DUNGU TOWNSHIP DEVELOPMENT

PRELIMINARY SHALLOW SOIL ENGINEERING GEOLOGICAL INVESTIGATION FOR PLANNING PURPOSES, DUNGU VILLAGE, UMTATA REGION, EASTERN CAPE PROVINCE

Basic Shallow Soil Investigation for Residential Planning

Project number: WF14066 **16 September 2014**

WSM LESHIKA CONSULTING (PTY) LTD

PO BOX 39942
MORELETA PARK
PRETORIA
0044
TEL: (012) 997-6769
E-mail: mvanrensburg@wsmleshika.co.za

623 RUBENSTEIN STREET
MORELETA PARK
PREOTIRA
0044
FAX: (012) 997-6768
ENQUIRIES: M van Rensburg

PRELIMINARY SHALLOW SOIL ENGINEERING GEOLOGICAL INVESTIGATION FOR PLANNING PURPOSES, DUNGU VILLAGE, UMTATA REGION, EASTERN CAPE PROVINCE

Client:	Mmaeshiba General Trade cc
Contact person:	Thabang Lamola
Project number:	**WF14066**
Project leader:	Jan Fanoy
Fieldwork conducted by:	Michael van Rensburg Engineering Geologist
Report compiled by:	Michael van Rensburg Engineering Geologist
Report reviewed by:	DH Wessels
Date completed:	**16 September 2014**
Report version:	Report Version 2

TABLE OF CONTENTS **Page no:**

LIST OF APPENDICES

LIST OF FIGURES:

LIST OF TABLES:

PRELIMINARY SHALLOW SOIL ENGINEERING GEOLOGICAL INVESTIGATION FOR PLANNING PURPOSES, DUNGU VILLAGE, UMTATA REGION, EASTERN CAPE PROVINCE

1. INTRODUCTION

WSM Leshika Consulting (Pty) Ltd. was appointed to conduct a basic shallow soil geotechnical assessment for the proposed housing units to be erected in the village known as Dungu, Umtata Region, Eastern Cape Province.

The area of interest is depicted in Figure 1 and Figure 2, Appendix A.

This report discusses the method of investigation, geotechnical conditions encountered with on-site material characteristics, recommendations and general considerations.

The level of information provided in this report is deemed suitable for planning purposes.

2. OBJECTIVES OF THE INVESTIGATION

The main objectives of the investigation were to:

- Identify and discuss the main on-site geotechnical constraints;
- Obtain the basic data concerning the use of in situ material;
- Comment on the excavation characteristics of the site soils;
- Comment on the potential for shallow seepage water conditions;
- Define the general ground conditions and provide site classifications including detailed soil profile and groundwater occurrences within the zone of influence of foundation work;
- Comment on the founding conditions;
- Provide the geotechnical basis for **planning** and **preliminary design** purposes.

3. INFORMATION USED DURING THE STUDY

The following information was available at the time of writing this report:

- Locality map;
- Approximate site boundaries;
- 1:50 000-scale 3129AC Topographical map;
- 1:250 000-scale 3128 UMTATA Geological Sheet;
- Existing GoogleEarth images.

Laboratory test results conducted on selectively retrieved soil horizons were also available at the time of writing this report. The laboratory tests consist of basic index tests and compaction tests conducted on a limited number of samples.

Localities for proposed units were not available and no tests for heave and/or collapse or consolidation quantification were conducted for the purposes of this basic investigation.

4. METHOD OF INVESTIGATION

The method of investigation can be summarized as:

- Desk study of available databases such as, aerial images and geological sheets;
- Field walkover survey;
- Excavation of a limited number of test pits with a TLB;
- Detailed soil profile descriptions;
- Soil profile photograph recordings;
- Selective soil sampling;
- Basic soil testing;
- Laboratory test results interpretation;
- Compilation of report with findings and recommendations.

Five test pits were excavated by means of a JCB 3CX TLB in the area of interest down to refusal or to near refusal excavation conditions. The test pit positions are depicted in Figure 3, Appendix A.

A suitably qualified engineering geologist positioned and inspected the test pits. The soil profiles were recorded using the standard procedures as per the SANS633:2012 standards. The individual soil profile descriptions are attached as Appendix B with photographs attached as Appendix C.

Disturbed samples were selectively retrieved in order to determine the soil grading, compaction characteristics and general material properties. The samples were submitted to an SANAS accredited laboratory, ControLab South Africa (Pty) Ltd. for testing. The test results are attached as Appendix D.

5. GEOLOGY

5.1 Regional Geology

According to the 1:250 000-scale geological sheet 3128 Umtata, the area of interest is underlain by:

- "Jd" – Dolerite.
- "Pa" – Grey and brownish-red mudstone, sandstone.

The onsite rock/geology was interpreted as shale/siltstone.

The site is not underlain by potentially soluble dolomitic formations and a specialized dolomite stability investigation **is not required**.

The geology is depicted in Figure 4, Appendix A.

5.2 Site Specific Geology

Five test pits were excavated by means of a TLB and terminated at between 1.10 to 2.80 mbngl (meters below natural ground level) in completely to highly weathered shale. Soft excavation conditions were encountered down to termination depth.

Based on the conditions encountered in the trial pits the site is seemingly covered with a moderately thick fine sandy silty clayey open very stiff colluvium down to between 0.30 and 0.85 m bngl.

The colluvial layer is underlain by very stiff fine sandy silty clayey residual shale with desiccation cracks in the profile down to between 0.75 and 2.80 m bngl. Test pits TP02 and TP05 were terminated in the residual shale horizon.

In test pits TP01, TP03 and TP04 the residual shale is underlain in by layered and jointed completely to highly weathered soft rock shale that terminates at 1.20 m, 1.10 m and 1.30 m respectively. The profiles become less weathered and harder with depth.

A summary of the soil profiles are provided in Table 1a and Table 1b. The detailed soil profiles are attached as Appendix B with the relevant profile photographs attached as Appendix C.

Table 1a: Soil profiles summary (co-ordinates and soil textures)

TP	Latitude	Longitude	Elevation	Clay	Silt	Sand	Gravel
TP01	-31.440531°	29.106473°	892	0.00-1.15	0.00-1.15	-	-
TP02	-31.441311°	29.110480°	910	0.00-2.60	0.00-2.60	-	-
TP03	-31.442644°	29.114631°	894	0.00-0.75	0.00-1.10	-	0.30-0.50
TP04	-31.439020°	29.112835°	890	0.00-0.80	0.00-1.30	-	-
TP05	-31.438112°	29.108505°	882	0.00-0.85	0.00-2.80	1.40-2.80	-

Table 1b: Soil profiles summary (soil horizons and excavation)

TP	Colluvium	Residuum	Completely Weathered Rock	Highly weathered rock	Moderately weathered rock	Termination depth	Excavatability up to termination depth	Excavatability at termination depth	Seepage
TP01	0.00-0.30	0.30-1.15	0.55-1.15	1.15-1.20	-	1.2	Soft	Hard	No
TP02	0.00-0.45	0.45-2.60	-	-	-	2.6	Soft	Soft	No
TP03	0.00-0.50	0.50-0.75	0.75-1.10	0.75-1.10	-	1.1	Soft	Hard	No
TP04	0.00-0.40	0.40-0.80	0.80-1.30	0.80-1.30	-	1.3	Soft	Hard	No
TP05	0.00-0.85	1.40-2.80	-	-	0.85-1.40	2.8	Soft	Soft	No

6. SITE DESCRIPTION

6.1 Locality and Size

The site is situated north-east of the town of Umtata and Libode in the village of Dungu. The approximate size of the investigated area is 81.1 ha.

The approximate centre coordinates of the investigated area is as follows (Decimal Degrees, Datum: WGS84):
Latitude: -31.440381°
Longitude: 29.109550°

The locality is depicted in Figure 1 and Figure 2, Appendix A.

6.2 Vegetation, Topography, Drainage and Existing Structures

The site is mainly covered with natural grass, small to medium sized trees and informal mud houses. The remainder of the site is fairly open with steep slopes surrounding the village. No detailed contour map was provided/available at the time of writing this report. The regional topography as per the 1:50 000-scale topographical sheet is attached as Figure 5, Appendix A. The village is located on top of a hill with the steep slopes from the center of the site decreasing to the edges of the site; see the elevation profile of the site from north-west to north-east in Figure 1 and from south-west to south-east in Figure 2 below. Drainage channels are located in the valleys at the bases of these slopes. The site is situated on a watershed.

Figure R1: Elevation profile from north-west to south-east.

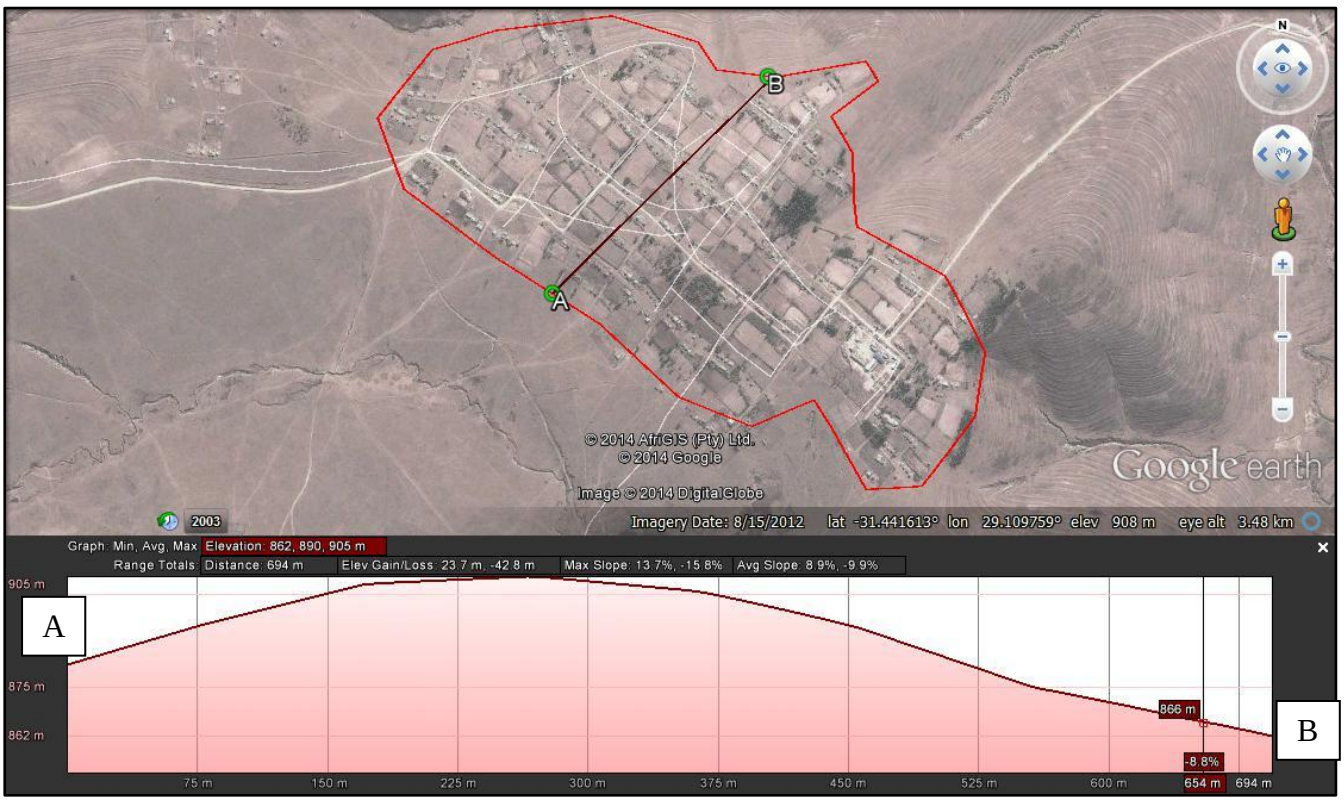


Figure R2: Elevation profile from south-west to north-east.

