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GEOTECHNICAL SITE INVESTIGATION REPORT

FOR

THE PROPOSED LUCKHOF WASTE DISPOSAL FACILITY, LETSEMENG LOCAL MUNICIPALITY, FREE STATE PROVINCE

FINAL REPORT

18th October, 2021

Table of Contents

List of Tables

List of Figure

DOCUMENT CONTROL

Report title		GEOTECHNICAL INVESTIGATION REPORT FOR THE PROPOSED LUCKHOF WASTE DISPOSAL FACILITY, LETSEMENG LOCAL MUNICIPALITY, FREE STATE PROVINCE				
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Abbreviations

AASHTO	American Association of Highway and Transport Officials
CBR	California Bearing Ratio
GM	Grading Modulus
LL	Liquid Limit
LS	Linear Shrinkage
MDD	Maximum Dry Density
NP	Non-Plastic
OMC	Optimum Moisture Content
PL	Plastic Limit
PI	Plasticity Index
SP	Slightly Plastic
TP	Test Pit
BNGL	Below Natural Ground Level

1. Introduction

On the 23rd July 2021 Dipabala Solutions (Pty) Ltd appointed Geotechnical Engineering Laboratory (Pty) Ltd (GEL) to carry out the geotechnical site investigation for the proposed Luckhof Waste Disposal Facility, Letsemeng Local Municipality in the Free State Province. The proposed Waste Disposal Facility will consist of the construction of Leachate Containment Structure, Leachate Collection System, Contaminated Stormwater Structures, Clean water Stormwater structures, Waste Sorting Facility and the Fencing of the entire Facility.

2. Investigation Objectives

The objectives of the investigation are to:

1. Identify any potential geotechnical hazards;
2. Define the ground conditions and provide provisional site class designations;
3. Comment on possible shallow groundwater conditions;
4. Provide foundation options;
5. Discuss suitability of on-site materials for general construction purposes;
6. Provide earthwork recommendations;
7. Discuss any shortcomings identified during this study with recommendations on the way forward.

The objectives are addressed in the relevant report sections.

3. Available information

The following available information was used in the assessment:

- 1:250 000-scale 2924 Koffiefontein geological sheets;
- Approximate site boundaries;
- Available Google-Earth satellite images;
- Detailed soil profile descriptions conducted for the purposes of this assessment;
- Soil profile photographs;
- Soil laboratory test results conducted specifically for the assessment;
- Site layout plan;
- Local knowledge of the area.

4. Site Description

4.1. Site Locality and Existing Services

Luckhoff
Luckhoff is situated some 180km South-East of the City of Bloemfontein. The proposed site for Development is located to the East of Relebohile Township (within 2km), along the R48 Road linking Koffiefontein with Pretrusville and Orania (through Luckhoff).

The site is currently not accessible through any road, however, there is an existing gravel road to the Electricity Substation that could easily be extended to gain access to the proposed site. Generally, the area slope towards the western direction at the slope of approximately 3%.

The approximate centre site coordinate is (Decimal degrees):

Lat: 29°44'11.59"S
Lon: 24°48'10.93"E

The site has an approximate surface area of ~24 Ha.

The site is currently being used as livestock grassing land. The site is within reach of water, sewer and electrical services.

Figure 1: Locality Map of Luckhoff Township Development

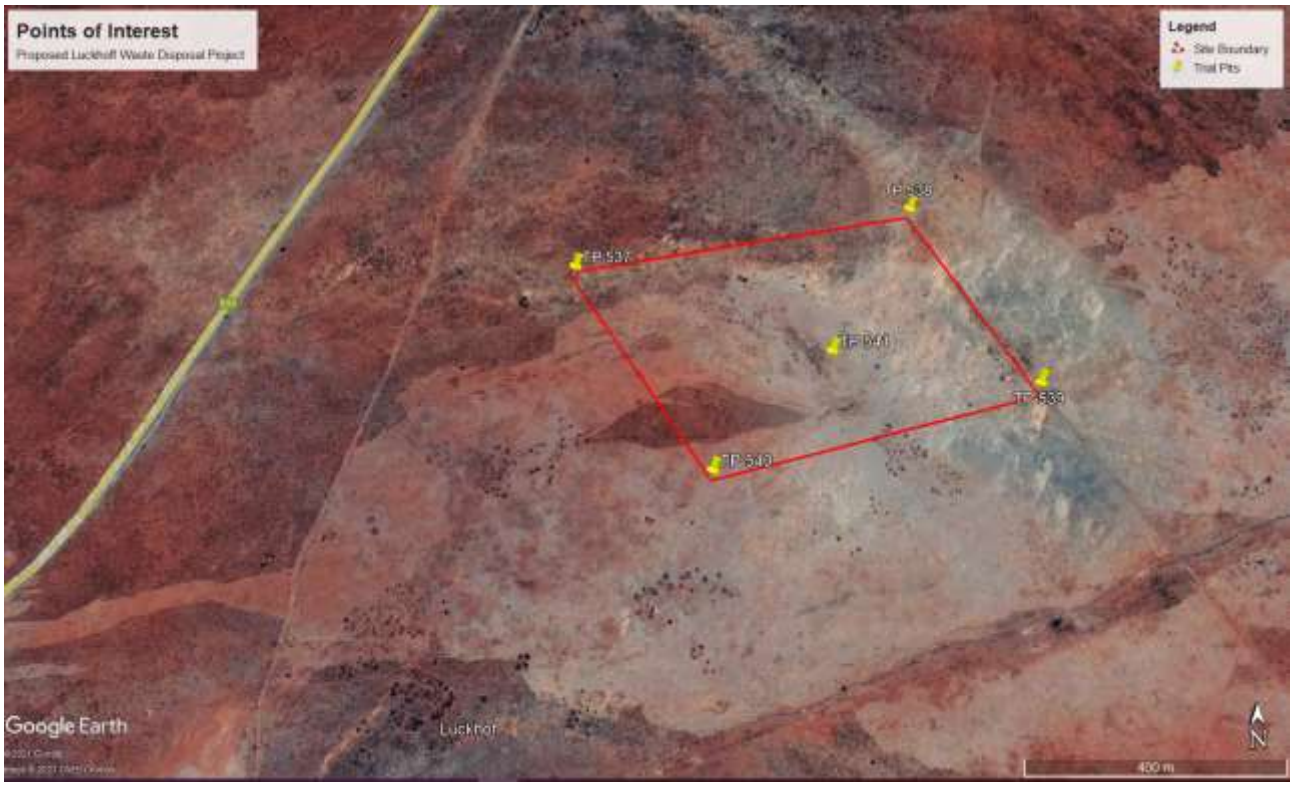


Figure 2: Approximate Site Boundary with 5 trial pits positions

4.2. Site Vegetation and Climate

The site is currently covered with sporadic natural tall grass with thorny shrubs. There were no trees recorded on site. Termites mounds were identified around the area of interest.

The climate of Luckhoff: Luckhoff normally receives about 395 mm of rain per year, with most rainfall occurring mainly during summer (January, February and March). The average rainfall values for Luckhoff per month; It receives the lowest rainfall (4 mm) in July and the highest (40 mm) in January, February and March. The monthly distribution of average daily maximum temperatures shows that the average midday temperatures for Luckhoff range from 1°C in June and July to 36°C in December to January. The region is the coldest during July when the mercury drops below -5°C on average during the night.

The climate is an important parameter in determining the climatic N-value, which is a function of the rainfall and evaporation rate. The N-value is used to determine the predominant mode of weathering that can be expected in a region.

N=5 represents the boundary between physical and chemical weathering, meaning that for areas with an N-value of less than 5 chemical weathering will predominate, and for areas with an N-value greater than 5 physical weathering processes will be the most pronounced (Weinert, 1980).

The Weinert's N-value is calculated from the climatic data as follows:

$N = (12 \times E_j) / P_a$

Where;

E_j = Evaporation during January

P_a = annual precipitation

According to the contour map of climatic N-values for Southern Africa (Weinert, 1980), the expected N-values for the area of study is greater than 5.

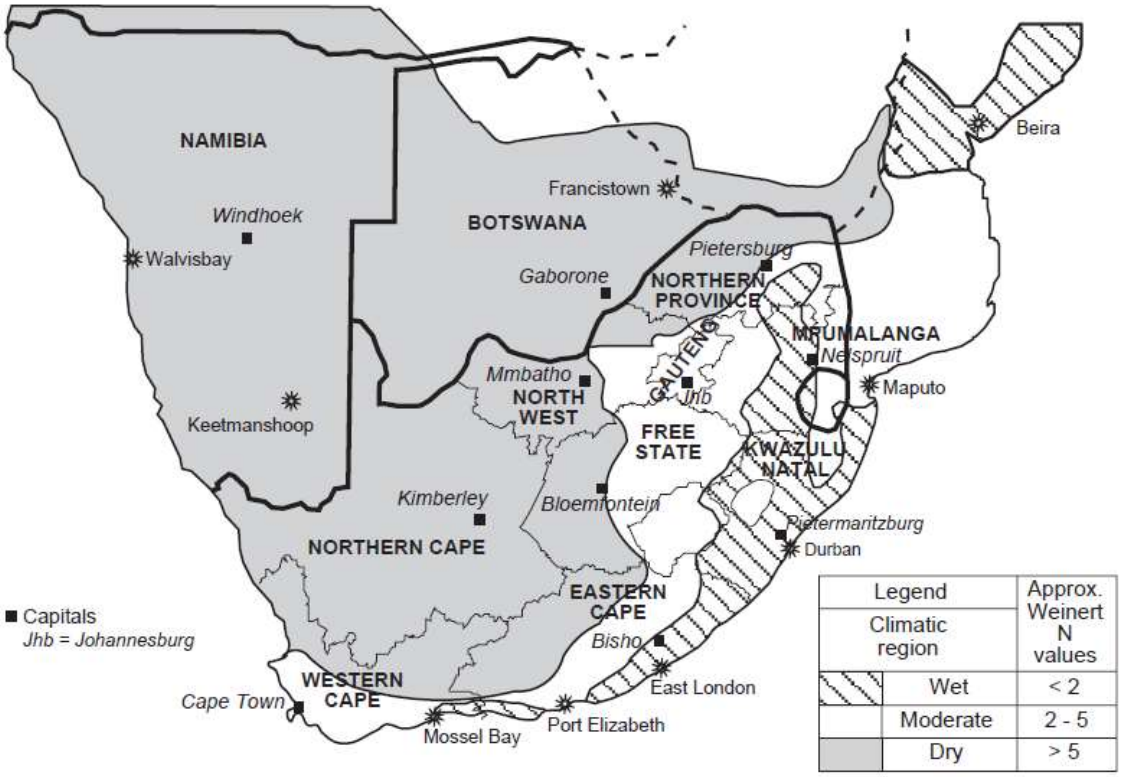


Figure 3: Macro-climatic regions of Southern Africa

The predominant form of weathering in the area are expected to be Physical of nature, with shallow expected soil profiles. The weathering mode is however also influenced by the topography and nature of drainage.

