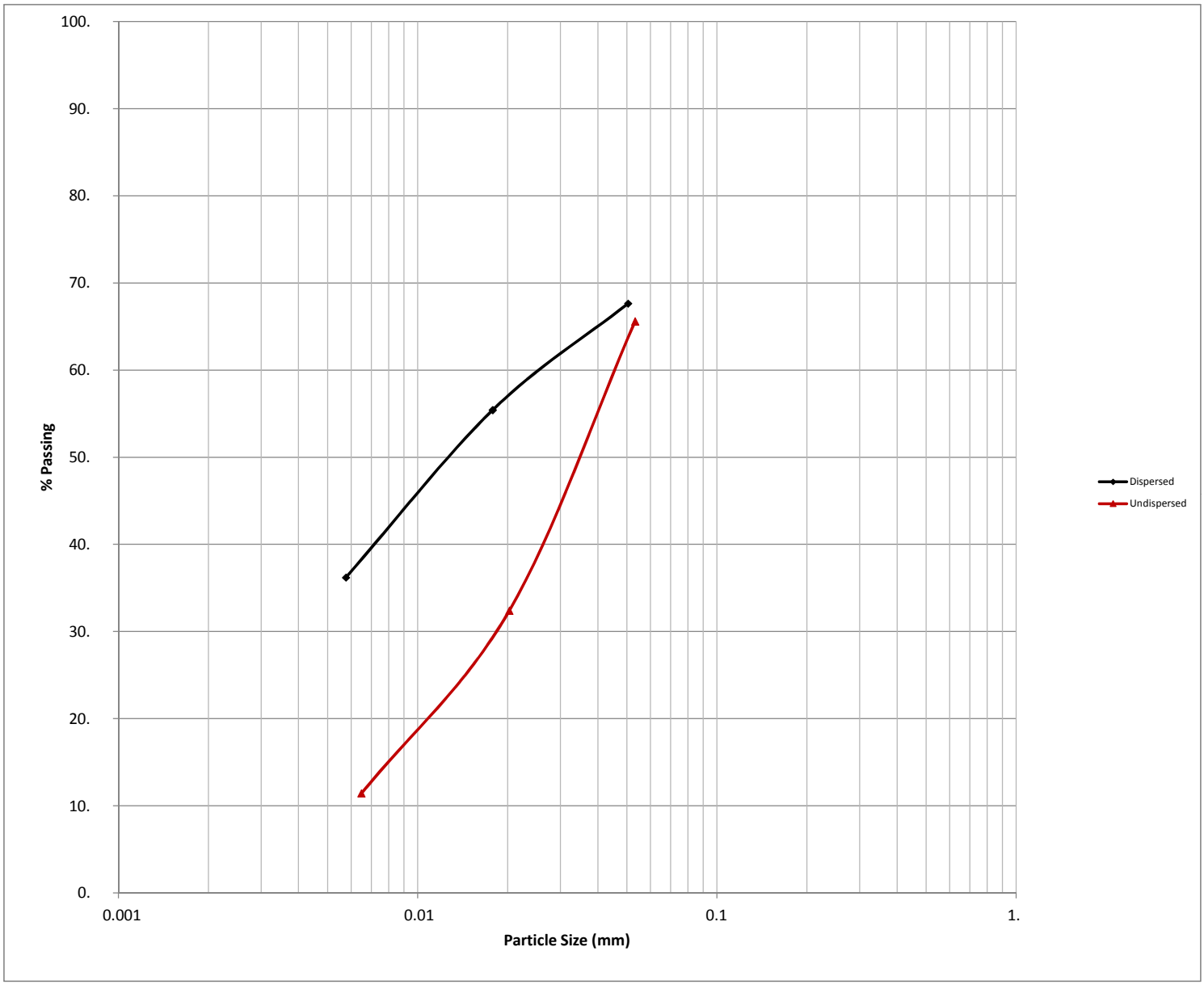
Dispersion: **14%**

GEOSTRADA	Double Hydrometer Test Result	ASTM D4221

Client Geomechanics **Project** J01763: uMkhomazi: Smithfield Dam **Job no** 2013-C-395

Sample no TP A15 + A22 + B9 **Depth (m)** - **Date** 10/05/2013

Lab no 3/2839



Dispersion: **32%**

Various test results

(tunnel outlet portal)

sanas Testing Laboratory T0023

GEOSTRADA engineering materials laboratory

SUMMARY OF TEST RESULTS ON SOILS - REP COM 2

Client: Aecom **Project:** uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study **Project Number:** J01763 **Job No:** 2013-C-746 Date: 30/07/2013

Sample No	Hole No / TP No	Depth (mm)	Description	Percentage Passing Sieve (mm) - TMH1 A1, A5, MT1																			% Gravel > 2.00 mm	% Sand 2.00 - 0.060 mm	% Silt 0.060-0.002 mm	% Clay < 0.002mm	Atterberg Limits (TMH1 A2-A4) < 0.425 mm			Maximum Dry Density (kg/m³) & OMC (%) (TMH1 A7)		CBR (Modified AASHTO) TMH1 A8						
				Sieve Analysis																																	
				53.0	37.5	26.5	19.0	13.2	9.5	4.75	2.00	0.425	0.250	0.150	0.075	0.060	0.050	0.020	0.005	0.002	GM					LL	PI	LS			% Swell	90%	93%	95%	97%	98%	100%
3/5439	TPE1	50 - 500	Clayey Silt with cobbles					100	99	95	81	57	52	49	47	43	42	38	29	24	1.15	19	38	19	24	40	19	7.5	1795	10.8	0.1	15	24	32	42	48	63
3/5442	TPO2	60 - 260	Clayey Silt with cobbles			100	95	95	93	90	88	87	87	87	86	86	84	73	60	50	0.39	12	2	36	50	57	27	12.0	1881	16.4	0.5	3.1	4.7	6.2	8.4	10	13
3/5443	BH2	175 - 225	Clayey Sand with gravel & cobbles						100	99	92	88	87	87	87	86	85	78	68	62	0.33	8	6	24	62	51	25	9.5									
3/5444	BH7	350 - 400	Sandy Clay								100	99	98	98	96	94	91	77	73	67	0.05	0	6	27	67	58	23	12.5									

Remarks: * Sample flocculated

T0023

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FOUNDATION INDICATOR TEST RESULTS - REP COM 7

Client:	**Aecom**	**Source/Location:**		**Job No:**	**2013-C-746**
Project Name:	**uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study**	**Layer:**		**Sample No:**	**3/5442**
Project No:	**J01763**	**Lane:**		**Date:**	**30/07/2013**
Hole/TP No:	**TPO2**	**Stabilizing Agent:**		**Test Method:**	**TMH1 A1, A5 & MT1**
Depth (mm):	**60 - 260**	**Section:**		**Client Ref No:**	
Description:	**Clayey Silt with cobbles**	**Chainage:**		**GPS X:**	
Additional Info:		**Offset:**		**GPS Y:**	

SIEVE ANALYSIS

Sieve (mm)	% Passing	Sieve (mm)	% Passing
75.0	**100**	0.425	**87**
63.0	**100**	0.250	**87**
53.0	**100**	0.150	**87**
37.5	**100**	0.075	**86**
26.5	**100**	0.060	**86**
19.0	**95**	0.050	**84**
13.2	**95**	0.020	**73**
9.5	**93**	0.005	**60**
4.75	**90**	0.002	**50**
2.00	**88**		

ATTERBERG LIMITS

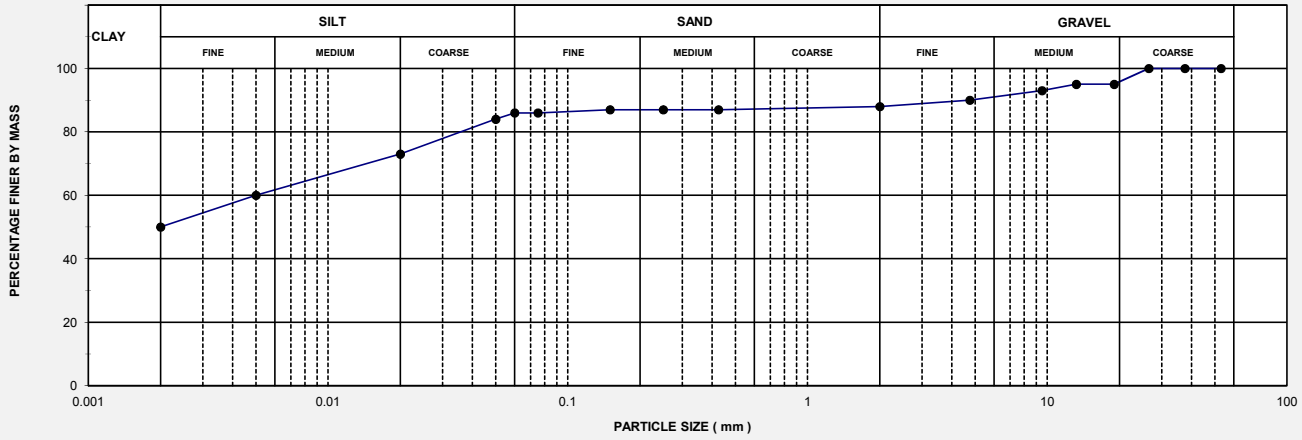
Liquid Limit	(%)	**57**
Plastic Limit	(%)	**30**
Plasticity Index	(%)	**27**
Weighted PI	(%)	**23**
Linear Shrinkage	(%)	**12.0**
Grading Modulus		**0.39**
Uniformity coefficient		**3**
Coefficient of curvature		**0.4**

Remarks:

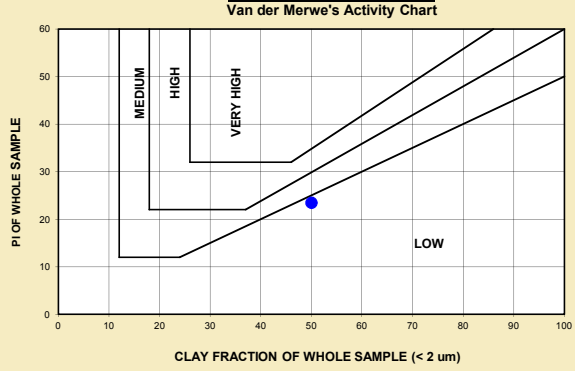
SOIL CLASSIFICATION

% Gravel	**12**
% Sand	**2**
% Silt	**36**
% Clay	**50**
Activity	**0.5**
Unified Classification	**MH or OH**
TRB Classification	**A - 7 - 5**

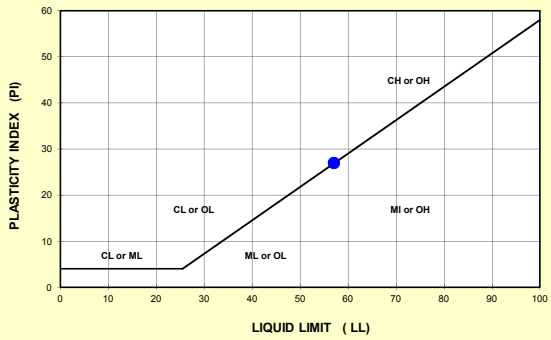
PARTICLE SIZE DISTRIBUTION



POTENTIAL EXPANSIVENESS
Van der Merwe's Activity Chart



CASAGRANDE 'A' LINE



SOIL ANALYSIS REPORT

TEL: 088 303 2967 FAX: 086 683 7781

COMPANY: Geostrada
ADRESS: 993 Park street
Hatfield
CODE: 0083
TEL NO: 012 432 0500

NAME: uMkhomazi
YOUR REF: 2013-C-746
EMAIL: gerriej@geostrada.co.za
FAX: -
Job NO: 10199
DATE: 30/07/2013

Lab No	Ref No	Position	Depth(mm)	pH (H_2O)	Conductivity	Na	Mg	CEC	ESP	EMgP	Na	Ca	Mg	SAR
					mS/m	me/100gsoil (cmol(+)/kg	me/100gsoil (cmol(+)/kg	cmol(+)/kg			me/l	me/l	me/l	
4253	3/5439	TPE 1	50 - 500	6.88	3.24	0.16	5.32	12.42	0.01	0.43	0.24	0.80	3.57	0.17
4254	3/5442	TPO 2	60 - 260	6.63	2.46	0.42	6.95	13.99	0.03	0.5	0.25	0.15	0.29	0.53

NF REEDERS

GEOSTRADA	SHEAR TESTS: BOX SHEAR	KH Head

Client Aecom **Project** uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study

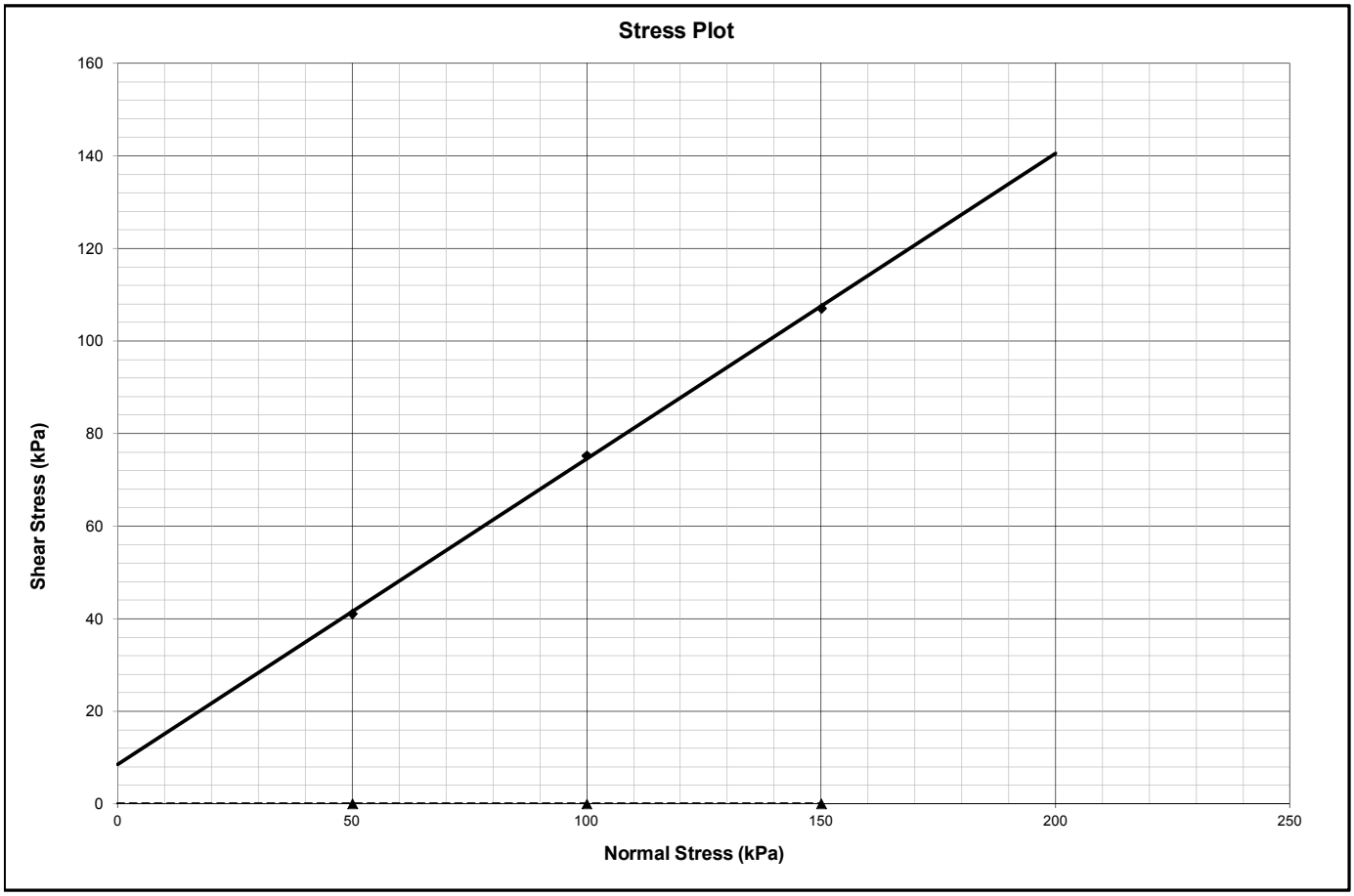
Sample no TPO1 **Depth (m)** 0.06 - 0.45 **Date** 31/07/2013

Lab no 3/5441 **Job no** 2013-C-746

Test Information		
Test Type	-	Slow Drained, saturated
Sample Condition	-	Remoulded to estimated OMC
Normal Stresses	kPa	50, 100, 150
Rate of Strain	mm/min	0.0460

Initial Sample Parameters	Unit	Test 1	Test 2	Test 3	Remarks
Moisture Content	%	28.5	28.5	28.5	Complete test specimen
Dry Density	Kg/m³	1601	1601	1601	
Void Ratio	-	0.711	0.710	0.710	
Degree of Saturation	%	110.0	109.9	109.9	
Relative Density (SG)	-	2.738			Determined

Final Sample Parameters	Unit	Test 1	Test 2	Test 3	Remarks
Moisture Content	%	35.5	34.5	34.5	
Normal Stress	kPa	50	100	150	
Shear Stress	kPa	41	75	107	
Residual Stress	kPa	Not Tested	Not Tested	Not Tested	
Angle of Internal Friction	Deg.	33			Peak
Cohesion	kPa	8			Peak

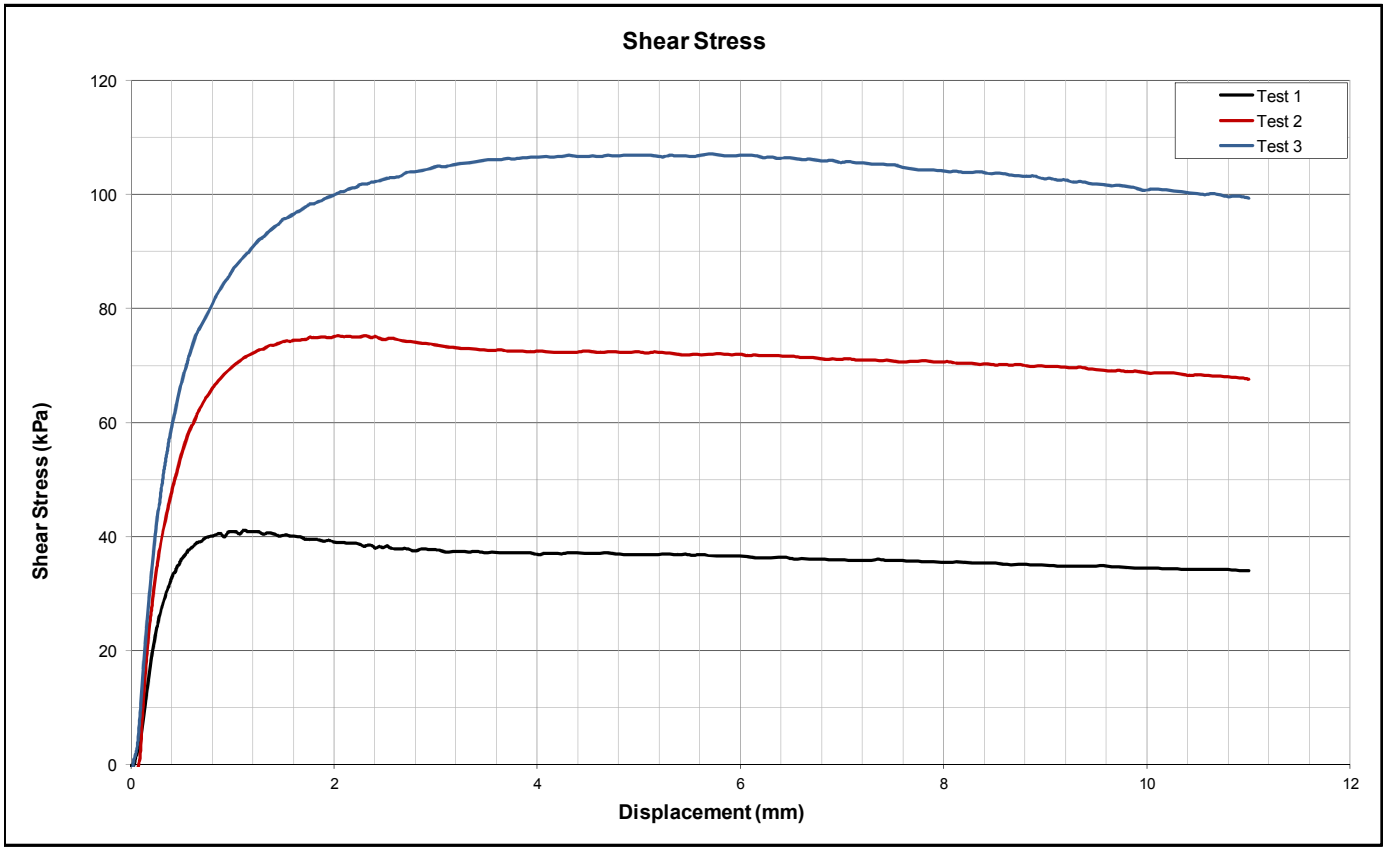


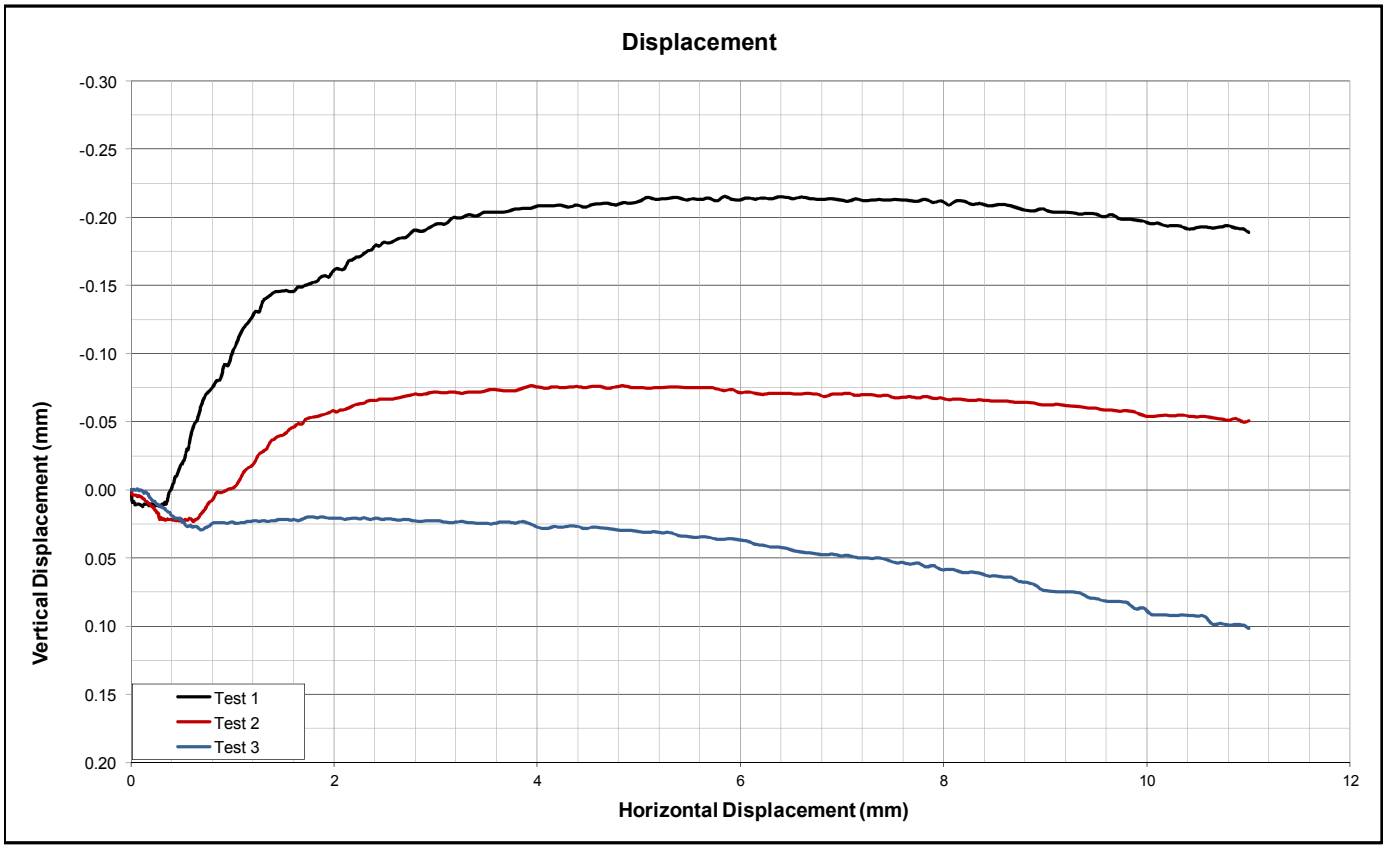
GEOSTRADA	SHEAR TESTS: BOX SHEAR	KH Head

Client Aecom **Project** uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study

Sample no TPO1 **Depth (m)** 0.06 - 0.45 **Date** 31/07/2013

Lab no 3/5441 **Job no** 2013-C-746





GEOSTRADA	Flexible Wall Permeability Test	BS 1377 Part 6

Client Aecom **Project** uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study

Sample no TPO1 **Depth (m)** 0.06 - 0.45 **Date** 31/07/2013

Lab no 3/5441 **Job no** 2013-C-746

Initial Sample Parameters		
Sample Condition	-	Remoulded to estimated OMC
MDD	kg / m^3	-
OMC	%	-
Consolidation Pressure	kPa	100
Pressure Difference	kPa	10

Test Information			
Moisture Content	Before	%	27.3
	After	%	30.8
Dry Density		Kg/m³	1529
Initial Void Ratio		-	0.790
Relative Density (SG)		-	2.738 - Determined
Final B Parameter		-	0.97
Co-efficient of Permeability	Min.	m/s	1.7E-10
	Max.	m/s	2.5E-10
	Ave.	m/s	2.0E-10

Tests on slightly and moderately weathered shale (quarry area)

T0023

GEOSTRADA
engineering materials laboratory

PROPERTIES OF AGGREGATE - REP AGG 3

Client: Geomechanics

Project Name: uMkhomazi: 2nd Batch Rock Core Testing

Project No: -

Job no : 2013-C-508

Date : 16-05-2013

Sample No	Description	Client Ref No	Sieve Analysis - Percentage Passing Sieve (TMH1 B4)																		FM	ACV (Dry) (%)	ACV (Wet) (%)	Atterberg Limits (TMH 1 A2 - A4) (-0.075mm)					
			75.0 mm	63.0 mm	53.0 mm	37.5 mm	26.5 mm	19.0 mm	13.2 mm	9.5 mm	6.7 mm	4.75 mm	3.35 mm	2.36 mm	1.18 mm	0.600 mm	0.425 mm	0.300 mm	0.150 mm	0.075 mm				LL	PI	LS			
3/3720	Slightly Weathered Shale					100	97	81	55	40	30	24	18	14	9	6	5	4	3	2.0	2.70	23.9	28.4	24	6	2.5			
3/3721	Moderately Weathered Shale				100	97	89	68	43	31	23	18	15	12	9	6	6	5	4	4.0	2.04	33.3	44.2	30	8	4.5			
																		Test Method			TMH1 B13	TMH1 B1	TMH1 B2						

Remarks:

Aggregate tests on slightly and moderately weathered shale (Smithfield quarries)

T0023

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engineering materials laboratory

SUMMARY OF TEST RESULTS ON SOILS - REP COM 2

Client: Geomechanics
Job No: 2013-C-317
Project Name: uMkhomazi: Rock Core Testing
Project Number: _
Date: 08/05/2013

Sample No	Sample Ref.	Additional Info	Percentage Passing Sieve (mm) - TMH1 A1 & A5													Atterberg Limits (TMH1 A2-A4)		
			Sieve Analysis													< 0.425 mm		
			75.0	63.0	53.0	37.5	26.5	19.0	13.2	9.5	4.75	2.00	0.425	0.075	GM	LL	PI	LS
3/2186	Completely Weathered	As received						100	99	91	61	36	21	16	2.27	31	12	6.0
		After Weathering				100	98	89	72	57	35	20	11	6	2.63	27	7	3.5
3/2187	Highly Weathered	As received						100	92	81	46	26	12	6	2.56	28	7	3.5
		After Weathering				100	98	84	61	44	22	12	6	4	2.78		NP	0
3/2188	Moderately weathered	As received						100	93	81	48	25	9	4	2.62		NP	0.0
		After Weathering				100	97	80	53	39	18	8	4	3	2.85		NP	0.0
3/2189	Moderately weathered - Slaked	As received						100	85	70	41	17	7	2	2.74		NP	0.0
		After Weathering					100	89	72	58	34	12	4	3	2.81		NP	0.0
3/2190	Slightly weathered	As received						100	90	79	46	21	7	2	2.70		NP	0.0
		After Weathering				100	88	69	41	27	15	7	3	2	2.88		NP	0.0
3/2191	Slightly weathered - Slaked	As received						100	94	85	54	26	10	4	2.60	20	3	1.5
		After Weathering				100	98	82	62	52	31	13	5	3	2.79	20	5	2.5

Remarks:

T0023

GEOSTRADA
engineering materials laboratory

AGGREGATE AND SAND SIEVE ANALYSIS TEST RESULTS - REP AGG 10

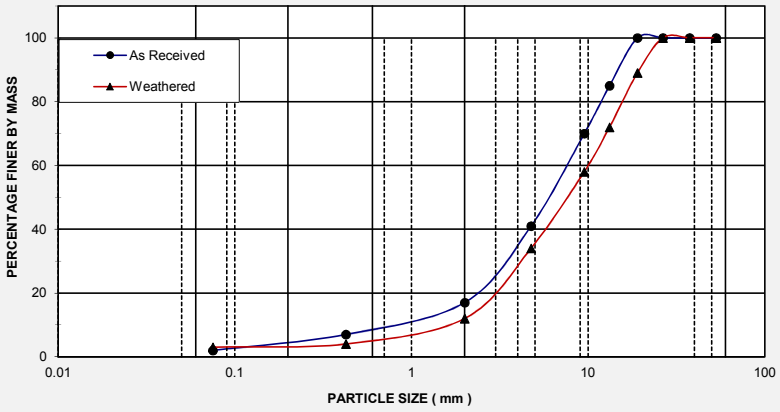
Client: Geomechanics **Project Name:** uMkhomazi: Rock Core Testing **Job No:** 2013-C-317