7. SHALLOW GROUNDWATER OR SEEPAGE WATER

Signs of seasonal shallow seepage water conditions are evident in the soil profiles excavated. Severe shallow seasonal seepage water are expected, water is expected to occur on the shallow completely to highly weathered shale. Concentration of flow will be from the top center of the village down slope to the sides of the village area towards the drainage features located in the lower lying areas.

Seasonal seepage water of less than 1.5 m below ground level will be a reality throughout the majority of the site. Localised areas of surface ponding conditions can also be expected and should be identified from the detailed ground contour survey data.

Typical seepage areas are generally more prominent in lower-lying areas. Seepage is expected to mainly occur for short periods after heavy and/or prolonged rainfall events.

8. EXCAVATION CONDITIONS

Excavatability of materials can be classified in five different categories according to the SABS 1200 D-1988 standards. Table 2 below is a summary of the SABS standards (refer to SABS 1200D-1988 document for detailed classification):

Table 2: Excavation classes (Modified SABS 1200D)

Sample Position	Simplified description of typical material properties
Soft excavation	Material that can be efficiently removed or loaded, without prior ripping, by means of a bulldozer, tractor-scraper, track type front-end loader or back-acting excavator without the use of pneumatic tools such as paving breakers
Intermediate excavation	Material that can be efficiently ripped by a bulldozer fitted with a single-tine ripper or with a back-acting excavator of flywheel power exceeding 0,10 kW per mm of tined-bucket width or the use of pneumatic tools before removal by equipment equivalent to that specified above.

Sample Position	Simplified description of typical material properties
Hard rock excavation	Excavation in material that cannot, before removal, be efficiently ripped by a bulldozer. This is material that cannot be efficiently removed without blasting or without wedging and splitting.
Boulder excavation (Class A)	Excavation in material containing more than 40 % by volume boulders of size in the range of 0,03-20m3, in a matrix of soft material or smaller boulders.
Boulder excavation (Class B)	Excavation in material containing 40 % or less by volume boulders of size in the range of 0,03-20m3, in a matrix of soft material or smaller boulders and which require individual drilling and blasting in order to be loaded by a track type front-end loader or back-acting excavator .

The trial pits were excavated by means of a JCB 3CX TLB and the TLB excavatability in the upper excavated material and at termination depths with SABS excavatability correlations are summarized in Table 1b.

The test pits were excavated down to between 1.10 to 2.80 m bngl with an average excavation depth of approximately 1.80 m bngl with a standard deviation of 0.83 m.

Refusal conditions were encountered in three of the test pits within completely to highly weathered shale in test pit TP01, TP03 and TP04 at 1.20 m, 1.10 m and 1.30 m bngl respectively. Intermediate excavation conditions were encountered at these termination depths where refusal conditions were experienced on jointed and layered soft rock shale.

Excavation took place with a TLB in a confined trench; deeper excavation could be possible with a TLB in unconfined trenches and there is a possibility that the material may be rippable due to bedding and jointing. The materials are however expected to be excavatable with a larger excavator down to at least 2 m to 2.50 m bngl in confined trenches.

Soft excavation was encountered down to termination depths for all the test pits.

The bedrock conditions are expected to be undulating with depths varying of 0.50 m to 1.00 m bngl over short distances due to the change in slope and location on the slope.

9. LABORATORY RESULTS AND GENERAL MATERIAL PROPERTIES

A number of disturbed soil samples were selectively retrieved and submitted to Controlab South Africa (Pty) Ltd. Umtata for testing.

Grading analysis, compaction testing, Atterberg Limit tests were conducted in order to determine the basic material properties for evaluation purposes. The laboratory test results are attached as Appendix D. The USCS (unified soil classification system) was not provided by the laboratory; the classifications used below where interpreted from the results received and should be used with caution as the classification may differ slightly. USCS (unified soil classification system) chart used to determine the classifications are attached in Appendix F as Chart C1 and C2.

9.1 Material Classifications and General Material Properties and Ratings

The material encountered and tested generally classifies as "**SM**", "**ML**", and "**CL**" according to the Unified Soil Classification System. The Foundation Indicator test results conducted on selectively retrieved samples are summarized in Table 3.

TABLE 3: Foundation Indicator Test Results

Test pit no	Sample depth (m)	Material description	Soil composition				Atterberg Limits		LS (%)	GM	Class (USCS)	Class (USCS) 2
			Clay (%)	Silt (%)	Sand (%)	Gravel (%)	LL (%)	PI (%)				
Du01	0.60-1.00	Residual to completely weathered shale	5	33	49	13	29	10	4	0	SM	ML
Du02	0.50-1.00	Residual shale	8	35	57	0	48	14	6	0	ML	0
Du02	1.50-2.0	Residual shale	22	43	35	0	51	15	7	0	MH	0
Du03	0.80-1.10	Completely to highly weathered shale	5	15	24	56	28	10	4	0	GC	0
Du04	1.00-1.30	Completely to highly weathered shale	6	19	42	33	29	9	4.5	2.12	SM	0
Du05	0.20-0.80	Colluvium	7	30	43	20	35	13	4	0	CL	0
Du05	1.00-2.00	Residual shale	5	16	39	40	25	9	4	1.72	SM	0

The following general descriptions can be assigned to the soil classes:

GC → Clayey gravels, gravel-sand-clay mixtures.

SM → Silty sands, poorly graded silt-sand mixtures.

ML → Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.

CL → Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.

Typical material properties for the above classifications are summarized in Table E1 and Table E2, Appendix F for guideline purposes.

10. GEOTECHNICAL EVALUATION

10.1 Soil Heave

The potential expansiveness of the material was evaluated based on the indicative laboratory test results and field observations. This included using the Plasticity Index and Linear Shrinkage of the material, Van der Merwe's Method and the material structure to evaluate the potential heave of the material. The potential expansiveness of the materials is visually depicted in Chart 1.

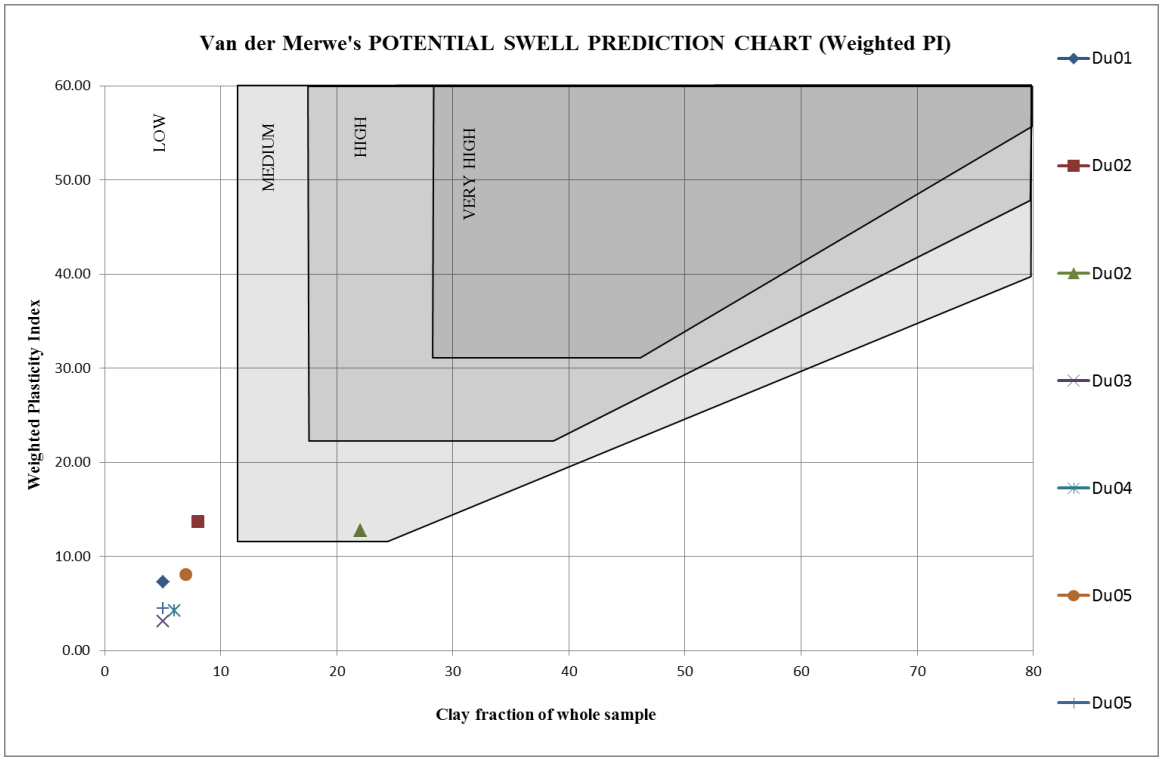


CHART 1: Swell Prediction Chart (Weighted PI and Clay Fraction of whole sample)

The indicator test results conducted on all the materials sampled indicate that the residual shale soil tested from TP02 at 1.50-2.00 m has a "Medium" heave potential which confirms the visual interpretations taking into consideration the clay content and soil structure. The test results indicate that the colluvium and completely to highly weathered shale has a "Low" heave potential with very little amount of clay present.