5. Method of Site Investigation

The site investigation was carried out on the 07th October, 2021 and involved excavation of five (5) shallow soil evaluation test pits with a JCB 4x4 TLB (Backhoe) to an approximate depth of 3.0m or refusal, whichever came first. The test pits were profiled using "Revised Guide to Soil Profiling for Civil Engineering Purposes in Southern Africa by Jennings JEB, Brink ABA and Williams AAB (1973)". Two representative soil samples were taken from each test pit and the following tests were carried out

- Sieve Analysis
- Atterberg Limits
- Hydrometer Test
- Mod AASHTO
- CBR

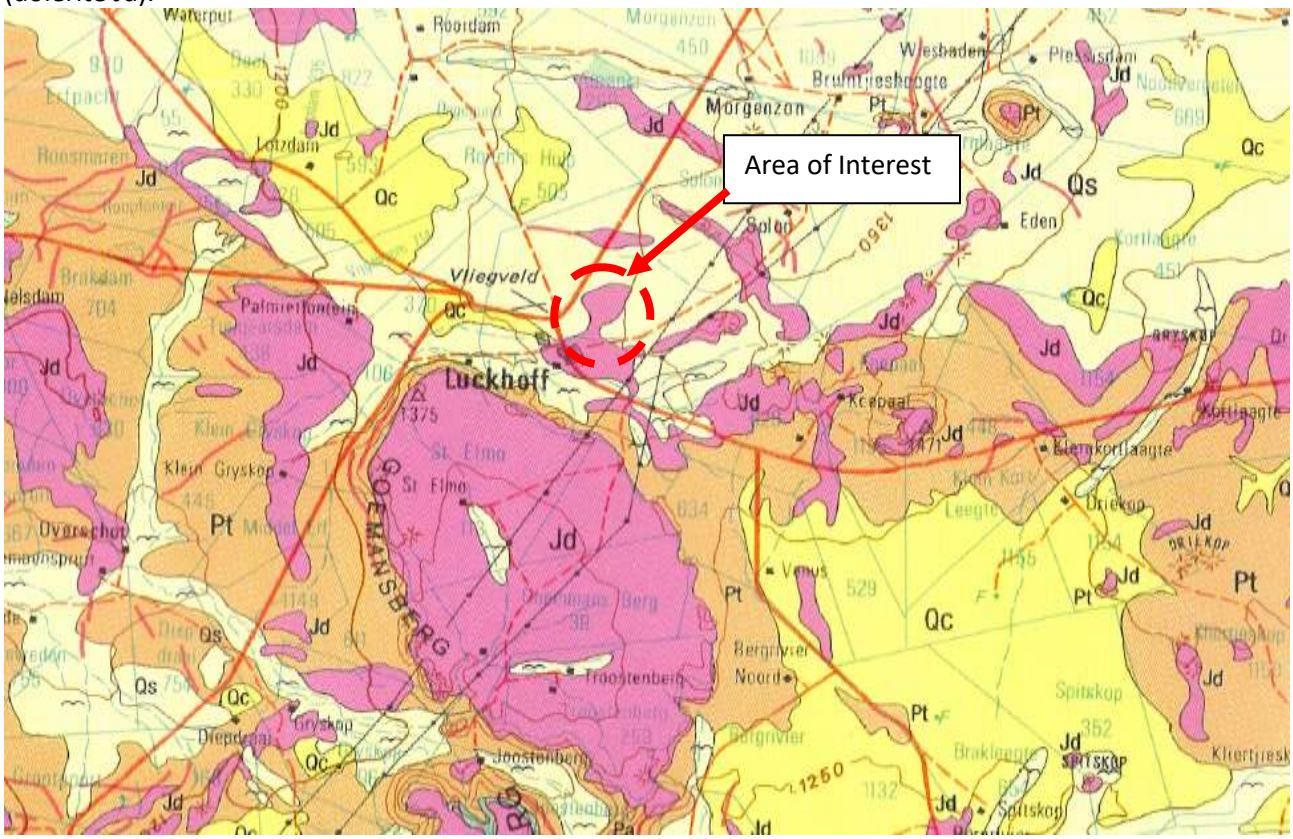
These tests were carried out mainly to classify the soils found on the project area and assess their suitability for use in construction activities.

6. Site Geology

6.1. Regional Geology

Luckhoff

General geology of Luckhoff is shown on the Geological Map series of the Republic of South Africa Sheet No. 2924 (Koffiefontein), and scale 1:250,000. The area is regionally characterised by the sedimentary rocks of Quaternary formation. The area is dominated by Aeolian sand (Qs) with crop up of intrusive rocks (dolerite Jd).



Luckhoff Location

Figure 4: Geological map showing the regional geology of site

6.2. Local Geology

The local geology of the site may be interpreted from fieldwork results. The site is covered by transported soils (Aeolian sand) underlain by intrusive rock (dolerite). The test pit profiling typically confirmed what is indicated on the geological sheet and revealed the following elements in the soil profile.

- **Transported Soils**: These are soils that have been transported by a natural agent (wind-blown sand, hill wash, etc) during relatively recent geological times and which have not undergone lithification into sedimentary rock or cementation into pedogenic material.
- **Residual soils**: Soils derived from the weathering of underlying dolerite rock and have not moved from the place of origin as with transported soils

6.3. Soil Profile

The soil layers found on these project sites are attached as ***Appendix A*** of this report and show the following soils

TP 537

29°44'6.07"S
24°47'56.22"E

0 – 300 mm	Moist red loose intact silty sand
300 – 700 mm	Moist greyish white dense intact decomposed sugary gravel

Refuse at Gravel

TP 538

29°44'2.53"S
24°48'18.43"E

0 – 300 mm	Moist red loose intact silty sand
300 – 500 mm	Moist brown dense intact decomposed sugary gravel

Refuse at Gravel

TP 539

29°44'13.59"S
24°48'25.57"E

0 – 400 mm	Moist red loose intact silty sand
400 – 1000 mm	Slightly moist grey dense intact sugary gravel

Refuse at Gravel

TP 540

29°44'18.06"S
24°48'4.99"E

0-700 mm	Moist red loose intact silty sand
700-2100mm	Slightly moist yellowish brown loose silty sand

TP 541

29°44'11.29"S
26°48'12.76"E

0-500 mm	Dry firm reddish brown silty sand
500-700mm	Slightly moist firm reddish-brown silty sand

The soil profiles from the project site indicate that the site is dominated by reddish silty sand underlain by greyish white, brown to grey sugary gravel. In TP 540 reddish silty sand is underlain by yellowish brown silty sand. In essence TP 540 comprises mostly of silty sand up to about 2100 mm depth

7. Groundwater Conditions

No groundwater encountered during site investigation.

8. Geotechnical Evaluation

The relevant engineering characteristics were evaluated visually during site investigation and soil profiling. This evaluation was also done from laboratory testing as discussed below.

8.1.Foundation Indicator Test Results

Foundation indicator test results i.e. Hydrometer Test, Sieve Analysis and Atterberg Limits test results are summarized in Table 8.1 below.

Table 8.1 Foundation Indicator Test Results

TP #	Depth (mm)	Sieve Analysis				Atterberg Limits					Hydrometer Test	
		% < 2.00 mm	% < 0.425 mm	% < 75 µm	GM	LL (%)	PL (%)	PI (%)	LS (%)	AASHTO Class	% Clay	Potential Heave
TP 537	0-300	**78.5**	**61**	**19.1**	**1.4**	**19**	**20**	**4**	**1**	**A-2-4**		
TP 537	300-700	**45.1**	**32.1**	**10.8**	**2.1**	**25**	**19**	**6**	**3**	**A-1-b**		
TP 538	0-300	**92.2**	**76.6**	**33.5**	**1.0**	**21**	**16**	**5**	**2**	**A-2-4**		
TP 538	300-500	**36.6**	**17.3**	**7.2**	**2.4**			**NP**		**A-1-b**	**0**	**LOW**
TP 539	0-400	**98.5**	**84.4**	**37.7**	**0.8**	**21**	**16**	**5**	**2**	**A-4**		
TP 539	400-1000	**51.7**	**17.6**	**7.5**	**2.2**	**27**	**19**	**8**	**4**	**A-1-b**		
TP 540	0-700	**99.7**	**89.8**	**39.8**	**0.7**	**22**	**16**	**6**	**3**	**A-4**		
TP 540	700-2100	**99.5**	**89.9**	**40.4**	**0.7**	**23**	**18**	**5**	**2**	**A-4**		
TP 541	300-500	**97**	**94**	**77**	**0.3**	**38**	**20**	**18**	**8.8**	**A-1-a**		
TP 541	600-1800	**98.5**	**84.4**	**37.7**	**0.8**	**23**	**28**	**5**	**2**	**A-4**		

The results in Table 8.1 indicate that

Soils from these project sites are classified as A-2-4 (Silty gravel of low compressibility), A-1-b (gravel and sand of low compressibility), A-4 (Silty Sand of low compressibility), and A-1-a (Stone fragments, gravel and sand of Low compressibility), according to AASHTO classification system.

According to Unified Soil Classification System (USCS), the soil from site classifies as the following GW/GM, and SM.

GW: Well graded gravels/Silty gravels, **(Gravel-sand mixtures with little or no fines)**
GM: Silty gravels, gravel-sand-silt mixtures **(Gravel-sand-silt mixtures (gravel with fines)**
SM: Silty Sands, poorly graded silt-sand mixtures, **(Silty sands/sand-silt mixtures)**

The USCS indicates that the project soils **(GW)** consist of Course-grained soils (more than 50 % retained on the 0.075 mm sieve), splits into gravels (50% or more of course fraction retained on the 4.75mm), these soils are clean gravels **(Gravel-sand mixtures with little or no fines),** have low compressibility, low potential heave **(compressible soils),** with an expected range of top soil movement less than 10 (Sandy and gravelly) and as a result the sites are classified as **S**

The USCS indicates that the project soils **(GM)** consist of Course-grained soils (more than 50 % retained on the 0.075 mm sieve), splits into gravels (50% or more of course fraction retained on the 4.75mm), these soils are gravels with fines **(Silty gravels, gravel-sand-silt mixtures),** have low compressibility, low potential

heave **(compressible soils),** with an expected range of top soil movement between 10-20mm (Clayey gravels) and as a result the sites are classified as **S1**

The USCS indicates that the project soils **(SM)** consist of Course grained soils with more 50% retained on 0.075 mm sieve, and further split into Sands (with Fines) (50% or more of course fraction passes on the 4.75 mm sieve). These soils (Silty Sand) thus have low Compressibility, low potential heave and low Potential Collapsibility with an expected range of top soil movement between 5-10mm (Silty sands) and as a result the sites are classified as **C1.**

In summary
TP 537, TP 538, and TP 539 = **GW/GM** and therefore classify as **S/S1**
TP 540 and TP 541 = **SM** and therefore classify as **C1**

8.2. Compaction and CBR Test Results

CBR and Compaction tests were carried out on soil samples obtained from the test pits. The results are summarized in Table 8.2 below.