Date: 08/03/2013

Sample Ref.: Moderately weathered - Slaked **Sample No.:** 3/2189

SIEVE ANALYSIS			
As received		After weathering	
Sieve (mm)	% Passing	Sieve (mm)	% Passing
53.0	**100**	53.0	**100**
37.5	**100**	37.5	**100**
26.5	**100**	26.5	**100**
19.0	**100**	19.0	**89**
13.2	**85**	13.2	**72**
9.5	**70**	9.5	**58**
4.75	**41**	4.75	**34**
2.00	**17**	2.00	**12**
0.425	**7**	0.425	**4**
0.075	**2**	0.075	**3**
GM	**2.74**	GM	**2.81**

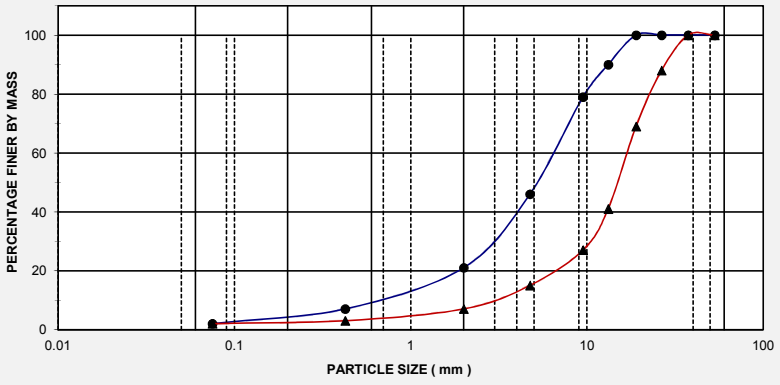
PARTICLE SIZE DISTRIBUTION



Sample Ref.: Slightly Weathered **Sample No.:** 3/2190

SIEVE ANALYSIS			
Sieve (mm)	% Passing	Sieve (mm)	% Passing
53.0	**100**	53.0	**100**
37.5	**100**	37.5	**100**
26.5	**100**	26.5	**88**
19.0	**100**	19.0	**69**
13.2	**90**	13.2	**41**
9.5	**79**	9.5	**27**
4.75	**46**	4.75	**15**
2.00	**21**	2.00	**7**
0.425	**7**	0.425	**3**
0.075	**2**	0.075	**2**
GM	**2.70**	GM	**2.88**

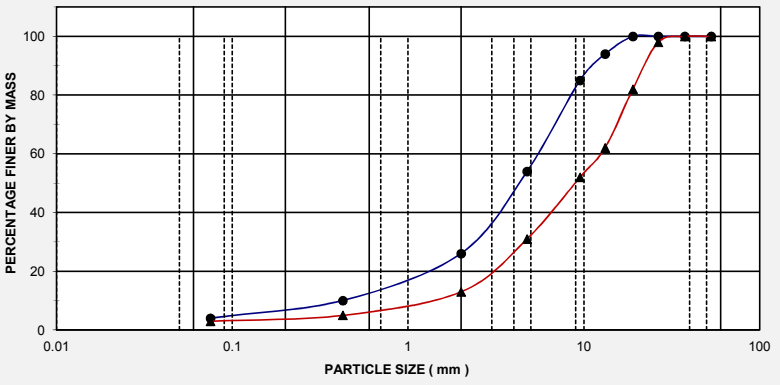
PARTICLE SIZE DISTRIBUTION



Sample Ref.: Slightly Weathered - Slaked **Sample No.:** 3/2191

SIEVE ANALYSIS			
Sieve (mm)	% Passing	Sieve (mm)	% Passing
53.0	**100**	53.0	**100**
37.5	**100**	37.5	**100**
26.5	**100**	26.5	**98**
19.0	**100**	19.0	**82**
13.2	**94**	13.2	**62**
9.5	**85**	9.5	**52**
4.75	**54**	4.75	**31**
2.00	**26**	2.00	**13**
0.425	**10**	0.425	**5**
0.075	**4**	0.075	**3**
GM	**2.60**	GM	**2.79**

PARTICLE SIZE DISTRIBUTION



T0023

GEOSTRADA
engineering materials laboratory

PROPERTIES OF AGGREGATE - REP AGG 3

Client: Geomechanics

Project Name: uMkhomazi: Rock Core Testing

Project No: -

Job no : 2013-C-317

Date : 2013-05-10

Sample No	Description	Client Ref No	Sieve Analysis - Percentage Passing Sieve (TMH1 B4)																		FM	ACV (Dry) (%)	ACV (Wet) (%)	ACV (Ethylene Glycol) (%)	Soundness ($MgSO_4$) % Loss after 5 Cycles	SE	ALD	Flakiness Index (%)
			75.0 mm	63.0 mm	53.0 mm	37.5 mm	26.5 mm	19.0 mm	13.2 mm	9.5 mm	6.7 mm	4.75 mm	3.35 mm	2.36 mm	1.18 mm	0.600 mm	0.425 mm	0.300 mm	0.150 mm	0.075 mm								
3/2186	Completely Weathered																					50.4	53.9					
3/2187	Highly Weathered																					39.1	40.5					
3/2188	Moderately Weathered																					33.5	42					
3/2189	Moderately Weathered - Slaked																					38.3	47.7					
3/2190	Slightly Weathered																					26.7	29.5					
3/2191	Slightly Weathered - Slaked																					35.3	46.2					
																		Test Method			TMH1 B13	TMH1 B1	TMH1 B2	TMH1 B2	SABS 839	TMH1 B19	TMH1 B18(a)	TMH1 B3

Remarks:

Annexure C

Driller's Journals

DAILY DRILLING REPORT No. 35766

23/03/2013	Contract Name: UMKHOMAZI		Rig No: P205	Machine Start Hour:	01050
Weather: HOT	Client:	Inclination: VERTICAL	Rig Type: YWE	Machine End Hour:	01052
Contract No: J01763	BH-no: NM 1	Direction: 90°	Pump Type: MONO	Diesel Received:	30L
Water Used 400L	Kilometers water Carted				

GEOGROUP
28 Central Road, Sunrella A/H, Lanseria
PO Box 68063, Bryanston, 2021
Phone: +27 86 143 6632
Fax: 086 6633 896
www.geogroup.co.za

Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
0.00	0.85	0.85	0.85	—	NXC	—								CR650	90%	Brown	Slow	S	—	NXC	0.85
0.85	1.57	0.72	0.45	0.27	NXC	—								CR650	90%	Creamy	Slow	S	—	NXC	1.57
1.57	2.79	1.22	0.80	0.36	NWD4	—								CR650	90%	Creamy	Slow	WR	—	OLD	OLD
WE	WENT		TO		WORK					BY			FOOD	AND		WE	DO	CLEARING		
THE		BUSH	AND		THEN					SET UP			THE	RIG		WE	START			
OUR		FAST			BY	11H30				AFTE			WE	HAVE		BURRGATING				
AND		DIGGING			SUMPS																
																Jan	mapmanga				
																Lucky	Makilanga				

Borehole complete? Yes		No	✓	Core boxes: 1 of	Corewriter Name: LAWRENCE NEVARI
Water level: m Time: am			Water level: m Time: pm		Supervisor Name: A Booysen

Signature: _____

Signature: _____

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

(5639)

DAILY DRILLING REPORT

No. 35767

GEOGROUP
28 Central Road, Sunrella A/H, Lanseria
PO Box 66063, Bryanston, 2021
Phone: +27 86 143 6632
Fax: 086 6633 696
www.geogroup.co.za

Date: 25/03/2013	Contract Name: UMKHOMAZI		Rig No: P205	Machine Start Hour:	01052
Weather: Cloudy	Client:	Inclination: VERTICAL	Rig Type: YWE	Machine End Hour:	01058
Contract No: J01763	BH-no: NM1	Direction: 90°	Pump Type: Mono	Diesel Received:	
Water Used 2600 L	Kilometers water Carted				

Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
2.79	4.37	1.58	1.56	0.02	NWD4	—								CR650	90%	Creamy	Slow	WR	—	OLD	OLD
4.37	5.00	0.63	0.59	0.04	NWD4	—								CR650	90%	Creamy	Slow	WR	—	OLD	"
5.00	5.87	0.87	0.91	+0.04	NWD4	—								CR650	90%	Creamy	Slow	WR	—	OLD	"
5.87	7.35	1.48	1.26	0.22	NWD4	—								CR650	90%	Creamy	Slow	WR	—	OLD	"
7.35	8.00	0.65	0.63	0.02	NWD4	—								CR650	90%	Creamy	Slow	WR	—	OLD	"
8.00	8.87	0.87	0.58	0.29	NWD4	1.50								CR650	90%	Creamy	Slow	WR	—	OLD	"
8.87	10.28	1.41	1.20	0.21	NWD4	1.50								CR650	90%	Grey	fast	WR	—	OLD	"
10.28	11.00	0.72	0.71	0.01	NWD4	1.50								CR650	90%	Grey	fast	WR	—	OLD	"
11.00	11.83	0.83	0.84	+0.01	NWD4	1.50								CR650	90%	Grey	fast	WR	—	OLD	"
11.83	13.35	1.52	1.50	0.02	NWD4	1.50								CR650	90%	Grey	fast	WR	—	OLD	"
13.35	14.00	0.65	0.65	—	NWD4	1.50								CR650	90%	Grey	fast	WR	—	OLD	"

3 PACKERS HAS BEEN DONE 2 - 5 AND 5 - 8 ALSO 8 - 11

Borehole complete? Yes [ ] No [✓]	Core boxes: 2 of	Corewriter Name: LAWRENCE NEVARI	Signature: [signature]	
Water level: m Time: am	Water level: m Time: pm	Supervisor Name: A Breytenbach	Signature: [signature]	

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

(5639)

DAILY DRILLING REPORT

No. 35768

Date: 26/03/2019	Contract Name: UMKHOMAZI		Rig No: P205	Machine Start Hour: 01058
Weather: Rain	Client:	Inclination: VERTICAL	Rig Type: YWE	Machine End Hour: 01059
Contract No: J01763	BH-no: NM 1	Direction:	Pump Type: MINU	Diesel Received: 26L
Water Used	Kilometers water Carted			

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined[deg(45)] **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters

WE WENT TO WORK AND WE HAVE JUST DO PACKER, IMMIDIATELY when we start put RODS down to HOLE RAIN CAME Heavely and we off by 10H02 TO THE CAMP WAITING to go for holiday

Borehole complete? Yes		No ✓	Core boxes: 2 of	Corewriter Name: LAWRENCE NEVARI	Signature: [signature]
Water level: m Time: am		Water level: m Time: pm		Supervisor Name: A Procyabn	Signature: [signature]

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT No. 35769

Date: 03/04/2015	Contract Name: UMKHOMAZI		Rig No: PA05	Machine Start Hour:	01058
Weather: RAIN	Client:	Inclination: VERTICAL	Rig Type: YWE	Machine End Hour:	01058
Contract No: J01763	BH-no: NM1	Direction: 0/0	Pump Type: MONO	Diesel Received:	
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
WE	DIDNT				WENT						TO		WORK				BECAUSE		OF		
HEAVY	RAIN				WE						GET		INSTRUCTION				FROM		MR		
ANDRIES					OUR						Manager										
																	Sam		Maphanga		
																	Lucky		Mavilana		

Borehole complete? Yes ☐ No ✓ Core boxes: 2 of

Corewriter Name: LAWRENCE NEVHALI Signature:

Water level: m Time: am Water level: m Time: pm

Supervisor Name: A BOOYSEN Signature:

Instruction by Geologist

Equipment replaced:

Equipment lost:

(5639)

DAILY DRILLING REPORT No. 35770

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Date: 04/04/2013	Contract Name: Baynes field		Rig No: P205	Machine Start Hour: 01058
Weather: COOL	Client:	Inclination: NERTICAL	Rig Type: YWE	Machine End Hour: 01066
Contract No: JO1763	BH-no: NM1	Direction: 90°	Pump Type: MONO	Diesel Received:
Water Used 2100 L	Kilometers water Carted			

Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length Bit type eg.: NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
14.00	14.87	0.87	0.68	0.19	NWD4	1.50								CR650	80%	Grey	fast	FR	–	OLD	OLD
14.87	17.00	2.13	2.07	0.06	TNW	1.50								CR650	80%	Grey	fast	FR	–	OLD	〃
17.00	20.00	3.00	3.01	+0.01	TNW	1.50								CR650	80%	Grey	fast	FR	–	OLD	〃
2.00	23.00	3.00	2.98	0.02	TNW	1.50								CR650	80%	Grey	fast	FR	–	OLD	〃
23.00	23.74	0.74	0.72	0.02	TNW	1.50								CR650	80%	Grey	fast	FR	–	OLD	〃

WE HAVE DONE 3 PACKERS 14-17 AND 17-20 AND ALSO 20-23

Tau Maphanga
Lucky Mabitla

Borehole complete? Yes		No ✓	Core boxes: 4 of	Corewriter Name: LAWRENCE NEVARI	Signature: [signature]
Water level: m Time: am		Water level: m Time: pm		Supervisor Name: A Booysen	Signature: [signature]
Instruction by Geologist					
Equipment replaced:					
Equipment lost:					

(5639)

DAILY DRILLING REPORT

No. 35771

Date: 05/04/2013	Contract Name: Baynes field			Rig No: P 205	Machine Start Hour:	01066
Weather: COOL	Client:	Inclination:	VERTICAL	Rig Type: Jure	Machine End Hour:	01067
Contract No: J01763	BH-no: NM1	Direction:	90°	Pump Type: Mono	Diesel Received:	—
Water Used 200 L	Kilometers water Carted					

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
23.74	25.16	1.42	1.41	0.01	TNW	1.50								CR650	80%	Grey	fast	FR	—	OLD	OLD

WE Complete bore hole by 08H57 and WE ALSO pull out Casing Close Sumps Clean the site. WE USE TRACTOR TO NEW site FOR 1,2 KM

Borehole complete? Yes ✓	No	Core boxes: 4 of 4	Corewriter Name: LAWRENCE NENARI	Signature: [signature]
Water level: 14.20m Time: 09H00 am	Water level: 14.20m Time: 04 pm		Supervisor Name: A ROOYSEN	Signature: [signature]

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

(5639)

DAILY DRILLING REPORT No. 38137

Date: 25/March/2013	Contract Name: Baynes field		Rig No: P0167	Machine Start Hour:	N/A
Weather: Cloudy	Client:	Inclination: Vertical	Rig Type: Jwe	Machine End Hour:	N/A
Contract No: Jor762	BH-no: NM2	Direction: 90°	Pump Type: Mono	Diesel Received:	—
Water Used 10000L	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined dog(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
~~0.00~~	~~1.65~~	~~1.65~~																			
We moved rig onto old site the km 29438.6 to the new site km 20440' and we had rig with the difficult formation way which took the hole day because the please were sloping																					
Borehole complete? Yes				No	—	Core boxes: — of —							Corewriter Name: Terrance Takemore						Signature:		
Water level: m Time: am					Water level: m Time: pm								Supervisor Name: A Booysen						Signature:		

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

(5639)

DAILY DRILLING REPORT No. 38138

Date: 26/March/2013	Contract Name: Beyers field		Rig No: P0167	Machine Start Hour:	1
Weather: Raining	Client:	Inclination: Vertical	Rig Type: GW6E	Machine End Hour:	—
Contract No: 10/1763	BH-no: MM2	Direction: 90°	Pump Type: Mono	Diesel Received:	—
Water Used 10000L	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length Bit type eg.: NWD4/ TNW/ NQ/ HLMC etc Drilling Response: FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
0.00	1.50	1.50	0.90	-0.60	HQLC	0.00								—	95%	Brown	Slow	S			
1.50	3.00	1.50	1.20	-0.30	HWDSP	1.50								—	90%	Brown	Slow	S			
3.00	4.50	1.50	1.37	-0.13	HWDSP	1.50								—	90%	Brown	Slow	S			

Borehole complete? Yes — No — Core boxes: 01 of

Water level: m Time: am Water level: m Time: pm

Corewriter Name: Terrance Signature:

Supervisor Name: A Reddy Signature:

Instruction by Geologist

Equipment replaced:

Equipment lost:

(5639)

DAILY DRILLING REPORT No. 38139

Date: 03/April/2013	Contract Name: Beynes field		Rig No: P0187	Machine Start Hour:	11/7
Weather: Raining	Client:	Inclination: Vertical	Rig Type: Jwe	Machine End Hour:	11/17
Contract No: J01673	BH-no:	Direction: 90°	Pump Type: Mono	Diesel Received:	—
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
From 07H00			TO 17H00		if	was		raining													

Borehole complete? Yes [ ] No [—] Core boxes: 01 of

Corewriter Name: Torrance Lakemane Signature:

Water level: m Time: am Water level: m Time: pm

Supervisor Name: A Booysen Signature:

Instruction by Geologist

Equipment replaced:

Equipment lost:

(5639)

DAILY DRILLING REPORT No. 38140

Date: 04/April/2013	Contract Name: Baynes Field		Rig No: 90167	Machine Start Hour:	—
Weather: Warmer	Client:	Inclination: Vertical	Rig Type: GWE	Machine End Hour:	—
Contract No: Jo1763	BH-no: MB72	Direction: 90°	Pump Type: Mono	Diesel Received:	
Water Used 10000L	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length Bit type eg.: NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
4.50	5.00	0.50	0.35	-0.15	HWD4	0.00								CR650	40%	Brown	Slow				
5.00	6.50	1.50	0.78	-0.72	HWD4	4.50								CR650	38%	Black	Slow				
6.50	8.00	1.50	1.30	-0.20	HWD4	4.50								CR650	30%	Black	Slow				
From morning waiting for water until at 11:42 We've done two pebbles test today																					

Borehole complete? Yes [ ] No [—] Core boxes: 01 of

Corewriter Name: Terrance Salemane Signature:

Water level: m Time: am Water level: m Time: pm

Supervisor Name: A Booysen Signature:

Instruction by Geologist

Equipment replaced:

Equipment lost:

(5639)

DAILY DRILLING REPORT No. 38141

Date: 05/April/2013	Contract Name: Boynes Road		Rig No: PO167	Machine Start Hour:	N/A
Weather: Warmer	Client:	Inclination: Vertical	Rig Type: YWE	Machine End Hour:	N/A
Contract No: Jo1763	BH-no: MW2	Direction: 90°	Pump Type: Mono	Diesel Received:	20 L
Water Used 10001	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
8.00	9.50	1.50	1.20	-0.30	NW84	4.50								BF650	30%	Rock	Slow				
9.50	11.00	1.50	1.35	-0.15	NW84	4.50								CR650	15%	Block	Slow				
11.00	14.00	3.00	2.70	-0.30	TNW	4.50								CR650	30%	Block	Slow				
14.00																					
Two pertage test done today.																					

Borehole complete? Yes [ ] No [—] Core boxes: 02 of

Water level: m Time: am

Water level: m Time: pm

Corewriter Name: Terrance Salomane Signature:

Supervisor Name: A Booysen Signature:

Instruction by Geologist

Equipment replaced:

Equipment lost:

(56391)

DAILY DRILLING REPORT No. 38142

Date: 06/April/2013	Contract Name: Beynes Field		Rig No: P0167	Machine Start Hour:	N/A
Weather: Warmer	Client:	Inclination: Vertical	Rig Type: Ingo	Machine End Hour:	N/A
Contract No: J01763	BH-no: HM12	Direction: 90°	Pump Type: Mono	Diesel Received:	
Water Used 10000L	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length Bit type eg.: NWD4/ TNW/ NQ/ HLMC etc Drilling Response: FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
14.00	17.00	3.00	3.00	—	THW	4.50								CR650	0%	Steel	Slow				
17.00					TNW	4.50															
We Stopped by Mono pump which was pumping on bad conditions from 10H33 to 11H36 trying 14H00.																					

Borehole complete?	Yes		No	—	Core boxes: 02	of	Corewriter Name: Terrance Lekmane
Water level:	m Time:	am	Water level:	m Time:		pm	Supervisor Name: [illegible]

Signature: Lekmane

Signature: [illegible]

Instruction by Geologist

Equipment replaced:

Equipment lost:

(6639)

DAILY DRILLING REPORT No. 38143

Date: 08/April/2013	Contract Name: Feynes Field		Rig No: P0167	Machine Start Hour:	—
Weather: Warmes	Client:	Inclination: Vertical	Rig Type: YWE	Machine End Hour:	—
Contract No: Je1763	BH-no: MH12	Direction: 90°	Pump Type: Mono	Diesel Received:	20L
Water Used 1000L	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
17.00	20.00	3.00	2.95	0.05	THW	4.50								CR650	01%	Black	Slow	FR		078	043
One package lost																					

Borehole complete? Yes — No — Core boxes: 02 of 03 Corewriter Name: Terrance Salemane Signature:

Water level: 06.50 m Time: 10H50am Water level: m Time: pm Supervisor Name: A Rossouw Signature:

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT

No. 39761

Date: 25 - 03 - 13	Contract Name: Baynes field		Rig No: 168	Machine Start Hour:	227.8
Weather: Changing	Client:	Inclination: Vertical	Rig Type: YWE	Machine End Hour:	
Contract No: J01763	BH-no: HM 3	Direction: 90°	Pump Type:	Diesel Received:	25L
Water Used 1000L	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
0,00	0,90	0,90	0,45	-0,45	HXC	0,00								CRbso	75%	Brown	Slow				
0,90	1.50	0,60	Corewash		"	"								"	"	Grey	"				
1.50	3.00	1.50	0,95	-0,55	NWD4	0,00								"	"	"	"				
3.00	4.50	1.50	1,35	-0,15	"	"								"	"	Black	fast				
4.50	5.00	0,50	0,50	—	"	"								"	"	"	"	Pertalen	15H15	- 16H05	

We waiting for truck as from 08H00 until 12H00 then we move 100m to next Hole & setup, We Start to Drill at 13H20

Borehole complete?	Yes		(No) ✓	Core boxes: 1 of	Corewriter Name: Ndifelani	Signature: [signature]
Water level: m Time: am		Water level: m Time: pm			Supervisor Name: A Roeyser	Signature: [signature]

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT

No. 39762

Date: 26-03-13	Contract Name: Bayness field		Rig No: 168	Machine Start Hour:	231
Weather: Raining	Client:	Inclination: Vertica	Rig Type: YWC	Machine End Hour:	
Contract No: J01763	BH-no: Mm3	Direction: 90°	Pump Type:	Diesel Received:	
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined (deg:45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
5.00	6.50	1.50	1.50	-	HWDH	3.50								CR650	75%	Black	fast				
6.50	8.00	1.50	1.45	-0,05	"	"								"	"	"	"				
																Lizwi		Siwela			
																Leonard		Mphephu			

Borehole complete? Yes		No	✓	Core boxes: 1 of	Corewriter Name: Ndifelani	Signature: [signature]
Water level: m Time: am			Water level: m Time: pm		Supervisor Name: A Rooyeen	Signature: [signature]

Instruction by Geologist

Equipment replaced:

Equipment lost:

(5639)

DAILY DRILLING REPORT No. 39763

Date: 03-04-13	Contract Name: Bayness field		Rig No: 168	Machine Start Hour:	
Weather: Raining	Client:	Inclination: Vertical	Rig Type: gwe	Machine End Hour:	
Contract No: JO1763	BH-no: HM3	Direction: 90°	Pump Type:	Diesel received:	
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
		We	dink	Manage		to					go		to	site	the		road	was	wet	1	Slippery
															Lizwi						
															Leonard						

Borehole complete? Yes		No		Core boxes: of	Corewriter Name: H Difeba
Water level: m Time: am				Water level: m Time: pm	Supervisor Name: A Bayness

Signature:

Signature:

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

DAILY DRILLING REPORT No. 39764

Date: 04-04-13	Contract Name: Bayens field		Rig No: 168	Machine Start Hour:	232.9
Weather: Hot	Client:	Inclination: Vertical	Rig Type: ywe	Machine End Hour:	
Contract No: J01763	BH-no: Hm 3	Direction: 90°	Pump Type:	Diesel Received:	20L
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length Bit type eg.: (NWD4)/TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal/(Vertical)/Inclined[Geog(45)] **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
8.00	9.50	1.50	1.55	+0.05	NWD4	9.50								CA650	75%	Black	Fast	Perlcer	13H00 -	13H55	
9.50	11.00	1.50	1.50	-	"	"								"	"	"	"	perlcer	14.11 55 -	15H50	
		WO	Waiting	for	water	&	the	key	as	from	08H00		until	12H30						1
		WO	Start	to	Drill	at	11H05														8
															Leonard	mphephu					
															Lizbi	Siwela					

Borehole complete? Yes [ ] No [✓] Core boxes: 2 of

Water level: m Time: am Water level: m Time: pm

Corewriter Name: Ndifelani Signature:

Supervisor Name: A Rooygard Signature:

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT No. 39765

Date: 05-04-13	Contract Name: Baynes field		Rig No: 168	Machine Start Hour:	235.9
Weather: Hot	Client:	Inclination: Vertical	Rig Type: yuce	Machine End Hour:	
Contract No: J01763	BH-no: HM3	Direction: 90°	Pump Type:	Diesel Received:	
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length Bit type eg.: (NWD4) TNW/ NQ/ HLMC etc Drilling Response: (FAST) SLOW/ EVEN/ UNEVEN

Inclination: Horizontal (Vertical) Inclined deg(45) **Direction**: Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
11.00	12.50	1.50	1.50	—	HWDH	H.50								CR650	75%	Black	Fast				
12.50	14.00	1.50	1.50	—	"	"								"	"	"	"	Parice	8H 4S	- 09 H	40
14.00	15.50	1.50	1.50	—	"	"								"	"	"	"				
15.50	17.00	1.50	1.50	—	HWDH	H.50								"	"	"	"	Perker	10H 3S	- 11 H	25
17.00	18.50	1.50	1.50	—	"	"								"	"	Black	"				
18.50	20.00	1.50	1.50	—	"	"								CR650	75%	"	Fast	Percem	13H 0S	- 13 H	55
				GHD	of	BH	HM	3													
				Depth		20,00															
		wa		Move	the	rig		to		next				Position							

Borehole complete?	Yes ✓	No	Core boxes: 3 of 3	Corewriter Name: Hafeiqmi	Signature:
Water level: m Time:	am 0,90		Water level: m Time:	pm Supervisor Name: A Baaysen	Signature:

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

DAILY DRILLING REPORT No. 39757

Date: 20-03-13	Contract Name: Mkhomazi		Rig No: 168	Machine Start Hour:	
Weather: Hot	Client:	Inclination: Vertical	Rig Type: ywe	Machine End Hour:	
Contract No: 501763	BH-no: Nw 4	Direction: 90°	Pump Type:	Diesel Received:	
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
We waiting for the truck to load the rig as from 07H00 until 12H00, then we load & Drive 36km to site, we offload & Setup.																					
																Lizwi Siwela					
																Leonard Mphephu					

Borehole complete?	Yes		No		Core boxes:	of	Corewriter Name: Ndifelani
Water level:	m	Time:	am		Water level:	m Time: pm	Supervisor Name: A Booysen

Signature:

Signature:

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

DAILY DRILLING REPORT

No. 39758

Date: 21-03-13	Contract Name: Michomazi		Rig No: 168	Machine Start Hour:	214
Weather: Hot	Client:	Inclination: Vertic	Rig Type: YWG	Machine End Hour:	
Contract No: J01763	BH-no: MH	Direction: 90°	Pump Type:	Diesel Received:	20L
Water Used 1000 L	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
0,00	0,90	0,90	0.45	-0,45	Nxc	0,00								CR650	90%	Brown	slow				
0.90	1.50	0,60	0,50	-0,10	"	"								"	"	"	"				
1.50	2.37	0,87	0,55	-0,32	NWD4	0,00								"	"	"	"				
2.37	3.50	1.13	1.00	-0,13	"	"								"	"	"	"				
3.50	5.00	1.50	1.35	-0,15	"	"								CR650	90°	Brown	slow	Parker 14H45 - 15H40			
5.00	6.50	1.50	1.50	—	NWD4	1.50								"	"	Grey	fast				

we waiting for water as from 08H00 until 12H00, then we start to drill at 12H30

Borehole complete? Yes ☐ (No) ✓	Core boxes: 1 of	Corewriter Name: Ndifelani	Signature: [signature]
Water level: m Time: am	Water level: m Time: pm	Supervisor Name: A Rooyen	Signature: [signature]

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT No. 39759

Date: 22-03-13	Contract Name: Mkhomazi		Rig No: 168	Machine Start Hour:	2145
Weather: HOT	Client:	Inclination: Vertical	Rig Type: GWC	Machine End Hour:	
Contract No: J01763	BH-no: MBH	Direction: 90°	Pump Type:	Diesel Received:	
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length Bit type eg.: NWD4/ TNW/ NQ/ HLMC etc Drilling Response: FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
6.50	8.00	1.50	1.50	—	NWD4	1.50								CR650	75%	Black	fast	Parker	09H10	10	H05
8.00	9.50	1.50	1.45	-0,05	"	"								"	"	"	"				
9.50	11.00	1.50	1.50	"	"	"								"	"	"	"	Parker	12H10	- 13	H35
11.00	12.50	1.50	1.50	"	"	"								"	"	"	"				
12.50	14.00	1.50	1.45	-0,05	NWD4	1.50								"	"	"	"	Parker	14H30	- 15	H25
14.00	15.50	1.50	1.45	-0,05	"	"								"	"	"	"				

Borehole complete? Yes [ ] (No) [✓] Core boxes: 3 of

Corewriter Name: Ndifelani Signature:

Water level: m Time: am Water level: m Time: pm

Supervisor Name: A Booysen Signature:

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT No. 39760

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Date: 23-03-13	Contract Name: Mkhomazi		Rig No: 168	Machine Start Hour:	224.9
Weather: Hot	Client:	Inclination: Vertical	Rig Type: YWE	Machine End Hour:	
Contract No: J01763	BH-no: MWH	Direction: 90°	Pump Type:	Diesel Received:	28L
Water Used 1000L	Kilometers water Carted				

