Geotechnical and Thermal Report

PHASE 2 REPORT FOR:

GEOTECHNICAL ASSESSMENT AND THERMAL INVESTIGATION AT THE MATIMBA POWER STATION ASH DISPOSAL FACILITY, LEPHALALE, LIMPOPO PROVINCE

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VERIFICATION PAGE

TITLE :		
PHASE 2 REPORT FOR: GEOTECHNICAL ASSESSMENT AND THERMAL INVESTIGATION AT THE MATIMBA POWER STATION ASH DISPOSAL FACILITY, LEPHALALE, LIMPOPO PROVINCE		
JGI NO. : 3145	**DATE :** 05-06-2015	**REPORT STATUS :** FINAL

CARRIED OUT BY :	**COMMISSIONED BY :**
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SYNOPSIS :

The report details Phase 2 of the Geotechnical Assessment and Thermal Investigation. The activities carried out include the site visit, on-site analysis of ash pile, establishment of geothermal testing stations, readings of geothermal activity, sampling of material for laboratory testing, final full assessment report.

KEY WORDS :

Geotechnical, Thermal, Temperature, Monitoring, Matimba, Ash Landfill

QUALITY VERIFICATION

This report has been prepared under the controls established by a quality management system that meets the requirements of ISO9001: 2008 which has been independently certified by DEKRA Certification under certificate number 90906882

Verification	Capacity	Name	Signature	Date
By Author	Design Engineer	L Wallace		05-06-2015
Checked by	Discipline Head	R Emery		05-06-2015
Authorised by	Discipline Head	R Emery		05-06-2015

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1. THIS REPORT

This element of the Works towards licencing the continuous-ash disposal facility for Matimba Power Station involves the assessment of the existing ash pile - thermal (geothermal) investigation and geotechnical assessment.

This is a stand-alone element of Work towards the greater purpose of licencing the continuous-ash disposal facility for Matimba Power Station.

This stand-alone element of Work is divided into two Phases:

Phase 1: Site visit, on-site analysis of ash pile, establishment of geothermal testing stations, initial readings of geothermal activity, sampling of material for laboratory testing, interim report.

Phase 2: Receipt of test results from soils laboratory, analysis of results, modelling of geotechnical characteristics of ash material, summary of geothermal testing, final report.

This Report covers both Phases and provides the conclusive analysis of the above.

The purpose of this Phase 2 report is to report on the findings of the geotechnical assessment and thermal investigation that was carried out at the existing Matimba Power Station Ash Disposal Facility (ADF) in Lephalale, Limpopo in February 2014 and the assessment thereof. The report presents the results from the soil laboratory testing and on-going thermal monitoring program setup at the existing Matimba Power Station ADF.

The results presented in this report will motivate the technical aspects of the conceptual engineering design feeding into the waste license application.

The works were approved by Royal Haskoning DHV as an extension of the existing terms of reference on the 21 January 2014.

2. THERMAL INVESTIGATION

2.1 Literature Review

The combustion of coal for electricity generation results in the generation of coal ash waste or coal combustion products (CCPs).

CCPs are typically divided into four separate by-product types (Environmental Protection Agency, 2013):

- Fly Ash
- Bottom Ash
- Boiler Slag
- Flue gas desulphurisation gypsum

The characteristics and physical properties of CCPs vary in size, shape and chemical composition based on the chemical nature of the raw material (coal) from which the CCP is derived and the process by which the coal is processed and the subsequent CCPs collected. These varying characteristics and properties determine the possible beneficial re-uses of the CCP. Examples of beneficial use are using CCPs as a replacement for natural building materials (such as sand, gravel or gypsum) or as a cement substitute in concrete mix designs (Environmental Protection Agency, 2013).

Hydration of pozzolans within fly ash has been shown to be an exothermic reaction. The heat of hydration has been used in the concrete industry to predict heat build-up in large scale concrete construction (Hasset and Eylands, 1997).

Limited literature is available when it comes to predicting heat build-up in a waste disposal facility that receives a homogenous Ash Waste as a singular waste.

The content of Calcium Oxide (CaO) present in a source of fly ash is seen as an indicator to the cementitious nature of the fly ash and results in a difference in the heat of hydration (Blondin et al., 1999).

ASTM C618 defines two classes of Fly Ash namely Class C and Class F. Class F fly ashes are generally low Calcium, typically less than 10% CaO, while Class C fly ashes typically have a CaO concentration in the order of 10% - 30%.

Chemical testing undertaken on Ash Waste from the Matimba Ash Disposal facility in May 2012 shows the **CaO concentration to be between 3.9% and 4.6%.**

This low concentration presents a lower potential for the hydration of available pozzolans within the ash waste and could result in a lower heat of hydration and subsequent lower temperature build up within the waste pile.

Yoshisa and Rowe (2003) modelled heat transport in a general domestic waste landfill due to conduction and water flow. The equation applied to model this heat transport is a one dimensional heat equation which has been seen as sufficient in this case due to landfills generally being much larger in surface area than in height (Rowe and Hoor, 2009).

Yoshida and Rowe (2003) presented observed temperatures versus temperatures calculated from the heat transport equation at a landfill in Tokyo that received both general and ash waste. The paper shows a strong correlation between observed and calculated values and the landfill is shown to reach average internal temperatures in the region of 60°C over 20 years.

Programming a computer simulation model to predict theoretical temperature values for the Matimba Ash Disposal facility, falls outside of the scope of this thermal investigation. This thermal investigation comprises conducting an on-site thermal investigation to compare temperatures at the base of the existing ADF against the figures presented in the limited literature that is available.

Variables from the heat modelling equation by Yoshida and Rowe (2003) were obtained as part of the testing schedule undertaken at the soils laboratory. This was done in order to carry out a rudimentary comparison of the ash waste at Matimba against the available literature. The results of the thermal conductivity testing are shown in **Table 1**.

Table 1: Thermal Conductivity of Ash Waste at Matimba

SAMPLE[1]	SAMPLE DESCRIPTION	MOISTURE (%)	THERMAL CONDUCTIVITY (J/ms.K)	SPECIFIC HEAT (J/kg.K)
BOREHOLE 1	Dry	-	0.140	742
	In-Situ Moisture	14.5	0.548	1304
	Saturated	19.7	0.661	1625
BOREHOLE 2	Dry	-	0.128	670
	In-Situ Moisture	15.1	0.563	1218
	Saturated	18.1	0.620	1545
BOREHOLE 3	Dry	-	0.130	748
	In-Situ Moisture	13.3	0.547	1299
	Saturated	16.7	0.598	1237

When comparing the thermal conductivity and specific heat of the Matimba Ash Waste against the values presented, it is noted that both the thermal conductivity and the specific heat of the Matimba Ash Waste are lower than in the example presented by Yoshida and Rowe (2003).

Due to the low concentration of CaO (free lime) and the lower thermal conductivity and specific heat of the Ash waste, it is anticipated that the on-site thermal investigation will measure temperatures well below 60℃ and this is confirmed below in Figure 10 to Figure 13.

The original results of the thermal conductivity and moisture content testing are attached under **Appendix A**.

[1] *Each sample was taken from a composite ash waste sample from between 10m to 25m deep from each borehole.*

2.2 On-site Thermal Investigation

The initial phase of the thermal investigation was completed on site towards the end of February 2014.

The investigation entailed establishing four monitoring stations that were to carry out continuous temperature monitoring (for a defined period of time) of the existing ash waste landfill at varying depths within the ash pile using equipment and thermoprobes sourced from Onset instrumentation. Each test station had the ability to monitor four temperature probes at each station.

The first three test stations were setup by using a borehole drilling rig to drill through ash placed within the past two years (based on indications from Eskom site staff) until such time as the underlying in-situ ground level was reached. Two thermal probes were placed at 5m and 10m deep from surface level respectively. The deepest probe was placed at the bottom of the ash pile and the final probe was placed 5m up from the deepest probe (i.e. the two deep probes were placed at approximately 35m and 40m deep from surface level respectively). See table 4 below.

The fourth thermal test station was setup by placing two thermal probes into the advancing ash face in order to monitor the development of heat in freshly placed ash. The final two probes in test station four were left on the surface of the landfill to monitor ambient temperatures experienced over the monitoring period.

Figure 1 shows the location of the four thermal test stations relative to the Matimba Ash Landfill.

Figure 2 through to **Figure 9** present captioned photos depicting the various stages of the on-site work that was undertaken for the Thermal Investigation.

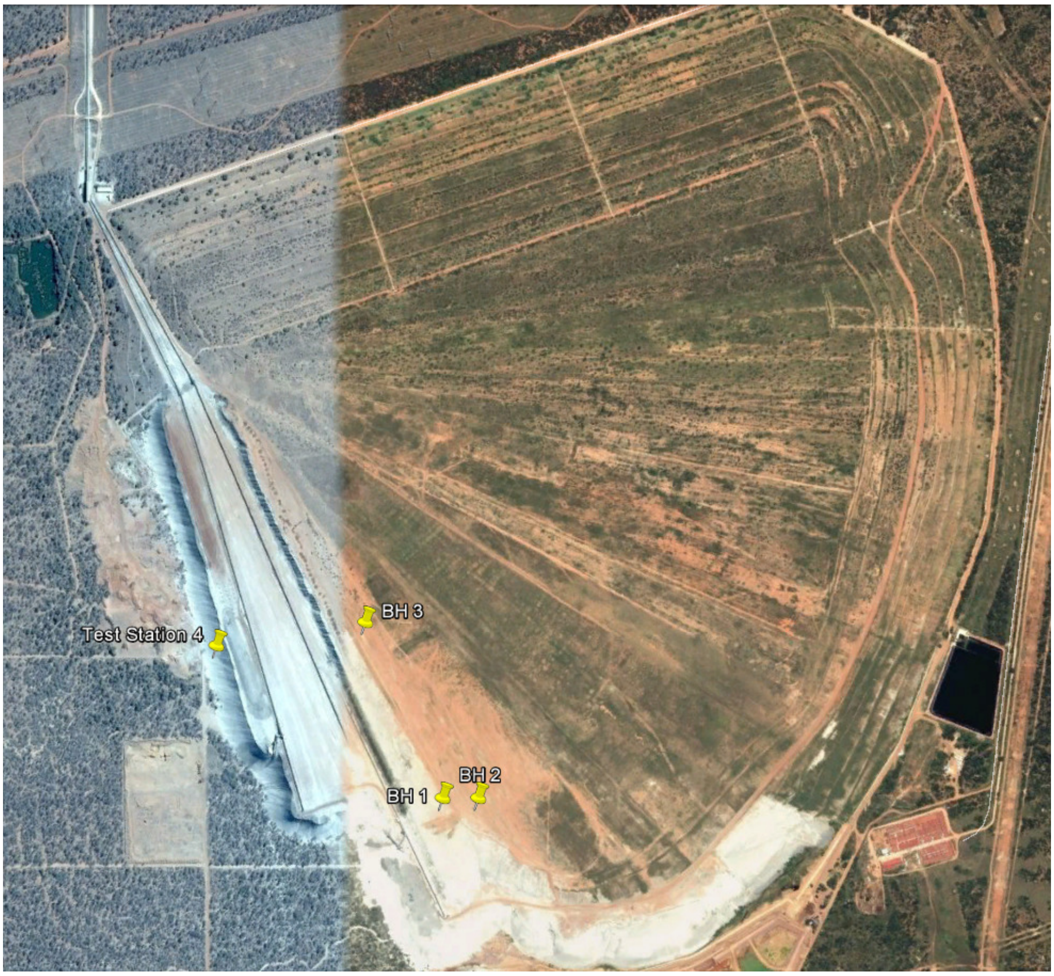


Figure 1 - Thermal Test Station Locations (Aerial imagery by Google Maps, 2013)

Figure 2 - Establishing Borehole

Figure 4 - Sinking Borehole Shaft

Figure 3 - Borehole Test Station Complete

Figure 5 - Borehole Samples for Soils Testing

Figure 6 - Initial Temperature Readings from Borehole Test Station

Figure 8 - Placement of Thermal Probes into Advancing Ash Pile

Figure 7 - Excavation of Trench to Establish Thermal Test Station 4

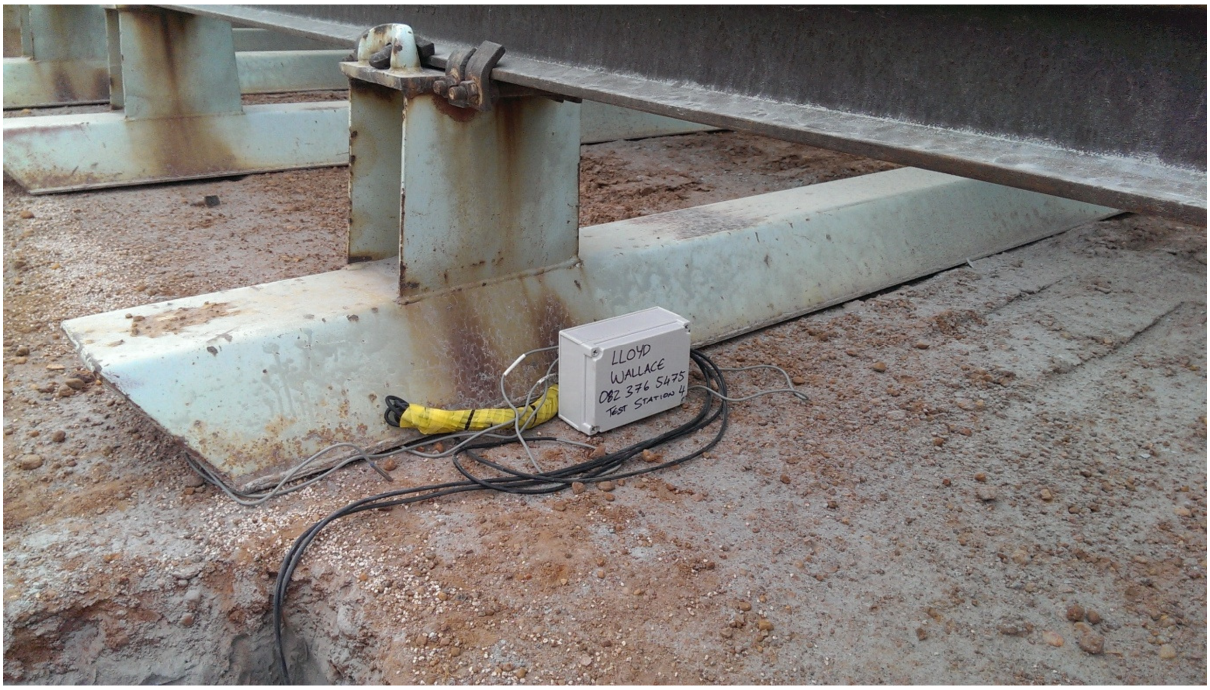


Figure 9 – Final Positioning of Thermal Test Station 4

Jeffares & Green oversaw the continuous thermal monitoring of the four test stations from the 28th February 2014 to the 30 April 2014. The thermal logging instrumentation has remained installed at the logging stations and the instrumentation was left to continue capturing thermal data. Since reporting on the initial thermal monitoring, J&G obtained the data from the ongoing monitoring up to February 2015. The data from 28th February 2014 to 4th February 2015 is presented below.

We experienced disturbances with the recordings due to the storm damage that occurred during the excessive rainfall that was experienced in the region in March 2014, which resulted in some stations going offline for a period. We further experienced technical difficulties for brief instances at logging station 1, 3 and 4 (shown in the graphical representations below). Despite the setbacks, we have recorded good, reliable results.

Table 2 presents a tabulated summary of the four temperature logging stations including maximum and minimum temperatures recorded during the on-site temperature monitoring.

The loggers were set to record temperature every minute for the entire duration of the investigation. ***Figure 10*** through to ***Figure 14*** show a graphical representation of the recorded temperature data for the four respective logging stations.

Large datasets for the thermal monitoring were obtained by recording temperatures at one minute intervals over the monitoring period. Due to the monitoring disturbances and technical challenges, the datasets showed occasional reading of obvious outliers' thus, minimal statistical manipulation was necessary to present the data as shown below. The maximum recorded temperature (Not considered a gross outlier due to technical fault) across all four logging stations did not exceed 48℃. The standard deviation for thermoprobes that did not experience technical disruptions was less than 2℃ which has given further confidence in the results.

Table 2: Summary of Temperature Monitoring undertaken at the Matimba Ash Disposal Facility

Logging station	Nature of Logging Station	Estimated Time Elapsed since Ash Placement	Probe Depth				Minimum Temp	Maximum Temp	Comments
			Probe 1	Probe 2	Probe 3	Probe 4			
1	Borehole	1 - 1.5 years	5m	10m	43m	48m	27.9℃	39.8℃	- Weather Damage experienced at the end of March. - Thermocouple (TC) 3 had a technical malfunction at the end of April.
2	Borehole	1.5 - 2.5 Years	5m	10m	43m	48m	31℃	40.12℃	- Thermocouple (TC) 3 showed irregular temperature oscillations from the beginning of the investigation.
3	Borehole	1 - 1.5 Years	5m	10m	40m	45m	21℃	41.2℃	- Logging station went offline from the beginning to the middle of March due to weather damage.
4	New Ash Waste Pile	Newly Placed Ash	Landfill Surface	Landfill Surface	15m (offline)	30m	36.5℃	48.0℃	- Two TCs were placed into the advancing Ash Pile. One of the TC went offline post placement and is not shown in this report. - Temperatures recorded at the Landfill Surface were not included for presenting the Maximum and Minimum temperatures.

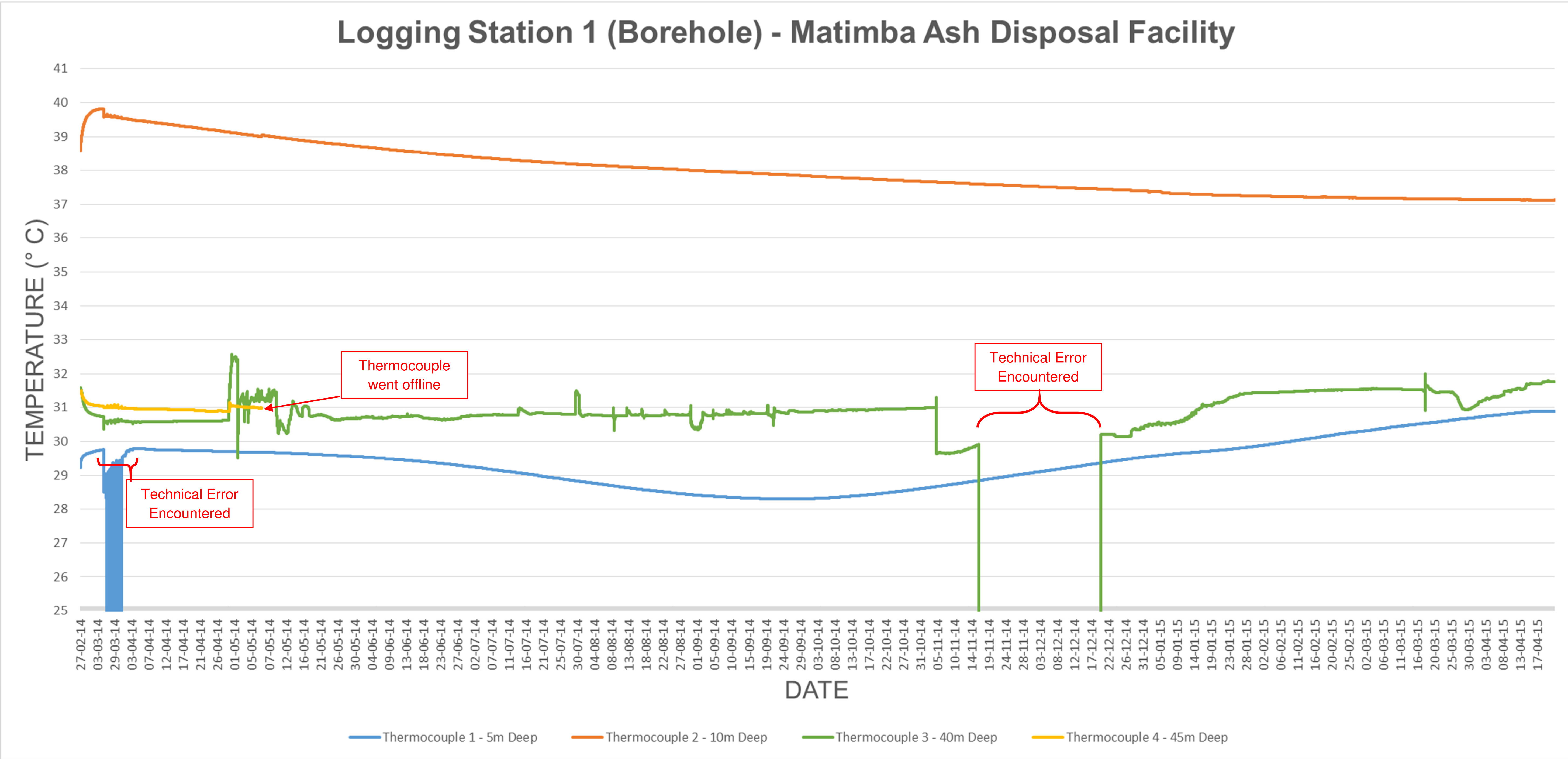


Figure 10 – Temperatures recorded at Logging Station 1 (Borehole 1) from February 2014 to April 2015

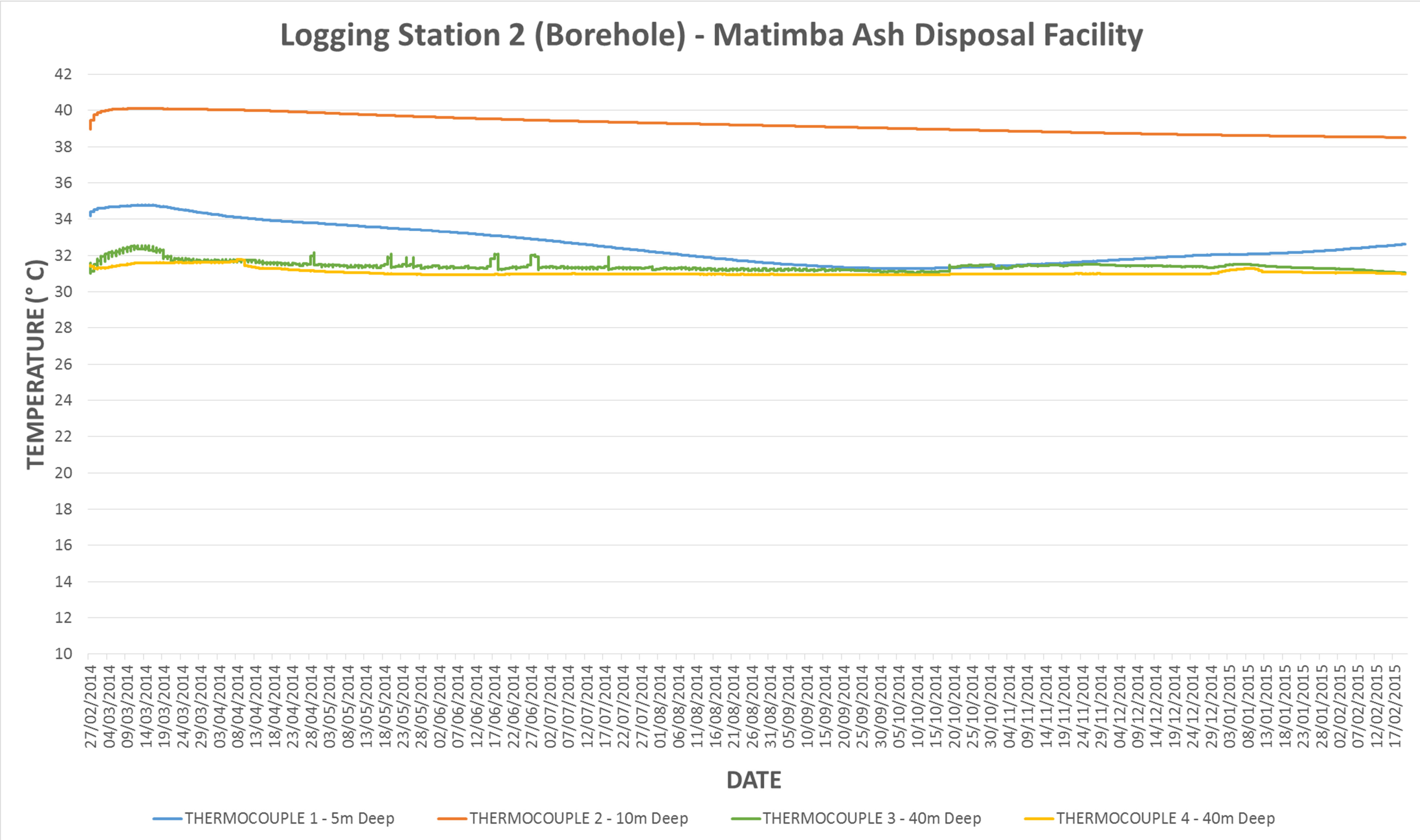


Figure 11 - Temperatures recorded at Logging Station 2 (Borehole 2) from February 2014 to February 2015