Table 8.2 Compaction and CBR Test Results

TP #	Depth (mm)	CBR @						COLTO Class
		100 %	98 %	97 %	95 %	93 %	90 %	
TP 537	300-700	36.3	32.6	31.3	27.5	24.3	19.3	**G6**
TP 538	300-500	29.8	26.5	24.8	21.8	18.5	13.8	**G7**
TP 539	400-1000	30	26.1	24.0	19.8	15.5	9.5	**G7**
TP 540	700-2100	14.0	12.5	12.0	10.8	9.5	7.8	**Unclassified**
TP 541	600-1800	14.0	12.5	12.0	10.8	9.5	7.8	**Unclassified**

Test results in Table 8.2 indicate that soil from Project Site TP 537, 538 and 539 are Classified as G6 and G7 respectively, whereas in TP540 and TP541 are Unclassified according to COLTO classification systems. According to COLTO unclassified materials are unsuitable for use as construction fill material.

8.3. Shear Strength Parameters

Shear box test was carried out on TP 538b (gravel). The shear strength parameters of this gravel are shown in Table 8.3 below.

Table 8.3 Shear Strength Parameters

TP #	Depth, mm	ϕ'	c'	ρ	γ	ρ_{dry}	γ_{dry}
TP 538b	300-500	39.7°	17.1 kPa	2375 kg/m^3	23.3 kN/m^3	2211 kg/m^3	21.7 kN/m^3

8.4.Bearing Capacity

Bearing capacity determination for this project is done using the shear strength parameters stated above. The determination is done per square metre and assuming a factor of safety of 3. Founding depth is also assumed to be 1 m. The calculations are shown in Table 8.5 below.

Table 8.4 Bearing Capacity Determination

TP #	Depth, mm	ϕ'	c'	ρ	γ	ρ_{dry}	γ_{dry}	q_u	q_a
TP 74b	350-450	39.7°	17.1 kPa	2375 kg/m³	23.3 kN/m³	2211 kg/m³	21.7 kN/m³	2213.3 kPa	737.7 kPa

Note: q_u = ultimate bearing capacity, q_a = allowable bearing capacity

8.5.Seepage

Falling head test was carried out on TP 538b to determine seepage properties of the soils found on the project site. The test results are summarized in Table 8.5 below.

Table 8.5 Falling Head Permeability

TP #	Depth (mm)	Specific Gravity	Permeability, k (cm/s)	Degree of Permeability
TP 538b	300-500	***2.770***	***8.45E-06***	***LOW***

Table 8.6 above indicates that the gravels on the proposed Luckhoff Waste Disposal site possess low degree of permeability.

8.3.Impact of geotechnical character on the site

The proposed Luckhoff Waste Disposal site is located on a dolerite intrusion and partly on sand. The material coming from this intrusion is porous and this property makes it easy for the water/leachate to flow. During construction of the landfill the gravel from this area will have to be compacted to at least 95 % of Mod AASHTO in order to reduce its porosity.

The site is dominated by reddish silty sand underlain by greyish white, brown to grey sugary gravel and silty sand at some points. In terms of US Classification System, the site has GW/GM and SM soils material.

GW/GM can be used for both as founding and filling material for construction as they possess excellent compaction characteristics. For the purpose of the Landfill GW/GM material are unsuitable to be used as Water retaining Embankments, and have excellent (GW) and average (GM) qualities to be used as None-water retaining Embankments.

SM can be used as founding material for building foundations as they possess good (density important) compaction characteristics; however, they are unsuitable to use as fill material as they possess average compaction characteristics. Similarly, for the purpose of the Landfill SM material are suitable (with compaction) to be used as Water retaining Embankments, and have average qualities to be used as None-water retaining Embankments.

All materials from this project were excavated using a TLB Excavation and as such the excavation can be classified as soft to intermediate excavation as per SABS 1200 D-1988 (as amended 1990).

8.4. Compaction Characteristics

The upper transported topsoil and colluvial materials in general contains high percentages of silts and silty sand. The compressibility and compaction ratings, based on the soil classifications are provided in **Appendix D**

Materials classifying as "**GW**" (the coarser grained soils) generally has excellent compaction characteristics. Materials classifying as "**GM**" (the coarser grained soils) generally has excellent compaction characteristics.

Materials classifying as "**SM**" (the coarser grained soils) generally has good compaction characteristics.

8.5. Slope Stability and Erosion

No natural steep slopes exist, and natural slope instability cannot occur.

The slopes of the confined vertical inspection trenches were stable during the short period of investigation (+/- 6 hours) with no indications of bulging/toppling/ravelling. It should however be emphasised that instability can be expected in unconfined and confined conditions with an increase in moisture content as expected during the wet season. Any excavations should be inspected by a competent person. Any manned excavations should be inspected and approved by a competent person as per the health and safety regulations.

The general safety regulations (GSR13) which stated that no employer may require or permit any person to and no person shall, work in an excavation more than 1.5m deep and which has not been adequately shored or braced if there is a danger of the sides of the excavation have a potential for collapse, **no longer apply.**

Regulation 13(2)(b) state that no work in unbraced excavations will be allowed unless:

1. Battered to angle of repose or
2. In stable material, and
3. permission in writing by competent person and where uncertain,
4. professional assessment in writing.

A competent person (suitably qualified and experienced preferably geotechnical engineer or and/or engineering geologist) should inspect any excavations to be entered:

1. Daily, prior to each shift;
2. After every blasting operation;
3. After an unexpected fall of ground;

4. After substantial damage to any supports; and
5. After any rain event.

Permission to enter any excavation should be granted in writing by the competent person daily and before/after the events as listed above for each separate pipeline section or excavation. The above is essential in order to evaluate the safety of the excavation to ensure the safety of persons working and around the trenches/excavations. The inspections are to be recorded in a register kept on site and made available to an inspector, client, client's agent, contractor or employee on request.

The excavation work requirements as per the Construction Regulations should be implemented by the client/agent/principal contractor/contractor as stipulated in the regulations or as otherwise specified in writing by the responsible engineer.

The following batter angles can be considered for low height cut slopes (Less than 3 m deep cuts) for planning purposes (the angles should be confirmed by a competent person once excavation details are known).

- Permanent slope batter: 1V:2H to 1V:5H (Height and load dependant for slopes within the residuum. Batters more than 3m should be evaluated).
- Temporary slope batter: Maximum of 1V:2H (Height and load dependant. Batters more than 2m should be evaluated).

The upper soils are expected to have a high susceptibility to erosion once exposed and subject to concentrated water flow. Basic surface water management will be required to avoid concentrated water flow in order to limit excessive soil erosion.

Basic erosion control measures will be recommended. Measures may comprise of one or a combination of the following:

- Construction phasing to limit vast exposed areas that may result in high run-off and concentrated water flow;
- Surface water management to prevent high run-off rates and concentrated water flow;
- Temporary surface protection during construction;
- Permanent surface protection after construction for example grass establishment and/or paving;
- Physical improvement of the upper soils such as compaction in order to increase resistance to erosion;
- Subsurface drainage where expected seasonal perched water contacts are exposed by possible cuts/excavations.

Site water management will be recommended, especially if the construction phase is during the wet season, in order to avoid concentrated water flow that may result in severe erosion of the upper soil horizons and/or undercutting of structures.

9. Construction Material

9.1. Suitability for Use in Soil Mattress Construction

The basic concept behind soil mattresses is that that material should be:

- Workable;
- Have a low compressibility once compacted (within the allowable tolerances of the structure/s);
- Have a low heave once compacted (within the allowable tolerances of the structure/s);
- Have suitable bearing capacity for the proposed foundation loads.

Considering the low expected and assumed induced loads, the following expected performances are assigned to the different soil horizons present on site:

Topsoil: Not ideal due to presence of organic matter and roots. Can be considered if roots are removed.

Colluvium: Considered an excellent source for mattress construction due to high percentages of sand and gravel.

9.2. Suitability for Use as Pipe Bedding and Backfill

The bedding and blanketing material can be evaluated by SANS or the more relaxed Department of Water Affairs (DWA) specifications. DWA developed a relaxed bedding specification especially for areas where materials with specifications as per SANS cannot be obtained. The specifications are summarized in **Table 9.1.**

Table 9.1: Relaxed Pipe Bedding Specifications (DWA)

Material Description	Percentage by Mass Passing Sieve Size (mm)				Atterberg Limits Shall Not Exceed (%)		
	9,5	4,75	0,425	0,002	LL*	PI*	LS*
Finely Graded A	100	100	80 - 100	0 - 45	30	15	5
Medium Graded B	100	80 - 100	60 - 80	0 - 40	35	18	7,5
Granular C	100	70 - 100	30 - 60	0 - 35	40	20	10

*Notes: * LL, PI and LS on material passing the 0,425mm sieve.*

Selective on-site materials (generally the topsoil) may be considered suitable for pipe bedding “Finely Graded A” as per the DWA relaxed specifications, providing that stones in excess of 10mm are sieved from especially the 75mm of material immediately surrounding the pipe.

10. Foundation Design

Considering all the test results of the soil samples taken from the project site as well as the potential expansiveness of the soil; the site is classified as **S/S1/C1.**

For **S** site class, normal construction (Strip footing or slab-on-the- ground foundation (No reinforcement required)) and for **S1 and C1** site class, modified normal construction (lightly reinforced strip footings, Articulation joints at all internal/external doors and openings, light reinforcement in masonry) are recommended respectively. Site drainage and services/plumbing precautions are also recommended. Foundation pressure not to exceed 50 kPa.

11. Conclusions and Recommendations

Considering site visits and investigations, fieldwork and laboratory test results; it is concluded as follows

- Refusal was encountered on test pits TP 537, TP 538 and TP 539, the rest of the remaining test pits (TP 540 and TP 541) refusal was not encountered.
- The site is dominated by silty sand underlain by greyish white, brown to grey sugary gravel and silty sand at some points. In terms of Unified Soil Classification System, the site has **GW/GM/SM** soils material.

  GM are suitable for use as foundation material in construction and have excellent compaction characteristics if used as fill material.

  GW are suitable for use as foundation material in construction and have excellent compaction characteristics if used as fill material.

  For the purpose of the Landfill GW/GM material are unsuitable to be used as Water retaining Embankments, and have excellent (GW) and average (GM) qualities to be used as None-water retaining Embankments.

  SM material can be used as founding material for building foundations; however, they are unsuitable to use as fill material as they possess average compaction characteristics.

  Similarly, for the purpose of the Landfill SM material are suitable (with compaction) to be used as Water retaining Embankments, and have average qualities to be used as None-water retaining Embankments.

- The site is classified as **S/S1/C1**

  For **S** site class, normal construction (Strip footing or slab-on-the- ground foundation (No reinforcement required))

  For **S1** and **C1** class Site, modified normal construction (lightly reinforced strip footings, Articulation joints at all internal/external doors and openings, light reinforcement in masonry) is recommended. Site drainage and services/plumbing precautions are also recommended.