Nature of Core Classification:	FR-FRESH	WR-WEATHERED	B-BOULDERS	S-SOILS	G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
15.50	17.00	1.50	1.50	—	NWD4	1.50								CR650	No water return	Black	Fast	Parker 10HW —			10H55
17.00	18.50	1.50	1.47	-0,03	"	"								"	"	"	"				
18.50	20.00	1.50	1.50		"	"								"	"	"	"	Perker 12H00 —			
			END of BH H.W H																		
			DEPTH 20,00																		
																Lizwi		Siwela			
																Leonard		mphephu			

Borehole complete? (Yes) ✓	No	Core boxes: 3 of 3	Corewriter Name: MDifelani	Signature: [signature]
Water level: m Time: am	Water level: m Time: pm		Supervisor Name: A Rooysiza	Signature: [signature]

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

DAILY DRILLING REPORT No. 42510

Date: 21 MARCH 2013	Contract Name: BAYMES FIELD		Rig No: P207	Machine Start Hour:	011934
Weather: HOT	Client:	Inclination: 90°	Rig Type: YWE 690	Machine End Hour:	
Contract No: JO 1763	BH-no: MM 5	Direction: VERTICAL	Pump Type: MONO	Diesel Received:	25L
Water Used 200L	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
0,00	0,90	0.90	0,90	—	MXC	—								CR650	100%	RED	FAST	S	SOIL	OLD	OLD
0,90	1.80	0,90	0,90	—	MXC	—								CR650	100%	RED	FAST	S	SOIL	OLD	OLD
1.80	3.22	1.42	1.00	-0,42	HW04	—								CR650	100%	RED	FAST	S	SOIL	OLD	OLD
3.22	4.37	1.15	1.00	-0.15	HW04	—								CR650	100%	RED	FAST	S	SOIL	OLD	OLD
4.37	5.00	0.63	0,90	+0,27	HW04	—								CR650	100%	RED	FAST	S	SOIL	OLD	OLD
WE	DID	PACKER	AT	2-5	M							FROM	ISHMS	TO	16H50						
WE	MOVE	THE RODS	FROM	HOLE	BH	5						TO	HM5	WITH	BAKKIES,	FROM	8H00	TO	10H30		
AFTER	THE	WE	SETUP	FROM	10H00	TO	13H00	BECAUSE	WE	MOVE	STAFF	BY	HAND	FOR							
TOM,	WE	WAIT	FOR	WATER	13H00	TO	13H30,	WE	START	TO	DRILL	UNTIL	14H40	WE	WAIT						
FOR	PACKER																				
																THAPELO, WILSON		LOW LEVEL			

Borehole complete?	Yes		No	✓	Core boxes: 1 of	Corewriter Name: THAPELO MOELA
Water level:	m Time: am		Water level:	m Time: pm		Supervisor Name: ANDRIES BOOYSEN

Signature:

Signature:

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

(5639)

DAILY DRILLING REPORT No. 42511

Date: 22-03-2013	Contract Name: BAYMES FIELD		Rig No: P207	Machine Start Hour:	011934
Weather: HOT	Client:	Inclination: 90°	Rig Type: YWE D90	Machine End Hour:	
Contract No: J00 1763	BH-no: MMS	Direction: VERTICAL	Pump Type: MUNO	Diesel Received:	—
Water Used 750L	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length:** Depth to - Depth from = Run length **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
5,00	5,67	0,67	0,67	—	NWD4	3,00									CROSS	GREY	SLOW	WR	ROCK	OLD	OLD
5,67	7,27	1,60	1,60	—	NWD4	3,00									CROSS	GREY	SLOW	WR	ROCK	OLD	OLD
7,27	8,00	0,73	0,50	-0,23	NWD4	3,00									CROSS	GREY	SLOW	WR	ROCK	OLD	OLD
SWE	DSD		PACKER	AT	5 - 8 M				OM			11H00	TO	12H00							
8,00	9,07	1,07	1,07	—	NWD4	3,00									CROSS	GREY	SLOW	WR	ROCK	OLD	OLD
9,07	10,37	1,30	1,17	-0,13	NWD4	3,00									CROSS	BLACK	SLOW	WR	ROCK	OLD	OLD
10,37	11,00	0,63	0,56	-0,07	NWD4	3,00									CROSS	BLACK	SLOW	WR	ROCK	OLD	OLD
WE	STOP	AT	14H00	BECAUSE	MACHINE				WAS			HOT		TO	16H00			THAPELO			
																		WILSON			
																		LOWRENCE			

Borehole complete?	Yes		No	✓	Core boxes: 2 of
Water level:	m Time:	am	Water level:	m Time:	pm

Corewriter Name: THAPELO MOELA Signature:

Supervisor Name: AMARIES BOOYSEN Signature:

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

(5639)

DAILY DRILLING REPORT

No. 42512

Date: 23-03-2013	Contract Name: BAYNES FIELD			Rig No: P207		Machine Start Hour:	011934
Weather: HOT	Client:	Inclination:	90°	Rig Type: YWE		Machine End Hour:	
Contract No: J01763	BH-no: MMS	Direction:	VERTICAL	Pump Type: MONO		Diesel Received:	28L
Water Used 250L	Kilometers water Carted						

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
11.00	11.45	0,45	0,45	–	NWD4	9.00								CR050	80%	BLACK	SLOW	WR	ROCK	OLD	OLD

WE DRILL FOR CASINGS FROM 3.00 TO 9.00 AFTER THERE WE WASH THE HOLE

THABELO
WILSON
LAWRENCE

Borehole complete? Yes		No	✓	Core boxes: 2 of	Corewriter Name: THABELO MOELA	Signature: [signature]
Water level: m Time: am		Water level: m Time: pm			Supervisor Name: ANDRIES BOOYSEN	Signature: [signature]

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT No. 42513

Date: 25-03-2013	Contract Name: BAYMES FIELD		Rig No: P207	Machine Start Hour: 011934
Weather: CLOUDY	Client:	Inclination: 90°c	Rig Type: YWE D90	Machine End Hour:
Contract No: J01763	BH-no: HM5	Direction: VERTICAL	Pump Type: MONO	Diesel Received: 25L
Water Used 750L	Kilometers water Carted			

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined (deg45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
11.45	11.53	0,08	0,08	—	HWD4	9.00									CA650	BLACK	SLOW	WR	ROCK	OLD	OLD
11.53	11.77	0,24	0,21	-0,03	TNW	9.00									CA650	BLACK	SLOW	WR	ROCK	AC3060	35,69
11.77	14.00	2,23	1,88	-0,35	TNW	9.00									CA650	BLACK	SLOW	WR	ROCK	AC3060	37,92
WE	DID	PACKER		AT	11 -	14 M															
14.00	14.77	0,77	1,12	+0,35	TNW	9.00									CA650	BLACK	SLOW	WR	ROCK	AC3060	38,69
14.77	17.00	2,23	2,00	-0,23	TNW	9.00									CA650	BLACK	SLOW	WR	ROCK	AC3060	40,92

ON 23-03-2013 WE DID PACKER AT 8-11 M
WE WAIT FOR WATER FROM 12H30 TO 14H30

Thapelo
Wilson
LAWRENCE

Borehole complete? Yes		No	✓	Core boxes: 3 of	Corewriter Name: THAPELO MNELA	Signature:
Water level: m Time: am		Water level: m Time: pm			Supervisor Name: ANDRIES BOOYSEN	Signature:

Instruction by Geologist	
Equipment replaced:	TNW CORE - SPRING X1
Equipment lost:	

(5639)

DAILY DRILLING REPORT No. 42514

Date: 26-03-2013	Contract Name: BAYMEB FIELD		Rig No: P207	Machine Start Hour:	011934
Weather: RAIN	Client:	Inclination: 90°	Rig Type: YAVE	Machine End Hour:	
Contract No: J01763	BH-no: MM5	Direction: VER	Pump Type: MINO	Diesel Received:	30 L.
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
RAIN ONLY			RAIN	GAUGE	10MM																
WE WAIT FOR			WATER	FROM			8MM						TO 10MM								
11,00 TO 17,00 M			WATER	RETURN			IS						50%								
																	THAPELO WILSON LORENCE				

Borehole complete?	Yes		No	✓	Core boxes: 3	of	Corewriter Name: THAPELO MOELA
Water level:	m Time:	am	Water level:	m Time:	pm		Supervisor Name: AMORIES BOOYSEN

Corewriter Name: THAPELO MOELA		Signature:	
Supervisor Name: AMORIES BOOYSEN		Signature:	

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

(5639)

DAILY DRILLING REPORT

No. 42515

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Date: 03-04-2013	Contract Name: BAYNES FIELD		Rig No: P207	Machine Start Hour:	
Weather: RAINY	Client:	Inclination: 90°	Rig Type: YWE	Machine End Hour:	
Contract No: JO 1763	BH-no: MM 5	Direction: VERTICAL	Pump Type: Mono	Diesel Received:	—
Water Used	Kilometers water Carted				

Nature of Core Classification:	**FR**-FRESH	**WR**-WEATHERED	**B**-BOULDERS	**S**-SOILS	**G**-GRAVELS		
Legend	**Run length: Depth to - Depth from = Run length**		**Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc			**Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN	
Inclination:	Horizontal, Vertical, Inclined deg(45)		**Direction:** Compass reading (or from Geologist)				

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
WE	DID	NOT	GO		TO	WORK			BECAUSE				OF	RAIN							
																	Thapelo		Moela		
																		Wilson			
																		Lowrence			

Borehole complete? Yes		No	✓	Core boxes: 3 of	Corewriter Name: Thapelo Moela	Signature: [signature]
Water level: — m Time: am		Water level: — m Time: pm			Supervisor Name: ANDRIES BOOYSEN	Signature: [signature]

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

DAILY DRILLING REPORT No. 42516

Date: 04-04-2013	Contract Name: BAYNESFIELD		Rig No: P267	Machine Start Hour:	11934
Weather: COLD	Client:	Inclination: 90°	Rig Type: DW E 90	Machine End Hour:	
Contract No: Jo 1763	BH-no: MMS	Direction: VERTICAL	Pump Type: MONO	Diesel Received:	—
Water Used 750 L	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
17.00	17.77	0.77	0.80	+0.03	TNW	9.00								CR650	NO WATER RETURN	BLACK	SLOW	FR	ROCK	AC3060	41.69
17.77	19.17	1.40	1.40	—	TNW	9.00								CR650	NO WATER RETURN	BLACK	SLOW	WR	ROCK	AC3060	43.09
19.17	20.00	0.83	0.83	—	TNW	9.00								CR650	NO WATER RETURN	BLACK	SLOW	WR	ROCK	AC3060	43.92
WE	DID	PACKER	AT	17 - 20 M																	
WE	GET	WATER	AT	10H00																	
RAIN		FROM	RAIN	GAUGE		38 MM															
WE	DID	PACKER	AT	14 - 17 M														THEMBELA WILSON LAWRENCE			

Borehole complete? Yes [ ] No [✓] Core boxes: 3 of

Water level: m Time: am

Water level: m Time: pm

Corewriter Name: Thembela Moeta

Signature:

Supervisor Name: AMARIES BOOYSEN

Signature:

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

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DAILY DRILLING REPORT

No. 42517

Date: 05-04-2013	Contract Name: BAYNES FIELD	Rig No: P207	Machine Start Hour: 011434
Weather: COOL	Client: / Inclination: 90°°	Rig Type: YWE D90	Machine End Hour: 011934
Contract No: Jo 1763	BH-no: HM 5 / Direction: VERTICAL	Pump Type: MONO	Diesel Received: 16L
Water Used 500L	Kilometers water Carted		

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
20,00	20,70	0,70	0,70	—	TNW	9,00								WATER	0%	BLACK	SLOW	WR	ROCK	AC3060	44,62
20,70	21,62	0,92	0,92	—	TNW	9,00								WATER	0%	BLACK	SLOW	WR	ROCK	AC3060	45,54
21,62	23,00	1,38	1,38	—	TNW	9,00								WATER	0%	BLACK	SLOW	WR	ROCK	AC3060	46,92
23,00	23,77	0,77	0,55	-0,22	TNW	9,00								WATER	0%	BLACK	SLOW	WR	ROCK	AC3060	47,69
23,77	25,27	1,50	1,72	+0,22	TNW	9,00								WATER	0%	BLACK	SLOW	WR	ROCK	AC3060	49,19
						EOH															

WE FINISH AT 13H30, WE PULL CASINGS OUT, CLOSE THE SUMPS AND MOVE THE STAFF BY HANDS TO THE ROAD FOR 12m UNTIL 15H00, WE WAIT FOR TRUCK UNTIL 17H00

Thapelo
Wilson
LAWRENCE

Borehole complete? Yes ✓ No	Core boxes: 4 of 4	Corewriter Name: Thapelo Moela	Signature: [signature]
Water level: m Time: am	Water level: 9,85 m Time: 13H30 pm	Supervisor Name: ANDRIES BOOYSEN	Signature: [signature]

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT

No. 35763

Date: 20/03/2013	Contract Name: UMKHOMAZI		Rig No: P205	Machine Start Hour:	01032
Weather: Cloudy	Client:	Inclination: VERTICAL	Rig Type: YWE	Machine End Hour:	01036
Contract No: J01763	BH-no: NM 6	Direction: 90°	Pump Type: MONO	Diesel Received:	30L
Water Used	Kilometers water Carted				

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Nature of Core Classification:	FR-FRESH	WR-WEATHERED	B-BOULDERS	S-SOILS	G-GRAVELS

Legend — **Run length: Depth to - Depth from = Run length** — **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc — **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined(deg 45) — **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
0.00	0.85	0.85	0.79	0.06	NXC	–								CR650	90%	Brown	Slow	S	–	NXC	0.85
0.85	1.65	0.80	0.76	0.04	NXC	–								CR650	90%	Creamy	Slow	WR	–	NXC	1.65
1.65	2.87	1.22	1.04	0.18	NWD4	–								CR650	90%	Creamy	Slow	WR	–	OLD	OLD
2.87	4.34	1.47	1.15	0.32	NWD4	–								CR650	90%	Creamy	Slow	WR	–	OLD	"
4.34	5.00	0.66	0.64	0.02	NWD4	–								CR650	90%	Creamy	Slow	WR	–	OLD	"
5.00	5.87	0.87	0.75	0.12	NWD4	–								CR650	90%	Creamy	Slow	WR	–	OLD	"
5.87	7.37	1.50	1.39	0.11	NWD4	1.50								CR650	90%	Creamy	Slow	WR	–	OLD	"
7.37	8.00	0.63	0.61	0.02	NWD4	1.50															

WE WENT TO NEW SITE by 7H00 and it take 84.3KM from OLD SITE TO NEW SITE, WE START OUR TASK by 11H40 WE ALSO DONE 2 PACKERS (1) 2–5 from 13H10 TO 14H00 AND Stage (2) by 15H00 TO 15H50.

Jan Mafanga
Lucky Mahlasela

Borehole complete?	Yes		No	✓	Core boxes: 2 of	Corewriter Name: LAWRENCE NEVANI	Signature: [signature]
Water level: m	Time: am		Water level: m	Time: pm		Supervisor Name: A Prozesen	Signature: [signature]

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT

No. 35764

Date: 21/03/2013	Contract Name: UMKHOMAZI		Rig No: P205	Machine Start Hour:	01036
Weather: Cool	Client:	Inclination: VERTICAL	Rig Type: JWE	Machine End Hour:	01044
Contract No: J01763	BH-no: NM6	Direction: 90°	Pump Type: Mono	Diesel Received:	30L
Water Used 1800	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
8.00	8.87	0.87	0.46	0.41	NWD4	1.50								CR650	90%	Creamy	Slow	WR	—	OLD	OLD
8.87	10.37	1.50	1.43	0.07	NWD4	1.50								CR650	90%	Creamy	Slow	S	—	OLD	"
10.37	11.00	0.63	0.64	0.01	NWD4	1.50								CR650	90%	Creamy	Slow	S	—	OLD	"
11.00	11.27	0.27	0.27	—	NWD4	1.50								CR650	90%	Creamy	Slow	S	—	OLD	"
11.27	12.77	1.50	1.36	0.14	NWD4	1.50								CR650	90%	Creamy	Slow	S	—	OLD	"
12.77	13.01	0.24	0.23	0.01	NWD4	1.50								CR650	90%	Creamy	Slow	S	—	OLD	"
13.01	14.00	0.99	0.65	0.34	NWD4	1.50								CR650	90%	Creamy	Slow	S	—	OLD	"
14.00	14.98	0.98	0.98	—	NWD4	1.50								CR650	90%	Creamy	Slow	S	—	OLD	"
14.98	15.50	0.52	0.38	0.14	NWD4	1.50								CR650	90%	Creamy	Slow	S	—	OLD	"
15.50	17.00	1.50	0.90	0.60	NWD4	1.50								CR650	90%	Creamy	Slow	S	—	OLD	

WE HAVE DONE 3 PACKERS 8-11 by 9H00 TO 9H50 and 11-14 by 12H30 TO 13H20 and 14-17 by 14H00 TO 14H50

Jan Maphanga
Lucky Majibolo

Borehole complete?	Yes	No ✓	Core boxes: 3 of	Corewriter Name: LAWRENCE NETARI	Signature: [signature]
Water level: m Time: am		Water level: m Time: pm		Supervisor Name: A Rooysen	Signature: [signature]

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT No. 35765

Date: 22/03/2013	Contract Name: UMKHOMAZI		Rig No: P205	Machine Start Hour: 01044
Weather: HOT	Client:	Inclination: VERTICAL	Rig Type: JWE	Machine End Hour: 01050
Contract No: JD1763	BH-no: NM6	Direction: 90°	Pump Type: Mono	Diesel Received:
Water Used 1700L	Kilometers water Carted			

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined[deg45] **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
17.00	17.84	0.84	0.42	0.42	NWD4	1.50								CR650	90%	Creamy	Slow	WR	–	OLD	OLD
17.84	19.34	1.50	1.53	+0.03	NWD4	1.50								CR650	80%	Grey	Slow	WR	–	OLD	11
19.34	20.00	0.66	0.62	0.04	NWD4	1.50								CR650	80%	Grey	fast	FR	–	OLD	11
20.00	20.87	0.87	0.93	+0.06	NWD4	1.50								CR650	80%	Grey	fast	FR	–	OLD	11
20.87	22.37	1.50	1.07	0.43	NWD4	1.50								CR650	80%	Grey	fast	FR	–	OLD	11
22.37	23.00	0.63	0.69	+0.06	NWD4	1.50								CR650	80%	Grey	fast	FR	–	OLD	11
23.00	23.87	0.87	0.74	0.13	NWD4	1.50								CR650	80%	Grey	fast	FR	–	OLD	11
23.87	25.06	1.19	1.19	—	NWD4	1.50								CR650	80%	Grey	fast	FR	–	OLD	11

WE HAVE DONE 2 PACKERS 17 – 20 by 09H05 TO 09H55 AND OTHER ONE wich is THE LAST ONE 20 – 23 by 11H00 TO 11H50, WE COMPLETE BORE HOLE AND WE CLEAN SITE, WE MOVE TO NEW HOLE 900 METERS from THE OLD SITE.

Jan Maphang
Lucky Mabilane

Borehole complete? Yes ✓ No	Core boxes: 4 of 4	Corewriter Name: LAWRENCE NEVARI	Signature: [signature]
Water level: m Time: am	Water level: 13.20m Time: 13H20pm	Supervisor Name: A Rooyenba	Signature: [signature]

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT

No. 38132

Date: 19/March/13	Contract Name: Boynes Field		Rig No: PO/67	Machine Start Hour:	
Weather: Cloudy	Client:	Inclination:	Rig Type: YWE	Machine End Hour:	
Contract No: 1763	BH-no: MM7	Direction:	Pump Type: Mono	Diesel Received:	22L
Water Used /	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters

Load:
From 07H00 loading the rig and the equipment to the new site and wait for the transport until at 11H00 and set up the rig until at 14H00

Borehole complete?	Yes		No	—	Core boxes: — of —	
Water level: m	Time: am		Water level: m	Time: pm		
Corewriter Name: Terrance Salemane	Signature: [signature]					
Supervisor Name: A Booysen	Signature: [signature]					

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT

No. 38133

Date: 20/March/2013	Contract Name: Beynes field		Rig No: PO167	Machine Start Hour:	
Weather: Cloudy	Client:	Inclination: Vertical	Rig Type: Cwe	Machine End Hour:	
Contract No: 70 1763	BH-no: MM 7	Direction: 90°	Pump Type: Mono	Diesel Received:	
Water Used 10000L	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length Bit type eg.: NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
0.00	1.50	1.50	1.30	-0.20	NXC	0.00								CR650	99%	Brown	Slow				
1.50	2.80	1.30	1.40	+0.10	HWD4	0.00								CR650	98%	Brown	Slow				
2.80	4.30	1.50	1.40	-0.10	HWD4	0.00								CR650	90%	Cream to white	Slow				
4.30	5.00	0.70	0.60	-0.10	HWD4	0.00								CR650	90%	Cream to white	Slow				
5.00	6.00	1.00	1.02	+0.02	HWD4	0.00								CR650		Cream to white	Slow				

We start drilling at 10 H45.

We've done one Perkas today.

Borehole complete? Yes	No —	Core boxes: of	Corewriter Name: Terrance Zulemore
Water level: m Time: am	Water level: m Time: pm		Supervisor Name: A Booysen
			Signature:
			Signature:

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

DAILY DRILLING REPORT

No. 38134

Date: 20/March/2018	Contract Name: Beynes Field		Rig No: PO/167	Machine Start Hour:	H/Working
Weather: Hot	Client:	Inclination: Vertical	Rig Type: YWE	Machine End Hour:	11
Contract No: J0/1763	BH-no: HM 7	Direction: 90°	Pump Type: Mono	Diesel Received:	
Water Used: 1000L	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length Bit type eg.: NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
6.00	7.50	1.50	1.27	-0.23	HWD4	0.00								CR650	97%	Cream white	Slow	WR	–	4C3162	1.50
7.50	8.00	0.50	0.51	+0.01	HWD4	0.00								CR650	99%	Cream white	Slow	WR	–	4C3286	0.50
8.00	9.50	1.50	1.27	-0.23	HWD4	0.00								CR650	97%	Cream white	Slow	WR	–	4C3162	1.50
9.50	11.00	1.50	0.90	-0.60	HWD4	0.00								CR650	60%	Cream white	Slow	WR	–	4C3286	1.50
11.00	12.50	1.50	1.18	-0.32	HWD4	0.00								CR650	32%	Cream white	Slow	WR	–	4C3162	1.50
12.50																				4C32.86	

We wait ~~for~~ Water Since from 08H09 to 10H52 And wait ~~for~~ to Start Machine until
~~And~~ wait to Start the machine at 11H10.

Borehole complete?	Yes		No	✓	Core boxes: of
Water level: m Time: am			Water level: m Time: pm		
Corewriter Name: Terrance Lalemane		Signature: [signature]			
Supervisor Name: A Booysen		Signature: [signature]			

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT No. 38135

Date: 22/March/13	Contract Name: Beynes field		Rig No: P0167	Machine Start Hour: Working	
Weather: HOT	Client:	Inclination: Vertical	Rig Type: YWE	Machine End Hour: 11	
Contract No: J01763	BH-no: H187	Direction: 90°	Pump Type: Mono	Diesel Received:	
Water Used 10000	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length:** Depth to - Depth from = Run length **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
12.50	14.00	1.50	1.15	-0.25	HWD4	1.50								CF650	75%	Cream white	Slow	WR	—	AC 31.62	1.50
14.00	15.50	1.50	1.06	-0.44	HWD4	1.50								CF650	36%	Cream White	Slow	WR	—	AC 32.86	1.50
15.50	17.00	1.50	1.15	-0.36	HWD4	1.50								CF650	36%	Cream white	Slow	G	—	AC 31.62	1.50
17.00	18.50	1.50	0.85	-0.65	HWD4	1.50								CF650	65%	Cream white	Slow	G	—	AC 32.86	1.50
18.50	20.00	1.50	1.03	-0.47	HWD4	1.50								CF650	47%	Cream white	Slow	G	—	AC 31.62	1.50
20.00					HWD4	1.50								CF650		Cream white	Slow			AC 32.86	1.50

We've done two perkors yesterday and today we've done three perkors.

Borehole complete? Yes		No	—	Core boxes: 03 of	Corewriter Name: Terrance Salemane
Water level: m Time: am		Water level: m Time: pm			Supervisor Name: A Roodman

Signature:

Signature:

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

DAILY DRILLING REPORT

No. 38136

Date: 23/March/2013	Contract Name: Beynes field			Rig No: 70/67	Machine Start Hour:		
Weather: Hot	Client:	Inclination: Vertical		Rig Type: Yuye	Machine End Hour:		
Contract No: Jo1763	BH-no: HM7	Direction: 90°		Pump Type: Mono	Diesel Received:	25	
Water Used 1000 L	Kilometers water Carted						

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
20.00	21.50	1.50	1.20	-0.30	NWD4	1.50								CR650	30%	Black	Slow	WR	—	HC 31.62	1.50
21.50	23.00	1.50	1.46	-0.04	NWD4	1.50								CR650	46%	Black	Slow	WR	—	HC 32.86	1.50
23.00	24.50	1.50	1.32	-0.18	NWD4	1.50								CR650	22%	Black	Slow	WR	—	HC 31.62	1.50
24.50	25.00	0.50	0.58	+0.08	NWD4	1.50								CR650	99%	Black	Slow	WR	—	HC 32.86	0.50

Borehole complete? Yes —	No	Core boxes: 03 of	Corewriter Name: Terrance Salomane	Signature: Salomane
Water level: 10.78 m Time: 11:28 am		Water level: m Time: pm	Supervisor Name: A Booysen	Signature:
Instruction by Geologist				
Equipment replaced:				
Equipment lost:				

DAILY DRILLING REPORT

No. 38144

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Date: 09/April/2013	Contract Name: Beynes field		Rig No: 70/67	Machine Start Hour: —
Weather: Warmer	Client:	Inclination: Vertical	Rig Type: ywe	Machine End Hour: —
Contract No: 701763	BH-no: HM8	Direction: 90°	Pump Type: Mono	Diesel Received: —
Water Used —	Kilometers water Carted			

Nature of Core Classification:	FR-FRESH	WR-WEATHERED	B-BOULDERS	S-SOILS	G-GRAVELS
Legend	**Run length: Depth to - Depth from = Run length**		**Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc		**Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN
Inclination:	Horizontal, Vertical, Inclined deg(45)		**Direction:** Compass reading (or from Geologist)		

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters

~~From old site km28474-1 to the new site is km 28275.6~~
From old site is 28275.6 to the new site is km 28474-1
After we ~~sit~~ set our rig in the difficult set up and move out equipment in the difficult way until at 17H00.

Borehole complete? Yes		No	—	Core boxes: — of —	Corewriter Name: Terrance Lalemane	Signature: [signature]
Water level: m Time: am		Water level: m Time: pm			Supervisor Name: +Prooysen	Signature: [signature]

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

DAILY DRILLING REPORT No. 39770

Date: 11 - 04 - 13	Contract Name: Baynesfield		Rig No: 167	Machine Start Hour:	
Weather: Cloudy	Client:	Inclination: Vertical	Rig Type: ywe	Machine End Hour:	
Contract No: J01763	BH-no: Nm 8	Direction: 90°	Pump Type:	Diesel Received:	15 L
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
0,00	1.50	1.50	1.35	-0,15	NXC	01,00								CR650	75%	Brown	Slow				
1.50	1.95	SPT No 1					2	2	3	3	3	3	=45								
1.95	3.00	1.05	1.00	-0,05	Mudd	0,00								"	"	"	"				
3.00	3.45	SPT No 2					2	4	4	4	4	5	=45								
3.45	4.50	1.05	0,90	-0,15	Mudd	0,00								CR650	75%	Brown	Slow				
	Wa	waiting	for	water	as	from							09H00	until	13H50	5	wa				
	Start	to	Drill	at	14.15																

Borehole complete? Yes		(No)	✓
Water level: m Time: am		Water level: m Time: pm	
Core boxes: 1 of			
Corewriter Name: Ndlovu			Signature:
Supervisor Name: A Booysen			Signature:

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

DAILY DRILLING REPORT

No. 39771

Date: 12-04-13	Contract Name: Baynesse field	Rig No: 167	Machine Start Hour:
Weather: Cold	Client: Inclination: Vertical	Rig Type: YWE	Machine End Hour:
Contract No: J01763	BH-no: HM8 Direction: 90	Pump Type:	Diesel Received: 20L
Water Used	Kilometers water Carted		

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length   Bit type eg.: (NWD4) TNW/ NQ/ HLMC etc   Drilling Response: FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal (Vertical) Inclined deg(45)   **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
4.50	4.95		SPT3				6	6	7	7	8	8	=45				Parker	10H	40 –	11H30	
4.95	6.00	1.05	1.05	–	NWD4	1.50								CRbs0	No water return	Brown	Slow				
6.00	6.45		SPT4				2	3	4	4	5	7	=45								
6.45	7.50	1,05	1.00	-0,05	NWD4	1.50								"	"	"	"				
7.50	7.65		SPT5	Refuse			9	...		25			Refuse				Perker	12H5	0 –	13 40	
7.65	9.00	1.35	1.30	-0,05	NWD4	6.00								CRbs0	No water Return	Brown	fast				
9.00	10,50	1.50	1.50	–	"	"								"	"	"	"	Perker	15H10	-16H00	

Lizwi Siwala
Leonard Mphephu

Borehole complete? Yes ☐ (No) ✓	Core boxes: 2 of	Corewriter Name: H difelani	Signature: [signature]
Water level: m Time: am	Water level: m Time: pm	Supervisor Name: A Phooy SBA	Signature: [signature]
Instruction by Geologist			
Equipment replaced:			
Equipment lost:			

DAILY DRILLING REPORT

No. 39772

Date: 13-04-13	Contract Name: Bayness field	Rig No: 167	Machine Start Hour:
Weather: Changing	Client: / Inclination: Vertical	Rig Type: YWE	Machine End Hour:
Contract No: J01763	BH-no: HM8 / Direction: 90°	Pump Type: mono	Diesel Received:
Water Used	Kilometers water Carted		

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
10.50	12.00	1.50	1.00	-0.50	NWD4	6.00								CR650	No water return	Brown	Fast				
12.00	13.50	1.50	1.05	-0.45	"	"								"	"	Black	"	Per-kel	09H10	- 10H05	
13.50	15.00	1.50	1.25	-0.25	NWD4	6.00								"	"	Brown	"				
15.00	16.50	1.50	1.50	+ -	"	"								"	"	"	"	Perker	11H400	- 11H55	

Lizwi Siwela
Leonard Mpheph

Borehole complete? Yes [ ] (No) [✓]	Core boxes: 3 of	Corewriter Name: Ndifelani	Signature: [signature]
Water level: m Time: am	Water level: m Time: pm	Supervisor Name: A Kooyser	Signature: [signature]

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT No. 39773

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Date: 15-04-13	Contract Name: Bayness field		Rig No: 167	Machine Start Hour:
Weather: Hot	Client:	Inclination: Vertical	Rig Type: YWG	Machine End Hour:
Contract No: J01763	BH-no: Hm8	Direction: 90°	Pump Type: Mono	Diesel Received:
Water Used	Kilometers water Carted			

Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
16.50	18.00	1.50	1.40	-0.10	HWD4	6.00								CR650	No water return	Brown	Fast				
18.00	19.80	1.50	1.50	—	"	"								"	"	"	"	Perker	10H	30 –	11-25
19.50	20.00	0.50	0.50	—	HWD4	6.00								"	"	"	"				

END of B.H Hm8
DEPTH 20,00

We setup at B.H HQ2 & waiting for water as from 13H00 until 14H30 & we start to drill at 14H40.