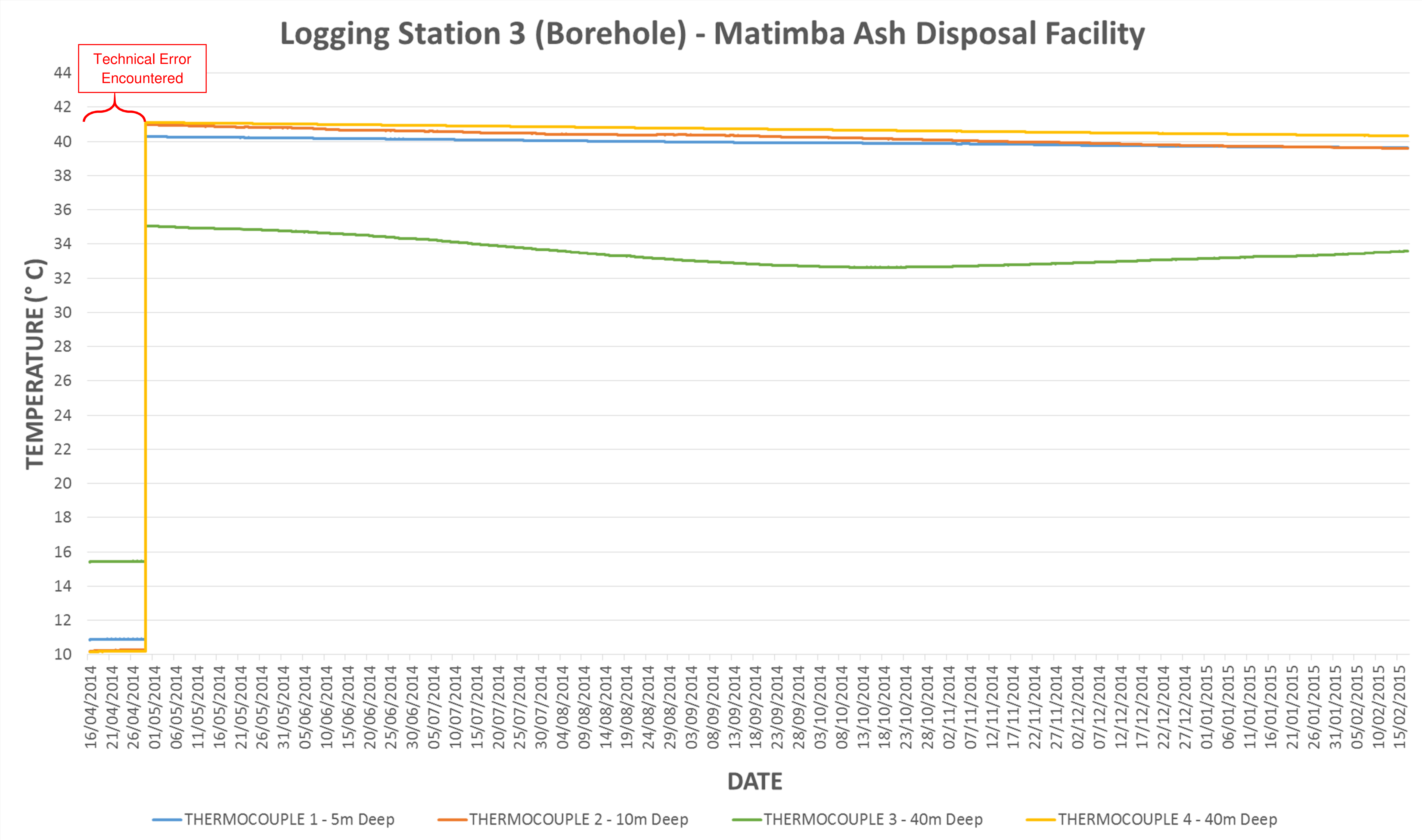


Figure 12 - Temperatures recorded at Logging Station 3 (Borehole 3) from April 2014 to February 2015

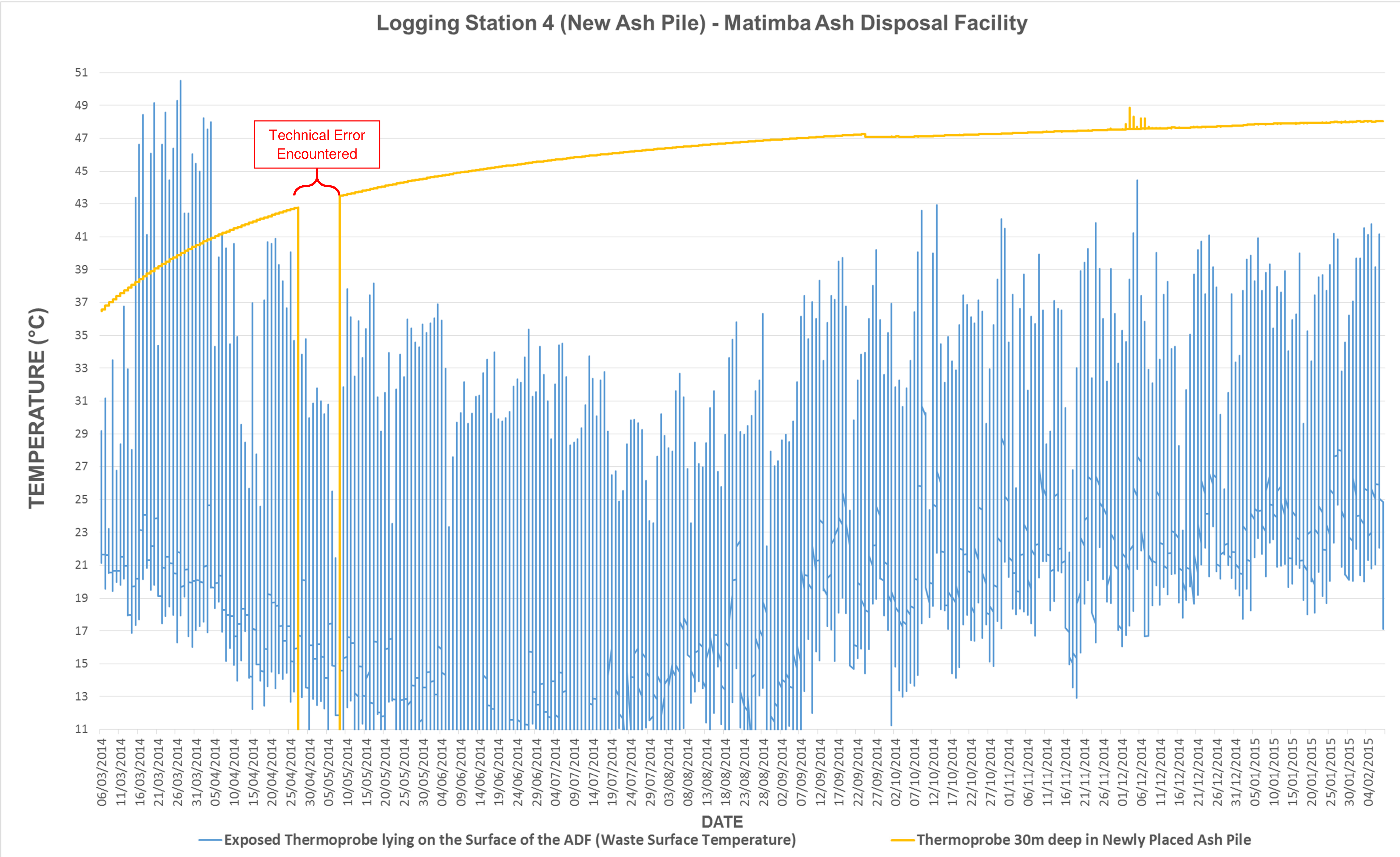


Figure 13 - Temperatures recorded at Logging Station 4 (New Ash Pile) from February 2014 to February 2015

3. GEOTECHNICAL ASSESSMENT

The following information was made available at the outset of the investigation:

- The report by Kai Batla Minerals Industry Consultants entitled, "Detailed Geotechnical Investigation for the Proposed Continuous Ash Disposal Facility for the Matimba Power Station in Lephalale, Limpopo Province, South Africa", dated 9th August 2013.
- Letter report by Jeffares & Green (Pty) Ltd, reference 3145\RE, entitled "Cost Implications for Updating the Terms of Reference – Matimba Ash Disposal", dated 19th December 2013.
- Various conceptual drawings and sections showing the proposed extent of extensions and raising.

3.1 Disclaimer

The interpretation of the overall geotechnical conditions across the site was based on observations and point information acquired from the respective investigation points. Subsurface geotechnical conditions intermediate to these have been inferred by extrapolation, interpolation and professional judgement. Consequently, whilst considered unlikely, there is a possibility of actual conditions encountered during construction being at a variance to those inferred and for this reason it is recommended that the services of an engineering geologist or geotechnical engineer be retained on an ad hoc basis during construction. The conditions prevailing beneath the existing ash discard dump and on the interface with the in-situ materials were also not revealed in detail by the scope of the investigations undertaken.

Consequently, whilst the information and interpretation made in this report are given in good faith as an indication of the geotechnical conditions and materials likely to be encountered, any interpretation and opinions expressed are given as a guideline only. There is no guarantee that the information given is totally representative of the entire area in every respect and no responsibility will be accepted for consequences arising out of the fact that actual conditions vary from those inferred. The contract specifications and drawings override this report, which is intended for information purposes only.

3.2 On-site Investigations

The on-site component of the geotechnical assessment was completed on-site by the end of February 2014.

The assessment involved the excavating and collecting of samples from 12 trial pits on-site. These trial pits were excavated in both in-situ soils surrounding the landfill site and in the existing Ash Landfill. The locations of the 12 trial pits are shown in **Figure 14**.

Sample material was collected from both the trial pits and the thermal monitoring boreholes. This material was catalogued and submitted to a soils laboratory in Pretoria on the 28 February 2014. A full set of the results of the soils testing are attached to **Appendix A**.

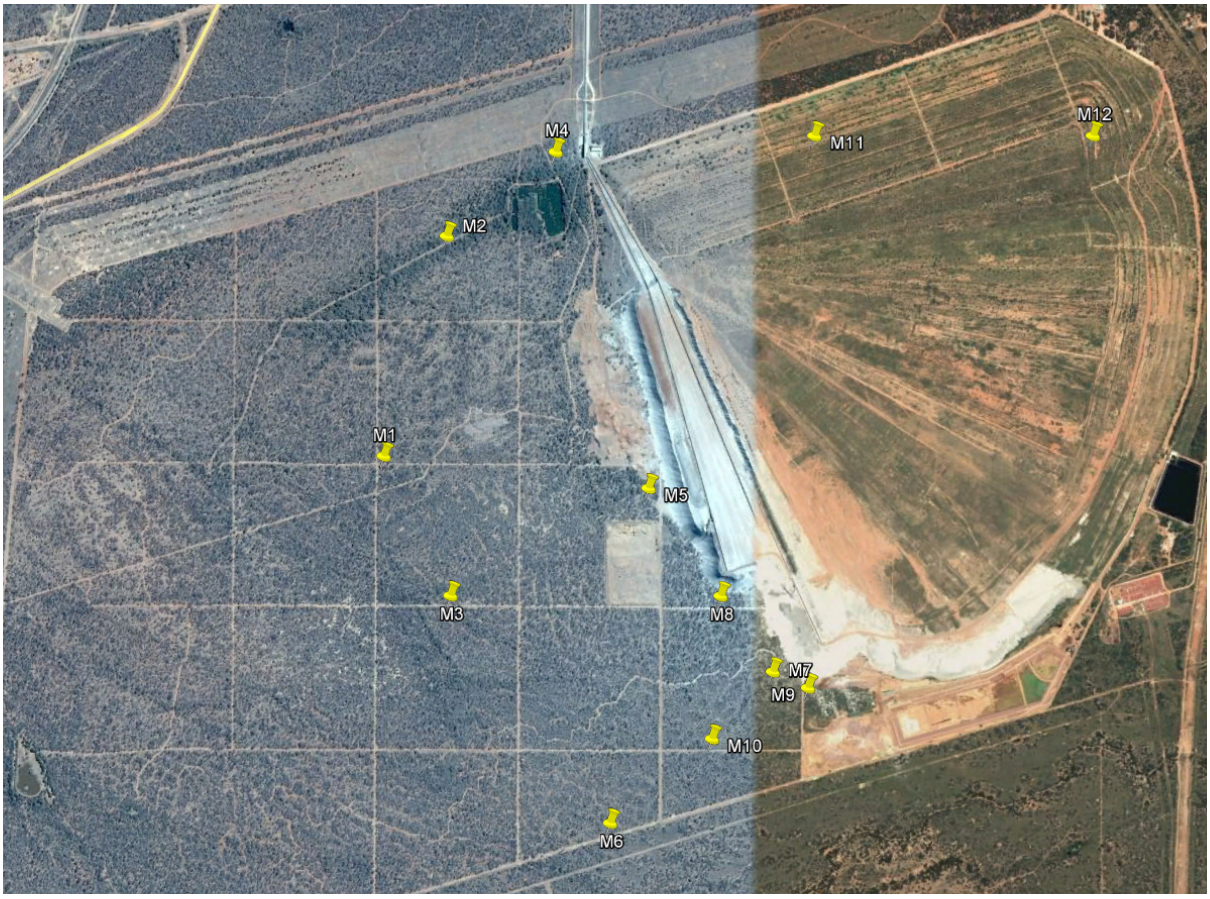


Figure 14 - Trial Pit Locations for Geotechnical Assessment (Aerial imagery by Google Maps, 2013)

Whilst absolute refusal of TLB excavation generally was not experienced, trial pits were terminated when excavation became difficult with concomitant slow advance to near refusal. **Table 3** summarises the depths at which the trial pits were terminated and the nature of the materials at the base of the trial pits.

Table 3: Trial Pit Investigation Depths

Trial Pit No.	Depth of Termination	Material Description at Trial Pit Base
M1	2.4m	Top of weathered sandstone
M2	2.7m	Honeycomb textured ferricrete
M3	2.55m	Honeycomb textured ferricrete
M4	2.1m	Ferruginous silty sand
M5	2.1m	Ferruginous gravely clayey sand / nodular ferricrete
M6	1.4m	Ferruginous gravely clayey sand / nodular ferricrete
M7	2.3m	Nodular ferricrete
M8	2.3m	Ferruginous gravely clayey sand / nodular ferricrete
M9	1.3m	Ferruginous silty sand
M10	1.0m	Ferruginous silty sand
M11	3.5m	No refusal – ash
M12	3.3m	No refusal - ash

The ash discard material was found to be consistent, both laterally and vertically. It is described in trial pits M11 and M12 and in the boreholes as slightly moist to moist, grey, very loose to loose, intact, low density, ash discard. It is a fine grained, non-cohesive material that categorises as sandy silt. Testing on the borehole samples indicated a moisture content range between 15% and 27%, which although erratic with no obvious trend, did generally indicated higher moisture contents at the higher depths. As drilling was by air percussion methods, cross sample contamination cannot be excluded and as a result the results may not be totally representative in every respect of actual conditions at the respective depth intervals. The boreholes were terminated on the ash / in-situ interface, indicated by coarser, more sandy and more cohesive material, but which due to staining by the ash was difficult to differentiate on colour.

Figure 15 through to **Figure 19** present captioned photos depicting the various stages of the on-site work that was undertaken for the Geotechnical Assessment.

Figure 16 – Ash Trial Pit Sampling

Figure 15 - Obtaining an undisturbed sample of Ash

Figure 17 - Sealing an undisturbed soil sample with wax

Figure 18 - TLB and engineer enroute to a trial pit on-site

Figure 19 - Undisturbed sample of ash for testing.

3.3 Sampling and Laboratory Testing

The following sampling and testing was undertaken:

Table 4: Schedule of Sampling and Laboratory Testing

TRIAL PIT No.	DEPTH (m)	TEST DESCRIPTION
M1	0 – 0.57	Sieve analysis to 0.075mm and Atterberg limits
	0.57 – 1.1	Sieve analysis to 0.075mm and Atterberg limits
	1.1 – 1.9	Sieve analysis to 0.075mm and Atterberg limits
M2	0.7 – 2.3	Sieve analysis to 0.075mm and Atterberg limits
M3	0.8 – 1.5	Sieve analysis to 0.075mm and Atterberg limits
	1.5 – 2.25	Sieve analysis to 0.075mm and Atterberg limits
	1.5 – 1.7 u/d block	In-situ moisture content In-situ density
	2.25 – 2.55	Sieve analysis to 0.075mm and Atterberg limits
M4	0.28 – 1.8	Sieve analysis to 0.075mm and Atterberg limits
	0.7 – 0.95 u/d block	In-situ moisture content In-situ density Collapse potential Shear box
M6	0.35 – 1.1 Disturbed & u/d block	Sieve analysis to 0.075mm and Atterberg limits In-situ moisture content In-situ density
M9	0.15 – 0.75	Sieve analysis to 0.075mm and Atterberg limits
	0.75 – 1.3	Sieve analysis to 0.075mm and Atterberg limits
M12 Ash	0.3 – 3.3	Sieve & hydrometer analysis and Atterberg limits Modified AASHTO moisture / density relationship
	0.7 – 0.95 u/d block	In-situ moisture content In-situ density Shear box Consolidation
Mixed		Mixed sample comprising equal proportions of M2 (0.7 – 2.3m), M3 (0.8 – 1.5m), M4 (0.28 – 1.8m) and M6 (0.35 – 1.1m). Sieve & hydrometer analysis and Atterberg limits Modified AASHTO moisture / density relationship

In addition, samples were retrieved from the boreholes at 5m intervals for the determination of the in-situ moisture content. One bulk sample was also retrieved from the lower half of each borehole for full grading analyses and Atterberg limits determinations. The laboratory test results are presented in **Appendix A**.

The results of the laboratory tests are summarised in **Table 5** and **Table 6**.

The aeolian sand generally categorises as slightly silty sand of low plasticity.
The pedogenic materials are slightly clayey and gravely moderately dense materials of low to moderate plasticity

The ash discard is a fine grained, non-plastic, low density material that categorises as sandy silt.

Table 5: Summary of Material Properties

Trial Pit No.	Depth (m)	Description	% Gravel	% Sand	% Silt	% Clay	GM	LL	PI	LS %
M1	0 – 0.57	Aeolian silty sand	2	84	14		1.31	-	NP	0
	0.57 – 1.1	Aeolian silty sand	3	75	22		1.26	20	8	3
	1.1 – 1.9	Ferruginous clayey silty sand	46	35	19		1.92	28	12	6
M2	0.7 – 2.3	Aeolian silty sand	3	76	21		1.22	15	4	1.5
M3	0.8 – 1.5	Aeolian silty sand	1	80	19		1.26	15	5	2
	1.5 – 2.25	Ferruginous gravely silty sand	3	68	29		1.14	19	9	3.5
	2.25 – 2.55	Ferricrete	29	47	24		1.58	24	10	4
M4	0.28 – 1.8	Aeolian silty sand	2	66	32		1.06	23	10	4.5
M6	0.35 – 1.1	Aeolian silty sand	2	74	24		1.19	16	6	2.5
M9	0.15 – 0.75	Aeolian silty sand	2	77	21		1.25	18	8	3
	0.75 – 1.3	Ferruginous silty sand	3	55	42		0.95	35	13	6
Mix *		Aeolian silty sand	2	72	14	12	1.15	19	7	3
* Mixed sample comprising equal proportions of M2 (0.7 – 2.3m), M3 (0.8 – 1.5m), M4 (0.28 – 1.8m), M6 (0.35 – 1.1m)										
M12	0.3 – 3.3	Ash	1	29	70	0	0.37	-	NP	0
BH1	25 – 45	Ash	2	26	72	0	0.35	-	NP	0
BH2	24 – 45	Ash	1	29	70	0	0.34	-	NP	0
BH3	25 – 45	Ash	1	29	70	0	0.34	-	NP	0

Table 6: Summary of Material Geotechnical Characteristics

Table 5: Summary of Material Geotechnical Characteristics										
Trial Pit No.	**Depth (m)**	**Description**	**Modified AASHTO**		**In-situ mc %**	**In-situ ɣ kg/m³**	**Shear Box**		**Collapse Potential %**	**Consolid-ation m_v (m²/MN)**
			MDD kg/m³	**OMC %**			**Φ (°)**	**C' (kPa)**		
M3	1.5 – 1.7	Ferruginous gravely silty sand			4.6	1946				
M4	0.28 – 1.8	Aeolian silty sand			4.2	1859	32.8	5.8	14	
M6	0.35 – 1.1	Aeolian silty sand			3.6	1734				
Mix *		Aeolian silty sand	2120	8.1						
* Mixed sample comprising equal proportions of M2 (0.7 – 2.3m), M3 (0.8 – 1.5m), M4 (0.28 – 1.8m), M6 (0.35 – 1.1m)										
M12	0.3 – 3.3	Ash	1168	13.1	13.5	1109	33.6	2.9		20–100kPa $2.12x10^{-2}$ 100–800kPa $6.33x10^{-5}$
BH1	5	Ash			22.5					
	10	Ash			23.2					
	15	Ash			24.8					
	20	Ash			18.8					
	25	Ash			20.0					
	30	Ash			18.8					
	35	Ash			18.2					
	40	Ash			17.5					
	45	Ash			22.3					
	47	Ash			16.0					

Table 6 (Continued): Summary of Material Geotechnical Characteristics

Trial Pit No.	Depth (m)	Description	Modified AASHTO		In-situ mc %	In-situ ɣ kg/m³	Shear Box		Collapse Potential %	Consolid-ation m_v (m²/MN)
			MDD kg/m³	OMC %			Φ (°)	C' (kPa)		
BH2	5	Ash			18.5					
	10	Ash			17.6					
	15	Ash			18.2					
	20	Ash			17.9					
	25	Ash			17.1					
	30	Ash			18.3					
	35	Ash			17.5					
	40	Ash			18.4					
	45	Ash			27.0					
	48	Ash			15.8					
BH3	5	Ash			19.5					
	10	Ash			17.9					
	15	Ash			16.6					
	20	Ash			15.9					
	25	Ash			16.1					
	30	Ash			16.4					
	35	Ash			15.4					
	40	Ash			17.1					

Explanation of abbreviations and symbols used in **Table 5** and **Table 6**:

GM = grading modulus
LL = liquid limit
PI = plasticity index
LS = linear shrinkage
MDD = maximum dry density
OMC = optimum moisture content
In-situ mc = in-situ moisture content
In-situ ɣ = in-situ density
Φ = angle of internal friction (degrees)
c' = cohesion
m_v = coefficient of volume compressibility

3.4 Founding Conditions

It is assumed that the current practice of exploiting the in-situ materials from in front of the advancing face of the discard dump as capping will continue. The continued utilisation of these material is encouraged as it offers the following advantages:

- It provides a ready source of good quality capping materials.
- It increases the discard dump capacity.
- It provides enhanced founding on rock, both in terms of bearing capacity and stability.

Assuming the above implies that foundations will be developed in soft to medium hard rock sandstone / conglomeratic sandstone with an estimated allowable safe bearing pressure of the order of 800kPa to in excess of 1 000kPa, with relatively high degrees of shearing resistance.

3.5 Slope Stability Modelling

The slope stability assessment was broken into two separate analysis scenarios in order to assess the slope stability of the upgraded Ash Disposal Facility (ADF). The analyses were setup as a function of shear strength parameters and slope gradient. The analysis scenarios have been broken up as follows:

- Assessment A; The slope stability was assessed on a 70 m embankment consisting of the placement of a basal lining system at the bottom of the proposed ADF.
- Assessment B; The slope stability of the ash fill was assessed with the additional fill height of 35 m “piggy-backing” on the existing 45 m high ash waste landfill. The slope stability was modelled with the basal lining system between the new proposed ADF and existing ADF.

The assessments are represented graphically in **Figure 20**. The figure presents a typical cross-section through the ADF. The green profile line represents the existing ADF and natural ground level while the blue line represents the new ADF including piggy-backing over the existing facility.