- Degree of permeability for gravels on this site is low. Since the gravel will be forming the base of the landfill, it is recommended that this material should be compacted to at least 95 % of Mod AASHTO in order to reduce its porosity

- TP 538b brown sugary gravel gives the ultimate and allowable bearing capacities of 2213.3 kPa and 737.7 kPa respectively

- **The groundwater movement of the site was not monitored during wet-season cycles and the degree of seasonal seepage are not known. Site water management is recommended, especially if the construction phase is during the wet season, in order to avoid concentrated water flow that may result in severe erosion of the upper soil horizons and/or undercutting of structures**

12. Way Forward

A competent person should inspect all open trenches, cuts and foundation excavations to identify conditions that may vary from the encountered conditions as discussed in this assessment. These inspections and modifications are generally termed the "Phase 2 assessment" or "Construction report".

It is recommended that a competent person is present during material selection, placement and compaction.

Proper quality control measures should be implemented for the soil mattresses and compaction below floors/foundations. No load schedules or foundation specifications were available at the time of writing this report. The guidelines provided are generic of nature. The design engineer should ideally calculate the necessary or consult with the evaluator of this report if any high load or sensitive footings, structures or foundations with high expected eccentricities are planned. These footings/structures should ideally be evaluated and optimised.

13. Report Provisions

While every effort was made during this assessment to identify the different geological materials, areas subject to a perched water table, hydrogeological conditions, areas of poor drainage and to estimate their distribution, it is impossible to guarantee that isolated zones of significantly different conditions have not been missed. Areas of poorer conditions are however not likely.

For this reason, this investigation has sought to highlight the significant issues regarding the influence of the proposed development on the geological environment to provide prior warning to the developer and to suggest precautionary measures.

The report may only be distributed in its full context. Geotechnical Engineering Laboratory (Pty) Ltd. and/or any of its employees or sub-contractors will not be held liable for any damages caused due to misinterpretation of the findings and/or recommendations due to selective data presentation or distribution.

14. References

Jennings JEB, Brink ABA and Williams AAB (1973). Revised Guide to Soil Profiling for Civil Engineering Purposes in Southern Africa

Brink ABA and Bruin RMH (2002). Guidelines for Soil and Rock Logging in South Africa

Geological Map series of the Republic of South Africa Sheet No. 2924(Koffiefontein), and scale 1:250,000

SAICE JSD & ISE (1995). Code of Practice for Foundations and Superstructures for Single Storey Residential Buildings of Masonry Construction.

SABS 1200 D-1988 (as amended 1990). Standardized specification for Civil Engineering Construction. D : Earthworks.

Google Earth Map: 2021 AfrGIS (Pty) Ltd

15. Appendices

Appendix A Soil Profile

Appendix B Photos

Appendix C Summary of Results

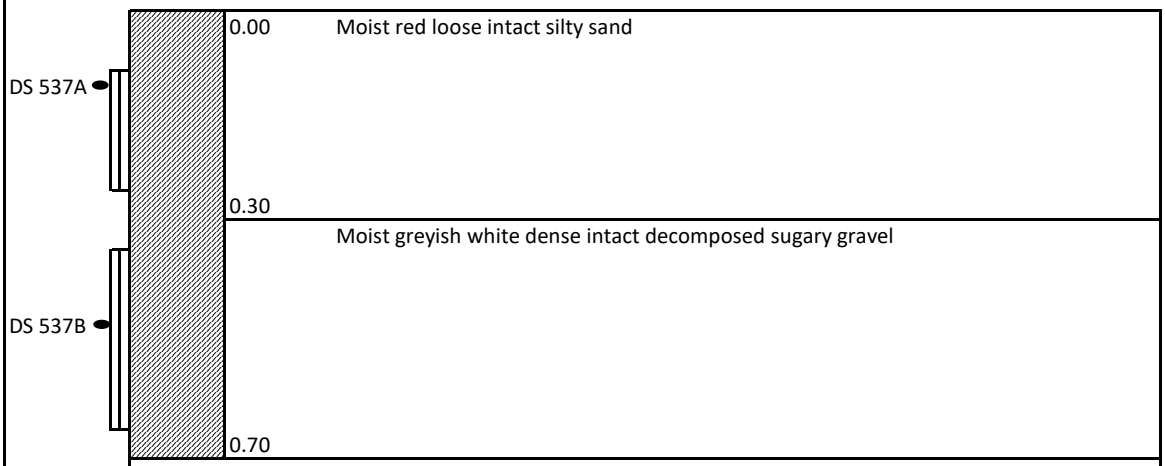
Appendix D Tables of General Information

GEOTECHNICAL ENGINEERING LABORATORY (PTY) LTD

DIPABALA SOLUTIONS - LUCKHOF WASTE DISPOSAL

HOLE No. TP 537
Sheet 1 of 1

JOB NUMBER:



0.00 Moist red loose intact silty sand

0.30 Moist greyish white dense intact decomposed sugary gravel

0.70

NOTES
1) Refusal on Gravel

2) No groundwater encountered

3) Disturbed sample DS 537A at 0.10 -- 0,25m

4) Disturbed sample DS 537B at 0.40 -- 0,65m

CONTRACTOR:
MACHINE:
DRILLED BY
PROFILED BY R MAKATENG

TYPE SET BY TJ MOKALOBA
SETUO FILE: STANDARD. SET

INCLINATION:
DIAM:
DATE: 8/10/2021
DATE: 8/10/2021

ELEVATION:
X - COORD:
Y - COORD:

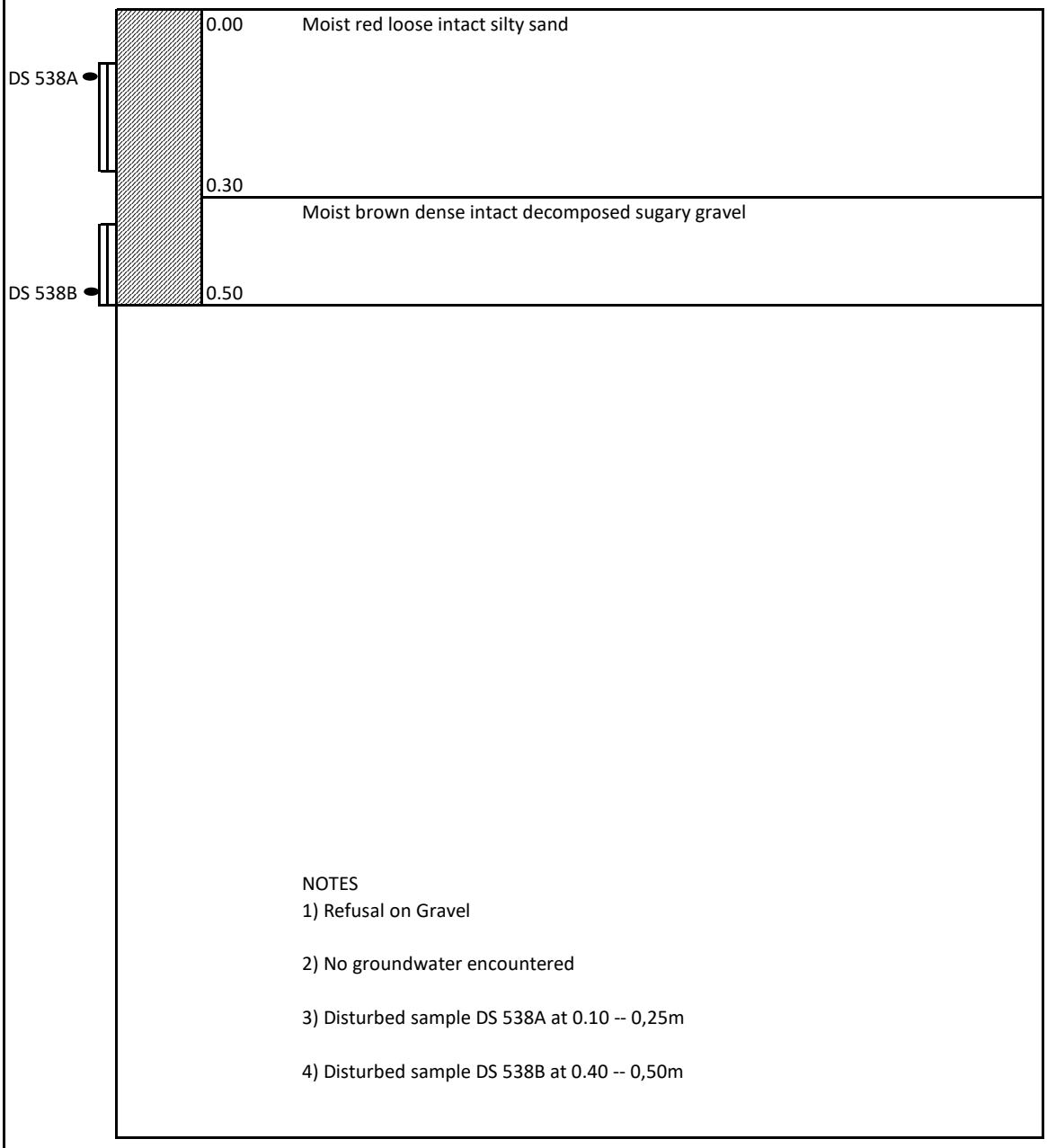
HOLE No. TP 537

GEOTECHNICAL ENGINEERING LABORATORY (PTY) LTD

DIPABALA SOLUTIONS - LUCKHOF WASTE DISPOSAL

HOLE No. TP 538
Sheet 1 of 1

JOB NUMBER:



0.00 Moist red loose intact silty sand

0.30 Moist brown dense intact decomposed sugary gravel

0.50

NOTES

1) Refusal on Gravel

2) No groundwater encountered

3) Disturbed sample DS 538A at 0.10 -- 0,25m

4) Disturbed sample DS 538B at 0.40 -- 0,50m

CONTRACTOR:
MACHINE:
DRILLED BY
PROFILED BY R MAKATENG

TYPE SET BY TJ MOKALOBA
SETUO FILE: STANDARD. SET

INCLINATION:
DIAM:
DATE: 8/10/2021
DATE: 8/10/2021

ELEVATION:
X - COORD:
Y - COORD:

HOLE No. TP 538

GEOTECHNICAL ENGINEERING LABORATORY (PTY) LTD

DIPABALA SOLUTIONS - LUCKHOF WASTE DISPOSAL

HOLE No. TP 539
Sheet 1 of 1

JOB NUMBER:

NOTES

1) Refusal on Gravel

2) No groundwater encountered

3) Disturbed sample DS 539A at 0.10 -- 0,25m

4) Disturbed sample DS 539B at 0.60 -- 0,95m

CONTRACTOR:
MACHINE:
DRILLED BY
PROFILED BY R MAKATENG

TYPE SET BY TJ MOKALOBA
SETUO FILE: STANDARD. SET

INCLINATION:
DIAM:
DATE: 7/10/2021
DATE: 7/10/2021

ELEVATION:
X - COORD:
Y - COORD:

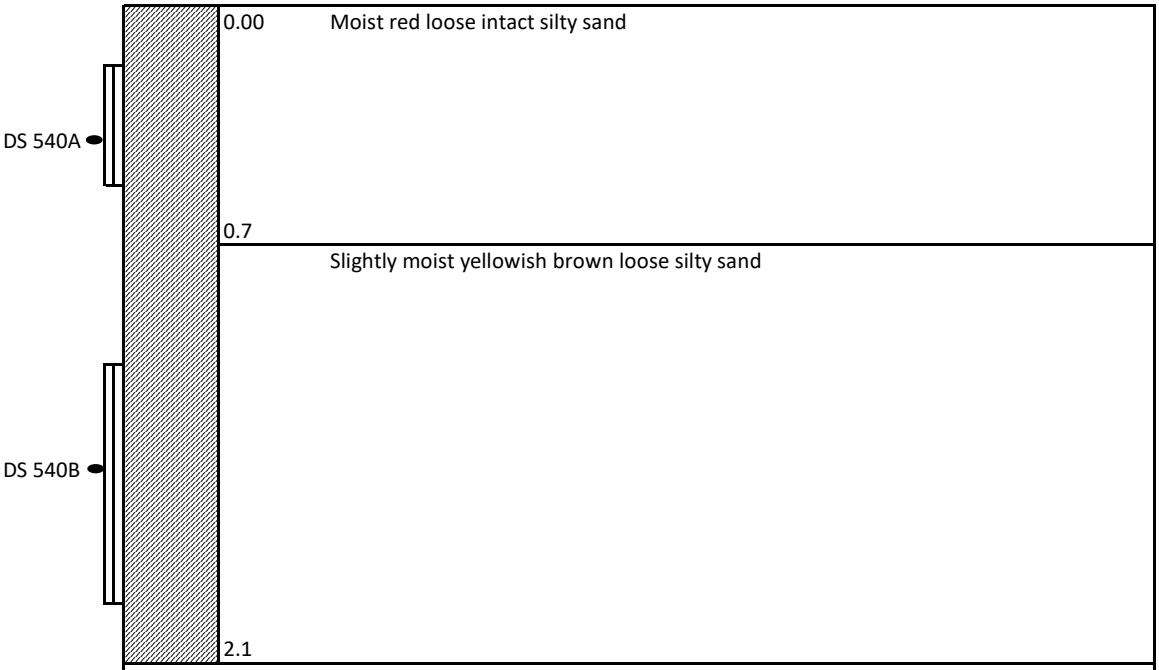
HOLE No. TP 539

GEOTECHNICAL
ENGINEERING LABORATORY (PTY) LTD

DIPABALA SOLUTIONS - LUCKHOF WASTE DISPOSAL

HOLE No. TP 540
Sheet 1 of 1

JOB NUMBER:



0.00 Moist red loose intact silty sand

0.7 Slightly moist yellowish brown loose silty sand

2.1

NOTES
1) No Refusal

2) No groundwater encountered

3) Disturbed sample DS 540A at 0.10 -- 0,25m

4) Disturbed sample DS 540B at 1.20 -- 1,90m

CONTRACTOR:
MACHINE:
DRILLED BY
PROFILED BY R MAKATENG

TYPE SET BY TJ MOKALOBA
SETUO FILE: STANDARD. SET

INCLINATION:
DIAM:
DATE: 7/10/2021
DATE: 7/10/2021

ELEVATION:
X - COORD:
Y - COORD:

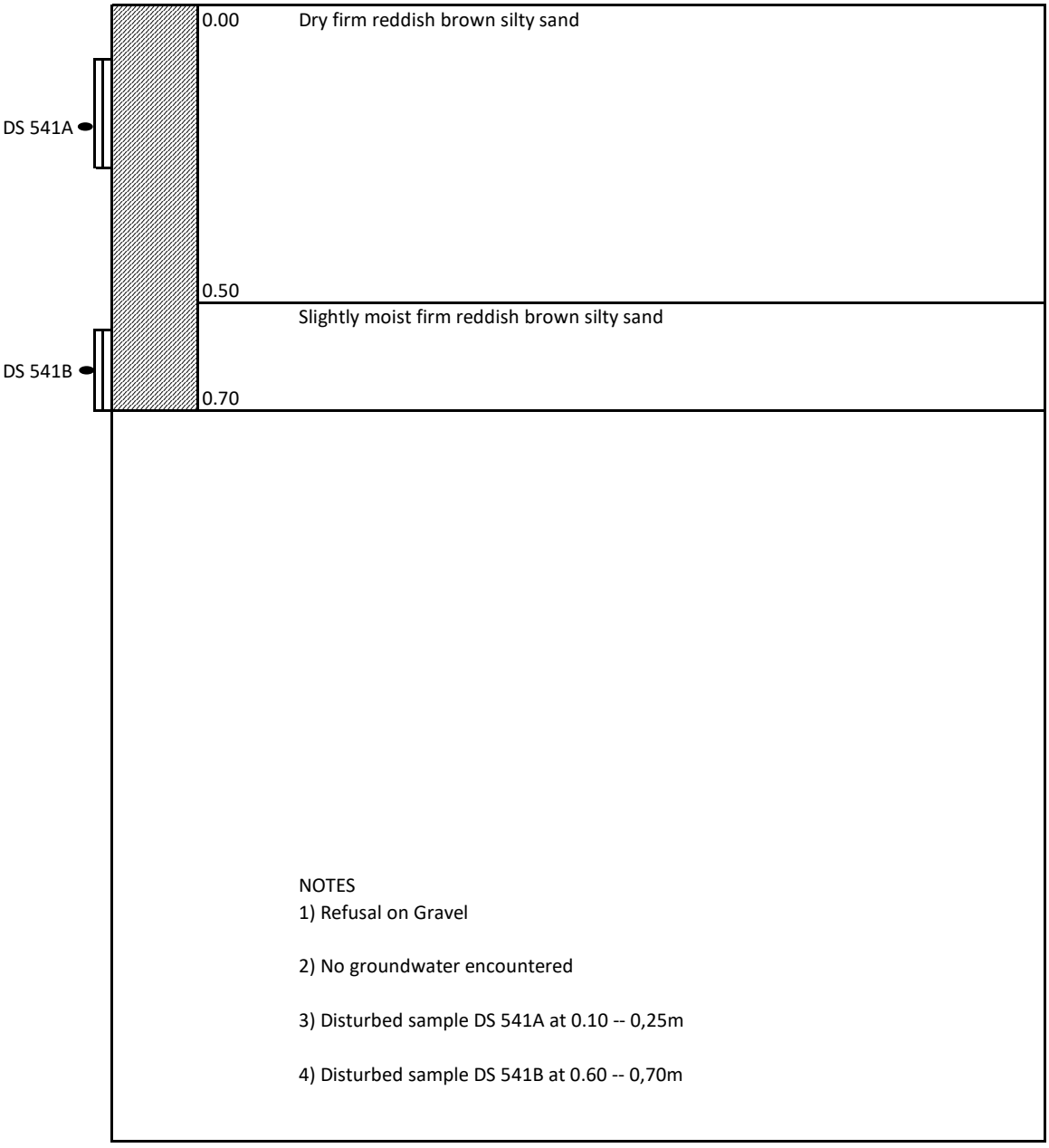
HOLE No. TP 540

GEOTECHNICAL ENGINEERING LABORATORY (PTY) LTD

DIPABALA SOLUTIONS - LUCKHOF WASTE DISPOSAL

HOLE No. TP 541
Sheet 1 of 1

JOB NUMBER:



NOTES

1) Refusal on Gravel

2) No groundwater encountered

3) Disturbed sample DS 541A at 0.10 -- 0,25m

4) Disturbed sample DS 541B at 0.60 -- 0,70m

CONTRACTOR:
MACHINE:
DRILLED BY
PROFILED BY R MAKATENG

TYPE SET BY TJ MOKALOBA
SETUO FILE: STANDARD. SET

INCLINATION:
DIAM:
DATE: 7/10/2021
DATE: 7/10/2021

ELEVATION:
X - COORD:
Y - COORD:

HOLE No. TP 541

TEST PITS AND SITE PHOTOS

TP 537. 29º 44' 6.07" S

24º 47' 56.22" E

TP 538. 29º 44' 2.53" S

24º 48' 18.43" E

TP 539. 29° 44' 13.59" S

24° 48' 25.57" E

TP 540. 29° 44' 18.06" S

24° 48' 4.99" E

TP 541. 29° 44' 11.29" S

26° 48' 4.99" E

EXISTING STRUCTURES, SERVICES, VEGETATION OR TREE ON SITE

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Bloemfontein, 9301
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E-mail: tsoeujm@hotmail.com

FORM M2.1 - REPORTING FORM FOR SOILS AND GRAVELS REV 4

Project Description

Project:	Luckhof Waste Disporsal	**Client:**	Dipabala Solutions	**Date Reported:**	15/10/2021
Date of Sampling	7/10/2021	**Date Checked:**	18/10/2021	**Reported by:**	LESHEGO
Report #:		**Checked by:**	R. MAKATENG		

Sample Description

ERF		-	-	-	-	-
Sample No.:		S21-642	S21-643	S21-644	S21-645	S21-646
Location of Sampling		TP 537	TP 537	TP 538	TP 538	TP 539
Depth in mm		0-300	300-700	0-300	300-500	0-400
Weather Conditions		SUNNY	SUNNY	SUNNY	SUNNY	SUNNY
Material Description		red silty sand	greyish white sugary gravel	red silty sand	grey sugary gravel	red silty sand
Screen Analysis (% Passing) - SANS 3001 : GR 1						
75,0 mm						
63,0 mm						
50,0 mm					100	
37,5 mm		100	100.0		92.7	
28,0 mm		93.0	82.4		79.5	
20,0 mm		89.1	73.9	100	76.4	
14,0 mm		86.9	65.7	97.9	70.6	
5,00 mm		82.2	54.6	96.6	61.5	100
2,00 mm		78.5	45.1	92.2	36.6	98.5
0,425 mm		61.0	32.1	76.6	17.3	84.4
0,075 mm		19.1	10.8	33.5	7.2	37.7
Soil Mortar Percentages - SANS 3001 : PR 5						
Coarse Sand	2.00-0.450mm	22.3	28.8	16.9	52.7	14.3
Coarse Fine Sand	0.450-0.250mm	8.5	10.5	8.1	6.3	9.5
Medium Fine Sand	0.250-0.150mm	18.2	14.8	14.5	8.0	14.8
Fine Fine Sand	0.150-0.075mm	25.3	20.5	23.4	12.9	22.2
Silt & Clay	<0.075mm	24.3	23.9	36.3	19.7	38.3
Atterberg Constants						
Grading modulus	SANS 3001 : PR 5	1.4	2.1	1.0	2.4	0.8
Liquid limit, %	SANS 3001 : GR 10	19.0	25	21		21
Plastic Limit, %		15.0	19	16		16
Plasticity Index, %		4	6	5	NP	5
Linear Shrinkage,%		2	3	2		2
AASHTO Class		**A-2-4**	**A-1-b**	**A-2-4**	**A-1-b**	**A-4**
MOD AASHTO - SANS 3001 : GR 30						
MDD (kg/m³)			1804		2212	
OMC (%)			12.9		7.4	
CBR - SANS 3001 : GR 40						
Mod. AASHTO						
Moulding Moisture Content (%)			12.1		7.7	
Dry density (kg/m³)			1788		2207	
% of Max Dry Density			99.1		99.8	
% swell			0.6		0.7	
NRB						
Dry density (kg/m³)			1716		2099	
% of Max Dry Density			95.1		94.9	
% swell			0.9		1	
Proctor						
Dry density (kg/m³)			1629		1993	
% of Max Dry Density			90.3		90.1	
% swell			1.8		1.4	
CBR						
100% Mod AASHTO			36.3		29.8	
98% Mod AASHTO			32.6		26.5	
97% Mod AASHTO			31.3		24.8	
95% Mod AASHTO			27.5		21.8	
93% Mod AASHTO			24.3		18.5	
90% Mod AASHTO			19.3		13.8	
COLTO Classification			**G6**		**G7**	