According to the compaction results the completely weathered and residual shale from test pits Du03 and Du05 at 0.80-1.10 m and 1.00-2.00 respectively have low swell percentages at 100 % MOD. ASSHTO compaction efforts of 0.66 % and 0.56 % respectively.

Medium soil heave corresponding to the SAICE (1995) site class designation "**H1**" (7.5 mm to 15 mm total range of expected soil movement, assumed 50% differential movement) is expected in the residual shale layer. Deeper residual shale that contains very small amounts of fines (clay) such as in test pit TP05 indicates a low potential heave.

Medium soil heave is only present in the overlying residual shale layer; the underlying weathered rock has a low soil heave potential.

The grading analysis, Atterberg Limits and compaction test results for the materials are attached in Appendix D.

10.2 Collapsible and/or Compressible Material

The lower lying completely to highly weathered shale has a layered and jointed structure which may result in some settlement when loaded.

The deep residual shale that did not refuse on bedrock such as test pit Du02 and the top colluvium layer consists of medium amounts of fines present that can experience a degree of consolidation. These horizons have an open structure such as desiccation cracks and small voids that will result in a degree of consolidation corresponding to the SAICE class "C1".

The layered and jointed completely to highly weathered shale has a slight collapse potential as for SAICE class "C" and "S" consolidation potential.

10.3 Erodability

The soils are considered to have a high susceptibility to erosion. Basic erosion protection measures will be recommended such as proper surface drainage in order to avoid concentrated water flow and potential erosion and undercutting of structures/floors and/or unwanted erosion of excavation/foundation/service trenches. A

typical erosion feature encountered in the vicinity of the village is depicted in Photograph 1.

Photograph 1: Typical erosion feature near Dungu village.

11. MAJOR GEOTECHNICAL CONSTRAINTS

Based on the conditions encountered during this investigation the major geotechnical constraints can be summarized as:

- Medium heave potential in upper residual shale and deeper residual shale containing high amounts of fines;
- Severe shallow seasonal seepage water conditions and/or saturated soil profiles;
- Very steep slopes surrounding entire village 6 to 12 degrees;
- Excavation difficulty due to shallow bedrock, depending on location on slope.

12. SITE CLASSIFICATION

The site is classified based on the different geotechnical and founding conditions as per the SAICE 1995 classification (NHBRC classification as for single story

residential/small type structures) and the SANS 634:2012 document of which the applicable tables are attached in Appendix F for reference purposes.

One broad geotechnical zone has been assigned for the site for the purposes of this basic investigation:

Zone I: C1-H1 (R) / 2ABCDE (2FI)

Where C, S and P before the / refer to:

C - Collapse settlement;

H - Expansive soils;

(R) - Localised shallow rock.

The A-B-C-D-E-F-H-I after the / refer to:

A - Collapsible soils;

B - Seasonal shallow seepage water or saturated soil conditions;

C – Active soils;

D - Consolidation settlement;

E - Erodability of the soil horizons;

F - Excavation difficulty;

I - Steep slopes.

The classification in brackets (2FI) indicates localised occurrences for excavation difficulty and moderately steep slopes which has a highly likelihood.

Refer to Table 1, Table 2, Table 3, Table 4 and Table 5, Appendix F.

13. FOUNDATION AND GERNAL RECOMMENDATIONS

For planning purposes the following foundation types/options can be considered for potential small size residential type structures (as for class “H1” and “C1” SAICE 1995 foundation options of which the appropriate tables are attached in Appendix F):

- Modified normal construction (As for class H1).
- Soil raft construction (As for class C1 or H1).

More conservative foundation options may be:

- Stiffened or cellular raft foundations (As for class H2).
- Split construction (As for class H2).

It is recommended that stiffened or cellular raft foundations are considered for planning purposes till more detailed investigations are conducted as required by the SANS634:2012 standards and accommodated with the necessary heave and consolidation quantification tests.

Modified normal construction to even normal construction may be suitable in areas. These foundation options however can only be considered if conditions are proven with more detailed investigations.

14. CONSTRUCTION MATERIALS

14.1 Soil Mattress and General Backfill

The basic requirements for material to be used for soil mattress construction can be summarized as:

- The material needs to be workable;
- The material needs to have good compaction characteristics;
- The material needs to have a low compressibility once properly compacted;
- The material needs to exhibit a low heave once properly compacted;
- The material needs to have suitable bearing capacity once properly compacted.

The on-site material is generally silty clays in the upper residual shale. The completely to highly weathered shale crumbles to silt and rock fragments when excavated and compacted. The residual shale material tested according to the USCS has the following workability:

CL – Good to fair workability rating;
MH – Good workability rating;
ML – Fair workability rating.
The completely to highly weathered shale and residual shale that classifies as "GC" and "SM" has a fair workability rating.

The completely to highly weathered shale material retrieved from test pit TP03 at 0.80-1.10 has a maximum dry density of 1 962 kg/m^3 with an optimum moisture content of 12 % and a measured swell of 0.66 % Mod. AASHTO compaction effort. The CBR of the material increases from 8 to 13 to 22 at 90%, 95% and 100% Mod. AASHTO compaction efforts. The samples tested classifies as "G9" according to the TRH/COLTO classification.

The residual shale material retrieved from test pit TP05 at 1.00-2.00 m has a maximum dry density of 1 956 kg/m^3 with an optimum moisture content of 11.1 % and a measured swell of 0.56 % Mod. AASHTO compaction effort. The CBR of the material increases from 8 to 12 to 17 at 90%, 95% and 100% Mod. AASHTO compaction efforts. The sample tested classifies as "G9" according to the TRH/COLTO classification.

The material has fair compaction characteristics based on the increase in CBR values, achieved maximum dry densities and relatively low percentage swell measured.

The weathered shale is expected to have a low compressibility once properly compacted. The residual shale and upper fines are expected to have a medium to high compressibility even when properly compacted due to the abundance of fines.

The weathered shale has are expected to have a low heave potential. The residual shale is expected to have a slight to medium heave potential.
The typical fill rating of the material is represented in Table 5 below.

TABLE 5: Fill and Foundation Material

Test	Sample	Material description	Unified	Typical rating	Typical rating for	Expected Dry

pit	depth (m)		Soil Class	for use as general fill material	use as fill for foundation purposes	Density (kg/m3) (PROCTOR)
Du01	0.60-1.00	Residual to completely weathered shale	SM	Average	Good (density important)	1 830 +/- 20
Du02	0.50-1.00	Residual shale	ML	Average	Good (Liquifaction problem)	1 650 +/- 20
Du02	1.50-2.0	Residual shale	MH	Poor	Unsuitable (Swell?)	1 310 +/- 60
Du03	0.80-1.10	Completely to highly weathered shale	GC	Good	Excellent	> 1 840
Du04	1.00-1.30	Completely to highly weathered shale	SM	Average	Good (density important)	1 830 +/- 20
Du05	0.20-0.80	Colluvium	CL	Average	Average (Swell?)	1 730 +/- 20
Du05	1.00-2.00	Residual shale	SM	Average	Good (density important)	1 830 +/- 20

The weathered and residual shale material in general (materials classifying as “SM” and “ML”) are considered to have an average rating for typical fill, whereas the material classifying as “GC” has an excellent rating for typical fill. The materials with an abundance of fines (soils classifying as “MH”) are considered to have a poor rating for typical fill.

14.2 Road Construction

A more detailed investigation should be conducted in order to comment the suitability of the on-site materials for pavement design. The colluvium and residual fines are expected to have a fair rating for subgrade construction and not suitable for subbase or base construction. The lower weathered shale is expected to have a good rating for subgrade construction with possibly a good to fair rating for subbase construction. None of the on-site materials encountered are considered suitable for base construction. It is recommended that borrowpits is identified and that suitable materials are sourced for subbase and base construction.

15. CONCLUSIONS

The site is underlain by grey and brownish-red mudstone, sandstone; identified on site to be shale/siltstone.

No potentially soluble dolomitic or limestone formations are present and a dolomite stability investigation is not required.

The area is not undermined and no significant economic mineral deposits are indicated on the relevant geological sheet in the proposed development area that may affect the developability of the site.

One broad geotechnical zone has been assigned for the site for the purposes of this basic investigation:

Zone I: C1-H1 (R) / 2ABCDE (2FI)

For planning purposes one or a combination of the following foundation types/options can be considered:

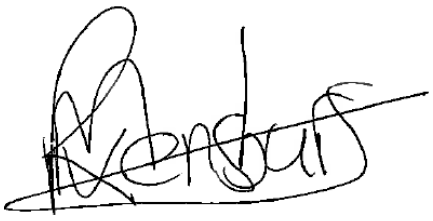
- Modified normal construction (As for class H1).
- Soil raft construction (As for class C1 or H1).
- Stiffened or cellular raft foundations (As for class H2).
- Split construction (As for class H2).

The stiffened or cellular raft foundations and split construction are considered the more conservative design approach. Proper surface, subsurface drainage and damp proofing will be essential in order to prevent or limit moisture damage to the floors and walls. Corrosion protection is recommended for any ferrous metals or services in contact with the soils. Termite and pesticide control will be recommended below all structures. Basic erosion protection will be highly recommended in order to prevent excessive erosion and potential undercutting of structures.

The report is deemed suitable for basic planning purposes. The standard engineering geological investigations associated with residential development with reference to the minimum requirements as outlined in the SANS634:2012 standards should be conducted for detailed planning, design and enrolment purposes.

16. REPORT PROVISIONS

The report is considered a basic investigation with level of detail considered suitable for basic planning purposes only. The report should be distributed in its full context in order to avoid miss-interpretation that may result from selective data distribution. The engineering geologist assumes no responsibilities for any damages or unforeseen circumstances resulting from any geotechnical hazard if detailed planning and/or design are based on this basic evaluation.