Borehole complete?	Yes ✓	No	Core boxes: 3 of 3	Corewriter Name: Ndifelani	Signature:
Water level: m Time: am		Water level: m Time: pm		Supervisor Name: A Kaoyana	Signature:

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT No. 35772

Date: 05/04/2013	Contract Name: Baynes field		Rig No: P205	Machine Start Hour:	01066
Weather: COOL	Client:	Inclination: VERTICAL	Rig Type: YWE	Machine End Hour:	01067
Contract No: JD1763	BH-no: NM 9	Direction: 090°	Pump Type: MONO	Diesel Received:	
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
WE		ARRIVE		AT		NEW				SITE			AND		WE		HAVE		DONE		
SET UP S				DIGGING		OF				SUMPS			ONLY		WAITING		TO		START		
DRILLING				TOMMOROW																	

Borehole complete? Yes [ ] No [✓] Core boxes: of

Water level: m Time: am Water level: m Time: pm

Corewriter Name: LAWRENCE NEVARI Signature:

Supervisor Name: A BOOYSEN Signature:

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT No. 35773

Date: 06/04/2013	Contract Name: Baynes Field		Rig No: P205	Machine Start Hour: 01067	
Weather: HOT	Client:	Inclination: VERTICAL	Rig Type: TWE	Machine End Hour: 01070	
Contract No: 101763	BH-no: NM9	Direction: 90°	Pump Type: Mono	Diesel Received:	
Water Used 600 L	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
0.00	0.85	0.85	0.85	—	NXC									CR650	90%	Brown	Slow	Soil	—	NXC	0.85
0.85	1.70	0.85	0.78	0.07	NXC									CR650	90%	Creamy	Slow	S	—	NXC	1.70
1.70	2.72	1.02	1.08	+0.06	NWD4									CR650	90%	Creamy	Slow	WR	—	04	11
2.72	4.22	1.50	1.50	—	NWD4									CR650	90%	Creamy	Slow	WR	—	04	11
4.22	5.00	0.78	0.40	0.38	NWD4									CR650	90%	Creamy	Slow	WR	—	04	11
														CR650	90%	Creamy	Slow	WR	—		
WE	WERE		WAITING			FOR							WATER			AND		WE	START		
DRILLING			BY	11H05																	
																		Jan Maphanga			
																		Luc/Jay Mabulana			

Borehole complete? Yes		No	✓	Core boxes: 1 of	Corewriter Name: LAWRENCE NEVARI
Water level: m Time: am				Water level: m Time: pm	Supervisor Name:

Signature:

Signature:

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

DAILY DRILLING REPORT No. 35774

Date: 08/04/2013	Contract Name: BAYNES FIELD			Rig No: P205	Machine Start Hour:	01070
Weather: HOT	Client:	Inclination: VERTICAL		Rig Type: TWE	Machine End Hour:	01077
Contract No: J01763	BH-no: NM 9	Direction: 90		Pump Type: MONO	Diesel Received:	
Water Used 2800 L	Kilometers water Carted					

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length Bit type eg.: NWD4/ TNW/ NQ/ HLMC etc Drilling Response: FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
5.00	5.73	0.73	0.83	+0.10	NWD4	1.50								CR650	80%	Creamy	Slow	WR	—	OLD	OLD
5.73	7.23	1.50	0.80	0.70	NWD4	1.50								CR650	80%	Creamy	Slow	WR	—	OLD	"
7.23	8.00	0.77	0.53	0.24	NWD4	1.50								CR650	80%	Creamy	Fast	WR	—	OLD	"
8.00	8.73	0.73	0.90	+0.17	NWD4	1.56								CR650	80%	Creamy	Fast	WR	—	OLD	"
8.73	10.23	1.50	1.52	+0.02	NWD4	1.50								CR650	80%	Grey	Fast	WR	—	OLD	"
10.23	11.00	0.77	0.63	0.14	NWD4	1.50								CR650	80%	Grey	Fast	WR	—	OLD	"
11.00	11.73	0.73	0.81	+0.08	NWD4	1.50								CR650	80%	Grey	Fast	WR	—	OLD	"
11.73	13.23	1.50	1.47	0.03	NWD4	1.50								CR650	80%	Grey	Fast	FR	—	"	"
13.23	14.00	0.77	0.69	0.08	NWD4	1.50								CR650	80%	Grey	Fast	FR	—	"	"
WE	HAVE		BONE		4		PACKERS							2-5	and		5-8	and	o/		
8.11	and		@150		11-	14.															

Borehole complete? Yes ☐ No ☑ Core boxes: 2 of

Water level: m Time: am Water level: m Time: pm

Corewriter Name: LAWRENCE NEVARY Signature:

Supervisor Name: J BOOYSEN Signature:

Instruction by Geologist

Equipment replaced:

Equipment lost:

(6639)

DAILY DRILLING REPORT

No. 35775

Date: 09/04/2013	Contract Name: BAYNES FIELD		Rig No: P205	Machine Start Hour:	01077
Weather: HOT	Client:	Inclination: VERTICAL	Rig Type: YWE	Machine End Hour:	
Contract No: J01763	BH-no: NM9	Direction: 90°	Pump Type: Mono	Diesel Received:	
Water Used 1000 L	Kilometers water Carted				

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Nature of Core Classification: **FR**-FRESH **WR**-WEATHERED **B**-BOULDERS **S**-SOILS **G**-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
14.00	16.12	2.12	1.98	0.14	TNW	1.50								CR650	70%	Grey	fast	FR	-	1214	OLD
16.12	17.00	0.88	0.66	0.22	TNW	1.50								CR650	70%	Grey	fast	FR	-	1214	OLD
17.00	19.12	2.12	2.026	0.14	TNW	1.50								CR650	0%	Grey	fast	FR	-	1214	〃
19.12	20.11	0.99	0.93	0.06	TNW	1.50								CR650	0%	Grey	fast	FR	-	1214	〃

WE HABE DONE 2 PACKER 14-17 WHERE THE WERE TOTAL WATER LOSS AND ALSO 17-20 WERE THE SAME. WE COMPLETE BORE HOLE AND WE MOVE TO THE NE BORE ONLY WANT TO GO SETUPS. AND GO FURTHER WITH OUR TASK TOMMORROW. Wich is 9 KM.

Jan Maphange
Lucky Mabilana

Borehole complete? Yes ✓	No	Core boxes: 3 of 3	Corewriter Name: LAWRENCE NEVAHI	Signature: [signature]	
Water level: m Time: am		Water level: 15.8 m Time: 13H20 pm	Supervisor Name: A Rooysen	Signature: [signature]	

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT No. 39766

Date: 06-04-13	Contract Name: Baynes field		Rig No: 168	Machine Start Hour:	
Weather: HOT	Client:	Inclination: Vertical	Rig Type: YWE	Machine End Hour:	
Contract No: J01763	BH-no: HM10	Direction: 90	Pump Type:	Diesel Received:	
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
			We	Setup	as	from								until	10:00	&	1 Waiting				
			for	water.																	
																Lizwi Siwela					
																Leonard Mpheshu					

Borehole complete? Yes ☐ No ☐ Core boxes: of Corewriter Name: Ndifelani Signature:

Water level: m Time: am Water level: m Time: pm Supervisor Name: Signature:

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

DAILY DRILLING REPORT No. 39767

Date: 08-04-13	Contract Name: Baynass field		Rig No: 168	Machine Start Hour:	240.7
Weather: Hot	Client:	Inclination: Vertical	Rig Type: YWE	Machine End Hour:	
Contract No: J01763	BH-no: HM 10	Direction: 90°	Pump Type:	Diesel Received:	25 L
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
0,00	0,90	0,90	0,40	-0,50	Nxc	0,00								CR650	75%	Brown	Slow				
0,90	1.50	0.60	0,30	-0,30	"	"								"	"	"	"				
1.50	2.77	1.27	1.27	—	Hwdh	1.50								"	"	"	"				
2.77	3.52	0,75	0,50	-0,25	"	"								"	"	"	fast				
3.52	5.02	1.50	0,95	-0,55	"	"								CR650	75%	"	"				
5.02	6.52	1.50	1.15	-0,35	Hwdh	1.50								"	"	Black	"				
6.52	8.02	1.50	1.40	-0,10	"	"								"	"	"	"				
8.02	11.02	3.00	2.80	-0,20	TNW	"								"	"	"	"				
		We	waiting	for	water	as	from	8H00	until	10H00							E/	WW			
		Start	to	Drill	at	10H20															
																Lizwi	Siwela				
																Leonard	Mphapha				

Borehole complete? Yes [ ] No [✓] Core boxes: 2 of

Corewriter Name: Ndifelani Signature:

Water level: m Time: am Water level: m Time: pm

Supervisor Name: A Baynass Signature:

Instruction by Geologist

Equipment replaced:

Equipment lost:

(56201)

DAILY DRILLING REPORT

No. 39768

Date: 09-04-13	Contract Name: Bayness field		Rig No: 168	Machine Start Hour:	246.6
Weather: Hot	Client:	Inclination: Vertical	Rig Type: YWE	Machine End Hour:	
Contract No: J01763	BH-no: Hm10	Direction: 90°	Pump Type:	Diesel Received:	
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
11.02	12.52	1.50	1.35	-0,15	TNW	1.50								CR650	75%	Black	Fast				
12.52	15.52	3.00	2.75	-0,25	"	"								"	"	"	"				
15.52	17.77	2.25	2.25	—	TNW	"								"	"	"	"				
17.77	18.52	0.75	0.75	—	NWD4	"								"	"	"	"				
18.52	20.02	1.50	1.50	—	"	"								"	"	"	"				

END of B.H Hm10
DEPTH 20.02

Lizwi Siwela
Leonard Mphephu

Borehole complete?	(Yes) ✓	No	Core boxes: 3 of 3	Corewriter Name: Ndifelani	Signature: [signature]
Water level: m Time: am		Water level: 5 m Time: 16H00 pm		Supervisor Name: A Booysen	Signature: [signature]

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT   No. 35779

Date: 13/04/2015	Contract Name: BAYNES FIELD		Rig No: P205	Machine Start Hour: 01092	
Weather: COOL	Client:	Inclination: VERTICAL	Rig Type: YWE	Machine End Hour: 01096	
Contract No: J01763	BH-no: NQ 1	Direction: 90°	Pump Type: Mono	Diesel Received:	
Water Used 900 L	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend Run length: Depth to - Depth from = Run length **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
0.00	0.85	0.85	0.82	0.03	NXC	—								CR650	90%	Brown	Slow	Soil	—	NXC	0.85
0.85	1.31	0.46	0.49	+0.03	NXC	—								CR650	90%	Creamy	Slow	Soil	—	NXC	1.31
1.31	2.82	1.51	1.30	0.21	NWD4	1.50								CR650	90%	Creamy	Slow	WR	—	OLD	OLD
2.82	4.32	1.50	1.36	0.14	NWD4	1.50								CR650	80%	Creamy	Slow	WR	—	OLD	11
4.32	5.82	1.50	1.18	0.32	NWD4	1.50								CR650	80%	Creamy	Slow	WR	—	OLD	11

WE WENT TO WORK by 7H00 AM WE move our Equipment To THE NEW BORE HOLE Doing Set ups and Start drilling After we HAVE DONE PTA.

Jan Maphanga
Lucky Mabilana

Borehole complete? Yes		No ✓	Core boxes: 1 of	Corewriter Name: LAWRENCE NEVARI	Signature: [signature]
Water level: m Time: am		Water level: m Time: pm		Supervisor Name: A Rooyman	Signature: [signature]

Instruction by Geologist

Equipment replaced:

Equipment lost:

DAILY DRILLING REPORT No. 35780

Date: 15/04/2013	Contract Name: BAYNES FIELD		Rig No: P205	Machine Start Hour:	01096
Weather: HOT	Client:	Inclination: VERTICAL	Rig Type: NWE	Machine End Hour:	01099
Contract No: J01763	BH-no: NQ1	Direction: 90°	Pump Type: MONO	Diesel Received:	
Water Used 2800	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
5.82	7.32	1.50	1.20	0.30	NWD4	4.50								CR65	80%	Creamy	Slow	WR	—	OLD	OLD
7.32	8.82	1.50	1.12	0.38	NWD4	4.50								CR65	80%	Creamy	Slow	WR	—	OLD	"
8.82	10.32	1.50	1.31	0.19	NWD4	4.50								CR65	80%	Creamy	fast	WR	—	OLD	"
10.32	11.82	1.50	1.30	0.20	NWD4	4.50								CR65	80%	Grey	fast	WR	—	OLD	"
11.82	13.32	1.50	1.37	0.13	NWD4	4.50								CR65	80%	Grey	fast	WR	—	OLD	"
13.32	14.82	1.50	1.58	+0.08	NWD4	4.50								CR65	80%	Grey	fast	WR	—	OLD	"
14.82	16.32	1.50	1.37	0.13	NWD4	4.50								CR65	80%	Grey	fast	FR	—	OLD	"
16.32	16.82	0.50	0.44	0.06	TNW	4.50								CR65	80%	Grey	fast	FR	—	OLD	"
16.82	18.32	1.50	1.45	0.05	NWD4	4.50								CR65	0%	Grey	fast	FR	—	OLD	"
18.32	19.82	1.50	1.47	0.03	NWD4	4.50								CR65	0%	Grey	fast	FR	—	OLD	"
19.82	20.19	0.37	0.47	+0.10	NWD4	4.50								CR65	0%	Grey	fast	FR	—	OLD	"
WE	COMPLETE				BORE		HOLE					BY		15HOS		NWE		ALSO		RUN	
OUT		CASING		WAITING			TO			LOAD				TOMORROW.							
																		Jan Maphanga			
																		Lucky Mabilanka			

Borehole complete?	Yes ✓	No	Core boxes: 3 of 3	Corewriter Name: LAWRENCE NEVARE	Signature:
Water level: m	Time: am		Water level: 18.20 m	Time: 15:20 pm	Supervisor Name: A Booysen	Signature:

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

(5639)

DAILY DRILLING REPORT No. 35781

Date: 16/04/2013	Contract Name: Baynes field		Rig No: P205	Machine Start Hour:	
Weather: HOT	Client:	Inclination: VERTICAL	Rig Type: JWE	Machine End Hour:	
Contract No: JO1763	BH-no: NQ1	Direction: 90°	Pump Type: MONO	Diesel Received:	
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
WE	WENT		TO	SITE		AND							WE	LOAD		THE	RIG		A	OTHER	
EQUIPMENT			TO	THE		CAMP							by	ISHIO							

Borehole complete? Yes ✓ No ☐ Core boxes: 3 of 3 Corewriter Name: LAWRENCE NEVARI Signature:

Water level: m Time: am Water level: m Time: pm Supervisor Name: A BOOYSEN Signature:

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

(6630)

DAILY DRILLING REPORT

No. 39774

Date: 15-04-13	Contract Name: Baynes field		Rig No: 168	Machine Start Hour:	
Weather: Hot	Client:	Inclination: Vertical	Rig Type: YWE	Machine End Hour:	
Contract No: J01763	BH-no: HG2	Direction: 90°	Pump Type: mono	Diesel Received:	
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B /S/G	Rock type	Bit NO.	Accum bit meters
0,00	0,90	0,90	0,35	-0,55	Hxc	0,00								CR650	75%	Brown	Slow				
0,90	1.50	0,60	0.40	-0,20	"	"								"	"	"	"				
1.50	2.07	0,57	0,35	-0,22	"	"								"	"	"	Fast				
2.07	3.57	1.50	1.45	-0,05	Nwd4	1.50								"	75%	"	"				

Lizwi Siwela
Leonard Mphephu

Borehole complete? Yes		No (circled)	✓	Core boxes: 1 of	Corewriter Name: Ndlfelani	Signature: [signature]
Water level: m Time: am		Water level: m Time: pm			Supervisor Name: A Roozeboom	Signature: [signature]

Instruction by Geologist	
Equipment replaced:	
Equipment lost:	

(5639)

DAILY DRILLING REPORT **No.** 39775

Date: 16-04-13	Contract Name: Bayness field		Rig No: 168	Machine Start Hour:	
Weather: Hot	Client:	Inclination: Vertical	Rig Type: YWG	Machine End Hour:	
Contract No: J01763	BH-no: HQ2	Direction: 90°	Pump Type:	Diesel Received:	20 L
Water Used	Kilometers water Carted				

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
3.57	5.07	1.50	1.50	—	Hwd4	1.50								CR650	75%	Brown	fast				
5.07	6.57	1.50	1.50	—	"	"								"	"	"	"				
6.57	8.07	1.50	1.05	-0,45	"	"								"	"	"	"				
8.07	9.57	1.50	1.20	-0,30	Hwd4	1.50								"	75%	"	"				
9.57	11.07	1.50	1.30	-0,20	"	"								"	"	Black	"				
11.07	12.57	1.50	1.50	-	"	"								"	"	"	"				
12.57	14.07	1.50	1.45	-0,05										CR650	75%	Black	fast				
14.07	15.57	1.50	1.50	—	Hwd4	1.50								"	"	"	"				
15.57	17.07	1.50	1.50	—	"	"								CR650	No water return	Black	fast				
17.07	18.57	1.50	1.25	-0,25	"	"								"	"	"	"				
18.57	20.07	1.50	1.60	+0,10	"	"								"	"	"	"				
			END OF B.H. HQ2																		
			DEPTH 20.07																		

Borehole complete? Yes	✓	No		Core boxes: 3 of 3	Corewriter Name: Hlifelan'	Signature:
Water level: m Time: am		Water level: 7.9 m Time: 13.35pm		Supervisor Name: A Booysen	Signature: [signature]

Instruction by Geologist

Equipment replaced:

Equipment lost:

(5639)

DAILY DRILLING REPORT No. 35776

Date: 10/04/2013	Contract Name: BayNES field		Rig No: P205	Machine Start Hour:	01081
Weather: Rain	Client:	Inclination: Vertical	Rig Type: YWT	Machine End Hour:	0181
Contract No: J01763	BH-no: NQ3	Direction: 90°	Pump Type: Mor	Diesel Received:	25
Water Used ~~1600~~	Kilometers water Carted.				

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Nature of Core Classification:	FR-FRESH	WR-WEATHERED	B-BOULDERS	S-SOILS	G-GRAVELS
Legend	**Run length: Depth to - Depth from = Run length**	**Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc		**Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN	
Inclination:	Horizontal, Vertical, Inclined deg(45)	**Direction:** Compass reading (or from Geologist)			

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters

WE DID'T START YET TO DRILL NEW BORE HOLE THAT MENTIONED ABOVE CAUSE OF HEAVY RAIN THERE WHERE RAIN THE whole DAY WE GET INSTRUCTION NOT TO GO THERE on site Cause There is NO ACCESS TO GET IN.

Tau Maphanga
Lucky Mahlaba

Borehole complete? Yes		No ✓	Core boxes: ___ of	Corewriter Name: LAWRENCE NEVARI	Signature: [signature]
Water level: m Time: am		Water level: m Time: pm		Supervisor Name: A ROOYSEIL	Signature: [signature]

Instruction by Geologist

Equipment replaced:

Equipment lost:

(5639)

DAILY DRILLING REPORT No. 35777

Date: 11/04/2013	Contract Name: Baynes Field			Rig No: D205	Machine Start Hour:	01081	
Weather: Cool	Client:		Inclination: VERTICAL	Rig Type: JWE	Machine End Hour:	01089	
Contract No: JO1763	BH-no: NQ3		Direction: 90°	Pump Type: MONO	Diesel Received:		
Water Used 1600	Kilometers water Carted						

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
0.00	0.85	0.85	0.70	0.15	NQC									CR650	90%	Creamy	Slow	WR	—	NQC	0.85
0.85	1.40	0.55	0.52	0.03	NQC									CR650	90%	Creamy	Slow	WR	—	NQC	1.40
1.40	2.85	1.45	1.38	0.07	NWD4									CR650	90%	Creamy	Slow	WR	—	QLD	QLD
2.85	4.35	1.50	1.32	0.18	NWD4	1.50								CR650	90%	Creamy	Slow	WR	—	QLD	11
4.35	5.83	1.48	1.21	0.27	NWD4	4.50								CR650	80%	Grey	Slow	WR	—	QLD	11
5.83	7.35	1.52	1.56	+0.04	NWD4	4.50								CR650	80%	Grey	Slow	WR	—	QLD	11
7.35	8.85	1.50	1.35	0.15	NWD4	4.50								CR650	80%	Grey	Slow	WR	—	QLD	11
8.85	10.37	1.52	1.58	+0.06	NWD4	4.50								CR650	80%	Gre	Slow	WR	—	QLD	11
WE	Have		Done		Set up's								and		Start		drilling		by		
10	H45.																				
																	Jan		mapham		
																	Lucky		Mabidaka		

Borehole complete? Yes [ ] No [✓] Core boxes: 2 of

Corewriter Name: LAWRENCE NEVARA Signature:

Water level: m Time: am Water level: m Time: pm

Supervisor Name: A Booysen Signature:

Instruction by Geologist

Equipment replaced:

Equipment lost:

(5639)

DAILY DRILLING REPORT

No. 35778

Date: 12/04/2013	Contract Name: BAYNES field	Rig No: P205	Machine Start Hour: 01089
Weather: Cloudy	Client:	Inclination: VERTICAL	Rig Type: Twe	Machine End Hour: 01092
Contract No: J01763	BH-no: NQ3	Direction: 0/0°	Pump Type: Mono	Diesel Received: 25L
Water Used 2100L	Kilometers water Carted			

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Nature of Core Classification: FR-FRESH WR-WEATHERED B-BOULDERS S-SOILS G-GRAVELS

Legend **Run length: Depth to - Depth from = Run length** **Bit type eg.:** NWD4/ TNW/ NQ/ HLMC etc **Drilling Response:** FAST/ SLOW/ EVEN/ UNEVEN

Inclination: Horizontal, Vertical, Inclined deg(45) **Direction:** Compass reading (or from Geologist)

Depth from	Depth to	Run Length	Core Recovered	Core loss	Bit type	Casing Depth	SPT Blow Count 0.075	0.150	0.225	0.300	0.375	0.450	Sample recovered - SPT, Undisturbed	Drill fluid	Water return %	Colour	Drilling response	FR/WR/B/S/G	Rock type	Bit NO.	Accum bit meters
10.37	11.87	1.50	1.43	0.07	NWD4	4.50								CR650	80%	Grey	fast	FR	–	OLD	OLD
11.87	14.76	2.89	2.95	+0.06	TNW	4.50								CR650	80%	Grey	fast	FR	–	OLD	OLD
14.76	17.76	3.00	2.97	0.03	TNW	4.50								CR650	80%	Grey	fast	FR	–	11	11
17.76	20.18	2.42	2.56	+0.14	TNW	4.50								CR650	80%	Grey	fast	FR	–	11	11

WE WENT TO work by 7H00 AM AND WE START DRilling by 09H40 because the WHERE NO WATER WE ALSO Complete BORE HOLE ONLY Going TO Load our Equip MENT TO THE NEW BOREHOLE tomorrow.

Jan Maphanga
Mabilana

Borehole complete? Yes ✓	No	Core boxes: 3 of 3	Corewriter Name: LAWRENCE NEVARI	Signature:
Water level: m Time: am		Water level: 12/0m Time: 15.10 pm	Supervisor Name: A Phengoba	Signature:

Instruction by Geologist

Equipment replaced:

Equipment lost:

(5639)

Water test results

1669

FIELD DATA FROM LUGEON TESTS

Drillhole No: NM1 Inclination: 90° Test No: 1

Date of Test: 25/03/2013
Packer Type: Single
Bottom of Casing: ... m
Base of Hole: 5. m

Test Section from ... m to ... m
Packer Pressure 12 kPa
Water Level ... m
Hole ∅ at test level NWD4 mm

Pressure gauge height above collar: 2.6 m
Details of test equipment: ...
Calibration Curve No: ...

GEOMECHANICS
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e-mail: info@geomechanics.co.za

FIRST STAGE 2-5		Gauge Pressure 12	20	28	20	12	
Time	(Minutes)	10	10	10	10	10	Av Flow q (Litres/Minute)
Flowmeter	Reading	1879,7	1881,0	1881,9	1882,9	1883,8	
Dipstick	(Litres)	1881,0	1881,9	1882,9	1883,8	1885,0	
Water Intake	(Litres)	2	0.9	0.1	0.9	1.2	

SECOND STAGE 5-8		Gauge Pressure 30	50	70	50	30	
Time	(Minutes)	10	10	10	10	10	Av Flow q (Litres/Minute)
Flowmeter	Reading	1885,0	1885,4	1886,2	1887,4	1887,8	
Dipstick	(Litres)	1885,4	1886,2	1887,4	1887,8	1888,2	
Water Intake	(Litres)	0.4	0.8	1.2	0.4	0.4	

THIRD STAGE 8-11		Gauge Pressure 48	80	112	80	48	
Time	(Minutes)	10	10	10	10	10	Av Flow q (Litres/Minute)
Flowmeter	Reading	1888,2	1885,7	1889,8	1893,2	1894,6	
Dipstick	(Litres)	1888,7	1889,8	1893,2	1894,6	1895,1	
Water Intake	(Litres)	0.5	1.1	3.4	1.4	0.5	

FOURTH STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow q (Litres/Minute)
Flowmeter	Reading						
Dipstick	(Litres)						
Water Intake	(Litres)						

FIFTH STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow q (Litres/Minute)
Flowmeter	Reading						
Dipstick	(Litres)						
Water Intake	(Litres)						

SIXTH STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow q (Litres/Minute)
Flowmeter	Reading						
Dipstick	(Litres)						
Water Intake	(Litres)						

1670

FIELD DATA FROM LUGEON TESTS

Drillhole No: NM1 Inclination: 90° Test No: 4

Date of Test: 26/03/2013
Packer Type: Single
Bottom of Casing: 1.5 m
Base of Hole: 14 m

Test Section from 11 m to 14 m
Packer Pressure 99 kPa
Water Level ..... m
Hole ∅ at test level TNW mm

Pressure gauge height above collar: 2.6 m
Details of test equipment: .....
Calibration Curve No: .....

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FIRST STAGE	11-14	99	Gauge Pressure 176	242	176	99	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	1895,1	1897,6	1902,6	1904,5	1904,5	q
Dipstick	(Litres)	1897,6	1902,0	1904,5	1904,5	1908,0	(Litres/Minute)
Water Intake	(Litres)	2.5	4.4	2.5	0	3.5	
SECOND STAGE	14-17	126	Gauge Pressure 224	308	224	126	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	1908,8	1911,7	1914,7	1919,4	1921,3	q
Dipstick	(Litres)	1911,7	1914,7	1919,4	1921,3	1923,0	(Litres/Minute)
Water Intake	(Litres)	2.9	3	4.7	1.9	1.7	
THIRD STAGE	17-20	153	Gauge Pressure 272	374	272	153	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	1923,0	1927,2	1932,7	1938,1	1942,9	q
Dipstick	(Litres)	1927,2	1932,7	1938,1	1942,9	1946,6	(Litres/Minute)
Water Intake	(Litres)	4.2	5.5	5.4	4.8	3.7	
FOURTH STAGE	20-23	180	Gauge Pressure 320	440	320	180	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	1946,6	1959,9	1972,3	1986,5	2000,5	q
Dipstick	(Litres)	1959,9	1972,3	1986,5	2000,5	2013,3	(Litres/Minute)
Water Intake	(Litres)	13.3	12.4	14.2	14	12.8	
FIFTH STAGE			Gauge Pressure				
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						
SIXTH STAGE			Gauge Pressure				
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						

FIELD DATA FROM LUGEON TESTS

Borehole No: JHM2 Inclination: Vertical Test No: 1

Date of Test: 04/April/2013 Test Section from .....m to.....m

Type of Test: Single Packer Pressure .....kPa

Length of Casing ..... m Water Level .....m

Length of Hole ..... m Hole Ø at test level .....mm

Pressure gauge height above collar: .....m

Type of water equipment: .....

Pump Curve No: .....