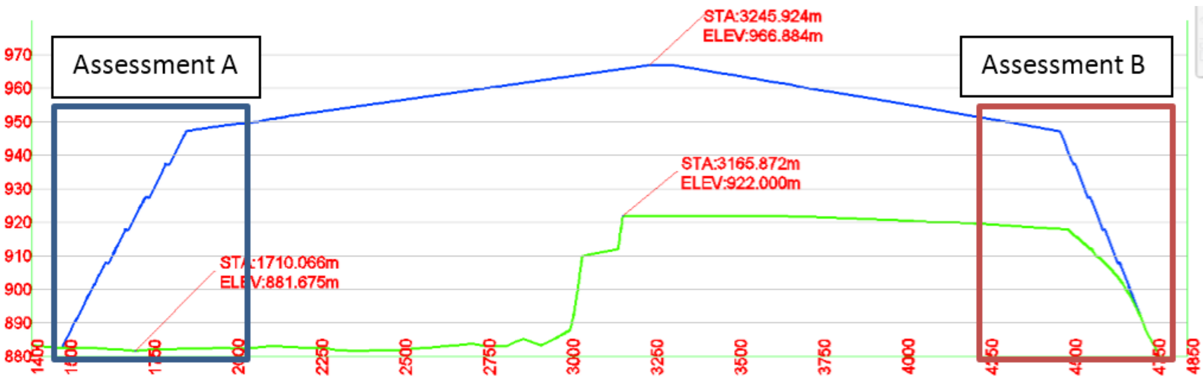


Figure 20 - Graphical Representation of Slope Stability Analyses

3.2.1 Design Parameters

<u>Soil Parameters</u>

The shear strength parameters are taken from the values obtained from the Shearbox and In-situ density tests undertaken on ash waste from the existing ADF sampled during the site investigation.

Shear strength parameters in the analyses are shown in **Table 7**

Table 7: Soil Shear Strength Parameters

Material	Unit weight (kN/m^3)	Friction angle, φ' (°)	Cohesion, c[2]
Ash	11	30	0
Sandstone/Siltstone/ Mudstone[3]	19	32	0

<u>Geosynthetic Barrier System Parameters</u>

The effects of a geosynthetic barrier lining system were taken into account for the slope stability analyses. The proposed basal lining system utilised is shown in **Figure 21**.

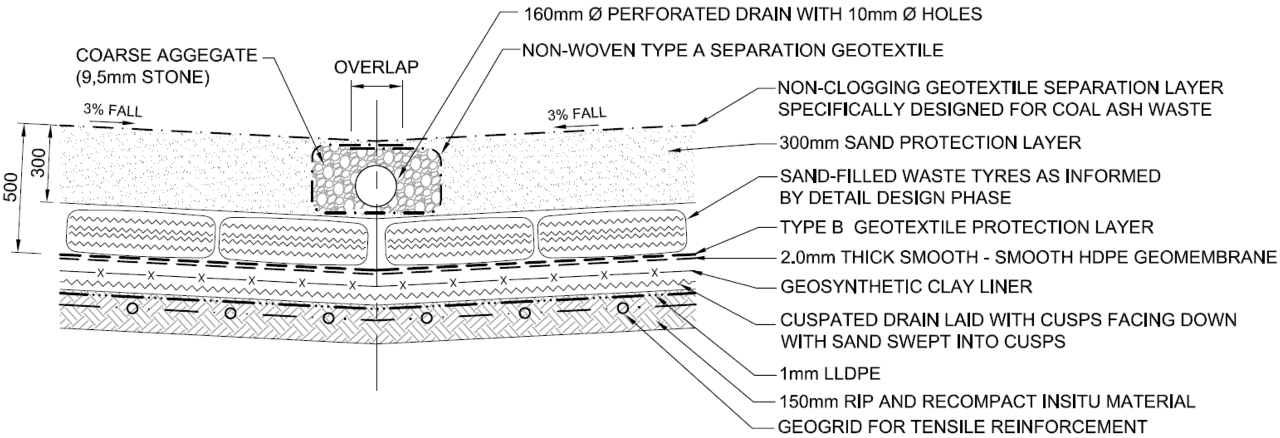


Figure 21 - Proposed Basal Lining System incorporated into the Analyses

A database containing shear strength parameters at the interface of different geosynthetic lining materials and soil types was compiled by Koerner, G. & Narejo, D (2005). By comparing this database against historical data it was found that the most critical shear strength parameters will be found at the interface between the Geosynthetic Clay Liner (GCL) and the Cuspated Drain layers. <u>Typical Shear Strength Parameters</u> for the critical interfaces are given in **Table 8.**

Table 8: Typical Shear Strength Parameters

Interface Type	Material 1	Material 2	Peak Friction Φ'	Peak Cohesion, c	Residual Friction Φ'	Residual Cohesion, c
Smooth/ Cuspated	Smooth Membrane	Cuspated Drain	13.5°	0 kPa	13°	0 kPa
Smooth/GCL	Smooth Membrane	Geosynthetic Clay Liner	19.1°	0 kPa	12.7°	11.55 kPa

[2] *Zero cohesion is taken as very conservative and has been assumed due to possible variability of the foundation material. The analysis shows that failure does not occur through the foundation material.*

[3] *The proposed ADF is assumed to be founded on sandstone. Conservative shear strength parameters were selected and are presented here.*

Based on the values above, the shear strength parameters for the smooth/cuspated interface were brought into the slope stability analyses as a thin band material denoted as "Basal Lining System" in the outputs from the computer modelling software. <u>This material band was assumed to have a unit weight of 15 kN/m^3</u>.

3.2.2 Assessment A

For this analysis it was assumed that the water table is situated at the foundation level of the proposed ADF. The stability of the slope was assessed assuming that both block failure and circular slip failure is a probability.

<u>Block Failure</u>

The block failure of the slope is depicted in

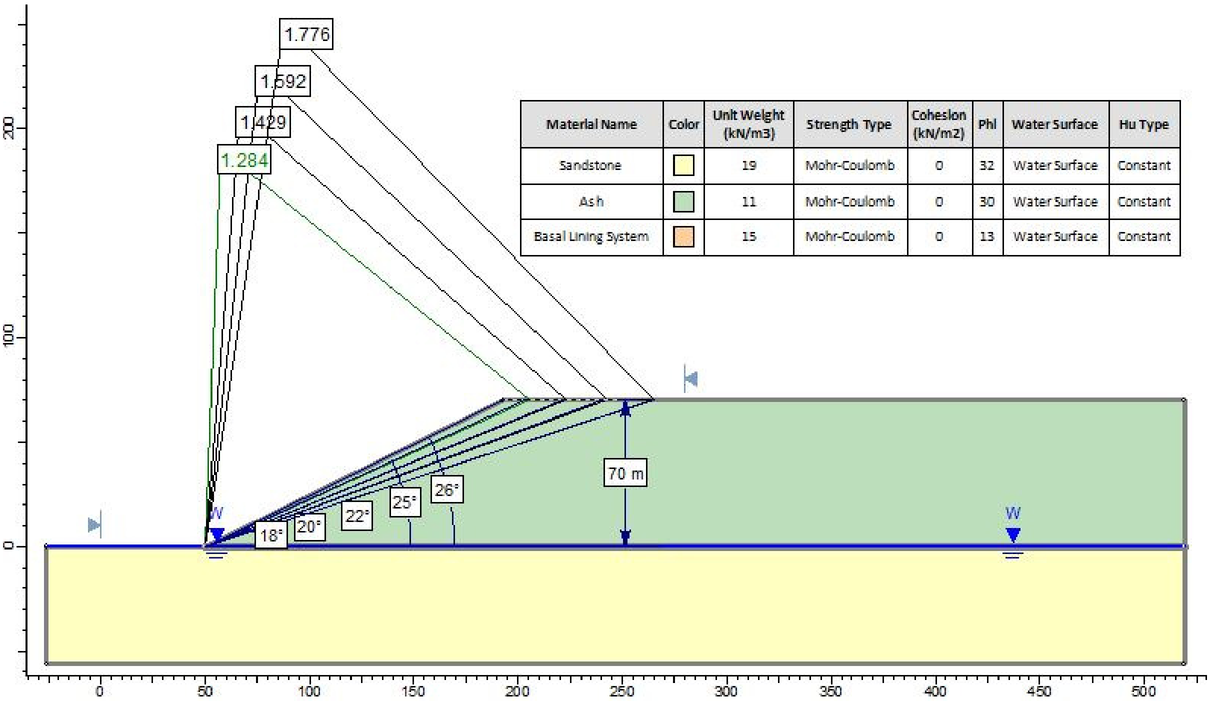


Figure *22*. The results of the analysis indicate that the slope will have suitable long term stability at a slope angle of approximately 22° (1V:2.5H) with an estimated Factor of Safety (FoS) of 1.43. Realistically, when depositing ash with the stacker spreader conveyor, the material would most likely settle at angle close to the friction angle of approximately 30°. However, this will mean that at the slope face the risk is high for small local failures to occur.

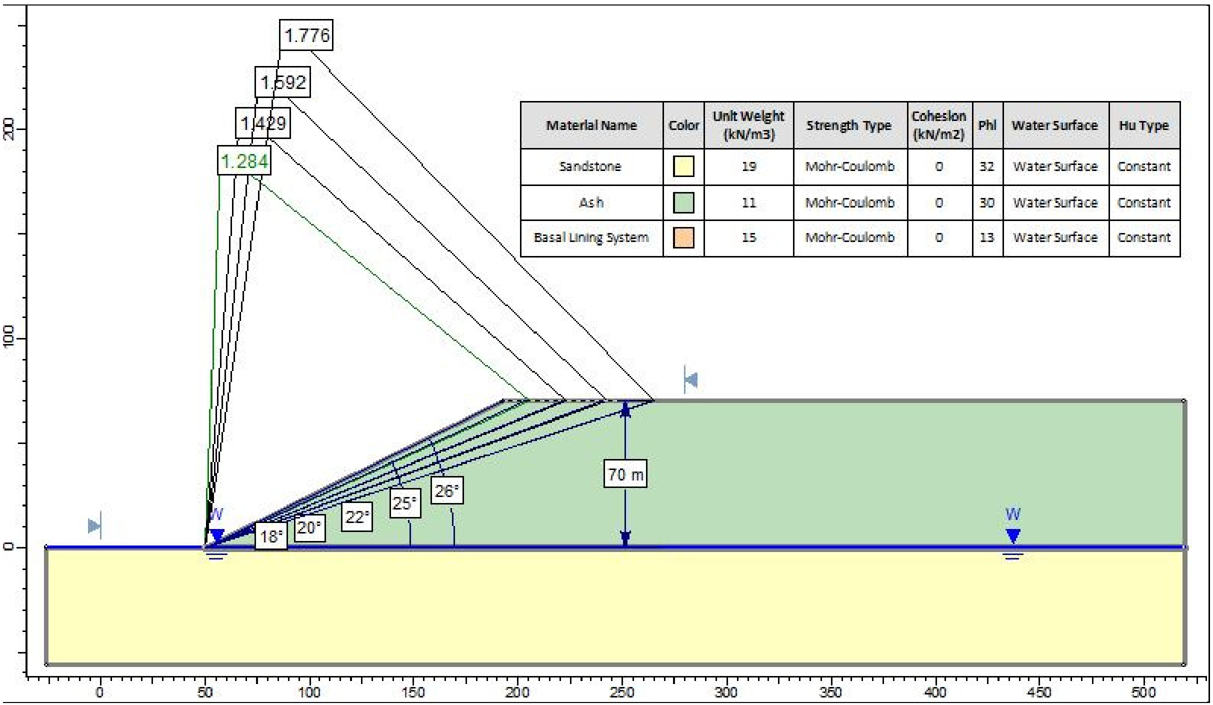


Figure 22 - Block Failure for Assessment A with a slope gradient of 1V:2.2H

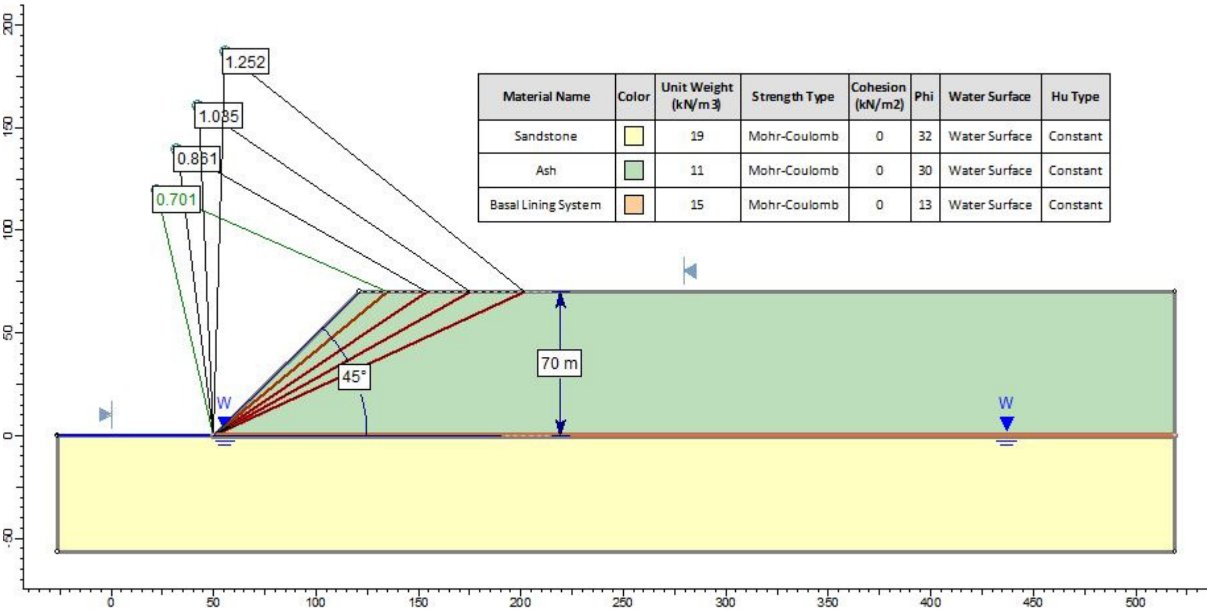


Figure *23* illustrates the results of numerous slope stability analyses at various angles of block failures and shows that increasing the angle of the slope will result in A FoS less than one. The results prove that the slope angle should remain lower than 1V:2H in order to reach suitable long term stability.

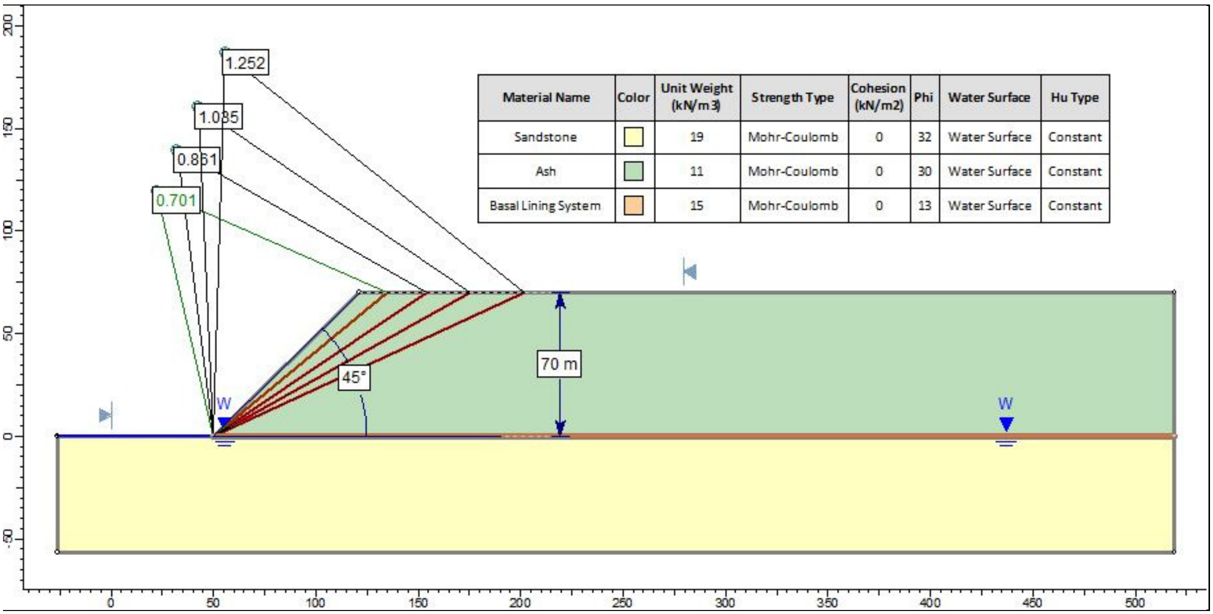


Figure 23 - Block Failure for Assessment A with a slope gradient of 1V:1H

<u>Circular Slip Failure</u>

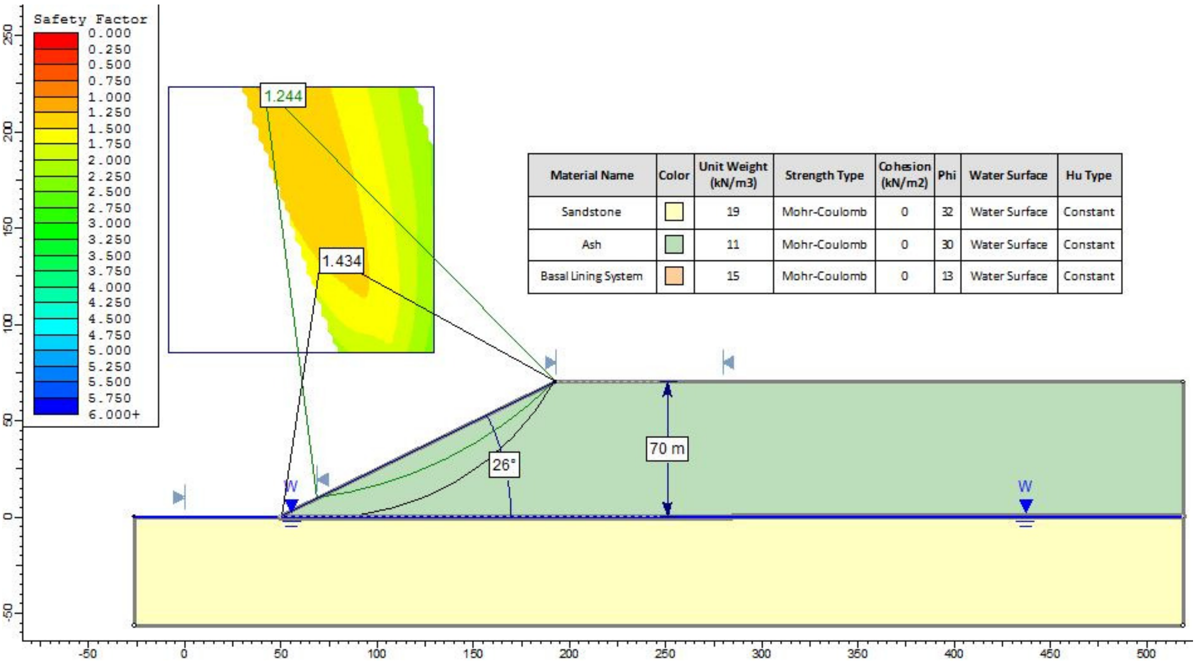


Figure *24* shows the results of a circular failure analysis a slope gradient of 26° (1V:2H). The results show that the slope may reach suitable stability at a slope gradient of approximately 1V:2H. The FoS was found to be 1.4. The probability for sloughing to occur is significant, with a FoS of 1.2.

1V:2H is close to the angle of repose, thus it is expected that sloughing would occur. <u>The results indicate that the risk for global circular failure to occur is negligible.</u>

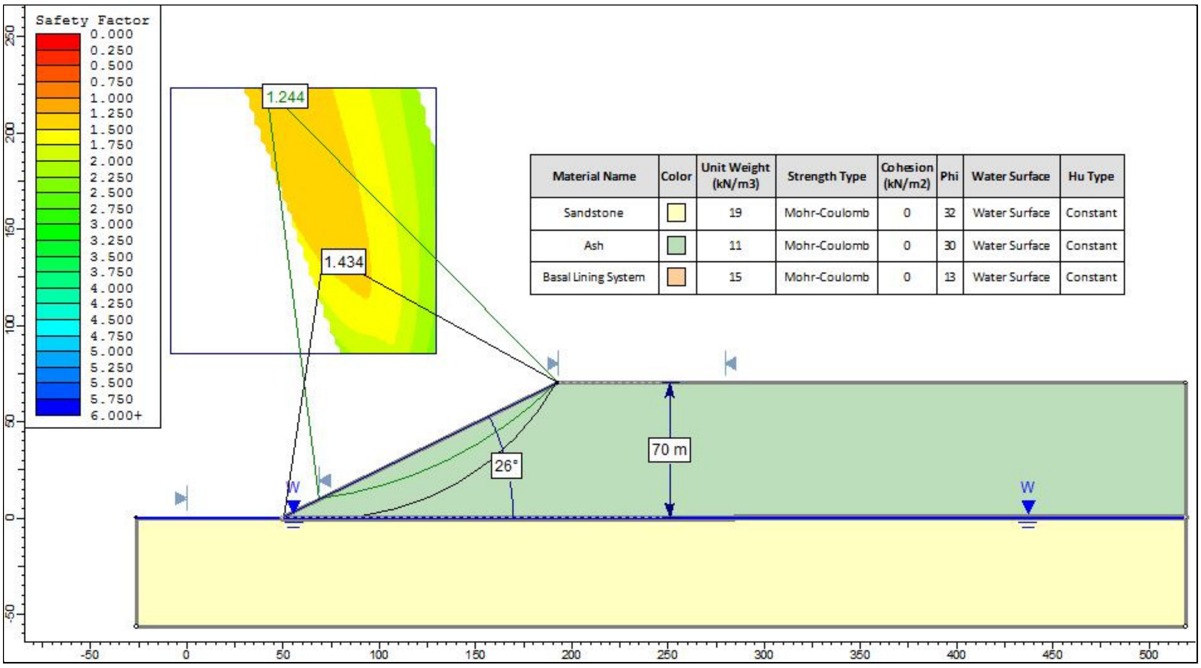


Figure 24 – Circular Slip Failure for Assessment A with a slope gradient of 1V:2H

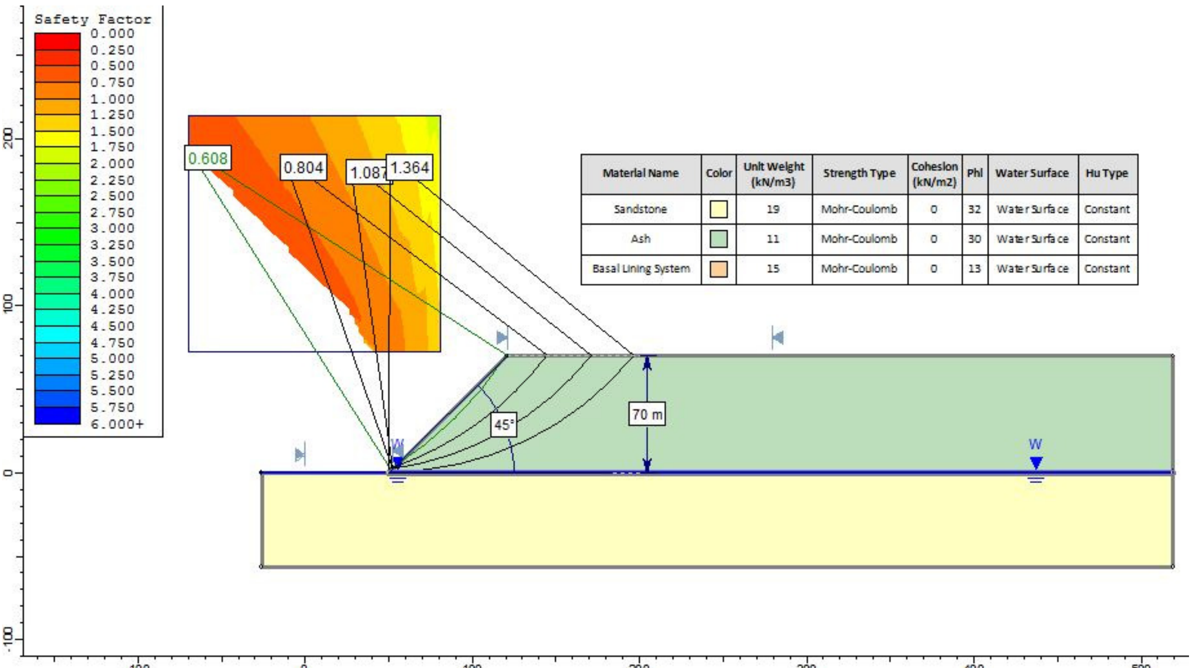


Figure 25 depicts the results of a slope stability analysis with a slope gradient of 1V:1H. From the results it was found that the FoS is less than one. Therefore the assumption can be made that a 1V:1H slope is too steep to establish sufficient stability.