MICHAEL van RENSBURG
Engineering Geologist

APPENDIX A

(Figures)

Figure 1: Locality map 1: Eastern Cape Housing (Dungu)

WSM LESHIKA CONSULTING (PTY) LTD

No: WF14066 © GoogleEarth 2014

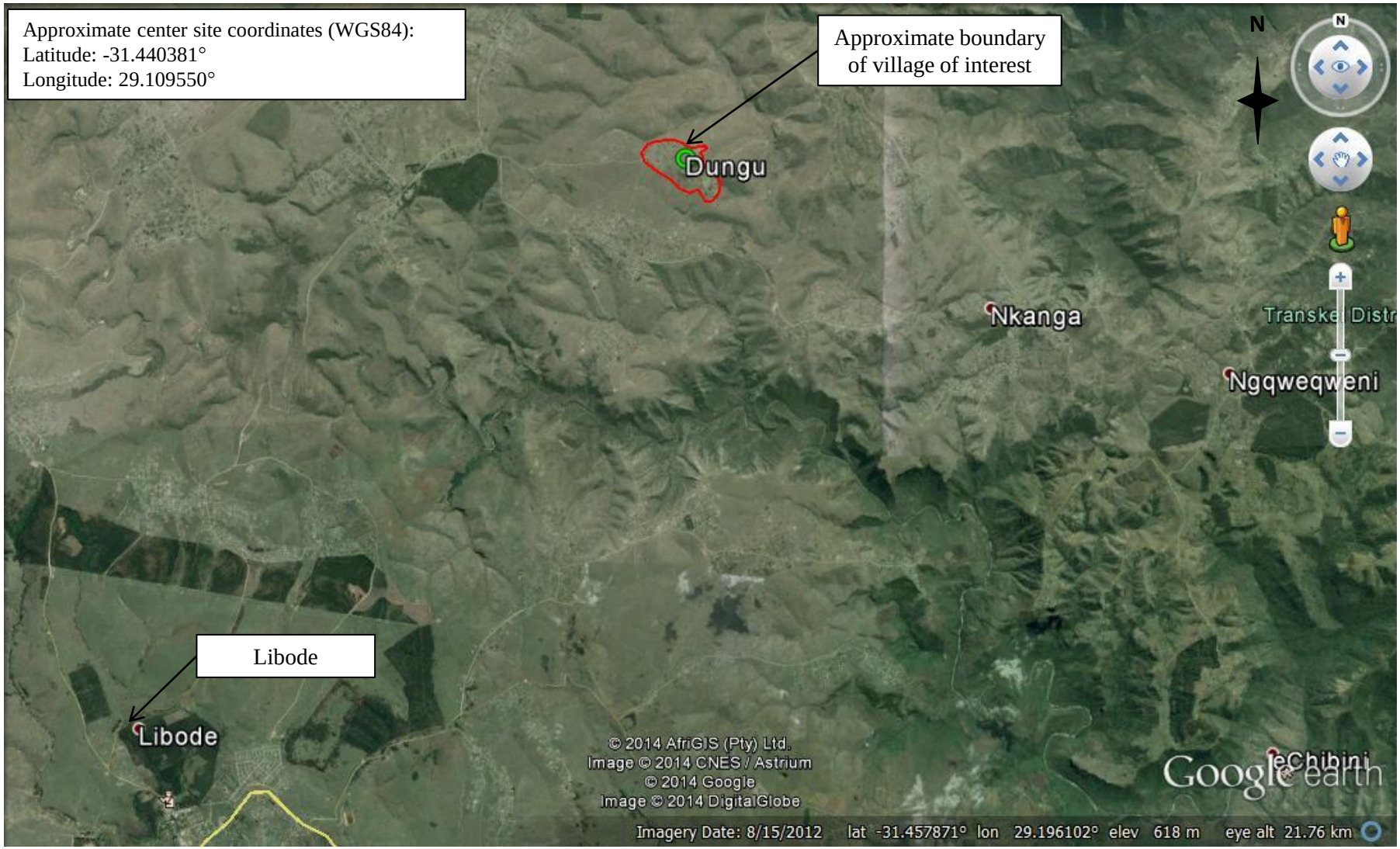


Figure 2: Locality map 2: Eastern Cape Housing (Dungu)

WSM LESHIKA CONSULTING (PTY) LTD

No: WF14066

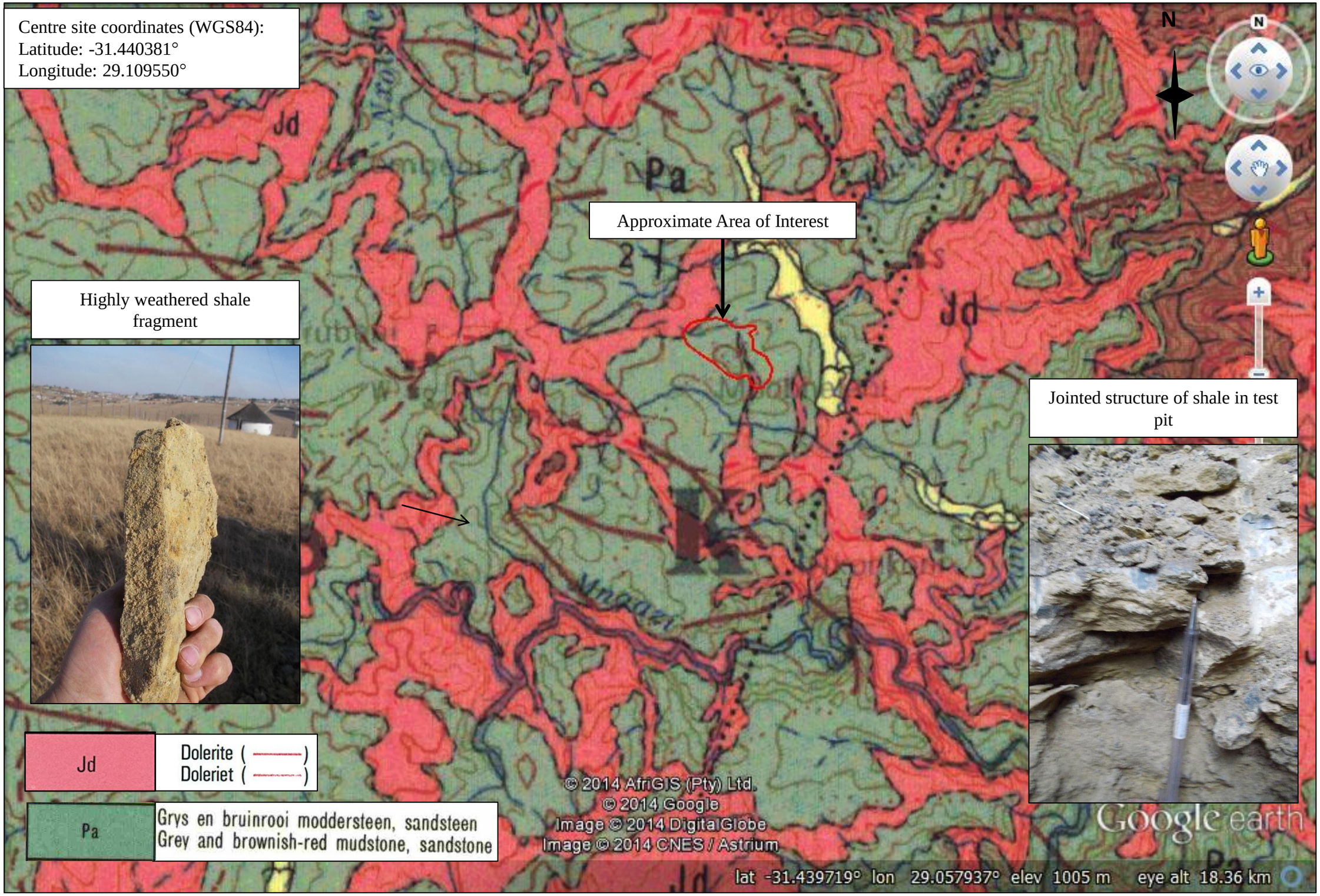


Figure 3: Geology map: Eastern Cape Housing (Dungu)

WSM LESHIKA CONSULTING (PTY) LTD

Project No: WF14066

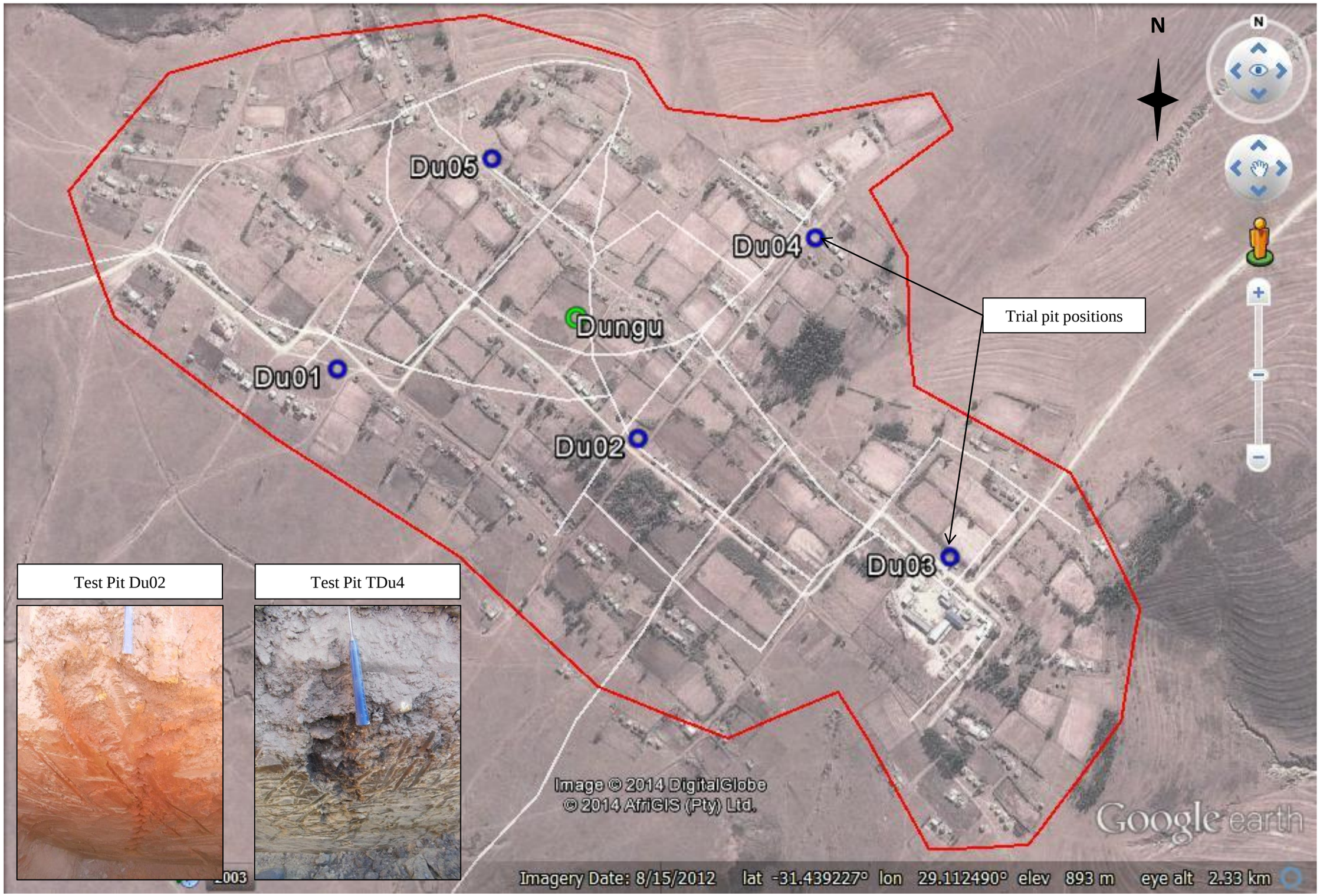


Figure 4: Test Pit Positions: Eastern Cape Housing (Dungu)