GEOMECHANICS

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STAGE 2-5 m

Gauge Pressure

Time (Minutes)	12	20	28	20	12	Av Flow q (Litres/Minute)
Reading	6.8	5.5	3.0	4.0	2.0	
Litres	5.5	3.0	4.0	2.0	0.5	
Litres	1.3	2.5	1.0	2.0	1.5	

STAGE 5.8m

Gauge Pressure

Time (Minutes)	30	50	70	50	30	Av Flow q (Litres/Minute)
Reading	0.5	2.4	1.9	1.8	2.0	
Litres	2.4	1.9	1.8	2.0	1.0	
Litres	1.9	0.5	0.1	0.2	1.0	

STAGE 03/04/2013 8-11

Gauge Pressure

Time (Minutes)	72	128	176	128	72	Av Flow q (Litres/Minute)
Reading	1.0	1.5	0.5	0.5	1.6	
Litres	1.5	0.5	0.5	1.6	0.5	
Litres	0.5	1.0	0.0	1.1	1.1	

STAGE 11-14 m

Gauge Pressure

Time (Minutes)	99	176	242	176	99	Av Flow q (Litres/Minute)
Reading	0.5	10.8	14.8	20.6	18.2	
Litres	10.8	14.6	20.6	18.8	9.8	
Litres	10.3	3.8	6.0	2.0	8.8	

STAGE 11-12 M 03/04/2013

Gauge Pressure

Time (Minutes)	126	284	~~284~~ 308	~~288~~	~~126~~	Av Flow q (Litres/Minute)
Reading						
Litres						
Litres						

STAGE 12

Gauge Pressure

Time (Minutes)						Av Flow q (Litres/Minute)
Reading						
Litres						
Litres						

FIELD DATA FROM LUGEON TESTS

Borehole No: BH 2 Inclination: Vertical Test No: 5

Date of Test: 03/April/2023 | Test Section from .....m to.....m

Type of Test: Single | Packer Pressure .....kPa

Length of Casing: 4.50 m | Water Level .....m

Depth of Hole: ..... m | Hole Ø at test level THW .....mm

Pressure gauge height above collar: .....m

Number of test equipment: .....

Calibration Curve No: .....

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FIRST STAGE 14-12m		Gauge Pressure					
Time	(Minutes)	120	224	308	224	126	Av Flow
Flowmeter	Reading	9.8	1.2	3.5	17.0	13.4	q
Discharge	(Litres)	1.2	3.5	17.0	13.4	7.6	(Litres/Minute)
Water intake	(Litres)	8.6	2.3	13.5	3.6	5.8	

SECOND STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Discharge	(Litres)						(Litres/Minute)
Water intake	(Litres)						

THIRD STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Discharge	(Litres)						(Litres/Minute)
Water intake	(Litres)						

FOURTH STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Discharge	(Litres)						(Litres/Minute)
Water intake	(Litres)						

FIFTH STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Discharge	(Litres)						(Litres/Minute)
Water intake	(Litres)						

SIXTH STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Discharge	(Litres)						(Litres/Minute)
Water intake	(Litres)						

FIELD DATA FROM LUGEON TESTS

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Cell: 082 772 3910

-M2 .... Inclination: Vertical Test No: 1

/04/2013

Single

Casing .... m | Test Section from ....m to............m

.... m | Packer Pressure ....kPa

Water Level ....m

Hole Ø at test level TNW ....mm

Gauge height above collar: ....m

equipment: ....

Curve No: ....

7-20m

	Gauge Pressure					
(Minutes)	152	272	374	242	153	Av Flow q (Litres/Minute)
Reading	7.6	8.9	8.8	11.8	16.0	
(Litres)	5.9	8.8	11.8	16.0	18.8	
(Litres)	1.7	0.1	3.0	5.8	2.8	

STAGE

	Gauge Pressure					
(Minutes)						Av Flow q (Litres/Minute)
Reading						
(Litres)						
(Litres)						

STAGE

	Gauge Pressure					
(Minutes)						Av Flow q (Litres/Minute)
Reading						
(Litres)						
(Litres)						

STAGE

	Gauge Pressure					
(Minutes)						Av Flow q (Litres/Minute)
Reading						
(Litres)						
(Litres)						

STAGE

	Gauge Pressure					
(Minutes)						Av Flow q (Litres/Minute)
Reading						
(Litres)						
(Litres)						

STAGE

	Gauge Pressure	
(Minutes)		Av Flow q (Litres/Minute)
Reading		
(Litres)		
(Litres)		

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MEMBER DAVE ROSSTER

Member of
Drilling Association of S.A.
Borehole Water Association of S.A.

1616

FIELD DATA FROM LUGEON TESTS

Drillhole No: NM3 Inclination: Vertical Test No:

Date of Test: 04-04-13
Packer Type: Single
Bottom of Casing: 4.50 m
Base of Hole: 8. m

Test Section from 5.00 m to 8.00 m
Packer Pressure 45 kPa
Water Level m
Hole ∅ at test level NWD mm

Pressure gauge height above collar: 2.7 m
Details of test equipment:
Calibration Curve No:

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FIRST STAGE 5m - 8m		45	Gauge Pressure 80	110	80	45	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	0	0	0	0	0	
SECOND STAGE 8m - 11m		72	Gauge Pressure 128	176	128	72	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	0	0	0	0	0	
THIRD STAGE 11 - 14m		99	Gauge Pressure 176	242	176	99	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	0	0	0	0	0	
FOURTH STAGE 14 - 17m		126	Gauge Pressure 224	308	224	126	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	0	0	0	0	0	
FIFTH STAGE 17 - 20m		153	Gauge Pressure 272	374	272	153	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	0	0	0	0	0	
SIXTH STAGE			Gauge Pressure				
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						

1615

FIELD DATA FROM LUGEON TESTS

Drillhole No: NM3 Inclination: Vertical Test No: 1

Date of Test: 25-03-13
Packer Type: Single
Bottom of Casing: 0,00 m
Base of Hole: 5 m

Test Section from 2 m to 5 m
Packer Pressure 12 kPa
Water Level ..... m
Hole∅ at test level NWL4 mm

Pressure gauge height above collar: 2.7 m

Details of test equipment: .....

Calibration Curve No: .....

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FIRST STAGE		Gauge Pressure 12	20	28	20	12	
Time	(Minutes)	10	10	10	10	10	Av Flow q (Litres/Minute)
Flowmeter	Reading	870	870	870	870	870	
Dipstick	(Litres)	870	870	870	870	870	
Water Intake	(Litres)	0	0	0	0	0	

SECOND STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow q (Litres/Minute)
Flowmeter	Reading						
Dipstick	(Litres)						
Water Intake	(Litres)						

THIRD STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow q (Litres/Minute)
Flowmeter	Reading						
Dipstick	(Litres)						
Water Intake	(Litres)						

FOURTH STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow q (Litres/Minute)
Flowmeter	Reading						
Dipstick	(Litres)						
Water Intake	(Litres)						

FIFTH STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow q (Litres/Minute)
Flowmeter	Reading						
Dipstick	(Litres)						
Water Intake	(Litres)						

SIXTH STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow q (Litres/Minute)
Flowmeter	Reading						
Dipstick	(Litres)						
Water Intake	(Litres)						

1613

NM4 FIELD DATA FROM LUGEON TESTS

Drillhole No: NW H Inclination: Vertical Test No: 1

Date of Test: 21-03-13
Packer Type: Single
Bottom of Casing: 0,W m
Base of Hole: 5 m

Test Section from 2 m to 5 m
Packer Pressure 12 kPa
Water Level m
Hole∅ at test level NWD H mm

Pressure gauge height above collar: 2.70 m
Details of test equipment:
Calibration Curve No:

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FIRST STAGE		Gauge Pressure 12	20	28	20	12	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	0	0	0	0	0	
COND STAGE 5-8m		30	Gauge Pressure 50	70	50	30	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	000	000	000	000	000	
THIRD STAGE 8-11m		48	Gauge Pressure 80	112	80	48	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	000	000	000	000	000	
FOURTH STAGE 11- 14m		99	Gauge Pressure 148	242	176	99	
Time	(Minutes)	10	10	10	10	10	Av Flow
wmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	000	000	000	000	000	
FIFTH STAGE			Gauge Pressure				
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						
SIXTH STAGE			Gauge Pressure				
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						

1614

FIELD DATA FROM LUGEON TESTS

Drillhole No: HW14 Inclination: Vertical Test No: 5

Date of Test: 23-03-13 Test Section from 15 m to 17 m

Packer Type: Single Packer Pressure 126 kPa

Bottom of Casing: 1.50 m Water Level m

Base of Hole: 17 m Hole ∅ at test level HW04 mm

Pressure gauge height above collar: 2.70 m

Details of test equipment:

Calibration Curve No:

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FIRST STAGE 14 – 17m		Gauge Pressure	126	224	308	224	126	
Time	(Minutes)		10	10	10	10	10	Av Flow
Flowmeter	Reading		870	870	870	870	870	q
Dipstick	(Litres)		870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)		0	0	0	0	0	
COND STAGE 14 – 20m		Gauge Pressure	153	272	344	272	153	
Time	(Minutes)		~~870~~10	10	10	10	10	Av Flow
Flowmeter	Reading		870	870 870	870	870 270	870	q
Dipstick	(Litres)		870		870		870	(Litres/Minute)
Water Intake	(Litres)		000	000	000	000	000	
THIRD STAGE		Gauge Pressure						
Time	(Minutes)							Av Flow
Flowmeter	Reading							q
Dipstick	(Litres)							(Litres/Minute)
Water Intake	(Litres)							
FOURTH STAGE		Gauge Pressure						
Time	(Minutes)							Av Flow
wmeter	Reading							q
Dipstick	(Litres)							(Litres/Minute)
Water Intake	(Litres)							
FIFTH STAGE		Gauge Pressure						
Time	(Minutes)							Av Flow
Flowmeter	Reading							q
Dipstick	(Litres)							(Litres/Minute)
Water Intake	(Litres)							
SIXTH STAGE		Gauge Pressure						
Time	(Minutes)							Av Flow
Flowmeter	Reading							q
Dipstick	(Litres)							(Litres/Minute)
Water Intake	(Litres)							

1709

FIELD DATA FROM LUGEON TESTS

Drillhole No: MM 5 Inclination: 90° Test No: 1

Date of Test: 21-03-2013 Test Section from 2 m to 5 m

Packer Type: SINGLE Packer Pressure kPa

Bottom of Casing: — m Water Level 3.10 m

Base of Hole: 5 m Hole ∅ at test level MUDDY mm

Pressure gauge height above collar: m

Details of test equipment:

Calibration Curve No:

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FIRST STAGE 2-5		Gauge Pressure 12	28	28	20	12	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	49.4	49.8	50.4	51.7	52.8	q
Dipstick	(Litres)	49.8	50.4	51.7	52.8	53.3	(Litres/Minute)
Water Intake	(Litres)	0.4	0.6	1.3	1.1	0.5	
SECOND STAGE	5-8	30	Gauge Pressure 50	70	50	30	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	59.6	63.4	68.1	72.3	73.4	q
Dipstick	(Litres)	63.4	68.1	72.3	73.4	74.9	(Litres/Minute)
Water Intake	(Litres)	3.8	4.7	4.2	1.1	1.5	
THIRD STAGE	8-11	48	Gauge Pressure 80	112	80	48	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	74.9	75.8	76.2	77.3	77.8	q
Dipstick	(Litres)	75.8	76.2	77.3	77.8	78.1	(Litres/Minute)
Water Intake	(Litres)	0.9	0.4	1.1	0.5	0.3	
FOURTH STAGE	11-14	99	Gauge Pressure 148	242	66	99	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	78.3	84.7	93.4	05.5	07.3	q
Dipstick	(Litres)	84.7	93.4	05.5	07.3	10.6	(Litres/Minute)
Water Intake	(Litres)	6.4	8.7	8.9	1.8	3.3	
FIFTH STAGE			Gauge Pressure				
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						
SIXTH STAGE			Gauge Pressure				
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						

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Member: Dave Rossiter
Member of
Drilling Association of SA
Borehole Water Association of SA
(5379)

1710

FIELD DATA FROM LUGEON TESTS

Drillhole No: JHM5 Inclination: 90° Test No: 5

Date of Test: 04-04-2013 Test Section from 14 m to 17 m

Packer Type: Single Packer Pressure kPa

Bottom of Casing: 9.00 m Water Level 12.30 m

Base of Hole: 17.00 m Hole∅ at test level JMW mm

Pressure gauge height above collar: m

Details of test equipment:

Calibration Curve No:

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FIRST STAGE 14-17		126	224	308	84	126	
		Gauge Pressure					
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	16,1	18,8	22,4	28,5	29,8	q
Dipstick	(Litres)	18,8	22,4	28,5	29,8	31,5	(Litres/Minute)
Water Intake	(Litres)	2,7	3,6	6,1	1,3	1,7	
SECOND STAGE	17-20	153	272	374	102	153	
		Gauge Pressure					
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	31,5	34,6	38,1	41,9	42,8	q
Dipstick	(Litres)	34,6	38,1	41,9	42,8	45,5	(Litres/Minute)
Water Intake	(Litres)	3,1	3,5	3,8	0,9	2,7	
THIRD STAGE							
		Gauge Pressure					
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						
FOURTH STAGE							
		Gauge Pressure					
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						
FIFTH STAGE							
		Gauge Pressure					
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						
SIXTH STAGE							
		Gauge Pressure					
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						

1711

FIELD DATA FROM LUGEON TESTS

Drillhole No: MM5 Inclination: 90° Test No: 7

Date of Test: 05-04-2013 Test Section from 20 m to 23 m

Packer Type: Single Packer Pressure kPa

Bottom of Casing: 9.00 m Water Level 14.50 m

Base of Hole: 23.00 m Hole∅ at test level TMW mm

Pressure gauge height above collar: m

Details of test equipment:

Calibration Curve No:

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FIRST STAGE 20 - 23		180	Gauge Pressure 320	440	120	180	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	45.5	46.1	49.3	54.5	54.7	q
Dipstick	(Litres)	46.1	49.3	54.5	54.7	55.8	(Litres/Minute)
Water Intake	(Litres)	0,6	3,2	5,2	0,2	1,1	
SECOND STAGE			Gauge Pressure				
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						
THIRD STAGE			Gauge Pressure				
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						
FOURTH STAGE			Gauge Pressure				
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						
FIFTH STAGE			Gauge Pressure				
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						
SIXTH STAGE			Gauge Pressure				
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						

1667

FIELD DATA FROM LUGEON TESTS

Drillhole No: NM6 Inclination: 90 Test No: 1

Date of Test: 20/03/2013 Test Section from 2 m to 5 m

Packer Type: Single Packer Pressure 12 kPa

Bottom of Casing: 3 m Water Level m

Base of Hole: 5 m Hole ∅ at test level NMD4 mm

Pressure gauge height above collar: 2.90 m

Details of test equipment:

Calibration Curve No:

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FIRST STAGE	2 - 5	12	20	28	20	12	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	1579,5	1591,9	1603,5	1617,5	1631,5	q
Dipstick	(Litres)	1591,9	1603,5	1617,5	1631,5	1645,9	(Litres/Minute)
Water Intake	(Litres)	12.4	11,6	14	14	14,4	
SECOND STAGE	5 - 8	30	50	70	50	30	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	1645,9	1653,4	1663,4	1673,5	1679,9	q
Dipstick	(Litres)	1653,4	1663,4	1673,5	1679,9	1689,0	(Litres/Minute)
Water Intake	(Litres)	7.5	10	10.1	6.4	9.1	
THIRD STAGE	8 - 11	48	80	112	80	48	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	1689,0	1709,2	1730,0	1751,4	1773,4	q
Dipstick	(Litres)	1709,2	1730,0	1751,4	1773,4	1795,4	(Litres/Minute)
Water Intake	(Litres)	20,2	20,8	21,4	22	22	
FOURTH STAGE	11 - 14	66	110	154	110	66	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	1795,4	1798,0	1800,8	1803,7	1806,1	q
Dipstick	(Litres)	1798,0	1800,8	1803,7	1806,1	1807,4	(Litres/Minute)
Water Intake	(Litres)	2,6	2,8	2,9	2,4	1.3	
FIFTH STAGE	14 - 17	84	140	196	140	84	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	1804,4	1809,6	1813,3	1817,7	1820,2	q
Dipstick	(Litres)	1809,6	1813,3	1817,7	1820,2	1822,5	(Litres/Minute)
Water Intake	(Litres)	2,2	3.7	4.4	2,5	2,3	
SIXTH STAGE							
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						

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FIELD DATA FROM LUGEON TESTS

Drillhole No: NM6 Inclination: 90° Test No: 6

Date of Test: 22/03/2013 Test Section from 17 m to 20 m

Packer Type: Single Packer Pressure 102 kPa

Bottom of Casing: 1.50 m Water Level m

Base of Hole: 20 m Hole ∅ at test level NWD4 mm

Pressure gauge height above collar: 2.9 m

Details of test equipment:

Calibration Curve No:

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FIRST STAGE 17-20		102	170	238	170	102	
		Gauge Pressure					
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	1822,5	1824,4	1828,5	1834,7	1840,1	q
Dipstick	(Litres)	1824,4	1828,5	1834,7	1840,1	1844,1	(Litres/Minute)
Water Intake	(Litres)	1.9	4,1	6.2	5.4	4	
SECOND STAGE 20-23		180	320	440	320	180	
		Gauge Pressure					
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	1844,1	1848,9	1857,5	1867,0	1871,9	q
Dipstick	(Litres)	1848,9	1857,5	1867,0	1871,9	1878,2	(Litres/Minute)
Water Intake	(Litres)	4,8	8.6	9.5	4.9	6.3	
THIRD STAGE							
		Gauge Pressure					
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						
FOURTH STAGE							
		Gauge Pressure					
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						
FIFTH STAGE							
		Gauge Pressure					
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						
SIXTH STAGE							
		Gauge Pressure					
Time	(Minutes)						Av Flow
Flowmeter	Reading						q
Dipstick	(Litres)						(Litres/Minute)
Water Intake	(Litres)						

FIELD DATA FROM LUGEON TESTS

Hole No: HM7 Inclination: Vertical Test No: 1

Date of Test: 20/March/13 Test Section from 2.00 m to 6.00 m

Packer Type: Single Packer Pressure ..... kPa

Diameter of Casing: 4" Casing m Water Level ..... m

Depth of Hole: 23 meters m Hole Ø at test level NWD4 mm

Pressure gauge height above collar: ..... m

Details of test equipment: .....

Calibration Curve No: .....

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FIRST STAGE 5–8 2–5		Gauge Pressure					
Time	(Minutes)	12	20	28	20	12	Av Flow
Flowmeter	Reading	188	02	2.0	3.0	3.0	q
Flowback	(Litres)	02	2.0	3.0	3.0	0.9	(Litres/Minute)
Water intake	(Litres)	18.6	18	1.0	0.0	2.1	

SECOND STAGE 21/03/2013 8–11 5–8		Gauge Pressure					
Time	(Minutes)	30	50	70	50	30	Av Flow
Flowmeter	Reading	0.4	2.2	2.6	3.4	1.8	q
Flowback	(Litres)	2.2	2.6	3.4	1.8	1.5	(Litres/Minute)
Water intake	(Litres)	1.3	0.4	0.8	1.6	0.3	

THIRD STAGE 8–11		Gauge Pressure					
Time	(Minutes)	72	128	176	128	72	Av Flow
Flowmeter	Reading	1.5	1.0	1.4	1.6	1.0	q
Flowback	(Litres)	1.0	1.4	1.6	1.0	1.0	(Litres/Minute)
Water intake	(Litres)	0.5	0.4	0.2	0.6	0.0	

FOURTH STAGE 11–14 22/03/2013		Gauge Pressure					
Time	(Minutes)	99	176	242	176	99	Av Flow
Flowmeter	Reading	1.0	9.8	7.8	20.5	18.9	q
Flowback	(Litres)	9.8	7.8	20.5	18.9	10.2	(Litres/Minute)
Water intake	(Litres)	8.8	2.0	12.7	1.6	8.7	

FIFTH STAGE 14–17m		Gauge Pressure					
Time	(Minutes)	126	224	308	224	126	Av Flow
Flowmeter	Reading	18.9	9.8	14.9	17.0	13.4	q
Flowback	(Litres)	9.8	14.8	17.0	13.4	7.6	(Litres/Minute)
Water intake	(Litres)	9.1	5.1	2.1	3.6	6.058	

SIXTH STAGE 17– 20m		Gauge Pressure					
Time	(Minutes)	153	272	374	242	153	Av Flow
Flowmeter	Reading	13.4	5.9	8.5	11.5	6.9	q
Flowback	(Litres)	5.9	8.8	11.5	6.9	4.4	(Litres/Minute)
Water intake	(Litres)	7.5	2.9	2.7	4.6	2.5	

FIELD DATA FROM LUGEON TESTS

Borehole No: YM7 Inclination: Vertical Test No: 1

Date of Test: 23/05/2013 | Test Section from 20 m to 23 m

Type: Single | Packer Pressure ..... kPa

Length of Casing: 7.50 m | Water Level ..... m

Length of Hole: ..... m | Hole Ø at test level NW/54 mm

Pressure gauge height above collar: ..... m

Details of test equipment: .....

Calibration Curve No: .....

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FIRST STAGE 20 - 23 m		Gauge Pressure					
Time	(Minutes)	180	320	440	320	180	Av Flow q (Litres/Minute)
Flowmeter	Reading	13.4	10.8	16.2	20.3	14.2	
Flow	(Litres)	10.8	16.2	20.3	14.2	6.8	
Water intake	(Litres)	2.6	5.4	4.1	6.1	7.4	

SECOND STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow q (Litres/Minute)
Flowmeter	Reading						
Flow	(Litres)						
Water intake	(Litres)						

THIRD STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow q (Litres/Minute)
Flowmeter	Reading						
Flow	(Litres)						
Water intake	(Litres)						

FOURTH STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow q (Litres/Minute)
Flowmeter	Reading						
Flow	(Litres)						
Water intake	(Litres)						

FIFTH STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow q (Litres/Minute)
Flowmeter	Reading						
Flow	(Litres)						
Water intake	(Litres)						

SIXTH STAGE		Gauge Pressure					
Time	(Minutes)						Av Flow q (Litres/Minute)
Flowmeter	Reading						
Flow	(Litres)						
Water intake	(Litres)						

1618

FIELD DATA FROM LUGEON TESTS

Drillhole No: NM 8 Inclination: Vertical Test No: 1

Date of Test: 12-04-13 Test Section from 2 m to 4.95 m

Packer Type: Single Packer Pressure 12 kPa

Bottom of Casing: 0,00 m Water Level m

Base of Hole: = 4.95 m Hole ∅ at test level Nwdh mm

Pressure gauge height above collar: 1.70 m

Details of test equipment:

Calibration Curve No:

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FIRST STAGE 2 - 5m		12	Gauge Pressure 20	28	20	12	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	0	0	0	0	0	
SECOND STAGE 5m - 7.65		30	Gauge Pressure 38	70	50	30	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	0	0	0	0	0	
THIRD STAGE 7.65 - 10,50		45.90	Gauge Pressure 76.50	107,10	76.50	45.90	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	0	0	0	0	0	
FOURTH STAGE 10,50 - 13,50		63	Gauge Pressure 105	147	105	63	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	0	0	0	0	0	
FIFTH STAGE 13,50 - 16,50		121,50	Gauge Pressure 216	297	216	121,50	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	0	0	0	0	0	
SIXTH STAGE 16,50 - 19,50		148,50	Gauge Pressure 264	363	264	148,50	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	870	870	870	870	870	q
Dipstick	(Litres)	870	870	870	870	870	(Litres/Minute)
Water Intake	(Litres)	0	0	0	0	0	

1671

FIELD DATA FROM LUGEON TESTS

Drillhole No: NM9 Inclination: 90° Test No: 1

Date of Test: 08/04/2013 Test Section from 2 m to 5 m

Packer Type: Single Packer Pressure 12 kPa

Bottom of Casing: ..... m Water Level ..... m

Base of Hole: 5.00 m Hole ∅ at test level NWD4 mm

Pressure gauge height above collar: 2.8 m

Details of test equipment: .....

Calibration Curve No: .....

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FIRST STAGE	2-5	12	Gauge Pressure 20	28	20	12	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	2013,5	2016,1	2016,4	2016,6	2016,9	q
Dipstick	(Litres)	2016,1	2016,4	2016,6	2016,9	2017,1	(Litres/Minute)
Water Intake	(Litres)	2.6	0.3	0.2	0.3	0.2	
SECOND STAGE	5-8	30	Gauge Pressure 50	70	50	30	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	2017,1	2017,7	2018,7	2020,1	2020,8	q
Dipstick	(Litres)	2017,7	2018,7	2020,1	2020,8	2020,8	(Litres/Minute)
Water Intake	(Litres)	0.6	1	1.4	0.7	0	
THIRD STAGE	8-11	48	Gauge Pressure 112	80	48		
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	2020,8	2020,8	2020,8	2022,2	2023,2	q
Dipstick	(Litres)	2020,8	2020,8	2022,2	2023,2	2023,6	(Litres/Minute)
Water Intake	(Litres)	0	0	1.4	1	0.4	
FOURTH STAGE	11-14	99	Gauge Pressure 242	176	99		
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	2023,6	2024,2	2027,3	2030,4	2033,4	q
Dipstick	(Litres)	2024,2	2027,3	2030,4	2033,4	2038,1	(Litres/Minute)
Water Intake	(Litres)	0.6	3.1	3.1	3	4.7	
FIFTH STAGE	14-17	176	Gauge Pressure 308	224	176		
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	2038,1	2061,1	TOTAL WATER LOSS			q
Dipstick	(Litres)	2061,1		PRESSURE TEST Cannot work			(Litres/Minute)
Water Intake	(Litres)						
SIXTH STAGE	17-20	153	Gauge Pressure 272	374	272	374	
Time	(Minutes)	10	10	10	10	10	Av Flow
Flowmeter	Reading	2072,6	TOTAL WATER LOSS				q
Dipstick	(Litres)		PRESSURE TEST CANNOT WORK				(Litres/Minute)
Water Intake	(Litres)						

Borehole core logs

Langa Dam site, left flank

(NM1, NM2, NM9)

HOLE No: NM 1
Sheet 1 of 2

JOB NUMBER: J01763

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

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

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

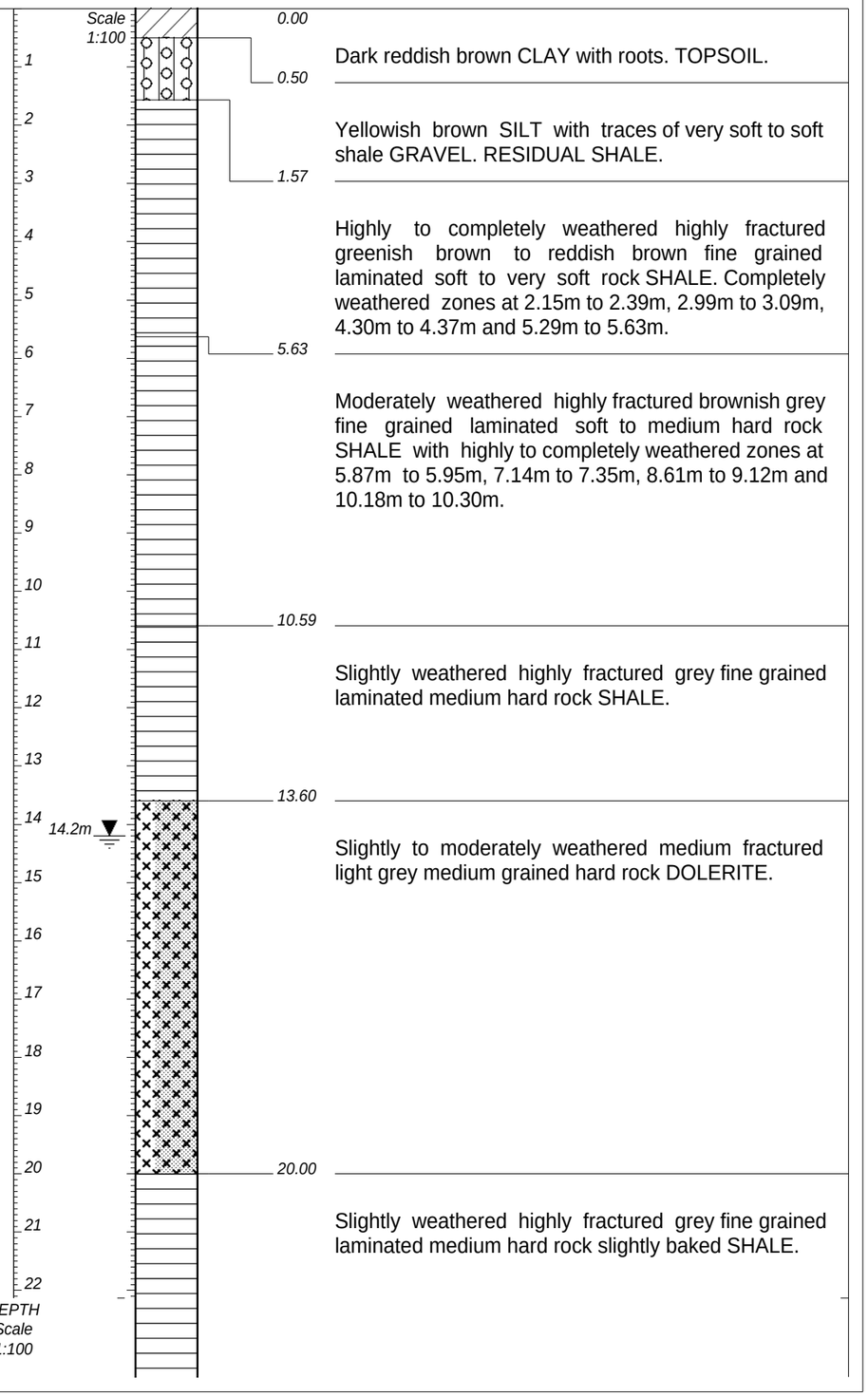
AECOM

Department of Water Affairs
uMkhomazi Water Project

HOLE No: NM 1
Sheet 1 of 2

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	LUGEON VALUES	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
91	0	0		NXC		-	-	-	-	-	-	-	-	-	-
64	0	0		NXC		-	-	-	-	-	-	-	-	-	-
67	38	0		NWD4	2	FG	LF	<1	B 1 2	0 45 90	10-20 >500 >500	SJ SJ SJ	silt silt silt	0-5 1 1	20 2 2
95	95	21		NWD4											
86	86	0		NWD4											
100	100	17		NWD4	0	FG	LF	<1	B 1	0 45	10-150 >500	SJ SJ	silt stained	<1 stained	15 2
74	74	9		NWD4											
92	92	54		NWD4											
64	64	17		NWD4	1	FG	LF	<1	B 1	0 85-90	10-300 -	SJ SJ	stained stained	stained stained	12 -
84	84	0		NWD4											
96	96	0		NWD4											
100	100	0		NWD4	1										
97	97	8		NWD4											
89	89	34		NWD4											
82	82	32		NWD4	0	FG-MG	MF	-	1 2	0 80-90	<300 -	RJ RJ	stained stained	stained stained	8 -
99	99	56		TNW											
100	100	72		TNW	1										
99	99	51		TNW	2										



0.00 – 0.50: Dark reddish brown CLAY with roots. TOPSOIL.