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18 -10- 2021
P.O. BOX 12827 • BRANDHOF 9324
40 NORMANDIE RD • BAYSWATER • BFN
CELL: 071 957 6309

<--------END OF REPORT-------->

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FORM M2.1 - REPORTING FORM FOR SOILS AND GRAVELS REV 4

Project Description

Project:	Luckhof Waste Disporsal	**Client:**	Dipabala Solutions	**Date Reported:**	15/10/2021
Date of Sampling	7/10/2021	**Date Checked:**	18/10/2021	**Reported by:**	LESHEGO
Report #:		**Checked by:**	R. MAKATENG		

Sample Description

ERF		-	-	-	-	-
Sample No.:		S21-647	S21-648	S21-649	S21-650	S21-651
Location of Sampling		TP 539	TP 540	TP 540	TP 541	TP 541
Depth in mm		400-1000	0-700	700-2100	300-500	0-400
Weather Conditions		SUNNY	SUNNY	SUNNY	SUNNY	SUNNY
Material Description		grey sugary gravel	brown silty sand	brown silty sand	grey sugary gravel	red silty sand
Screen Analysis (% Passing) - SANS 3001 : GR 1						
75,0 mm						
63,0 mm						
50,0 mm					100	
37,5 mm					92.7	
28,0 mm		100			79.5	
20,0 mm		95.6			76.4	
14,0 mm		94.5			71.3	100
5,00 mm		82.5	100.0	100	62.3	99
2,00 mm		51.7	99.7	99.5	36.6	98.5
0,425 mm		17.6	89.8	89.9	17.3	84.4
0,075 mm		7.5	39.8	40.4	7.2	37.7
Soil Mortar Percentages - SANS 3001 : PR 5						
Coarse Sand	2.00-0.450mm	66.0	9.9	9.6	52.7	14.3
Coarse Fine Sand	0.450-0.250mm	5.6	7.5	7.8	6.3	9.5
Medium Fine Sand	0.250-0.150mm	6.4	14.4	14.6	8.0	14.8
Fine Fine Sand	0.150-0.075mm	7.5	25.8	26.7	12.9	22.2
Silt & Clay	<0.075mm	14.5	39.9	40.6	19.7	38.3
Atterberg Constants						
Grading modulus	SANS 3001 : PR 5	2.2	0.7	0.7	2.4	0.8
Liquid limit, %	SANS 3001 : GR 10	27.0	22	23	22	23
Plastic Limit, %		19.0	16	18	17	28
Plasticity Index, %		8	6	5	5	5
Linear Shrinkage,%		4	3	2	3	2
AASHTO Class		**A-1-b**	**A-4**	**A-4**	**A-1-a**	**A-4**
MOD AASHTO - SANS 3001 : GR 30						
MDD (kg/m³)		2173		1964		2020
OMC (%)		8.6		10		11
CBR - SANS 3001 : GR 40						
Mod. AASHTO						
Moulding Moisture Content (%)		8.5		1964		10.5
Dry density (kg/m³)		2184		10		1999
% of Max Dry Density		100.5		1964		99
% swell		0.9		10		2
NRB						
Dry density (kg/m³)		2067		1868		1919
% of Max Dry Density		95.1		95.1		95
% swell		1.3		2		2.5
Proctor						
Dry density (kg/m³)		1962		1773		1824
% of Max Dry Density		90.3		90.3		90.3
% swell		1.5		2.2		2.9
CBR						
100% Mod AASHTO		30.0		14.0		14.0
98% Mod AASHTO		26.1		12.5		12.5
95% Mod AASHTO		24.0		12.0		12.0
95% Mod AASHTO		19.8		10.8		10.8
93% Mod AASHTO		15.5		9.5		9.5
90% Mod AASHTO		9.5		7.8		7.8
COLTO Classification		**G7**		**UNCLASSIFIED**		**UNCLASSIFIED**

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<--------END OF REPORT-------->

Shearbox

Project:	Laboratory Testing
Client:	Civil Engineering Lab
Geolab Job Nr:	G18-082
Test Method:	ASTM 3080-72

Sample Nr:	TP74b
Sample Depth:	0.35-0.45m_SB
Date:	2018-04-18

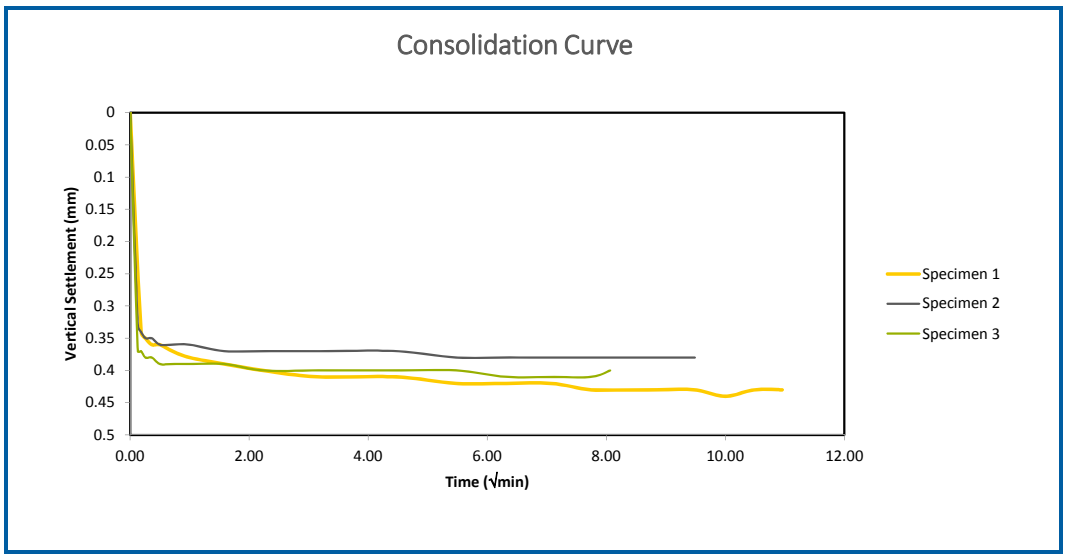
Results		
ϕ' =	**39.7**	**°**
c' =	**17.1**	**kPa**

Sampling Method:	Bag
Disturbed/Undist:	Disturbed
Remoulded To:	2212 kg/m³ Dry Density

Initial Sample Details	1	2	3	
Sample Height:	20	20	20	mm
Sample Diameter:	60	60	60	mm
Sample Mass	134.3	134.3	134.3	g
Dry Density:	2211.4	2211.4	2211.4	kg/m³
Density:	2374.9	2374.9	2374.9	kg/m³
Void Ratio:	0.253	0.253	0.253	
Moisture Content:	7.4	7.4	7.4	%
Specific Gravity		2.770		kg/m³

Shear Stage	1	2	3	
Rate of Shear:	0.007	0.007	0.007	mm/min
Normal Stress at Failure:	74.0	151.0	303.0	kPa
Max Shear Stress:	77.5	144.3	268.4	kPa
Strain at Failure:	2.5	3.0	4.5	%

Final Sample Details	1	2	3	
Moisture Content:	17.8	18.0	17.7	%



GEOLAB
Part of the SMEC Group

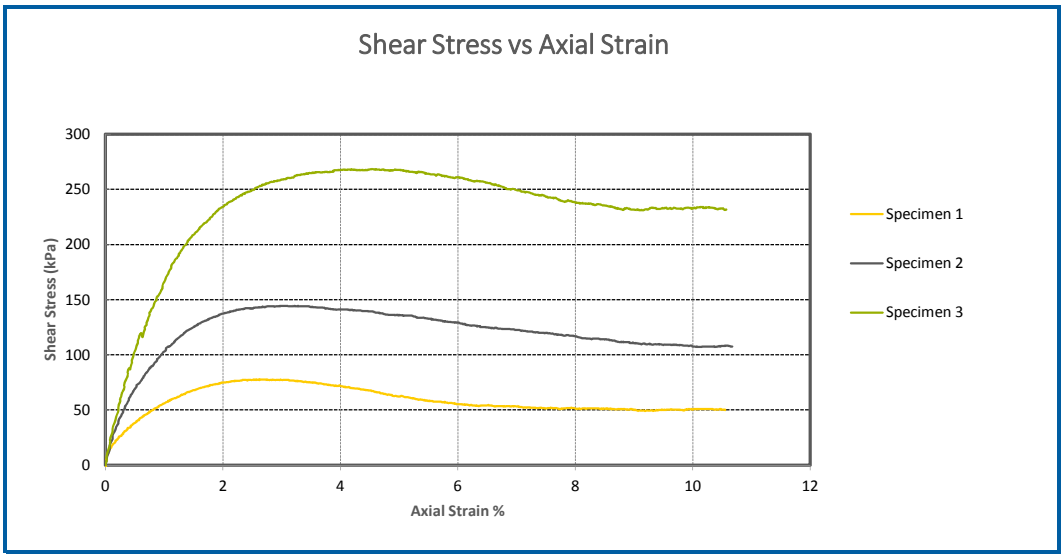
Geotechnical Laboratory
T +27 12 813 4936
E geolab@soillab.co.za
Geolab
www.soillab.co.za