WSM LESHIKA CONSULTING (PTY) LTD

Project no: WF14066

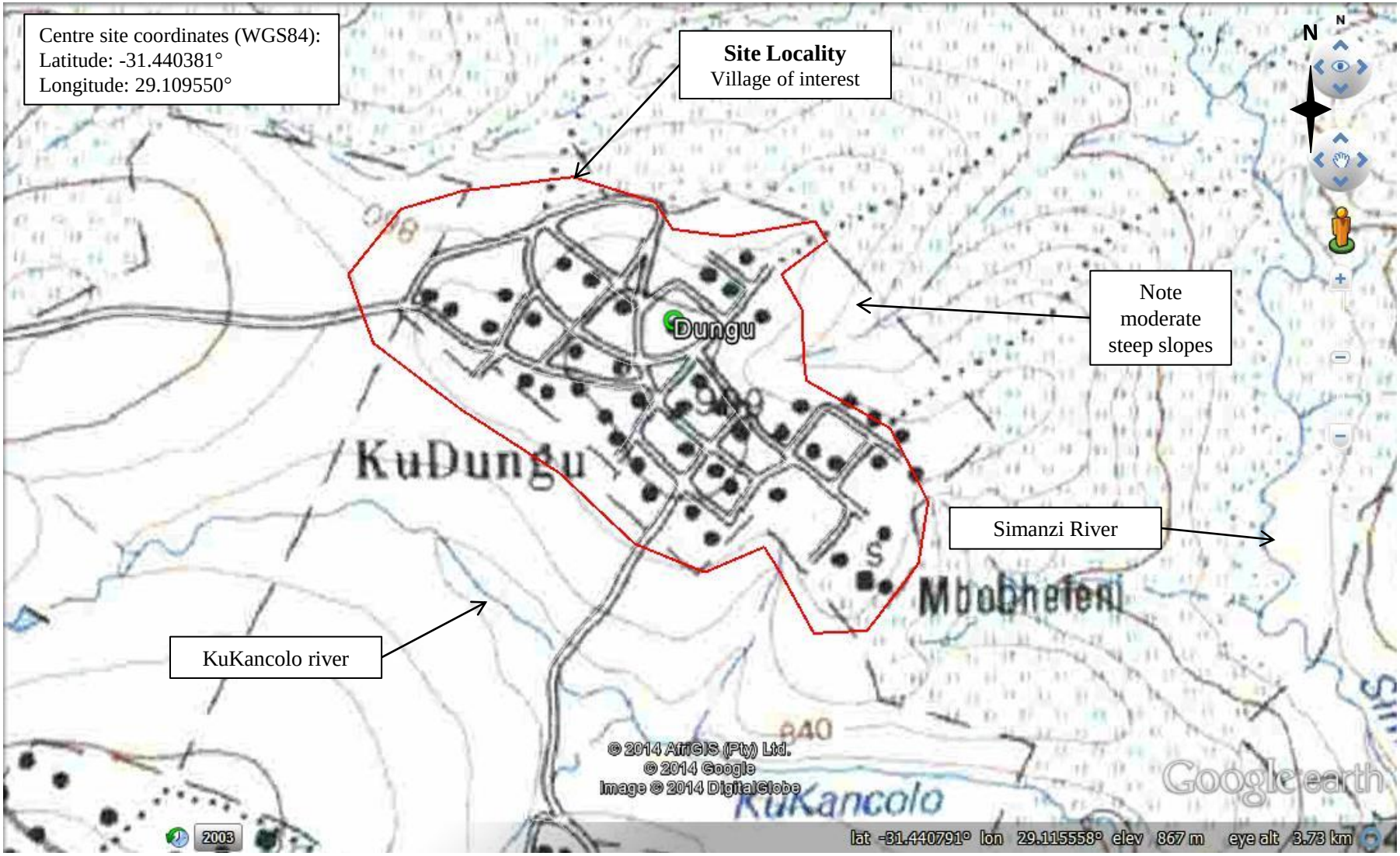


Figure 5: Topographical map: Eastern Cape Housing (Dungu)

WSM LESHIKA CONSULTING (PTY) LTD

Zone
Zone I: C1-H1 (R) / 2ABCDE (2FI)

Notes:
1) Refer to the report for constraints, foundation options and general recommendations.
2) Zonation needs to be confirmed during phase2 investigation excavations and environmental/flood/wetland investigation studies.

Figure 6: Geotechnical Zonation: Eastern Cape Housing (Dungu)

WSM LESHIKA CONSULTING (PTY) LTD

Project no: WF14066

APPENDIX B

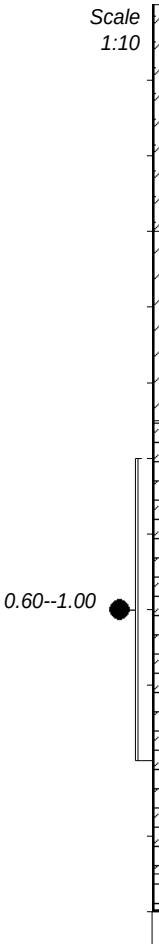
(Soil Profile Descriptions)

WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Du01
Sheet 1 of 1

JOB NUMBER: WF14066



0.00 Dry to slightly moist, grey, very stiff, **open**, fine sandy silty CLAY, colluvium.

0.30 Moist, black and grey, very stiff, **desiccation cracks**, silty CLAY, residual shale.

0.55 Moist, yellow streaked brown, dense, slightly open and layered, clayey SILT, residuum to completely weathered shale.

1.15 Grey, **jointed and layered**, highly weathered soft rock shale.

1.20

NOTES

1) Refusal, TLB confined excavation.

2) Sample: 0.60--1.00 m.

3) No seepage.

4) Hole stable during investigation.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:03
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: Du01

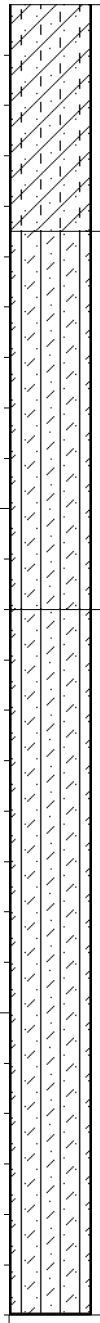
WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Du02
Sheet 1 of 1

JOB NUMBER: WF14066

Scale 1:15



0.00 Dry to slightly moist, dark grey, very stiff, **open slightly shattered**, fine sandy silty CLAY, colluvium.

0.45 Moist, maroon mottled black and red, very stiff to dense, **open and slickensided**, fine sandy clayey SILT, residual shale.

1.20 Moist, maroon red speckled yellow orange black and red, medium dense to dense, **slightly open**, fine sandy clayey SILT, residual shale.

2.60

NOTES

1) Hole stopped.

2) Sample: 0.50--1.00 m and 1.50--2.00 m.

3) No seepage.

4) Hole stable during investigation.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:03
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

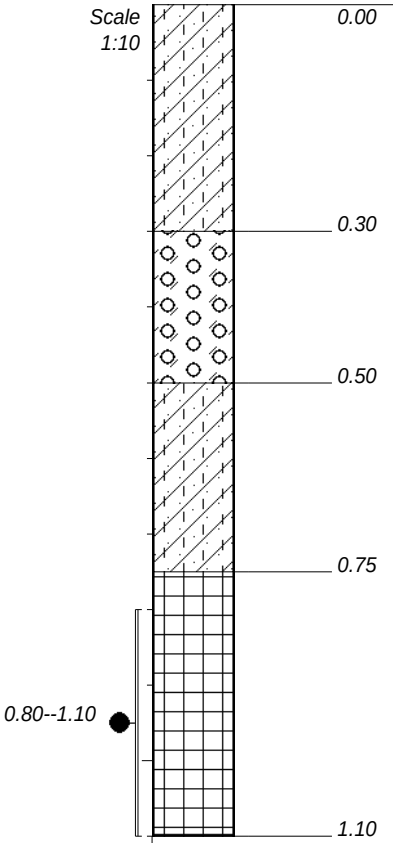
HOLE No: Du02

WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Du03
Sheet 1 of 1

JOB NUMBER: WF14066



0.00 Slightly moist, grey mottled red, very stiff, **very open**, fine sandy silty CLAY, colluvium.

0.30 Slightly moist, grey mottled red, very stiff, **very open**, clayey fine GRAVEL, colluvium.

0.50 Slightly moist, black, very stiff, **desiccation cracks**, fine sandy silty CLAY, residual shale.

0.75 Slightly moist, yellow streaked black, very dense, **layered and jointed**, completely to highly weathered soft rock shale that excavates to silt and fragments.

1.10

NOTES

1) Refusal, TLB confined excavation.

2) Sample: 0.80--1.10 m.

3) No seepage.

4) Hole stable during investigation.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:03
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: Du03

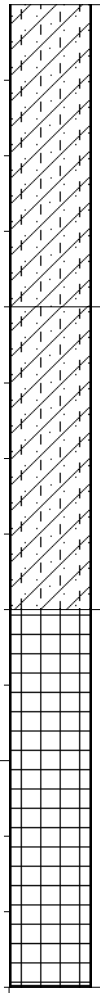
WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Du04
Sheet 1 of 1

JOB NUMBER: WF14066

Scale 1:10



0.00

Slightly moist, grey mottled red, very stiff, **very open**, fine sandy silty CLAY, colluvium.

0.40

Slightly moist, black, very stiff, **desiccation cracks**, fine sandy silty CLAY, residual shale.