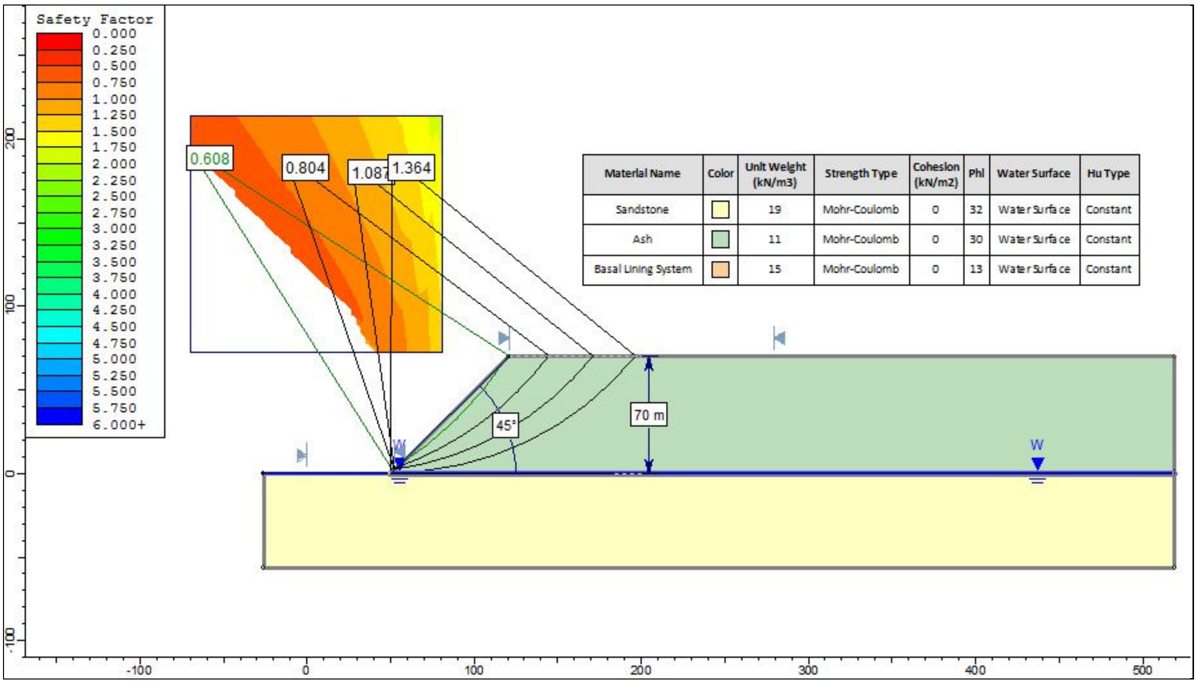


Figure 25 – Circular Slip Failure for Assessment A with a slope gradient of 1V:1H

3.2.3 Assessment B

Assessment B is aimed at assessing the stability of the slope as a function of the slope gradient when the existing ADF is upgraded to accommodate an increased height of 35 m. This assessment was also aimed at establishing the influence of the Basal Lining System on the slope stability when constructed on the slope of the existing ADF, prior to the placement of the new ash material.

Stability analyses were done to assess a block failure and circular failure mechanisms.

<u>Block Failure</u>

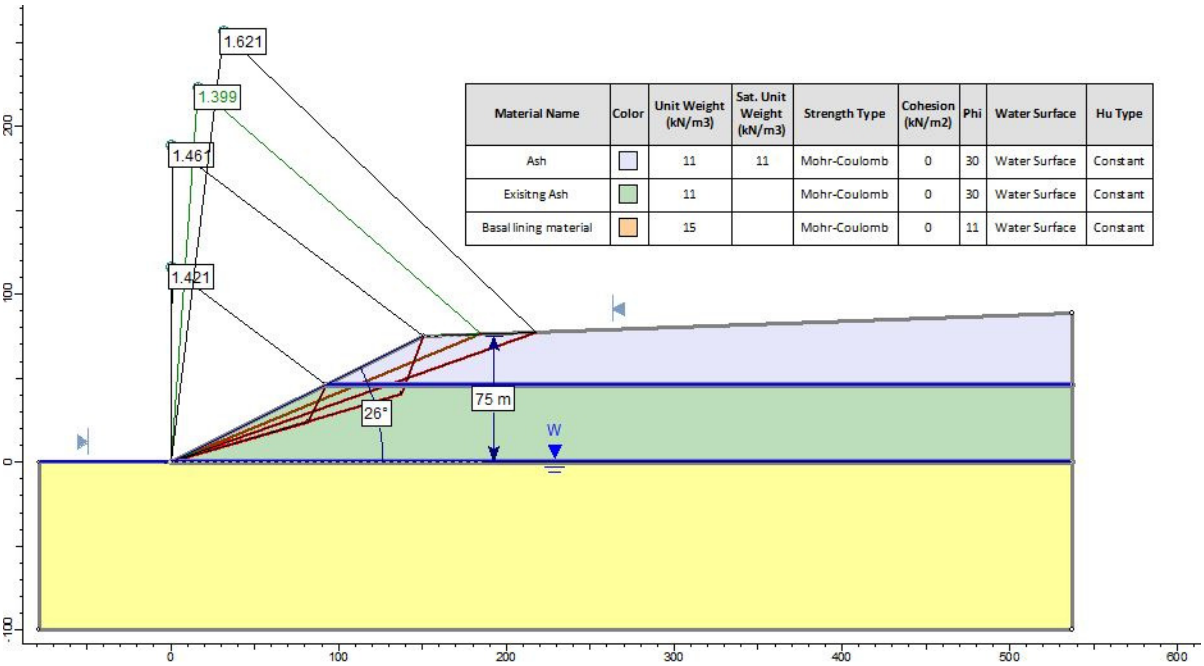


Figure *26* illustrates the results of a slope stability analysis at a final height of approximately 75 m. The model is constructed with a basal lining system at the foundation level and at the top of the existing ADF. The basal lining is represented as a blue line and denotes the interface between old and new Ash Disposal Facilities showing the extent of the piggy-backing over the existing facility.

The FoS was found to be 1.4 for a slope gradient of 1V:2H.

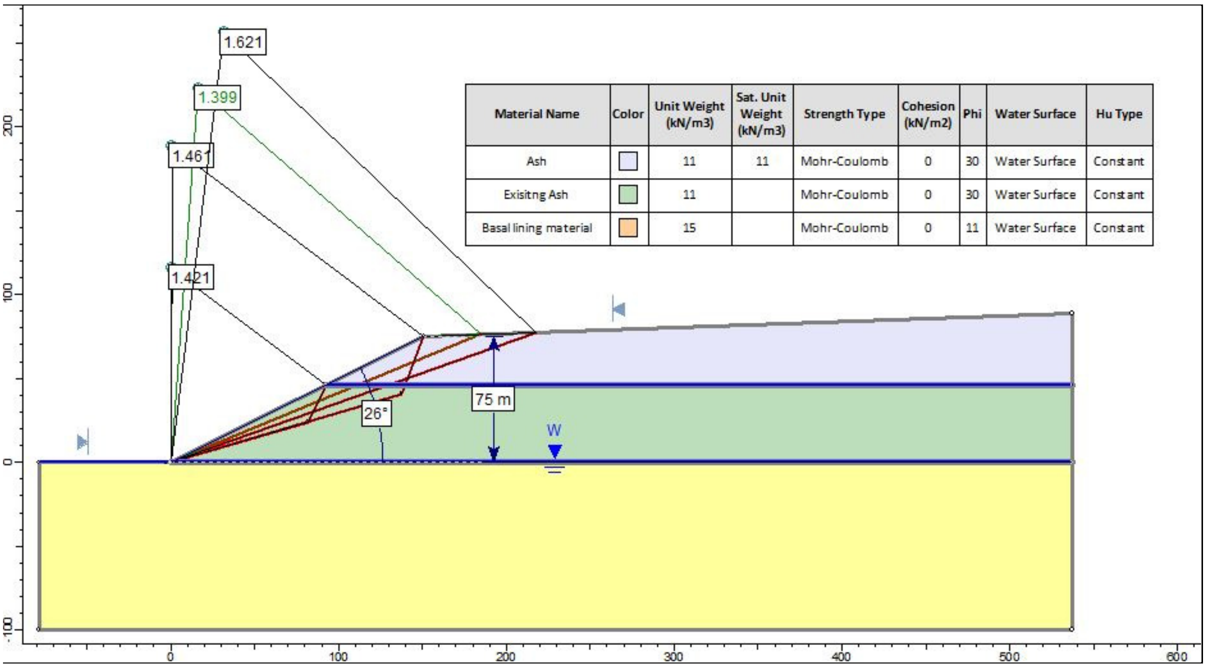


Figure 26 - Block Failure for Assessment B with a slope gradient of 1V:2H

<u>Circular failure</u>

The slope was also assessed to determine the FoS of the ash slope to resist a circular failure mechanism at a slope gradient of 1V:2H. The results of the assessment are shown in

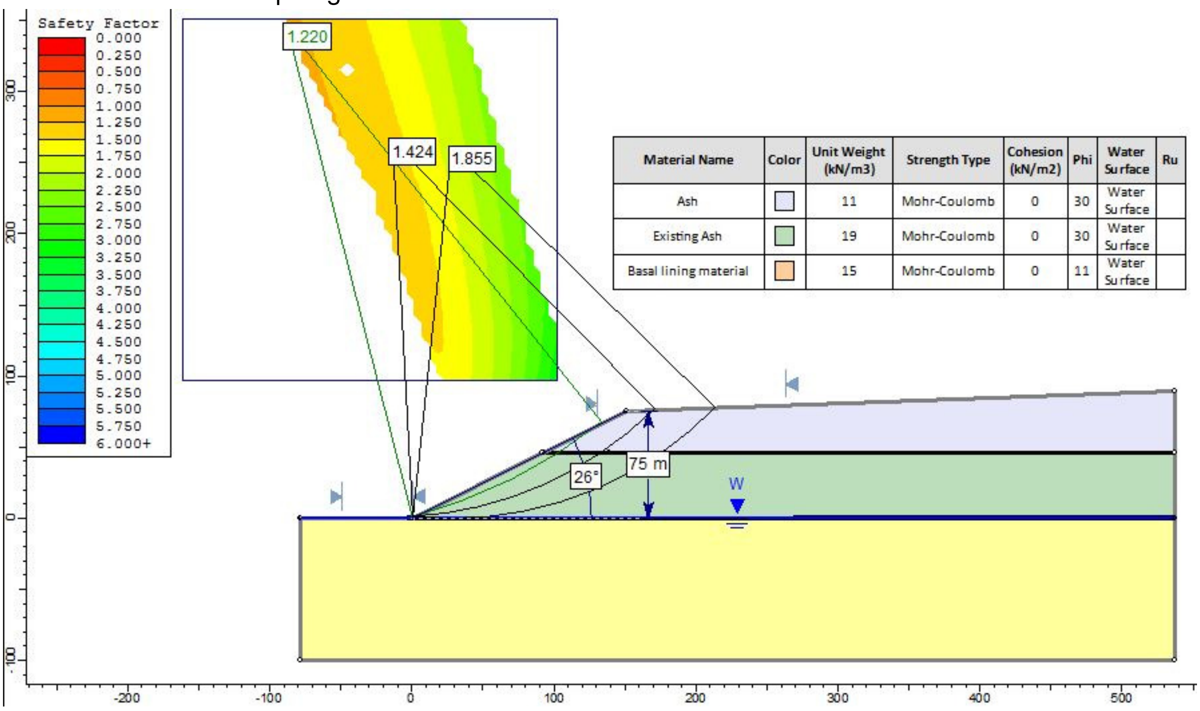
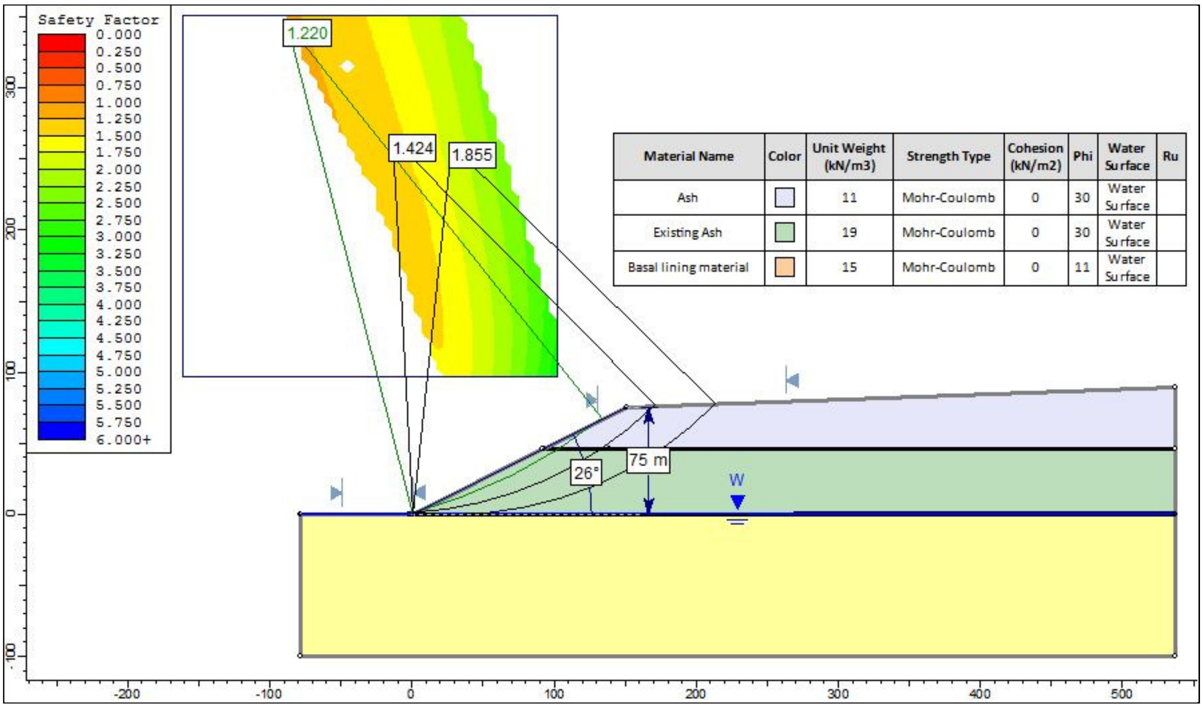


Figure *27***.** The analysis shows that the <u>FoS is 1.22</u> and increases considerably as the slope angle decreases. The results show that the slope will stabilise at the natural repose angle.



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kN/m2)	Phi	Water Surface	Ru
Ash		11	Mohr-Coulomb	0	30	Water Surface	
Existing Ash		19	Mohr-Coulomb	0	30	Water Surface	
Basal lining material		15	Mohr-Coulomb	0	11	Water Surface	

Figure 27 – Circular Slip Failure for Assessment B with a slope gradient of 1V:2H

3.2.4 Existing ADF Settlement

The ash material, whilst being fine grained, is non-plastic with zero clay content. This implies it to be relatively free draining so allowing the dissipation of excess pore pressure build-up. The material is unlikely to undergo long term consolidation and settlement is expected to take place rapidly during the construction. The ash material was found to be very consistent and the material characteristics do not indicate a likelihood for excessive differential settlements in the existing discard facility, which is considered to have a**lready taken place.**

The "piggy-backing" **of** the new facility on top of the existing facility is not expected to bring about excessive differential settlements that could compromise stability or the integrity of the separator basal lining between the existing and the new.

4. CONCLUSION

4.1 Thermal Investigation

A review of the thermal conductivity variables against values from the literature review lead to the assumption that temperatures within the disposal facility should be lower than those predicted by Yoshida and Rowe (2003).

The temperature monitoring program undertaken at the ADF under consideration has shown that temperatures within the ash waste do not exceed 43ºC. These recorded temperatures are in line with the temperatures from facilities receiving general municipal solid waste.

Both the literature review and on-site investigation indicate that the ash waste at Matimba poses no additional threat to the basal lining system when taking the thermal resistivity of the design into account.

4.2 Geotechnical Slope Stability Assessment

The slope stability analyses for both Assessment A and Assessment B shows that the gradient of proposed ADF should not exceed 1V:2H (26°). The ash waste material is shown to stabilise at the natural angle of repose (approximately 30°).

When the ash is placed with the stacker spreader conveyor system it will settle close to its friction angle value of approximately 30° as seen in current operations. Post placement manipulation of the ash-waste is NOT seen as a requirement in maintaining a stable side slope for the new proposed ADF.

Steeper slope angles steeper than 1V:2H may be achieved at a low embankment height but will not be sustainable as the embankment height increases and are subsequently not recommended.

The analysis confirms that the concept of developing the new ADF over the existing ADF through the concept of piggy-backing over the existing facility DOES NOT pose any additional risks in terms of slope stability and differential settlement.

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APPENDIX A

CLIENT : JEFFARES & GREEN

PROJECT : MATIMBA POWER STATION

PROJECT NO. : S14-0264

DATE : 20/03/2014

THERMAL CONDUCTIVITY

Soillab No.	Sample No.	Moisture %	Thermal Conductivity (K) W/m.K	Thermal Resistivity (p) ˚C.cm/W	Volumetric Specific heat (c) $mJ/m^3 \cdot K$	Thermal Diffusivity (D) mm^2/s
S14-0264-14	BH01 DRY	-	0.140	712.5	0.866	0.162
	BH01 IN-SITU MOISTURE	14.5	0.548	182.4	1.523	0.362
	BH01 SATURATED	19.7	0.661	151.3	1.897	0.352
S14-0264-15	BH02 DRY	-	0.128	783.1	0.782	0.163
	BH02 IN-SITU MOISTURE	15.1	0.563	178.0	1.422	0.397
	BH02 SATURATED	18.1	0.620	161.4	1.804	0.344
S14-0264-16	BH03 DRY	-	0.130	770.6	0.873	0.149
	BH03 IN-SITU MOISTURE	13.3	0.547	182.9	1.517	0.362
	BH03 SATURATED	16.7	0.598	167.6	1.444	0.425

SOILLAB (PTY) LTD
Reg No 1971/000112/07
230 Albertus Street
La Montagne 0184
Tel (012) 481-3801
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Lynnwood Ridge 0040
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Eskom

Central Coal Laboratory

TEST REPORT

Attention	Ramahlari	**Report Reference**	
Client Name	Matimba Power Station	COA2012-010149	
Address	Private Bag 215	**Date**	**2012/05/16**
	Elisras	**Tel. No.**	**+27 11 629 5430**
	0555	**Fax. No.**	**+27 86 664 8568**

Fax 014 763 8059

Telephone 014 763 8404

Report Title Matimba FA and CA

Unit 2 and Unit3 February 2012

These results are reported on an air dried basis.

Number of Samples 5

Description of Samples

Date Received 2012/05/15

Date Reported

Task Comments

Approved By : ________________________

Patrick Musie

Senior Technician (Coal & X-Ray)

Date : ________________________

Lower Germiston Road Cleveland 2022 Private Bag 40175 Cleveland 2022 SA
Tel +27 11 629 5430 Fax +27 86 664 8568 maria.kgaphola@eskom.co.za
Eskom Holdings Reg No 2002/015527/06

Sample ID 3793324 **WMCC-2012-05-15/4395**
Matimba FA Unit2
Fly ash

Component	Unit	Value
Elemental Analysis		
SiO2	%	60.6
Al2O3	%	23.3
Fe2O3	%	7.5
TiO2	%	1.4
P2O5	%	0.38
CaO	%	3.4
MgO	%	0.8
Na2O	%	0.0
K2O	%	0.5
SO3	%	0.3
MnO	%	0.00

Sample ID 3793325 **WMCC-2012-05-15/4396**
Matimba FA Unit3
Fly ash

Component	Unit	Value
Elemental Analysis		
SiO2	%	59.5
Al2O3	%	24.8
Fe2O3	%	7.0
TiO2	%	1.2
P2O5	%	0.30
CaO	%	3.9
MgO	%	0.0
Na2O	%	0.0
K2O	%	0.6
SO3	%	0.2
MnO	%	0.24

Sample ID 3793326 **WMCC-2012-05-15/4397**
Matimba CA Unit2
Coarse ash

Component	Unit	Value
Elemental Analysis		
SiO2	%	57.2
Al2O3	%	21.0
Fe2O3	%	7.7
TiO2	%	1.2
P2O5	%	0.23

Sample ID 3793326	**WMCC-2012-05-15/4397**	
Matimba CA Unit2		
Coarse ash		
Component	**Unit**	**Value**

Elemental Analysis

CaO	%	3.6
MgO	%	0.9
Na2O	%	0.0
K2O	%	1.2
SO3	%	0.0
MnO	%	0.00

Sample ID 3793327	**WMCC-2012-05-15/4398**	
Matimba CA Unit3		
Coarse ash		
Component	**Unit**	**Value**

Elemental Analysis

SiO2	%	58.5
Al2O3	%	21.0
Fe2O3	%	7.3
TiO2	%	1.3
P2O5	%	0.00
CaO	%	2.9
MgO	%	0.7
Na2O	%	0.0
K2O	%	0.5
SO3	%	0.0
MnO	%	0.00

Sample ID 3793328	**WMCC-2012-05-15/4399**	
Matimba Rock		
rock		
Component	**Unit**	**Value**

Elemental Analysis

SiO2	%	45.5
Al2O3	%	25.8
Fe2O3	%	7.6
TiO2	%	1.6
P2O5	%	0.42
CaO	%	2.5
MgO	%	0.0
Na2O	%	0.0
K2O	%	0.7
SO3	%	5.8

Sample ID 3793328	**WMCC-2012-05-15/4399**	
Matimba Rock		
rock		
Component	**Unit**	**Value**

Elemental Analysis

MnO	%	0.00

The analysis was performed using the following methods:

Elemental Analysis	**ESKOM METHOD No 121**	**Not Accredited**

Tests marked "Not SANAS accredited" in this report are not included in the SANAS Schedule of Accreditation for this laboratory.

Opinions and interpretations expressed herein are outside the scope of SANAS accredition.

The results contained in this report only pertain to the sample submitted. If you rely on the information and data contained in this report you are responsible for ensuring by independent verification the accuracy or completeness of the sample submitted.

End of Report

Eskom

Central Coal Laboratory

TEST REPORT

Attention	Ramahlari	**Report Reference**	
Client Name	Matimba Power Station	COA2012-010147	
Address	Private Bag 215	**Date**	**2012/05/16**
	Elisras	**Tel. No.**	**+27 11 629 5430**
	0555	**Fax. No.**	**+27 86 664 8568**

Fax 014 763 8059

Telephone 014 763 8404

Report Title Matimba Unit2 and 3

February 2012

These results are reported on an air dried basis.

Number of Samples 2

Description of Samples

Date Received 2012/05/15

Date Reported

Task Comments

Approved By : ________________________

Patrick Musie

Senior Technician (Coal & X-Ray)

Date : ________________________

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Tel +27 11 629 5430 Fax +27 86 664 8568 maria.kgaphola@eskom.co.za

Eskom Holdings Reg No 2002/015527/06

Central Coal Laboratory Test Report	Report Reference COA2012-010147

Sample ID 3793054	WMCC-2012-05-15/4392	
Matimba Unit 2		
February 2012		
Component	**Unit**	**Value**
Analytical Moisture	%	2.7
Ash	%	34.8
Volatile Matter	%	25.6
Fixed Carbon (by difference)	%	36.9
Carbon	%	47.04
Hydrogen	%	2.73
Nitrogen	%	0.94
Total Sulphur	%	0.78
Carbonate	%	2.37
Oxygen (by difference)	%	8.64
Gross Calorific Value	MJ/kg	20.26
Elemental Analysis		
SiO2	%	60.5
Al2O3	%	21.9
Fe2O3	%	5.9
TiO2	%	1.8
P2O5	%	0.00
CaO	%	4.6
MgO	%	1.0
Na2O	%	0.0
K2O	%	1.1
SO3	%	2.9
MnO	%	0.25
Ash Fusion Temperature		
Deformation Temperature	℃	1350
Softening Temperature	℃	1380
Hemisphere Temperature	℃	1410
Flow Temperature	℃	1450

Sample ID 3793055	WMCC-2012-05-15/4393	
Matimba Unit 3		
February 2012		
Component	**Unit**	**Value**
Analytical Moisture	%	3.0
Ash	%	36.3
Volatile Matter	%	24.4
Fixed Carbon (by difference)	%	36.3
Carbon	%	44.58

Central Coal Laboratory **Report Reference**
Test Report **COA2012-010147**

Sample ID 3793055	**WMCC-2012-05-15/4393**	
Matimba Unit 3		
February 2012		
Component	**Unit**	**Value**
Hydrogen	%	2.85
Nitrogen	%	0.92
Total Sulphur	%	0.86
Carbonate	%	2.27
Oxygen (by difference)	%	8.26
Gross Calorific Value	MJ/kg	20.04
Elemental Analysis		
SiO2	%	60.5
Al2O3	%	21.9
Fe2O3	%	5.9
TiO2	%	1.8
P2O5	%	0.00
CaO	%	4.6
MgO	%	1.0
Na2O	%	0.0
K2O	%	1.1
SO3	%	2.9
MnO	%	0.25
Ash Fusion Temperature		
Deformation Temperature	℃	1330
Softening Temperature	℃	1360
Hemisphere Temperature	℃	1390
Flow Temperature	℃	1400

The analysis was performed using the following methods:

Analytical Moisture	**ESKOM METHOD No 103 Rev 2**	**Not Accredited**
Ash	**ESKOM METHOD No 101 Rev 1**	**Not Accredited**
Volatile Matter	**ESKOM METHOD No 102 REV 1**	**Not Accredited**
Fixed Carbon	**ESKOM METHOD No 128 REV 1**	**Accredited**
Carbon, Nitrogen, Hydrogen	**ESKOM METHOD No 118 REV 1**	**Not Accredited**
Carbonate	**ESKOM METHOD No 100**	**Not Accredited**
Total Sulphur	**ESKOM METHOD No 104 REV 1**	**Not Accredited**
Oxygen (Difference)	**ESKOM METHOD No 132 REV 1**	**Not Accredited**
Gross Calorific Value	**ESKOM METHOD No 105 REV 1**	**Not Accredited**
Elemental Analysis	**ESKOM METHOD No 121**	**Not Accredited**
Ash Fusion	**ESKOM METHOD No 125**	**Not Accredited**

The analysis was performed using the following methods:

Ash Fusion	**ESKOM METHOD No 125**	**Not Accredited**

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The results contained in this report only pertain to the sample submitted. If you rely on the information and data contained in this report you are responsible for ensuring by independent verification the accuracy or completeness of the sample submitted.