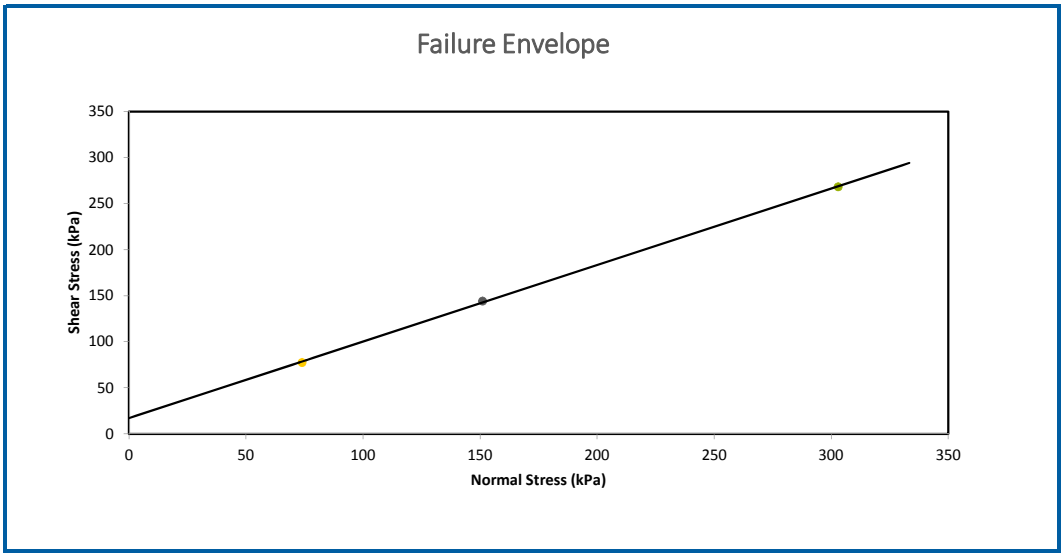
Shearbox

Project:	Laboratory Testing
Client:	Civil Engineering Lab
Geolab Job Nr:	G18-082
Test Method:	ASTM 3080-72

Sample Nr:	TP74b
Sample Depth:	0.35-0.45m_SB
Date:	2018-04-18

Results		
ϕ' =	**39.7**	**°**
c' =	**17.1**	**kPa**





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Falling Head Permeability

Project:	Laboratory Testing
Client:	Civil Engineering Laboratory
Geolab Job Nr:	G18-082
Date:	2018-04-13
Test Mothod:	ASTM D2434:1974

		Remoulded to:							
Sample Number:	**Depth: m**	**Dry Density: kg/m³**	**w %**	**H1 cm**	**H2 cm**	**Time h**	**m**	**s**	**Permeability cm/s**
TP74b	0.35-0.45	2103	7.4	60	12.5	4	26	48	8.45E-06

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E-mail: tsoeujm@hotmail.com

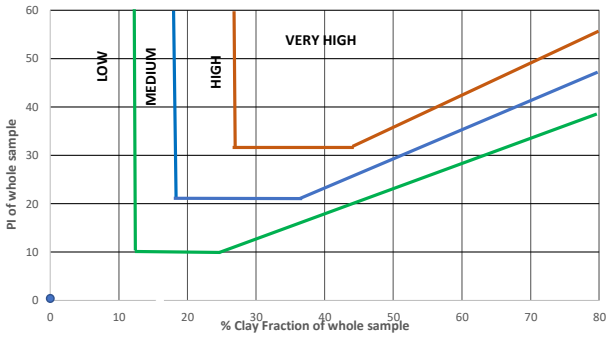
PARTICLE SIZE ANALYSIS

Date of Sampling.	7/10/2021
GEL Sample No.	S21-645
Depth (m)	300-500
Position	TP 538
Material Descrption	Brown decomposed sugary gravel
Relative Density on <2mm **(SANS 5844)**	2650
Organic Material	-
Moisture (%) Dispersion (%)	-
SCREEN ANALYSIS (% PASSING) **(SANS 3001: GR1)**	
63.0 mm	
50.0 mm	
37.5 mm	
28.0 mm	
20.0 mm	100.0
14.0 mm	92.0
5.0 mm	91.0
2.00 mm	93.6
0.425 mm	22.0
0.075 mm	7.0
HYDROMETER ANALYSIS (% PASSING) **(SANS 3001: GR3)**	
57µm	7.0
34µm	3.0
14µm	2.0
6µm	1.0
2µm	0.0
% Clay	0
% Silt	22
% Sand	71.6
% Gravel	6.4
ATTERBERG LIMITS **(SANS 3001: GR10)**	
Liquid Limit	
Plasticity Index	NP
Linear Shrinkage (%)	
Grading Modulus	1.8
ASSHTO Classification	A-1-b
Unified Classification	GW
Colto Classification	-

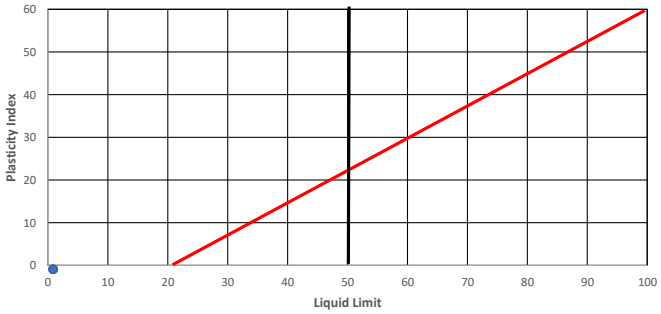
PROJECT: Luckhof Waste Disposal
Client. : Dipabala Solutions
DATE : 18/10/2021

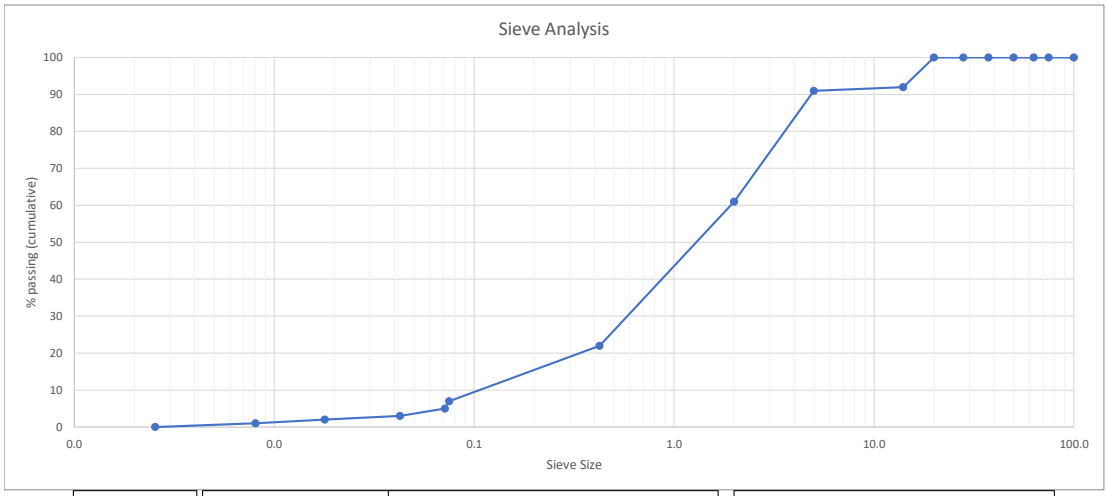
POTENTIAL EXPANSIVENESS

Van der Merwe's POTENTIAL SWELL PREDICTION CHART



PLASTICITY CHART





CLAY	SILT	SAND	GRAVEL

Table D1: Unified Soil Classification System (from ASTM D 2487)

Major Divisions			Group Symbols	Typical Names
Course-Grained Soils More than 50% retained on the 0.075 mm (No. 200) sieve	**Gravels** 50% or more of course fraction retained on the 4.75 mm (No. 4) sieve	Clean Gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
		Gravels (with Fines)	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	Sands 50% or more of course fraction passes the 4.75 (No. 4) sieve	Clean Sands	SW	Well-graded sands and gravelly sands, little or no fines
			SP	Poorly graded sands and gravelly sands, little or no fines
		Sands (with Fines)	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
Fine-Grained Soils More than 50% passes the 0.075 mm (No. 200) sieve		**Silts and Clays** Liquid Limit 50% or less	ML	Inorganic silts, very fine sands, rock four, silty or clayey fine sands
			CL	Inorganic clays of low to medium plasticity, gravelly/sandy/silty/lean clays
			OL	Organic silts and organic silty clays of low plasticity
		Silts and Clays Liquid Limit greater than 50%	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
			CH	Inorganic clays or high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
Highly Organic Soils			PT	Peat, muck, and other highly organic soils

Prefix: G = Gravel, S = Sand, M = Silt, C = Clay, O = Organic

Suffix: W = Well Graded, P = Poorly Graded, M = Silty, L = Clay, LL < 50%, H = Clay, LL > 50%

Note: These definitions are Unified Soil Classification system definitions and are slightly different than those of AASHTO.

Table D2: AASHTO Soil Classification System (from AASHTO M 145 or ASTM D3282)

General Classification	Granular Materials (35% or less passing the 0.075 mm sieve)							Silt-Clay Materials (>35% passing the 0.075 mm sieve)			
Group Classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve Analysis (% passing)											
2.00 mm (No. 10)	50 max	-	-	-	-	-	-	-	-	-	-
0.425 (No. 40)	30 max	50 max	51 min	-	-	-	-	-	-	-	-
0.075 (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40)											
Liquid Limit	-		-	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity Index	6 max		N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min*
Group index	0		0	0		4 max		8 max	12 max	16 max	20 max
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as a subgrade	Excellent to Good							Fair to Poor			

* Plasticity index of A-7-5 subgroup is equal to or less than the LL - 30. Plasticity index of A-7-6 subgroup is greater than LL - 30

Table D3: Engineering suitability ratings based upon Unified Soil Classification groups

USCS group symbol	Typical description	Source of borrow			Resources	Suitability for:					
		Embankments		Fill	Clean sand / gravel	Road subgrade	Building foundations	Slope stability	Trenching/ tunneling	Septic tanks	Untreated roads
		Water retaining	None-water retaining								
GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Unsuitable	Excellent	Excellent	Good	Excellent	Excellent	Excellent	Shoring	Good	Average
GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.	Unsuitable	Average	Excellent	Good	Excellent	Excellent	Average	Shoring	Excellent	Unsuitable
GM	Silty gravels, poorly graded gravel-sand-silt mixtures.	Unsuitable	Average	Good	Average	Excellent	Excellent	Average	Shoring	Average	Average
GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.	Suitable	Average	Good	Poor	Excellent	Excellent	Average	Good	Unsuitable	Excellent
SW	Well-graded sands, gravelly sands, little or no fines.	Unsuitable	Excellent	Excellent	Good	Good	Excellent	Average	Shoring	Good	Average
SP	Poorly graded sands, gravelly sands, little or no fines.	Unsuitable	Average	Good	Good	Good	Excellent	Excellent	Shoring	Good	Unsuitable
SM	Silty sands, poorly graded silt-sand mixtures.	Suitable (with compaction)	Average	Average	Average	Average	Good (density important)	Average	Mostly good, but shoring may be required	Poor	Poor
SC	Clayey sands, poorly graded sand-clay mixtures.	Suitable	Average	Average	Poor	Average	Good (density important)	Average	Good	Unsuitable	Good
ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.	Unsuitable	Poor	Average	N/A	Average	Good (Liquifaction problem)	Average	Shoring	Average	Unsuitable
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Suitable (erosion protection required)	Good	Average	N/A	Average	Average (Swell?)	Poor	Good	Unsuitable	Poor
OL	Organic silts and organic silt-clays of low plasticity	Unsuitable	Unsuitable	Poor	N/A	Average	Poor (Swell)	Good	Shoring	Poor	Unsuitable
MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic soils.	Unsuitable	Poor	Poor	N/A	Poor	Unsuitable (Swell?)	Unsuitable	Shoring	Average	Unsuitable
CH	Inorganic clays of high plasticity, fat clays, silty soils, elastic soils.	Suitable (erosion protection required)	Average	Unsuitable	N/A	Poor	Poor (Swell?)	Poor	Good	Unsuitable	Unsuitable
OH	Organic clays of medium to high plasticity.	Unsuitable	Unsuitable	Unsuitable	N/A	Unsuitable	Unsuitable (Swell?)	Average	Shoring	Unsuitable	Unsuitable
PT	Peat or other highly organic soils.	Unsuitable	Unsuitable	Unsuitable	N/A	Unsuitable	Unsuitable (Swell?)	Unsuitable	Shoring	Average	Unsuitable

Source: Finlayson (1982)

Note: These recommendations are based on the construction of earthworks with adequate access to compaction and engineering equipment. They are based solely on the USCS classification, which does not take account of the full effects of particle size, dispersion or the conditions under which soil conservation earthworks are constructed. This then in not a DLWC based set of recommendations for the construction of soil conservation earthworks.