0.50 – 1.57: Yellowish brown SILT with traces of very soft to soft shale GRAVEL. RESIDUAL SHALE.

1.57 – 5.63: Highly to completely weathered highly fractured greenish brown to reddish brown fine grained laminated soft to very soft rock SHALE. Completely weathered zones at 2.15m to 2.39m, 2.99m to 3.09m, 4.30m to 4.37m and 5.29m to 5.63m.

5.63 – 10.59: Moderately weathered highly fractured brownish grey fine grained laminated soft to medium hard rock SHALE with highly to completely weathered zones at 5.87m to 5.95m, 7.14m to 7.35m, 8.61m to 9.12m and 10.18m to 10.30m.

10.59 – 13.60: Slightly weathered highly fractured grey fine grained laminated medium hard rock SHALE.

13.60 – 20.00: Slightly to moderately weathered medium fractured light grey medium grained hard rock DOLERITE.

20.00 – : Slightly weathered highly fractured grey fine grained laminated medium hard rock slightly baked SHALE.

HOLE No: NM 1
Sheet 2 of 2

JOB NUMBER: J01763

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

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

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

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Department of Water Affairs
uMkhomazi Water Project

HOLE No: NM 1
Sheet 2 of 2

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	LUGEON VALUES	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
						FG	LF	<1	B	0	10-300	SJ	stained	stained	12
									1	85-90	-	SJ	stained	stained	-
97	97	84		TNW											
99	99	85		TNW											

DEPTH Scale 1:100

23
24
25
25.16

NOTES

1) Water table at 14.2m.

2) Poor material recovery is attributed to washing out of fines.

CONTRACTOR : Geomech
MACHINE : YWE
DRILLED BY : Jan Kiri
PROFILED BY : JJ Ehlers

TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

INCLINATION : VERTICAL
DIAM :
DATE : 2013/03/23
DATE : 2013/04/08

DATE : 11/10/2013 15:54
TEXT : ..HOLES\Notepads\NM110.txt

ELEVATION :
X-COORD : X3296840
Y-COORD : 31 Y0067796

HOLE No: NM 1

HOLE No: NM 2
Sheet 1 of 1

JOB NUMBER: J01763

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

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

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

AECOM

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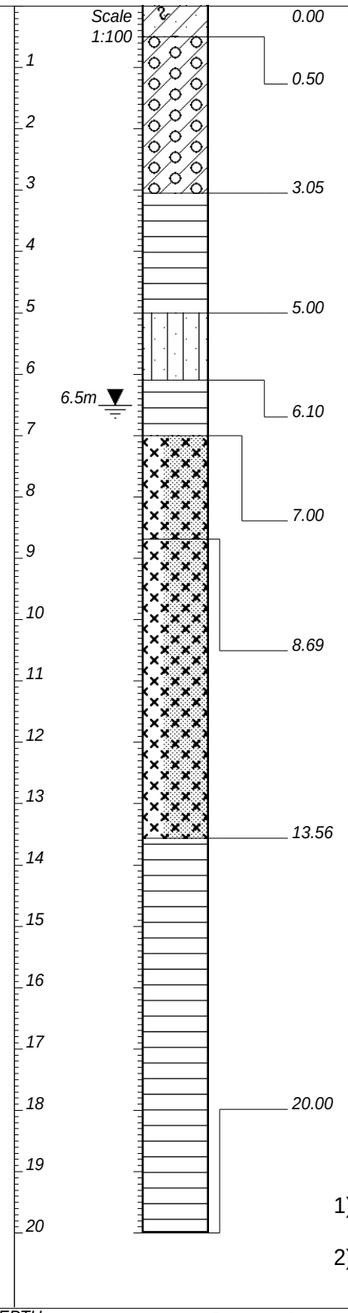
uMkhomazi Water Project

HOLE No: NM 2
Sheet 1 of 1

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	LUGEON VALUES	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
						-	-	-	-	-	-	-	-	-	-
56	0	0		NXC		-	-	-	-	-	-	-	-	-	-
60	0	0		NWD4											
87	83	0		NWD4	3	FG	LF	<1	B 1	0 80-90	<40 -	SJ SJ	silt silt	<1 <1	30 -
64	64	0		NWD4											
45	32	0		NWD4		-	-	-	-	-	-	-	-	-	-
85	85	13		NWD4	1	FG	LF	<1	B 1	0 80-90	<40 -	SJ SJ	silt silt	<1 <1	30 -
77	77	35		NWD4		FG-MG	MF	-	-	-	-	-	-	-	-
89	89	31		NWD4	0										
90	90	60		TNW	2	FG-MG	MF	-	1	0	<100	RJ	-	-	10
98	98	61		TNW	1	FG	LF	<1	B 1	0 80-90	10-200 -	SJ SJ	- -	- -	15 -
98	98	45		TNW	0										



DEPTH Scale 1:100

0.00 Reddish brown sandy CLAY with roots. TOPSOIL.

0.50 Reddish brown CLAY with angular soft shale gravel. RESIDUAL SHALE.

3.05 Moderately weathered highly fractured light brown to grey fine grained laminated soft rock SHALE.

5.00 Dark brown sandy SILT with angular shale gravel. HIGHLY WEATHERED SHALE.

6.10 Moderately weathered highly fractured light brown to grey fine grained laminated medium hard rock SHALE.

7.00 Moderately to highly weathered highly fractured light grey fine to medium grained medium hard rock DOLERITE.

8.69 Unweathered medium fractured grey fine to medium grained hard to very hard rock DOLERITE with a moderately weathered zone at 9.40m to 10.36m.

13.56 Unweathered highly fractured dark grey fine grained laminated medium hard rock SHALE.

20.00

NOTES

1) Water table measured at 6.5m.

2) Poor material recovery is attributed to washing out of fines.

CONTRACTOR : Geomech
MACHINE : YWE
DRILLED BY : Jacson
PROFILED BY : JJ Ehlers
TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

INCLINATION : VERTICAL
DIAM :
DATE : 2013/03/26
DATE : 2013/04/08
DATE : 11/10/2013 15:54
TEXT : ..HOLES\Notepads\NM110.txt

ELEVATION :
X-COORD : X3296827
Y-COORD : 31 Y0067760

HOLE No: NM 2

HOLE No: NM 9
Sheet 1 of 1

JOB NUMBER: J01763

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

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

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

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Department of Water Affairs
uMkhomazi Water Project

HOLE No: NM 9
Sheet 1 of 1

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	LUGEON VALUES	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
98	0	0		NXC		-	-	-	-	-	-	-	-	-	-
87	0	0		NXC		-	-	-	-	-	-	-	-	-	-
100	0	0		NWD4		-	-	-	-	-	-	-	-	-	-
95	75	29		NWD4	1										
46	38	0		NWD4											
100	95	16		NWD4											
51	51	0		NWD4	0	FG	LF	<1	B	0	<100	SJ	silt	0-2	20
68	52	0		NWD4											
100	100	19		NWD4											
100	100	7		NWD4	0	FG	LF	<1	B 1	0 80	<100 -	SJ SJ	silt silt	<1 <0.5	25 -
75	75	0		NWD4											
100	100	33		NWD4											
99	99	23		NWD4	1										
87	87	17		NWD4											
93	93	31		TNW	Total water loss	FG	LF	<1	B	0	10-150	SJ	stained	stained	15
76	76	50		TNW											
100	100	58		TNW	Total water loss										
92	92	55		TNW											

DEPTH Scale 1:100

Scale 1:100

0.00 Dark brown clayey SAND with roots. TOPSOIL.

0.25 Reddish brown clayey SILT with shale GRAVEL. RESIDUAL SHALE.

0.90 Yellowish brown mottled red SILT. RESIDUAL SHALE.

1.70 Highly to moderately weathered highly fractured light brown fine grained soft rock SHALE.

8.53 Moderately to slightly weathered highly fractured dark grey to brown fine grained laminated medium hard rock SHALE.

10.45 Slightly weathered highly fractured grey fine grained laminated hard rock SHALE.

15.8m ▼

20.11

NOTES

1) Water table at 15.8m.

2) Poor material recovery is attributed to washing out of fines.

CONTRACTOR : Geomech
MACHINE : YWE
DRILLED BY : Jan Kiri
PROFILED BY : JJ Ehlers

TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

INCLINATION : VERTICAL
DIAM :
DATE : 2013/04/06
DATE : 2013/04/11

DATE : 11/10/2013 15:54
TEXT : ..HOLES\Notepads\NM110.txt

ELEVATION :
X-COORD : X3296887
Y-COORD : 31 Y0068039

HOLE No: NM 9

Department of Water Affairs
uMkhomazi Water Project

LEGEND
Sheet 1 of 1

JOB NUMBER: J01763

	GRAVEL	{SA02}
	SAND	{SA04}
	SANDY	{SA05}
	SILT	{SA06}
	SILTY	{SA07}
	CLAY	{SA08}
	CLAYEY	{SA09}
	SHALE	{SA12}
	DOLERITE	{SA18}{SA42}
9.5	PERMANENT WATER TABLE	{SA35}
	ROOTS	{SA40}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :

INCLINATION :
DIAM :
DATE :
DATE :

ELEVATION :
X-COORD :
Y-COORD :

TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

DATE : 11/10/2013 15:54
TEXT : ..HOLES\Notepads\NM110.txt

LEGEND
SUMMARY OF SYMBOLS

Langa Dam site, river section (NM3)

HOLE No: NM 3
Sheet 1 of 1

JOB NUMBER: J01763

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

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

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

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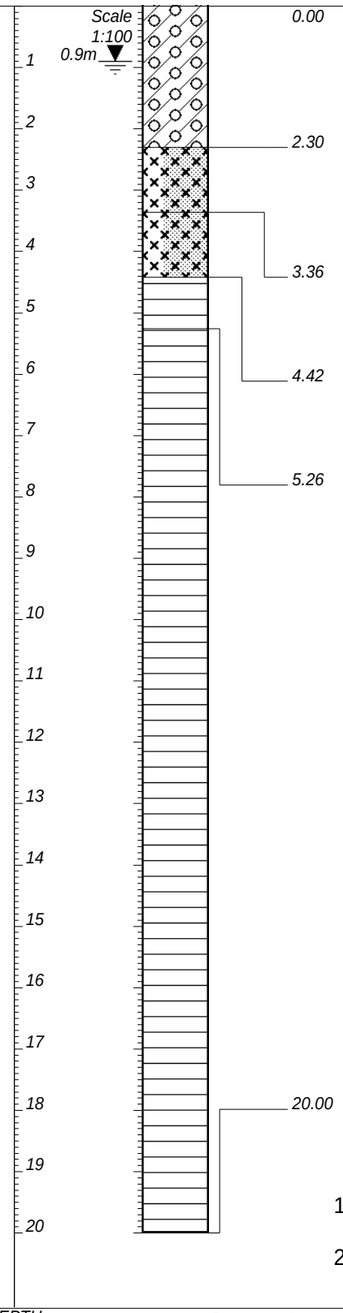
uMkhomazi Water Project

HOLE No: NM 3
Sheet 1 of 1

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	LUGEON VALUES	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
59	0	0		NXC	0	-	-	-	-	-	-	-	-	-	-
10	0	0		NXC											
57	53	53		NWD4		MG	MF	-	1	80-90	-	RJ	sand	<1	-
88	88	27		NWD4		MG	MF	-	1	0	>20	RJ	stained	stained	8
100	100	0		NWD4		FG	LF	<1	B	0	<10	SJ	stained	stained	40
89	89	0		NWD4	0										
96	96	49		NWD4											
100	100	31		NWD4	0										
97	97	11		NWD4											
99	99	35		NWD4	0				B	0	>20	SJ	stained	stained	10
96	96	35		NWD4		FG	LF	<1	1	45	>500	SJ	stained	stained	2
97	97	7		NWD4	0				2	70	>400	SJ	stained	stained	2-3
98	98	37		NWD4											
100	100	49		NWD4	0										
100	100	23		NWD4											



DEPTH Scale 1:100

Dark brown CLAY with sub angular dolerite and shale gravel. TRANSPORTED.

Highly to completely weathered highly fractured brown to grey speckled black medium grained soft to medium hard rock DOLERITE.

Moderately weathered medium fractured light grey speckled black medium grained hard rock DOLERITE.

Slightly weathered very highly fractured grey soft to hard rock SHALE.

Slightly weathered dark grey fine grained laminated hard rock SHALE.

NOTES

1) Water table measured at 0.9m.

2) Poor material recovery is attributed to washing out of fines.

CONTRACTOR : Geomech
MACHINE : YWE
DRILLED BY : Polite
PROFILED BY : JJ Ehlers
TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

INCLINATION : VERTICAL
DIAM :
DATE : 2013/03/25
DATE : 2013/04/08
DATE : 11/10/2013 15:54
TEXT : ..HOLES\Notepads\NM110.txt

ELEVATION :
X-COORD : X3296829
Y-COORD : 31 Y0067717

HOLE No: NM 3

Langa Dam site, right flank

(NM4 – NM7)

HOLE No: NM 4
Sheet 1 of 1

JOB NUMBER: J01763

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

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

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

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uMkhomazi Water Project

HOLE No: NM 4
Sheet 1 of 1

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	LUGEON VALUES	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
0	0	0		NXC		-	-	-	-	-	-	-	-	-	-
0	0	0		NXC		-	-	-	-	-	-	-	-	-	-
64	23	0		NWD4	0	FG	LF	<1	B	0	<10	SJ	silt	<1	40
85	85	0		NWD4											
85	85	7		NWD4		FG	LF	<1	B 1	0 80	10-80 -	SJ SJ	silt silt	<0.5 <0.5	30 -
96	96	41		NWD4	0										
100	100	12		NWD4											
98	98	17		NWD4	0										
100	100	9		NWD4											
99	99	36		NWD4	0	FG	LF	<1	B 1 2	0 30 70	60-180 >1000 >500	SJ SJ SJ	stained stained stained	stained stained stained	15 1 2
95	95	37		NWD4											
95	95	11		NWD4	0										
100	100	26		NWD4											
95	95	43		NWD4	0										
100	100	28		NWD4											

DEPTH Scale 1:100

Scale 1:100

0.00 — Reddish brown SAND with roots. TOPSOIL.

0.20 — Reddish brown becoming light brown SILT. RESIDUAL SHALE.

1.67 — Highly to completely weathered highly fractured reddish yellowish brown fine grained laminated soft rock SHALE.

2.67 — Highly to moderately weathered highly fractured brownish grey to reddish brown fine grained laminated soft rock SHALE. Highly weathered at 3.30m to 3.60m.

4.60 — Slightly weathered highly fractured dark grey fine grained medium hard rock SHALE.

20.00

NOTES

1) No water table measured.

2) Poor material recovery is attributed to washing out of fines.

CONTRACTOR : Geomech
MACHINE : YWE
DRILLED BY : Polite
PROFILED BY : JJ Ehlers
TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

INCLINATION : VERTICAL
DIAM :
DATE : 2013/03/21
DATE : 2013/03/25
DATE : 11/10/2013 15:54
TEXT : ..HOLES\Notepads\NM110.txt

ELEVATION :
X-COORD : X3296879
Y-COORD : 31 Y0067686

HOLE No: NM 4

HOLE No: NM 5
Sheet 1 of 2

JOB NUMBER: J01763

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

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

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

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uMkhomazi Water Project

HOLE No: NM 5
Sheet 1 of 2

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	LUGEON VALUES	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
100	0	0		NXC		-	-	-	-	-	-	-	-	-	-
94	0	0		NXC		-	-	-	-	-	-	-	-	-	-
68	0	0		NWD4	1										
84	0	0		NWD4		-	-	-	-	-	-	-	-	-	-
100	0	0		NWD4											
99	57	0		NWD4											
97	97	0		NWD4	2	FG	LF	<1	B 1	0 45	<20 >500	SJ SJ	silt silt	<1 <1	30 2
71	71	0		NWD4											
100	100	22		NWD4											
89	89	11		NWD4	0	FG	LF	<1	B 1	0 70	<20 >500	SJ-RJ SJ-RJ	silt silt	<0.5 <0.5	20 2
92	92	27		NWD4											
100	100	0		NWD4											
87	87	54		TNW											
100	100	0		NWD4											
84	84	33		TNW	1										
100	100	75		TNW											
91	91	44		TNW	1										
75	75	47		TNW					B	0	20-300	SJ	-	-	7
100	100	45		TNW	0	FG	LF	<1	1 2	70 80-90	>500 >500	SJ SJ	- -	- -	2 2
95	95	0		TNW											
99	99	99		TNW											
95	95	32		TNW	0										

Scale 1:100

0.00 Dark reddish brown CLAY. TOPSOIL with roots.

0.24 Reddish brown CLAY with traces of roots. TRANSPORTED.

3.29 Orange brown SILT with traces of very soft shale gravel. RESIDUAL SHALE.

5.13 Highly weathered highly fractured greenish brown fine grained laminated very soft rock SHALE.

7.10 Moderately weathered highly fractured brown to light grey fine grained laminated soft rock SHALE with highly to completely weathered zone at 9.00m to 9.47m.

9.85m

10.12 Slightly weathered moderately fractured grey to dark grey fine grained laminated hard rock SHALE. Highly weathered joint at 20.08m to 20.13m.

DEPTH Scale 1:100

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

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

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

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uMkhomazi Water Project

HOLE No: NM 5
Sheet 2 of 2

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	LUGEON VALUES	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)	DEPTH Scale 1:100
99	99	15		TNW												
73	73	29		TNW												
100	100	65		TNW												

23
24
25
25.27

NOTES

1) Water table measured at 9.85m.

2) Poor material recovery is attributed to washing out of fines.

CONTRACTOR : Geomech
MACHINE : YWE
DRILLED BY : Wilson
PROFILED BY : JJ Ehlers

TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

INCLINATION : VERTICAL
DIAM :
DATE : 2013/03/21
DATE : 2013/04/08

DATE : 11/10/2013 15:54
TEXT : ..HOLES\Notepads\NM110.txt

ELEVATION :
X-COORD : X3296866
Y-COORD : 31 Y0067658

HOLE No: NM 5

HOLE No: NM 6
Sheet 1 of 2

JOB NUMBER: J01763

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

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

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

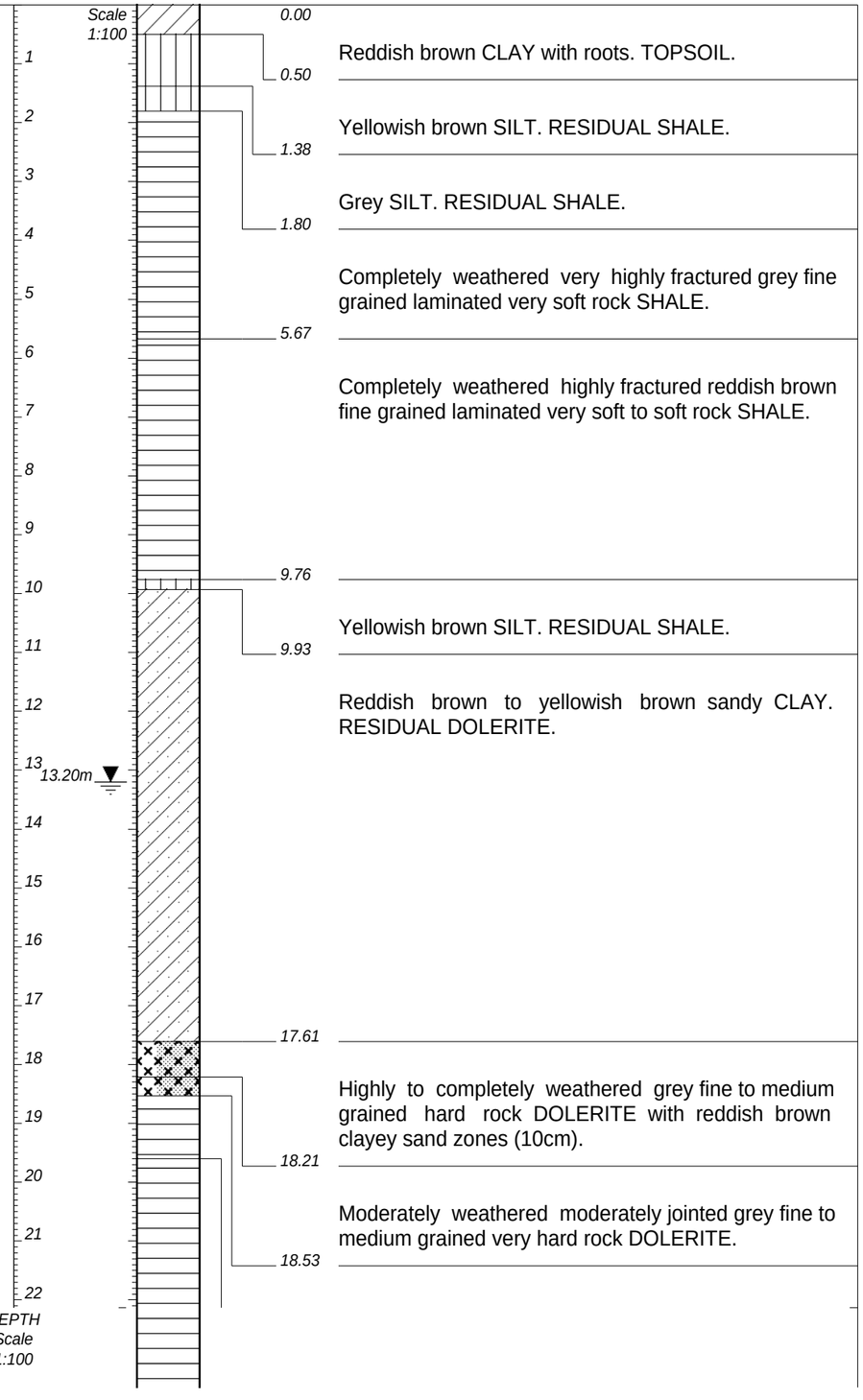
AECOM

Department of Water Affairs
uMkhomazi Water Project

HOLE No: NM 6
Sheet 1 of 2

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	LUGEON VALUES	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
92	0	0		NXC		-	-	-	-	-	-	-	-	-	-
94	0	0		NXC		-	-	-	-	-	-	-	-	-	-
82	18	0		NWD4	17	-	-	-	-	-	-	-	-	-	-
79	49	0		NWD4		FG	LF	<1	B	0	<10	SJ	silt	>1	>50
95	76	0		NWD4											
86	86	0		NWD4	10										
90	90	9		NWD4											
100	100	0		NWD4		FG	LF	<1	B	0	<20	SJ	silt	1	40
49	23	0		NWD4	6										
94	48	0		NWD4											
100	0	0		NWD4		-	-	-	-	-	-	-	-	-	-
93	0	0		NWD4	1										
88	0	0		NWD4											
92	0	0		NWD4											
66	0	0		NWD4											
100	0	0		NWD4	1										
67	0	0		NWD4											
53	0	0		NWD4											
48	0	0		NWD4	1										
100	91	21		NWD4		FG-MG	MF	-	-	-	-	-	-	-	-
86	86	0		NWD4		FG-MG	MF	-	-	-	-	-	-	-	-
100	100	0		NWD4	1	FG	MF	-	B	0	<80	SJ	silt	>1	30
69	69	0		NWD4											
%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	LUGEON VALUES	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
						-	-	-	1	0	<100	SJ	stained	stained	15



ROCK FABRIC
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AECOM

Department of Water Affairs
uMkhomazi Water Project

HOLE No: NM 6
Sheet 2 of 2

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	LUGEON VALUES	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)	DEPTH Scale 1:100
100	100	0		NWD4		FG	MF	<1	2 3	60 45	300 100	SJ SJ	stained stained	stained stained	3 10	23 24
84	84	29		NWD4												
95	97	43		NWD4												25

19.60 Moderately weathered highly fractured dark grey fine grained laminated soft rock SHALE.

25.06 Slightly weathered highly fractured dark grey fine grained laminated hard rock SHALE with a very highly fractured zone between 22.00m and 22.23m.

NOTES

1) Water table at 13.20m.

2) Poor material recovery is attributed to washing out of fines.

CONTRACTOR : Geomech
MACHINE : YWE
DRILLED BY : Jan Kiri
PROFILED BY : JJ Ehlers

TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

INCLINATION : VERTICAL
DIAM :
DATE : 2013/03/20
DATE : 2013/03/23

DATE : 11/10/2013 15:54
TEXT : ..HOLES\Notepads\NM110.txt

ELEVATION :
X-COORD : X3296909
Y-COORD : 31 Y0067563

HOLE No: NM 6

HOLE No: NM 7
Sheet 1 of 2

JOB NUMBER: J01763

ROCK FABRIC
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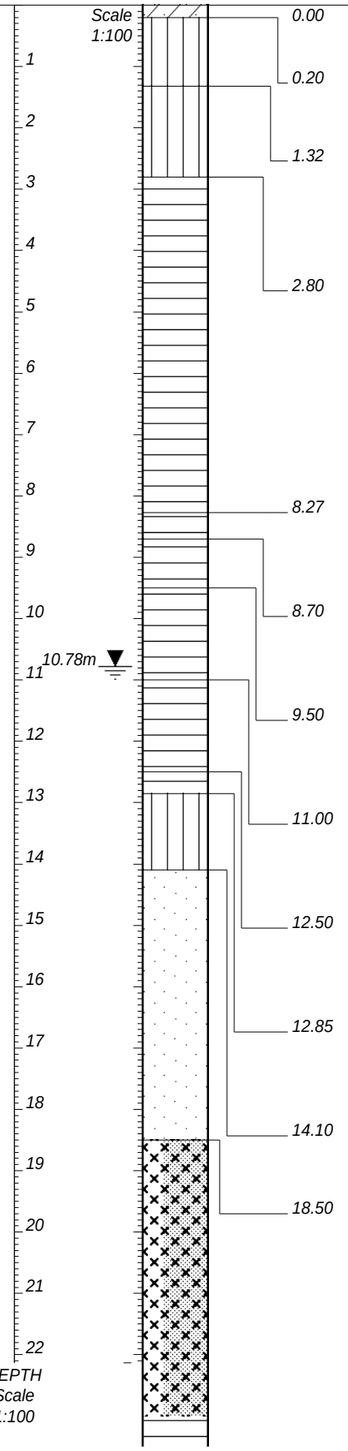
AECOM

Department of Water Affairs
uMkhomazi Water Project

HOLE No: NM 7
Sheet 1 of 2

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	LUGEON VALUES	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
83	0	0		NXC		-	-	-	-	-	-	-	-	-	-
100	0	0		NWD4		-	-	-	-	-	-	-	-	-	-
93	93	0		NWD4	6	-	-	-	-	-	-	-	-	-	-
84	8	0		NWD4											
99	70	0		NWD4	1	FG	LF	<1	B	0	<20	SJ	silt	<1	30
85	85	0		NWD4											
100	100	0		NWD4											
80	80	0		NWD4	0	FG	LF	<1	B	0	<20	SJ	silt	<0.5	30
						FG	LF	<1	B	0	<20	SJ	silt	<1	30
57	57	8		NWD4		FG	LF	<1	B	0	<20	SJ	silt	<0.5	30
63	63	0		NWD4	2	FG	LF	<1	B	0	<20	SJ	silt	<1	30
						FG	LF	<1	B	0	<20	SJ	silt	<0.5	30
73	36	0		NWD4		-	-	-	-	-	-	-	-	-	-
73	0	0		NWD4	1	-	-	-	-	-	-	-	-	-	-
67	0	0		NWD4											
54	0	0		NWD4	1										
60	23	0		NWD4											
79	79	13		NWD4	1	FG-MG	MF	-	-	-	-	-	-	-	-



DEPTH Scale 1:100

0.00 Dark brown sandy CLAY with roots. TOPSOIL.

0.20 Reddish brown SILT. RESIDUAL SHALE.

1.32 Yellowish brown SILT with very soft completely weathered brown to yellowish brown fine grained laminated very soft rock shale. Residual shale.

2.80 Highly to completely weathered brown to yellowish brown fine grained laminated very soft rock SHALE.

8.27 Moderately weathered highly fractured brown fine grained laminated soft rock SHALE.

8.70 Moderately weathered brown to yellowish brown fine grained laminated very soft rock SHALE.

9.50 Moderately weathered highly fractured brown fine grained laminated soft rock SHALE.

11.00 Moderately weathered brown to yellowish brown fine grained laminated very soft rock SHALE.

12.50 Moderately weathered highly fractured brown fine grained laminated soft rock SHALE.

12.85 Yellowish brown to dark brown SILT with black soft shale gravel at the bottom. RESIDUAL SHALE.

14.10 Orange brown SANDY CLAY. RESIDUAL DOLERITE.

18.50 Highly to completely weathered highly fractured grey with dark brown infill fine to medium grained hard rock DOLERITE.

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uMkhomazi Water Project

HOLE No: NM 7
Sheet 2 of 2

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	LUGEON VALUES	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
91	91	0		NWD4											
100	100	44		NWD4		FG	LF	<1	B 1	0 90	<200 -	SJ SJ	stained stained	stained stained	20 -
80	80	0		NWD4											

DEPTH Scale 1:100

23
24
25

23.00

Slightly weathered highly fractured light grey fine grained laminated hard rock SHALE.

25.00

NOTES

1) Water table at 10.78m.

2) Poor material recovery is attributed to washing out of fines.