End of Report

Moisture Content

Results Summary

Project:	**Matimba Power Station**
Client:	**Jeffares & Green**
Soillab Job Nr:	**G14-0028**

Sample Nr:	Depth:	Moisture
	m	%
BH01	5	22.5
BH01	10	23.2
BH01	15	24.8
BH01	20	18.8
BH01	25	20.0
BH01	30	18.8
BH01	35	18.2
BH01	40	17.5
BH01	45	22.3
BH01	47	16.0
BH02	5	18.5
BH02	10	17.6
BH02	15	18.2
BH02	20	17.9
BH02	25	17.1
BH02	30	18.3
BH02	35	17.5
BH02	40	18.4
BH02	45	27.0
BH02	48	15.8
BH03	5	19.5
BH03	10	17.9
BH03	15	16.6
BH03	20	15.9
BH03	25	16.1
BH03	30	16.4
BH03	35	15.4
BH03	40	17.1

Comments:

Test method:	ASTM D7263-09
Operator:	MM
Checked:	TG
Approved:	TG

GEOLAB (PTY) LTD
Registration Number 1971/000112/07
A Division of Soillab
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Royal Haskoning DHV
Matimba Power Station Ash Discard Dump

LEGEND
Sheet 1 of 1

JOB NUMBER: 3145

	GRAVEL	{SA02}
	GRAVELLY	{SA03}
	SAND	{SA04}
	SANDY	{SA05}
	SILT	{SA06}
	SILTY	{SA07}
	CLAYEY	{SA09}
	SANDSTONE	{SA11}
	FERRICRETE NODULES	{SA24}
Name	UNDISTURBED SAMPLE	{SA37}
Name	DISTURBED SAMPLE	{SA38}
	ROOTS	{SA40}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :

INCLINATION :
DIAM :
DATE :
DATE :

ELEVATION :
X-COORD :
Y-COORD :

TYPE SET BY : B. Newton
SETUP FILE : BH1TT-A4.SET

DATE : 30/05/2014 13:37
TEXT : C\DOTPLOT\3145TPLOG(2).TXT

LEGEND
SUMMARY OF SYMBOLS

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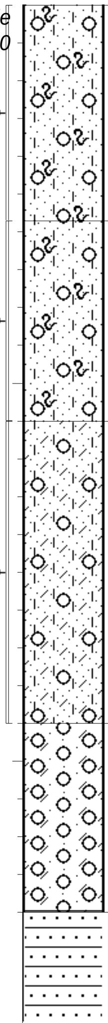
Royal Haskoning DHV
Matimba Power Station Ash Discard Dump

HOLE No: TP M1
Sheet 1 of 1

JOB NUMBER: 3145

Scale 1:20

0.0--0.57m
0.57--1.1m
1.1--1.9m



Depth (m)	Description
0.00	Dry, brown to light reddish brown, loose, open voided, SILTY SAND with quartz gravel inclusions, colluvium / aeolian. Roots.
0.57	Dry becoming slightly moist, reddish brown blotched light yellow and orange, loose to medium dense, open voided, SILTY SAND with quartz gravel inclusions, aeolian. Occasional roots.
1.10	Slightly moist at top becoming moist, blotched grey, orange and yellow, medium dense, intact with voids, slightly ferruginous CLAYEY SILTY SAND containing numerous, densely packed, matrix supported, quartz pebbles, pedogenic.
1.90	Slightly moist, grey blotched yellow and orange, medium dense to dense, intact, ferruginous CLAYEY SANDY GRAVEL (clast supported quartz pebbles in a clayey sand matrix), pedogenic / pebble marker.
2.40	Pinkish brown stained orange (oxidation), highly weathered, soft rock SANDSTONE.

NOTES

1) No water seepage observed.

2) No refusal, but difficult excavation / near refusal.

3) Disturbed samples taken between 0.0--0.57m, 0.57--1.1m and 1.1--1.9m.

CONTRACTOR :
MACHINE : CAT 428E TLB
DRILLED BY :
PROFILED BY : T. Speirs
TYPE SET BY : B. Newton
SETUP FILE : BH1TT-A4.SET

INCLINATION :
DIAM :
DATE :
DATE : 25-26 Feb 2014
DATE : 30/05/2014 13:37
TEXT : C\DOTPLOT\3145TPLOG(2).TXT

ELEVATION :
X-COORD : 23d42'52.8" S
Y-COORD : 27d35'35.4" E

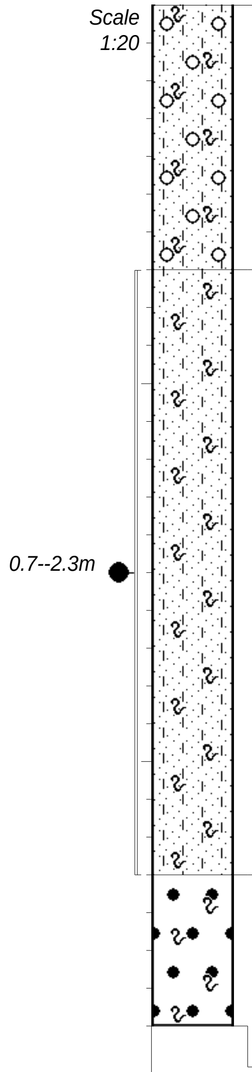
HOLE No: TP M1

Royal Haskoning DHV
Matimba Power Station Ash Discard Dump

HOLE No: TP M2
Sheet 1 of 1

JOB NUMBER: 3145

Scale 1:20



0.00

Dry, light reddish brown, loose, incipiently open voided, SILTY SAND with occasional quartz gravel inclusions, colluvium / aeolian. Roots.

0.70

Dry, reddish orange blotched yellow, medium dense, open voided, SILTY SAND, aeolian. Roots.
At bottom becomes ferruginous and blotched grey.

2.30

Dry, grey blotched black and orange, dense to very dense, intact, coalesced / partially indurated to indurated, FERRICRETE (honeycombed), pedogenic. Occasional tree roots at the top.

2.70

NOTES

1) No water seepage observed.

2) No refusal, but difficult excavation / near refusal.

3) Disturbed sample taken between 0.7--2.3m.

CONTRACTOR :
MACHINE : CAT 428E TLB
DRILLED BY :
PROFILED BY : T. Speirs

INCLINATION :
DIAM :
DATE :
DATE : 25-26 Feb 2014

ELEVATION :
X-COORD : 23d42'27.7" S
Y-COORD : 27d35'43.0" E

HOLE No: TP M2

TYPE SET BY : B. Newton
SETUP FILE : BH1TT-A4.SET

DATE : 30/05/2014 13:37
TEXT : C\DOTPLOT\3145TPLOG(2).TXT

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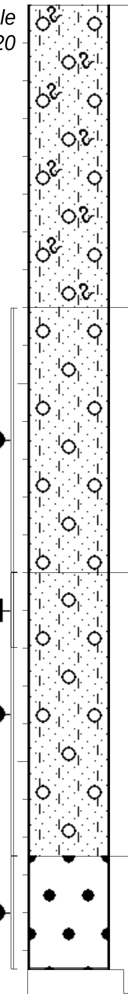
Royal Haskoning DHV
Matimba Power Station Ash Discard Dump

HOLE No: TP M3
Sheet 1 of 1

JOB NUMBER: 3145

Scale 1:20



	0.00	Dry, light reddish brown, loose, with roots, open voided, SILTY SAND with quartz gravel inclusions, colluvial / aeolian. Roots.
0.8--1.5m	0.80	Slightly moist, reddish brown blotched yellowish grey and orange, loose, open voided, SILTY SAND with quartz gravel inclusions, aeolian.
1.5--1.7m, *1.5--2.25m*	1.50	Dry, grey blotched yellow and orange, dense, intact with open voids, ferruginous GRAVELLY SILTY SAND, pedogenic.
2.25--2.55m	2.25	Dry, grey blotched black and orange, dense to very dense, intact, nodular to honeycomb textured FERRICRETE, pedogenic.
	2.55	

NOTES

1) No water seepage observed.

2) No refusal, but slow advance of TLB.

3) Disturbed samples taken between 0.8--1.5m, 1.5--2.25m and 2.25--2.55m.

4) Undisturbed sample taken between 1.5--1.7m.

CONTRACTOR :
MACHINE : CAT 428E TLB
DRILLED BY :
PROFILED BY : T. Speirs
TYPE SET BY : B. Newton
SETUP FILE : BH1TT-A4.SET

INCLINATION :
DIAM :
DATE :
DATE : 25-26 Feb 2014
DATE : 30/05/2014 13:37
TEXT : C\DOTPLOT\3145TPLOG(2).TXT

ELEVATION :
X-COORD : 23d43’08.6" S
Y-COORD : 27d35’43.8" E

HOLE No: TP M3

Royal Haskoning DHV
Matimba Power Station Ash Discard Dump

HOLE No: TP M4
Sheet 1 of 1

JOB NUMBER: 3145

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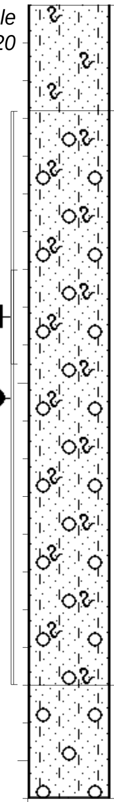
Scale 1:20



0.7--0.95m

0.28--1.8m

0.00 Slightly moist, light reddish brown, loose, open voided, SILTY SAND, colluvium. Roots.

0.28 Dry, dark reddish brown speckled yellow, medium dense becoming almost dense, open voided, SILTY SAND with quartz gravel inclusions, aeolian. Roots at top.

1.80 Dry, reddish orange blotched yellow speckled black, medium dense, intact to incipiently voided, ferruginous SILTY SAND with quartz gravel inclusions, aeolian / pedogenic.

2.10

NOTES

1) No water seepage observed.

2) No refusal.

3) Undisturbed sample taken between 0.7--0.95m.

4) Disturbed sample taken between 0.28--1.8m

5) Roots and termites in the top approximately 0.8-1.0m.

CONTRACTOR :
MACHINE : CAT 428E TLB
DRILLED BY :
PROFILED BY : T. Speirs

INCLINATION :
DIAM :
DATE :
DATE : 25-26 Feb 2014

ELEVATION :
X-COORD : 23d42'18.0" S
Y-COORD : 27d35'56.4" E

HOLE No: TP M4

TYPE SET BY : B. Newton
SETUP FILE : BH1TT-A4.SET

DATE : 30/05/2014 13:37
TEXT : C\DOTPLOT\3145TPLOG(2).TXT

Royal Haskoning DHV
Matimba Power Station Ash Discard Dump

HOLE No: TP M5
Sheet 1 of 1

JOB NUMBER: 3145

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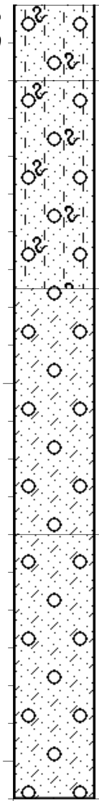
Scale 1:20



Depth (m)	Description
0.00	Dry, light reddish brown, loose, incipiently voided, SILTY SAND with quartz gravel inclusions, colluvium / aeolian. Roots.
0.20	Dry, dark reddish brown speckled yellow and orange, loose to medium dense, open voided, SILTY SAND with quartz gravel inclusions, aeolian. Roots.
0.75	Dry to slightly moist, blotched light orange, grey and yellowish grey, dense, intact, ferruginous GRAVELLY CLAYEY SAND, pedogenic.
1.40	As above with black nodular ferricrete nodules.
2.10	

NOTES

1) No water seepage observed.

2) No refusal, but very slow advance of TLB at the bottom.

CONTRACTOR :
MACHINE : CAT 428E TLB
DRILLED BY :
PROFILED BY : T. Speirs
TYPE SET BY : B. Newton
SETUP FILE : BH1TT-A4.SET

INCLINATION :
DIAM :
DATE :
DATE : 25-26 Feb 2014
DATE : 30/05/2014 13:37
TEXT : C\DOTPLOT\3145TPLOG(2).TXT

ELEVATION :
X-COORD : 23d42’56.2" S
Y-COORD : 27d36’08.3" E

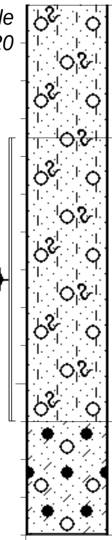
HOLE No: TP M5

Royal Haskoning DHV
Matimba Power Station Ash Discard Dump

HOLE No: TP M6
Sheet 1 of 1

JOB NUMBER: 3145

Scale 1:20



Depth (m)	Description
0.00	Dry, light reddish brown, very loose at top becoming loose, with roots, incipiently open voided, SILTY SAND with quartz gravel inclusions, colluvium / aeolian. Roots.
0.35	Dry, reddish brown speckled yellow, speckled and blotched orange, loose at the top becoming medium dense, open voided, SILTY SAND with quartz gravel inclusions, aeolian. Roots at the top.
1.10	Slightly moist, grey blotched orange speckled black, dense, occasionally voided, ferruginous GRAVELLY CLAYEY SAND with coalesced / partially indurated nodular FERRICRETE, pedogenic.
1.40	

0.35--1.1m

NOTES

1) No water seepage observed.

2) No refusal, but slow advance of TLB at the bottom.

3) Undisturbed sample taken between 0.35--1.1m.

4) Disturbed sample taken between 0.35--1.1m.

CONTRACTOR :
MACHINE : CAT 428E TLB
DRILLED BY :
PROFILED BY : T. Speirs
TYPE SET BY : B. Newton
SETUP FILE : BH1TT-A4.SET

INCLINATION :
DIAM :
DATE :
DATE : 25-26 Feb 2014
DATE : 30/05/2014 13:37
TEXT : C\DOTPLOT\3145TPLOG(2).TXT

ELEVATION :
X-COORD : 23d43’34.4" S
Y-COORD : 27d36’03.9" E

HOLE No: TP M6

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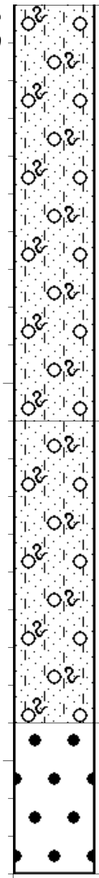
Royal Haskoning DHV
Matimba Power Station Ash Discard Dump

HOLE No: TP M7
Sheet 1 of 1

JOB NUMBER: 3145

Scale 1:20



0.00	Stripped area with reworked topsoil contaminated with ash on the surface, underlain by slightly moist, dark reddish brown speckled yellow, medium dense, open voided, SILTY SAND with quartz gravel inclusions, aeolian. Roots.
1.10	As above, but ferruginous orange-yellow blotched, partially coalesced to partially indurated, with a dense consistency.
1.90	Slightly moist, light yellowish grey blotched orange and black, dense, intact with occasional voids, NODULAR FERRICRETE and quartz pebbles with interstitial silty sand, pedogenic./
2.30	

NOTES

1) No water seepage observed.

2) No refusal, but difficult TLB excavation at the bottom.

CONTRACTOR :
MACHINE : CAT 428E TLB
DRILLED BY :
PROFILED BY : T. Speirs
TYPE SET BY : B. Newton
SETUP FILE : BH1TT-A4.SET

INCLINATION :
DIAM :
DATE :
DATE : 25-26 Feb 2014
DATE : 30/05/2014 13:37
TEXT : C\DOTPLOT\3145TPLOG(2).TXT

ELEVATION :
X-COORD : 23d43’17.0" S
Y-COORD : 27d36’24.0" E

HOLE No: TP M7

Royal Haskoning DHV
Matimba Power Station Ash Discard Dump

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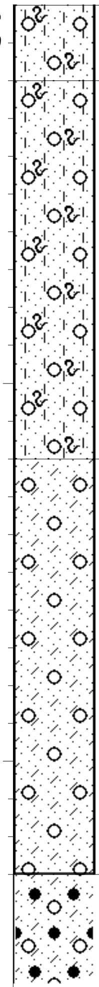
HOLE No: TP M8
Sheet 1 of 1

JOB NUMBER: 3145

Scale 1:20



Depth (m)	Description
0.00	Topsoil stripped. Thin layer of ash on the surface underlain by dry, light reddish brown, loose, incipiently voided, SILTY SAND with quartz gravel inclusions, colluvium / aeolian. Roots.
0.20	Dry, dark reddish brown speckled yellow and orange, loose to medium dense, open voided, SILTY SAND with quartz gravel inclusions, aeolian. Roots.
1.20	Dry to slightly moist, blotched light orange, grey and yellowish grey, dense, intact, ferruginous GRAVELLY CLAYEY SAND, pedogenic.
2.30	As above with black FERRICRETE nodules.

NOTES

1) No water seepage observed.

2) No refusal, but difficult TLB excavation at the bottom.

CONTRACTOR :
MACHINE : CAT 428E TLB
DRILLED BY :
PROFILED BY : T. Speirs

INCLINATION :
DIAM :
DATE :
DATE : 25-26 Feb 2014

ELEVATION :
X-COORD : 23d43’08.4" S
Y-COORD : 27d36’17.4" E

HOLE No: TP M8

TYPE SET BY : B. Newton
SETUP FILE : BH1TT-A4.SET

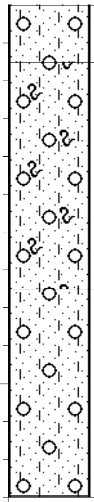
DATE : 30/05/2014 13:37
TEXT : C\DOTPLOT\3145TPLOG(2).TXT

Royal Haskoning DHV
Matimba Power Station Ash Discard Dump

HOLE No: TP M9
Sheet 1 of 1

JOB NUMBER: 3145

Scale 1:20



	0.00	Dry, light reddish brown, loose, intact, SILTY SAND with scattered quartz gravel inclusions, colluvium. Roots
0.15--0.75	0.15	Dry, dark reddish brown blotched orange, medium dense, open voided, SILTY SAND with quartz gravel inclusions, aeolian. Roots at the top.
0.75--1.3m	0.75	Dry, reddish brown blotched orange, grey and yellow, dense, open voided, ferruginous SILTY SAND with quartz gravel inclusions, pedogenic.
	1.30	

NOTES

1) No water seepage observed.

2) No refusal.

3) Disturbed samples taken between 0.15--0.75 and 0.75--1.3m.

CONTRACTOR :
MACHINE : CAT 428E TLB
DRILLED BY :
PROFILED BY : T. Speirs
TYPE SET BY : B. Newton
SETUP FILE : BH1TT-A4.SET

INCLINATION :
DIAM :
DATE :
DATE : 25-26 Feb 2014
DATE : 30/05/2014 13:37
TEXT : C\DOTPLOT\3145TPLOG(2).TXT

ELEVATION :
X-COORD : 23d43’18.8" S
Y-COORD : 27d36’28.4" E

HOLE No: TP M9

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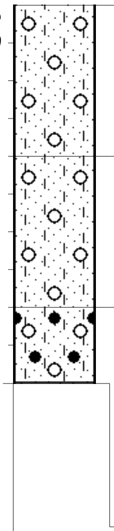
Royal Haskoning DHV
Matimba Power Station Ash Discard Dump

HOLE No: TPM10
Sheet 1 of 1

JOB NUMBER: 3145

Scale 1:20



0.00	Dry, brown to light reddish brown, loose, intact with visible voids, SILTY SAND with scattered quartz gravel inclusions, colluvium.
0.40	Dry, dark reddish brown with occasional yellow specks, medium dense, open voided, SILTY SAND with quartz gravel inclusions, aeolian.
0.80	Dry to slightly moist, blotched orange and grey speckled black, dense, intact, (voided), ferruginous slightly clayey SILTY SAND containing quartz gravel and FERRICRETE nodules, partially coalesced to indurated, pedogenic.
1.00	

NOTES

1) No water seepage observed.
2) No refusal, but difficult TLB excavation at the bottom.

CONTRACTOR :
MACHINE : CAT 428E TLB
DRILLED BY :
PROFILED BY : T. Speirs
TYPE SET BY : B. Newton
SETUP FILE : BH1TT-A4.SET

INCLINATION :
DIAM :
DATE :
DATE : 25-26 Feb 2014
DATE : 30/05/2014 13:37
TEXT : C\DOTPLOT\3145TPLOG(2).TXT

ELEVATION :
X-COORD : 23d43’24.7" S
Y-COORD : 27d36’16.5" E

HOLE No: TPM10

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Royal Haskoning DHV
Matimba Power Station Ash Discard Dump

HOLE No: TP M11
Sheet 1 of 1

JOB NUMBER: 3145

Scale 1:20

Depth (m)	Description
0.00 – 0.20	Slightly moist, reddish orange-brown speckled yellow, loose, intact, GRAVELLY SILTY SAND, fill (capping).
0.20 – 3.50	Slightly moist, grey, very loose to loose, intact, low density, ash discard.

NOTES

1) No water seepage observed.

2) No refusal.

CONTRACTOR :
MACHINE : CAT 428E TLB
DRILLED BY :
PROFILED BY : T. Speirs
TYPE SET BY : B. Newton
SETUP FILE : BH1TT-A4.SET

INCLINATION :
DIAM :
DATE :
DATE : 25-26 Feb 2014
DATE : 30/05/2014 13:37
TEXT : C\DOTPLOT\3145TPLOG(2).TXT

ELEVATION :
X-COORD : 23d42’16.1" S
Y-COORD : 27d36’28.4" E

HOLE No: TP M11

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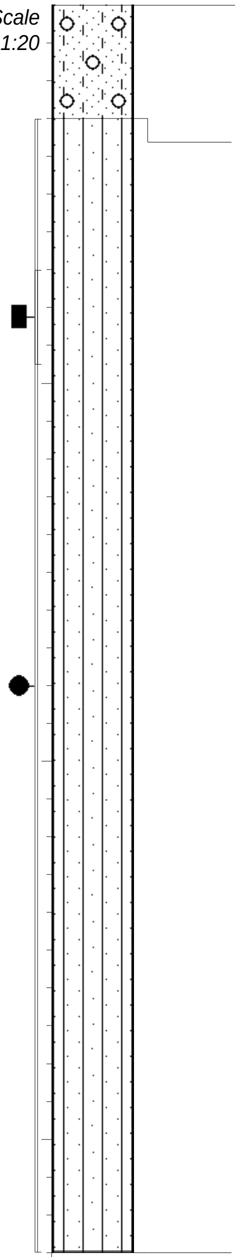
Geotechnical & Environmental Consultants

Royal Haskoning DHV
Matimba Power Station Ash Discard Dump

HOLE No: TP M12
Sheet 1 of 1

JOB NUMBER: 3145

Scale 1:20



Depth (m)	Description
0.00	Slightly moist, reddish orange-brown speckled yellow, loose, intact, GRAVELLY SILTY SAND, fill (capping).
0.30	Slightly moist, grey, very loose to loose, intact, low density, ash discard.
3.30	

NOTES

1) No water seepage observed.

2) No refusal.

3) Undisturbed sample taken between 0.7--0.95m.