0.80

Slightly moist, yellow streaked black, very dense, **layered and jointed**, completely to highly weathered soft rock shale that excavates to silt and fragments.

1.00--1.30

1.30

NOTES

1) Refusal, TLB confined excavation.

2) Sample: 1.00--1.30 m.

3) No seepage.

4) Hole stable during investigation.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:03
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: Du04

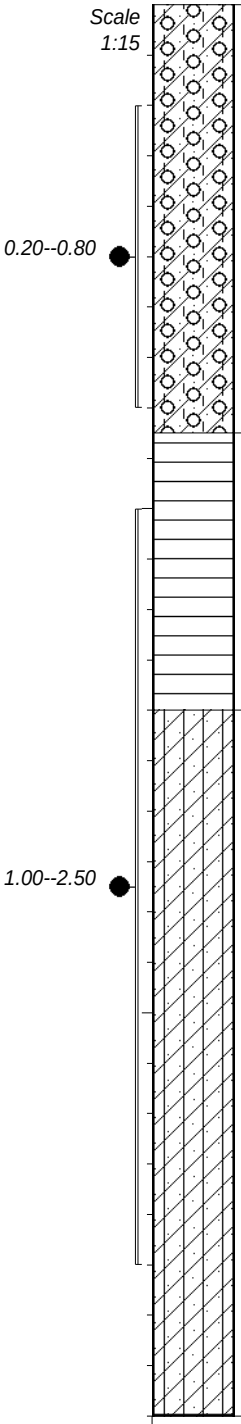
WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

HOLE No: Du05
Sheet 1 of 1

JOB NUMBER: WF14066

Scale 1:15



0.00 Slightly moist, dark grey, very stiff, **open slightly shattered**, fine sandy silty CLAY, with abundant fine gravel, colluvium.

0.85 Light yellow white, **jointed fractured and layered**, moderately weathered medium hard rock shale with patches of top layer.

1.40 Moist, dull yellow patched yellow and grey, medium dense, **slightly open**, fine sandy SILT, with patches of grey black clay, residual shale.

2.80

NOTES

1) Hole stopped.

2) Sample: 0.20--0.80 m and 1.00--2.50 m.

3) No seepage.

4) Hole stable during investigation.

CONTRACTOR :
MACHINE : TLB JCB
DRILLED BY :
PROFILED BY : HAM van Rensburg
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 2014/07/16-18
DATE : 11/09/14 12:03
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: Du05

WSM LESHIKA CONSULTING (PTY) LTD

Housing project in Eastern Cape

LEGEND
Sheet 1 of 1

JOB NUMBER: WF14066

	GRAVEL	{SA02}
	SANDY	{SA05}
	SILT	{SA06}
	SILTY	{SA07}
	CLAY	{SA08}
	CLAYEY	{SA09}
	SHALE	{SA12}
Name ●	DISTURBED SAMPLE	{SA38}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :
TYPE SET BY :
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE :
DATE : 11/09/14 12:03
TEXT : ..C:\DOTFILES\SP_DP.TXT

ELEVATION :
X-COORD :
Y-COORD :

LEGEND
SUMMARY OF SYMBOLS

APPENDIX C

(Soil Profile Photographs)

Test Pit number: Du01

Note: TLB refusal soft excavation till refusal.

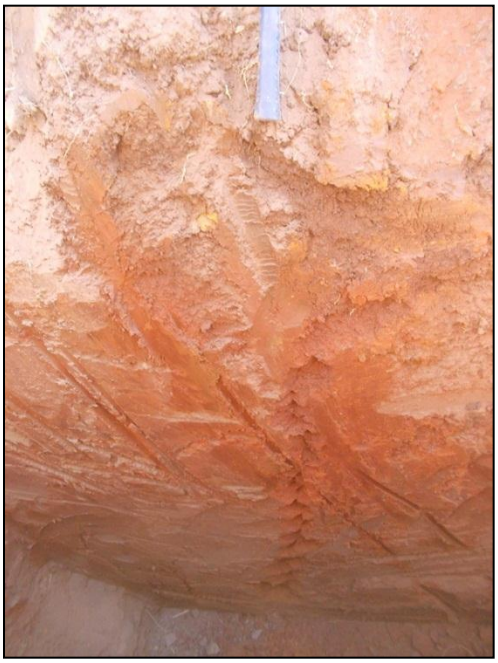
Test Pit number: Du01

Note: Desiccation cracks in profile.

Test Pit number: Du01

Note: Highly weathered shale fragment..

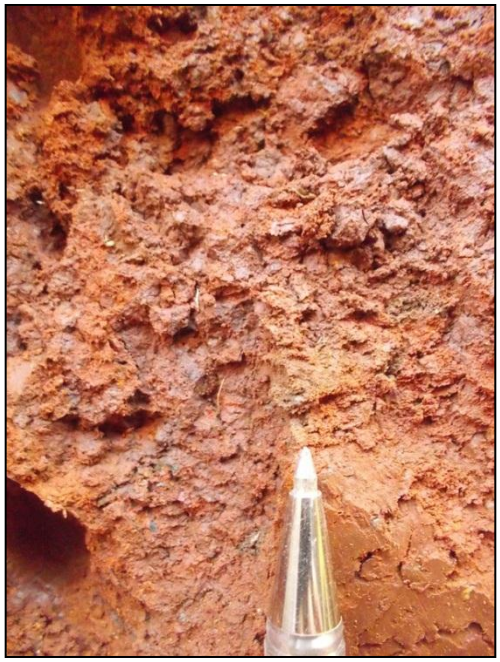
Test Pit number: Du02



Note: Hole stopped TLB soft excavation.

PROJECT: Housing Project in Eastern Cape (Dungu) PROJECT no: WF14066

Test Pit number: Du02



Note: Slight slickensided structure in profile.

Test Pit number: Du03

Note: TLB refusal. soft excavation till refusal.

Test Pit number: Du03

Note: Highly weathered shale fragments.

Test Pit number: Du03

Note: Open structure in profile.

Test Pit number: Du03

Note: Jointed structure at base of test pit.

Test Pit number: Du04

Note: TLB refusal soft excavation till refusal.

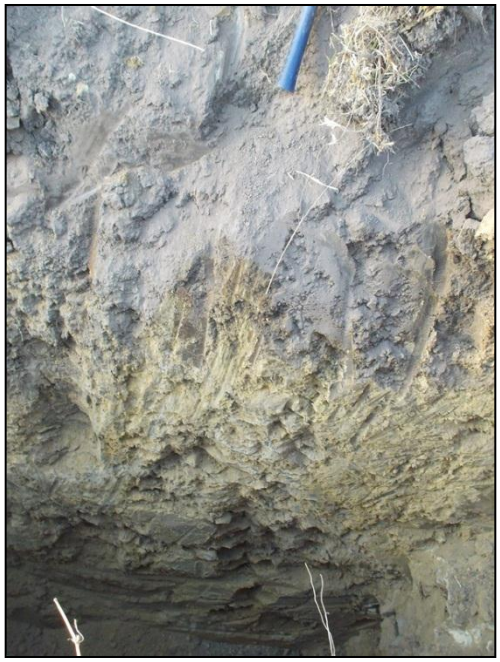
Test Pit number: Du04

Note: Clay horizon in profile.

Test Pit number: Du04

Note: Soft rock shale fragments.

Test Pit number: Du05

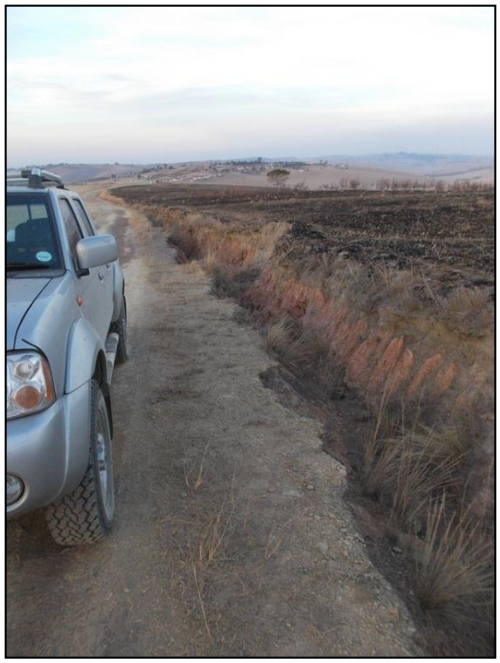


Note: Hole stopped TLB soft excavation.

Test Pit number: Du05

Note: Fractured and jointed structure of medium hard rock shale.

Test Pit number: Du05



Note: Erosion feature near village.

Test Pit number: Du05

Note: Top clay horizon.

APPENDIX D

(Laboratory Test Results)

ControLab South Africa (Pty) Ltd

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

www.controlab.co.za

HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7859, Fax: 043 726 7426
CENTRAL LABORATORY : 10 St Pauls Road, East London, 5201, Tel: 043 722 5420 / 722 8565, Fax: 043 743 9942, P O Box 346, East London, 5200
OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Port Elizabeth, Lusaka - Zambia

CLIENT: WSM Leshika Consulting (PTY) Ltd
P.O. Box 39942
Moleretа Park
PRETORIA 0044
ATT : Mr M. Van Rensburg

PROJECT: HOUSING PROJECT IN E.C. DUNGU VILLAGE
DATE: 2014.08.12
REF: MT 24746

O.N. WF 14066

FOUNDATION INDICATOR TEST

SAMPLE NO	3132	3133	3134	3135	3136	3137
POSITION	Du 01	Du 02	Du 02	Du 03	Du 04	Du 05
	DUNGU VILL	DUNGU VILL	DUNGU VILL	DUNGU VILL	DUNGU VILL	DUNGU VILL
DEPTH	0.60 - 1.00	0.50 - 1.00	1.50 - 2.00	0.80 - 1.10	1.00 - 130	0.20 - 0.80
DESCRIPTION	lt Y Ss	dk R Sty s	dk R Sty s	dk Br Ms	dk Br Ms	dk Br Sty cl Ss

SIEVE ANALYSIS

% PASSING							
75	mm				71		
37.5	mm				61	100	100
19	mm	100			54	84	97
9.5	mm	91			49	74	89
4.75	mm	87		100	44	67	80
2.36	mm	82	100	97	38	60	71
1.18	mm	78	99	94	34	54	65
0.600	mm	75	99	88	32	49	63
0.425	mm	73	98	85	31	47	62
0.300	mm	73	91	84	31	47	62
0.150	mm	71	72	82	30	42	57
0.075	mm	38.0	42.5	65.0	20.1	25.1	37.1