CONTRACTOR : Geomech
MACHINE : YWE
DRILLED BY : Jacson
PROFILED BY : JJ Ehlers

TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

INCLINATION : VERTICAL
DIAM :
DATE : 2013/03/20
DATE : 2013/03/25

DATE : 11/10/2013 15:54
TEXT : ..HOLES\Notepads\NM110.txt

ELEVATION :
X-COORD : X3296926
Y-COORD : 31 Y0067530

HOLE No: NM 7

Langa Dam, left spillway

(NM10)

HOLE No: NM 10
Sheet 1 of 1

JOB NUMBER: J01763

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
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GF -gneissose
LF -laminated

GRAIN SIZE
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ROCK HARDNESS
EHR-extremely hard rock
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HR -hard rock
MHR-medium hard rock
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VSR-very soft rock

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Department of Water Affairs
uMkhomazi Water Project

HOLE No: NM 10
Sheet 1 of 1

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
33	9	0		NXC										
53	0	0		NXC										
99	0	0		NWD4	-	-	-	-	-	-	-	-	-	-
92	92	0		NWD4										
47	47	0		NWD4	FG	LF	<1	B	0	<50	SJ	silt	<2	30
73	73	15		NWD4	-	-	-	-	-	-	-	-	-	-
95	95	9		NWD4										
88	88	32		TNW										
85	85	0		TNW										
87	87	19		TNW	FG	LF	<1	B 1	0 80-90	20-150 0	SJ SJ	stained stained	stained stained	20 -
100	100	22		TNW										
100	100	0		NWD4										
90	90	24		NWD4										

DEPTH Scale 1:100

Scale 1:100

0.00

Light brown shale GRAVEL with SILT. COMPLETELY WEATHERED SHALE.

2.77

Highly to completely weathered very highly fractured light brown to grey fine grianed laminated soft to very soft rock SHALE.

5.0m

5.28

Slightly weathered becoming unweathered grey fine grained laminated medium hard rock SHALE. Highly fractured with a thin silt infill at 10.80m to 11.02m and highly fractured at 16.37m to 19.80m.

20.02

NOTES

1) Water table at 5.0m.

2) Poor material recovery is attributed to washing out of fines.

CONTRACTOR : Geomech
MACHINE : YWE
DRILLED BY : Polite
PROFILED BY : JJ Ehlers

INCLINATION : VERTICAL
DIAM :
DATE : 2013/04/06
DATE : 2013/04/11

ELEVATION :
X-COORD : X3296672
Y-COORD : 31 Y0068163

HOLE No: NM 10

TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

DATE : 11/10/2013 15:54
TEXT : ..HOLES\Notepads\NM110.txt

Langa Dam, right spillway

(NM8)

HOLE No: NM 8
Sheet 1 of 1

JOB NUMBER: J01763

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

JOINT SPACING
VCJ-very close spacg
CJ -close spacing
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WJ -wide spacing
VWJ-very wide spacng

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
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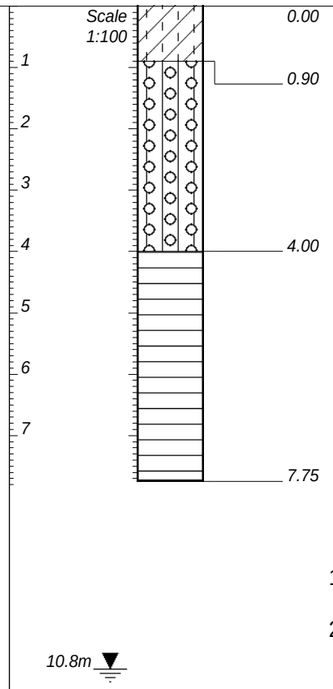
Department of Water Affairs
uMkhomazi Water Project

HOLE No: NM 8
Sheet 1 of 1

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	LUGEON VALUES	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
90	0	0		NXC		-	-	-	-	-	-	-	-	-	-
73	0	0	12	SPT											
90	0	0		NWD4	0										
64	0	0	17	SPT											
81	0	0		NWD4		-	-	-	-	-	-	-	-	-	-
89	0	0	30	SPT											
100	0	0		NWD4	0										
80	0	0	20	SPT											
95	0	0		NWD4	0										
100	0	0	REFUSAL	SPT											
96	89	42		NWD4	0										
99	99	7		NWD4		FG	LF	<1	B 1 2	0 45 45	10-150 >500 >500	SJ SJ SJ	silt silt silt	0-3 1 1	20 1 1
67	53	10		NWD4	0										
71	71	11		NWD4		FG	LF	<1	B 1	0 70	30-150 >500	SJ SJ	silt silt	<1 <1	18 1
83	83	0		NWD4	0										
100	100	0		NWD4		FG	LF	<1	B 1 2	0 45 45	10-150 >500 >500	SJ SJ SJ	silt silt silt	0-3 1 1	20 1 1
95	95	0		NWD4	0										
98	98	11		NWD4		FG	LF	<1	B 1	0 70	30-150 >500	SJ SJ	silt silt	<1 <1	18 1
100	22	0		NWD4		-	-	-	-	-	-	-	-	-	-

DEPTH Scale 1:100



Red silty CLAY with roots. TRANSPORTED.

Reddish brown mottled yellow, orange and grey SILT with minor angular soft shale gravel. RESIDUAL SHALE.

Highly weathered highly fractured light brown fine grained laminated soft rock SHALE. 20.00
Highly weathered highly fractured light brown fine grained laminated soft rock SHALE.

NOTES

1) Water table at 10.8m.

2) Poor material recovery is attributed to washing out of fines.

CONTRACTOR : Geomech
MACHINE : YWE
DRILLED BY : Polite
PROFILED BY : JJ Ehlers

TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

INCLINATION : VERTICAL
DIAM :
DATE : 2013/04/11
DATE : 2013/04/16

DATE : 11/10/2013 15:54
TEXT : ..HOLES\Notepads\NM110.txt

ELEVATION :
X-COORD : X3296906
Y-COORD : 31 Y0067415

HOLE No: NM 8

Langa quarry site

(NQ1 – NQ3)

HOLE No: NQ 1
Sheet 1 of 1

JOB NUMBER: J01763

ROCK FABRIC
MF -massive
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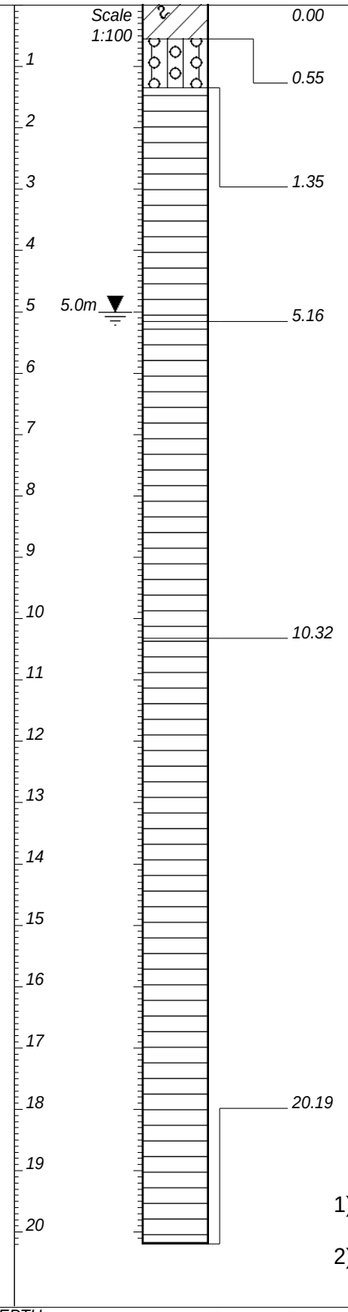
Department of Water Affairs
uMkhomazi Water Project

HOLE No: NQ 1
Sheet 1 of 1

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
96	0	0		NXC	-	-	-	-	-	-	-	-	-	-
100	0	0		NXC	-	-	-	-	-	-	-	-	-	-
84	0	0		NWD4	-	-	-	-	-	-	-	-	-	-
88	82	9		NWD4	FG	LF	<1	B	0	<100	SJ	silt	0-3	17
77	65	40		NWD4	FG	LF	<1	B 1	0 80-90	20-150 -	SJ SJ	silt silt silt	<1 <1	15 -
79	79	0		NWD4										
75	75	0		NWD4										
89	89	15		NWD4										
84	84	9		NWD4										
91	91	62		NWD4										
100	100	61		NWD4										
89	89	35		NWD4	FG	LF	<1	B 1 2	0 70 80-90	<200 >1000 -	SJ SJ SJ	stained stained stained	stained stained stained	10 - -
90	90	0		TNW										
97	97	81		NWD4										
99	99	73		NWD4										
100	100	57		NWD4										



0.00

Dark brown CLAY with roots. TOPSOIL.

0.55

Light reddish brown SILT with angular shale gravel. RESIDUAL SHALE.

1.35

Highly weathered highly fractured light brown fine grained laminated soft rock SHALE. Completely weathered at 4.25m to 4.45m.

5.16

Moderately weathered highly fractured brown to grey fine grained laminated medium hard rock SHALE.

10.32

Unweathered highly fractured grey fine grained laminated hard rock SHALE. Highly weathered zone at 10.95m to 11.57m.

20.19

NOTES

1) Water table at 5.0m.

2) Poor material recovery is attributed to washing out of fines.

DEPTH Scale 1:100

CONTRACTOR : Geomech
MACHINE : YWE
DRILLED BY : Jan Kiri
PROFILED BY : JJ Ehlers

INCLINATION : VERTICAL
DIAM :
DATE : 2013/04/13
DATE : 2013/04/16

ELEVATION :
X-COORD : X3297827
Y-COORD : 31 Y0068121

TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

DATE : 11/10/2013 15:55
TEXT : ..OLES\Notepads\NQ12&3.txt

HOLE No: NQ 1

HOLE No: NQ 2
Sheet 1 of 1

JOB NUMBER: J01763

ROCK FABRIC
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Department of Water Affairs
uMkhomazi Water Project

HOLE No: NQ 2
Sheet 1 of 1

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
33	10	0		NXC	-	-	-	-	-	-	-	-	-	-
72	35	0		NXC										
61	18	0		NXC										
94	94	0		NWD4	FG	LF	<1	B	0	<100	SJ	silt	0-2	23
99	99	0		NWD4										
100	100	53		NWD4	FG	LF	<1	B	0	<150	SJ	silt	<2	14
59	59	0		NWD4	FG	LF	<1	B	0	<50	SJ	silt	0.5	40
77	77	0		NWD4										
83	83	83		NWD4	FG	LF	<1	B 1	0 80-90	<20 -	SJ SJ	silt silt	<1 <1	>50 -
97	97	22		NWD4	FG	LF	<1	B 1 2	0 70 80-90	>50 >1000 -	SJ SJ SJ	stained stained stained	stained stained stained	8 1 -
98	98	69		NWD4										
100	100	71		NWD4										
98	98	49		NWD4										
84	84	36		NWD4										
100	100	53		NWD4										

Scale 1:100

0.00

Highly weathered highly fractured reddish brown to brown fine grained laminated very soft to soft rock SHALE.

5.12

Moderately weathered highly fractured brown layered fine grained laminated medium hard rock SHALE.

6.57

7.9m

Highly to completely weathered highly fractured reddish brown fine grained laminated soft rock SHALE.

8.93

Moderately weathered very highly fractured grey fine grained laminated medium hard rock SHALE.

11.05

Slightly weathered moderately fractured grey fine grained laminated hard rock SHALE.

20.07

NOTES

1) Water table at 7.9m.

2) Poor material recovery is attributed to washing out of fines.

DEPTH Scale 1:100

CONTRACTOR : Geomech
MACHINE : YWE
DRILLED BY : Polite
PROFILED BY : JJ Ehlers
TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

INCLINATION : VERTICAL
DIAM :
DATE : 2013/04/15
DATE : 2013/04/17
DATE : 11/10/2013 15:55
TEXT : ..OLES\Notepads\NQ12&3.txt

ELEVATION :
X-COORD : X3297649
Y-COORD : 31 Y0068037

HOLE No: NQ 2

HOLE No: NQ 3
Sheet 1 of 1

JOB NUMBER: J01763

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

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

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

AECOM

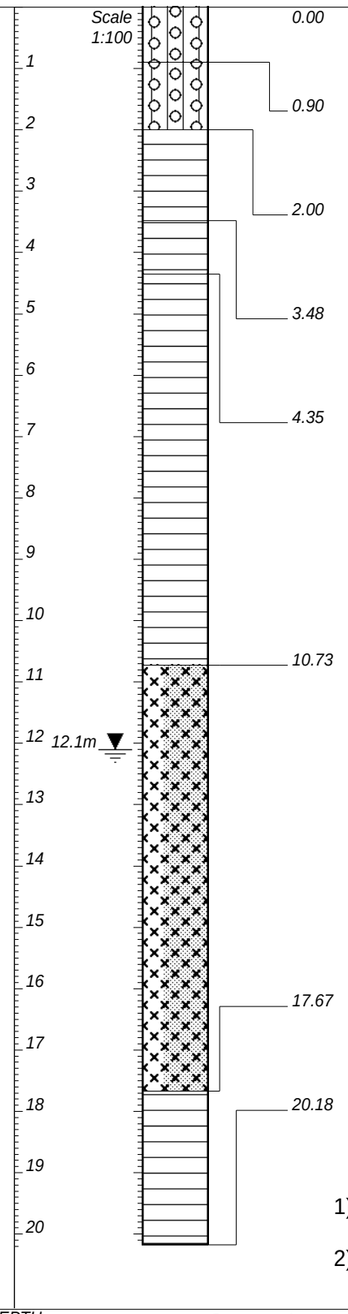
Department of Water Affairs
uMkhomazi Water Project

HOLE No: NQ 3
Sheet 1 of 1

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing (mm)	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
82	0	0		NXC	-	-	-	-	-	-	-	-	-	-
100	0	0		NXC	-	-	-	-	-	-	-	-	-	-
88	81	34		NWD4	FG	LF	<1	B	0	<100	SJ	silt	0-2	30
87	87	7		NWD4	FG	LF	<1	B	0	<100	SJ	silt	0-2	25
80	80	7		NWD4	FG	LF	<1	B 1 2	0 70 80-90	10-400 >1000 -	SJ SJ SJ	stained stained stained	stained stained stained	20 1 -
100	100	34		NWD4										
90	90	0		NWD4										
99	99	25		NWD4										
100	94	19		NWD4										
100	100	96		TNW	FG-MG	MF	-	1	0-10	10-500	RJ	stained	stained	8
100	100	77		TNW										
100	100	55		TNW	FG	LF	<1	B 1 2	0 70 80-90	10-400 >1000 -	SJ SJ SJ	stained stained stained	stained stained stained	20 1 -

DEPTH Scale 1:100



Light brown to brown SILT with abundant soft shale gravel. RESIDUAL SHALE.

Soft light brown to brown shale GRAVEL with minor brown SILT. RESIDUAL SHALE.

Highly weathered highly fractured light brown to dark grey fine grained laminated soft rock SHALE.

Moderately weathered highly fractured grey fine grained laminated medium hard rock SHALE.

Slightly weathered to unweathered highly fractured dark grey hard rock SHALE.

Slightly weathered highly fractured grey fine to medium grained very hard rock DOLERITE.

Slightly weathered to unweathered highly fractured dark grey hard rock SHALE.

NOTES

1) Water table at 12.1m.

2) Poor material recovery is attributed to washing out of fines.

CONTRACTOR : Geomech
MACHINE : YWE
DRILLED BY : Jan Kiri
PROFILED BY : JJ Ehlers

TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

INCLINATION : VERTICAL
DIAM :
DATE : 2013/04/11
DATE : 2013/04/15

DATE : 11/10/2013 15:55
TEXT : ..OLES\Notepads\NQ12&3.txt

ELEVATION :
X-COORD : X3297477
Y-COORD : 31 Y0067933

HOLE No: NQ 3

AECOM

Department of Water Affairs
uMkhomazi Water Project

LEGEND
Sheet 1 of 1

JOB NUMBER: J01763

	GRAVEL	{SA02}
	SILT	{SA06}
	CLAY	{SA08}
	SHALE	{SA12}
	DOLERITE	{SA18}{SA42}
5.5 ▼	PERMANENT WATER TABLE	{SA35}
	ROOTS	{SA40}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :

INCLINATION :
DIAM :
DATE :
DATE :

ELEVATION :
X-COORD :
Y-COORD :

TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

DATE : 11/10/2013 15:55
TEXT : ..OLES\Notepads\NQ12&3.txt

LEGEND
SUMMARY OF SYMBOLS

Tunnel outlet

(BH8)

HOLE No: BH 8
Sheet 1 of 1

JOB NUMBER: J01763

ROCK FABRIC
MF -massive
BF -bedded
FF -foliated
CF -cleaved
SF -schistose
GF -gneissose
LF -laminated

GRAIN SIZE
FG -fine grained
MG -medium grain
CG -coarse grain

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

JOINT ROUGHNESS
SLJ-slickensided
SJ -smooth
RJ -rough

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR -hard rock
MHR-medium hard rock
SR -soft rock
VSR-very soft rock

AECOM

Department of Water Affairs
uMkhomazi Water Project

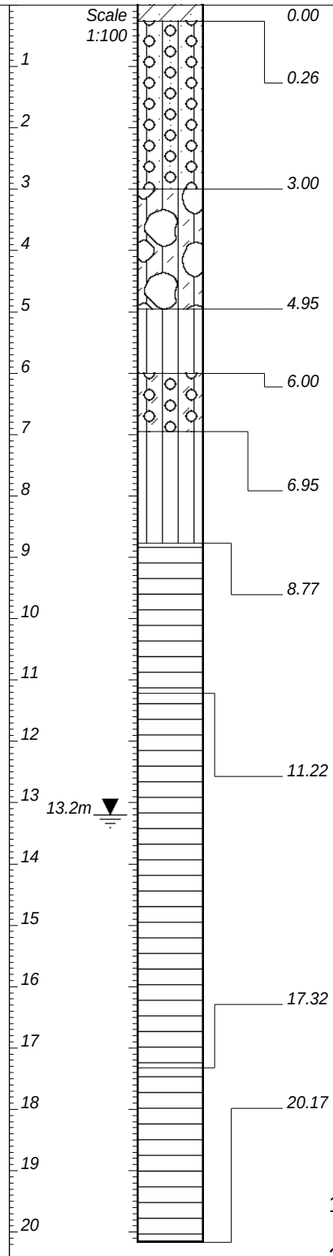
HOLE No: BH 8
Sheet 1 of 1

JOB NUMBER: J01763

%Mater recov	%Core recov	%RQD	SPT	DRILLING METHOD	Grain Size	Rock Fabric	Fabric Spacing (mm)	No. of Joints sets	Joints incl (deg)	Joints spacing	Joints rough & Shape	Fill type	Fill thick (mm)	Frac Freq (m)
70	0	0		NXC	-	-	-	-	-	-	-	-	-	-
87	0	0		NXC										
60	0	0	8	SPT	-	-	-	-	-	-	-	-	-	-
100	0	0		NWD4										
43	23	0		NWD4										
100	0	0		NWD4	-	-	-	-	-	-	-	-	-	-
51	0	0	15	SPT										
100	0	0		NWD4										
92	0	0		NWD4	-	-	-	-	-	-	-	-	-	-
89	0	0	35	SPT	-	-	-	-	-	-	-	-	-	-
93	0	0		NWD4										
49	0	0	55	SPT	-	-	-	-	-	-	-	-	-	-
54	0	0		NWD4										
100	100	0		NWD4										
100	100	60		NWD4	FG	LF	<1	B 1	0 70	10-150 -	SJ SJ	silt silt	<0.5 <0.5	11 -
100	100	22		NWD4										
96	96	14		NWD4										
100	100	45		NWD4	FG	LF	<1	B 1	0 45	<100 >200	SJ SJ	stained stained	stained stained	13 4
87	87	0		NWD4										
78	78	0		NWD4	FG	LF	<1	B 1	0 45	<100 <200	SJ SJ	stained stained	stained stained	30 8
95	95	0		NWD4										
81	81	21		NWD4	FG	LF	<1	B 1	0 45	<100 >200	SJ SJ	stained stained	stained stained	13 4
67	67	60		NWD4										

DEPTH Scale 1:100

Scale 1:100



0.00 – 0.26: Moist dark brown sandy CLAY with roots. TOPSOIL.

0.26 – 3.00: Moist yellowish brown soft sandy SILT with soft sub angular shale GRAVEL. RESIDUAL SHALE.

3.00 – 4.95: Moist reddish brown stiff clayey SILT with soft shale BOULDERS. RESIDUAL SHALE.

4.95 – 6.00: Moist light brownish grey SILT. RESIDUAL SHALE.

6.00 – 6.95: Moist reddish brown very stiff clayey SILT with soft shale GRAVEL. RESIDUAL SHALE.

6.95 – 8.77: Moist light brownish grey very stiff SILT. RESIDUAL SHALE.

8.77 – 11.22: Moderately to highly weathered highly fractured greenish brown to greenish grey fine grained laminated medium hard rock SHALE. 13.27
Slightly weathered highly fractured dark grey fine grained laminated hard rock SHALE.

11.22 – 17.32: Slightly to moderately weathered very highly fractured dark grey fine grained laminated hard rock SHALE.

17.32 – 20.17: Slightly weathered highly fractured dark grey fine grained laminated hard to very hard rock SHALE.

NOTES

1) Water table at 13.2m.

2) Poor material recovery is attributed to washing out of fines during drilling.

CONTRACTOR : Geomech
MACHINE : YWE
DRILLED BY : Wilson
PROFILED BY : JJ Ehlers
TYPE SET BY : JJ Ehlers
SETUP FILE : Borehole.SET

INCLINATION : VERTICAL
DIAM :
DATE : 2013/03/16
DATE : 2013/03/22
DATE : 06/11/2013 15:16
TEXT : ..REHOLES\Notepads\BH8.txt

ELEVATION :
X-COORD : X3295219
Y-COORD : 31 Y 067426

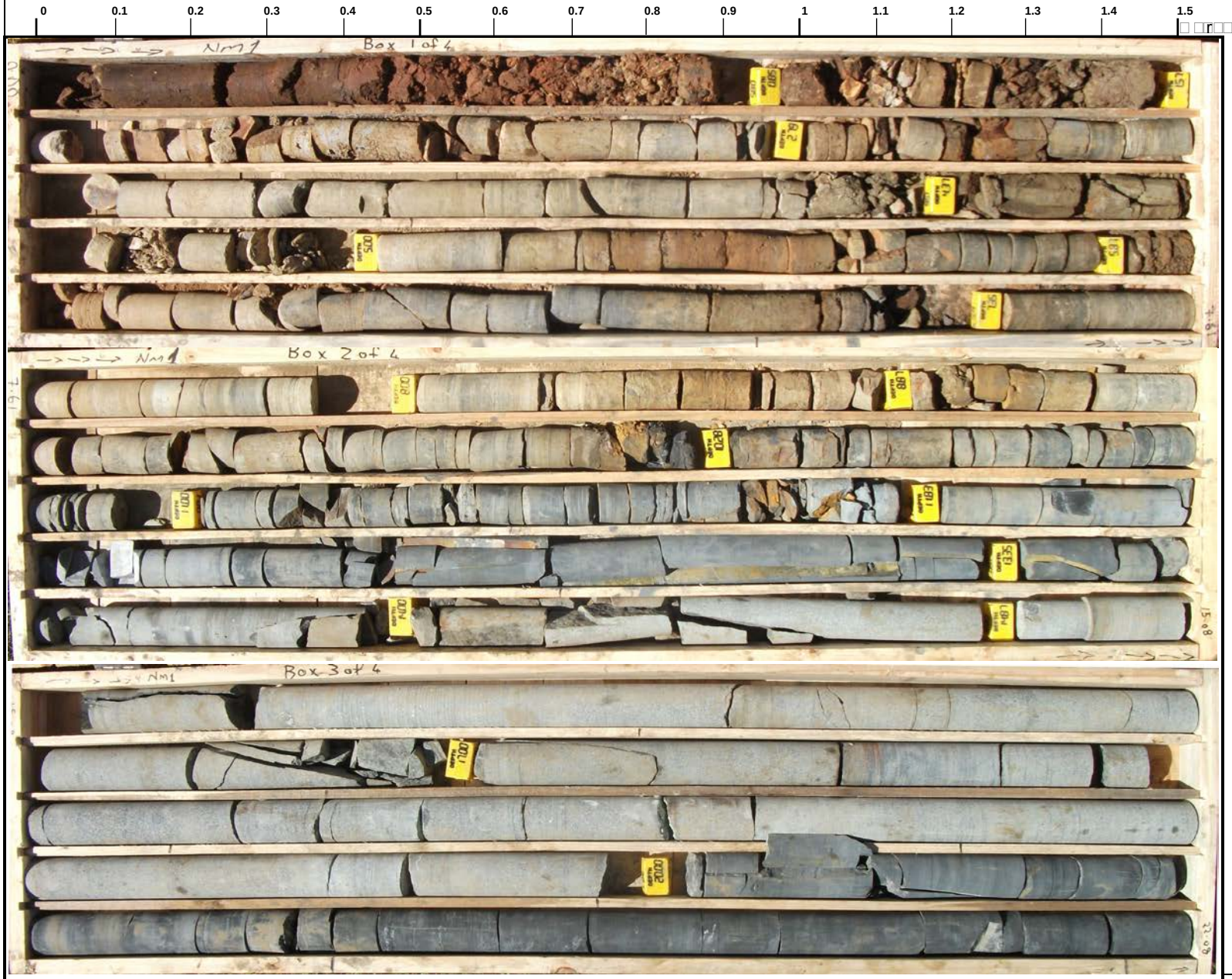
HOLE No: BH 8

Borehole core photographs

Langa Dam site, left flank

(NM1, NM2, NM9)

BOREHOLE: NM 1 LENGTH: 25.16m INCLINATION: VERTICAL



Box 1 of 4

0.00m to 7.61m

Box 2 of 4

7.61m to 15.08m

Box 3 of 4

15.08m to 22.08m

uMkhomasi Water Project

GEOTECHNICAL INVESTIGATIONS

NM 1

BOREHOLE: NM 2 LENGTH: 20.00m INCLINATION: VERTICAL

Box 1 of 3

0.00m to 9.50m

Box 2 of 3

9.50m to 17.00m

Box 3 of 3

17.00m to 20.00m

NM 2

uMkhomasi Water Project

GEOTECHNICAL INVESTIGATIONS

BOREHOLE: NM 9 LENGTH: 20.11m INCLINATION: VERTICAL

Box 1 of 3

0.00m to 8.00m

Box 2 of 3

8.00m to 14.80m

Box 3 of 3

14.80m to 20.11m

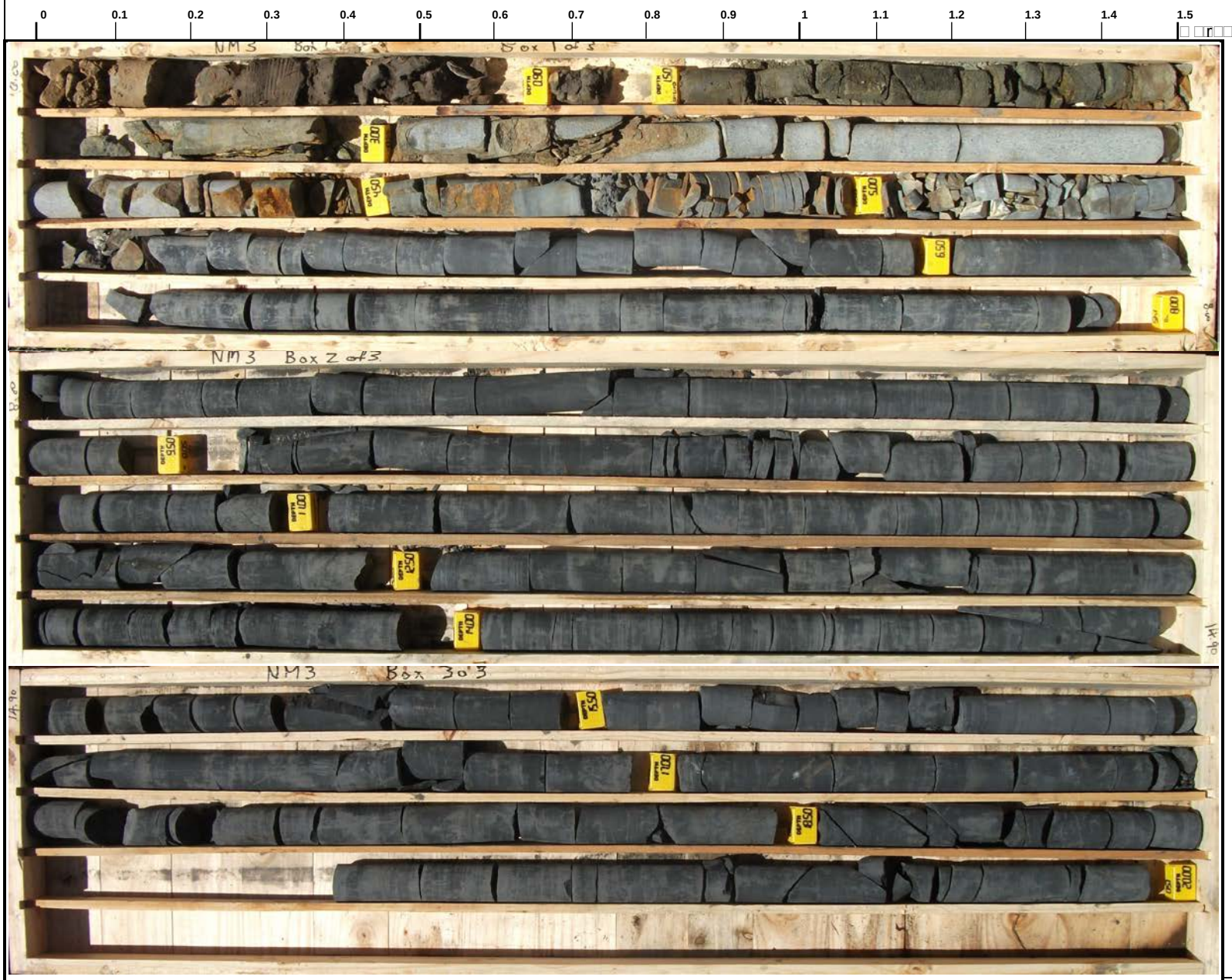
NM 9

uMkhomasi Water Project

GEOTECHNICAL INVESTIGATIONS

Langa Dam site, river section (NM3)