4) Disturbed sample taken between 0.3--3.3m

CONTRACTOR :
MACHINE : CAT 428E TLB
DRILLED BY :
PROFILED BY : T. Speirs

TYPE SET BY : B. Newton
SETUP FILE : BH1TT-A4.SET

INCLINATION :
DIAM :
DATE :
DATE : 25-26 Feb 2014

DATE : 30/05/2014 13:37
TEXT : C\DOTPLOT\3145TPLOG(2).TXT

ELEVATION :
X-COORD : 23d42'15.9" S
Y-COORD : 27d37'02.7" E

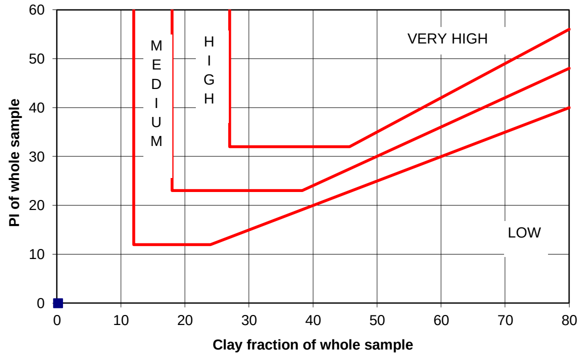
HOLE No: TP M12

PARTICLE SIZE ANALYSIS

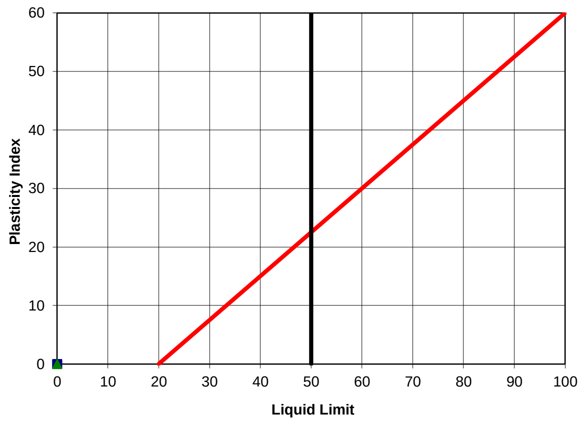
PROJECT : MATIMBA POWER STATION
JOB No. : S14-0264
DATE : 13/03/2014

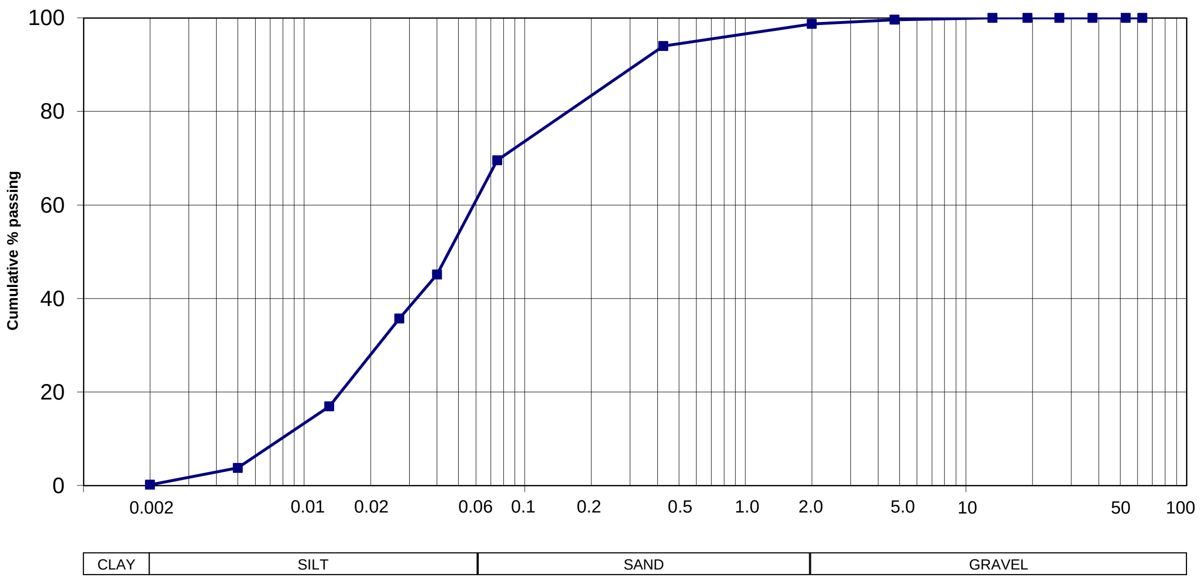
Sample No.		
Soillab sample no.	S14-0264-12	
Depth (m)	0.3 - 3.3	
Position	M12	
Material Description	LIGHT GREY ASH + QUARTZ SANDY SILT	
Moisture (%)		
Dispersion (%)		
SCREEN ANALYSIS (% PASSING) **(TMH 1 A1(a) & A5)**		
63.0 mm	100	
53.0 mm	100	
37.5 mm	100	
26.5 mm	100	
19.0 mm	100	
13.2 mm	100	
4.75 mm	100	
2.00 mm	99	
0.425 mm	94	
0.075 mm	70	
HYDROMETER ANALYSIS (% PASSING) **(TMH 1 A6)**		
0.040 mm	45	
0.027 mm	36	
0.013 mm	17	
0.005 mm	4	
0.002 mm	0	
% Clay	0	
% Silt	59	
% Sand	40	
% Gravel	1	
ATTERBERG LIMITS **(TMH 1 A2 - A4)**		
Liquid Limit		
Plasticity Index	NP	
Linear Shrinkage (%)	0.0	
Grading Modulus	0.38	
Uniformity coefficient	7	
Coefficient of curvature	1.0	
Classification	A-4 (0)	
Unified Classification	ML	
Chart Reference	■	▲

POTENTIAL EXPANSIVENESS



PLASTICITY CHART





HIDROMETER/0264-01

SOILLAB (PTY) LTD
Registration Number 1971/000112/07
SMEC Part of the SMEC Group
Engineering Materials Laboratory

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Email: info@soillab.co.za
www.soillab.co.za

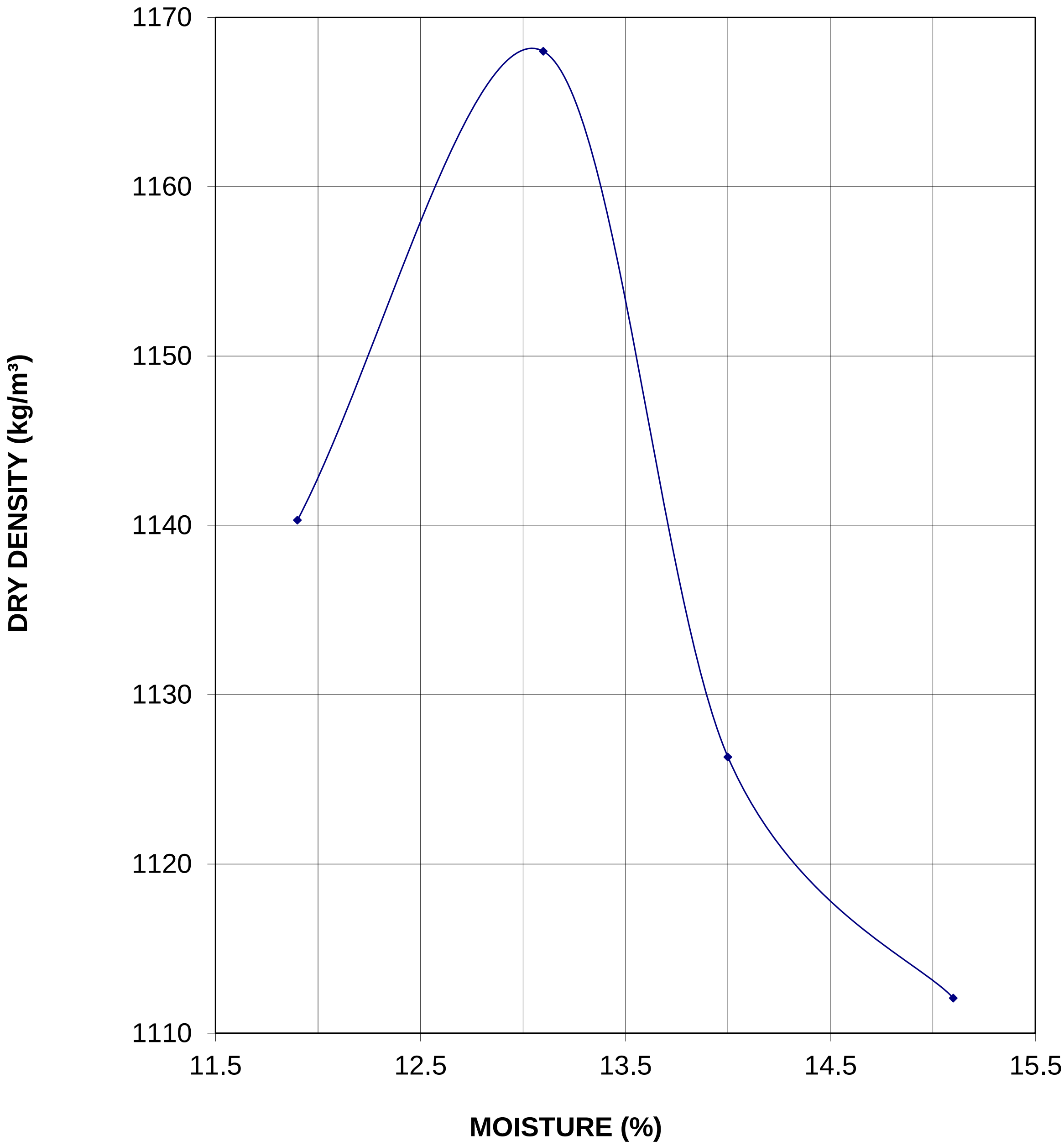
PROJECT: MATIMBA POWER STATION

MOISTURE/DENSITY RELATIONSHIP @ MOD AASHTO COMPACTIVE EFFORT
(TMH 1 A7)

SAMPLE NO.: M12 (S14-0264-12)

Maximum dry density (kg/m³): 1168

Optimum moisture content(%): 13.1



NOTE:

MODS/0264-01

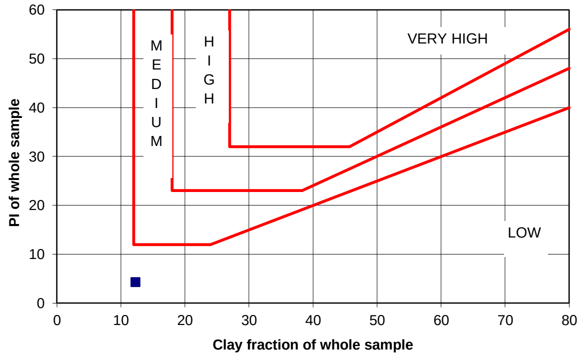
SOILLAB (PTY) LTD
Reg No 1971/000112/07
230 Albertus Street
La Montagne 0184
Tel (012) 481-3999
P O Box 72928
Lynnwood Ridge 0040
Fax (012) 481-3812

PARTICLE SIZE ANALYSIS

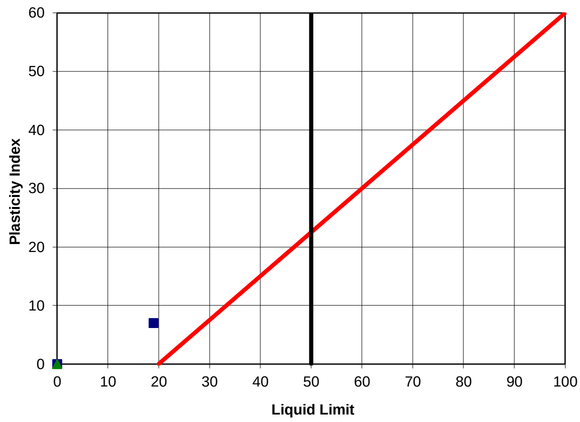
Sample No.		
Soillab sample no.	S14-0264-13	
Depth (m)		
Position	MIXED SAMPLES	
Material Description	DARK BROWN SAND CLAYEY SAND	
Moisture (%)		
Dispersion (%)		
SCREEN ANALYSIS (% PASSING) **(TMH 1 A1(a) & A5)**		
63.0 mm	100	
53.0 mm	100	
37.5 mm	100	
26.5 mm	100	
19.0 mm	100	
13.2 mm	100	
4.75 mm	100	
2.00 mm	98	
0.425 mm	61	
0.075 mm	26	
HYDROMETER ANALYSIS (% PASSING) **(TMH 1 A6)**		
0.040 mm	18	
0.027 mm	16	
0.013 mm	15	
0.005 mm	14	
0.002 mm	12	
% Clay	12	
% Silt	10	
% Sand	76	
% Gravel	2	
ATTERBERG LIMITS **(TMH 1 A2 - A4)**		
Liquid Limit	19	
Plasticity Index	7	
Linear Shrinkage (%)	3.0	
Grading Modulus	1.15	
Uniformity coefficient	-	
Coefficient of curvature	-	
Classification	A-2-4 (0)	
Unified Classification	SM & SC	
Chart Reference		

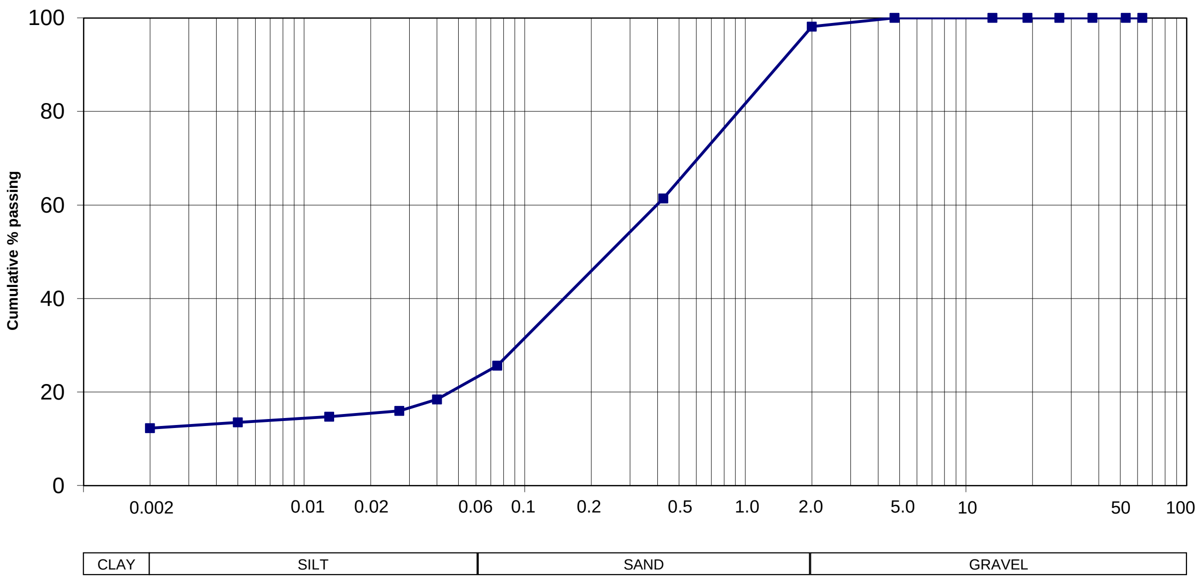
PROJECT : MATIMBA POWER STATION
JOB No. : S14-0264
DATE : 13/03/2014

POTENTIAL EXPANSIVENESS



PLASTICITY CHART





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Engineering Materials Laboratory

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www.soillab.co.za

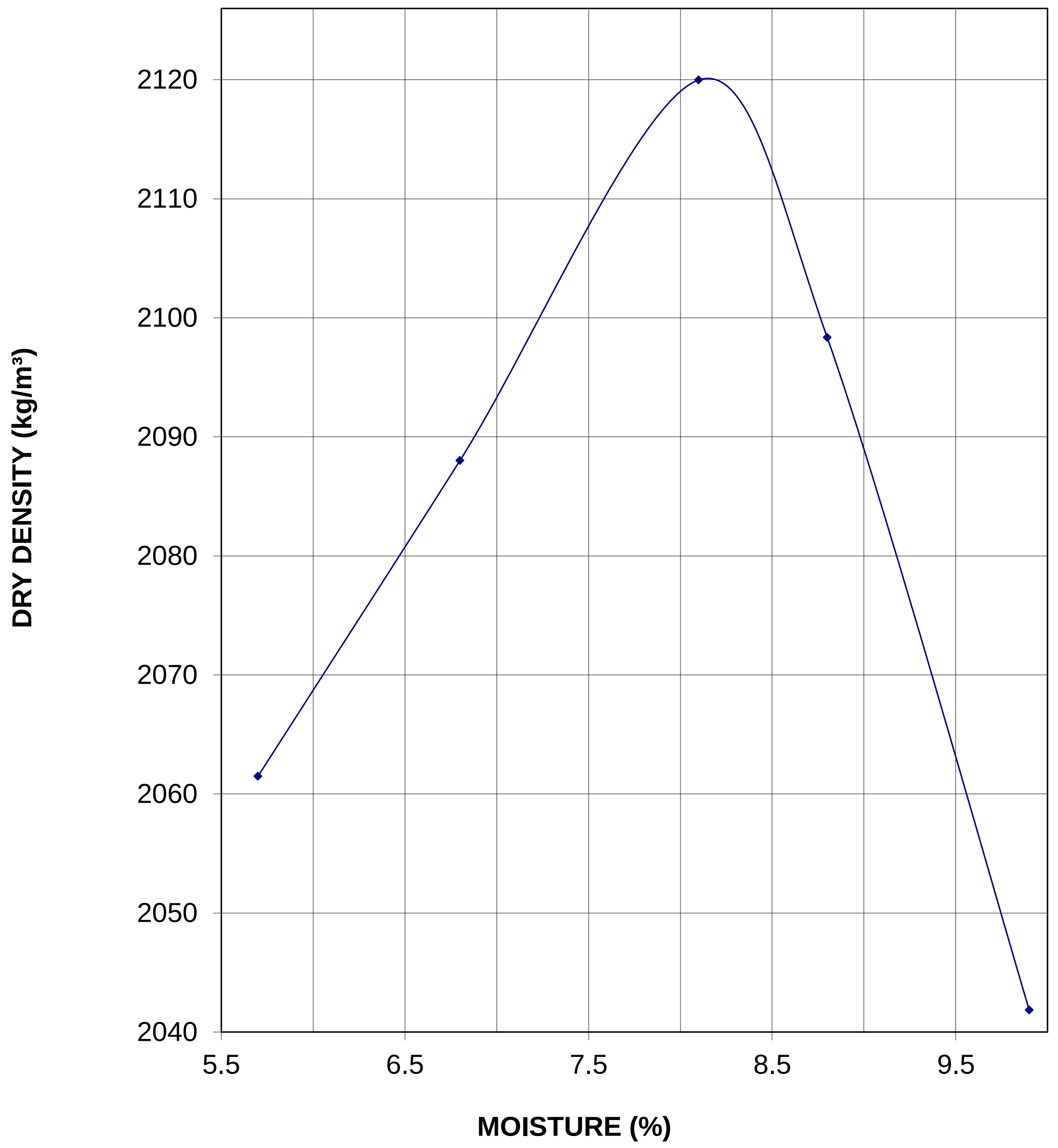
PROJECT: MATIMBA POWER STATION

MOISTURE/DENSITY RELATIONSHIP @ MOD AASHTO COMPACTIVE EFFORT
(TMH 1 A7)

SAMPLE NO.: IXED SAMPLES (S14-0264-13)

Maximum dry density (kg/m³): 2120

Optimum moisture content(%): 8.1



NOTE:

MODS/0264-02

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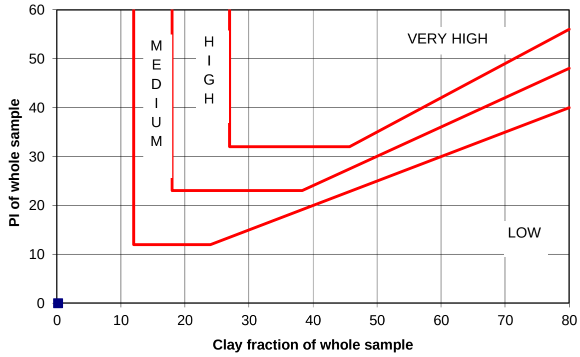
PARTICLE SIZE ANALYSIS

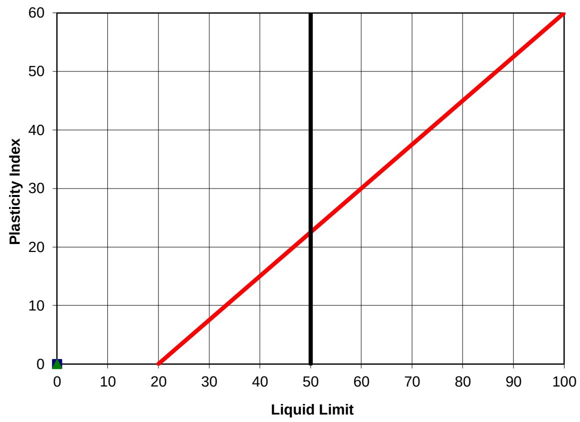
PROJECT : MATIMBA POWER STATION
JOB No. : S14-0264
DATE : 13/03/2014

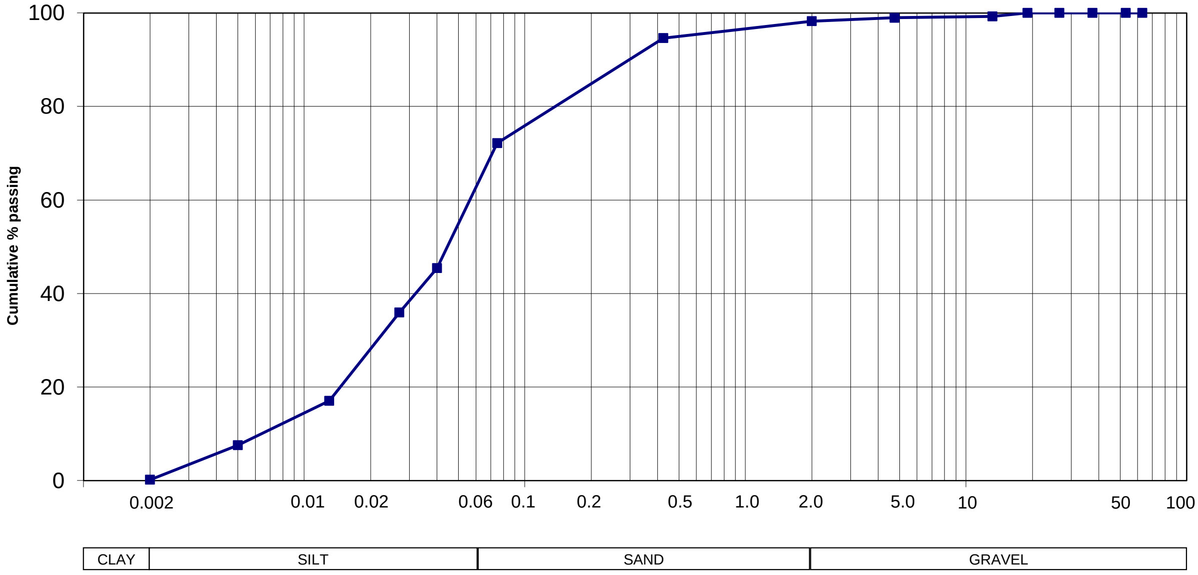
Sample No.		
Soillab sample no.	S14-0264-14	
Depth (m)	25 - 45	
Position	BH 1	
Material Description	LIGHT GREY ASH +QUARTZITE SANDY SILT	
Moisture (%)		
Dispersion (%)		
SCREEN ANALYSIS (% PASSING) **(TMH 1 A1(a) & A5)**		
63.0 mm	100	
53.0 mm	100	
37.5 mm	100	
26.5 mm	100	
19.0 mm	100	
13.2 mm	99	
4.75 mm	99	
2.00 mm	98	
0.425 mm	95	
0.075 mm	72	
HYDROMETER ANALYSIS (% PASSING) **(TMH 1 A6)**		
0.040 mm	45	
0.027 mm	36	
0.013 mm	17	
0.005 mm	8	
0.002 mm	0	
% Clay	0	
% Silt	61	
% Sand	38	
% Gravel	2	
ATTERBERG LIMITS **(TMH 1 A2 - A4)**		
Liquid Limit		
Plasticity Index	NP	
Linear Shrinkage (%)	0.0	
Grading Modulus	0.35	
Uniformity coefficient	9	
Coefficient of curvature	1.3	
Classification	A-4 (0)	
Unified Classification	ML	
Chart Reference		

POTENTIAL EXPANSIVENESS



PLASTICITY CHART





HIDROMETER/0264-03

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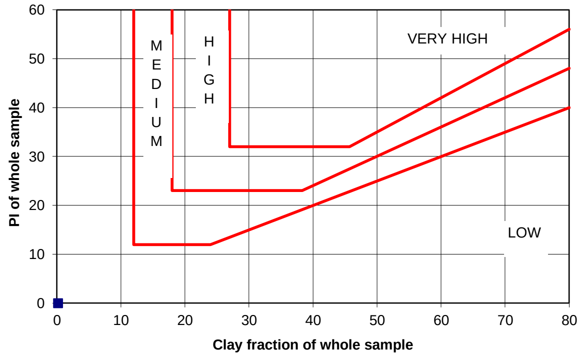
PARTICLE SIZE ANALYSIS