MECHANICAL ANALYSIS

0.06	mm	32	37	61	18	22	32
0.02	mm	15	20	13	11	13	18
0.006	mm	8	12	57	6	8	10
0.002	mm	5	8	22	5	6	7

SOIL CONSTANTS

LIQUID LIMIT	29	48	51	28	29	35
PLASTICITY INDEX	10	14	15	10	9	15
LINEAR SHRINKAGE	4.0	6.0	7.0	4.0	4.5	4.0

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

MOISTURE CONTENT %						
PI WHOLE SAMPLE	7.3	13.7	13.1	3.1	4.2	6.2
ACTIVITY						
POTENTIAL EXPANSIVENESS	LOW	MED	MED	LOW	LOW	LOW

The above test results are pertinent to the samples received and tested only.
While the tests are carried out according to recognized standards Controlab shall not be liable for erroneous testing or reporting thereof. This report may not be reproduced except in full without prior consent of Controlab.
Remarks:

For Controlab:

ConSR19

ControLab South Africa (Pty) Ltd

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

www.controlab.co.za

HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7859, Fax: 043 726 7426
CENTRAL LABORATORY : 10 St Pauls Road, East London, 5201, Tel: 043 722 5420 / 722 8565, Fax: 043 743 9942, P O Box 346, East London, 5200
OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Port Elizabeth, Lusaka - Zambia

CLIENT: .
WSM Leshika Consulting (PTY) Ltd
P.O. Box 39942
MORELERA PARK 0044

ATT : Mr M. Van Rensburg

PROJECT: HOUSING PROJECT IN E.C. DUNGU VILLAGE

DATE: 2014.08.12

REF: MT 24746

O.N. WF 14066

FOUNDATION INDICATOR PREDICTION OF HEAVE

SAMPLE NO	3136					
POSITION	Du 05					
	DUNGU VILL					
DEPTH	1.00 - 2.00					
DESCRIPTION	dk Br Ms +					
	P Ss					

SIEVE ANALYSIS

% PASSING	75 mm	100					
	37.5 mm	77					
	19 mm	69					
	9.5 mm	64					
	4.75 mm	60					
	2.36 mm	57					
	1.18 mm	54					
	0.600 mm	53					
	0.425 mm	50					
	0.300 mm	47					
	0.150 mm	38					
	0.075 mm	21.7					

MECHANICAL ANALYSIS

0.06 mm	19					
0.02 mm	11					
0.006 mm	6					
0.002 mm	5					

SOIL CONSTANTS

LIQUID LIMIT	25					
PLASTICITY INDEX	9					
LINEAR SHRINKAGE	4.0					

PREDICTION OF HEAVE (VAN DER MERWE METHOD)

MOISTURE CONTENT %						
PI WHOLE SAMPLE	4.6					
ACTIVITY						
POTENTIAL EXPANSIVENESS	LOW					

The above test results are pertinent to the samples received and tested only.
While the tests are carried out according to recognized standards Controlab shall not be liable for erroneous testing or reporting thereof. This report may not be reproduced except in full without prior consent of Controlab.
Remarks:

For Controlab:

ConSR19

ControLab South Africa (Pty) Ltd

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

www.controlab.co.za

HEAD OFFICE: 1 Alfred Road, Vincent 5247, Tel: 043 726 7850, Fax: 043 726 7426
CENTRAL LABORATORY : 10 St Pauls Road, East London, 5201, Tel: 043 722 5420 / 722 8565, Fax: 043 743 9942, P O Box 346, East London, 5200
OTHER BRANCH OFFICES: Cape Town, Kokstad, Mthatha, Port Elizabeth, Lusaka - Zambia

CLIENT: WSM Leshika Consulting (PTY) Ltd
P.O. Box 39942
Moreleta Park
PRETORIA, 0044
ATT: Mr. M. van Rensburg

PROJECT: HOUSING PRJCT IN EC
DATE RECEIVED: 2014.07.18
DATE TESTED: 2014.08.04
DATE REPORTED: 2014.08.19
TEST REPORT NO.: MT 24746

O.N. WF14066

MATERIALS TEST REPORT

SAMPLE NO:	3135	3138				
POSITION	Du 3	Du 5				
VILLAGE NAME	DUNGU VILLAGE					
DEPTH mm	0.80 - 1.10	1.00 - 2.00				
DESCRIPTION	dk Br Ms	dk Br Ms +				
		P Ms				
CLASSIFICATION (TRH 14)	G 9	G 9				

Sieve Analysis (Wet Preparation) TMH1 - Method A1 (a)

% PASSING	75 mm	71	100				
	63 mm	69	95				
	53 mm	66	90				
	37.5 mm	61	77				
	26.5 mm	58	73				
	19 mm	54	69				
	13.2 mm	51	66				
	4.75 mm	44	60				
	2.00 mm	37	56				
	0.425 mm	31	50				
	0.075 mm	20.1	21.7				

Soil Mortar Analysis - TMH1 - Method A6

COURSE SAND (%)	16	11				
FINE SAND (%)	29	51				
SILT / CLAY (%)	54	39				
GRADING MODULUS	2.12	1.72				

Atterberg Limits - TMH1 - Methods A2, A3, A4

LIQUID LIMIT (%)	31	25				
PLASTICITY INDEX (%)	10	9				
LINEAR SHRINKAGE (%)	4.0	4				

Maximum Dry Density & Optimum Moisture Content - TMH1 - Method A7 / California Bearing Ratio - TMH1 - Method A8

Maximum Dry Density (kg/m^3)	1962	1956				
Optimum Moisture Content (%)	12.0	11.1				
C.B.R. @ 100% COMPACTION	22	17				
C.B.R. @ 98 % COMPACTION	18	14				
C.B.R. @ 95 % COMPACTION	13	12				
C.B.R. @ 93 % COMPACTION	10	10				
C.B.R. @ 90 % COMPACTION	8	8				
SWELL @ 100% COMP. (%)	0.66	0.56				

Lab Manager:

Remarks:
Sample Delivered by Customer
Sampled by Controlab [X]

APPENDIX E

(Typical Material Properties)

TABLE E1: 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
GP	Poorly grade gravel (<5% fines)	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
SP	Poorly graded sand (<5% fines)	Fair to good	Fair	Poor to not suitable	Excellent	Good	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
CH	Silts and clays (LL>50)	Poor to fair	Not suitable	Not suitable	Practically impervious	Fair to poor	Fair stability	Medium to high
MH	Silts and clays (LL>50)	Poor	Not suitable	Not suitable	Fair to poor, semi-pervious to pervious	Fair to poor	Poor stability	Medium to high

TABLE E2: Material properties after NAVFAC DM7 (1971)

Group symbol	Soil type	Max yd	Optimum moisture (%)	Typical strength characteristics			
				Cu (kPa)	C` (kPa)	ϕ` (deg.)	tan ϕ`
GW	Well-graded clean gravels, gravel-sand mixtures	19.7-21.2	11-8	0	0	>38	>0.78
GC	Clayey gravels, poorly graded gravel-sand-clay	18.1-20.5	14-9	0	0	>31	>0.60
SM	Silty sands, poorly graded sand-silt mixtures	17.3-19.7	16-11	50	5	34	0.67
SC	Clayey sands poorly graded sand-clays	16.5-19.7	19-11	75	10	31	0.60
CL	Inorganic clays of low to medium plasticity	15.0-18.9	24-12	85	12	28	0.54
ML	Inorganic silts and clayey silts	15.0-18.9	24-12	65	10	32	0.62
CH	Inorganic clays of high plasticity	11.8-16.5	36-19	100	12	19	0.35

yd – Dry density; Cu – Undrained cohesion; C` - Drained cohesion; ϕ`(deg.) – Shearing resistance

APPENDIX F

(Classification Tables)

TABLE C1. GEOTECHNICAL CLASSIFICATION FOR URBAN DEVELOPMENT (after Partridge, Wood and Brink 1993)

CONSTRAINT		Most favourable (1)	Intermediate (2)	Least favourable (3)
A	Collapsible Soil	Any collapsible horizon or consecutive horizons totalling a depth of less than 750 mm in thickness.*	Any collapsible horizon or consecutive horizons with a depth of more than 750 mm in thickness.	A least favourable situation for this constraint does not occur.
B	Seepage	Permanent or perched water table more than 1,5 m below ground surface.	Permanent or perched water table less than 1,5 m below ground surface	Swamps and marshes.
C	Active soil	Low soil-heave potential predicted. *	Moderate soil heave potential predicted.	High soil-heave potential predicted.
D	Highly compressible soil	Low soil compressibility expected.*	Moderate soil compressibility expected.	High soil compressibility expected.
E	Erodability of soil	Low.	Intermediate.	High.
F	Difficulty of excavation to 1,5 m depth	Scattered or occasional boulders less than 10% of the total volume.	Rock or hardpan pedocretes between 10 and 40 % of the total volume.	Rock or hardpan pedocretes more than 40 % of the total volume.
G	Undermined ground	Undermining at a depth greater than 100 m below surface (except where total extraction mining has not occurred.)	Old undermined areas to a depth of 100m below surface where stope closure has ceased.	Mining within less than 100 m of surface or where total extraction mining has taken place.
H	Instability in areas of soluble rock	Possibly unstable.	Probably unstable.	Known sinkholes and dolines
I	Steep slopes	Between 2 and 6 degrees (all regions).	Slopes between 6 and 18 degrees and less than 2 degrees (Natal and Western Cape). Slopes between 6 and 12 degrees and less than 12 degrees (all other regions).	More than 18 degrees (Natal and Western Cape). More than 12 degrees (all other regions).
J	Areas of unstable natural slopes	Low risk.	Intermediate risk.	High risk (especially in areas subject to seismic activity).
K	Areas subject to seismic activity	10% probability of an event less than 100 cm/s^2 within 50 years	Mining-induced seismic activity more 100 cm/s^2.	Natural seismic activity more than 100 cm/s^2.
L	Areas subject to flooding	A “most favourable” situation for this constraint does not occur.	Areas adjacent to a known drainage channel or floodplain with slope less than 1%.	Areas within a known drainage channel or floodplain.

* These areas are designated as 1A, 1C, 1D, or 1F where localised occurrences of the constraint may arise.