BOREHOLE: NM 3 LENGTH: 20.00m INCLINATION: VERTICAL



Box 1 of 3

0.00m to 8.00m

Box 2 of 3

8.00m to 14.90m

Box 3 of 3

14.90m to 20.00m

NM 3

Page 1 of 1

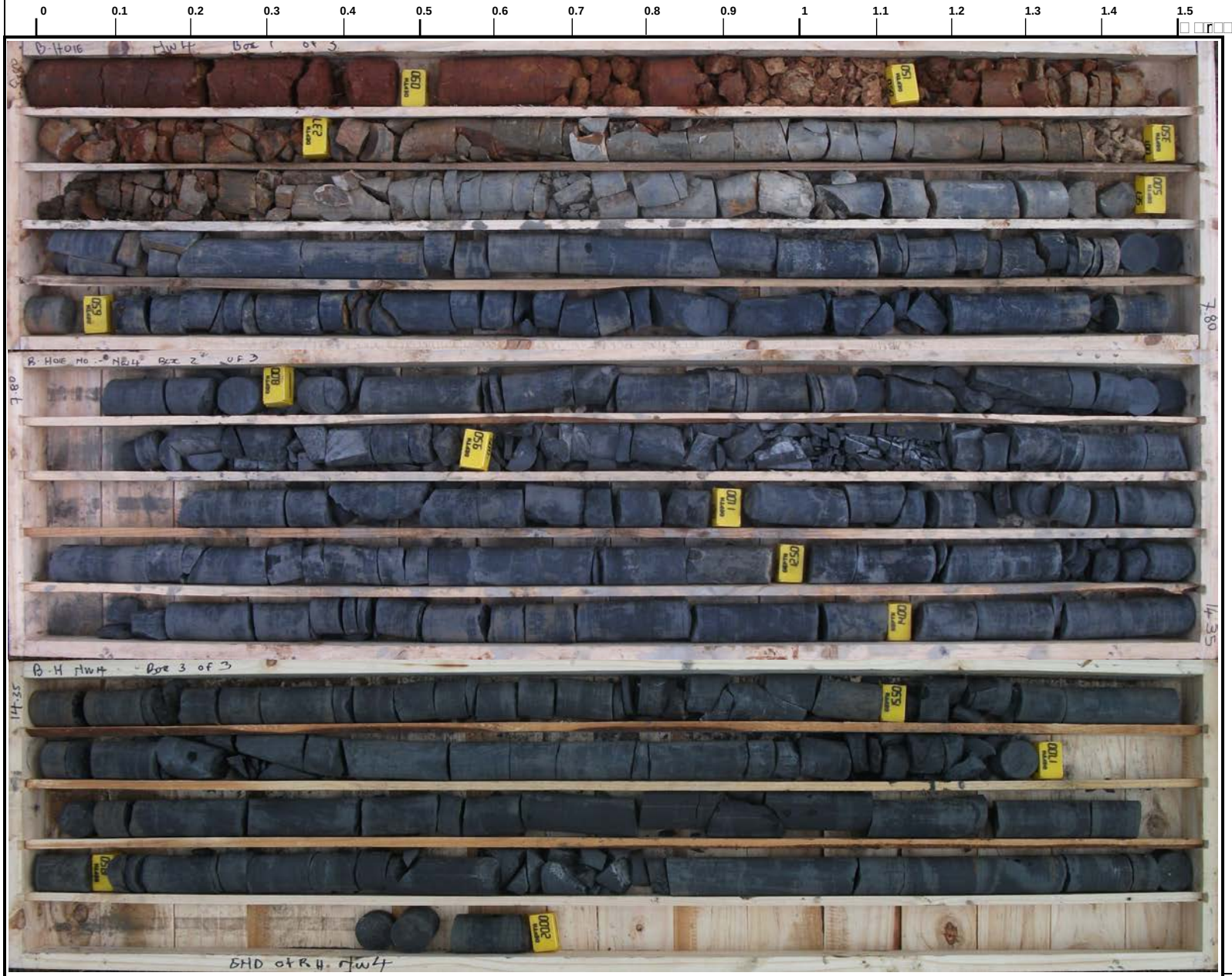
uMkhomasi Water Project

GEOTECHNICAL INVESTIGATIONS

Langa Dam site, right flank

(NM4 – NM7)

BOREHOLE: NM 4 LENGTH: 20.00m INCLINATION: VERTICAL



Box 1 of 3

0.00m to 7.80m

Box 2 of 3

7.80m to 14.35m

Box 3 of 3

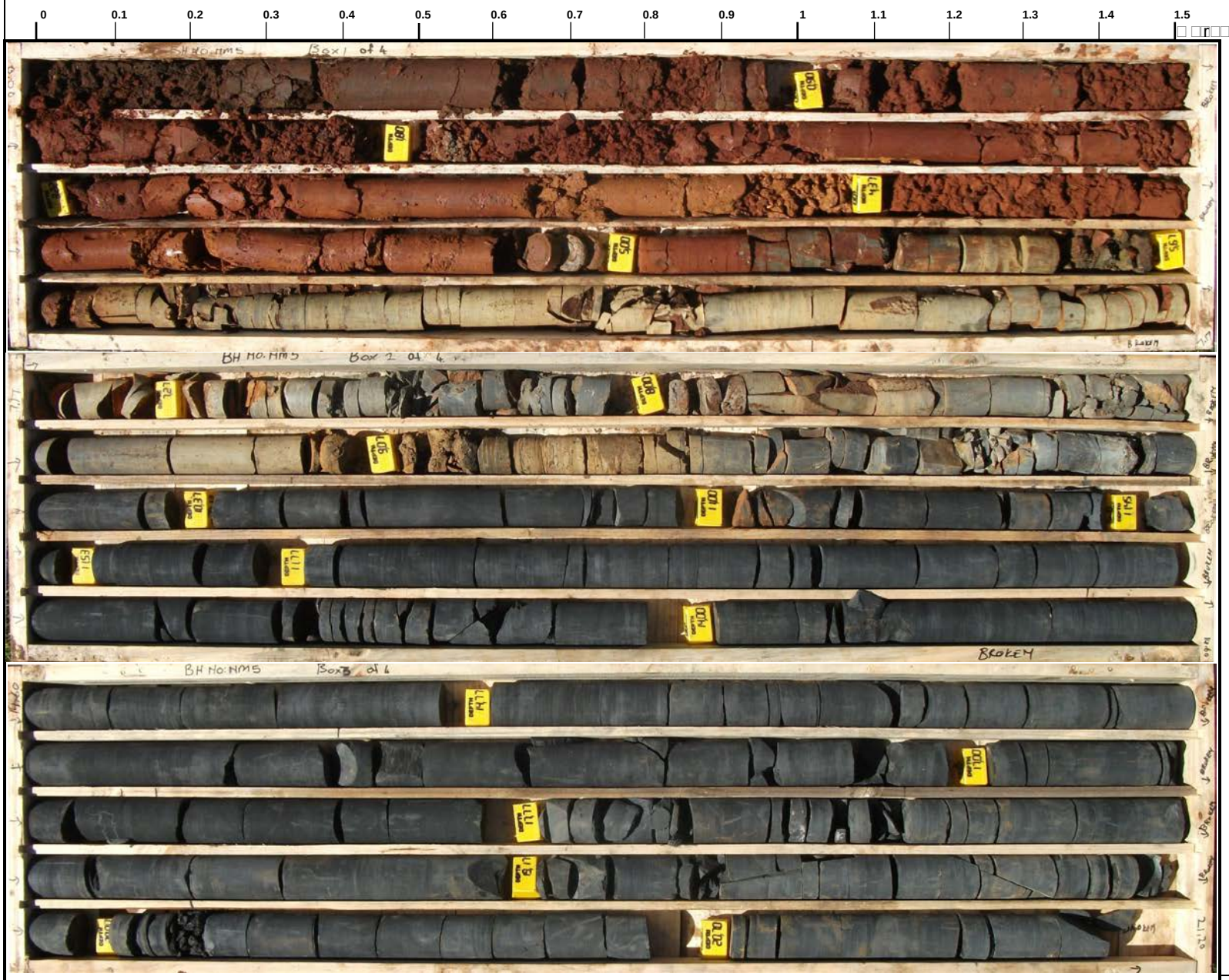
14.35m to 20m

NM 4

uMkhomasi Water Project

GEOTECHNICAL INVESTIGATIONS

BOREHOLE: NM 5 LENGTH: 25.27m INCLINATION: VERTICAL



Box 1 of 4

0.00m to 7.17m

Box 2 of 4

7.17m to 14.60m

Box 3 of 4

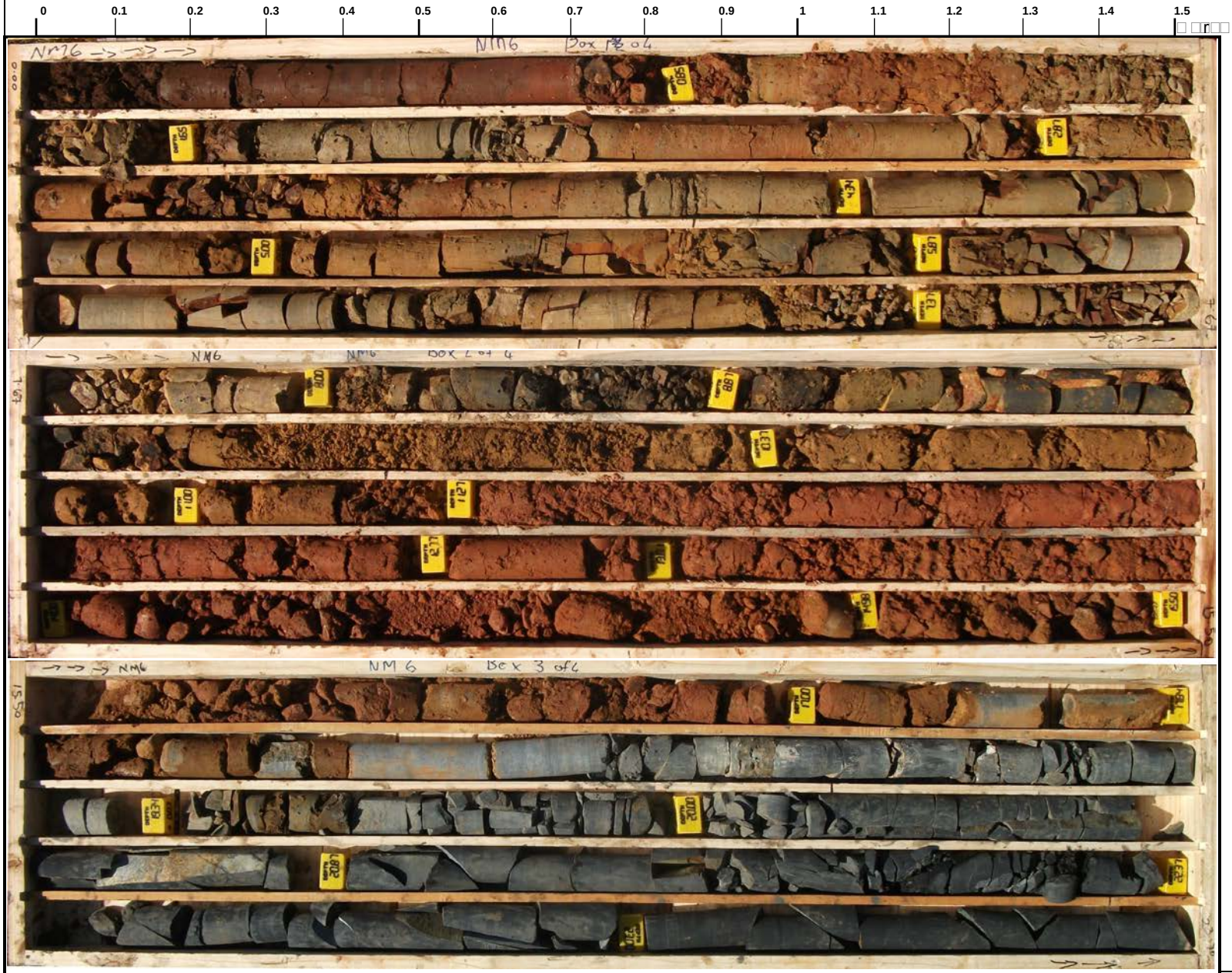
14.60m to 21.20m

NM 5

uMkhomasi Water Project

GEOTECHNICAL INVESTIGATIONS

BOREHOLE: NM 6 LENGTH: 25.11m INCLINATION: VERTICAL



Box 1 of 4

0.00m to 7.69m

Box 2 of 4

7.69m to 15.50m

Box 3 of 4

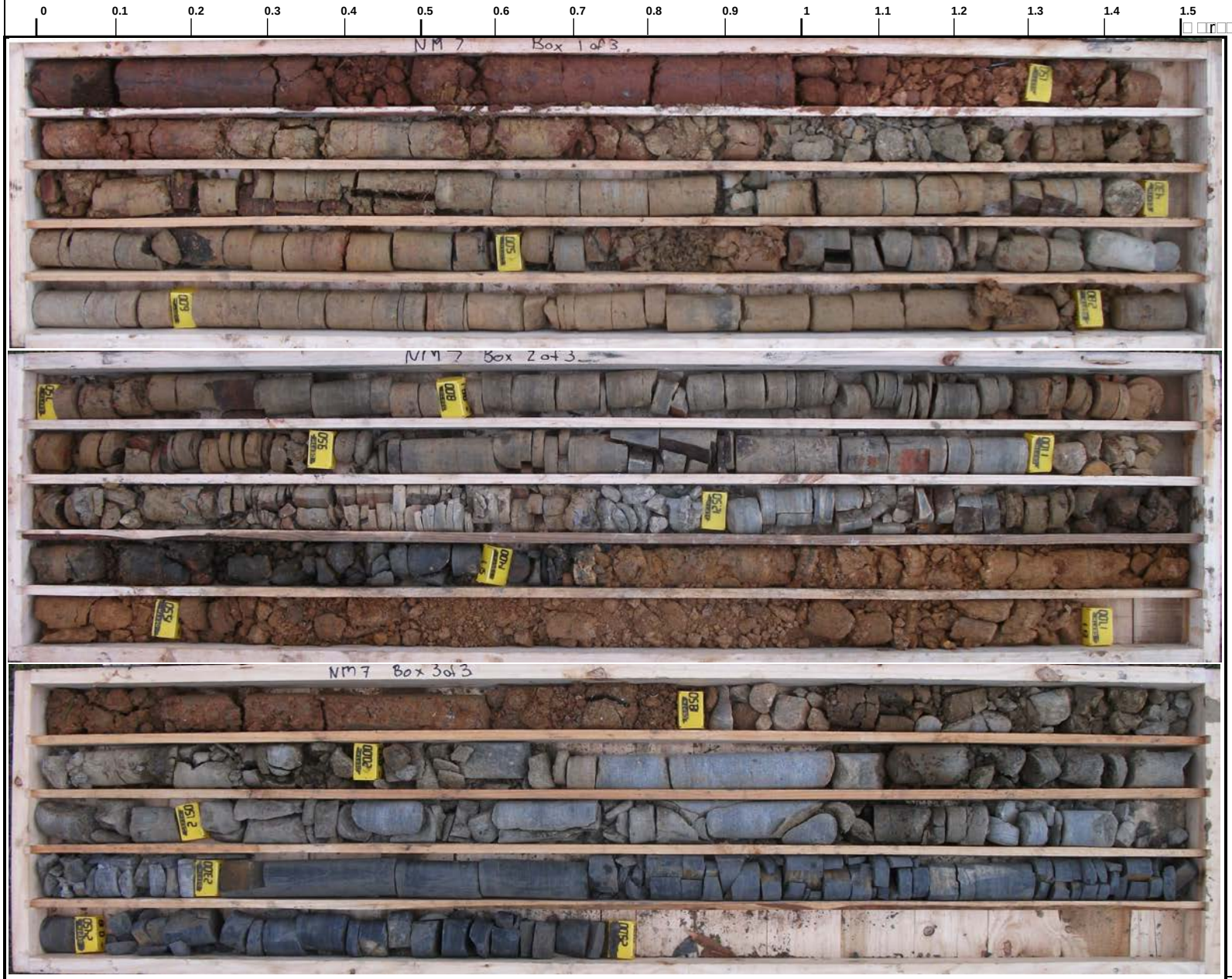
15.50m to 23.70m

uMkhomasi Water Project

GEOTECHNICAL INVESTIGATIONS

NM 6

BOREHOLE: NM 7 LENGTH: 25.00m INCLINATION: VERTICAL



Box 1 of 3

0.00m to 7.50m

Box 2 of 3

7.50m to 17.00m

Box 3 of 3

17.00m to 25.00m

NM 7

uMkhomasi Water Project

GEOTECHNICAL INVESTIGATIONS

Langa Dam, left spillway

(NM10)

BOREHOLE: NM 10 LENGTH: 20.02m INCLINATION: VERTICAL

Box 1 of 3

0.00m to 8.62m

Box 2 of 3

8.62m to 16.37m

Box 3 of 3

16.37m to 20.02m

NM 10

Page 1 of 1

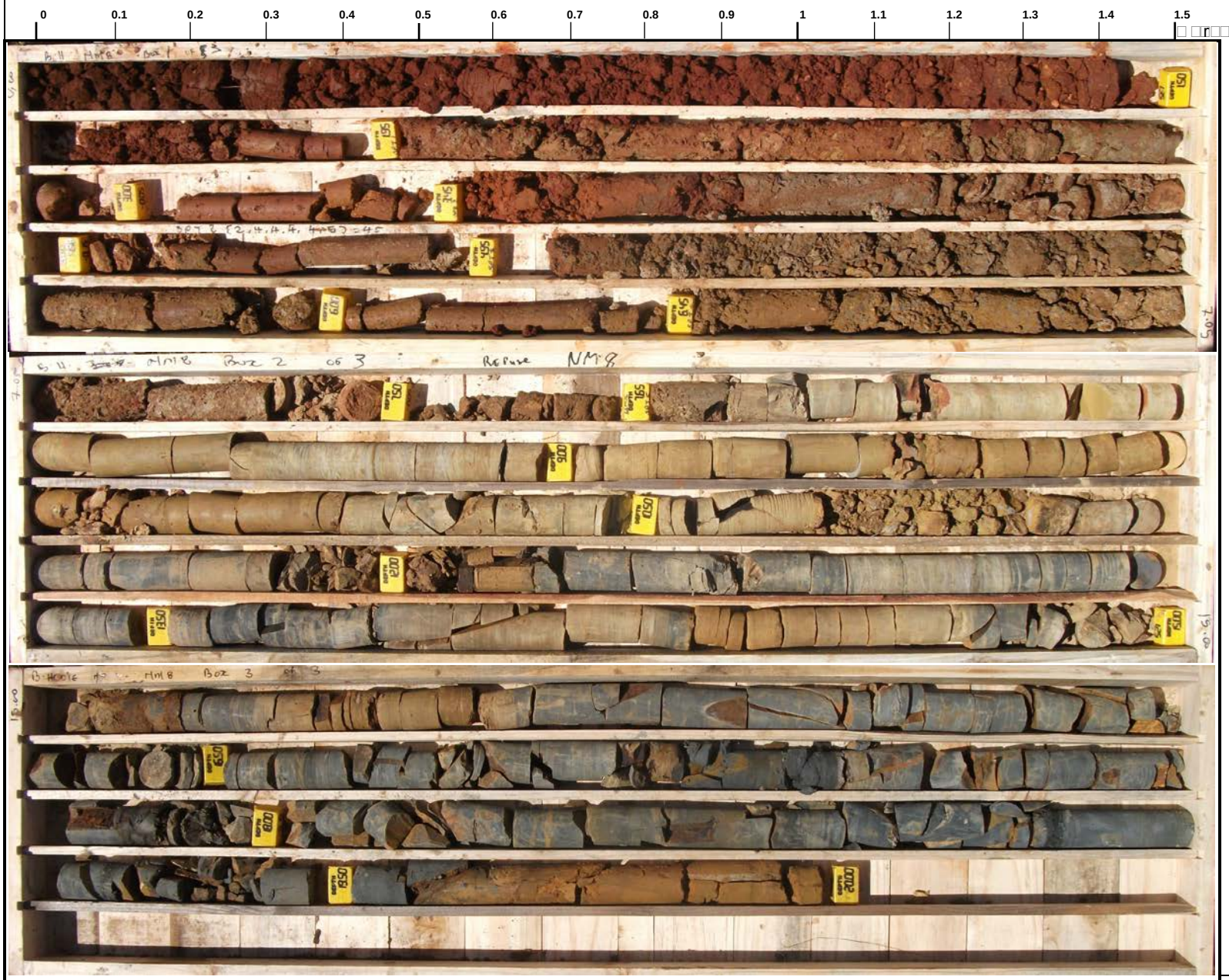
uMkhomasi Water Project

GEOTECHNICAL INVESTIGATIONS

Langa Dam, right spillway

(NM8)

BOREHOLE: NM 8 LENGTH: 20.00m INCLINATION: VERTICAL



Box 1 of 3

0.00m to 7.05m

Box 2 of 3

7.05m to 15.00m

Box 3 of 3

15.00m to 20.00m

NM 8

Page 1 of 1

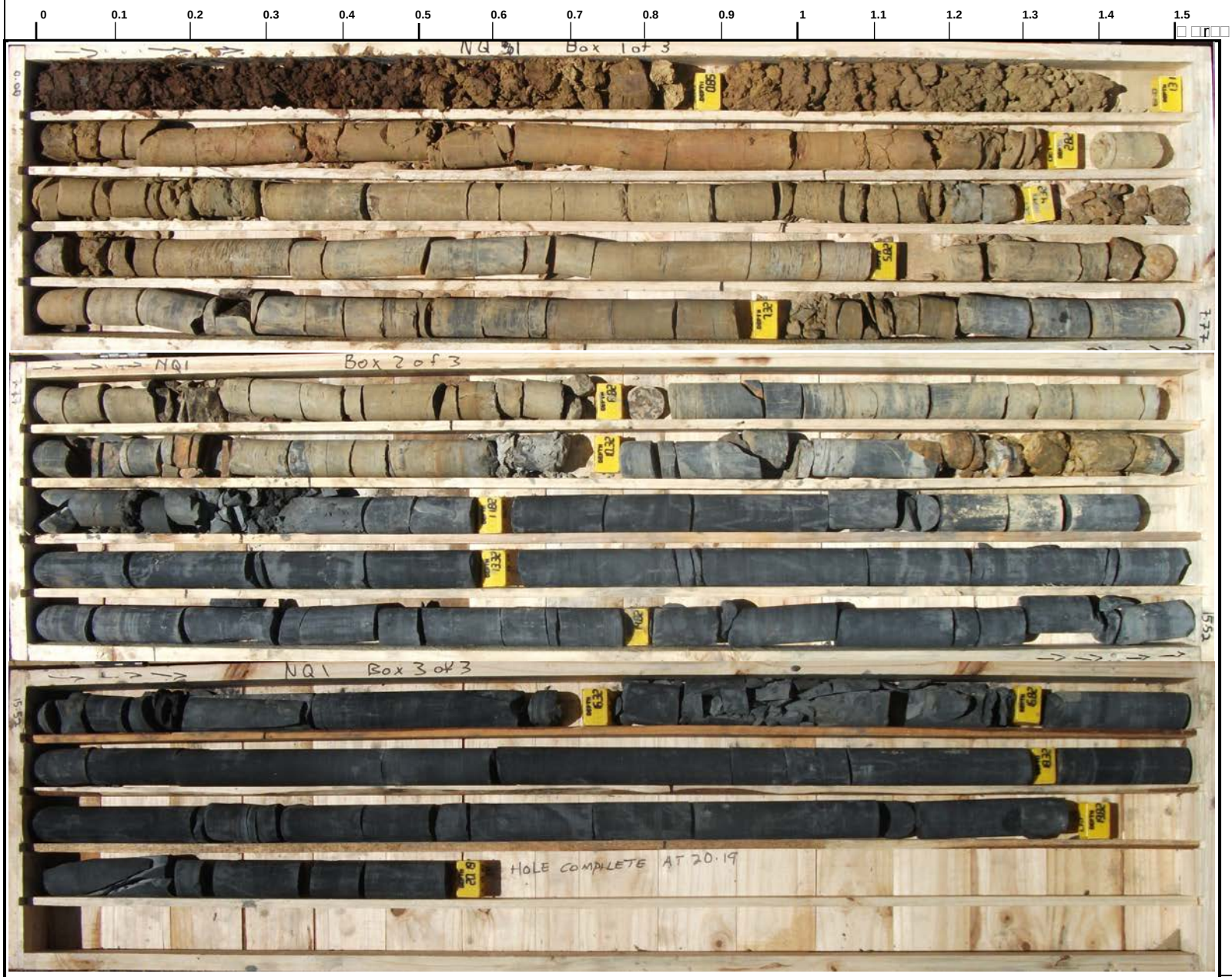
uMkhomasi Water Project

GEOTECHNICAL INVESTIGATIONS

Langa quarry site

(NQ1 – NQ3)

BOREHOLE: NQ 1 LENGTH: 20.19m INCLINATION: VERTICAL



Box 1 of 3

0.00m to 7.77m

Box 2 of 3

7.77m to 15.52m

Box 3 of 3

15.52m to 20.19m

NQ 1

Page 1 of 1

uMkhomasi Water Project

GEOTECHNICAL INVESTIGATIONS

BOREHOLE: NQ 2 LENGTH: 20.07m INCLINATION: VERTICAL

Box 1 of 3

0.00m to 8.07m

Box 2 of 3

8.07m to 15.57m

Box 3 of 3

15.57m to 20.07m

NQ 2

uMkhomasi Water Project

GEOTECHNICAL INVESTIGATIONS

BOREHOLE: NQ 3 LENGTH: 20.18m INCLINATION: VERTICAL

Box 1 of 3

0.00m to 7.44m

Box 2 of 3

7.44m to 14.71m

Box 3 of 3

14.71m to 20.18m

NQ 3

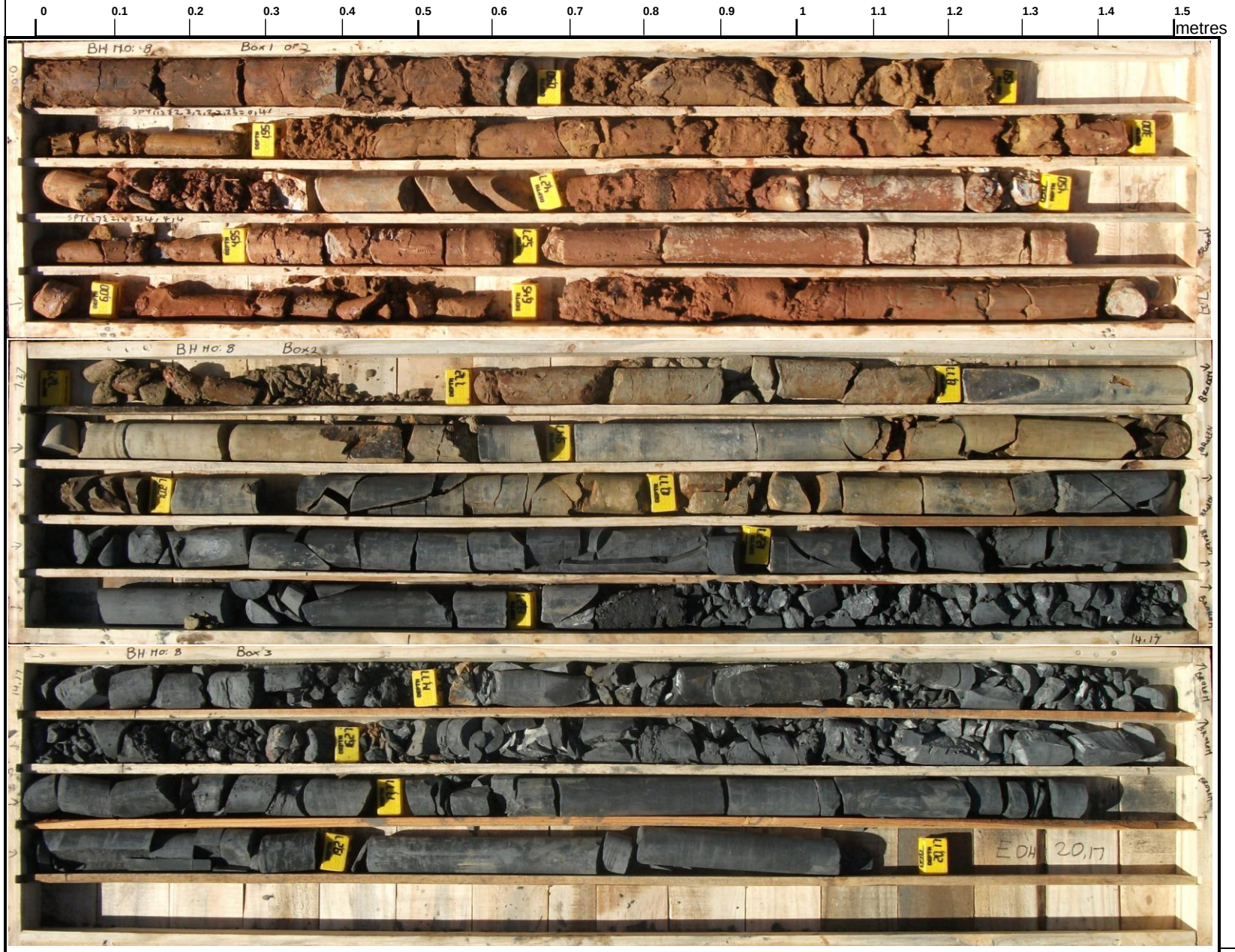
uMkhomasi Water Project

GEOTECHNICAL INVESTIGATIONS

Tunnel outlet

(BH8)

BOREHOLE: BH 8 LENGTH: 20.10m INCLINATION: VERTICAL



Box 1 of 3

0.00m to 7.27m

Box 2 of 3

7.27m to 14.17m

Box 3 of 3

14.17m to 20.17m

BH 8

Page 1 of 1

uMkhomasi Water Project

GEOTECHNICAL INVESTIGATIONS