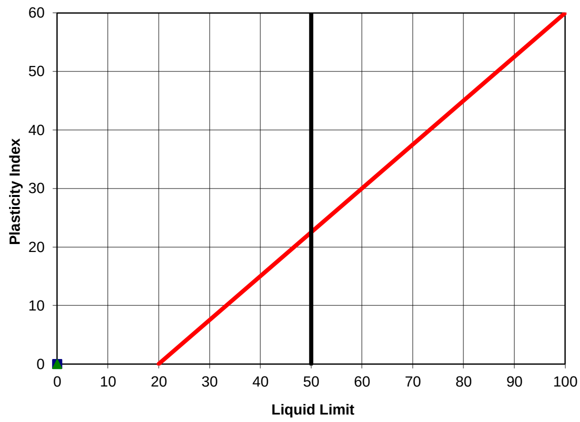
PROJECT : MATIMBA POWER STATION
JOB No. : S14-0264
DATE : 13/03/2014

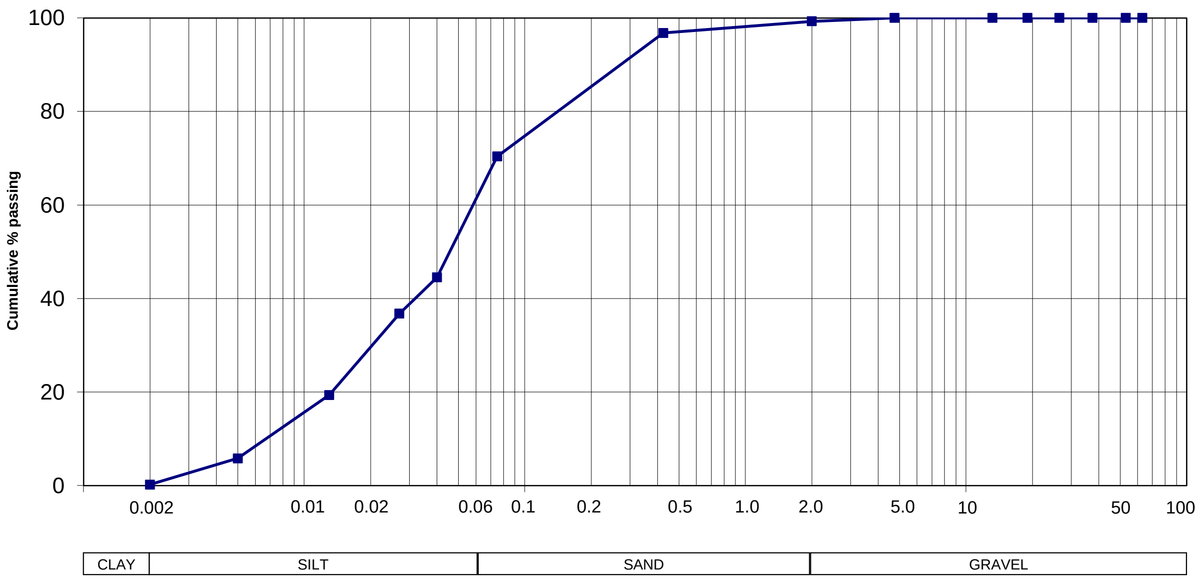
Sample No.		
Soillab sample no.	S14-0264-15	
Depth (m)	24 -45	
Position	BH 2	
Material Description	LIGHT GREY ASH SANDY SILT	
Moisture (%)		
Dispersion (%)		
SCREEN ANALYSIS (% PASSING) **(TMH 1 A1(a) & A5)**		
63.0 mm	100	
53.0 mm	100	
37.5 mm	100	
26.5 mm	100	
19.0 mm	100	
13.2 mm	100	
4.75 mm	100	
2.00 mm	99	
0.425 mm	97	
0.075 mm	70	
HYDROMETER ANALYSIS (% PASSING) **(TMH 1 A6)**		
0.040 mm	45	
0.027 mm	37	
0.013 mm	19	
0.005 mm	6	
0.002 mm	0	
% Clay	0	
% Silt	59	
% Sand	40	
% Gravel	1	
ATTERBERG LIMITS **(TMH 1 A2 - A4)**		
Liquid Limit		
Plasticity Index	NP	
Linear Shrinkage (%)	0.0	
Grading Modulus	0.34	
Uniformity coefficient	9	
Coefficient of curvature	1.1	
Classification	A-4 (0)	
Unified Classification	ML	
Chart Reference		

POTENTIAL EXPANSIVENESS



PLASTICITY CHART





HIDROMETER/0264-04

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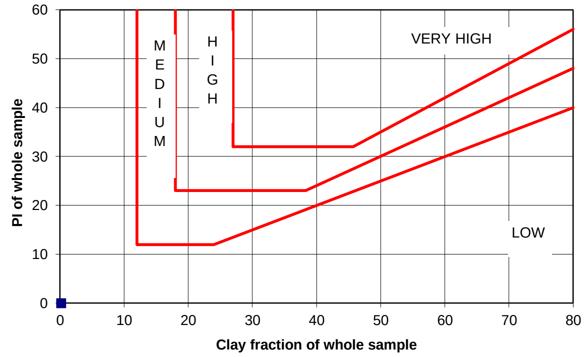
PARTICLE SIZE ANALYSIS

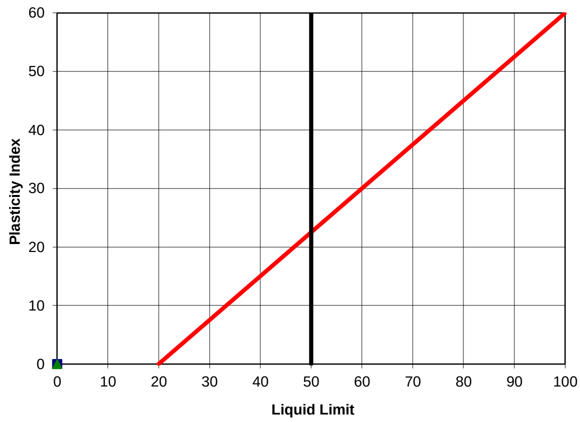
Sample No.		
Soillab sample no.	S14-0264-16	
Depth (m)	25 - 45	
Position	BH 3	
Material Description	LIGHT GREY ASH + QUARTZITE SANDY SILT	
Moisture (%)		
Dispersion (%)		
SCREEN ANALYSIS (% PASSING) **(TMH 1 A1(a) & A5)**		
63.0 mm	100	
53.0 mm	100	
37.5 mm	100	
26.5 mm	100	
19.0 mm	100	
13.2 mm	100	
4.75 mm	100	
2.00 mm	99	
0.425 mm	97	
0.075 mm	70	
HYDROMETER ANALYSIS (% PASSING) **(TMH 1 A6)**		
0.040 mm	45	
0.027 mm	37	
0.013 mm	19	
0.005 mm	6	
0.002 mm	0	
% Clay	0	
% Silt	59	
% Sand	40	
% Gravel	1	
ATTERBERG LIMITS **(TMH 1 A2 - A4)**		
Liquid Limit		
Plasticity Index	NP	
Linear Shrinkage (%)	0.0	
Grading Modulus	0.34	
Uniformity coefficient	9	
Coefficient of curvature	1.1	
Classification	A-4 (0)	
Unified Classification	ML	
Chart Reference		

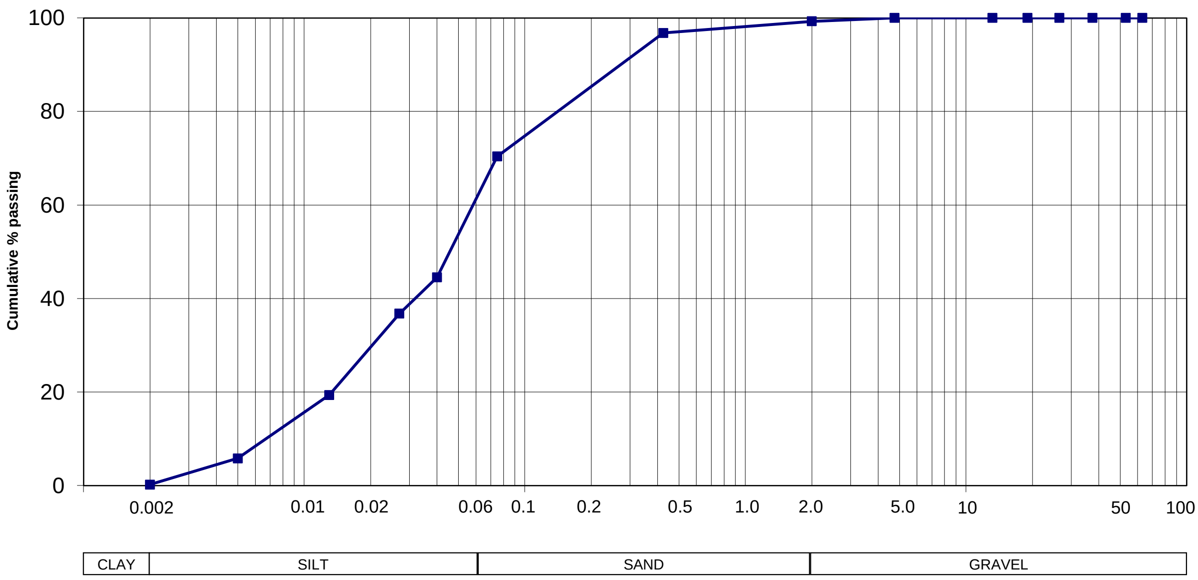
PROJECT : MATIMBA POWER STATION
JOB No. : S14-0264
DATE : 13/03/2014

POTENTIAL EXPANSIVENESS



PLASTICITY CHART





HIDROMETER/0264-05

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Fax: (+27) (12) 481 3941 / 3812
Email: info@soillab.co.za
www.soillab.co.za

SOIL ANALYSIS BY ...... : SOILLAB (Pty) Ltd
Lab reference No. .... : S14-0264

Customer .... : JEFFARES & GREEN (PTY) LTD	Job Number .... : S14-0264
Job Description .... : MATIMBA POWER STATION	Contract Number .... :
Road Number .... :	Date .... : 2014-03-27

SAMPLE DESCRIPTION						
Sample Number	53079	53080	53081	53082	53083	53084
Sample Position	M1	M1	M1	M2	M3	M3
Sample Depth (mm)	0-0.57	0.57 -1.1	1.1-1.9	0.7-2.3	0.8-1.5	1.5-2.25
Material Description	DARK BROWN SAND	DARK RED BROWN SAND	LIGHT ORANGE FERRICRETE CLAYEY GRAVEL	LIGHT RED SAND	DARK RED BROWN SAND	DARK BROWN SAND
Max size of boulder (mm)	-		-	-	-	-
SCREEN ANALYSIS (% PASS)						
75,00 mm	100	100	100	100	100	100
63,00 mm	100	100	100	100	100	100
53,00 mm	100	100	100	100	100	100
37,50 mm	100	100	100	100	100	100
26,50 mm	100	100	100	100	100	100
19,00 mm	100	100	100	100	100	100
13,20 mm	100	100	90	100	100	100
4,750 mm	100	100	66	100	100	100
2,000 mm	98	97	54	97	99	97
0,425 mm	57	55	35	60	56	60
0,075 mm	14	22	19	21	19	29
SOIL MORTAR						
Coarse Sand 2,000-0,425	42	44	36	37	43	38
Coarse Fine Sd 0,425-0,250	16	15	11	15	16	11
Medium Fine Sd 0,250-0,150	13	9	8	11	10	9
Fine Fine Sand 0,150-0,075	15	9	10	15	11	12
Material <0,075	14	23	35	22	20	30
CONSTANTS						
Grading Modulus	1.31	1.26	1.92	1.22	1.26	1.14
Liquid Limit		20	28	15	15	19
Plasticity Index	NP	8	12	4	5	9
Linear Shrinkage (%)	0.0	3.0	6.0	1.5	2.0	3.5
Sand Equivalent						
Classification - TRB	A-2-4 (0)	A-2-4 (0)	A-2-6 (0)	A-2-4 (0)	A-2-4 (0)	A-2-4 (0)
Classification - COLTO						
CBR / UCS VALUES						
MOD. AASHTO						
Max Dry Density (kg/m³)						
Optimum Moisture Cont (%) ...						
Moulding Moisture Cont (%) ...						
Dry Density (kg/m³)						
% of Max Dry Density						
100% Mod CBR/UCS						
% Swell						
NRB						
Dry Density (kg/m³)						
% of Max Dry Density						
100% NRB CBR/UCS						
% Swell						
PROCTOR						
Dry Density (kg/m³)						
% of Max Dry Density						
100% Proc CBR/UCS						
% Swell						
CBR / UCS VALUES						
100% Mod AASHTO						
98% Mod AASHTO						
97% Mod AASHTO						
95% Mod AASHTO						
93% Mod AASHTO						
90% Mod AASHTO						
SOILLAB NO.	S14-0264-01	S14-0264-02	S14-0264-03	S14-0264-04	S14-0264-05	S14-0264-06

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SOIL ANALYSIS BY ..... : SOILLAB (Pty) Ltd
Lab reference No. .... : S14-0264

Date Printed : 2014-04-01

Customer .... : JEFFARES & GREEN (PTY) LTD
Job Description .... : MATIMBA POWER STATION
Road Number .... :

Job Number .... : S14-0264
Contract Number .... :
Date .... : 2014-03-27

SAMPLE DESCRIPTION						
Sample Number	53085	53086	53087	53088	53089	
Sample Position	M3	M4	M6	M9	M9	
Sample Depth (mm)	2.25-2.55	0.28-1.8	0.35-1.1	0.15-0.75	0.75 -1.3	
Material Description	D/GREY, FERRICRETE SAND	PALE RED SAND	DARK BROWN SAND	LIGHT BROWN SAND	LIGHT ORANGE SANDY CLAY	
Max size of boulder (mm)	-	-	-	-	-	
SCREEN ANALYSIS (% PASS)						
75,00 mm	100	100	100	100	100	
63,00 mm	100	100	100	100	100	
53,00 mm	100	100	100	100	100	
37,50 mm	100	100	100	100	100	
26,50 mm	100	100	100	100	100	
19,00 mm	100	100	100	100	100	
13,20 mm	96	100	100	100	100	
4,750 mm	79	100	100	100	100	
2,000 mm	71	98	98	98	97	
0,425 mm	47	64	59	56	66	
0,075 mm	24	32	24	21	42	
SOIL MORTAR						
Coarse Sand 2,000-0,425	35	35	41	43	32	
Coarse Fine Sd 0,425-0,250	12	11	14	15	10	
Medium Fine Sd 0,250-0,150	8	9	9	10	7	
Fine Fine Sand 0,150-0,075	11	13	12	10	8	
Material <0,075	34	32	24	22	43	
CONSTANTS						
Grading Modulus	1.58	1.06	1.19	1.25	0.95	
Liquid Limit	24	23	16	18	35	
Plasticity Index	10	10	6	8	13	
Linear Shrinkage (%)	4.0	4.5	2.5	3.0	6.0	
Sand Equivalent						
Classification - TRB	A-2-4 (0)	A-2-4 (0)	A-2-4 (0)	A-2-4 (0)	A-6 (2)	
Classification - COLTO						
CBR / UCS VALUES						
MOD. AASHTO						
Max Dry Density (kg/m³)						
Optimum Moisture Cont (%) ...						
Moulding Moisture Cont (%) ...						
Dry Density (kg/m³)						
% of Max Dry Density						
100% Mod CBR/UCS						
% Swell						
NRB						
Dry Density (kg/m³)						
% of Max Dry Density						
100% NRB CBR/UCS						
% Swell						
PROCTOR						
Dry Density (kg/m³)						
% of Max Dry Density						
100% Proc CBR/UCS						
% Swell						
CBR / UCS VALUES						
100% Mod AASHTO						
98% Mod AASHTO						
97% Mod AASHTO						
95% Mod AASHTO						
93% Mod AASHTO						
90% Mod AASHTO						
SOILLAB NO.	S14-0264-07	S14-0264-08	S14-0264-09	S14-0264-10	S14-0264-11	

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JEFFARES GREEN
P O BOX 2973
PRETORIA
0001

Tax Invoice

Date	31/03/14
Page	1
Document No	PTA03816

Account	Your Reference	Tax Exempt	Tax Reference	Sales Code	
C00627	S14-0264 / JAG-009	N	4860118654		Exclusive

ATTENTION: MR T SPEIRS
PROJECT: MATIMBA POWER STATION
REQUESTED: 2014-03-04

Code	Description	Quantity	Unit	Unit Price	Disc%	Tax	Nett Price
3.1.1V	Road Ind Sieve Anal to 0075mm Aberg Lim	11.00	Test	420.00		14.00%	4 620.00
3.1.2V	Found Ind Sieve Anal to µ2 Aberg Limit	5.00	Test	490.00		14.00%	2 450.00
3.1.8.1V	Max Dry Dens Opt Moist Mod AASHTO	2.00	Test	470.00		14.00%	940.00
3.1.18V	Thermal Conductivityresistivity	9.00	Test	1 000.00		14.00%	9 000.00

IN ACCORDANCE WITH OUR
SCALE OF FEES OF 01.08.2013

YOURS FAITHFULLY

SOILLAB (PTY) LTD

OUR BANKING DETAILS:
STANDARD BANK SILVERTON
BRANCH CODE : 010545
ACCOUNT NO : 012409871
PLEASE USE YOUR ACCOUNT NUMBER AS REFERENCE WHEN PAYING

Note: All accounts that are not paid within 30 days of date of statement will be charged interest at the ruling prime bank rate plus 2%

Sub Total		17 010.00
Discount @	0.00%	0.00
Amount Excl Tax		17 010.00
Tax		2 381.40
Total		19 391.40

TEST REPORT: S14-0264

For: JEFFARES GREEN
PO BOX 2973
PRETORIA
0001

Date: 2014-03-31

Attention: MR T SPEIRS

Your Reference: MATIMBA POWER STATION

Sample(s)	Date requested	Test Method(s) used	Sample Condition/Description	Sampling method/Date	Test(s) done at	Test(s) dates	Sampling Environmental conditions
S14-0264-01 - 11	2014-03-04	TMH 1 A1(a)** - A5	Soils	Client Not Given	Soillab Pretoria	2014-03-27	Not Given
S14-0264-12 - 16		TMH 1 A1(a)** - A6				2014-03-13	
S14-0264-12 - 13		TMH 1 A7				2014-03-11	
S14-0264-14 - 16		SANS 10198-5*				2014-03-20	

Note: **Used tap water to wash and not distilled water.
* Not SANAS Accredited

JF van Zijl
Manager.

The results relate only to the items tested. Any opinions, comments and interpretations do not fall within the scope of SANAS accreditation. Test(s) marked "Not SANAS Accredited" in this report are not included in the SANAS Schedule of Accreditation for this laboratory.

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Collapse Potential

Results

Project:	**Matimba Power Station**
Client:	**Jeffares and Green**
Geolab Job Nr:	**G14-0028**
Test Method:	**TMH 6 ST10 + Jennings**

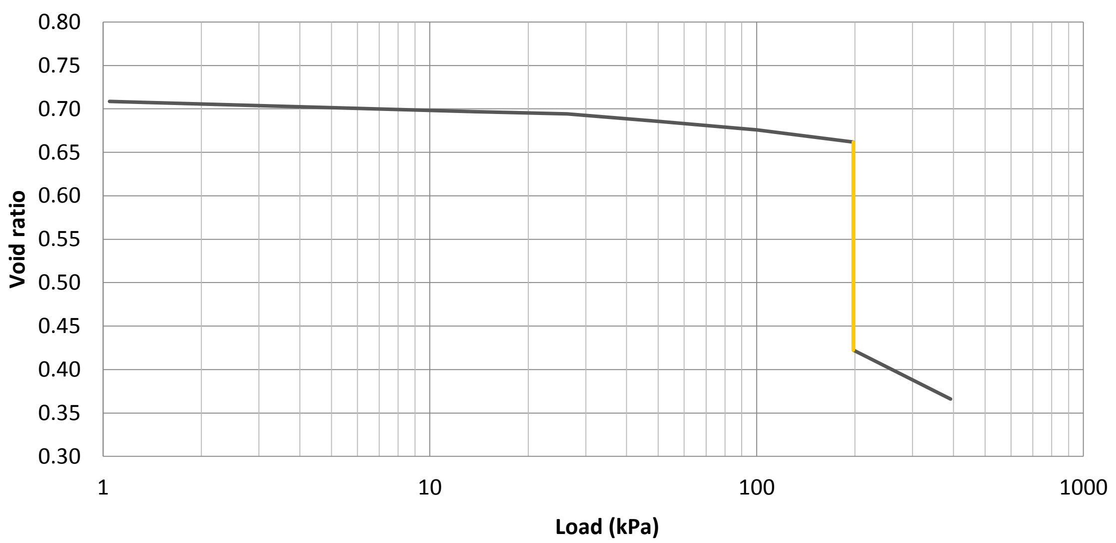
Sample Nr:	**M4**
Sample Depth:	**0.28-1.8m**
Date:	**2014/05/16**

Sample	
Sampling Method:	Block
Disturbed/Undisturbed:	Undisturbed
Remoulded To:	NA

Results		
Collapse Potential	**14.0**	%

Load (kPa)	Height (mm)	Void Ratio	
1.0	18.99	0.709	
13.7	18.862	0.697	
26.3	18.832	0.694	
51.0	18.733	0.685	
100.2	18.625	0.676	
197.5	18.47	0.662	
197.5	15.809	0.422	*
391.6	15.183	0.366	

Sample Detail		
Initial Sample Height:	18.99	mm
Initial Sample Weight:	61.9	g
Initial Dry Density:	1550	kg/m^3
Initial Moisture Content:	6.2	%
Final Moisture Content:	14.1	%
Final Saturation:	101.8	%
Specific Gravity:	2.65	Mg/m^3



Comments:
* Water Added

Operator (Preperation):	MM
Operator (Equipment):	MM
Compiled By:	VS
Checked By:	TG
Approved By:	TG

Collapse Potential

Results

Project:	Matimba Power Station
Client:	Jeffares and Green
Geolab Job Nr:	G14-0028
Test Method:	TMH 6 ST10 + Jennings

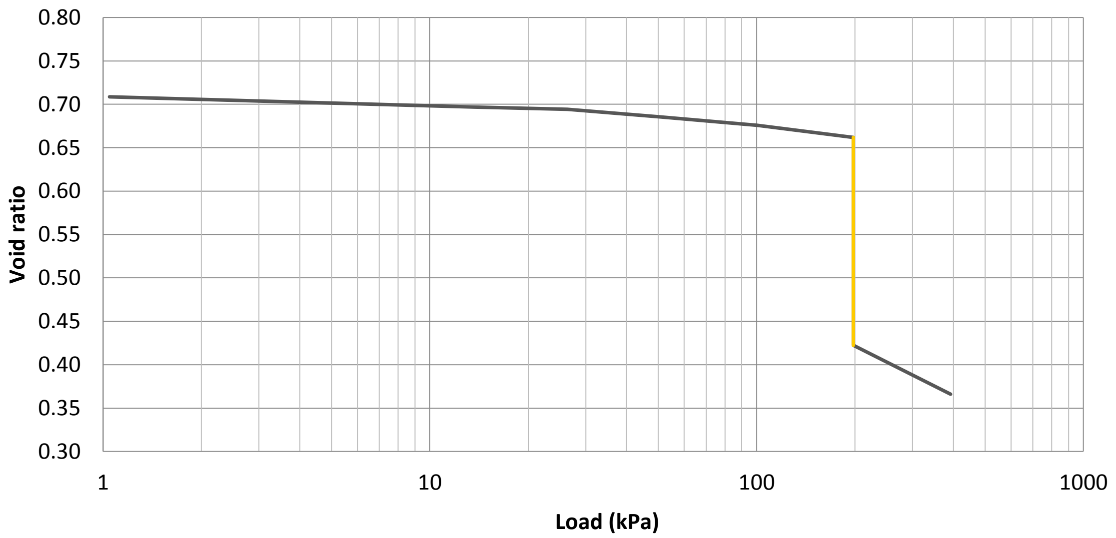
Sample Nr:	M4
Sample Depth:	0.28-1.8m
Date:	2014/05/16

Results		
Collapse Potential	14.0	%

Sample	
Sampling Method:	Block
Disturbed/Undisturbed:	Undisturbed
Remoulded To:	NA

Load (kPa)	Height (mm)	Void Ratio	
1.0	18.99	0.709	
13.7	18.862	0.697	
26.3	18.832	0.694	
51.0	18.733	0.685	
100.2	18.625	0.676	
197.5	18.47	0.662	
197.5	15.809	0.422	*
391.6	15.183	0.366	

Sample Detail		
Initial Sample Height:	18.99	mm
Initial Sample Weight:	61.9	g
Initial Dry Density:	1550	kg/m³
Initial Moisture Content:	6.2	%
Final Moisture Content:	14.1	%
Final Saturation:	101.8	%
Specific Gravity:	2.65	Mg/m³



Comments:
* Water Added

Operator (Preperation):	MM
Operator (Equipment):	MM
Compiled By:	VS
Checked By:	TG
Approved By:	TG