Table D4: Typical material properties (Unified Soil Classification System)

Class:	Material description	Subgrade	Subbase	Base	Drainage when compacted	Compaction characteristics	Embankment material	Compressibility when compacted
GW	Well-graded gravel	Good to Excellent	Good	Fair to good	Excellent	Good	Reasonably stable	Low
GC	Clayey gravel (>12% fines)	Good	Fair	Poor to not suitable	Poor to practically impervious	Good to fair	Reasonably stable	Low
SM	Silty sand (sand with fines PI<4)	Fair to good	Fair to good	Poor to not suitable	Fair to practically impervious to impervious	Good	Reasonably stable	Low
SC	Clayey sand (>12% fines PI>7)	Fair	Poor	Not suitable	Poor, impervious when compacted	Good to fair	Reasonably stable	Low
CL	Silts and clays (LL<50 & PI>7)	Fair to poor	Not suitable	Not suitable	Practically impervious	Good to fair	Good stability	Medium
ML	Silts and clays (LL<50 & PI<4)	Fair to poor	Not suitable	Not suitable	Semi-pervious to impervious	Good to poor	Poor stability	Medium

Table D5: Residential Site Class Designations (SAICE, 1995)

Typical Founding Material	Character of Founding Material	Expected Range of Total Soil Movements (mm)	Assumed Differential Movement (% of total)	Site Class
Rock (excluding mud rocks which exhibit swelling to some depth)	Stable	NEGLIGIBLE	-	R
Fine-grained soils with moderate to very high plasticity (clays, silty clays, clayey silts and sandy clays)	Expansive Soils	< 7,5 7,5 – 15 15 – 30 > 30	50% 50% 50% 50%	H H1 H2 H3
Silty sands, sands, sandy and gravelly soils	Compressible and Potentially Collapsible Soils	< 5,0 5,0 – 10 > 10	75% 75% 75%	C C1 C2
Fine-grained soils (clayey silts and clayey sands of low plasticity), sands, sandy and gravelly soils	Compressible Soils	< 10 10 – 20 > 20	50% 50% 50%	S S1 S2
Contaminated soils Controlled fill Dolomitic areas Land fill Marshy areas Mine waste fill Mining subsidence Reclaimed areas Very soft silt/silty clays Uncontrolled fill	Variable	Variable		P

NOTES:

1. The classifications C, H, R and S are not intended for dolomitic area sites unless specific investigations are carried out to assess the stability (risk of sinkholes and doline formation) of the dolomites. Where this risk is found to be acceptable, the site shall be designated as Class P (dolomitic areas).
2. Site classes are based on the assumption that differential movements, experienced by single-storey residential buildings, expressed as a percentage of the total movements are equal to about 50% for soils that exhibit expansive or compressive characteristics and 75% for soils that exhibit both compressible and collapse characteristics. Where this assumption is incorrect or inappropriate, the total soil movements must be adjusted so that the resultant different movements implied by the table are equal to that which is expected in the field.
3. In some instances, it may be more appropriate to use a composite description to describe a site mote fully e.g. C1/H2 or S1 and/or H2. Composite Site Classes may lead to higher differential movements and result in design solutions appropriate to a higher range of differential movement e.g. a Class R/C1 site. Alternatively, a further site investigation may be necessary since the final design solution may depend on the location of the building on a particular site.
4. Where it is not possible to provide a single site designation and a composite description is inappropriate, sites may be given multiple descriptions to indicate the range of possible conditions e.g. H-H1-H2 or C1-C2.
5. Soft silts and clays usually exhibit high consolidation and low bearing characteristics. Structures founded on these horizons may experience high settlements and such sites should be designated as being Class S1 or S2 as relevant and appropriate.
6. Sites containing contaminated soils include those associated with reclaimed mine land, land down-slope of mine tailings and old land fills.
7. Where a site is designated as Class P, full particulars relating to the founding conditions on the site must be provided.
8. Where sites are designated as being Class P, the reason for such classification shall be placed in brackets immediately after the suffix – i.e. P(contaminated soils). Under certain circumstances, composite description may be more appropriate – e.g. P(dolomite areas)-C1.
9. Certain fills may contain contaminates which present a health risk. The nature of such fill should be evaluated and should be clearly demarcated as such.

Table D6: Residential Site Class Designations (SAICE, 1995)

Site Class	Estimated Total Settlement	Construction Type	Foundation Design and Building Procedures
S	<10 mm	Normal	- Normal construction (strip footing or slab-on-the-ground foundations) - Good site drainage
S1	10-20 mm	Modified normal	- Reinforced strip footings - Articulation joints at some internal and all external doors - Light reinforcement in masonry - Site drainage and service/plumbing precautions - Foundation pressure not to exceed 50 kPa
		Compaction of in situ soils below individual footings	- Remove in situ material below foundations to a depth and width of 1,5 times the foundation width or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at –1% to +2% of optimum moisture content. - Normal construction with lightly reinforced strip foundations and light reinforcement in masonry.
		Deep strip foundations	- Normal construction with drainage requirements. - Founding on a competent horizon below the problem horizon
		Soil raft	- Remove in situ material to 1,0m beyond perimeter of building to a depth and width of 1,5 times the widest foundation or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at –1% to +2% of optimum moisture content. - Normal construction with lightly reinforced strip footings and light reinforcement in masonry.
S2	>20 mm	Stiffened strip footings, stiffened or cellular raft	- Stiffened strip footing or stiffened or cellular raft with articulation joints or solid lightly reinforced masonry. - Bearing pressure not to exceed 50kPa. - Fabric reinforcement in floor slabs. - Site drainage and service/plumbing precautions.
		Deep strip foundations	- As for S1 but with fabric reinforcement in floor slabs
		Compaction of in-situ soils below individual footings	- As for S1.
		Piled or pier foundations	- Reinforced concrete ground beams or solid slabs on piled or pier foundations. - Ground slabs with fabric reinforcement. - Good site drainage.
		Soil raft	- As for S1.

Notes:

1. Differential settlement assumed to equal 50% of total settlement.
2. The relaxation of some of these requirements, e.g. the reduction or omission of steel or articulation joints, may result in a Category 2 level of expected damage.
3. Account must be taken on sloping site since differential fill heights may lead to greater differential settlements.
4. Settlements induced by loads imposed by deep filling beneath surface beds may necessitate the adoption of a construction type appropriate to a more severe site class.

Table D6: Residential Site Class Designations (SAICE, 1995)

Site Class	Estimated Total Settlement	Construction Type	Foundation Design and Building Procedures
C	<5 mm	Normal	- Normal construction (strip footing or slab-on-the-ground foundations) - Good site drainage
C1	5 – 10 mm	Modified normal	- Reinforced strip footings - Articulation joints at some internal and all external doors - Light reinforcement in masonry - Site drainage and service/plumbing precautions - Foundation pressure not to exceed 50 kPa
		Compaction of in situ soils below individual footings	- Remove in situ material below foundations to a depth and width of 1,5 times the foundation width or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at –1% to +2% of optimum moisture content. - Normal construction with lightly reinforced strip foundations and light reinforcement in masonry.
		Deep strip foundations	- Normal construction with drainage requirements. - Founding on a competent horizon below the problem horizon
		Soil raft	- Remove in situ material to 1,0m beyond perimeter of building to a depth and width of 1,5 times the widest foundation or to a competent horizon and replace with material compacted to 93% MOD AASHTO density at –1% to +2% of optimum moisture content. - Normal construction with lightly reinforced strip footings and light reinforcement in masonry.
C2	>10 mm	Stiffened strip footings, stiffened or cellular raft	- Stiffened strip footing or stiffened or cellular raft with articulation joints or solid lightly reinforced masonry. - Bearing pressure not to exceed 50kPa. - Fabric reinforcement in floor slabs. - Site drainage and service/plumbing precautions.
		Deep strip foundations	- As for C1 but with fabric reinforcement in floor slabs
		Compaction of in situ soils below individual footings	- As for C1.
		Piled or pier foundations	- Reinforced concrete ground beams or solid slabs on piled or pier foundations. - Ground slabs with fabric reinforcement. - Good site drainage.
		Soil raft	- As for C1.

Notes:

1. Differential settlement assumed to equal 75% of total settlement
2. The relaxation of some of these requirements, e.g. the reduction or omission of steel or articulation joints, may result in a Category 2 level of expected damage.

Table D7: Foundation design, building procedures and precautionary measures for single-storey residential buildings founded on expansive soil horizons (SAICE, 1995)

Site Class	Estimated Total Heave	Construction Type	Foundation Design and Building Procedures
H	<7,5 mm	Normal	- Normal construction (strip footing or slab-on-the-ground foundations) - Good site drainage and service/plumbing precautions recommended.
H1	7,5 – 15 mm	Modified normal	- Lightly reinforced strip footings - Articulation joints at all internal/external doors - Light reinforcement in masonry - Site drainage and service/plumbing precautions
		Soil raft	- Remove in situ material to 1,0m beyond perimeter of the structure and replace with inert backfill, compacted to 93% MOD AASHTO density at –1% to +2% of optimum moisture content. - Normal construction with lightly reinforced strip footings and light reinforcement in masonry if residual movements are <7,5mm, or construction type appropriate to residual movements. - Site drainage and plumbing/service precautions.
H2	15-30 mm	Stiffened or cellular raft	- Stiffened or cellular raft with articulation joints or lightly reinforced masonry. - Site drainage and plumbing/service precautions.
		Piled construction	- Piled foundations with suspended floor slabs with or without ground beams. - Site drainage and plumbing/service precautions.
		Split construction	- Combination of reinforced brickwork/block work and full movement joints. - Suspended floors of fabric-reinforced ground slabs acting independently from the structure. - Site drainage and plumbing/service precautions.
		Soil raft	- As for H1.
H3	>30 mm	Stiffened or cellular raft	- As for H2.
		Piled construction	- As for H2.
		Soil raft	- As for H1.

Notes:

1. Differential movement assumed to equal 50% of total heave.
2. The relaxation of some of these requirements, e.g. the reduction or omission of steel or articulation joints, may result in a Category 2 level of expected damage.