TABLE C2: RESIDENTIAL SITE CLASS DESIGNATIONS (SAICE, 1995)

TYPICAL FOUNDATION 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 SOIL	< 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 C3: FOUNDATION DESIGN, BUILDING PROCEDURES AND PRECAUTIONARY MEASURES FOR SINGLE-STOREY RESIDENTIAL BUILDINGS FOUNDED ON HORIZONS SUBJECT TO CONSOLIDATION SETTLEMENT (SAICE, 1995)

SITE CLASS	ESTIMATED TOTAL SETTLEMENT (mm)	CONSTRUCTION TYPE	FOUNDATION DESIGN AND BUILDING PROCEDURES
S	**<10**	Normal	- Normal construction (strip footing or slab-on-the-ground foundations) - Good site drainage
S1	**10-20**	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**	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 C4: FOUNDATION DESIGN, BUILDING PROCEDURES AND PRECAUTIONARY MEASURES FOR SINGLE-STOREY RESIDENTIAL BUILDINGS FOUNDED ON HORIZONS SUBJECT TO BOTH CONSOLIDATION AND COLLAPSE SETTLEMENT
(SAICE, 1995)

SITE CLASS	ESTIMATED TOTAL SETTLEMENT (mm)	CONSTRUCTION TYPE	FOUNDATION DESIGN AND BUILDING PROCEDURES
C	**<5**	Normal	- Normal construction (strip footing or slab-on-the-ground foundations) - Good site drainage
C1	**5 – 10**	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**	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 C5: FOUNDATION DESIGN, BUILDING PROCEDURES AND PRECAUTIONARY MEASURES FOR SINGLE-STOREY RESIDENTIAL BUILDINGS FOUNDED ON HORIZONS SUBJECT TO HEAVE (SAICE, 1995)

SITE CLASS	ESTIMATED TOTAL EXPANSION (mm)	CONSTRUCTION TYPE	FOUNDATION DESIGN AND BUILDING PROCEDURES
H	**<7,5**	Normal	- Normal construction (strip footing or slab-on-the-ground foundations) - Good site drainage and service/plumbing precautions recommended.
H1	**7,5 – 15**	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**	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**	Stiffened or cellular raft	- As for H2.
		Piled construction	- As for H2.
		Soil raft	- As for H1.

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.

CHART C1: USCS MATERIAL DESIGNATION CHART

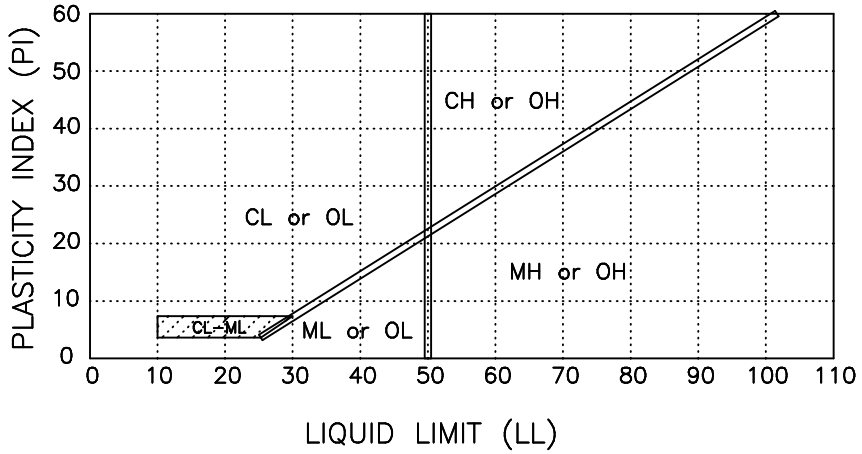
UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified by the United Soil Classification System (USCS) on the boring logs presented in this report. Grain size analysis and Atterberg limits tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see "The Unified Soil Classification System" Corps of Engineers, US Army Technical Memorandum No. 3–357 (Revised April 1960) or ASTM Designation: D2487–66T.

MAJOR DIVISIONS				GROUP SYMBOL	TYPICAL NAMES
COARSE – GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)		GW	Well graded gravels, gravel–sand mixtures, or sand–gravel–cobble mixtures.
				GP	Poorly graded gravels, gravel–sand mixtures, or sand–gravel–cobble mixtures.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below the "A" line & hatched zone on plasticity chart	GM	Silty gravels, gravel–sand–silt mixtures.
			Limits plot above the "A" line & hatched zone on plasticity chart	GC	Clayey gravels, gravel–sand–clay mixtures.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 sieve)		SW	Well graded sands, gravelly sands.
				SP	Poorly graded sands, gravelly sands.
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below the "A" line & hatched zone on plasticity chart	SM	Silty sands, sand–silt mixtures.
			Limits plot above the "A" line & hatched zone on plasticity chart	SC	Clayey sands, sand–clay mixtures.
FINE – GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS (Limits Plot Below "A" Line & hatched Zone on Plasticity Chart)	SILTS OF LOW PLASTICITY (Liquid Limit Less Than 50)		ML	Inorganic silts, non–plastic or slightly plastic.
		SILTS OF HIGH PLASTICITY (Liquid Limit More Than 50)		MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts.
	CLAYS (Limits Plot Above "A" Line & hatched Zone on Plasticity Chart)	CLAYS OF LOW PLASTICITY (Liquid Limit Less Than 50)		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid Limit More Than 50)		CH	Inorganic clays of high plasticity, fat clays, sandy clays of high plasticity.

NOTE:
Coarse grained soils with between 5% & 12% passing the No. 200 sieve and fine grained soils with Atterberg limits plotting in the hatched zone on the plasticity chart shall have dual symbol. In Arizona, local streams contain sand, gravel & cobble type material, which are locally known as SGC or riverrun material. The USCS is not used to divide and symbolize this material.

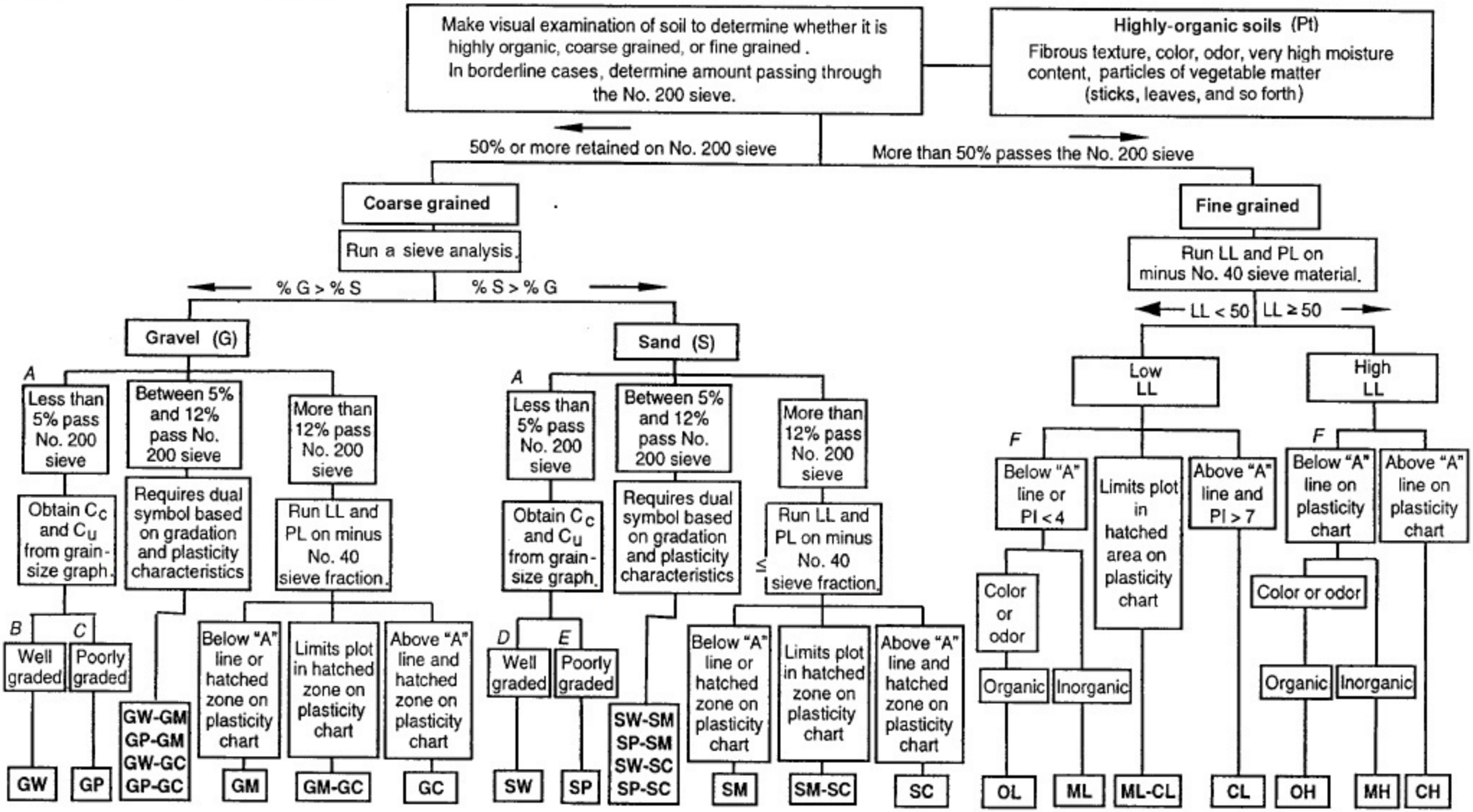
PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Cobbles	Above 3 in.
Gravel	3 in. to No. 4 sieve
Coarse gravel	3 in. to 3/4 in.
Fine gravel	3/4 in. to No. 4 sieve
Sand	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Fines (silt & clay)	Below No. 200 sieve
Clay	Smaller than 2 microns
Colloid	Smaller than 5 microns

CHART C2: USCS DESIGNATION FLOW CHART



A If fines interfere with free-draining properties, use a double symbol such as GW-GM.

B For well-graded gravel, the C_U must be > 4 and the C_C must be ≥ 1 and ≤ 3.

C For poorly graded gravel, the C_U must be ≤ 4 and/or the C_C is < 1 or > 3.

D For well graded sand, the C_U must be > 6 and the C_C must be ≥ 1 and ≤ 3.

E For poorly graded sand, the C_U must be ≤ 6 and/or the C_C is < 1 or > 3.

F In cases where organic material can't be determined by color or odor, a LL and PL test must be conducted on a sample of natural moisture content and a sample that has been oven-dried. Organic soils will show a radical drop in plasticity for the oven-dried sample compared to the retained-moisture sample. Inorganic soils generally fall within ± 1 or 2 percent of each other.