Oedometer

Results

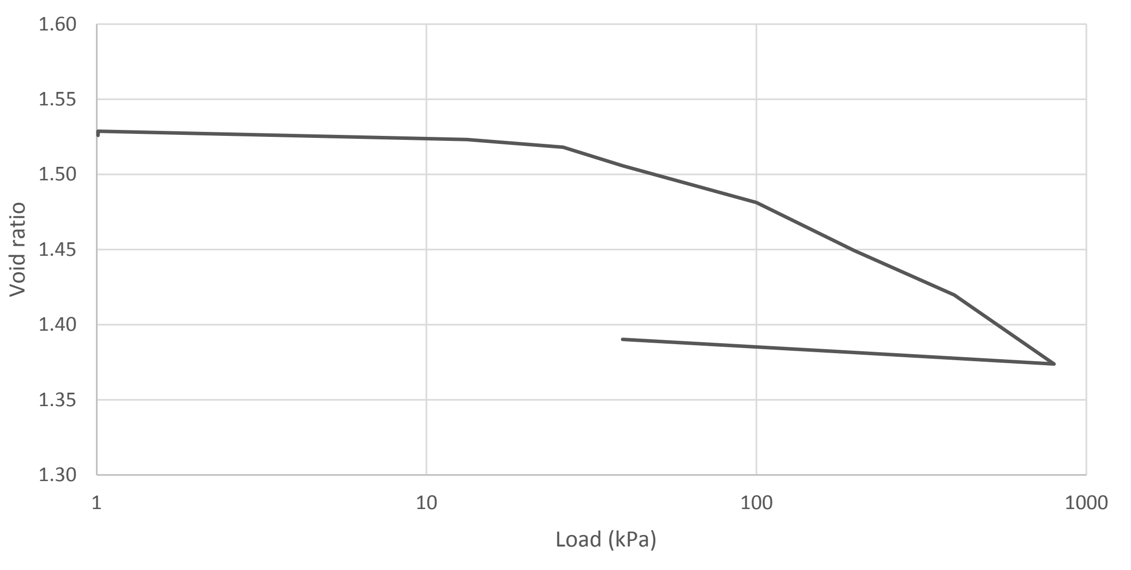
Project:	Matimba Power station
Client:	Jeffares and Green
Geolab Job Nr:	G14-0028
Test Method:	TMH 6 ST10

Sample Nr:	M12
Sample Depth:	0.7-0.45m
Date:	04 June 2014

Load (kPa)	Height (mm)	Void Ratio
1.0	18.79	1.526
1.0	18.81	1.529
13.2	18.769	1.523
25.9	18.732	1.518
39.3	18.64	1.506
100.0	18.457	1.481
197.4	18.22	1.449
397.1	18	1.420
797.3	17.659	1.374
197.4	17.715	1.381
39.3	17.78	1.390

Sample	
Sampling Method:	Block
Disturbed/Undisturbed:	Undisturbed
Remoulded To:	NA

Sample Detail		
Initial Sample Height:	18.79	mm
Initial Sample Weight:	39.9	g
Initial Dry Density:	926	kg/m³
Initial Moisture Content:	16.3	%
Final Moisture Content:	53.9	%
Final Saturation:	82.67	%
Specific Gravity:	2.34	Mg/m³



Comments:

Operator (Preperation):	MM
Operator (Equipment):	MM
Compiled By:	VS
Checked By:	TG
Approved By:	TG

Oedometer

Results

Project:	Matimba Power station
Client:	Jeffares and Green
Geolab Job Nr:	G14-0028
Test Method:	TMH 6 ST10

Sample Nr:	M12
Sample Depth:	0.7-0.45m
Date:	04 June 2014

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197.4	17.715	1.381
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Sample	
Sampling Method:	Block
Disturbed/Undisturbed:	Undisturbed
Remoulded To:	NA

Sample Detail		
Initial Sample Height:	18.79	mm
Initial Sample Weight:	39.9	g
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Final Saturation:	82.67	%
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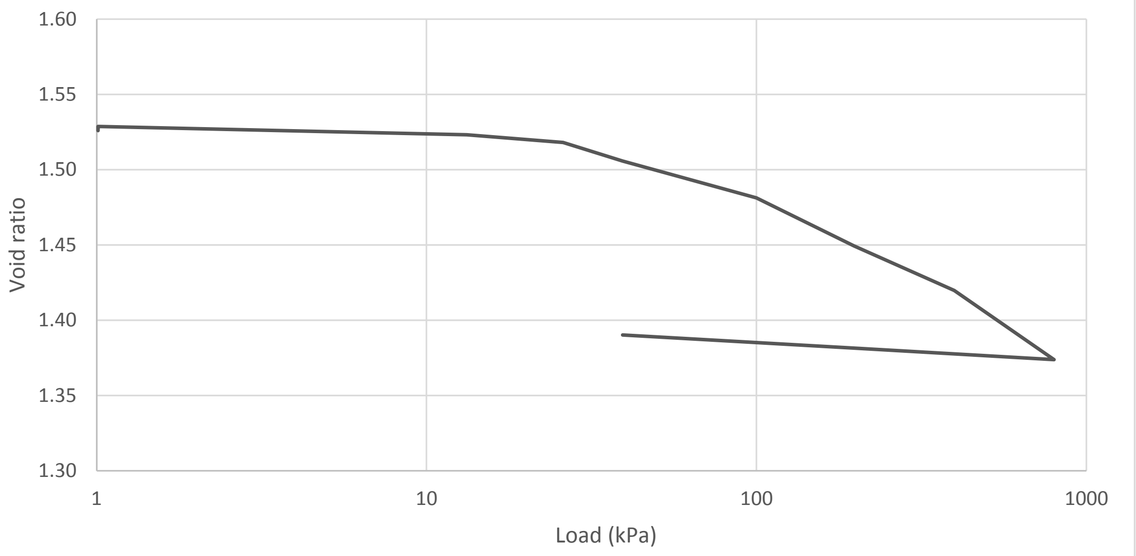


Comments:

Operator (Preperation):	MM
Operator (Equipment):	MM
Compiled By:	VS
Checked By:	TG
Approved By:	TG

Shearbox Test

Results Summary

Project:	Matimba Power Station
Client:	Jeffares & Green
Geolab Job Nr:	G14-0028
Test Method:	BS1377-7: 1990

Sample Nr:	M4
Sample Depth:	0.70-0.95m
Date:	04-Jun-14

Results		
ϕ' =	32.8	°
c' =	5.8	kPa

Sample	
Sampling Method:	Block
Disturbed/Undisturbed:	Undisturbed
Remoulded To:	-

Initial Sample Details	1	2	3	
Sample Length:	21	21	21	mm
Sample Diameter:	60	60	60	mm
Sample Volume:	59.38	59.38	59.38	cm^3
Sample Area:	28.3	28.3	28.3	cm^2
Sample Weight:	116.4	116.4	116.2	g
Specific Gravity:		2.698		
Moisture Content:	3.6	2.8	3.9	%
Dry Density:	1795	1810	1787	kg/m^3

Shear Stage	1	2	3	
Rate of Shear:	0.006	0.006	0.006	mm/min
Normal Stress:	74.3	149.8	299.8	kPa
Max Shear Stress:	55.2	99.7	199.5	kPa
Strain at Failure:	8.45	10.57	11.08	%

Final Sample Details	1	2	3	
Sample Weight:	128.5	127.8	125.8	g
Moisture Content:	14.9	13.4	12.9	%

Comments:

Operator (Preperation):	MM
Operator (Equipment):	FC
Compiled By:	MG
Checked By:	TG
Approved By:	TG

SMEC
Local People. Global Experience.

GEOLAB
Part of the SMEC Group

Shearbox Test

Graphs

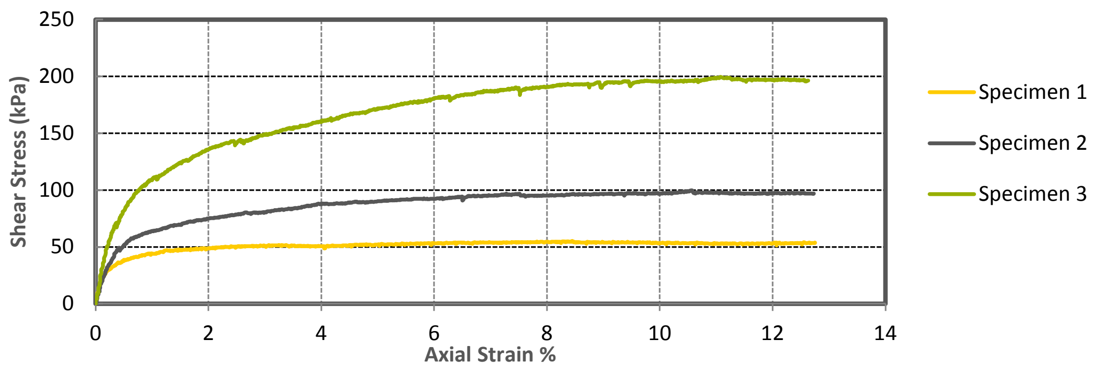
Project:	Matimba Power Station
Client:	Jeffares & Green
Geolab Job Nr:	G14-0028
Test Method:	BS1377-7: 1990

Sample Nr:	M4
Sample Depth:	0.70-0.95m
Date:	04-Jun-14

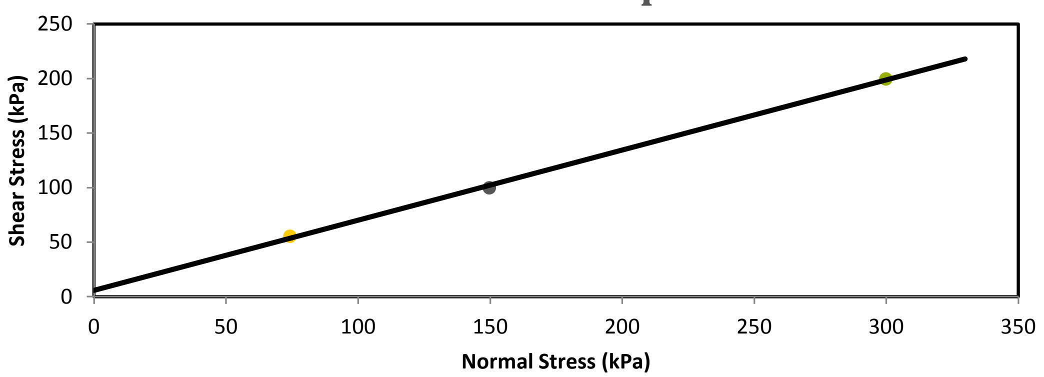
Results		
ϕ' =	32.8	°
c' =	5.8	kPa

Sample	
Sampling Method:	Block
Disturbed/Undisturbed:	Undisturbed
Remoulded To:	-

Shear Stress vs Axial Strain



Failure Envelope



Comments:	

Operator (Preperation):	MM
Operator (Equipment):	FC
Compiled By:	MG
Checked By:	TG
Approved By:	TG

Shearbox Test

Results Summary

Project:	Matimba Power Station
Client:	Jeffares & Green
Geolab Job Nr:	G14-0028
Test Method:	BS1377-7: 1990

Sample Nr:	M4
Sample Depth:	0.70-0.95m
Date:	04-Jun-14

Results		
ϕ' =	32.8	°
c' =	5.8	kPa

Sample	
Sampling Method:	Block
Disturbed/Undisturbed:	Undisturbed
Remoulded To:	-

Initial Sample Details	1	2	3	
Sample Length:	21	21	21	mm
Sample Diameter:	60	60	60	mm
Sample Volume:	59.38	59.38	59.38	cm^3
Sample Area:	28.3	28.3	28.3	cm^2
Sample Weight:	116.4	116.4	116.2	g
Specific Gravity:		2.698		
Moisture Content:	3.6	2.8	3.9	%
Dry Density:	1795	1810	1787	kg/m^3

Shear Stage	1	2	3	
Rate of Shear:	0.006	0.006	0.006	mm/min
Normal Stress:	74.3	149.8	299.8	kPa
Max Shear Stress:	55.2	99.7	199.5	kPa
Strain at Failure:	8.45	10.57	11.08	%

Final Sample Details	1	2	3	
Sample Weight:	128.5	127.8	125.8	g
Moisture Content:	14.9	13.4	12.9	%

Comments:

Operator (Preperation):	MM
Operator (Equipment):	FC
Compiled By:	MG
Checked By:	TG
Approved By:	TG

Shearbox Test

Graphs

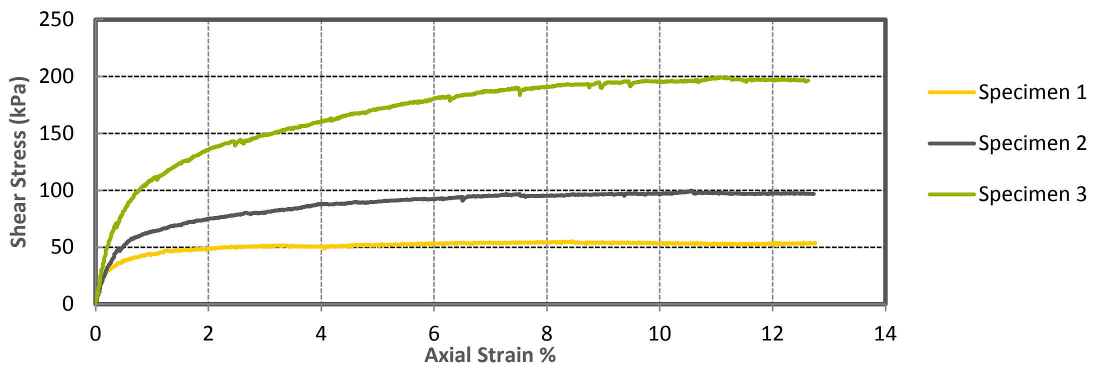
Project:	Matimba Power Station
Client:	Jeffares & Green
Geolab Job Nr:	G14-0028
Test Method:	BS1377-7: 1990

Sample Nr:	M4
Sample Depth:	0.70-0.95m
Date:	04-Jun-14

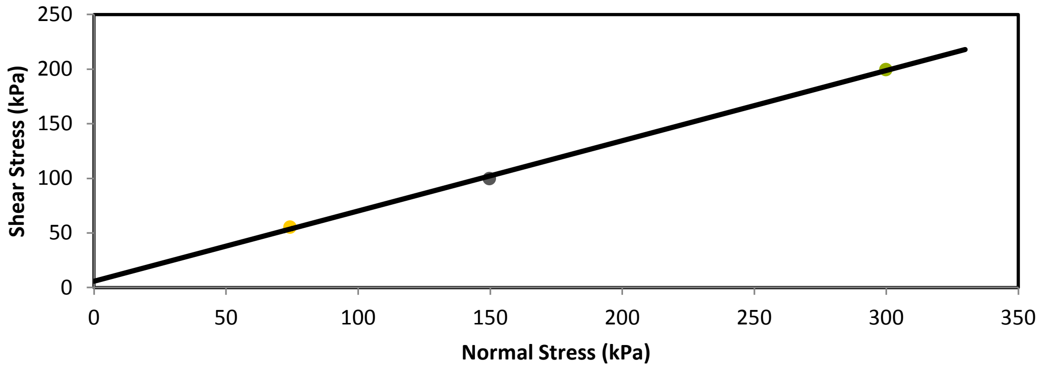
Results		
ϕ' =	32.8	°
c' =	5.8	kPa

Sample	
Sampling Method:	Block
Disturbed/Undisturbed:	Undisturbed
Remoulded To:	-

Shear Stress vs Axial Strain



Failure Envelope



Comments:

Operator (Preperation):	MM
Operator (Equipment):	FC
Compiled By:	MG
Checked By:	TG
Approved By:	TG

Shearbox Test

Results Summary

Project:	Matimba Power Station
Client:	Jeffares & Green
Geolab Job Nr:	G14-0028
Test Method:	BS1377-7: 1990

Sample Nr:	M12
Sample Depth:	0.70-0.95m
Date:	04-Jun-14

Results		
ϕ' =	33.6	°
c' =	2.9	kPa

Sample	
Sampling Method:	Block
Disturbed/Undisturbed:	Undisturbed
Remoulded To:	-

Initial Sample Details	1	2	3	
Sample Length:	20.09	20.09	20.09	mm
Sample Diameter:	59.93	59.93	59.93	mm
Sample Volume:	56.67	56.67	56.67	cm^3
Sample Area:	28.2	28.2	28.2	cm^2
Sample Weight:	59.4	59.5	62.8	g
Specific Gravity:		2.34		
Moisture Content:	9.8	10.9	10.7	%
Dry Density:	849	842	895	kg/m^3

Shear Stage	1	2	3	
Rate of Shear:	0.004	0.004	0.004	mm/min
Normal Stress:	74.4	150.0	299.4	kPa
Max Shear Stress:	56.1	97.2	204	kPa
Strain at Failure:	8.38	13.17	9.23	%

Final Sample Details	1	2	3	
Sample Weight:	84.6	82.9	82.2	g
Moisture Content:	62.2	60.0	48.9	%

Comments:

Operator (Preperation):	MM
Operator (Equipment):	FC
Compiled By:	MG
Checked By:	TG
Approved By:	TG

Shearbox Test

Graphs

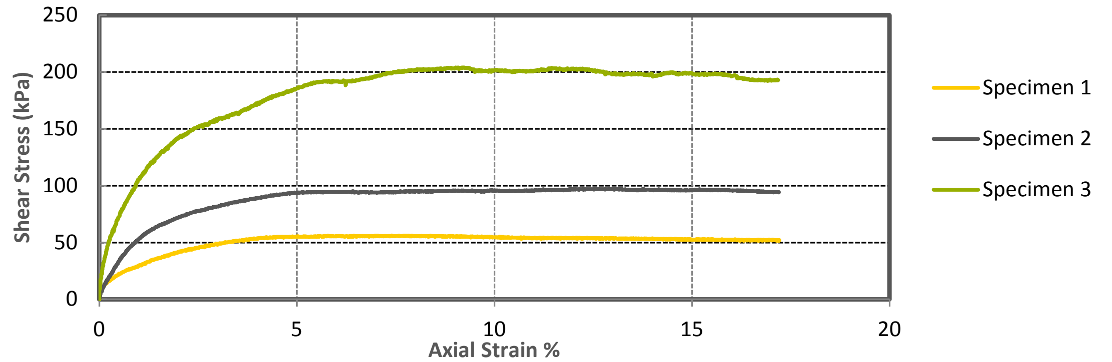
Project:	Matimba Power Station
Client:	Jeffares & Green
Geolab Job Nr:	G14-0028
Test Method:	BS1377-7: 1990

Sample Nr:	M12
Sample Depth:	0.70-0.95m
Date:	04-Jun-14

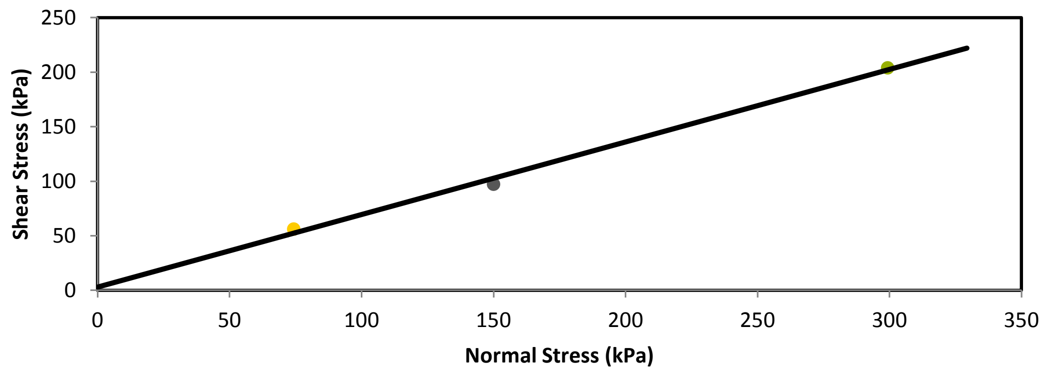
Results		
ϕ' =	33.6	°
c' =	2.9	kPa

Sample	
Sampling Method:	Block
Disturbed/Undisturbed:	Undisturbed
Remoulded To:	-

Shear Stress vs Axial Strain



Failure Envelope



Comments:

Operator (Preperation):	MM
Operator (Equipment):	FC
Compiled By:	MG
Checked By:	TG
Approved By:	TG

Shearbox Test

Results Summary

Project:	**Matimba Power Station**
Client:	**Jeffares & Green**
Geolab Job Nr:	**G14-0028**
Test Method:	**BS1377-7: 1990**

Sample Nr:	**M12**
Sample Depth:	**0.70-0.95m**
Date:	**04-Jun-14**

Results		
ϕ' =	**33.6**	**°**
c' =	**2.9**	**kPa**

Sample	
Sampling Method:	Block
Disturbed/Undisturbed:	Undisturbed
Remoulded To:	-

Initial Sample Details	1	2	3	
Sample Length:	20.09	20.09	20.09	mm
Sample Diameter:	59.93	59.93	59.93	mm
Sample Volume:	56.67	56.67	56.67	cm^3
Sample Area:	28.2	28.2	28.2	cm^2
Sample Weight:	59.4	59.5	62.8	g
Specific Gravity:		2.34		
Moisture Content:	9.8	10.9	10.7	%
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Comments:

Operator (Preperation):	MM
Operator (Equipment):	FC
Compiled By:	MG
Checked By:	TG
Approved By:	TG

Version No: SB.03.02.03

Shearbox Test

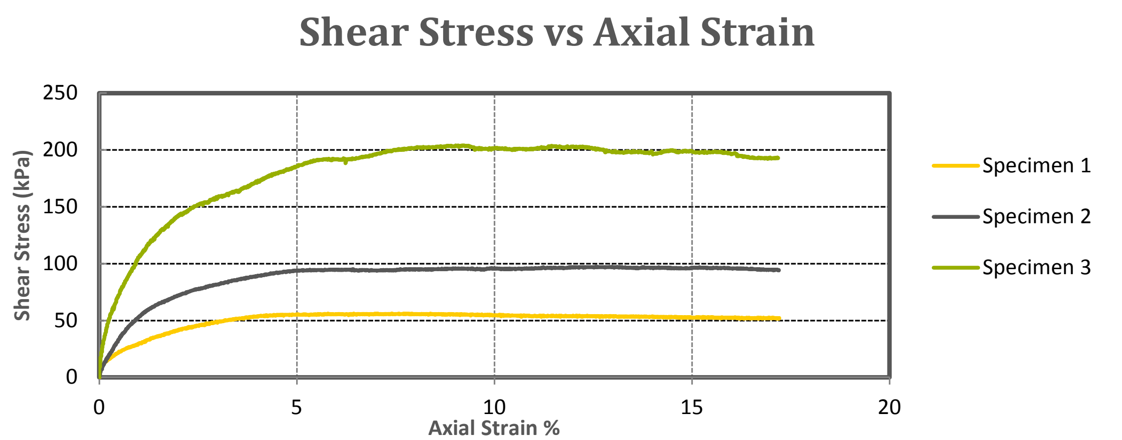
Graphs

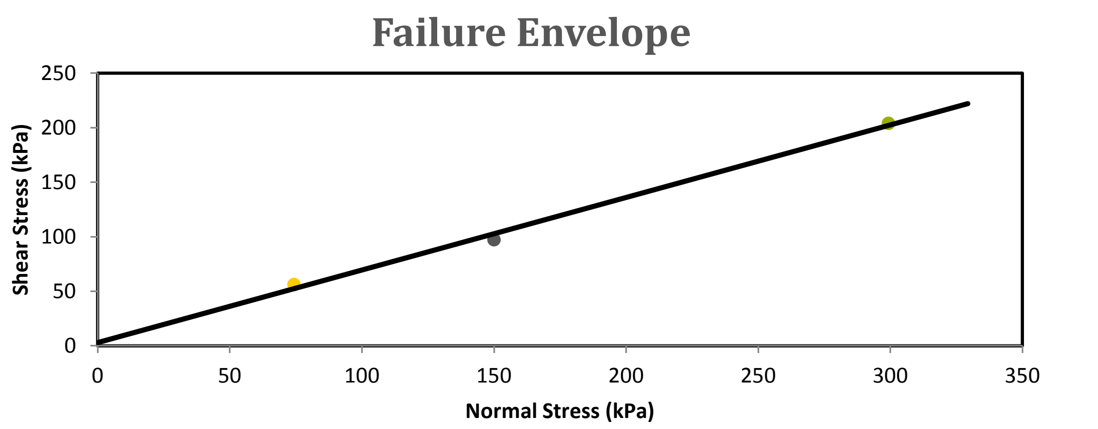
Project:	Matimba Power Station
Client:	Jeffares & Green
Geolab Job Nr:	G14-0028
Test Method:	BS1377-7: 1990

Sample Nr:	M12
Sample Depth:	0.70-0.95m
Date:	04-Jun-14

Results		
ϕ' =	33.6	°
c' =	2.9	kPa

Sample	
Sampling Method:	Block
Disturbed/Undisturbed:	Undisturbed
Remoulded To:	-





Comments:

Operator (Preperation):	MM
Operator (Equipment):	FC
Compiled By:	MG
Checked By:	TG
Approved By:	TG